

International Journal of SCIENCE AND HUMANITIES

Volume 1, Number 1 : February 2015

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ISLAMIAH COLLEGE PUBLICATIONS
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From the Editors' Desk . . .

It gives us immense pleasure to launch this new journal, **International Journal of Science and Humanities (IJSH)** - a new kind of peer reviewed research journal published by Islamiah College (Autonomous), Vaniyambadi, a century old College serving for the cause of education mainly for rural lot. The College was started in 1919 by the philanthropists of Vaniyambadi who have founded the *Vaniyambadi Muslim Educational Society (VMES)*. It was recognized as Post Graduate and Research Centre during 1975 and 1986, respectively. Within the span of 3 decades enormous amount of research work in the field of science and Humanities have been done by the scholars and faculty that are recognized by various reputed journals, both national and international. The strength and vision provided by the teachers of the yester years has gone into the development of this journal and we believe that one can see the effort reflected in this edition and in the impact it will have on the field.

Science and Humanities are two separate entities that can play a very distinct role in bringing about the changes in the society. One of the key objectives of research is to unite and integrate the research articles related to Science and Humanities in a single volume that can document and spark a debate on the research focused on emerging technology. First, we want IJSH to be the premiere Academic and Research Journal. We want it to look different, to be different, to be one journal that will be as dynamic as the work going on in our disciplines, a rarity in academic publishing. Second, we want it to be a transporter for a new type of conversation about community development and its place in the academic review, promotion and reward process. Third, we want IJSH to lead the way in redefining and integrating the Research and Academy in a new platform, in which Scientists, Faculty, Students and Community can participate together.

The first issue has been very carefully put together covering a range of articles in the field of Applied Mathematics, Nanotechnology, Computational Chemistry, Medical Biochemistry, Biotechnology, Languages, Commerce, History and Education. The contributions have come in not only from academics, but also from very renowned research institutions as well. We thank the Secretary of Islamiah college and the Members of VMES, who had the vision to embark on this project. Our sincere thanks are due to the contributors who have contributed their research work to this journal. We also thank our Students and Research Scholars and those we teach and transform us vice versa. We look forward to our journey together as we develop IJSH into its fullest potential.

The Journal is intended to run on a non-commercial and non-profitable basis. The entire funding for the execution of this IJSH is being taken care of completely by the Vaniyambadi Muslim Educational Society.

Finally, we dedicate this work to the Almighty, who has given us the strength and capacity to carry out this project.

K. PREM NAZEER

U. RIZWAN

A. NOOR MOHAMED

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Part A :

SCIENCE

Extreme Shock Maintenance Models Under Some Bivariate Replacement Policies in An Alternative Repair Model

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Abstract

In this paper some Bivariate Replacement Policies (T, N) , (U, N) , (T^+, N) , (U^-, N) with NONN repair times where T is the working age of the system, N is the number of failures of the system, U is the cumulative repair time of the system, T^+ is the system replaced at the first failure point after the cumulative operating time exceeds T and U^- is the failure point just before the total repair time exceed U are studied. Explicit expressions for the long run average cost for the models are derived. Optimality conditions are deduced.

AMS Subject Classification: 60K10

Keywords: Geometric Process, NONN repair times, Optimal Replacement Policy.

1. Introduction

The study of maintenance problem plays an important role in reliability. Most of the maintenance models just pay attention on the internal cause of the system failure, but do not on an external cause of the system failure. A system failure may be caused by some external cause, such as a shock. The shock models have been successfully applied to different fields, such as physics, communication, electronic engineering and medicine, etc. However, only a very few authors consider the deteriorating systems interrupted by random shocks. In our model, the system will fail, if the amount of shock damage by one big shock exceeds a specific threshold. In these models, the shock is called a deadly shock if the amount of damage of the shock to the system exceeds a specific threshold so that the system will fail. This kind of shock models is called an extreme shock model. Chen and Li [2008] have considered an extreme shock model and studied the maintenance problem under N policy. Also an alternative repair model, called the *Negligible Or Non-Negligible* (NONN) repair times introduced by Thangaraj and Rizwan [2001] is incorporated in this paper to develop an extreme shock

model for the maintenance problem under some bivariate replacement policies. The long-run average cost for a multistate degenerative system under the following bivariate replacement policies (T, N) - policy, (U, N) - policy, (T^+, N) - policy, and (U^-, N) - policy are derived. Here T is the working age of the system, N is the number of failures of the system, U is the cumulative repair time of the system, T^+ is the system replaced at the first failure point after the cumulative operating time exceeds T and U^- is the failure point just before the total repair time exceed U . Existence of optimality under the aforesaid bivariate replacement policies are deduced.

The rest of the paper is organized as follows: In Section 2, we give a general description of the model. In Section 3, we derive explicit expressions for the long-run average cost per unit time for this model under the bivariate replacement policies (T, N) , (U, N) , (T^+, N) and (U^-, N) . Finally, conclusion is given in Section 4.

Definition 1.1 *If a repair to a system after failure is done in negligible or non-negligible time, then it will be called a model with NONN repair times.*

In this case, whenever the system fails, two possibilities may arise: either, the repair takes Negligible time with probability p ; or Non-Negligible time with probability $1 - p$.

2. The Model

We make the following assumptions about the model for a simple degenerative repairable system subject to shocks.

2.1 At time $t=0$, a new system is installed. Whenever the system fails, it will be repaired. The system will be replaced by an identical new one, some times later.

2.2 Once the system is operating, the shocks from the environment arrive according to a renewal process. Let X_{ni} , $i = 1, 2, \dots$ be the time intervals between the $(i - 1)$ -st and i -th shock, after the $(n - 1)$ -st repair. Let $E(X_{11}) = \lambda$. Assume that X_{ni} , $i = 1, 2, \dots$, are i.i.d. sequences, for all $n \in \mathbb{N}$.

2.3 Let Y_{ni} , $i = 1, 2, \dots$ be the sequence of the amount of shock damage produced by the i -th shock, after the $(n - 1)$ -st repair. Let $E(Y_{11}) = \mu$. Then $\{Y_{ni}, i = 1, 2, \dots\}$ are i.i.d. sequences, for all $n \in \mathcal{N}$. If the system fails, it is closed, so that the random shocks have no effect on the system during the repair process.

In the n -th operating stage, that is, after the $(n - 1)$ -st repair, the system will fail, if the amount of the shock damage first exceed $a^{n-1}M$, where $0 < a \leq 1$ and M is a positive constant.

2.4 Let Z_n , $n = 1, 2, \dots$ be the repair time after the n -th repair and Z_n , $n = 1, 2, \dots$ constitute a non decreasing geometric process with $E(Z_1) = \delta$ and ratio b , such

that $0 < b \leq 1$. $N_n(t)$ is the counting process denoting the number of shocks after the $(n - 1)$ -st repair.

2.5 Let r be the reward rate per unit time of the system when it is operating and c be the repair cost rate per unit time of the system and the replacement cost is R . The replacement time is a random variable Z with $E(Z) = \tau$.

2.6 The sequences $\{X_{ni}, i = 1, 2, \dots\}$, $\{Y_{ni}, i = 1, 2, \dots\}$, $\{Z_n, n = 1, 2, \dots\}$ and Z are independent.

2.7 Assume that $F_n(t)$ is the cumulative distribution of $U_n = \sum_{i=1}^n W_i$ and $G_n(t)$ be the cumulative distribution of $V_n = \sum_{i=1}^n Z_i$.

2.8 Define

$$\xi_n = \begin{cases} Z_n & \text{if } Z_n > 0 \\ 1 & \text{if } Z_n = 0 \end{cases}$$

for $n = 1, 2, \dots$.

2.8 The replacement policies (T, N) , (U, N) , (T^+, N) , (U^-, N) are adapted.

3. The Bivariate Policies with NONN repair times

3.1. The Policy (T, N) with NONN repair times

In this section, we study an extreme shock model for the maintenance problem of a simple repairable system under (T, N) policy. Let $L_n = \min\{l; Y_{nl} > a^{n-1}M\}$ and $W_n = \sum_{i=1}^{L_n} X_{ni}$. Thus, L_n is the number of shocks until the first deadly shock occurred following the $(n - 1)$ -st failure and L_n has a geometric distribution with $P\{L_n = k\} = p_n q_n^{k-1}$, $k = 1, 2, \dots$, where $p_n = P\{Y_{nl} > a^{n-1}M\}$ and $q_n = 1 - p_n$. We have $E(L_n) = \frac{1}{p_n}$. Clearly, L_n and $\{X_{ni}, i = 1, 2, \dots\}$ are independent, since $\{X_{ni}, i = 1, 2, \dots\}$ and $\{Y_{ni}, i = 1, 2, \dots\}$ are independent. Now

$$E(W_n) = E\left(\sum_{i=1}^{L_n} X_{ni}\right) = E(L_n)E(X_{n1}) = \frac{\lambda}{p_n}.$$

The distribution function of W_n is $F_n(\cdot)$. The *working age* T of the system at time t is the cumulative life-time given by

$$T(t) = \begin{cases} t - V_n, & U_n + V_n \leq t < U_{n+1} + V_n \\ U_{n+1}, & U_{n+1} + V_n \leq t < U_{n+1} + V_{n+1} \end{cases}$$

where $U_n = \sum_{i=1}^n W_i$ and $V_n = \sum_{i=1}^n Z_i$ and $U_0 = V_0 = 0$.

By assumption,

$$\begin{aligned} E(\xi_n) &= E(Z_n)P(Z_n > 0) + 1P(Z_n = 0) \\ &= \frac{\delta}{b^{n-1}}(1-p) + p, \end{aligned}$$

Let T_1 be the first replacement time. In general for $n = 2, 3, \dots$, let T_n be the time between the $(n-1)$ -st replacement and the n -th replacement. Thus the sequence $\{T_n, n = 1, 2, \dots\}$ forms a renewal process. A cycle is completed, if a replacement is done. A cycle is actually the time interval between the installation of the system and the first replacement or the time interval between two consecutive replacements. Finally, the successive cycles together with the cost incurred in each cycle will constitute a renewal reward process.

Let $\mathcal{C}(T, N)$ be the long run average cost per unit time. By the renewal reward theorem, the long run average cost per unit time under the replacement policy (T, N) for a multistate degenerative system with NONN repair times, is given by

$$\begin{aligned} \mathcal{C}(T, N) &= \frac{\text{the expected cost incurred in a cycle}}{\text{the expected length of a cycle}} \\ &= \frac{\left[\begin{aligned} &E \left\{ \left(c \sum_{n=1}^{\eta} \xi_n - rT \right) \chi_{(U_N > T)} \right\} + c_p E(Z) + \\ &E \left\{ \left(c \sum_{n=1}^{N-1} \xi_n - r \sum_{n=1}^N W_n \right) \chi_{(U_N \leq T)} \right\} + R \end{aligned} \right]}{E(W)} \end{aligned} \quad (3.1)$$

where η is a random variable denoting the number of failures before the working age of the system reaches T , W is the length of a cycle and $\chi(\cdot)$ denotes the indicator function.

The length of the cycle under the replacement policy (T, N) is

$$W = \left(T + \sum_{n=1}^{\eta} \xi_n \right) \chi_{(U_N > T)} + \left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_N \leq T)} + Z,$$

where $\eta = 0, 1, 2, \dots, N - 1$ is the number of failures before the working age of the system exceeds T . Now

$$\begin{aligned} E \left[\left(\sum_{n=1}^N W_n \right) \chi_{(U_N \leq T)} \right] &= E \left\{ E \left[\left(\sum_{n=1}^N W_n \right) \chi_{(U_N \leq T)} | U_N \right] \right\} \\ &= \int_0^T E \left(\sum_{n=1}^N W_n | U_N = u \right) dF_N(u) \\ &= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^T u dF_N(u) \end{aligned}$$

where $F_N(\cdot)$ is the n -fold convolution of $F(\cdot)$ with itself.

$$\begin{aligned} E \left[\left(\sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_N \leq T)} \right] &= E \left\{ E \left[\left(\sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_N \leq T)} | U_N \right] \right\} \\ &= \int_0^T E \left(\sum_{n=1}^{N-1} \xi_n | U_N = u \right) dF_N(u) \\ &= \int_0^T \left(\sum_{n=1}^{N-1} E(\xi_n) \right) dF_N(u) \\ &= \int_0^T \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) dF_N(u) \\ &= \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) \int_0^T dF_N(u) \\ &= \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) F_N(T). \end{aligned}$$

Further

$$\begin{aligned} E(W) &= E \left[\left(T + \sum_{n=1}^{\eta} \xi_n \right) \chi_{(U_N > T)} \right] + E \left[\left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_N \leq T)} \right] + E(Z) \\ &= E [T\chi_{(U_N > T)}] + E \left[\left(\sum_{n=1}^{\eta} \xi_n \right) \chi_{(U_N > T)} \right] \\ &\quad + E \left\{ E \left[\left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_N \leq T)} | U_N = u \right] \right\} + E(Z) \end{aligned}$$

$$\begin{aligned}
&= T\bar{F}_N(T) + E \left[\left(\sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_n < T < U_N)} \right] \\
&\quad + \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^T u dF_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta(1-p)}{b^{n-1}} + p \right) F_N(T) + \tau \quad (3.2)
\end{aligned}$$

where $b = \left(\sum_{i=1}^k \frac{p_i}{b_i} \right)^{-1}$. Let $W_{N-n} = \sum_{j=n+1}^N W_j$. Then $U_N = U_n + W_{N-n}$. Moreover U_n and W_{N-n} are independent and

$$H_{N-n}(t) = \int_0^\infty H_{N-1-n}(a(t-y)) dH(y), \quad (3.3)$$

where $H_{N-1-n}(t)$ is the distribution of $\sum_{j=n+1}^N X_j$ and $\left(\sum_{i=1}^k \frac{p_i}{a_i} \right)^{-1} = a$. Since the distribution function of X_{n+1} is $H(t) = F(a^n t)$, equation (3.3) can be written, by induction, as $H_{N-n}(t) = F_{N-n}(a^n t)$. Now

$$\begin{aligned}
E \left[\chi_{(U_n < T < U_N)} \right] &= P(U_n < T < U_n + W_{N-n}) \\
&= \int_0^T \int_{T-u}^\infty dH_{N-n}(t) dF_n(u) \\
&= \int_0^T \bar{F}_{N-n}(a^n(T-u)) dF_n(u),
\end{aligned}$$

so that equation (3.2) becomes

$$\begin{aligned}
E(W) &= T\bar{F}_N(T) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) \int_0^T \bar{F}_{N-n}(a^n(T-u)) dF_n(u) \\
&\quad + \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^T u dF_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) F_N(T) + \tau \\
&= \int_0^T \bar{F}_N(u) du + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) F_N(T) \\
&\quad + \sum_{n=1}^{N-1} \frac{\lambda}{p_n} \left(\frac{(1-p)}{b^{n-1}} + p \right) \int_0^T \bar{F}_{N-n}(a^n(T-u)) dF_n(u) + \tau.
\end{aligned}$$

The equation (3.1) then becomes

$$\mathcal{C}(T, N) = \frac{\left[\begin{aligned} &\sum_{n=1}^{N-1} \left(\frac{\delta(1-p)}{b^{n-1}} + p \right) \int_0^T \bar{F}_{N-n}(a^n(T-u)) dF_n(u) \\ &-rT\bar{F}_N(T) + c \sum_{n=1}^{N-1} \left(\frac{\delta(1-p)}{b^{n-1}} + p \right) F_N(T) \\ &-r \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^T u dF_N(u) + R + c_p \tau \end{aligned} \right]}{\left[\begin{aligned} &T\bar{F}_N(T) + \sum_{n=1}^{N-1} \left(\frac{\delta(1-p)}{b^{n-1}} + p \right) F_N(T) \\ &+ \sum_{n=1}^{N-1} \frac{\lambda}{p_n} \left(\frac{(1-p)}{b^{n-1}} + p \right) \int_0^T \bar{F}_{N-n}(a^n(T-u)) dF_n(u) + \tau \end{aligned} \right]} \quad (3.4)$$

Deductions

The long-run average cost $\mathcal{C}(T, N)$ is a bivariate function in T and N . Obviously, when N is fixed, $\mathcal{C}(T, N)$ is a function of T . For fixed $N = m$, it can be written as

$$\mathcal{C}(T, N) = \mathcal{C}_m(T), \quad m = 1, 2, \dots$$

Thus, for a fixed m , we can find T_m^* by analytical or numerical methods such that $\mathcal{C}_m(T_m^*)$ is minimized. That is, when $N = 1, 2, \dots, m, \dots$, we can find $T_1^*, T_2^*, T_3^*, \dots, T_m^*, \dots$, respectively, such that the corresponding $\mathcal{C}_1(T_1^*), \mathcal{C}_2(T_2^*), \dots, \mathcal{C}_m(T_m^*), \dots$ are minimized. Because the total life-time of a multistate degenerative system is limited, the minimum of the long-run average cost per unit time exists. So we can determine the minimum of the long-run average cost per unit time based on $\mathcal{C}_1(T_1^*), \mathcal{C}_2(T_2^*), \dots, \mathcal{C}_m(T_m^*), \dots$.

Then, if the minimum is denoted by $\mathcal{C}_n(T_n^*)$, we obtain the bivariate optimal replacement policy $(T, N)^*$ such that

$$\begin{aligned} \mathcal{C}((T, N)^*) &= \min_N \mathcal{C}_n(T_n^*) \\ &= \min_N [\min_T \mathcal{C}(T, N)] \\ &\leq \min_N \mathcal{C}(\infty, N) \equiv \mathcal{C}(N^*) \end{aligned}$$

the optimal policy $(T, N)^*$ is better than the optimal policy N^* . Moreover, under some mild conditions, Stadge and Zuckerman[1990] showed that an optimal replacement policy N^* is better than the optimal policy T^* . So under the same conditions, an optimal policy $(T, N)^*$ is better than the optimal replacement policies N^* and T^* .

3.2. The Policy (U, N) with NONN repair times

In this section, we introduce and study a bivariate replacement policy (U, N) with NONN repair times for the multistate degenerative system, under which the system is replaced at the time of N -th failure or the total repair time exceeds U , whichever occurs earlier. The problem is to choose an optimal replacement policy $(U, N)^*$ such that the long-run average cost per unit time is minimized.

3.2.1 The length of a Cycle and its Mean

Let U_1 be the first replacement time; in general for $n = 2, 3, \dots$, let U_n be the time between the $(n - 1)$ -st replacement and the n -th replacement. Thus the sequence $\{U_n, n = 1, 2, \dots\}$ forms a renewal process. A cycle is completed, if a replacement is done. A cycle is actually the time interval between the installation of the system and the first replacement or the time interval between two consecutive replacements. Finally, the successive cycles together with the cost incurred in each cycle will constitute a renewal reward process.

Let $\mathcal{C}(U, N)$ be the long run average cost per unit time under the bivariate replacement policy (U, N) . By the renewal reward theorem, the long run average cost per unit time under the replacement policy (U, N) for a multistate degenerative system with NONN repair times, is given by

$$\begin{aligned} \mathcal{C}(U, N) &= \frac{\text{the expected cost incurred in a cycle}}{\text{the expected length of a cycle}} \\ &= \frac{\left[\begin{array}{l} E \left\{ \left(c \sum_{n=1}^{\eta} \xi_n - rU \right) \chi_{(V_N > U)} \right\} + c_p E(Z) + \\ E \left\{ \left(c \sum_{n=1}^{N-1} \xi_n - r \sum_{n=1}^N W_n \right) \chi_{(V_N \leq U)} \right\} + R \end{array} \right]}{E(W)} \end{aligned} \quad (3.5)$$

where η is a random variable denoting the number of failures before the working age of the system reaches T , W is the length of a cycle and $\chi(\cdot)$ denotes the indicator function. Therefore $\eta = 0, 1, \dots, N - 1$.

The length of a cycle W under the bivariate replacement policy (U, N) with NONN Repair times is

$$W = \left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(V_N \leq U)} + \left(\sum_{n=1}^{\eta} W_n + U \right) \chi_{(V_N > U)} + Z,$$

where $\eta = 0, 1, 2, \dots, N - 1$ is the number of failures before the total repair time exceeds U and $\chi_{(\cdot)}$ denotes the indicator function. Now

$$\begin{aligned} E \left[\left(\sum_{n=1}^N W_n \right) \chi_{(V_N \leq U)} \right] &= E \left\{ E \left[\left(\sum_{n=1}^N W_n \right) \chi_{(V_N \leq U)} | U_N \right] \right\} \\ &= \int_0^U E \left(\sum_{n=1}^N W_n | G_N = u \right) dG_N(u) \\ &= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) \end{aligned}$$

where $G_N(\cdot)$ is the n -fold convolution of $G(\cdot)$ with itself.

$$\begin{aligned} E \left[\left(\sum_{n=1}^{N-1} \xi_n \right) \chi_{(V_N \leq U)} \right] &= E \left\{ E \left[\left(\sum_{n=1}^{N-1} \xi_n \right) \chi_{(V_N \leq U)} | U_N \right] \right\} \\ &= \int_0^U E \left(\sum_{n=1}^{N-1} \xi_n | V_N = u \right) dG_N(u) \\ &= \int_0^U \left(\sum_{n=1}^{N-1} E(\xi_n) \right) dG_N(u) \\ &= \int_0^U \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) dG_N(u) \\ &= \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) \int_0^U dG_N(u) \\ &= \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) G_N(U). \end{aligned}$$

Further

$$\begin{aligned} E(W) &= E \left[\left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(V_N \leq U)} \right] + \left[\left(\sum_{n=1}^{\eta} W_n + U \right) \chi_{(V_N > U)} \right] + E(Z) \\ &= E \left\{ E \left[\left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(V_N \leq U)} | V_N = u \right] \right\} \\ &\quad + E \left[\sum_{n=1}^{\eta} W_n \chi_{(V_N > U)} \right] + E [U \chi_{(V_N > U)}] + E(Z) \end{aligned}$$

$$\begin{aligned}
&= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) G_N(U) \\
&\quad + \sum_{n=1}^{N-1} E(W_n) E[\chi_{(V_n \leq U < V_N)}] + U \bar{G}_N(U) + \tau, \tag{3.6}
\end{aligned}$$

Let

$$W_{N-n} = \sum_{j=n+1}^N W_j$$

Then $V_N = V_n + W_{N-n}$. Moreover V_n and W_{N-n} are independent and

$$H_{N-n}(t) = \int_0^\infty H_{N-1-n}(a(t-y)) dH(y), \tag{3.7}$$

where $H_{N-1-n}(t)$ is the distribution of $\sum_{j=n+1}^N W_j$. Since the distribution function of X_{n+1} is $H(t) = G(a^n t)$, equation (3.6) can be written, by induction, as $H_{N-n}(t) = G_{N-n}(a^n t)$.

Now

$$\begin{aligned}
E[\chi_{(V_n < U < V_N)}] &= P(V_n < U < V_n + W_{N-n}) \\
&= \int_0^U \int_{U-u}^\infty dH_{N-n}(t) dG_n(u) \\
&= \int_0^U \bar{G}_{N-n}(a^n(T-u)) dG_n(u),
\end{aligned}$$

so that equation (3.6) becomes

$$\begin{aligned}
E(W) &= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) G_N(U) \\
&\quad + \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) \int_0^U \bar{G}_{N-n}(a^n(T-u)) dG_n(u), + U \bar{G}_N(U) + \tau, \\
&= \frac{\lambda}{p_n} \int_0^U \bar{G}_N(U) du + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) G_N(U) \\
&\quad + \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u \bar{G}_{N-n}(a^n(U-u)) dG_n(u) + \tau
\end{aligned}$$

Now the equation (3.5) becomes

$$\mathcal{C}(U, N) = \frac{\left[\begin{aligned} &\sum_{n=1}^{N-1} \left(\frac{\delta(1-p)}{b^{n-1}} + p \right) G_N(U) \\ &-r \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^T \bar{G}_{N-n}(a^n U - u) dG_n(u) \\ &-r \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_n(u) + R + c_p \tau \end{aligned} \right]}{\left[\begin{aligned} &\frac{\lambda}{p_n} \int_0^U \bar{G}_N(U) du + \sum_{n=1}^{N-1} \left(\frac{\delta(1-p)}{b^{n-1}} + p \right) G_N(U) \\ &+ \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u \bar{G}_{N-n}(a^n(U-u)) dG_n(u) + \tau \end{aligned} \right]} \quad (3.8)$$

Deductions

The long-run average cost $\mathcal{C}(U, N)$ with NONN Repair times is a bivariate function in U and N . Obviously, when N is fixed, $\mathcal{C}(U, N)$ is a function of T . For fixed $N = m$, it can be written as

$$\mathcal{C}(U, N) = \mathcal{C}_m(U), \quad m = 1, 2, \dots$$

Thus, for a fixed m , we can find U_m^* by analytical or numerical methods such that $\mathcal{C}_m(U_m^*)$ is minimized. That is, when $N = 1, 2, \dots, m, \dots$, we can find $U_1^*, U_2^*, U_3^*, \dots, U_m^*, \dots$, respectively, such that the corresponding $\mathcal{C}_1(U_1^*), \mathcal{C}_2(U_2^*), \dots, \mathcal{C}_m(U_m^*), \dots$ are minimized.

Because the total life-time of a multistate degenerative system is limited, the minimum of the long-run average cost per unit time exists. So we can determine the minimum of the long-run average cost per unit time based on $\mathcal{C}_1(U_1^*), \mathcal{C}_2(U_2^*), \dots, \mathcal{C}_m(U_m^*), \dots$.

Then, if the minimum is denoted by $\mathcal{C}_n(U_n^*)$, we obtain the bivariate optimal replacement policy $(U, N)^*$ such that

$$\begin{aligned} \mathcal{C}((U, N)^*) &= \min_N \mathcal{C}_n(U_n^*) \\ &= \min_N [\min_U \mathcal{C}(U, N)] \\ &\leq \min_N \mathcal{C}(\infty, N) \equiv \mathcal{C}(N^*) \end{aligned}$$

the optimal policy $(U, N)^*$ is better than the optimal policy N^* . Moreover, under some mild conditions, Stadje and Zuckerman [1990] showed that an optimal replacement policy N^* is better than the optimal policy U^* . So under the same conditions, an optimal policy $(U, N)^*$ is better than the optimal replacement policies N^* and U^* .

3.3. The Policy (T^+, N) with NONN repair times

It is a policy for which the multistate degenerative system, under which the system will be replaced at the first failure point after the cumulative operating time exceeds T or at the occurrence of the N -th failure, whichever occurs earlier. The technique of replacing *at the first failure point after the cumulative operating time exceeds a predetermined value* is used in Muth [1977].

3.3.1 The Length of a Cycle and its Mean

The length of the cycle under the bivariate replacement policy (T^+, N) is

$$W = \left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_N \leq T)} + \left(\sum_{n=1}^{\eta} W_n + \sum_{n=1}^{\eta} \xi_{n-1} \right) \chi_{(U_N > T)} + Z,$$

where $\eta = 1, 2, \dots, N - 1$ is the number of failures before the total operating time exceeds T .

The random variable η has a geometric distribution given by

$$\begin{aligned} P(\eta = j) &= P(W_1 \leq T, W_2 \leq T, \dots, W_{\eta-1} \leq T, W_{\eta} > T); \quad j = 1, 2, \dots \\ &= F^{j-1}(T) \bar{F}(T). \end{aligned}$$

Since η is a random variable,

$$\begin{aligned} E(\eta - 1) &= \sum_{j=1}^{\infty} (j - 1) P(\eta = j) \\ &= F(T) \sum_{j=1}^{\infty} (j - 1) F^{j-1}(T) \\ &= \frac{F(T)}{\bar{F}(T)}. \end{aligned}$$

Lemma 3.1 *The mean length of the cycle under the policy (T^+, N) with NONN repair times is*

$$\begin{aligned} E(W) &= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^T u dF_N(u) + \frac{F(T)}{\bar{F}(T)} \sum_{n=1}^{N-1} \frac{\lambda}{p_n} [F_n(T) - F_N(T)] \\ &\quad + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}} (1 - p) + p \right) [(1 - b)F_N(T) + bF_n(T)] + \tau. \end{aligned} \quad (3.9)$$

Proof. Consider

$$\begin{aligned}
 E(W) &= E \left[\left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_N \leq T)} \right] \\
 &\quad + E \left[\left(\sum_{n=1}^{\eta} W_n + \sum_{n=1}^{\eta} \xi_{n-1} \right) \chi_{(U_N > T)} \right] + E(Z) \\
 &= E \left\{ E \left[\left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(U_N \leq T)} \middle| U_N \right] \right\} \\
 &\quad + E \left[\sum_{n=1}^{\eta} W_n \chi_{(U_N > T)} \right] + E \left[\left(\sum_{n=1}^{\eta} \xi_{n-1} \right) \chi_{(U_N > T)} \right] + E(Z) \\
 &= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^T u dF_N(u) + \int_0^T \sum_{n=1}^{N-1} E(\xi_n) dF_N(u) \\
 &\quad + \sum_{n=1}^{N-1} E(W_n | \eta = N-1) P(U_n \leq T < U_N) \\
 &\quad \quad \quad + \sum_{n=1}^{N-1} E(\xi_{n-1}) E[\chi(U_n \leq T < U_N)] + \tau \\
 &= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^T u dF_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}} (1-p) + p \right) F_N(T) \\
 &\quad + \frac{F(T)}{F(T)} \sum_{n=1}^{N-1} \frac{\lambda}{p_n} [F_n(T) - F_N(T)] \\
 &\quad \quad \quad + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-2}} (1-p) + p \right) [F_n(T) - F_N(T)] + \tau,
 \end{aligned}$$

which on simplification yields (3.9). This completes the proof of the lemma. ■

3.3.2 The Long-run Average Cost under Policy (T^+, N) With NONN Repair times

By the renewal reward theorem, the long-run average cost per unit time under the bivariate replacement policy- (T^+, N) for a multistate degenerative system is given by

$$\mathcal{C}(T^+, N) = \frac{\text{the expected cost incurred in a cycle}}{\text{the expected length of a cycle}}$$

$$= \frac{\left[\begin{aligned} & E \left\{ \left(c \sum_{n=1}^{N-1} \xi_n - r \sum_{n=1}^N W_n \right) \chi_{(U_N \leq T)} \right\} + R \\ & + E \left\{ \left(c \sum_{n=1}^{\eta} \xi_{n-1} - r \sum_{n=1}^{\eta} W_n \right) \chi_{(U_N > T)} \right\} + c_p E(Z) \end{aligned} \right]}{E(W)},$$

Using Lemma 3.1 and simplifying, we have the following result.

Theorem 3.1 *For the model described in Section 2, under the assumptions 2.1 - 2.8, the long-run average cost per unit time under the bivariate replacement policy (T^+, N) for a multistate degenerative system is given by*

$$\mathcal{C}(T^+, N) = \frac{c\Psi_2(T, N) - r\Psi_1(T, N) + c_p\tau + R}{\Psi_1(T, N) + \Psi_2(T, N) + \tau}, \quad (3.10)$$

where

$$\Psi_1(T, N) = \sum_{n=1}^{N-1} \frac{\lambda}{p_n} \int_0^T u dF_N(u) + \frac{F(T)}{\overline{F}(T)} \sum_{n=1}^{N-1} \frac{\lambda}{p_n} [F_n(T) - F_N(T)]$$

and

$$\Psi_2(T, N) = \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) [(1-b)F_N(T) + bF_n(T)].$$

The bivariate optimal replacement policy $(T^+, N)^*$ is obtained in a manner similar to that used for finding optimal policy $(T, N)^*$.

3.4. The Policy (U^-, N) with NONN repair times

Under the policy (U^-, N) , we will replace the multistate degenerative system at the failure point just before the total repair time exceed U or at the occurrence of the N -th failure, whichever occurs earlier.

3.4.1 Virtual Repair Times

In the policy (U, N) , an optimal policy may be such that we will have to replace the system, in the middle of a repair, after (say) s units of repair time. Then the question naturally arises whether it would not have been more profitable to replace the system at the failure point itself, as we might have been saved the repair cost. In fact, Stadje and Zuckerman [1992] have proved for their policy U that if Y'_n 's are $NBUE$, then there is an optimal replacement policy that does not replace at the middle of a repair period. Since no additional costs are involved for replacing at failure in our policies, it is profitable not to replace the system in the middle of an operating interval.

3.4.2 The length of a Cycle and its Mean

The length of a cycle W under the bivariate replacement policy (U^-, N) with NONN repair times is

$$W = \left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(V_N \leq U)} + \left(\sum_{n=1}^{\eta} W_n + \sum_{n=0}^{\nu} \xi_n \right) \chi_{(V_N > U)} + Z,$$

where $\eta = 1, 2, \dots, N - 1$ is the number of failures before the total repair time exceeds U and $\nu = 0, 1, \dots, N - 1$ is the number of repairs before the total repair time is expected to exceed U . If $V_n \leq U < V_{n+1}$ for $n = 1, 2, \dots, N - 1$, then $U - V_i$ will be the virtual repair time. The random variable η has a geometric distribution given by

$$\begin{aligned} P(\eta = j) &= P(W_1 \leq T, W_2 \leq T, \dots, W_{\eta-1} \leq T, W_{\eta} > T); \quad j = 1, 2, \dots \\ &= G^{j-1}(U) \overline{G}(U). \end{aligned}$$

Since η is a random variable,

$$\begin{aligned} E(\eta - 1) &= \sum_{j=1}^{\infty} (j - 1) P(\eta = j) \\ &= G(U) \sum_{j=1}^{\infty} (j - 1) G^{j-1}(U) \\ &= \frac{G(U)}{\overline{G}(U)}. \end{aligned}$$

Lemma 3.2 *The mean length of the cycle under policy (U^-, N) with NONN repair times is*

$$\begin{aligned} E(W) &= \sum_{n=1}^{N-1} \frac{\lambda}{p_n} [G_{n-1}(U) - G_N(U)] + \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) \\ &\quad + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}} (1 - p) + p \right) G_N(U) \\ &\quad + \frac{G(U)}{\overline{G}(U)} \sum_{n=0}^{N-1} \left(\frac{\delta}{b^{n-1}} (1 - p) + p \right) [G_n(U) - G_N(U)] + \tau. \quad (3.11) \end{aligned}$$

Proof. Consider

$$E(W) = E \left[\left(\sum_{n=1}^N W_n + \sum_{n=1}^{N-1} \xi_n \right) \chi_{(V_N \leq U)} \right] + \left[\left(\sum_{n=1}^{\eta} W_n + \sum_{n=0}^{\nu} \xi_n \right) \chi_{(V_N > U)} \right] + E(Z)$$

$$\begin{aligned}
&= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) G_N(U) \\
&\quad + E \left[\sum_{n=1}^{\eta} W_n \chi_{(V_N > U)} \right] + E \left[\sum_{n=0}^{\nu} \xi_n \chi_{(V_N > U)} \right] + E(Z) \\
&= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) G_N(U) \\
&\quad + \sum_{n=1}^{N-1} E(W_n) P[V_{n-1} \leq U < V_N] + \sum_{n=0}^{N-1} E(\xi_n | \nu) P[V_n \leq U < V_N] + E(Z) \\
&= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) G_N(U) \\
&\quad + \sum_{n=1}^{N-1} \frac{\lambda}{p_n} [G_{n-1}(U) - G_N(U)] + \sum_{n=0}^{N-1} E(\xi_n) E(\nu - 1) [G_n(U) - G_N(U)] + \tau \\
&= \sum_{n=1}^N \frac{\lambda}{p_n} \int_0^U u dG_N(u) + \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) G_N(U) \\
&\quad + \sum_{n=1}^{N-1} \frac{\lambda}{p_n} [G_{n-1}(U) - G_N(U)] \\
&\quad + \frac{G(U)}{G(U)} \sum_{n=0}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) [G_n(U) - G_N(U)] + \tau.
\end{aligned}$$

This completes the proof of the lemma. ■

3.4.3 The Long-run Average Cost under Policy (U^-, N) With NONN Repair times

By the renewal reward theorem, the long-run average cost per unit time under the bivariate replacement policy- (U^-, N) for a multistate degenerative system is given by

$$\mathcal{C}(U^-, N) = \frac{\text{the expected cost incurred in a cycle}}{\text{the expected length of a cycle}}$$

$$= \frac{\left[\begin{aligned} & E \left\{ \left(c \sum_{n=1}^{N-1} \xi_n - r \sum_{n=1}^N W_n \right) \chi_{(V_N \leq U)} \right\} + R \\ & + E \left\{ \left(c \sum_{n=0}^{\nu} \xi_{n-1} - r \sum_{n=1}^{\eta} W_n \right) \chi_{(V_N > U)} \right\} + c_p E(Z) \end{aligned} \right]}{E(W)},$$

Using Lemma 3.2 and simplifying, we have the following result.

Theorem 3.2 For the model described in Section 2, under the assumptions 2.1 - 2.8, the long-run average cost per unit time under the bivariate replacement policy (U^-, N) for a multistate degenerative system is given by

$$C(U^-, N) = \frac{c\Psi_4(U, N) - r\Psi_3(U, N) + c_p\tau + R}{\Psi_3(U, N) + \Psi_4(U, N) + \tau}, \quad (3.12)$$

where

$$\Psi_3(U, N) = \sum_{n=1}^{N-1} \frac{\lambda}{p_n} \int_0^U u dG_N(u) + \frac{G(U)}{\bar{G}(U)} \sum_{n=1}^{N-1} \frac{\lambda}{p_n} [G_n(U) - G_N(U)]$$

and

$$\Psi_4(U, N) = \sum_{n=1}^{N-1} \left(\frac{\delta}{b^{n-1}}(1-p) + p \right) [(1-b)G_N(U) + bG_n(U)].$$

The bivariate optimal replacement policy $(U^-, N)^*$ is obtained in a manner similar to that used for finding optimal policy $(U, N)^*$.

4. Conclusion

Considering an extreme shock maintenance model for a multistate degenerative simple repairable system, explicit expressions for the long-run average cost under the bivariate replacement policies (T, N) , (U, N) , (T^+, N) , and (U^-, N) have been obtained. Existence of optimality under these models have been deduced.

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Stability of an Additive-Quartic Functional Equation in Orthogonality Spaces

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Abstract

Using the fixed point method, we prove the Hyers-Ulam stability of the following additive-quartic functional equation

$$f(x + 2y) + f(x - 2y) = f(2x + y) + f(2x - y) - f(2x) - 7[f(x) + f(-x)] + 15[f(y) + f(-y)], \quad (0.1)$$

for all x, y with $x \perp y$, in orthogonality spaces. Here \perp is the orthogonality in the sense of Rätz.

AMS Subject Classification: 39B55, 47H10, 39B52, 46H25.

Keywords: Hyers-Ulam stability; orthogonally additive-quartic functional equation; orthogonality space; fixed point method.

1. Introduction

Assume that X is a real inner product space and $f : X \rightarrow R$ is a solution of the orthogonal Cauchy functional equation $f(x + y) = f(x) + f(y)$, $\langle x, y \rangle = 0$. By the Pythagorean theorem $f(x) = \|x\|^2$ is a solution of the conditional equation. Of course, this function does not satisfy the additivity equation everywhere. Thus orthogonal Cauchy equation is not equivalent to the classic Cauchy equation on the whole inner product space.

The stability problem of functional equations originated from a question of Ulam [37] in 1940, concerning the stability of group homomorphisms in metric groups. Let (G_1, \cdot) be a group and let (G_2, \circ) be a metric group with the metric $d(\cdot, \cdot)$. Given $\epsilon > 0$, does there exist a $\delta > 0$ such that if a mapping $h : G_1 \rightarrow G_2$ satisfies the inequality $d(h(x \cdot y), h(x) \circ (y)) < \epsilon$ for all $x, y \in G_1$, then there exists a homomorphism $H : G_1 \rightarrow G_2$ with $d(h(x), H(x)) < \delta$ for all $x \in G_1$? The case of approximately additive functions was solved by Hyers [14] under the assumption that G_1 and G_2 are Banach spaces. In 1951 and in 1978, a generalized version of the theorem of Hyers for approximately linear mappings was given by Aoki [1] and Rassias [33]. The stability problem of functional equations has been extensively investigated by some mathematicians (see [5, 17, 24, 25, 30, 34]).

There are several orthogonality notations on a real normed space are available. But here, we present the orthogonality concept introduced by Rätz [35].

Definition 1.1 ([35]) *A real vector space X is called an orthogonality vector space if there is a relation $x \perp y$ on X such that*

- (i) $x \perp 0, 0 \perp x$ for all $x \in X$;
- (ii) if $x \perp y$ and $x, y \neq 0$, then x, y are linearly independent;
- (iii) $x \perp y, ax \perp by$ for all $a, b \in \mathbb{R}$;
- (iv) if P is a two-dimensional subspace of X , then
 - (a) for every $x \in P$ there exists $0 \neq y \in P$ such that $x \perp y$,
 - (b) there exists vectors $x, y \neq 0$ such that $x \perp y$ and $x + y \perp x - y$.

Any vector space can be made into an orthogonality vector space if we define $x \perp 0, 0 \perp x$ for all x , and define $x \perp y$ if and only if x, y are linearly independent for nonzero vectors x, y . The relation \perp is called symmetric if $x \perp y$ implies that $y \perp x$ for all $x, y \in X$.

The pair (X, \perp) is called an orthogonality space. It becomes an orthogonality normed space when the orthogonality space is equipped with a norm.

The orthogonal Cauchy functional equation

$$f(x + y) = f(x) + f(y), x \perp y \tag{1.1}$$

in which \perp is an abstract orthogonality was first investigated by Gudder and Strawther [13]. Ger and Sikorska discussed the orthogonal stability of the equation (1.1) in [12].

The orthogonally quadratic equation

$$f(x + y) + f(x - y) = 2f(x) + 2f(y), x \perp y$$

was first investigated by F. Vajzovic [38] when X is a Hilbert space, Y is the scalar field, f is continuous and \perp means the Hilbert space orthogonality. Later, Drljevic [7], Fochi [11], Moslehian [22, 23] and Szab [36] generalized this result.

Let X be a set. A function $d : X \rightarrow X \rightarrow [0, \infty]$ is called a generalized metric on X if d satisfies

- (1) $d(x, y) = 0$ if and only if $x = y$;
- (2) $d(x, y) = d(y, x)$ for all $x, y \in X$;
- (3) $d(x, z) = d(x, y) + d(y, z)$ for all $x, y, z \in X$.

We recall a fundamental result in fixed point theory.

Theorem 1.1 ([2, 6]) *Let (X, d) be a complete generalized metric space and let $J : X \rightarrow X$ be a strictly contractive mapping with Lipschitz constant $\alpha < 1$. Then for each given element $x \in X$, either*

$$d(J^n x, J^{n+1} x) = \infty$$

for all nonnegative integers n or there exists a positive integer n_0 such that

- (1) $d(J^n x, J^{n+1} x) < \infty, \quad \forall n \geq n_0$;
- (2) *the sequence $\{J^n x\}$ converges to a fixed point y^* of J ;*
- (3) *y^* is the unique fixed point of J in the set $Y = \{y \in X / d(J^{n_0} x, y) < \infty\}$;*
- (4) $d(y, y^*) \leq \frac{1}{1 - \alpha} d(y, Jy)$ for all $y \in Y$.

In 1996, Isac and Rassias [15] were the first to provide applications of stability theory of functional equations for the proof of new fixed point theorems with applications. By using fixed point methods, the stability problems of several functional equations have been extensively investigated by a number of authors ([3, 4, 8–10, 18, 21, 26–29, 31, 32]).

In [16], Jun and Kim considered the following additive functional equation

$$f(x + 2y) + f(x - 2y) = f(2x + y) + f(2x - y) - f(2x). \quad (1.2)$$

It is easy to show that the function $f(x) = x$ satisfies the functional equation (1.2), which is called an additive functional equation and every solution of the additive functional equation is said to be an additive mapping.

In [19], Lee et al. considered the following quartic functional equation

$$f(x + 2y) + f(x - 2y) = f(2x + y) + f(2x - y) - f(2x) - 14f(x) + 30f(y). \tag{1.3}$$

It is easy to show that the function $f(x) = x^4$ satisfies the functional equation (1.3), which is called a quartic functional equation and every solution of the quartic functional equation is said to be a quartic mapping.

This paper is organized as follows: In Section 2, we prove the Hyers-Ulam stability of the orthogonally additive-quartic functional equation (0.1) in orthogonality spaces for an odd mapping.

In Section 3, we prove the Hyers-Ulam stability of the orthogonally additive-quartic functional equation (0.1) in orthogonality spaces for an even mapping.

Throughout this paper, assume that (X, \perp) is an orthogonality space and that $(Y, \|\cdot\|_Y)$ is a real Banach space.

2. Stability of the Orthogonally Additive-Quartic Functional Equation: An Odd Mapping Case

In this section, we deal with the stability problem for the orthogonally additive-quartic functional equation

$$Df(x, y) := f(x + 2y) + f(x - 2y) - f(2x + y) - f(2x - y) + f(2x) + 7[f(x) + f(-x)] - 15[f(y) + f(-y)]$$

for all $x, y \in X$ with $x \perp y$: an odd mapping case.

Definition 2.1 *An odd mapping $f : X \rightarrow Y$ is called an orthogonally additive mapping if*

$$f(x + 2y) + f(x - 2y) = f(2x + y) + f(2x - y) - f(2x)$$

for all $x, y \in X$ with $x \perp y$.

Theorem 2.1 *Let $\phi : X^2 \rightarrow [0, \infty)$ be a function such that there exists an $\alpha < 1$ with*

$$\varphi(x, y) \leq 2\alpha\varphi\left(\frac{x}{2}, \frac{y}{2}\right) \tag{2.1}$$

for all $x, y \in X$ with $x \perp y$. Let $f : X \rightarrow Y$ be an odd mapping satisfying

$$\|Df(x, y)\|_Y \leq \varphi(x, y) \tag{2.2}$$

for all $x, y \in X$ with $x \perp y$. Then there exists a unique orthogonally additive mapping $A : X \rightarrow Y$ Such that

$$\|f(x) - A(x)\|_Y \leq \frac{1}{2 - 2\alpha} \varphi(x, 0) \quad (2.3)$$

for all $x \in X$.

Proof. Putting $y = 0$ in (2.2), we get

$$\|2f(x) - f(2x)\|_Y \leq \varphi(x, 0) \quad (2.4)$$

for all $x \in X$, since $x \perp 0$. So

$$\left\| f(x) - \frac{1}{2}f(2x) \right\|_Y \leq \frac{1}{2} \varphi(x, 0) \quad (2.5)$$

for all $x \in X$.

Consider the set

$$S := \{h : X \rightarrow Y\}$$

and introduce the generalized metric on S :

$$d(g, h) = \inf \{ \mu \in R_+ : \|g(x) - h(x)\|_Y \leq \mu \varphi(x, 0), \quad \forall x \in X \},$$

where, as usual, $\inf \varphi = +\infty$. It is easy to show that (S, d) is complete (see [20]).

Now we consider the linear mapping $J : S \rightarrow S$ such that

$$Jg(x) := \frac{1}{2}g(2x)$$

for all $x \in X$.

Let $g, h \in S$ be given such that $d(g, h) = \epsilon$. Then

$$\|g(x) - h(x)\|_Y \leq \varphi(x, 0)$$

for all $x \in X$. Hence

$$\|Jg(x) - Jh(x)\|_Y = \left\| \frac{1}{2}g(2x) - \frac{1}{2}h(2x) \right\|_Y \leq \alpha \varphi(x, 0)$$

for all $x \in X$. So $d(g, h) = \epsilon$ implies that $d(Jg, Jh) \leq \alpha \epsilon$. This means that

$$d(Jg, Jh) \leq \alpha d(g, h)$$

for all $g, h \in S$.

It follows from (2.5) that $d(f, Jf) \leq \frac{1}{2}$.

By Theorem 1.1, there exists a mapping $A : X \rightarrow Y$ satisfying the following:

(1) A is a fixed point of J , i.e.,

$$A(2x) = 2A(x) \tag{2.6}$$

for all $x \in X$. The mapping A is a unique fixed point of J in the set

$$M = \{g \in S : d(h, g) < \infty\}.$$

This implies that A is a unique mapping satisfying (2.6) such that there exists a $\mu \in (0, \infty)$ satisfying

$$\|f(x) - A(x)\|_Y \leq \mu\varphi(x, 0)$$

for all $x \in X$.

(2) $d(J^n f, A) \rightarrow 0$ as $n \rightarrow \infty$. This implies the equality

$$\lim_{n \rightarrow \infty} \frac{1}{2^n} f(2^n x) = A(x)$$

for all $x \in X$.

(3) $d(f, A) \leq \frac{1}{1-\alpha} d(f, Jf)$, which implies the inequality

$$d(f, A) \leq \frac{1}{2-2\alpha}.$$

This implies that the inequality (2.3) holds.

It follows from (2.1) and (2.2) that

$$\begin{aligned} \|DA(x, y)\|_Y &= \lim_{n \rightarrow \infty} \frac{1}{2^n} \|Df(2^n x, 2^n y)\|_Y \\ &\leq \lim_{n \rightarrow \infty} \frac{1}{2^n} \varphi(2^n x, 2^n y) \\ &\leq \lim_{n \rightarrow \infty} \frac{2^n \alpha^n}{2^n} \varphi(x, y) \\ &= 0 \end{aligned}$$

for all $x, y \in X$ with $x \perp y$. So $DA(x, y) = 0$ for all $x, y \in X$ with $x \perp y$. Since f is odd, A is odd. Hence $A : X \rightarrow Y$ is an orthogonally additive mapping, i.e.,

$$A(x + 2y) + A(x - 2y) = A(2x + y) + A(2x - y) - A(2x)$$

for all $x, y \in X$ with $x \perp y$. Thus $A : X \rightarrow Y$ is a unique orthogonally additive mapping satisfying (2.3), as desired. ■

From now on, in corollaries, assume that (X, \perp) is an orthogonality normed space.

Corollary 2.2 *Let θ be a positive real number and p a real number with $0 < p < 1$. Let $f : X \rightarrow Y$ be an odd mapping satisfying*

$$\|Df(x, y)\|_Y \leq \theta (\|x\|^p + \|y\|^p) \quad (2.7)$$

for all $x, y \in X$ with $x \perp y$. Then there exists a unique orthogonally additive mapping $A : X \rightarrow Y$ such that

$$\|f(x) - A(x)\|_Y \leq \frac{\theta}{2 - 2^p} \|x\|^p$$

for all $x \in X$.

Proof. The proof follows from Theorem 2.1 by taking $\phi(x, y) = \theta (\|x\|^p + \|y\|^p)$ for all $x, y \in X$ with $x \perp y$. Then we can choose $\alpha = 2^{p-1}$ and we get the desired result. ■

Theorem 2.3 *Let $f : X \rightarrow Y$ be an odd mapping satisfying (2.2) for which there exists a function $\phi : X^2 \rightarrow [0, \infty)$ such that*

$$\varphi(x, y) \leq \frac{\alpha}{2} \varphi(2x, 2x)$$

for all $x, y \in X$ with $x \perp y$. Then there exists a unique orthogonally additive mapping $A : X \rightarrow Y$ such that

$$\|f(x) - A(x)\|_Y \leq \frac{\alpha}{2 - 2\alpha} \varphi(x, 0) \quad (2.8)$$

for all $x \in X$.

Proof. Let (S, d) be the generalized metric space defined in the proof of Theorem 2.1. Now we consider the linear mapping $J : S \rightarrow S$ such that

$$Jg(x) := 2g\left(\frac{x}{2}\right)$$

for all $x \in X$.

It follows from (2.4) that $d(f, Jf) \leq \frac{\alpha}{2}$. So

$$d(f, A) \leq \frac{\alpha}{2 - 2\alpha}.$$

Thus we obtain the inequality (2.8). The rest of the proof is similar to the proof of Theorem 2.1. ■

Corollary 2.4 *Let θ be a positive real number and p a real number with $p > 1$. Let $f : X \rightarrow Y$ be an odd mapping satisfying (2.7) Then there exists a unique orthogonally additive mapping $A : X \rightarrow Y$ such that*

$$\|f(x) - A(x)\|_Y \leq \frac{\theta}{2^p - 2} \|x\|^p$$

for all $x \in X$.

Proof. The proof follows from Theorem 2.3 by taking $\phi(x, y) = \theta (\|x\|^p + \|y\|^p)$ for all $x, y \in X$ with $x \perp y$. Then we can choose $\alpha = 2^{1-p}$ and we get the desired result. ■

3. Stability of the Orthogonally Additive-Quartic Functional Equation: An Even Mapping Case

In this section, we deal with the stability problem for the orthogonally additive-quartic functional equation given in the previous section: an even mapping case.

Definition 3.1 *An even mapping $f : X \rightarrow Y$ is called an orthogonally quartic mapping if*

$$f(x + 2y) + f(x - 2y) = f(2x + y) + f(2x - y) - f(2x) - 14f(x) + 30f(y)$$

for all $x, y \in X$ with $x \perp y$.

Theorem 3.1 *Let $\phi : X^2 \rightarrow [0, \infty)$ be a function such that there exists an $\alpha < 1$ with*

$$\varphi(x, y) \leq 16\alpha\varphi\left(\frac{x}{2}, \frac{y}{2}\right)$$

for all $x, y \in X$ with $x \perp y$. Let $f : X \rightarrow Y$ be an even mapping satisfying $f(0) = 0$ and (2.2). Then there exists a unique orthogonally quartic mapping $Q : X \rightarrow Y$ such that

$$\|f(x) - Q(x)\|_Y \leq \frac{1}{16 - 16\alpha} \varphi(x, 0)$$

for all $x \in X$.

Proof. Putting $y = 0$ in (2.2), we get

$$\|16f(x) - f(2x)\|_Y \leq \varphi(x, 0) \tag{3.1}$$

for all $x \in X$, since $x \perp 0$. So

$$\left\| f(x) - \frac{1}{16}f(2x) \right\|_Y \leq \frac{1}{16} \varphi(x, 0) \quad \text{for all } x \in X.$$

Let (S, d) be the generalized metric space defined in the proof of Theorem 2.1. Now we consider the linear mapping $J : S \rightarrow S$ such that

$$Jg(x) := \frac{1}{16}g(2x)$$

for all $x \in X$. The rest of the proof is similar to the proof of Theorem 2.1. ■

Corollary 3.2 *Let θ be a positive real number and p a real number with $0 < p < 4$. Let $f : X \rightarrow Y$ be an even mapping satisfying $f(0) = 0$ and (2.7) Then there exists a unique orthogonally quartic mapping $Q : X \rightarrow Y$ such that*

$$\|f(x) - Q(x)\|_Y \leq \frac{\theta}{16 - 2^p} \|x\|^p$$

for all $x \in X$.

Proof. The proof follows from Theorem 3.1 by taking $\phi(x, y) = \theta (\|x\|^p + \|y\|^p)$ for all $x, y \in X$ with $x \perp y$. Then we can choose $\alpha = 2^{p-4}$ and we get the desired result. ■

Theorem 3.3 *Let $f : X \rightarrow Y$ be an even mapping satisfying (2.2) and $f(0) = 0$ for which there exists a function $\phi : X^2 \rightarrow [0, \infty)$ such that*

$$\varphi(x, y) \leq \frac{\alpha}{16} \varphi(2x, 2y)$$

for all $x, y \in X$ with $x \perp y$. Then there exists a unique orthogonally quartic mapping $Q : X \rightarrow Y$ such that

$$\|f(x) - Q(x)\|_Y \leq \frac{\alpha}{16 - 16\alpha} \varphi(x, 0) \tag{3.2}$$

for all $x \in X$.

Proof. Let (S, d) be the generalized metric space defined in the proof of Theorem 2.1. Now we consider the linear mapping $J : S \rightarrow S$ such that

$$J_g(x) := 16g\left(\frac{x}{2}\right)$$

for all $x \in X$.

It follows from (3.1) that $d(f, Jf) \leq \frac{\alpha}{16}$. So we obtain the inequality (3.2). The rest of the proof is similar to the proof of Theorem 2.1. ■

Corollary 3.4 *Let θ be a positive real number and p a real number with $p > 4$. Let $f : X \rightarrow Y$ be an even mapping satisfying $f(0) = 0$ and (2.7). Then there exists a unique orthogonally quartic mapping $Q : X \rightarrow Y$ such that*

$$\|f(x) - Q(x)\|_Y \leq \frac{\theta}{2^p - 16} \|x\|^p$$

for all $x \in X$.

Proof. The proof follows from Theorem 3.3 by taking $\phi(x, y) = \theta(\|x\|^p + \|y\|^p)$ for all $x, y \in X$ with $x \perp y$. Then we can choose $\alpha = 2^{4-p}$ and we get the desired result. ■

Let

$$f_o(x) = \frac{f(x) - f(-x)}{2} \quad \text{and} \quad f_e(x) = \frac{f(x) + f(-x)}{2}$$

Then f_o is an odd mapping and f_e is an even mapping such that $f = f_o + f_e$. The above corollaries can be summarized as follows:

Theorem 3.5 *Assume that (X, \perp) is an orthogonality normed space. Let θ be a positive real number and p a real number with $0 < p < 1$ or $p > 4$. Let $f : X \rightarrow Y$ be a mapping satisfying $f(0) = 0$ and (2.7). Then there exist an orthogonally additive mapping $A : X \rightarrow Y$ and an orthogonally quartic mapping $Q : X \rightarrow Y$ such that*

$$\|f(x) - A(x) - Q(x)\|_Y \leq \theta \left(\frac{1}{|2 - 2^p|} + \frac{1}{|16 - 2^p|} \right) \|x\|^p$$

for all $x \in X$.

Acknowledgments

C. Park was supported by Basic Science Research Program through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology (NRF-2012R1A1A2004299).

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Characterization of Ageing Classes in Excess Wealth Transform Order

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Abstract

In this paper, we introduce some new ageing classes based on excess wealth transform order. Preservation properties of the excess wealth transform order under some reliability operations for the newly introduced ageing classes are derived.

AMS Subject Classification: 60K10

Keywords: Ageing classes, TTT transform, Excess wealth transform, Convolution, Mixture, Stochastic order.

1. Introduction

Reliability theory is a body of ideas, mathematical models and methods aimed at predicting, estimating, understanding and optimizing the life span and failure distributions of systems and their components. Also, it allows researchers to predict the age-related failure for a system of given architecture and given reliability of its components. The study of changes in the properties of a model is also of great interest.

Accordingly, since the stochastic components of models involve random variables the topic of stochastic orders among random variables plays an important role in these areas. Two such well-known stochastic orders are the total time on test transform order and the excess wealth transform order. Kochar et al (2002) introduced excess wealth transform and also known in literature as right spread order. Let X and Y denote two random variables having distributions F and G , respectively and denote by $\bar{F} = 1 - F$ and $\bar{G} = 1 - G$ their respective survival functions. Let F^{-1} and G^{-1} denote their corresponding right continuous inverses. Moreover, we will use the term increasing in place of non-decreasing and decreasing in place of non-increasing.

A desirable property of excess wealth transform ordering (\leq_{ew}) is that it is location independent. The excess wealth transform order has several applications in reliability theory. For example, if $X \leq_{ew} Y$, then the lifetime of a series system of n independent components whose lifetimes are distributed as X is less than that of a similar system with independent components whose lifetimes are distributed as Y , in the excess wealth transform order. More applications can be found in Kochar and Li (2002) and Shaked, Ahmad, Kayid and Li (2005). The rest of the paper is organized as follows: In section 2, we give some definitions of life distributions and related concepts that are needed for further discussion. In section 3 characterization, in section 4 convolution, in section 5 mixture of distribution in section 6 formation of coherent of systems Finally conclusion is given section 7.

2. Definitions and Some Related Concepts

In this section we first give some known definitions and then define the new ageing classes based an excess wealth transform order.

Definition 2.1 *If X is a non negative random variable with an absolutely continuous distribution function F , then the failure rate or hazard rate of X at t is defined as*

$$r(t) = \frac{d}{dt}(-\log(1 - F(t)))$$

which can alternatively be expressed as

$$\begin{aligned} r(t) &= \lim_{\Delta t \downarrow 0} \frac{P\{t < X \leq t + \Delta t | X > t\}}{\Delta t} \\ &= \frac{f(t)}{\bar{F}(t)} \quad t \geq 0 \end{aligned}$$

where $\bar{F} \equiv 1 - F$ is the survival function and f is the corresponding density function.

Suppose that X and Y are non-negative random variables representing the life lengths of equipments with respective distributions $F(t)$ and $G(t)$ and survival functions $\bar{F}(t) = 1 - F(t)$ and $\bar{G}(t) = 1 - G(t)$. Let X_t be the residual life of the equipment of age t with distribution $F_t(X)$ and survival function

$$\bar{F}_t(X) = \begin{cases} \frac{\bar{F}(t+x)}{\bar{F}(t)}, & \bar{F}(t) > 0 \\ 0, & \bar{F}(t) = 0. \end{cases}$$

Definition 2.2 X is said to smaller than Y in stochastic order, denoted by $X \leq_{st} Y$, if $\bar{F}(x) \leq \bar{G}(x)$, for all t

Definition 2.3 Let X and Y be the lifetime of two components with lifetime distributions F and G , respectively. Then X is smaller than Y in the increasing concave ordering, $X \leq_{icv} Y$, if

$$\int_0^t \bar{F}(x) dx \leq \int_0^t \bar{G}(x) dx,$$

for all $t > 0$, where $\bar{F}(x) = 1 - F(x)$ and $\bar{G}(x) = 1 - G(x)$ are the reliability functions of X and Y respectively.

Definition 2.4 X is said to smaller than Y in total time on test transform (TTT) order, denoted by $X \leq_{ttt} Y$, if and only if

$$\int_0^{F^{-1}(p)} \bar{F}(t) dt \leq \int_0^{G^{-1}(p)} \bar{G}(t) dt,$$

for all $p \in (0, 1)$.

Definition 2.5 X is said to smaller than Y in excess wealth transform order, denoted by $X \leq_{ew} Y$, if

$$\int_{F^{-1}(p)}^{\infty} \bar{F}(t) dt \leq \int_{G^{-1}(p)}^{\infty} \bar{G}(t) dt,$$

for all $p \in (0, 1)$.

Definition 2.6 X is said to be smaller than Y in excess wealth transform average order, denoted by $X \leq_{ewa} Y$, if

$$\int_0^1 \int_{F^{-1}(p)}^{\infty} \bar{F}(t) dt dp \leq \int_0^1 \int_{G^{-1}(p)}^{\infty} \bar{G}(t) dt dp$$

for all $p \in (0, 1)$.

Definition 2.7 A non negative random variable X or its distribution F is said to be Increasing Failure Rate in Excess Wealth Transform order or equivalently $X \in IFR_{ew}$ if

$$\int_{F^{-1}(p)}^{\infty} r(t) dt \leq \int_{F^{-1}(p)}^{\infty} r(x+t) dt,$$

for $x > 0$ and for all $p \in (0, 1)$.

Definition 2.8 A non negative random variable X or its distribution F is said to be New Better than Used in Excess Wealth Transform order denoted by $X_t \leq_{ew} X$ for $t \geq 0$, or equivalently $X \in NBUeW$ if,

$$\int_{F_t^{-1}(p)}^{\infty} \bar{F}(u+t) du \leq \bar{F}(t) \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du$$

for all $p \in (0, 1)$.

Definition 2.9 A non negative random variable X or its distribution F is said to be New Better than Used Average in Excess Wealth Transform order, $X_t \leq_{ewa} X$, or equivalently $X \in NBUAeW$, if and only if

$$\int_0^1 \int_{F_t^{-1}(p)}^{\infty} \bar{F}(u+t) du dp \leq \bar{F}(t) \int_0^1 \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du dp,$$

for $t \geq 0$ and for all $p \in (0, 1)$.

Definition 2.10 A non negative random variable X or its distributions F is said to be New Better than Used of Second Order in Excess Wealth Transform order, denoted by $X_t \geq_{icv} X$ or equivalently $X \in NBUeW(2)$ if and only if

$$\int_{F^{-1}(p)}^{\infty} \bar{F}(u) du \leq \int_{F^{-1}(p)}^{\infty} \frac{\bar{F}(u+t)}{\bar{F}(t)} du$$

for all $t \geq 0$, $p \in (0, 1)$.

Definition 2.11 A random variable X or its distribution F is said to be Decreasing Cumulative Conditional Survival in Excess Wealth Transform order, or equivalently $X \in DCCSeW$, if

$$\bar{F}(t_1) \int_{F^{-1}(p)}^{\infty} \bar{F}(t_2+u) du \leq \bar{F}(t_2) \int_{F^{-1}(p)}^{\infty} \bar{F}(t_1+u) du,$$

for all $p \in (0, 1)$ and $0 \leq t_1 \leq t_2 \leq \infty$.

3. Characterization

We consider the ageing classes NBU, NBU(2), NBUA, DCCS in excess wealth transform order class of life distributions, their residual life at fixed and at random times. These results offer more insight into the structure of these classes.

Theorem 3.1 F is $NBUeW$ if and only if $X_t \leq_{ew} X$, for $t \geq 0$.

Proof. Consider

$$\begin{aligned} X_t \leq_{ew} X &\iff \int_{F_t^{-1}(p)}^{\infty} \bar{F}_t(u) du \leq \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du \\ &\iff \int_{F_t^{-1}(p)}^{\infty} \frac{\bar{F}(t+u)}{\bar{F}(t)} du \leq \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du \\ &\iff \int_{F_t^{-1}(p)}^{\infty} \bar{F}(t+u) du \leq \bar{F}(t) \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du, \end{aligned}$$

for $p \in (0, 1)$. It follows that F is $NBUeW$ and the proof is complete. ■

Theorem 3.2 F is $NBUAeW$ if and only if $X_t \leq_{ewa} X$, for $t \geq 0$.

Proof. Consider

$$\begin{aligned} X_t \leq_{ewa} X &\iff \int_0^1 \int_{F_t^{-1}(p)}^{\infty} \bar{F}_t(u) du dp \leq \int_0^1 \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du dp \\ &\iff \int_0^1 \int_{F_t^{-1}(p)}^{\infty} \frac{\bar{F}(t+u)}{\bar{F}(t)} du dp \leq \int_0^1 \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du dp \\ &\iff \int_0^1 \int_{F_t^{-1}(p)}^{\infty} \bar{F}(t+u) du dp \leq \bar{F}(t) \int_0^1 \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du dp, \end{aligned}$$

for $p \in (0, 1)$. It follows that F is $NBUAeW$ and the proof is complete. ■

Theorem 3.3 F is $NBUeW(2)$ if and only if $X_t \geq_{icv} X$, for $t \geq 0$.

Proof. Consider

$$\begin{aligned} X_t \geq_{ew} X &\iff \int_{F^{-1}(p)}^{\infty} \bar{F}_t(u) du \geq \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du \\ &\iff \int_{F^{-1}(p)}^{\infty} \frac{\bar{F}(t+u)}{\bar{F}(t)} du \geq \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du \\ &\iff \int_{F^{-1}(p)}^{\infty} \bar{F}(t+u) du \geq \bar{F}(t) \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du \end{aligned}$$

Substitute $x = F^{-1}(p)$ in the above inequality and simplify we obtain

$$\int_0^x \bar{F}(t+u) du \geq \bar{F}(t) \int_0^x \bar{F}(u) du,$$

for $p \in (0, 1)$. It follows that F is $NBU(2)$ and the proof is complete. ■

Theorem 3.4 F is $DCCSeW$ if and only if $X_{t_1} \geq_{ew} X_{t_2}$, for $t_1, t_2 \geq 0$.

Proof. Consider

$$\begin{aligned} X_{t_1} \geq_{ew} X_{t_2} &\iff \int_{F^{-1}(p)}^{\infty} \bar{F}_{t_1}(u) du \geq \int_{F^{-1}(p)}^{\infty} \bar{F}_{t_2}(u) du \\ &\iff \int_{F^{-1}(p)}^{\infty} \frac{\bar{F}(t_1 + u)}{\bar{F}(t_1)} du \geq \int_{F^{-1}(p)}^{\infty} \frac{\bar{F}(t_2 + u)}{\bar{F}(t_2)} du \\ &\iff \bar{F}(t_2) \int_{F^{-1}(p)}^{\infty} \bar{F}(t_1 + u) du \geq \bar{F}(t_1) \int_{F^{-1}(p)}^{\infty} \bar{F}(t_2 + u) du, \end{aligned}$$

for $p \in (0, 1)$. It follows that F is $DCCSeW$ and the proof is complete. \blacksquare

Remark. By reversing the inequalities in the above theorems, we obtain the characteristic results of the corresponding negative ageing classes.

4. Convolution

Convolution of life distributions for ageing class is often paid much attention. The ageing classes based on excess wealth transform order are closed under this operation. In the next theorems we establish the closure property of the ageing classes $NBUeW$, $NBUAeW$ and $DCCSeW$ under convolution.

Theorem 4.1 Suppose $\bar{F}_1(\cdot)$ and $\bar{F}_2(\cdot)$ are two independent $NBUeW$ life distributions. Then their convolution is $NBUeW$.

Proof. The survival function of the convolution of two life distribution $\bar{F}_1(\cdot)$ and $\bar{F}_2(\cdot)$ is

$$\bar{F}(t + u) = \int_0^{\infty} \bar{F}_1(t + u - z) dF_2(z)$$

Consider

$$\begin{aligned} \int_{F_t^{-1}(p)}^{\infty} \bar{F}(t + u) du &= \int_{F_t^{-1}(p)}^{\infty} \int_0^{\infty} \bar{F}_1(t + u - z) dF_2(z) du \\ &= \int_0^{\infty} \left[\int_{F_t^{-1}(p)}^{\infty} \bar{F}_1(t + u - z) du \right] dF_2(z) \\ &\leq \int_0^{\infty} \bar{F}_1(t) \int_{F^{-1}(p)}^{\infty} \bar{F}_1(u - z) du dF_2(z) \\ &= \bar{F}_1(t) \int_{F^{-1}(p)}^{\infty} \int_0^{\infty} \bar{F}_1(u - z) dF_2(z) du \end{aligned}$$

$$\begin{aligned}
 &= \bar{F}_1(t) \int_{F^{-1}(p)}^{\infty} \left[\int_0^{\infty} \bar{F}_1(u-z) dF_2(z) \right] du \\
 &\leq \bar{F}(t) \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du.
 \end{aligned}$$

The first inequality is because $\bar{F}_1(\cdot)$ is *NBUeW* and the last inequality follows from the fact that $F_1 \leq_{st} F$. This proves that $F(\cdot)$ is also *NBUeW*. ■

Theorem 4.2 Suppose $\bar{F}_1(\cdot)$ and $\bar{F}_2(\cdot)$ are two independent *NBUA* in excess wealth transform order life distributions. Then their convolution is *NBUAeW*.

Proof. The survival function of the convolution of two life distribution $\bar{F}_1(\cdot)$ and $\bar{F}_2(\cdot)$ is

$$\bar{F}(t+u) = \int_0^{\infty} \bar{F}_1(t+u-z) dF_2(u)$$

Consider

$$\begin{aligned}
 \int_0^1 \int_{F_t^{-1}(p)}^{\infty} \bar{F}(u+t) du dp &= \int_0^1 \int_{F_t^{-1}(p)}^{\infty} \int_0^{\infty} \bar{F}_1(u+t-z) dF_2(z) du dp \\
 &= \int_0^{\infty} \int_0^1 \int_{F_t^{-1}(p)}^{\infty} \bar{F}_1(u+t-z) du dp dF_2(z) \\
 &\leq \int_0^{\infty} \bar{F}_1(t) \int_0^1 \int_{F^{-1}(p)}^{\infty} \bar{F}_1(u-z) du dp dF_2(z) \\
 &= \bar{F}_1(t) \int_0^1 \int_{F^{-1}(p)}^{\infty} \int_0^{\infty} \bar{F}_1(u-z) dF_2(z) du dp \\
 &\leq \bar{F}(t) \int_0^1 \int_{F^{-1}(p)}^{\infty} \bar{F}(u) du dp.
 \end{aligned}$$

The first inequality is because $\bar{F}_1(\cdot)$ is *NBUAeW* and the last inequality follows from the fact that $F_1 \leq_{st} F$. This proves that $F(\cdot)$ is also *NBUAeW*. ■

5. Mixture of Distributions

Mixture of distributions arise naturally in a number of reliability situations. More generally, the distributions being mixed may be uncountably infinite in number. Let $\{F_\alpha\}$ be a set of life distributions, where the index α is governed by the distribution G . Then the mixture F of F_α is given by

$$F(x) = \int_0^{\infty} F_\alpha(x) dG(\alpha).$$

Theorem 5.1 *The NBUEW class is preserved under mixture .*

Proof. Suppose F_α is NBUEW. Then their mixture is

$$\bar{F}(x) = \int_0^\infty \bar{F}_\alpha(x) dG(\alpha).$$

Consider

$$\begin{aligned} \int_{F_t^{-1}(p)}^\infty \bar{F}(t+u) du &= \int_{F_t^{-1}(p)}^\infty \left[\int_0^\infty \bar{F}_\alpha(t+u) dG(\alpha) \right] du \\ &= \bar{F}_\alpha(t) \int_{F_t^{-1}(p)}^\infty \int_0^\infty \bar{F}_\alpha(u) dG(\alpha) du \\ &\leq \bar{F}(t) \int_{F^{-1}(p)}^\infty \int_0^\infty \bar{F}(u) du dG(\alpha) \\ &\leq \bar{F}(t) \int_{F^{-1}(p)}^\infty \left[\int_0^\infty \bar{F}(u) dG(\alpha) \right] du \\ &\leq \bar{F}(t) \int_{F^{-1}(p)}^\infty \bar{F}(u) du \end{aligned}$$

It follows that NBUEW class is closed under mixture of distributions. ■

Theorem 5.2 *The NBUAeW class is preserved under mixture .*

Proof. Suppose F_α is NBUAeW then their mixture is

$$\bar{F}(x) = \int_0^\infty \bar{F}_\alpha(x) dG(\alpha).$$

Consider

$$\begin{aligned} \int_0^1 \int_{F_t^{-1}(p)}^\infty \bar{F}(u+t) du dp &= \int_0^1 \int_{F_t^{-1}(p)}^\infty \int_0^\infty \bar{F}_\alpha(u+t) dG_\alpha(z) du dp \\ &= \int_0^\infty \int_0^1 \int_{F_t^{-1}(p)}^\infty \bar{F}_\alpha(u+t) du dp dG_\alpha(\alpha) \\ &\leq \bar{F}_\alpha(t) \int_0^\infty \int_0^1 \int_{F^{-1}(p)}^\infty \bar{F}_\alpha(u) du dp dG_\alpha(\alpha) \\ &\leq \bar{F}(t) \int_0^1 \int_{F^{-1}(p)}^\infty \int_0^\infty \bar{F}(u) dG_\alpha(\alpha) du dp \\ &\leq \bar{F}(t) \int_0^1 \int_{F^{-1}(p)}^\infty \bar{F}(u) du dp \end{aligned}$$

It follows that NBUAeW class is closed under mixture of distributions. ■

Remark: The DCCSeW class is not preserved under mixture.

6. Formation of Coherent Systems

In this section, we deduce the preservation properties of some ageing classes based on excess wealth transform order.

Let X_1, X_2, \dots be a sequence of independent and identically distributed (i.i.d.) random variables and N be a positive integer valued random variable which is independent of each X_i . Let

$$\begin{aligned} X_{1:N} &\equiv \min\{X_1, X_2, \dots, X_N\} \\ X_{N:N} &\equiv \max\{X_1, X_2, \dots, X_N\}, \end{aligned}$$

The random variables $X_{1:N}$ and $X_{N:N}$ arise naturally in reliability theory as the lifetimes of a series and parallel systems, respectively, with the random number N of identical components with lifetimes X_1, X_2, \dots, X_N . In life-testing, if a random censoring is adopted, then the completely observed data constitute a sample of random size, say X_1, X_2, \dots, X_N , where $N > 0$ is a random variable of integer value. In actuarial science, the claims received by an insurer in a certain time interval should also be a sample of random size and, $X_{N:N}$ denotes the largest claim amount of the period. Also $X_{1:N}$ arises naturally in survival analysis as the minimal survival time of a transplant operation, where N of them are defective and hence may cause death. Some authors have made efforts to investigate preservation properties of some stochastic orders under random minima and maxima while other have centered their attention on investigating behavior of ageing properties in coherent structure, parallel (series) systems, convolution, mixture and renewal process (see, Shaked (1975), Bartozewicz (2001), Li and Zuo (2004) and Ahmad and Kayid (2004)). Ahmed, *et.al*, (2005) have introduced and studied the new better than used in total time on test transform ordering class of life distribution.

In the following, we present the preservation results for the *IFReW*, *NBUeW*, *NBUAeW* and *DCCSeW* classes under formation of random maxima and minima.

Theorem 6.1 *Let X_1, X_2, \dots be a sequence of independent and identically distributed random lives and N be independent of X_i 's. If X_1 is *IFReW*, then $\max\{X_1, X_2, \dots, X_N\}$ is also *IFReW*.*

Proof: The proof is an immediate consequence of the result by Grosh (1992). ■

We now recall the following result about the preservation of the TTT order and the right spread order (See Li and Zuo (2004)).

Theorem 6.2 *Let X_1, X_2, \dots and Y_1, Y_2, \dots be a sequence of independent and identically distributed random variables, and N is independent of X_i 's and Y_i 's are both non-negative and with common left end point 0, then $X_i \leq_{ew} Y_i$, for $i = 1, 2, \dots$, implies*

$$\max\{X_1, X_2, \dots, X_N\} \leq_{ew} \max\{Y_1, Y_2, \dots, Y_N\}.$$

Theorem 6.3 *Let X_1, X_2, \dots be a sequence of i.i.d random lives, and N be independent of X_i 's. If X_1 is NBUEW, then $\max\{X_1, X_2, \dots, X_N\}$ is also NBUEW.*

Proof. Since X_1 is NBUEW, then for all $t \geq 0$, we have

$$(X_i)_t \leq_{ew} X_i, \quad \text{for all } t \geq 0.$$

By Theorem 6.2, we have,

$$\max\{(X_1)_t, (X_2)_t, \dots, (X_N)_t\} \leq_{ew} \max\{X_1, X_2, \dots, X_N\}, \quad \text{for all } t \geq 0.$$

According to Pellerrey and Petakos, (2002), we have

$$\max\{(X_1)_t, (X_2)_t, \dots, (X_n)_t\} \stackrel{st}{=} (\max\{X_1, X_2, \dots, X_n\})_t, \quad \text{for all } t \geq 0$$

it holds also that

$$\max\{(X_1)_t, (X_2)_t, \dots, (X_N)_t\} \stackrel{st}{=} (\max\{X_1, X_2, \dots, X_N\})_t, \quad \text{for all } t \geq 0$$

and hence

$$(\max\{X_1, X_2, \dots, X_N\})_t \leq_{ew} \max\{X_1, X_2, \dots, X_N\}, \quad \text{for all } t \geq 0.$$

It follows that, $\max\{X_1, X_2, \dots, X_N\}$ is NBUEW and completes the proof. ■

We now give a result about the preservation of excess wealth average order.

Theorem 6.4 (Li and Zuo (2002)) *Let X_1, X_2, \dots and Y_1, Y_2, \dots be a sequence of independent and identically distributed random variables, and N is independent of X_i 's and Y_i 's are both non-negative and with common left end point 0. If $X_i \leq_{ewa} Y_i$, for $i = 1, 2, \dots$, then*

$$\max\{X_1, X_2, \dots, X_N\} \leq_{ewa} \max\{Y_1, Y_2, \dots, Y_N\}, \quad N \geq 1.$$

We shall now prove the following.

Theorem 6.5 *Let X_1, X_2, \dots be a sequence of i.i.d random lives, and N is independent of X_i 's. If X_1 is NBUAeW, then $\max\{X_1, X_2, \dots, X_N\}$ is also of NBUAeW.*

Proof. If X_1 is NBUAeW, then for all $t \geq 0$,

$$(X_i)_t \leq_{\text{ewa}} X_i \quad \text{for all } t \geq 0$$

and by Theorem 6.4, we have, for all $t \geq 0$

$$\max\{X_1, X_2, \dots, X_N\} \leq_{\text{ewa}} \max\{X_1, X_2, \dots, X_N\}.$$

For any integer $n \geq 1$ and for $t \geq 0$, it holds that

$$(\max\{(X_1)_t, (X_2)_t, \dots, (X_n)_t\}) \stackrel{st}{=} (\max\{X_1, X_2, \dots, X_n\})_t,$$

so

$$(\max\{X_1, X_2, \dots, X_N\})_t \leq_{\text{ewa}} \max\{X_1, X_2, \dots, X_N\}, \quad \text{for } t \geq 0.$$

It follows that $\max\{X_1, X_2, \dots, X_N\}$ is NBUAeW and the proof is complete. ■

Theorem 6.6 *Let X_1, X_2, \dots be a sequence of independent identically distributed random lives and N be independent of X_i 's. If X_1 is IFRew, then $\max\{X_1, X_2, \dots, X_N\}$ is also IFRew.*

Proof. The proof is an immediate consequence of the result by Grosh (1992). ■

The following lemma is due to Franco et al (2001) and is useful for proving the closure property of certain ageing class.

Lemma 6.1 *Let $\{X_1, X_2, \dots, X_N\}$ and $\{Y_1, Y_2, \dots, Y_N\}$ be two sets independent random variables. If $X_i \leq_{\text{icv}} Y_i$ for all $i = 1, 2, \dots, n$ then $g(X_1, X_2, \dots, X_N) \leq_{\text{icv}} g(Y_1, Y_2, \dots, Y_N)$ for all increasing and concave components function g .*

Theorem 6.7 *Let X_1, X_2, \dots be a sequence of independent identically distributed random lives and N be independent of X_i 's. If X_i is IFRew(2), for all $i = 1, 2, \dots, n$, then $\min\{X_1, \dots, X_N\}$ is also IFRew(2)*

Proof. By the definition of IFRew(2), we have

$$(X_i)_{t_1} \geq_{\text{icv}} (X_i)_{t_2} \quad \text{for all } 0 \leq t_1 < t_2.$$

Using increasing and concave componentwise function

$$g(X_1, \dots, X_n) = \min\{X_1, \dots, X_n\},$$

Lemma 6.1 yields

$$\min\{(X_1)_{t_1}, (X_2)_{t_1}, \dots, (X_N)_{t_1}, \} \geq_{icv} \min\{(X_1)_{t_2}, (X_2)_{t_2}, \dots, (X_N)_{t_2}, \}$$

for all $0 \leq t_1 < t_2$.

According to Pellerey and Petakos (2002), we have

$$\min\{(X_1)_t, \dots, (X_N)_t\} \stackrel{st}{=} (\min\{(X_1), \dots, (X_N)\})_t$$

so that

$$(\min\{X_1, \dots, X_N\})_{t_1} \geq_{icv} (\min\{X_1, \dots, X_N\})_{t_2}$$

consequently, $\min\{X_1, \dots, X_N\}$ is IFR_eW and the proof is complete. ■

Theorem 6.8 *Let X_1, X_2, \dots be a sequence of independent identically distributed random lives and N be independent of X_i 's. If X_i is DCCSeW, for all $i = 1, 2, \dots, n$, then $\min\{X_1, \dots, X_N\}$ is also DCCSeW.*

Proof. By the definition of DCCSeW, we have

$$(X_i)_{t_1} \geq_{icv} (X_i)_{t_2}$$

for all $0 \leq t_1 < t_2$.

Using increasing and concave componentwise function

$$g(X_1, \dots, X_n) = \min\{X_1, \dots, X_n\},$$

Lemma 6.1 yields

$$\min\{(X_1)_{t_1}, (X_2)_{t_1}, \dots, (X_N)_{t_1}, \} \geq_{icv} \min\{(X_1)_{t_2}, (X_2)_{t_2}, \dots, (X_N)_{t_2}, \}$$

for all $0 \leq t_1 < t_2$.

According to Pellerey and Petakos (2002), we have

$$\min\{(X_1)_t, \dots, (X_N)_t\} \stackrel{st}{=} (\min\{(X_1), \dots, (X_N)\})_t$$

so that

$$(\min\{X_1, \dots, X_N\})_{t_1} \geq_{icv} (\min\{X_1, \dots, X_N\})_{t_2}$$

consequently, $\min\{X_1, \dots, X_N\}$ is DCCSeW and the proof is complete. ■

Theorem 6.9 *Let X_1, X_2, \dots be a sequence of independent identically distributed random lives and N be independent of X_i 's. If X_i is NBUEW for all $i = 1, 2, \dots, n$, then $\min\{X_1, X_2, \dots, X_N\}$ has the NBUEW(2).*

Proof. The proof is on similar lines to that of Theorem 6.8 and is omitted.

7. Conclusion

In this paper, some ageing classes based on excess wealth transform order is introduced. We present the characterization of the ageing classes defined in terms of Excess Wealth Transform order. Preservation properties of the excess wealth transform order under some reliability operations for the newly introduced ageing classes are derived.

Acknowledgements

The second author is highly thankful to the Management of Islamiah College Vaniyambadi, for the financial assistance rendered to carryout the research work.

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On Some Ageing Properties of Bivariate Life Distributions under Convolution

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Abstract

In this paper we introduce new class of Bivariate distribution based on some ageing classes. Namely bivariate new better than used (BNBU), bivariate new better than used expectation (BNBUE) and bivariate new better than used failure rate (BNBUFR). This class is bivariate closure properties, The closure properties under various reliability operations such as convolution, on some aging classes of life-time models are transformed into the corresponding transform properties are derived.

AMS Subject Classification: 60K10

Keywords: Ageing classes, Bivariate transform, Convolution, BNBU, BNBUE, BNBUFR.

1. Introduction

We introduce the concepts of aging class like BNBU (Bivariate New Better than Used), BNBUE (Bivariate New Better then Used Expectation), BNBUFR (Bivariate New Better then Used Failure Rate), with have played an important role in survival analysis. It covers most of results in the literature pertaining to ageing classes and bivariate life distributions; so it can be regarded as a compendium of ageing concepts. And will be useful to researchers in reliability engineering and other disciplines, bivariate ageing concepts have already appeared in the literature for a long time.

The following aspects of bivariate ageing concepts will be considered in this section.

Bivariate reliability classes

Bivariate NBU

Bivariate NBUE

Bivariate NBUFR

We introduce concepts of some aging class and we give the preservation properties of this class under reliability operations. It has been found very useful to classify bivariate life distributions using the concept of Stochastic ordering. For a review of the ageing classes, we refer to Rizwan and Kasthuri (2011)

2. Definitions and Some Related Concepts

In reliability theory, ageing life is usually characterized by a nonnegative random variable $x \geq 0$ with cumulative distribution function (cdf) $F(\cdot)$ and survival function $\bar{F}(\cdot) = 1 - F(\cdot)$. For any random variable X , let

$$X_t \cong [X - t | X > t], \quad t \in \{x : F(x) < 1\}$$

denote a random variable whose distribution is the same as the conditional distribution of $X - t$ given that $X > t$. When X is the lifetime of a device, X_t can be regarded as the residual lifetime of the device at time t , given that the device has survived upto time t . Its survival function is

$$\bar{F}_t(x) = \frac{\bar{F}(t+x)}{\bar{F}(t)}, \quad \bar{F}(t) > 0$$

where $F(x)$ is the survival function of X

Remark. If $F(\cdot)$ is an exponential distribution then $\bar{F}_t(x) = \bar{F}(x)$

Definition 2.1 A bivariate random variable $(X; Y)$ or its distribution $\bar{F}(t, s)$ is Bivariate New Better than Used if,

$$\int_0^\infty \int_0^\infty \frac{\bar{F}(t+x, s+y)}{\bar{F}(t)\bar{F}(s)} ds dt$$

is decreasing in x, y .

Definition 2.2 A bivariate random variable $(x; y)$ or its distribution $\bar{F}(t, s)$ is Bivariate Increasing Failure Rate if,

$$(i) \quad \frac{1}{\sqrt{u+v^2}} \int_0^u \int_0^v r(x, y) dx dy \text{ is increasing in } t > 0,$$

$$(ii) \quad \frac{1}{\sqrt{u+v^2}} \int_0^u \int_0^v r(x, y) dx dy \text{ is increasing in } u > 0,$$

where $r(x, y) = \frac{f(, \cdot)}{F(, \cdot)}$

Definition 2.3 A bivariate random variable $(X;Y)$ or its distribution $\bar{F}(t,s)$ is Bivariate New Better than Used if,

$$\int_0^\infty \int_0^\infty \bar{F}(x+t, y+s) ds dt \leq \bar{F}(x, y) \quad \text{for } x, y, t, s \geq 0.$$

Definition 2.4 A bivariate random variable $(X;Y)$ or its distribution $\bar{F}(t,s)$ is Bivariate Harmonic New Better than Used Expectation if,

$$\int_t^\infty \int_s^\infty \bar{F}(x, y) dx dy \leq \mu \exp \left[-\frac{(t+s)}{\mu} \right] \quad \text{for } t \geq 0, s \geq 0.$$

Definition 2.5 A bivariate random variable $(X;Y)$ or its distribution $\bar{F}(t,s)$ is Bivariate New Better than Used Failure Rate if,

$$r(0,0) \leq r(x, y).$$

Definition 2.6 A bivariate random variable $(X;Y)$ or its distribution $\bar{F}(t,s)$ is Bivariate New Better than Used Failure Rate Average if,

$$r(0,0) \leq \frac{1}{\sqrt{t^2 + s^2}} \int_0^t \int_0^s r(x, y) dy dx; \quad 0 \leq t < \infty; \quad 0 \leq s < \infty.$$

Definition 2.7 Suppose X_1 and X_2 are non-negative random variables with respective distributions $F_1(\cdot)$ and $F_2(\cdot)$ then,

$$\bar{F}(t_1, t_2) = \int_{-\infty}^\infty \bar{F}_1(t_1 - u, t_2 - v) d\bar{F}_2(u, v)$$

is the convolution of \bar{F}_1 and \bar{F}_2 .

3. Convolution

Convolution of Bivariate distributions for certain class is often paid much attention. The BNBU, BNBUE and BNBUFR classes are closed under this operation. In the next theorems we establish the closure property of BNBU, BNBUE and BNBUFR under convolution.

Theorem 3.1 Suppose $\bar{F}_1(\cdot, \cdot)$ and $F_2(\cdot, \cdot)$ are two independent BNBU life distributions. Then their convolution is BNBU.

Proof. The survival function of the convolution of two life distribution \bar{F}_1 and \bar{F}_2 is

$$\bar{F}(t_1, t_2) = \int_{-\infty}^{\infty} \bar{F}_1(t_1 - u, t_2 - v) d\bar{F}_2(u, v)$$

Consider

$$\begin{aligned} \bar{F}(x + t_1, y + t_2) &= \int_{-\infty}^{\infty} \bar{F}_1(x + t_1 - u, y + t_2 - v) d\bar{F}_2(u, v) \\ &\leq \int_{-\infty}^{\infty} \bar{F}_1(x, y) \bar{F}_1(t_1 - u, t_2 - v) d\bar{F}_2(u, v) \\ &= \bar{F}_1(x, y) \int_{-\infty}^{\infty} \bar{F}_1(t_1 - u, t_2 - v) d\bar{F}_2(u, v) \\ &= \bar{F}_1(x, y) \bar{F}(t_1, t_2) \\ &\leq \bar{F}(x, y) \bar{F}(t_1, t_2) \end{aligned}$$

The first inequality is because \bar{F}_1 is BNBU and the last inequality follows from the fact that $\bar{F}_1 \leq_{st} \bar{F}$. Thus prove that \bar{F} is also BNBU. ■

Theorem 3.2 Suppose $\bar{F}_1(\cdot, \cdot)$ and $F_2(\cdot, \cdot)$ are two independent BNBUE life distributions. Then their convolution is BNBUE.

Proof. The survival function of the convolution of two life distribution \bar{F}_1 and \bar{F}_2 is

$$\bar{F}(t_1, t_2) = \int_{-\infty}^{\infty} \bar{F}_1(t_1 - u, t_2 - v) d\bar{F}_2(u, v)$$

Consider

$$\begin{aligned} &\int_0^{\infty} \int_0^{\infty} \bar{F}(x + t, y + s) dt ds \\ &= \int_0^{\infty} \int_0^{\infty} \left[\int_{-\infty}^{\infty} \bar{F}(x + t - u, y + s - v) d\bar{F}_2(u, v) \right] dt ds \\ &= \int_{-\infty}^{\infty} \left[\int_0^{\infty} \int_0^{\infty} \bar{F}_1(x + t - u, y + s - v) dt ds \right] d\bar{F}_2(u, v) \\ &\leq \int_{-\infty}^{\infty} \bar{F}_1(x - u, y - v) d\bar{F}_2(u, v) \\ &= \bar{F}(x, y) \end{aligned}$$

The first inequality is because \bar{F}_1 is BNBUE and the last inequality follows from the fact that $\bar{F}_1 \leq_{st} \bar{F}$. Thus prove that \bar{F} is also BNBUE. ■

Theorem 3.3 Suppose $\bar{F}_1(\cdot, \cdot)$ and $F_2(\cdot, \cdot)$ are two independent BHNBU life distributions. Then their convolution is BHNBU.

Proof. The survival function of the convolution of two life distribution \bar{F}_1 and \bar{F}_2 is

$$\bar{F}(t_1, t_2) = \int_{-\infty}^{\infty} \bar{F}_1(t_1 - u, t_2 - v) d\bar{F}_2(u, v)$$

Consider

$$\begin{aligned} \int_t^{\infty} \int_s^{\infty} \bar{F}(x, y) dx dy &= \int_t^{\infty} \int_s^{\infty} \left[\int_{-\infty}^{\infty} \bar{F}_1(x - u, y - v) d\bar{F}_2(u, v) \right] dx dy \\ &= \int_{-\infty}^{\infty} \left[\int_t^{\infty} \int_s^{\infty} \bar{F}_1(x - u, y - v) dx dy \right] d\bar{F}_2(u, v) \\ &\leq \int_{-\infty}^{\infty} \mu \exp \left[\frac{-(t + s)}{\mu} \right] d\bar{F}_2(u, v) \\ &= \mu \exp \left[\frac{-(t + s)}{\mu} \right] \int_{-\infty}^{\infty} d\bar{F}_2(u, v) \\ &= \mu \exp \left[- \frac{(t + s)}{\mu} \right] \end{aligned}$$

The first inequality is because \bar{F}_1 is BHNBU and the last inequality follows from the fact that $\bar{F}_1 \leq_{st} \bar{F}$. Thus prove that \bar{F} is also BHNBU. ■

Theorem 3.4 Suppose $\bar{F}_1(\cdot, \cdot)$ and $F_2(\cdot, \cdot)$ are two independent BNBUFR life distributions. Then their convolution is BNBUFR.

Proof. The survival function of the convolution of two life distribution \bar{F}_1 and \bar{F}_2 is

$$\bar{F}(t_1, t_2) = \int_{-\infty}^{\infty} \bar{F}_1(t_1 - u, t_2 - v) d\bar{F}_2(u, v)$$

Consider

$$\bar{F}(0, 0) = \int_{-\infty}^{\infty} \bar{F}_1(-u, -v) d\bar{F}_2(u, v)$$

The first inequality is because \bar{F}_1 is BNBUFR and the last inequality follows from the fact that $\bar{F}_1 \leq_{st} \bar{F}$. Thus prove that \bar{F} is also BNBUFR. ■

4. Conclusion

In this paper, we introduce and investigate the properties of aging classes. The properties of on aging classes of the stochastic life-time models are transformed into the corresponding Bivariate properties.

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Some Properties of Intuitionistic Fuzzy Sets of Third Type

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Abstract

In this paper, we prove some properties of Intuitionistic Fuzzy Sets of Third Type (IFSTT).

Keywords: Intuitionistic Fuzzy Set (IFS), Intuitionistic Fuzzy Set of Second Type (IFSST), Intuitionistic Fuzzy Set of Root Type (IFSRT), Intuitionistic Fuzzy Set of Third Type (IFSTT).

1. Introduction

Fuzzy sets were introduced by Lofti A. Zadeh in 1965 as a generalization of Classical (crisp) sets. Further, the fuzzy sets are generalized by Krassimir T. Atanassov in which he has taken non-membership values also into consideration and he introduced IFS and its extensions. In this paper, we study the extension of Intuitionistic fuzzy set, namely, IFSTT and some of its properties.

2. Preliminaries

In this section, we give some definitions of various types of IFS.

Definition 2.1 *Let X be a non-empty set. An Intuitionistic Fuzzy Set (IFS) A in X is defined as an object of the form $A = \{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\}$, where $\mu_A(x) : X \rightarrow [0, 1]$ and $\nu_A(x) : X \rightarrow [0, 1]$ denote the membership and non-membership functions of A respectively, and $0 \leq \mu_A(x) + \nu_A(x) \leq 1$, for each $x \in X$.*

Definition 2.2 *Let X be the non-empty set. An Intuitionistic Fuzzy Set of Second Type (IFSST) A in X is defined as an object of the form $A = \{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\}$, where $\mu_A(x) : X \rightarrow [0, 1]$ and $\nu_A(x) : X \rightarrow [0, 1]$ denote the degree of membership and non-membership functions of A respectively and $0 \leq [\mu_A(x)]^2 + [\nu_A(x)]^2 \leq 1$, for each $x \in X$.*

Definition 2.3 Let X be the non-empty set. An Intuitionistic Fuzzy Set of Root Type A in X is defined as an object of the form $A = \{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\}$ where $\mu_A(x) : X \rightarrow [0, 1]$ and $\nu_A(x) : X \rightarrow [0, 1]$ denote the membership and non-membership functions of A respectively, and $0 \leq \frac{\sqrt{\mu_A(x)}}{2} + \frac{\sqrt{\nu_A(x)}}{2} \leq 1$, for each $x \in X$.

Definition 2.4 Let X be the non-empty set. An Intuitionistic fuzzy set of third type (IFSTT) A in X is defined as an object of the form $A = \{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\}$, where $\mu_A(x) : X \rightarrow [0, 1]$ and $\nu_A(x) : X \rightarrow [0, 1]$ denote the membership and non-membership functions of A respectively and $0 \leq [\mu_A(x)]^3 + [\nu_A(x)]^3 \leq 1$, for each $x \in X$.

Definition 2.5 Let A and B be two IFSTTs of the non-empty set X such that

$$A = \{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\},$$

$$B = \{\langle x, \mu_B(x), \nu_B(x) \rangle : x \in X\}.$$

We define the following basic operations on A and B .

- (i) $A \subset B$ iff $\mu_A(x) \leq \mu_B(x)$ and $\nu_A(x) \geq \nu_B(x)$, $\forall x \in X$
- (ii) $A \supset B$ iff $\mu_A(x) \geq \mu_B(x)$ and $\nu_A(x) \leq \nu_B(x)$, $\forall x \in X$
- (iii) $A = B$ iff $\mu_A(x) = \mu_B(x)$ and $\nu_A(x) = \nu_B(x)$, $\forall x \in X$
- (iv) $A \cup B = \{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\nu_A(x), \nu_B(x)) \rangle : x \in X\}$
- (v) $A \cap B = \{\langle x, \min(\mu_A(x), \mu_B(x)), \max(\nu_A(x), \nu_B(x)) \rangle : x \in X\}$
- (vi) $\bar{A} = \{\langle x, \nu_A(x), \mu_A(x) \rangle : x \in X\}$, where \bar{A} is the complement of A .

Definition 2.6 For every IFSTT A , we define the following two operators

$$C(A) = \{\langle x, K, L \rangle : x \in X\},$$

where $K = \max_{y \in X} \mu_A(y)$, $L = \min_{y \in X} \nu_A(y)$ and

$$I(A) = \{\langle x, k, l \rangle : x \in X\},$$

where $k = \min_{y \in X} \mu_A(y)$, $l = \max_{y \in X} \nu_A(y)$. We call $C(A)$ and $I(A)$, respectively, as

Closure and Interior of A over the universe X .

Remark. Clearly, $C(A)$ and $I(A)$ are IFSTTs.

Example. Let $X = \{a, b, c\}$ and let the IFSTT be

$$A = \{\langle a, 0.2, 0.3 \rangle, \langle b, 0.4, 0.4 \rangle, \langle c, 0.6, 0.2 \rangle\}$$

Then

$$C(A) = \{\langle a, 0.6, 0.2 \rangle, \langle b, 0.6, 0.2 \rangle, \langle c, 0.6, 0.2 \rangle\}$$

and

$$I(A) = \{\langle a, 0.2, 0.4 \rangle, \langle b, 0.2, 0.4 \rangle, \langle c, 0.2, 0.4 \rangle\}$$

are IFSTTs.

3. Some Properties of the topological operators

In this section, we prove some properties of the topological operators $C(A)$ and $I(A)$ on IFSTT.

Proposition 3.1 For every IFSTTs A and B

- (i) $I(A) \subset A \subset C(A)$
- (ii) $C(C(A)) = C(A)$
- (iii) $C(I(A)) = I(A)$
- (iv) $I(C(A)) = C(A)$
- (v) $I(I(A)) = I(A)$

Proof. We have

$$\begin{aligned} A &= \{ \langle x, \mu_A(x), \nu_A(x) \rangle : x \in X \}, \\ B &= \{ \langle x, \mu_B(x), \nu_B(x) \rangle : x \in X \}, \\ C(A) &= \{ \langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X \}, \\ I(A) &= \{ \langle x, \min_{y \in X} \mu_A(y), \max_{y \in X} \nu_A(y) \rangle : x \in X \} \end{aligned}$$

(i) Since

$$\min_{y \in X} \mu_A(y) \leq \mu_A(x) \leq \max_{y \in X} \mu_A(y), \forall x \in X$$

and

$$\max_{y \in X} \nu_A(y) \geq \nu_A(x) \geq \min_{y \in X} \nu_A(y), \forall x \in X,$$

it is clear from the definitions that $I(A) \subset A \subset C(A)$.

$$\begin{aligned}
(ii) \quad C(C(A)) &= C(C(\{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\})) \\
&= C(\{\langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X\}) \\
&= \{\langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X\} = C(A) \\
(iii) \quad C(I(A)) &= C(I(\{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\})) \\
&= C(\{\langle x, \min_{y \in X} \mu_A(y), \max_{y \in X} \nu_A(y) \rangle : x \in X\}) \\
&= \{\langle x, \max_{y \in X} \min_{y \in X} \mu_A(x), \min_{y \in X} \max_{y \in X} \nu_A(x) \rangle : x \in X\} \\
&= \{\langle x, \min_{y \in X} \mu_A(y), \max_{y \in X} \nu_A(y) \rangle : x \in X\} = I(A) \\
(iv) \quad I(C(A)) &= I(C(\{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\})) \\
&= I(\{\langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X\}) \\
&= \{\langle x, \min_{y \in X} \max_{y \in X} \mu_A(x), \max_{y \in X} \min_{y \in X} \nu_A(x) \rangle : x \in X\} \\
&= \{\langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X\} = C(A) \\
(v) \quad I(I(A)) &= I(I(\{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\})) \\
&= I(\{\langle x, \min_{y \in X} \mu_A(y), \max_{y \in X} \nu_A(y) \rangle : x \in X\}) \\
&= \{\langle x, \min_{y \in X} \min_{y \in X} \mu_A(x), \max_{y \in X} \max_{y \in X} \nu_A(x) \rangle : x \in X\} \\
&= \{\langle x, \min_{y \in X} \mu_A(y), \max_{y \in X} \nu_A(y) \rangle : x \in X\} = I(A)
\end{aligned}$$

■

Proposition 3.2 For every IFSTTs A and B

$$\begin{aligned}
(i) \quad C(A \cup B) &= C(A) \cup C(B) \\
(ii) \quad C(A \cap B) &\subset C(A) \cup C(B) \\
(iii) \quad I(A \cup B) &\supset I(A) \cup I(B) \\
(iv) \quad I(A \cap B) &= I(A) \cap I(B) \\
(v) \quad \overline{I(\overline{A})} &= C(A)
\end{aligned}$$

Proof. We have

$$\begin{aligned}
A &= \{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X\}, \\
B &= \{\langle x, \mu_B(x), \nu_B(x) \rangle : x \in X\}, \\
C(A) &= \{\langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X\}, \\
I(A) &= \{\langle x, \min_{y \in X} \mu_A(y), \max_{y \in X} \nu_A(y) \rangle : x \in X\}
\end{aligned}$$

$$\begin{aligned}
(i) \quad C(A \cup B) &= C(\{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\nu_A(x), \nu_B(x)) \rangle : x \in X\}) \\
&= \{\langle x, \max_{y \in X}(\max(\mu_A(y), \mu_B(y))), \min_{y \in X}(\min(\nu_A(y), \nu_B(y))) \rangle : x \in X\} \\
&= \{\langle x, \max_{y \in X}(\max \mu_A(y), \max \mu_B(y)), \min_{y \in X}(\min \nu_A(y), \min \nu_B(y)) \rangle : x \in X\} \\
&= \{\langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X\} \cup \\
&\quad \{\langle x, \max_{y \in X} \mu_B(y), \min_{y \in X} \nu_B(y) \rangle : x \in X\} \\
&= C(A) \cup C(B)
\end{aligned}$$

$$\begin{aligned}
(ii) \quad C(A \cap B) &= C(\{\langle x, \min(\mu_A(x), \mu_B(x)), \max(\nu_A(x), \nu_B(x)) \rangle : x \in X\}) \\
&= \{\langle x, \max_{y \in X}(\min(\mu_A(y), \mu_B(y))), \min_{y \in X}(\max(\nu_A(y), \nu_B(y))) \rangle : x \in X\} \\
&= \{\langle x, \min(\mu_A(x), \mu_B(x)), \max(\nu_A(x), \nu_B(x)) \rangle : x \in X\}
\end{aligned}$$

and

$$\begin{aligned}
C(A) \cup C(B) &= \{\langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X\} \cup \\
&\quad \{\langle x, \max_{y \in X} \mu_B(y), \min_{y \in X} \nu_B(y) \rangle : x \in X\} \\
&= \{\langle x, \max_{y \in X}(\max \mu_A(y), \max \mu_B(y)), \min_{y \in X}(\min \nu_A(y), \min \nu_B(y)) \rangle : x \in X\} \\
&= \{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\nu_A(x), \nu_B(x)) \rangle : x \in X\}
\end{aligned}$$

Since $\min(\mu_A(x), \mu_B(x)) \leq \max(\mu_A(x), \mu_B(x))$

and $\max(\nu_A(x), \nu_B(x)) \geq \min(\mu_A(x), \mu_B(x))$

Hence $C(A \cap B) \subset C(A) \cup C(B)$

(iii)

$$\begin{aligned}
I(A \cup B) &= I(\{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\nu_A(x), \nu_B(x)) \rangle : x \in X\}) \\
&= \{\langle x, \min_{y \in X}(\max(\mu_A(y), \mu_B(y))), \max_{y \in X}(\min(\nu_A(y), \nu_B(y))) \rangle : x \in X\} \\
&= \{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\nu_A(x), \nu_B(x)) \rangle : x \in X\}
\end{aligned}$$

and

$$\begin{aligned}
I(A) \cup I(B) &= \{\langle x, \min_{y \in X} \mu_A(y), \max_{y \in X} \nu_A(y) \rangle : x \in X\} \cup \{\langle x, \min_{y \in X} \mu_B(y), \max_{y \in X} \nu_B(y) \rangle : x \in X\}
\end{aligned}$$

$$\begin{aligned}
&= \{ \langle x, \max_{y \in X}(\min \mu_A(y), \min \mu_B(y)), \min_{y \in X}(\max \nu_A(y), \max \nu_B(y)) \rangle : x \in X \} \\
&= \{ \langle x, \min(\mu_A(x), \mu_B(x)), \max(\nu_A(x), \nu_B(x)) \rangle : x \in X \}
\end{aligned}$$

Hence $I(A \cup B) \supset I(A) \cup I(B)$.

(iv) $I(A \cap B)$

$$\begin{aligned}
&= I(\{ \langle x, \min(\mu_A(x), \mu_B(x)), \max(\nu_A(x), \nu_B(x)) \rangle : x \in X \}) \\
&= \{ \langle x, \min_{y \in X}(\min(\mu_A(y), \mu_B(y))), \max_{y \in X}(\max(\nu_A(y), \nu_B(y))) \rangle : x \in X \} \\
&= \{ \langle x, \min_{y \in X}(\min \mu_A(y), \min \mu_B(y)), \max_{y \in X}(\max \nu_A(y), \max \nu_B(y)) \rangle : x \in X \} \\
&= \{ \langle x, \min_{y \in X} \mu_A(y), \max_{y \in X} \nu_A(y) \rangle : x \in X \} \cap \\
&\quad \{ \langle x, \min_{y \in X} \mu_B(y), \max_{y \in X} \nu_B(y) \rangle : x \in X \}
\end{aligned}$$

$$= I(A) \cap I(B)$$

$$\begin{aligned}
(v) \quad I(\bar{A}) &= \overline{I(\{ \langle x, \mu_A(x), \nu_A(x) \rangle : x \in X \})} \\
&= \overline{I(\{ \langle x, \nu_A(x), \mu_A(x) \rangle : x \in X \})} \\
&= \overline{\{ \langle x, \min_{y \in X} \nu_A(y), \max_{y \in X} \mu_A(y) \rangle : x \in X \}} \\
&= \{ \langle x, \max_{y \in X} \mu_A(y), \min_{y \in X} \nu_A(y) \rangle : x \in X \} \\
&= C(A). \quad \blacksquare
\end{aligned}$$

4. Conclusion

We have made an attempt to prove some topological properties of operators defined on IFSTT. It is still open to check whether there exist an IFSTT in case of the operators already defined on an IFS.

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Optimal Replacement Policy for a Multistate Degenerative System under Quasi Renewal Process

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Abstract

In this paper, we consider a simple repairable system for a monotone process model of a one component multistate degenerative system. Explicit expression for the long-run average cost per unit time under a univariate replacement policy T under quasi renewal process is derived. The conditions for existence of the optimal replacement policy T^* are deduced.

Keywords: Quasi Renewal Process, Maintenance Models, Renewal Reward Process.

AMS Subject Classification (2010) : 60K10, 90B25.

1. Introduction

The maintenance problem of a multistate degenerative system with k -working states and l -failure states is studied. The long-run average cost for a multistate degenerative system under the replacement policy T , where T is the working age of the system, is derived. Existence of optimality under the policy T is deduced. Numerical example is given to illustrate the results developed.

The classical reliability theory is based on the binary assumption that each component or the system is either working perfectly or completely failed. However in many practical situations, a system may experience more than two possible states. For instance, a microwave transmitter may be working with full transmission range, working with degraded transmission range or completely failed. A special type of multistate system experiences multiple distinct failure modes. In another instance, a home security system may fail to detect a break-in due to a mechanical or electrical circuit failures. It

may also create a false alarm due to the presence of a pet. Lesanovsky [1993] provided a review of research on systems with dual failure modes. In engineering, a failure of machine may be classified by its seriousness, a slight failure or a serious failure. In this case, the system will have two different failure states and one working state. In general, we may assume that a system, in general, may have k different working states and l distinct failure states. In this Chapter, we study a monotone process model for a one-component multistate system with $(k + l)$ states, namely k -working states and l -failure states. By making different assumptions, the model can be applied to a multistate deteriorating system.

The rest of the paper is arranged as follows: In Section 2, we present some known definitions and concepts. We present the monotone process model of a one-component multistate system and the relevant results regarding their probability structure, in Section 3. In section 4, explicit expression for the long-run average cost of the policy T under quasi renewal process is derived. Also the conditions for the existence of univariate optimal replacement policy T^* are derived. Finally, conclusion is given Section 5.

2. Preliminaries

In this section, we first give the definitions required for further discussion.

Definition 2.1 Given two random variables X and Y , if

$$P(X > t) \geq P(Y > t)$$

for all real t , then X is called **stochastically larger than Y** (or Y is **stochastically smaller than X**). It is denoted by $X \geq_{st} Y$ (or $Y \leq_{st} X$).

Definition 2.2 Given a stochastic process $\{Z_n, n = 1, 2, \dots\}$, if for all n

$$Z_n \leq_{st} (\geq_{st}) Z_{n+1},$$

then $\{Z_n, n = 1, 2, \dots\}$ is called a **stochastically increasing (decreasing) process**.

Definition 2.3 If the sequence of non-negative random variable $\{X_1, X_2, \dots\}$ is independent and $X_i = \alpha X_{i-1}$, for $i > 2$, where $\alpha > 0$ is a constant, then the counting process $N(t), t \geq 0$ is said to be a **quasi renewal process with parameter α and the first interarrival time X_1** .

When $\alpha = 1$, this process becomes the ordinary renewal process. Later, we will see that this quasi renewal process can be used in maintenance models when $\alpha \leq 1$; and a reliability growth process in product development and burn-in, for $\alpha > 1$.

Assuming that the probability density function, cumulative distribution function, survival function and failure rates of the random variable X_1 are $f_1(x)$, $F_1(x)$, $s_1(x)$ and $r_1(x)$ respectively, then the probability density function, cumulative distribution function, survival function, failure rate, mean and variance of X_n for $n = 1, 2, \dots$ are

$$\left. \begin{aligned} f_n(x) &= \frac{1}{\alpha^{n-1}} f_1\left(\frac{x}{\alpha^{n-1}}\right) \\ E(X_n) &= \alpha^{n-1} E(X_1) \\ r_n(x) &= \left(\frac{r_1}{\alpha^{n-1}}\right) \left(\frac{x}{\alpha^{n-1}}\right) \end{aligned} \right\} \begin{aligned} s_n(x) &= s_1\left(\frac{x}{\alpha^{n-1}}\right) \\ F_n(x) &= F_1\left(\frac{x}{\alpha^{n-1}}\right) \\ \text{Var}(X_n) &= \alpha^{2n-2} \text{Var}(X_1) \end{aligned}$$

Because of the non-negativity of X_1 and the fact that X_1 is not identically zero, it is concluded that $E(X_1) = \lambda_1 \neq 0$.

Definition 2.4 An integer valued random variable N is said to be a stopping time for the sequence of independent random variables X_1, X_2, \dots , if the event $\{N = n\}$ is independent of X_{n+1}, X_{n+2}, \dots , for all $n = 1, 2, \dots$.

Theorem 2.1 Wald's equation. If X_1, X_2, \dots are independent and identically distributed random variables having finite expectations and if N is the stopping time for X_1, X_2, \dots such that $E[N] < \infty$, then

$$E\left[\sum_{n=1}^N X_n\right] = E(N)E(X_1).$$

Definition 2.5 The N -policy

It is a policy under which the system will be replaced upon the N -th failure of the system, after the last replacement.

Definition 2.6 The T -policy

It is a policy under which the system will be replaced whenever the working age of the system reaches T .

3. Description of the Model

In this section, we describe the model of a one-component multistate system. We also evaluate the conditional probabilities of the operating times and failure times given the state of the system.

Consider a one-component multistate system with $(k + l)$ states having k -working states and l -failure states.

The system state at time t is given by

$$S(t) = \begin{cases} i & \text{if the system is in the } i\text{-th working state at time } t \\ & (i = 1, 2, \dots, k) \\ k + j & \text{if the system is in the } j\text{-th failure state at time } t \\ & (j = 1, 2, \dots, l) \end{cases}$$

The set of working states is $\Omega_1 = \{1, 2, \dots, k\}$; the set of failure states is $\Omega_2 = \{k + 1, k + 2, \dots, k + l\}$ and the state space is $\Omega = \Omega_1 \cup \Omega_2$. Initially, assume that a new system in working state 1 is installed. Whenever the system fails, it will be repaired. Let t_n be the completion time of the n -th repair, $n = 0, 1, \dots$ with $t_0 = 0$ and let s_n be the time of occurrence of the n -th failure, $n = 1, 2, \dots$. Then

$$t_0 < s_1 < t_1 < \dots < s_n < t_n < \dots$$

Consider a monotone process model for a multistate one-component system described in this section and make the following package of assumptions: **3.1 - 3.8**.

- 3.1** At the beginning, a new system is installed. The system has $(k + l)$ possible states, where the states $1, 2, \dots, k$ denote, respectively, the first-type working state, the second-type working state, \dots , k -th-type working state and the states $(k + 1), (k + 2), \dots, (k + l)$ denote, respectively, the first-type failure state, the second-type failure state, \dots and the l -th type failure state of the system. The occurrences of these types of failures are random and mutually exclusive.
- 3.2** Whenever the system fails in any of the working states, it will be repaired. The system will be replaced by an identical one, some times later.
- 3.3** Let X_n be the survival time of the system after $(n - 1)$ -st repair. Then $\{X_n, n = 1, 2, \dots\}$ forms a non-increasing quasi renewal process with parameter $\alpha < 1$ and $E(X_1) = \lambda > 0$.
- 3.4** Let Y_n be the repair time after n -th failure. Then $\{Y_n, n = 1, 2, \dots\}$ forms a non-decreasing quasi renewal process with parameter $\beta, \beta > 1$ and $E(Y_1) = \mu \geq 0$. Here $\mu = 0$ means that repair time is negligible.
- 3.5** If the system in working state i is operating, then let the reward rate be R_i . If the system in failure state $(k + i)$ is under repair, the repair cost is C_i . The replacement cost comprises of two parts: one part is the basic replacement cost B and the other proportional to the replacement time Z at rate c_p . In other words, the replacement cost is given by $B + c_p Z$.

3.6 Assume that $1 \leq a_1 \leq a_2 \leq \dots \leq a_k$ and $1 \geq b_1 \geq b_2 \geq \dots \geq b_l > 0$.

3.7 Assume that $F_n(t)$ is the cumulative distribution of $L_n = \sum_{i=1}^n X_i$ and $G_n(t)$ be the cumulative distribution of $M_n = \sum_{i=1}^n Y_i$.

3.8 The random variables $X_n, n = 1, 2, \dots, Y_n, n = 1, 2, \dots$, and the replacement time Z are independent.

3.9 During the repair time, the system is closed so that any further repair during repair time is ineffective.

We now describe the probability structure of the model:

Assume that the transition probability from working state $i, i = 1, 2, \dots, k$, to failure state $k + j, j = 1, 2, \dots, l$, is

$$P(S(s_{n+1}) = (k + j) | S(t_n) = i) = q_j,$$

with $\sum_{j=1}^l q_j = 1$. Moreover, the transition probability from failure state $k + j, j = 1, 2, \dots, l$, to working state $i, i = 1, 2, \dots, k$ is given by

$$P(S(t_n) = i | S(s_n) = k + j) = p_i,$$

with $\sum_{i=1}^k p_i = 1$.

Assume that there exist a life-time distribution $U(t)$ and $a_i > 0, i = 1, 2, \dots, k$ such that

$$\begin{aligned} P(X_1 \leq t) &= U(t) \\ P(X_2 \leq t | S(t_1) = i) &= U(a_i t), \quad i = 1, 2, \dots, k \end{aligned}$$

where $1 \leq a_1 \leq a_2 \leq \dots \leq a_k$. In general, for $i_j \in \{1, 2, \dots, k\}$,

$$P(X_n \leq t | S(t_1) = i_1, \dots, S(t_{n-1}) = i_{n-1}) = U(a_{i_1} \dots a_{i_{n-1}} t).$$

Similarly, assume that there exist a life-time distribution $V(t)$ and $b_i > 0, i = 1, 2, \dots, l$ such that

$$P(Y_1 \leq t | S(s_1) = k + i) = V(b_i t),$$

where $1 \geq b_1 \geq b_2 \geq \dots \geq b_l > 0$ and in general, for $i_j \in \{1, 2, \dots, l\}$,

$$P(Y_n \leq t | S(s_1) = k + i_1, \dots, S(s_n) = k + i_n) = V(b_{i_1} \dots b_{i_n} t)$$

4. The Replacement Policy T

The *working age* T of the system at time t is the cumulative life-time given by

$$T = \begin{cases} t - M_n, & L_n + M_n \leq t < L_{n+1} + M_n \\ L_{n+1}, & L_{n+1} + M_n \leq t < L_{n+1} + M_{n+1} \end{cases}$$

where $L_n = \sum_{i=1}^n X_i$ and $M_n = \sum_{i=1}^n Y_i$ and $L_0 = M_0 = 0$.

Following Lam [2005], the distribution of the survival time X_n in assumption **3.3** and the distribution of the repair time Y_n in assumption **3.4** are given by

$$P(X_n \leq t) = \sum_{\sum_{i=1}^k j_i = n-1} \frac{(n-1)!}{j_1! \cdots j_k!} p_1^{j_1} \cdots p_k^{j_k} U(a_1^{j_1} \cdots a_k^{j_k} t),$$

where $j_1, j_2, \dots, j_k \in \mathbb{Z}^+$ and

$$P(Y_n \leq t) = \sum_{\sum_{i=1}^l j_i = n} \frac{n!}{j_1! \cdots j_l!} q_1^{j_1} \cdots q_l^{j_l} V(b_1^{j_1} \cdots b_l^{j_l} t),$$

where $j_1, j_2, \dots, j_l \in \mathbb{Z}^+$. Further, if $E(X_1) = \lambda$, then the mean survival time is

$$E(X_n) = \alpha^{n-1} \lambda,$$

for $n > 1$, where

$$\alpha = \sum_{i=1}^k \frac{p_i}{a_i} \quad (4.1)$$

and if $E(Y_1) = \mu$, then the mean repair time is

$$E(Y_n) = \beta^n \mu$$

for $n > 1$, where

$$\beta = \sum_{j=1}^l \frac{q_j}{b_j}. \quad (4.2)$$

Define r_n , the reward rate after the $(n-1)$ -st repair, as

$$r_n = R_i; \quad \text{if } S(t_{n-1}) = i, \quad i = 1, 2, \dots, k.$$

Because $S(t_0) = 1$, we have $r_1 = R_1$ and, so, the expected reward after installation (or one replacement) is given by

$$E(r_1 X_1) = E(R_1 X_1) = R_1 \lambda.$$

In general, for $n = 2, 3, \dots$, the expected reward after $(n - 1)$ -st repair is

$$\begin{aligned}
 E(r_n X_n) &= \sum_{i_1=1}^k \cdots \sum_{i_{n-1}=1}^k E(r_n X_n | S(t_1) = i_1, \dots, S(t_{n-1}) = i_{n-1}) \\
 &\quad \times P(S(t_1) = i_1, \dots, S(t_{n-1}) = i_{n-1}) \\
 &= \sum_{i_1=1}^k \cdots \sum_{i_{n-1}=1}^k p_{i_1} \cdots p_{i_{n-1}} \int_0^\infty R_{i_{n-1}} t dU(a_{i_1} \cdots a_{i_{n-1}} t) \\
 &= \left(\sum_{i_1=1}^k \cdots \sum_{i_{n-2}=1}^k \frac{p_{i_1} \cdots p_{i_{n-2}}}{q_{i_1} \cdots q_{i_{n-2}}} \right) \left(\sum_{i_{n-1}=1}^k \frac{R_{i_{n-1}} p_{i_{n-1}}}{a_{i_{n-1}}} \right) \lambda \\
 &= \gamma \lambda \left(\frac{p_1}{a_1} + \cdots + \frac{p_k}{a_k} \right)^{n-2} \\
 &= \gamma \lambda \alpha^{n-2}, \tag{4.3}
 \end{aligned}$$

where

$$\gamma = \sum_{i=1}^k \frac{R_i p_i}{a_i}. \tag{4.4}$$

To evaluate the expected repair cost incurred after the n -th failure, we define EC_n , the repair cost rate after the n -th failure, as

$$EC_n = C_i; \text{ if } S(s_n) = k + i, \quad i = 1, 2, \dots, l.$$

The calculation is similar to the above. The expected repair cost after the n -th failure is

$$\begin{aligned}
 E(EC_n Y_n) &= \delta \mu \left(\frac{q_1}{b_1} + \cdots + \frac{q_l}{b_l} \right)^{n-1} \\
 &= \delta \mu \beta^{n-1}, \tag{4.5}
 \end{aligned}$$

where

$$\delta = \sum_{i=1}^l \frac{C_i q_i}{b_i}. \tag{4.6}$$

We consider a T -policy under which the system will be replaced whenever its working age reaches T . Under the replacement policy T , the problem is to determine an optimal T^* such that the long-run average cost per unit time is minimized.

Let T_1 be the first replacement time and in general for $n = 2, 3, \dots$, let T_n be the time between $(n - 1)$ -st replacement and n -th replacement. Thus the sequence T_1, T_2, \dots

constitutes a renewal process. Thus a cycle is completed, if a replacement is done. By the renewal reward theorem (Ross [1996]), the long-run average cost per unit time under the replacement policy T is given by

$$\begin{aligned} \mathcal{C}(T) &= \frac{\text{the expected cost incurred in a cycle}}{\text{the expected length of a cycle}} \\ &= \frac{E\left(\sum_{i=1}^{\eta-1} EC_i Y_i\right) + B + c_p E(Z) - E\left(\sum_{i=1}^{\eta} r_i X_i\right)}{E\left(\sum_{i=1}^{\eta} X_i\right) + E\left(\sum_{i=1}^{\eta-1} Y_i\right) + E(Z)}, \end{aligned} \quad (4.7)$$

where η is a random variable which denotes the number of failures in time T .

Since η is also a stopping time with respect to the σ fields $\{\sigma\langle X_1, X_2, \dots, X_\eta \rangle, \eta = 1, 2, \dots\}$, by Wald's equation, we have

$$\begin{aligned} E\left(\sum_{i=1}^{\eta} X_i\right) &= E[E(X_n | \eta = n)] \\ &= \sum_{n=1}^{\infty} \left[\sum_{i=1}^n E(X_i) \right] P(\eta = n) \\ &= \sum_{n=1}^{\infty} \left(\sum_{i=1}^n \alpha^{i-1} \lambda \right) [F_n(T) - F_{n+1}(T)] \\ &= \lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n(T), \end{aligned} \quad (4.8)$$

where $F_n(\cdot)$ is the n -fold convolution of $F(\cdot)$ with itself and

$$\begin{aligned} E\left(\sum_{i=1}^{\eta-1} Y_i\right) &= \sum_{n=1}^{\infty} \left[\sum_{i=1}^{n-1} E(Y_i) \right] P(\eta = n - 1) \\ &= \sum_{n=1}^{\infty} \left(\sum_{i=1}^{n-1} \beta^{i-1} \mu \right) [G_{n-1}(T) - G_n(T)] \\ &= \mu \sum_{n=1}^{\infty} \beta^n G_n(T), \end{aligned} \quad (4.9)$$

where $G_n(\cdot)$ is the n -fold convolution of $G(\cdot)$ with itself. Further

$$\begin{aligned}
 E \left(\sum_{i=2}^{\eta} r_i X_i \right) &= E [E(r_n X_n | \eta = n)] \\
 &= \sum_{n=2}^{\infty} \left[\sum_{i=2}^n E(r_i X_i) \right] P(\eta = n) \\
 &= \sum_{n=2}^{\infty} \sum_{i=2}^n \gamma \alpha^{i-2} \lambda [F_n(T) - F_{n+1}(T)] \\
 &= \sum_{n=2}^{\infty} \gamma \lambda (1 + \alpha + \alpha^2 + \dots + \alpha^{n-2}) [F_n(T) - F_{n+1}(T)] \\
 &= \sum_{n=2}^{\infty} \gamma \lambda \left(\frac{1 - \alpha^{n-1}}{1 - \alpha} \right) [F_n(T) - F_{n+1}(T)] \\
 &= \gamma \lambda \sum_{n=2}^{\infty} \alpha^{n-2} F_n(T)
 \end{aligned} \tag{4.10}$$

and

$$\begin{aligned}
 E \left(\sum_{i=1}^{\eta-1} EC_i Y_i \right) &= E [E(Y_{n-1} | \eta = n - 1)] \\
 &= \sum_{n=1}^{\infty} \left[\sum_{i=1}^{n-1} E(EC_i Y_i) \right] P(\eta = n - 1) \\
 &= \sum_{n=1}^{\infty} \left(\sum_{i=1}^{n-1} \delta \mu \beta^{i-1} \right) [G_{n-1}(T) - G_n(T)] \\
 &= \delta \mu \sum_{n=1}^{\infty} \beta^n G_n(T).
 \end{aligned} \tag{4.11}$$

Using equations (4.8) to (4.11), the equation (4.7) becomes

$$\mathcal{E}(T) = \frac{\delta \mu \sum_{n=1}^{\infty} \beta^n G_n(T) + B + c_p \tau - \gamma \lambda \sum_{n=2}^{\infty} \alpha^{n-2} F_n(T) - R_1 \lambda}{\lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n(T) + \tau}, \tag{4.12}$$

where $E(Z) = \tau$. Further

$$\mathcal{E}(T) = \frac{(\delta + \frac{\gamma}{\alpha}) \mu \sum_{n=1}^{\infty} \beta^n G_n(T) + \frac{\gamma \lambda}{\alpha} F_1(T) + K}{\lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n(T) + \tau} - \frac{\gamma}{\lambda}, \tag{4.13}$$

where $K = \left(B + c_p \tau - R_1 \lambda + \frac{\gamma}{\alpha} \tau \right)$ is constant.

We observe here that the series $\sum_{n=1}^{\infty} \beta^n G_n(T)$ and $\sum_{n=2}^{\infty} \alpha^{n-1} F_n(T)$ converges absolutely. It follows from Mertens Theorem (Rudin [1976]) that

$$\sum_{n=1}^{\infty} \beta^n G_n(T) \sum_{n=1}^{\infty} \alpha^{n-1} F_n(T) = \sum_{n=1}^{\infty} \sum_{k=1}^n \alpha^{n-k-1} \beta^k G_k(T) F_{n-k}(T).$$

Since both the series are uniformly convergent, term-by-term differentiation is applicable. On differentiating the equation (4.17) with respect to T , we obtain on simplification that

$$\mathcal{C}'(T) = \frac{\left[\begin{aligned} & \lambda \mu \left(\delta + \frac{\gamma}{\alpha} \right) \sum_{n=1}^{\infty} \sum_{k=1}^n \left\{ \alpha^{k-1} \beta^{n-k} F_k(T) G'_{n-k}(T) \right. \\ & \quad \left. - \alpha^{n-k-1} \beta^k F'_{n-k}(T) G_k(T) \right\} \\ & + \frac{\gamma}{\alpha} \lambda F_1'(T) \left\{ \lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n(T) + \tau \right\} \\ & - \left[\frac{\gamma}{\alpha} \lambda F_1(T) + K \right] \left\{ \lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n'(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n'(T) \right\} \end{aligned} \right]}{\left[\lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n(T) + \tau \right]^2}. \quad (4.14)$$

On equating $\mathcal{C}'(T)$ to zero, we obtain

$$\begin{aligned} & \lambda \mu \left(\delta + \frac{\gamma}{\alpha} \right) \sum_{n=1}^{\infty} \sum_{k=1}^n \left\{ \alpha^{k-1} \beta^{n-k} F_k(T) G'_{n-k}(T) - \alpha^{n-k-1} \beta^k F'_{n-k}(T) G_k(T) \right\} \\ & + \frac{\gamma}{\alpha} \lambda F_1'(T) \left\{ \lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n(T) + \tau \right\} \\ & - \left[\frac{\gamma}{\alpha} \lambda F_1(T) + K \right] \left\{ \lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n'(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n'(T) \right\} = 0. \quad (4.15) \end{aligned}$$

If $\mathcal{C}''(T) > 0$, then we must have

$$\begin{aligned} & \lambda\mu \left(\delta + \frac{\gamma}{\alpha} \right) \sum_{n=1}^{\infty} \sum_{k=1}^n \left\{ \alpha^{k-1} \beta^{n-k} F_k(T) \frac{G''_{n-k}(T)}{\mu} - \alpha^{n-k-1} \beta^k F''_{n-k}(T) G_k(T) \right\} \\ & + \frac{\gamma}{\alpha} \lambda F_1''(T) \left\{ \lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n(T) + \tau \right\} \\ & - \left[\frac{\gamma}{\delta} \lambda F_1(T) + K \right] \left\{ \lambda \sum_{n=1}^{\infty} \alpha^{n-1} F_n''(T) + \mu \sum_{n=1}^{\infty} \beta^n G_n''(T) \right\} > 0. \quad (4.16) \end{aligned}$$

For $\mathcal{C}(T)$ to attain its minimum, $\mathcal{C}'(T) = 0$ and $\mathcal{C}''(T) > 0$. Thus the equation (4.15) gives T^* for which $\mathcal{C}(T^*)$ is minimum. Summarizing the above facts, we have the following result.

Theorem 4.1 *The long-run average cost per unit per unit time, $\mathcal{C}(T)$ given by (4.12) for the monotone process model for a multistate one-component system under T -policy is minimum, if (4.15) and (4.16) hold.*

Moreover, the minimization procedure can also be done by numerical method. The optimal replacement policy T^* can be determined by minimizing $\mathcal{C}(T)$.

5. Conclusion

By considering a simple repairable system for a monotone process model of a one component multistate degenerative system, an explicit expression for the long-run average cost per unit time under a univariate replacement policy T under quasi renewal process is derived. The conditions for existence of the optimal replacement policy T^* are deduced.

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Fuzzy Matrix Analysis - A Study on Induced Fuzzy Cognitive Maps

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Abstract

A person as a transsexual transvestite who identifies with or expresses a gender identity that differs them the one which corresponds to the person's sex at birth. In day to day these peoples are facing so many problems without solutions. This paper analyzes the problems of transgender through the parents and the nongovernmental organizations. From this paper, we can analyze the major problems of Transgender in India by using Induced Fuzzy Cognitive Maps. This paper has four sections. First section gives the information about the major problems of transgender. Second section gives preliminaries of FCM and Induced FCM. In section three, we explain the method of determining the hidden pattern with which we analyze the major problems of Transgender in Tamilnadu. In the fourth section we give the conclusion and suggestions based on our study.

Keywords: Unsupervised Transgenders, Fuzzy Cognitive Maps, Induced Fuzzy Cognitive Maps, Hidden patterns.

1. Introduction

Transgender is one who is in between category of gender. They are these peoples be the combination of both male and female. They are called such as transgender, multi-transgender, third gender. In India there are estimated 1,50,000 transgenders. But this third gender is not accepted society anywhere in the world. It is due to different activities such as way of behavior, the way of talking, hair style, dressing, etc. This can be changed by supporting them in education, health care etc. Parents, colleagues, friends and society should give equal rights in all activities. Gender identity refers to a internal feeling of being male of female gender expression. On the other hand in external, the social and behavioral characteristics with being male or female. A transgender person

would be nuterosexual, gay or lesbian or bisexual. The policeman who is given the safeguard, they also misusing themselves. So, these peoples are affected deadly like HIV/AIDS due to illiteracy. For this government should take actions such as counseling, job, education, etc.

How and when they know that they are transgender?

The feelings of *not fitting in* the assigned sex occurs at any part of their childhood. Those who realize early, have less problem compared to those who transition later in life.

Medical Intervention / Gender affirmation

The term *transsexual* refers to people whose gender identity is different from the *assigned sex*. Often transsexual people alter or wish to alter their bodies through hormones, surgery, and other means to make their bodies as congruent as possible with their gender identities. This process of transition through medical intervention is often referred to as sex or gender reassignment. More recently this process is termed as gender affirmation.

Transsexual Men (Female to Male FTM)

People who were assigned as Female at birth, but identify and live as male and alter or wish to alter their bodies through medical intervention to more closely resemble their gender identity are known as transsexual men or trans men (also known as Female to Male - FTM).

Transsexual Women (Male to Female MTF)

Conversely, people who were assigned male at births, but identify latter and live as female, and alter or wish to alter their bodies through medical intervention to more closely resemble their gender identity are known as transsexual women or trans women (also known as Male to Female - MTF). Some individuals, who transition from one gender to another prefer to be referred to as a man or a woman, rather than as transgender.

Problems faced by Transgender

Medical intervention is possible only with people who are well to-do. But the transgender from families below poverty line, face immense problem at every level in the family, school and in the society at large. The problem is omnipresent. The cause for such problem is not ascertained as yet. Though the meanings of gender non conformity vary from, culture to culture, their existence is documented in many indigenous western and eastern cultures and societies from antiquity until the present day. Many experts believe that biological factors such as genetic influences and prenatal hormone levels, early experiences, and experiences later in adolescence or adulthood may all contribute to the development of transgender identities. As there are no population studies that accurately and completely account for the range of gender identity and gender expression, it is difficult to accurately estimate the proportion of transgender people.

Kinds of discrimination faced by transgender

Transgender face discrimination in nearly every aspect of their lives. The study

report in 2011 by the National Centre for Transgender Equality and the National Gay and Lesbian Task Force in USA confirmed the pervasive and severe discrimination faced by transgender people. Out of a sample of about 6500 transgender people, the report found that transgender experience high levels of discrimination in employment, education, housing, health care, legal systems, and even in their societies and families.

2. FCMs and Induced FCMs:

Basic Notions of Fuzzy Cognitive Maps

Fuzzy Cognitive Maps are techniques that attempt to depict and analyze the cognitive process of human thinking and human behavior on specific domains by creating models. These models are represented assigned directed graphs of concepts and by the various casual relationships that exists between the concepts. In 1976 Axelrod [1] proposed cognitive maps as a formal tool for decision-making. He used the matrix representation of the directed graph to represent and study the social scientific knowledge. In 1986 Kosko [2] proposed FCMs based on the cognitive maps structure.

In this section we recall the notion of Fuzzy Cognitive Maps (FCMs), which was introduced by Bart Kosco [2] in the year 1986. FCMs have a major role to play mainly when the data concerned is an unsupervised one. Further this method is most simple and an effective one as it can analyze the data by directed graphs and connection matrices.

Definition 2.1 *An FCM is a directed graph with concepts like policies, events etc. as nodes and causalities as edges. It represents causal relationship between concepts. If increase (or decrease) in one concept, leads to increase (or decrease) in another, then give the value 1. If there exists no relation between two concepts, then the value 0 is given. If increase (or decrease) in one causalities decreases (or increases) another, then give the value -1 . Thus FCMs are described in this way.*

Definition 2.2 *When the nodes of the FCM are fuzzy sets then they are called as fuzzy nodes.*

Definition 2.3 *FCMs with edge weights or causalities from the set $\{-1, 0, 1\}$, are called simple FCMs.*

Definition 2.4 *Consider the nodes or concepts of the FCM. Suppose the directed graph is drawn using edge weight $e_{ij} \in \{0, 1, -1\}$. The matrix E is defined by $E = e_{ij}$ where e_{ij} is the weight of the directed edge $C_i C_j$. E is called the adjacency matrix of the FCM, also known as the connection matrix of the FCM.*

It is important to note that all matrices associated with an FCM are always square matrices with diagonal entries as zero.

Definition 2.5 Let C_1, C_2, \dots, C_n be the nodes of an FCM. Let $A = \{a_1, a_2, \dots, a_n\}$, where $a_i \in (0, 1)$. A is called the instantaneous state vector and it denotes the on-off position of the node at an instant

$$a_i = \begin{cases} 0 & \text{if } a_i \text{ is OFF} \\ 1 & \text{if } a_i \text{ is ON} \end{cases}$$

where $i = 1, 2, \dots$.

Definition 2.6 Let C_1, C_2, \dots, C_n be the nodes of an FCM. Let $\overline{C_1 C_2}, \overline{C_2 C_3}, \dots, \overline{C_i C_j}$ be the edges of the FCM ($i \neq j$). Then the edges form a directed cycle. An FCM is said to be cyclic if it possesses a directed cycle. An FCM is said to be acyclic if it does not possess any directed cycle.

Definition 2.7 An FCM with cycles is said to have a feedback.

Definition 2.8 When there is a feedback in an FCM, that is, when the causal relations flow through a cycle in a revolutionary way, the FCM is called a dynamical system.

Definition 2.9 Let $\overline{C_1 C_2}, \overline{C_2 C_3}, \dots, \overline{C_i C_j}$ be a cycle. When C_i is switched ON and if the causality flows through the edges of a cycle and if it again causes C_i , we say that the dynamical system goes round and round. This is true for any node C_i for $i = 1, 2, \dots, n$. The equilibrium state for this dynamical system is called the hidden pattern.

Definition 2.10 If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point.

Example.

Consider a FCM with C_1, C_2, \dots, C_n as nodes. For example, let us start the dynamical system by switching ON C_i . Let us assume that the FCM settles down with C_1 and C_n ON, that is, the state vector remains as $(1, 0, 0, \dots, 0, 1)$. This state vector $(1, 0, 0, \dots, 0, 1)$ is called the fixed point.

Definition 2.11 If the FCM settles down with a state vector repeating in the form $A_1 \rightarrow A_2 \rightarrow \dots \rightarrow A_i \dots \rightarrow A_1$, then this equilibrium is called a limit cycle.

Definition 2.12 We denote the combined FCM adjacency matrix by $E = E_1 + E_2 + \dots + E_p$. Finite number of FCMs can be combined together to produce the joint effect of all the FCMs. Let E_1, E_2, \dots, E_p be adjacency matrices of the FCMs with nodes C_1, C_2, \dots, C_n , then the combined FCM is got by adding all the adjacency matrices E_1, E_2, \dots, E_p .

Notation

Suppose $A = (a_1, a_2, \dots, a_n)$ is a vector which is passed into a dynamical system E . Then $AE = (a_1, a_2, \dots, a_n)$. After thresholding and updating the vector suppose we get (b_1, b_2, \dots, b_n) we denote that by $(a_1, a_2, \dots, a_n) \leftrightarrow (b_1, b_2, \dots, b_n)$. Thus, the symbol \leftrightarrow means the resultant vector has been threshold and updated.

3. Advantages and Disadvantages of FCM

The main advantage of this method it is simple. It functions on expert's opinion. When the data happens to be an unsupervised one the FCM comes handy. This is the only known fuzzy technique that gives the hidden pattern of the situation. As we have a very well known theory, which states that the strength of the data depends on, the number of experts' opinion we can use combined FCMs with several experts' opinions.

At the same time the disadvantage of FCM is when the weightages are 1 and -1 for the same $C_i C_j$, we have the sum adding to zero thus at all times the connection matrices E_1, \dots, E_k may not be conformable for addition. Combined conflicting opinions tend to cancel out and assisted by the strong law of large numbers, a consensus emerges as the sample opinion approximates the underlying population opinion. This problem will be *easily* overcome if the FCM entries are *only 0 and 1*.

Applications of FCM in Various Field:

Modeling- Knowledge representation, Decision making, Enterprise Resource Management, Socio-economic systems, Engineering & Technology Management, Adaptation and Learning, Classification tasks, Robots and control, Political and Social Fields, Military planning, Production Systems, Prediction capabilities, Ecology and environmental.

Algorithmic Approach in Induced Fuzzy Cognitive Maps (IFCMs)

Even though IFCM is an advancement of FCM it follows the foundation of FCM, it has a slight modification only in Algorithmic approaches. To derive an optimistic solution to the problem with an unsupervised data, the following steps to be followed:

- Step 1** For the given model (problem), collect the unsupervised data that is in determinant factors called nodes.
- Step 2** According to the expert opinion, draw the directed graph.
- Step 3** Obtain the connection matrix, M , from the directed graph (FCM). Here the number of rows in the given matrix = number of steps to be performed.
- Step 4** Consider the state vector C_1 which is in ON position. Find $C_1 \times M$. The state vector is updated and threshold at each stage.
- Step 5** Threshold value is calculated by assigning 1 for the values > 1 and 0 for the values < 0 . The symbol \leftrightarrow represents the threshold value for the product of the result.
- Step 6** Now each component in the C_1 vector is taken separately and product of the given matrix is calculated. The vector which has maximum number of one's is found. The vector with maximum number of one's which occurs first is considered as C_2 .

Step 7 When the same threshold value occurs twice. The value is considered as the fixed point. The iteration gets terminated.

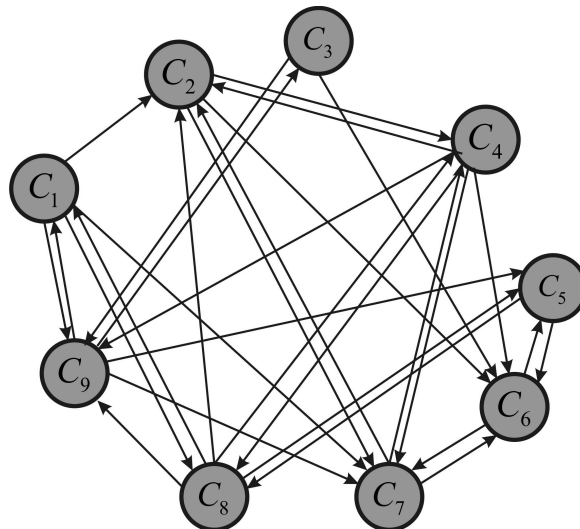
Adaptation of Induced FCMS to the Problems Faced by the Transgender in India:

Now we illustrate the dynamical system by a very simple model from the problem of Transgenders. At the first stage we have taken the following nine arbitrary attributes (S_1, S_2, \dots, S_9) . It is not a hard and fast rule we need to consider only these nine attributes but one can increase or decrease the number of attributes according to needs. The following attributes are taken as the main nodes for study.

An expert system spells out the nine major concepts relating to Transgenders as:

- S_1 Discrimination
- S_2 Lackofeducationfacilities
- S_3 Unemployment
- S_4 Lackofshelter
- S_5 LackofmedicalfacilitieslikeHIVcareandhygiene
- S_6 Depression
- S_7 Hormonepillabuse
- S_8 Tobaccoandalcoholabuse
- S_9 Noproperty

Directed Graph



Implementation of IFCMs Model to the Study

Based on the expert’s opinion, the directed diagram is drawn and the corresponding connection matrix M is given as

$$\begin{matrix}
 & C_1 & C_2 & C_3 & C_4 & C_5 & C_6 & C_7 & C_8 & C_9 \\
 M = \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ C_7 \\ C_8 \\ C_9 \end{matrix} & \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 \end{pmatrix}
 \end{matrix}$$

Now using the matrix M we determined the problems. Let us start Illiteracy is taken as the ON state and all the other nodes are in the OFF state. Let $C_1 = (1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$. Product of C_1 and M is calculated.

$$\begin{aligned}
 S_1 M &= (0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0) = C'_1 \\
 C'_1 \times M &= (0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0) \\
 &= (0\ 0\ 0\ 1\ 0\ 1\ 1\ 0\ 0).
 \end{aligned}$$

Threshold value is calculated by assigning 1 for the values > 1 and 0 for the values < 0 . The symbol \leftrightarrow represents the threshold value for the product of the result.

Now as per Induced Fuzzy Cognitive Map methodology, each component in the S'_1 vector is taken separately and product of the given matrix is calculated. The vector which has the maximum number of one’s which occurs first is considered as C_2 . The symbol \square denotes the calculation performed with the respective vector, here C'_1 .

Now

$$\begin{aligned}
 C'_1 \times M &= (0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0) \times M = (0\ 1\ 0\ 1\ 0\ 1\ 0\ 0\ 0) \\
 C'_1 \times M &= (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1) \times M = (1\ 1\ 0\ 1\ 1\ 0\ 0\ 0\ 1) = C_2 \\
 C_2 M &= (1\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1) \times M = (3\ 2\ 1\ 2\ 1\ 3\ 4\ 3\ 2) \\
 &\quad \square(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) = C'_2
 \end{aligned}$$

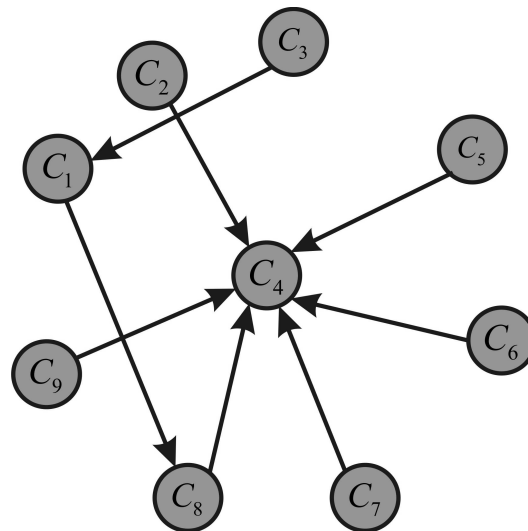
$$\begin{aligned}
C'_2 \times M &\approx (100000000) \times M = (010000111) \\
C'_2 \times M &= (010000000) \times M = (000101100) \\
C'_2 \times M &= (100000000) \times M = (000001001) \\
C'_2 \times M &= (000100000) \times M = (110001111) = C_3 \\
C'_2 \times M &= (000010000) \times M = (100001010) \\
C'_2 \times M &= (000001000) \times M = (000010100) \\
C'_2 \times M &= (000000100) \times M = (010101000) \\
C'_2 \times M &= (000000010) \times M = (110110001) \\
C'_2 \times M &= (000000001) \times M = (101010100) \\
C'_3 \times M &\approx (010000111) \times M = (010001111) \\
C_3 \times M &= (110110001) \times M = (231332412) \\
&\quad \square(111111111) = C'_3 \\
C'_3 \times M &= (010000000) \times M = (000101100) \\
C'_3 \times M &= (100000000) \times M = (000001001) \\
C'_3 \times M &= (000100000) \times M = (110001111) = C_4 \\
C'_3 \times M &= (000010000) \times M = (100001010) \\
C'_3 \times M &= (000001000) \times M = (000010100) \\
C'_3 \times M &= (000000100) \times M = (010101000) \\
C'_3 \times M &= (000000010) \times M = (110110001) \\
C'_3 \times M &= (000000001) \times M = (101010100) \\
C_3 \times M &= (110110001) \times M = (231332412) \\
&\quad \square(111111111) = C'_4 \\
C'_3 \times M &= (110001111) = C_4
\end{aligned}$$

Therefore $C_3 = C_4$. (110001111) is the fixed point which is the triggering pattern is when the first attributes kept in on state vector. Similarly, the following table is the Triggering patterns when other attributes kept ON state.

Induced Patterns for M by IFCM

| No. | Attr ON State | Triggering Pattern |
|--------|-------------------------------------|---|
| Step 1 | $C_1 : (1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$ | $C_1 \rightarrow C_8 \rightarrow c_4 \rightarrow C_4$ |
| Step 2 | $C_2 : (0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$ | $C_2 \rightarrow c_4 \rightarrow C_4$ |
| Step 3 | $C_3 : (0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$ | $C_3 \rightarrow C_1 \rightarrow c_4 \rightarrow C_4$ |
| Step 4 | $C_4 : (0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0)$ | $C_4 \rightarrow c_4 \rightarrow C_4$ |
| Step 5 | $C_5 : (0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0)$ | $C_5 \rightarrow c_4 \rightarrow C_4$ |
| Step 6 | $C_6 : (0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0)$ | $C_6 \rightarrow c_4 \rightarrow C_4$ |
| Step 7 | $C_7 : (0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)$ | $C_7 \rightarrow c_4 \rightarrow C_4$ |
| Step 8 | $C_8 : (0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0)$ | $C_8 \rightarrow c_4 \rightarrow C_4$ |
| Step 9 | $C_9 : (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)$ | $C_9 \rightarrow c_4 \rightarrow C_4$ |

Induced Path on a Merged Graph



Calculations:

The inter relationship between the attributes reveals that C4 Lack of shelter is the terminal node. Therefore, the limit point corresponding $C_4 : (1\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1)$ highlights the attributes and $(C_1, C_2, C_6, C_7, C_8, C_9)$ which seem to be major problems of Transgender. The fixed point $C_3 = C_4 : (1\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1)$. When the same threshold value occurs twice, the value is considered as the fixed point. The iteration gets terminated and the calculation gets terminated.

If discrimination C_1 is ON state, C_1 Discrimination, C_2 Lack of education facilities,

C_6 Depression, C_7 Hormone pill abuse, C_8 Tobacco and alcohol abuse, C_9 - no property are also ON state. This clearly shows that $C_1, C_2, C_6, C_7, C_8, C_9$ are the main causes of the problems.

4. Conclusion

$C_1, C_2, C_6, C_7, C_8, C_9$ are the main causes of the problems of Transgender. Based on the above calculation If discrimination C_1 is ON state, C_1 Discrimination, C_2 -Lack of education facilities, C_6 Depression, C_7 Hormone pill abuse, C_8 - Tobacco and alcohol abuse, C_9 - no property are also ON state. This clearly shows that $C_1, C_2, C_6, C_7, C_8, C_9$ are the main causes of the problems. The Transgender are thus abandoned by their parents at a very early age and so finding no other way they come in contact with bad companionship. They stay away from their family are forced to cut all these from relatives. They are often abused by the society and starve from Depression. From the many causes of the sufferings of a transgender Discrimination is one of the causes which also lead to the lack of education. Transgender should be considered as *god gift* due to their unique characteristic but in today's society, they are being shamelessly cheated upon and are sexually harassed. Due to their exploitation, they get affected by SID's like HIV/AIDS. Since the public is unaware of the Transgender plight, they are mistreated and it only adds up to their suffering. Thus it is essential to eradicate public irresponsibility and also improve to cure the hormonal defects. Since, the transgenders are stay away from their homes, they have no one by their side and this makes them even more guilty and lonely and might even lead to many mental problems. They don't have their own parents to support them or encourage them. Being transgender is not a choice but it happens as a result of hormonal problems. So it's really stupid on the part of humans to discriminate them. Transgender should be treated equally likely how the other sexes are treated, because even they are humans. Another main cause of the discrimination in lack of property. Since, these transgender are sent away from home, they have nobody who can fund them for their education. This results in poverty as even nobody is ready to fund them with any job opportunities. This leads to lack of property.

Solutions

- Equal rights should be given to these people just like how other men and women are treated.
- They should be given the right to education.
- Severe punishment should be imposed on people ill-treating or discriminating them.
- Instead of seducing them as inferior people, they should be treated as one among us.

- They should be encouraged in other fields like sports, research, etc.,
- They should not send out of the home, they should be brought up with the same love and affection that a normal child receives.
- Transgender should be treated as another sex and that should be present in all forms that ask for sex.
- Transgender should have the right to marry if they require partner.
- Adoption should also be considered for such parents.
- People should be educated about these people and learn to treat them as equals.

Parents, colleagues, friends and society should give equal rights in all activities. They should not repeat. For, this government should take actions such as counseling, job, Co education, etc., Peoples are also should give the proper respect to them. Government can give poverty reduction through economic growth. And there is no domination between male, female and multi transgender. Their suggestions should be taken in public and anywhere. Their names should be added in ration card, election card, etc.

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Synthesis and Characterisation of Iron Oxide Nano Particles on Biopolymer Polysaccharide Templates

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Abstract

Nano-sized iron oxide powder particle with uniform particle size by template free method and with biopolymer template method were synthesized and subjected to various studies. The X-ray diffraction and infra-red spectra of prepared Iron oxide were analysed and compared with reported data. The distinct peaks visible at low diffraction angles are similar to the traces reported earlier confirms its presence of iron oxide Nano crystallites in the prepared samples. We have further studied the formation of iron oxide in the presence of polysaccharide templates like starch, glucose, sucrose and subsequently analysed the result.

Keywords: Iron Oxide, Nanoparticles, Formation, Polysaccharide templates, XR, D, IR

1. Introduction

The nano materials exhibit very interesting electrical, optical, magnetic and chemical properties, which could not be achieved by their bulk counterparts [1]. Nanomaterials may also be used in various technological applications viz. refrigeration systems, medical imaging, drug targeting and other biological applications, and catalysis [2]. The synthesis of nanoparticles of magnetic metal and metal oxides have been reported in recent times by using different chemical methods viz. sonochemical, solvothermal, micro emulsion etc[3]. The biopolymer organic compounds arrange themselves in semi-crystalline granules, can able to swell and burst on interaction with water and acids, are composed of mono, di and polysaccharide carbohydrates that occurs naturally. They are used as templates to synthesize iron oxide. Biopolymer molecules, in the past, templates like aluminium oxide, carbon nanotubes, surfactants, polymer fibres and egg shell membranes have been employed. In this work, we have reported the preparation of nanoparticles of iron oxides in the presence of polysaccharides templates [4]. In the presence of template (starch, glucose, and sucrose) the spatial separation of the particles, coupled with the careful removal of the template through selective conditions, enable the synthesis of highly crystalline, monodispersed particles of < 100 nm [5].

2. Experimental

2.1. Synthesis of Iron Oxide

Magnetic nanoparticles were synthesized according to the following procedures. 4.95 g of $FeCl_2 \cdot 4H_2O$ (5mmole in 5 ml of deionized water and 8.15 g of $FeCl_2 \cdot 6H_2O$ (6 mmole) in 5 ml of deionized water were mixed at room temperature. The above mixture was dropped in to 200 ml aqueous ammonia solution (0.6M) in 20 min with vigorous stirring. The pH values of reaction mixture were kept in the range 9-13 with the addition of concentrate ammonium hydroxide solution . The resulting nanoparticles were separated by centrifugation at 2800 rpm for 10 minute. The product was washed with distilled water three times and further washed with tetrahydrofurane (THF) three times and dried in air.

2.2. Synthesis of Iron Oxide with Polysaccharide Templates

To prepare iron oxide with starch / glucose / sucrose templates, 2.5 g of starch / glucose / sucrose was dissolved in 100 ml of water. $FeSO_4 \cdot 7H_2O$ was added to know volume of the template solutions such that the polysaccharide Fe ratio as 1:4. The resultant solution was stirred for 30 min. The template-iron mixed solution was treated at 800°C (heating rate of 5° C / min) and maintained at that temperature for 120 minutes after which it was cooled to room temperature at a rate of 10°C/min.

3. Results and Discussion

3.1. FT-IR Analysis

The iron oxide without and with polysaccharide templates like starch, glucose and sucrose were subjected to FT-IR analysis (Fig.1). The characteristic peak of Fe-O group of iron oxide without template located at 560 cm^{-1} matches with the reported result. In case of iron oxide with glucose templates the characteristic peak reduced to 542.23 cm^{-1} with sucrose templates the characteristic peak reduced 545.79 cm^{-1} with starch templates the characteristic peak reduced to 551.78 cm^{-1} .

The NH_2 stretching vibration at band seen at 3423 cm^{-1} for the template free method shifts to 3430.45 cm^{-1} for the glucose template, 3427.44 cm^{-1} for sucrose template and 3415.04 cm^{-1} in the case of starch template.

The wave numbers of characteristic peak for $Fe-O$ group reduced and NH_2 group increased on synthesizing the iron oxide on polysaccharide templates shows the better co-ordination of iron oxide with Glucose and Sucrose than Starch.

3.2. XRD Analysis

The iron oxide without and with polysaccharide templates like glucose, starch and sucrose were subjected to XRD analysis and its patterns were compared. [Fig. 2] The peak at angles 30.25 degree, 35.60 degree, 43.23 degree, 57.25 degree and 62.71 degree in the pure iron oxide without template is shifted to 33.47 degree, 35.94 degree and a many minor peaks around 24.47 degree, 41.16 degree, 49.74 degree and 54.36 degree for iron oxide with glucose template, for iron oxide with sucrose template is shifted to 27.28 degree, 29.74 degree and a many minor peaks around 34.97 degree, 43.56, 48.17, 56.52, 58.09 and 66.01 degree and shift of peaks to 33.48 degree, 35.95 degree and a many minor peaks around 24.49, 41.17, 49.76 and 54.36 degree correspondingly with decrease in breadth and with improving an intensity for iron oxide with templates. The size of the iron oxide particles without templates shows 12 to 18 nm. When iron oxide particles synthesis with polysaccharide starch to glucose templates we got the particle size as 31.8 to 43.4 nm. On synthesizing iron oxide with different polysaccharide template crystalline nature of iron oxide is improved.

3.3. UV-Visible and Micro structural analysis

The Iron oxide particles without templates and with polysaccharide templates were characterised with respect size and morphology. SEM images of the Iron oxide particles [Fig. 3] show the size varies between 50-200 nm for the iron oxide particles with templates and for template free method it shows 12 to 18 nm.

The iron oxide without and with polysaccharide templates like glucose, starch and sucrose were subjected to UV-visible analysis in the spectral region of (350-800 nm). Analysis of the absorption coefficient has been carried out and the nature of transitions and the optical band gap E_g are determined. The Fig . 4 indicates the existence of direct allowed transitions.

Extrapolation of linear dependence of both the relations to abscissa yields the corresponding bandwidth (Eg). The value of the optical energy gap obtained for iron oxide Sucrose (0.546 eV); starch (1.1068 eV); glucose (2.698 eV) templates. The same order is observed in particle size for sucrose(89.5396 nm); Starch (67.7165 nm); Glucose (43.3938 nm).

4. Summary and Conclusions

The iron oxide without and with polysaccharide templates starch, glucose and sucrose were synthesized. FTIR Spectra of the iron oxide without and with polysaccharide templates. Clearly shows the coordination of template for the formation of nano iron oxide. XRD studies shows the size of the iron oxide particles without templates as 12 to 18 nm. Iron oxide particles synthesis with polysaccharides templates showed an improved particle size around 50 nm. SEM images of the Iron oxide particles

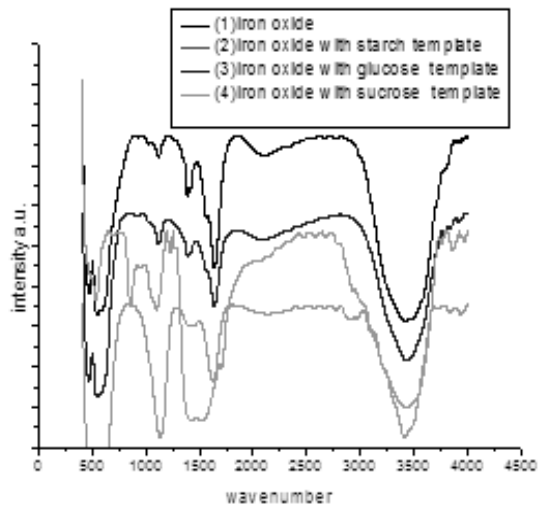


Figure 1: FT-IR Analysis

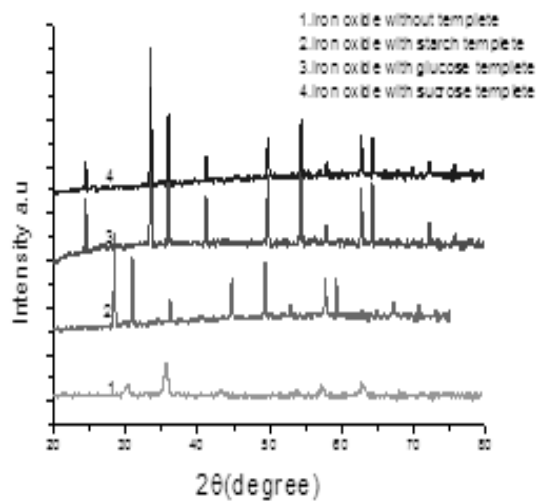


Figure 2: XRD Analysis

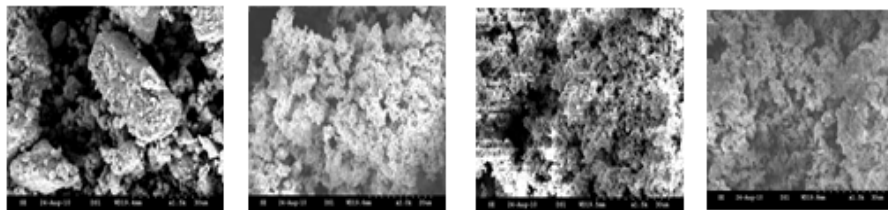


Figure 3: SEM of a) Iron oxide, b) Iron oxide with Starch template, c) Iron oxide with Glucose template and d) Iron oxide with Sucrose template

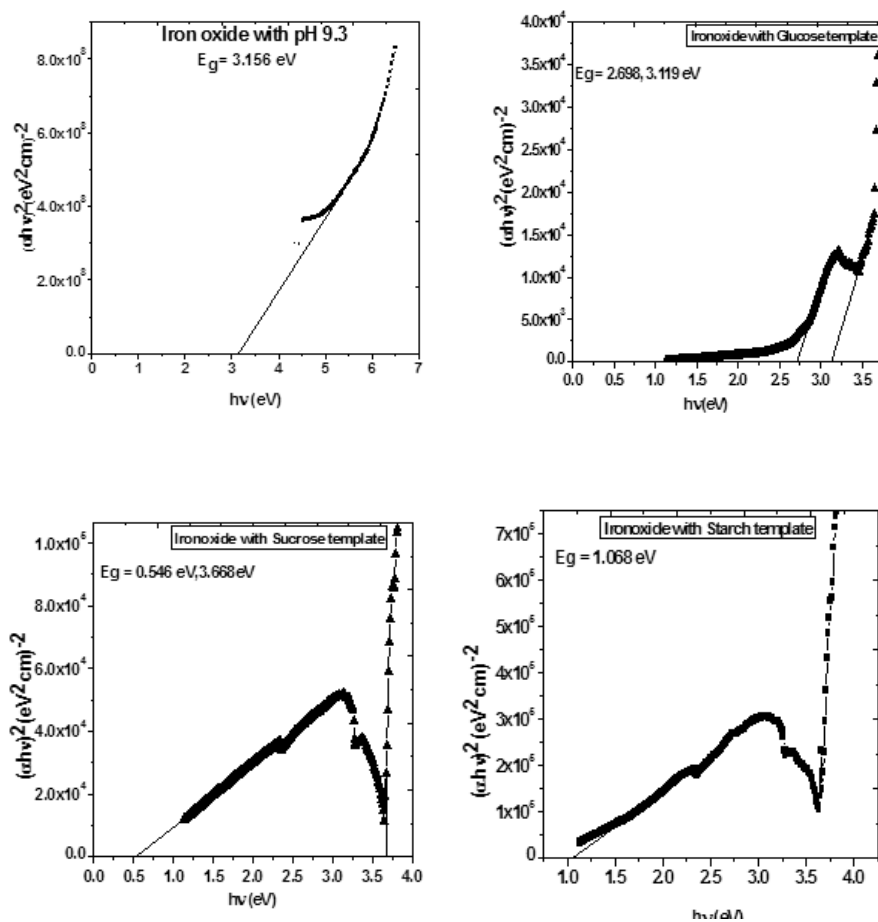


Figure 4: Optical band of a) Iron oxide with Starch template, b) Iron oxide with Glucose template and c) Iron oxide with Sucrose template

with and without templates shows the synthesized particles were in the nano size and their morphology resembles with the cauliflower nanostructure. The UV - Visible analysis, shows the existence of direct allowed transitions and the band gap values lie in the semiconductor range. Results of different studies indicate the possibility of controlled size iron oxide particles in the presence of polysaccharide templates and it may be used for dilute magnetic semiconductors.

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Optical and Structural Characteristics of Hematite Nanoparticles Prepared by Thermal Decomposition Process via Polysaccharide Template

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Abstract

Hematite ($\alpha - Fe_2O_3$) nanoparticles with Xanthan template were successfully synthesized via simple thermal decomposition method. The samples were characterized with several analytical techniques including X-ray diffraction (*XRD*), high resolution scanning electron microscopy (HRSEM), Fourier-transform infrared (FT-IR) spectroscopy and Ultraviolet-Visible (*UV-Visible*) absorption spectroscopy. *XRD* measurements confirmed the formation of pure phase $\alpha - Fe_2O_3$ nanoparticles and the presence γ -phase of Fe_2O_3 was confirmed by FTIR spectroscopy. The particle size was calculated by HRSEM measurements and it turns out to be 30nm for XF respectively. The band gap values were higher than that of bulk iron oxide Fe_2O_3 (2.1eV) due to the quantum confinement of Fe_2O_3 nanoparticles.

Keywords: Hematite; Polysaccharide; Thermal decomposition; *XRD*, *UV-Vis*.

1. Introduction

Hematite ($\alpha - Fe_2O_3$), the most stable iron oxide with *n*-type semiconducting properties ($E_g = 2.1eV$) under ambient conditions, is a very important multifunctional material because of its peculiar and fascinating electrical, optical and magnetic properties, low processing cost, high resistance to corrosion and wide variety of potential uses in diverse fields such as catalysis, gas sensors, magnetic devices, pigments and lithium ion battery [1 – 3]. Stimulated by both the promising applications of $\alpha - Fe_2O_3$ and the novel chemical and physical properties of nanoscale materials, considerable efforts have been devoted to the development of $\alpha - Fe_2O_3$ nanoparticles

with different shapes and sizes. Up to now, various physical and chemical processes, such as pulsed laser ablation, chemical vapour deposition and the solution phase process have been employed to prepare $\alpha - Fe_2O_3$ nanostructured materials in various geometrical morphologies. In addition, magnetic properties of pseudocubic and trapezoidal particles, nanorods, micropines, nanocrystals and cantaloupe-like microparticles of $\alpha - Fe_2O_3$ have been investigated. It is found that magnetic properties of $\alpha - Fe_2O_3$ nanomaterials depend strongly on their size and shape.

Polysaccharides are macromolecules carrying a relatively large number of functional groups that are either charged or under suitable conditions, can be charged. The molecules may constitute either polycations or polyanions since the net charge of these macromolecules depends on the functional groups, which may be either positively or negatively charged, or both. Templating is one of the most frequently used methods of synthesizing materials with structural units ranging from nanometers to micrometers. Aqueous gel-like lyotropic liquid crystal with extensive hydrogen bonding and nanoscale hydrophilic compartments can be employed for direct templating of nanoscale features. The use of biological materials as templates is gaining momentum and biotemplating takes advantage of the structural stability and specificity of biological systems to create novel materials. Xanthan gum (XG) is an anionic polysaccharide produced by the microorganism *Xanthomonas campestris*, whose primary structure consists of a pentasaccharide repeating units with a (1 \rightarrow 4)- β -D-mannopyranosyl-(1 \rightarrow 4)-O- β -D-glucopyranosyluronic acid-(1 \rightarrow 2)-6-O-acetyl- α -D-mannopyranosyl side chains 3-linked to alternate glucose residues. The most important properties of XG are high low-shear viscosity and strong shear-thinning character [4]. The relatively low viscosity at high shear rate makes it easy to mix, pour, and swallow; its high viscosity at low shear rate gives it good suspension properties and lends stability to colloidal suspensions. XG is stable over a broad range of pH values and in foods containing salt or alcohol or with high enzymatic activity.

In this communication, we report a simple thermal decomposition route to synthesize $\alpha - Fe_2O_3$ nanoparticles using only ferrous sulfate hydrate ($FeSO_4 \cdot 7H_2O$) as raw material. The iron oxide bound xanthan template can be used directly by removal of unbound ions, owing to their remarkable stability, biocompatibility and biodegradability. The iron oxide nanoparticles thus synthesized have been characterized for the structural and optical studies.

2. Materials and Methods

2.1. Materials

All chemical reagents were analytical grade and used without further purification. Ferrous sulfate ($FeSO_4 \cdot 7H_2O$), Xanthan gum, deionized water, and ethanol were purchased from M/s Fishur Scientific, India. High alumina crucibles were engaged for

the calcination reactions.

2.2. Preparation of Xanthan – Fe_2O_3 (XF)

A quantity of 2.5 g of polysaccharide (Xanthan) was added to 100 ml distilled water, then the mixture was heated at 90° C for about 10 min with constant stirring for dissolution of the polysaccharide. $FeSO_4 \cdot 7H_2O$ (10g) were added to the solution, the resultant solution was stirred for 30 min. The template-iron mixed solution was treated at 800° C (heating rate of 5 ° C / min) and maintained at that temperature for 120 min, after which it was cooled down to room temperature at a rate of 10° C / min. The so obtained powder was collected, washed four times in deionized water and ethanol, and dried at 80° C for 5 h. Thus obtained sample was characterized.

2.3. Physical Characterization

The X-ray diffractometer (Bruker Model: D8 Advance) employing $CuK\alpha(\lambda = 1.5406 \text{ \AA}, 2\theta = 10 - 80^\circ)$ radiation was used to characterize the crystal structure of the sample. IR spectra were recorded with an FTIR spectrometer (Perkin Elmer IR Spectrometer) in the range of 400-4000 cm^{-1} on pressed disks using KBr as binding material. The surface morphology of the sample was studied by high resolution scanning electron microscopy (HRSEM) (F E I Quanta FEG 200). The UV visible spectra of the sample were taken in wavelength range from 200 to 1100 nm using Lambda 35, Perkin Elmer spectrophotometer.

3. Results and Discussion

3.1. Structure and Morphology Analysis of the Sample

The structure of the sample is determined by X-ray powder diffraction (XRPD) measurements. The recorded and indexed diffraction pattern is depicted in Fig. 1 where sharp peaks can be observed, as expected for a highly crystalline sample. The positions of all the maxima coincide with the peaks characteristic of the hematite phase (JCPDS card 33-0664). No diffraction line corresponding to other phases has been observed, indicating a high purity of the sample [5]. The mean crystallite diameter D was estimated using Scherrer's equation and the (1 0 4) reflection:

$$D \approx 0.9 \lambda / \beta \cos \theta$$

where λ is the wave length of the incident X-ray, θ is the diffraction angle and β is the full-width at half maximum. We obtained the value of $D \approx 16.5$ nm. The surface morphologies of the prepared XF were studied using high resolution scanning electron microscope, as shown in Fig. 2. It is evident from the HRSEM image that the particles are dumbbell nature and the average size of hematite nanoparticles are about 30 nm,

respectively.

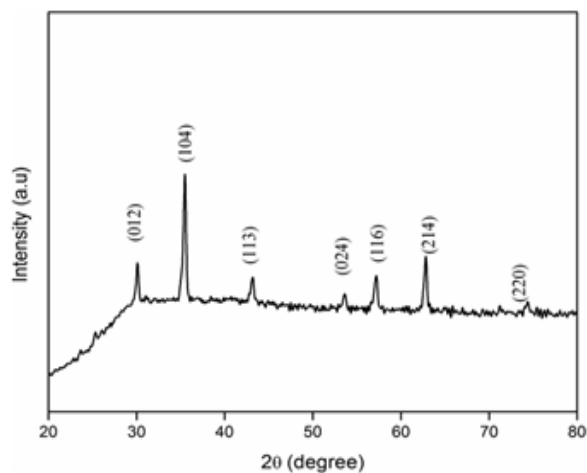


Fig.1. XRD Pattern of XF

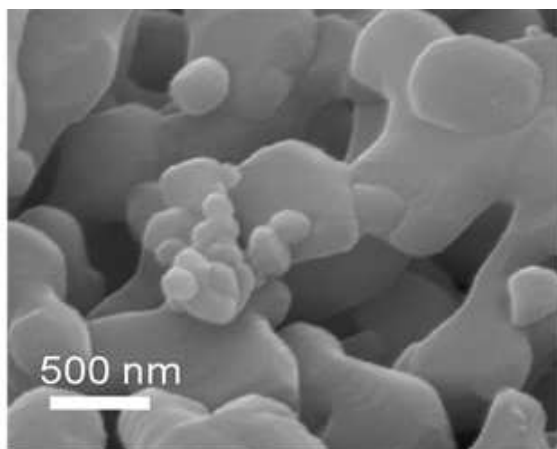


Fig.2. HRSEM image of the XF

3.2. FTIR Analysis

The FTIR spectrum of XF is shown in Fig.3. FTIR spectrum not only provides an exact chemical structure of a compound, but also provides information about its functionality based on band location and intensity. The characteristic absorption peaks of Xanthan appearing at 2918 cm^{-1} and 1055 cm^{-1} were assigned to $-CH_2$ and acetal groups, respectively [6]. The vibration peaks of OH appeared at 3524 cm^{-1} in Xanthan, respectively. Moreover, the peak at 1623 cm^{-1} could be assigned to $-C = O$ of

pyruvate acid [7]. In the FTIR spectrum of XF, the bands around 3700 and 1635 cm^{-1} are assigned to the stretching vibration of OH groups and bending vibration of water molecules, respectively. The absorptions at 560 cm^{-1} are the characteristic stretching vibrations of $Fe - O$ bond in hematite particles. It can be seen that the peak of carboxylate group and hydroxyl group was apparently reduced or in fact disappeared in XF.

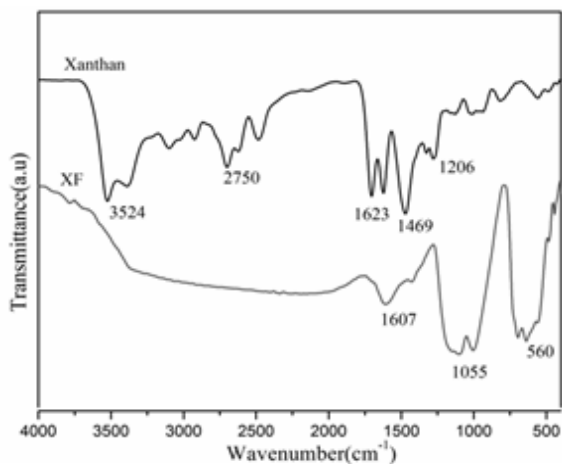


Fig.3. FTIR spectra of XF

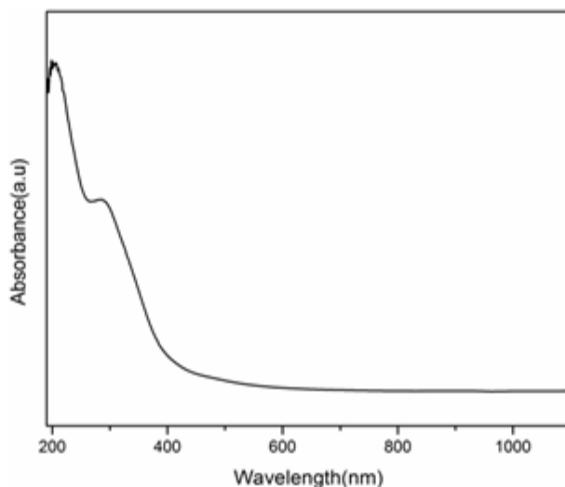


Fig.4. UV-vis absorption spectra of XF

3.3. UV-Vis absorption Analysis

Nanostructured materials usually exhibit blue-shift phenomena in optical properties compared with the bulk counterparts. To reveal the electronic structure and size effect, UV-vis absorption measurement of the as-prepared XF nanoparticles were carried out. According to the literature [8, 9], two absorption regions are expected between 200 nm and 600 nm. The absorptions were observed at 200-300 nm centered at 270 nm (region 1) and at 400-600 nm with maximum about 540 nm (region 2) in Fig. 3. The first region mainly results from the ligand to metal charge transfer transitions and partly contributed from the Fe^{3+} ligand field transitions ${}^6A_1 \rightarrow {}^4T_1({}^4P)$. In the second region the absorption peaks are mainly due to the ${}^6A_1 + {}^6A_1 \rightarrow {}^4T_1({}^4G) + {}^4T_1({}^4G)$ excitation of an $Fe^{3+} - Fe^{3+}$ pair, possibly overlapped with the contributions of ${}^6A_1 \rightarrow {}^4E, {}^4A_1({}^4G)$ ligand field transition and the charge-transfer band tail. The direct band gap energy (E_g) of Fe_2O_3 nanoparticles was estimated using Tauc equation [10]

$$(\alpha h\nu)^n = B(h\nu E_g)$$

where α is the absorption coefficient, $h\nu$ is the photo energy, and B is the material-dependent constant. Fig.5 shows the plots of $(\alpha h\nu)^2$ vs $h\nu$ as linear functions for XF. This linearity indicates the existence of direct allowed transitions. The obtained E_g values were 2.52 eV for XF nanoparticles. The band gap values were higher than that of bulk iron oxide Fe_2O_3 (2.1 eV) due to the quantum confinement of Fe_2O_3 nanoparticles.

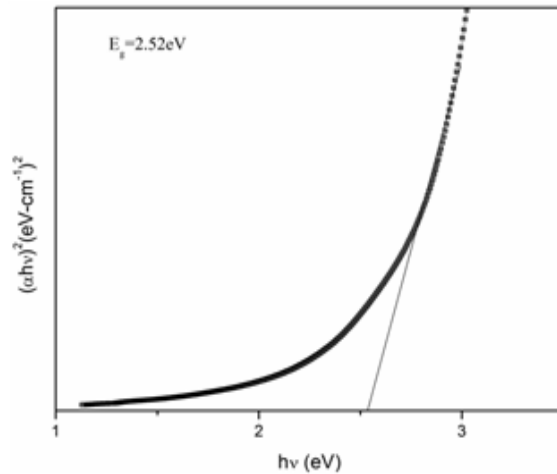


Fig.4. Plot of $(\alpha h\nu)^2$ versus $h\nu$ for XF

4. Conclusion

The Hematite nanoparticles were synthesized on to novel biopolymer template using the simple thermal decomposition method. The XRD measurements revealed a pure phase $\alpha - Fe_2O_3$. HRSEM confirmed dumbbell nature of the hematite nanoparticles obtained at 800° C and the particle size was found to be 30nm for XF. As evidenced from FTIR, good interaction between hematite and polysaccharide functional groups controls the hematite crystal growth. From the optical absorption spectrum, it is seen that the blue shift of 540 nm with respect to the bulk counterpart is contributed by the quantum confinement effect. The value of the bandgap is found to be 2.52 eV. This convenient and low-cost method provides a rational synthetic alternative for the preparation of hematite nanoparticles, which may be applied to many interesting and potential applications for polysaccharide- Fe_2O_3 nanoparticles and to be further explored.

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Convective Heat Transfer Characteristics of Water Based Fe_3O_4 Nanofluids Flows Through Circular Tube Heat Exchanger

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Abstract

Homogeneous and stable magnetic nanofluids containing Fe_3O_4 nanoparticles were prepared using a two-step method, and their thermal transport properties were investigated using counter flow heat exchanger experimental setup. Thermal conductivities of the nanofluids were measured to be higher than that of base fluid, and the enhanced values increase with the volume fraction of the nanoparticles. The Fe_3O_4 nano particle with a nominal diameter of 50nm are functionalized and then dispersed in distilled water to form stable suspension. The convective heat transfer coefficients tested in a laminar flow circular tube heat exchanger showed that the coefficients increased with the augment of volume fraction.

Keywords: Fe_3O_4 nanoparticle, Magnetic nanofluid, Thermal conductivity, Viscosity, Heat transfer coefficient.

1. Introduction

Nano fluids are engineered colloids made of a base fluid and nanoparticles (1-100 nm). Common base fluids include water, organic liquids (e.g. ethylene, tri-ethylene-glycols, refrigerants, etc.), oils and lubricants, bio-fluids, polymeric solutions and other common liquids. Materials commonly used as nanoparticles include chemically stable metals (e.g. gold, copper), metal oxides (e.g., alumina, silica, zirconium, titania), oxide ceramics (e.g. Al_2O_3 , CuO), metal carbides (e.g. SiC), metal nitrides (e.g. AlN, SiN), carbon in various forms (e.g., diamond, graphite, carbon nanotubes, fullerene) and functionalized nanoparticles. Solids have thermal conductivities which are orders

of magnitude larger than those of conventional heat transfer fluids. By suspending nanoparticles in conventional heat transfer fluids, the heat transfer performance of the fluids can be significantly improved.

As a fluid class, nanofluids have a unique feature which is quite different from those of conventional solid-liquid mixtures in which millimeter and/or micro meter-sized particles are added. Such particles settle rapidly, clog flow channels, erode pipelines and cause severe pressure drops. All these shortcomings prohibit the application of conventional solid-liquid mixtures to micro channels while nanofluids instead can be used in micro-scale heat transfer. Furthermore, compared to nucleate pool boiling enhancement by addition of surfactants, Nanofluids can enhance the critical heat flux (CHF) while surfactants normally do not. Nanofluids, which contain nanoparticles dispersed in base fluids, have been proposed as a new kind of heat transfer media because they can improve the heat transport and energy efficiency and may have potential applications in the field of heat transfer enhancement.

The thermal conductivity of the nanofluids can be enhanced obviously when nanoparticles, such as CNTs, *Fe*, *Cu* and *Al₂O₃*, are dispersed into the base fluids. Viscosity of the fluids also increases with the augment of the nanoparticles concentrations when nanoparticles are dispersed into the base fluids as well. At the same time, temperature and nanoparticles size may have effects on the viscosity of the nanofluids. Nanofluids can improve the convective heat transfer coefficient considerably comparing to the conventional heat transfer fluids and can be used in thermal devices or systems such as heat exchangers or cooling system to enhance heat transfer. Magnetic fluids, suspension containing magnetic nanoparticles, show both magnetic and fluid properties and have important applications in industrial and biomaterial fields. However, seldom experiments and applications on the heat transfer of magnetic fluids have been reported.

The conductivity of magnetic nanofluids could be improved through controlling the alignment of nanoparticles by the external magnetic field. With the development of the industry and the technology, the performance elevation of the traditional heat transfer medium using mixture of water and ethylene glycol (EG) is necessary. Kulkarni et al (2007) investigated the thermal properties of aluminium oxide nanofluids based on the mixture of EG and water and that found that the heat transfer was enhanced efficiently. Thus, nanofluids appear promising as coolants for dissipating very high heat fluxes in various applications.

According to the application, nanofluids are classified as heat transfer nanofluids, tribological nanofluids, surfactant and coating nanofluids, chemical nanofluids, process/extraction nanofluids, environmental (pollution cleaning)nanofluids, bio- and pharmaceutical nanofluids and medical nanofluids (drug delivery, functional and tissue-cell interaction). Heat transfer nanofluids were first reported by the Argonne National Laboratory, USA in 1995. Since then, a number of studies have been conducted on the thermal properties (mainly thermal conductivity) and single phase and boiling heat

transfer performance (mainly single phase heat transfer). It has been demonstrated that nanofluids can have significantly better heat transfer characteristics than the base fluids. Several good comprehensive reviews have summarized the available studies on heat transfer of nanofluids. Guo et al.(2004) obtained 60% convective heat transfer coefficient enhancement compared to (60/40) ethylene glycol/water base fluid with 2 vol.% γ - Fe_2O_3 nanofluid under laminar flow conditions in a circular tube. Sundar et al. (2012) presented an experiment in plain circular tube inturbulent flow of Fe_3O_4 /water nanofluid at the concentrations of 0-0.6 vol.% and concluded the enhancement of 30.96% and 10.01% in convective heattransfer coefficient and friction factor compared with water, respectively at Reynolds number of 22,000. Sarkar et al. (2011)

The overall heat transfer coefficient of Fe_2O_3 /water nanofluid in an air-cooled heat exchanger has not been reported experimentally yet. In this work, an experimental study has been performed to evaluate effective parameters on the overall heat transfer coefficient of stabilized iron oxide/water nanofluid (Fe_2O_3 /water) in the laminar flow regime with using a compact air-cooled heat exchanger in different concentrations of the nanofluid, several operating temperatures, various nanofluid flow levels and different air flow rates. Choi et al.(1995) compared with millimetre or micrometre sized particle suspensions that nanofluids have shown a number of potential advantages, such as better long-term stability, little penalty in pressure drop, and can have significantly greater thermal conductivity.

As a result, many researchers have investigated the heat transfer performance and flow characteristics of various nanofluids with different nanoparticles and base fluid materials. Several following existing published articles which associate with the use of nanofluids are described in the following sections. Zhu et al.(2010) measured the thermal conductivity of Fe_3O_4 /water nanofluids. They found that the ratios of the thermal conductivity enhanced by more than 15.0% even at the volume fraction of 0.005.

2. Experimental

2.1. Preparation of Fe_3O_4 Nanoparticles

The process for preparing Fe_3O_4 nanoparticles by controlled chemical co-precipitation is systematically explained. In the iron process 7.8 g $FeSO_4 \cdot 7H_2O$, 5.41 g $FeCl_3 \cdot 6H_2O$ was dissolved in 100 mL distilled water. Aqueous ammonium hydroxide solution (1.5mol/L) was also obtained in the same manner. Then, a surfactant (sodium oleate) was added to the former solutions to obtain Precursor solution I and later to obtain Precursor solution II. Secondly, Precursor solution I was added into Precursor solution II drop wise under strong stirring with the protection of dry nitrogen at the desired temperature. Just after mixing the solutions, the colour of the solution changes from light brown to black, indicating the formation of Fe_3O_4 nanoparticles, which was lowed to crystallize completely for another 60 min under rapid stirring.

The precipitated Fe_3O_4 nanoparticles were washed by repeated cycles of centrifugation and redispersion in distilled water. Washing was performed for five times in distilled water. During the third process the precipitate Fe_3O_4 nanoparticles were redispersed in the same surfactant solution under the conditions of ultrasonic agitation for 30 min and strong stirring for another 40 min. The products (Fe_3O_4 nanoparticles) were also washed by repeated cycles of centrifugation and redispersion in distilled water. Washing was performed for four times in distilled water, then the final product was dried in a vacuum oven at room temperature for 24 h, and the Fe_3O_4 nanoparticles were finally obtained.

2.2. Preparation of Fe_3O_4 Nanofluid

Two-step method was used to prepare nanofluids. Synthesized spherical-shaped Fe_3O_4 nanoparticles with diameter of 50 nm were selected as additives, and deionized water was selected as a base fluid. In a typical procedure, adequate surfactant (sodium oleate) was dissolved into the deionized water at first, and then the nanoparticles were gradually added into the base fluid with violent stirring. Afterward, the suspensions were stirred using disperse mill (7,200 r/min) for 40 min. Nanofluids with different volume fractions ($\varphi = \text{Volume of nanoparticles/Volume of base fluids}$) of 0.005, 0.01, 0.015, and 0.02 were obtained by intensive ultrasonication for 45 min.

2.3. Experimental Setup

The experimental apparatus mainly consists of a test section, one water heater tank, one nanofluid tank, and a collection tank with submersible pump of 10L/Hr. The test section is of 1m long counter flow horizontal double tube heat exchanger with nanofluid flowing inside the tube while hot water flows in annular. The inner tube is made from smooth copper tubing with a 7.35 mm outer diameter and 6.35 mm inner diameter, while the outer tube is made from GI tubing and has a 32.9 mm outer diameter and 31.75 mm inner diameter.

The test section is thermally isolated from its upstream and downstream sections by plastic tubes in order to reduce heat loss along the axial direction. The thermo couple are mounted at both ends of the test section to measure the temperature, respectively. The inlet and exit temperatures of hot water are measured using two thermocouples which are inserted directly into the flow. The tanks of 20 L and 15 L capacity are made from GI sheet to store the nanofluid and hot water leaving from the test section. The collection tank has a submersible water pump with 10L/Hr of discharge to the nanofluid receiver tank.

The hot water and nanofluids flow rate is evaluated by the time taken for a given volume of nanofluid to be discharged. During the test run, mass flow rates of the hot water and nanofluids, the inlet temperature is 27 °C and outlet temperatures is 52-60 °C of the hot water and nanofluids were recorded.

3. Results and Discussion

In recent years, extensive research has been conducted on manufacturing of materials whose grain sizes are measured in nanometres. These materials have been found to have unique optical, electrical, and chemical properties. Recognizing an opportunity to apply this emerging nanotechnology to established thermal energy engineering, it has been proposed that nanometer- sized particles could be suspended in industrial heat transfer fluids such as water, ethylene glycol, or oil to produce a new class of engineered fluids with high thermal conductivity.

Because the thermal conductivities of most solid materials are higher than those of liquids, thermal conductivities of particle-fluid mixtures are expected to increase. Fluids with higher thermal conductivities would have potentials for many thermal management applications. Because of the very small size of the suspended particles; nanoparticle-fluid mixtures could be suitable as heat transfer fluids in many existing heat transfer devices, including those miniature devices in which sizes of components and flow passages are small. Furthermore, because of their small sizes, nanoparticles also act as a lubricating medium when they are in contact with other solid surfaces.

| | | |
|--|--------|----------|
| Base Fluid (Hot) flow rate (kg/s) | | 0.11 |
| Base Fluid (Cold) flow rate (kg/s) | | 0.119 |
| Temperature of Base Fluid (Hot) °C | Inlet | 55 |
| | Outlet | 48 |
| Temperature of Base Fluid (Cold) °C | Inlet | 29 |
| | Outlet | 46 |
| Heat Transfer Coefficient h _{bb} W/m ² .K | | 23608.98 |

Table. 1 Heat Transfer Coefficient of Base fluid / Base fluid

To validate the accuracy and reliability of the experimental system for measuring the convective heat transfer coefficient and to provide a baseline for comparison the nanofluid data, first the tests are performed for distilled water. Experimental results for distilled water and various volume fractions of Fe_3O_4 nanofluids compared. Results obtained from the calculations are compared with the measured data to evaluate the validity of the effective thermal conductivity theories for liquids with nanometer size

inclusions. Other possible microscopic energy transport mechanisms in nanoparticle-fluid mixtures and the potential applications of these fluids are discussed.

The above table explains the amount of heat transferred by the base fluid in the absence of Fe_3O_4 nanoparticles. The next table (Table. 1.) shows a sudden decline of heat transfer coefficient at a volume fraction of 0.2 and then a gradual increase with increase of Fe_3O_4 content. The trend after 0.2 volume fraction is similar to any normal suspended particles that carry heat from one end to other in the steam lined flow. The Brownian motion of any normal suspended particles within the fluid results in collision and loss of energy during the laminar flow.

However, if the particle size is in nanometer dimension the possibility for the collision is minimum and additional energy transport can arise from the motions induced by stochastic (Brownian) and inter particle forces. The SEM image shows the particles size of the Fe_3O_4 is around 40-50nm. Motions of these particles cause micro convection that enhances heat transfer.

| Volume Fraction % | Base Fluid flow rate (kg/s) | Nanofluid flow rate (kg/s) | Temperature of Basefluid °C | | Temperature Nanofluid ° | | Heat Transfer Coefficient hb/nf W/m ² · K |
|----------------------|--------------------------------|-------------------------------|--------------------------------|--------|----------------------------|--------|--|
| | | | Inlet | Outlet | Inlet | Outlet | |
| 0.2 | 0.11 | 0.109 | 55 | 42 | 29 | 39 | 18233.22 |
| 0.4 | 0.11 | 0.106 | 55 | 38 | 29 | 40 | 27078.28 |
| 0.6 | 0.11 | 0.105 | 55 | 37 | 29 | 42 | 34013.05 |
| 0.8 | 0.11 | 0.105 | 55 | 36 | 29 | 43 | 39507.15 |
| 1.0 | 0.11 | 0.100 | 55 | 35 | 29 | 45 | 50706.40 |

Table. 2 Heat Transfer Coefficient of Base Fluid / Fe_3O_4 nanofluid

In all of the effective conductivity models, the particles are assumed to be stationary when there is no bulk motion of the fluids, which is true when the particle is large. In nanoparticle-fluid mixtures, microscopic forces can be significant. Forces acting on a nanometer size particle include the Vander Waals force, the electrostatic force resulting from the electric double layer at the particle surface, the stochastic force that gives rise to the Brownian motion of particles, and the hydrodynamic force. Motions of the particles and fluids are induced and affected by the collective effect of these forces.

The experimental result shows that the heat transfer rate of nanoparticle-fluid mixture increase relative to those of the base fluid. The heat transfer rate decrease up to a volume fraction of 0.2 due to failure of formation of laminar flow by the nanoparticles. As the volume fraction increases, the formation of electric double layer is significant that enhances the heat transfer of the spherical iron particles.

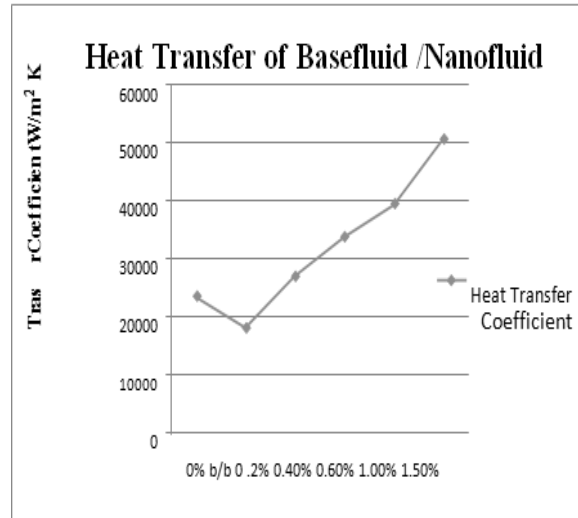


Figure 1: Volume Fraction %

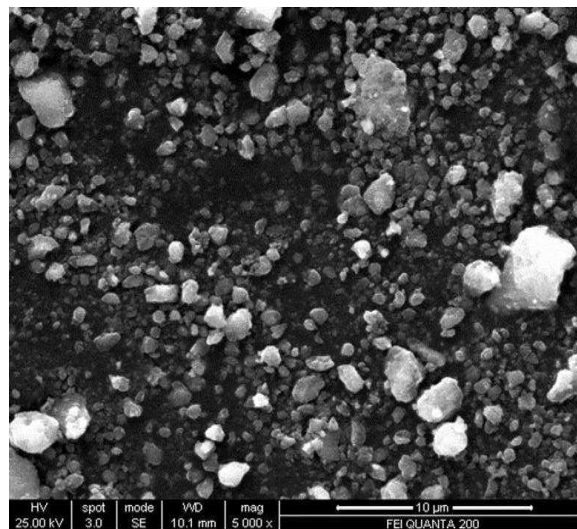


Figure 2: SEM image of the Fe₃O₄ nanoparticles

4. Conclusion

This work presented a technical route for preparing stable nanofluids composed of Fe_3O_4 nanoparticles and the deionised water (DW) as the base fluid. Sodium oleate

was used as surfactant, and it was proved to be beneficial to the dispersion of the nanoparticles in the nanofluids. The viscosity of the Fe_3O_4 nanofluids strongly depends on the temperature and the volume fraction. Thermal conductivities of the nanofluids are higher than that of base fluid, and the enhanced values increase with the volume fraction of the nanoparticles. The convective heat transfer co-efficient of the nanofluids has substantial enhancement when compared to that of the base fluid. These results indicate that the enhanced thermal conductivity is not the only mechanism responsible for heat transfer enhancement and other factors such as stability of nanofluids, thermal properties, and viscosity of the nanofluids also should be considered.

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Molecular Interaction in Conductive Polyaniline - Polyimide Blend Films

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Abstract

Conducting films of ± 10 camphorsulfonic acid (CSA)-doped polyaniline / polyimide (PANI/PI) blends with various compositions were prepared by solvent casting process. The molecular level interaction in these blend films were experimentally characterized by Fourier transform infrared (FTIR), Ultraviolet-Visible (UV-Vis), X-ray diffraction (XRD) and X-ray Photoelectron spectroscopic techniques. Density functional theory (DFT) was utilized to study the structure and interacting nature of PANI/PI blends and to substantiate our experimental observation. The interacting structure and observed red shift confirm the presence of hydrogen bonding between the carbonyl group of PI with the amine of PANI with the typical lengths of 1.950 and 2.193 \rightarrow A, which affects the optical band gap (E_g), electrical conductivity (σ) as well as the morphology of the blends. The disappearance of the characteristic peaks of PANI/PI blends suggest some kind of molecular mixing between the two components. The graphical evaluation of the frontier molecular orbital (FMO) also provides qualitative information on nature and extent of interaction. The elemental and the composition analysis on PANI/PI blend films show the variation in doping levels (S/N) and the binding energies support the results of FTIR, optical, XRD and electrical conductivity.

Keywords: Conductive PANI-PI blend films, Molecular interaction, FTIR and UV-Vis spectroscopy, Optical band gap, Electrical conductivity, Elemental analysis, Density functional theory, Hydrogen bonding, Frontier Molecular Orbitals (FMO).

1. Introduction

Polymer blends are a key component of current polymer research and technology, owing to their ease in production of new materials by mixing and in the diversity of their properties that result. Polyaniline (PANI) is an attractive conducting polymer since last decade due to its considerable conductivity, easy synthesis route and good thermal stability. However, the conducting forms of PANI are inherently brittle and poor in processability [1, 2]. A way of overcoming this problem is to prepare blends of PANI with conventional polymers, such as polyvinylchloride [3], nylons [4], and poly (methyl methacrylate) [5] or with high performance polymers such as polyimide, polysulfone and poly (amide imide) [6, 7] to maintain the mechanical properties, the processability, and the thermal stability of conventional or high performance polymers, together with the electrical properties of conducting polyaniline.

Aromatic polyimides (PI) show outstanding thermal, mechanical, electrical and solvent resistance properties that have been widely used as the high performance parts in electronic, aerospace and automobile industries [8]. Many reports are available on the preparation and characterization of conductive blends of PANI / PI by the conversion process of PANI / polyamic acid that involves some kind of critical processing conditions [9-13]. The characteristics of this type of blend are different from the *mixed conducting polymers*, which are merely a physical mixture of non-conductive polymer with conducting polymer. It is imperative to understand both theoretically and experimentally the behaviour and molecular interactions in such mixed polymers will throw some light on the relationship between structures and properties as well as to predict properties or even to design new materials with specific characteristics.

The objectives of this study are to report on the investigation of the molecular interactions in PANI / PI blend films using Fourier infra-red (FTIR) spectroscopy along with the theoretical justifications applying density functional theory (DFT). The blend films were also examined by ultraviolet-visible (UV-Vis) spectroscopy to probe the nature of transition and to determine the optical band gap. We have also reported our observations of the electrical conductivity and structural analysis of PANI / PI blend films. The X-ray Photoelectron Spectroscopy (XPS) was utilized to study the variation in doping levels (S/N ratio) and the binding energies in PANI / PI blend films. To best of our knowledge no theoretical calculations so far have been carried out on the PANI / PI blend structure. In order to acquire the nature of interaction in PANI / PI blend structure at an atomic level and also to substantiate further the experimental observations, theoretical investigation has been performed on D(P)ANI / PI where D(P)ANI is a dianiline, a smaller unit of polyaniline, considered to avoid computational cost.

2. Experiment

2.1. Chemicals and Preparation of Polyaniline-Polyimide (PANI / PI) Blend films

Aniline (synthetic grade from Aldrich) was purified by distillation before use and ammonium peroxydisulfate ($(NH_4)_2S_2O_8$), HCl and NH_4OH were used as received for the synthesis of polyaniline emeraldine base. (\pm) -10-camphor sulfonic acid (Lancaster), m-cresol (Aldrich) and polyimide (Indian space research organization (ISRO), India) were also used as received to prepare conductive PANI / PI blend films.

Polyaniline emeraldine base (PANI-EB) powder was prepared by conventional chemical method [14]. Conductive PANI powder was prepared by mixing PANI-EB and (\pm) -10-camphor sulfonic acid (CSA) powders in a molar ratio of 0.2 CSA to phenyl nitrogen repeat unit of polymer. The $(PANI)_x - (PI)_{1-x}$ polymer blend solutions (2wt %) were prepared by mixing the conductive PANI with PI in the specified stoichiometric ratio ($x = 0, 25, 50, 75$ and 100 % wt) and stirred mechanically in the presence of m-cresol for about 24 hours at room temperature. The resulting polymer blend solutions appeared to be very uniform with no visible un-dissolved portion, which was used for the preparation of PANI / PI blend films by solution casting technique [15].

2.2. Measurements

Infrared measurements in the range $400-2000\text{ cm}^{-1}$ were recorded with a fully computerized Bruker IFS - 66V spectrometer with 200 scans per spectrum at 2 cm^{-1} resolution. All the measurements were performed ex situ in the transmission mode as KBr tablets. The optical transmittance spectra were recorded from 300 to 800 nm wavelength using a Hitachi UV-Vis-NIR spectrophotometer (U-3400). Unpolarized radiation at room temperature with a resolution of 2 nm was used in this study. The measurements were made on films of typical thickness ($10\ \mu\text{m}$) deposited on glass substrates. The substrate absorption is corrected by introducing an uncoated cleaned glass substrate in the reference beam. In the present study, X-ray diffraction patterns were recorded at room temperature using Philips X-ray generator (Model PW 1390) with an Ni filter and CuK radiation ($\lambda = 1.5418\ \text{\AA}$) at 40 kV and 20 mA in the 2 range of 10° to 70° with an accuracy of 0.02° . The X-ray photoelectron spectroscopy (XPS) was performed using a VG Scientific 220-IXL with its packaged software and data analysis with a resolution of 0.1 eV.

Thickness of the PANI film ($9.8 \times 10^{-6}\text{ m}$) employed in this investigation was measured using a universal length-measuring instrument (TRIMOS, Switzerland) to an accuracy of $\pm 0.1 \times 10^{-6}\text{ m}$ (the pressure maintained in the ball contact was 2.47 Pa) and confirmed with alpha step surface profilometer (TENCOR Alpha step 200-ALO2). The area of the film, used for the conduction study was $\sim 5 \times 10^{-6}\text{ m}^2$, as measured using

a profile projector (Nikon-V-20A, Japan) with 10 times magnification. For conduction measurements, Metal-Polyaniline-Metal (MPM) sandwich devices were prepared by evaporating gold in a vacuum of 2.7×10^{-3} Pa onto well-cleaned glass substrates through suitable masks to form bottom and top electrodes. The dc conductivity data was acquired using a constant current source coupled with a high-input impedance electrometer (Lab Equip, India). For all conductivity data presented here, the sample container was pumped for few hours before the data acquisition, to eliminate the effects of any absorbed moisture.

| Peak assignment ^a | FT-IR | | | |
|----------------------------------|-------------------|---------|----------------------|---------------------|
| | Experimental | | Theoretical | |
| | Isolated | Complex | Isolated | Complex |
| C=O (PI) | 1776 ^b | 1720 | 1805.77 (401.99) | 1798.34 (126.37) |
| N-H (PANI) | 3450 ^c | -- | 3550.48 (8.46) | 3488.66 (120.48) |
| C=C (Q ring of PANI) | 1597 | 1597 | 1559.55 (1741.81) | 1589.62 (268.99) |
| C-N=C (N-B-N of PANI) | 1502 | 1502 | 1508.60 (36.60) | 1507.74 (6.68) |
| C-C Stretching of Q ring of PANI | 1371 | 1354 | 1378.46 (10.28) | 1365.05 (521.19) |
| C _{ar} -N (PANI) | 1336 | 1345 | 1329.32 (1.40) | 1348.35 (123.31) |
| C-H (in plane mode of PANI) | 1175 | 1175 | 1176.74 (37.78) | 1181.90 (11.83) |
| C-H (out of plane mode of PANI) | 804 | 817 | 793.72 (276.91) | 801.73 (40.82) |

Table. 1 Assignments of main peaks of PANI-PI blend spectra (wave number in cm^{-1})

| Concentration PANI-PI (w/w)% | Type of transition | Band gap (E_g) (eV) | | Percentage of transmittance | Range of transparency (nm) | Conductivity (S cm) |
|------------------------------|--------------------|-------------------------|------------------------|-----------------------------|----------------------------|-----------------------|
| | | Experimental | Theoretical D(P)ANI-PI | | | |
| 0:100 (PI) | Indirect allowed | 2.2 and 3.51 | 2.81 | 94 | 550-800 | 5.43×10^{-9} |
| 25:75 | Indirect allowed | 3.67 | -- | 72 | 350-800 | 1.54×10^{-8} |
| 50:50 | Indirect allowed | 3.58 | 2.42 | 41 | 360-800 | 3.14×10^{-7} |
| 75:25 | Indirect allowed | 3.47 | -- | 22 | 360-800 | 2.38×10^{-5} |
| 100:0 (PANI) | Direct allowed | 3.0 | 1.01 | 7.5 | 330-800 | 7.82×10^{-5} |

Table. 2 Optical parameters of PANI, PI and PANI / PI blend films.

| Sample | Relative atomic concentration (%) | | | | |
|--|-----------------------------------|--------|-------|--------|-------|
| | C 1s | O 1s | N 1s | S 2p | S/N |
| PI | 83.846 | 12.820 | 3.334 | - | - |
| (PANI-CSA) _{0.25} -(PI) _{0.75} | 82.903 | 13.845 | 3.165 | 0.087 | 0.027 |
| (PANI-CSA) _{0.5} -(PI) _{0.5} | 85.230 | 11.299 | 3.270 | 0.201 | 0.061 |
| (PANI-CSA) _{0.75} -(PI) _{0.25} | 83.215 | 11.571 | 4.434 | 0.781 | 0.176 |
| PANI-CSA | 76.0486 | 18.616 | 4.342 | 0.9934 | 0.23 |

Table. 3 Relative atomic concentration (%) of PI, PANI-CSA, (PANI-CSA)_x - (PI)_{1-x} blend films from XPS results

| Sample | C1s Binding energy (eV) | Type of species involved | N1s Binding energy (eV) | Type of species involved |
|---|-------------------------|--------------------------------------|-------------------------|-------------------------------------|
| PI | 284.823 | Phenyl Carbon bonded to H | 400.742 | Imide N |
| | 286.076 | C-C or C-N | | |
| | 288.760 | C-O | | |
| | 291.706 | C=O | | |
| (PANI-CSA) _{0.25} - (PI) _{0.75} | 284.858 | C-C or C-H | 400.638 | Imide N |
| | 286.157 | C-N or C=N | | |
| | 288.710 | C-N ⁺ or C=N ⁺ | | |
| | 291.592 | C=O | | |
| (PANI-CSA) _{0.50} - (PI) _{0.50} | 284.957 | C-C or C-H | 400.542 | Imide N |
| | 286.355 | C-N or C=N | | |
| | 288.569 | C-N ⁺ or C=N ⁺ | | |
| | 291.554 | C=O | | |
| (PANI-CSA) _{0.75} - (PI) _{0.25} | 284.903 | C-C or C-H | 399.918 | -NH from Benzenoid amine |
| | 286.242 | C-N or C=N | 401.083 | -N ⁺ species of PANI-CSA |
| | 288.602 | C-N ⁺ or C=N ⁺ | | |
| | 291.492 | C=O | | |
| | | | | |
| PANI-CSA | 284.941 | C-C or C-H | 399.819 | -NH from Benzenoid amine |
| | 286.722 | C-N or C=N | 401.625 | -N ⁺ species of PANI-CSA |
| | 288.708 | C-N ⁺ or C=N ⁺ | | |
| | | | | |

Table. 4 Binding energy of C1s and N1s atoms in PI, PANI-CSA, (PANI-CSA)_x - (PI)_{1-x} blend films from XPS results

3. Theoretical Background

The interacting nature of dianiline (D(P)ANI) (a smaller unit of PANI) with that of polyimide (PI) is taken for quantum chemical calculation. The geometry of all the three structures D(P)ANI, PI and D(P)ANI-PI are fully optimized using density functional theory (DFT). Becke's three-parameter non-local hybrid exchange potential (functional) with the non-local correlation functional of Lee, Yang, Parr (B3LYP) [16-17] in concert with 6-31G* basis set have been used in this study. Harmonic vibrational frequency analysis suggested that all the optimized geometries belong to minima at the respective potential energy surfaces. The energy difference of the Frontier orbitals: HOMO (Highest Occupied Molecular Orbital) and LUMO (Lowest Unoccupied Molecular Orbital), largely responsible for chemical and spectroscopic properties of the molecules, represents the energy band gap that provides the basis for conduction. All computations were performed using Gaussian 03W program package and all graphical representations were prepared with the aid of Molden program [18].

| Type | Parameters | D(P)ANI | PI | D(P)ANI-PI |
|-------------------------|--------------------------|----------|-----------|------------|
| Bond Length/Å | C(8)-N(7) | 1.407 | | 1.383 |
| | N(7)-H(20) | 1.019 | | 1.021 |
| | N(7)-C(2) | 1.437 | | 1.414 |
| | N(14)-H(26) | 1.018 | | 1.020 |
| | N(14)-C(5) | 1.433 | | 1.408 |
| | O(28)-C(25) | | 1.211 | 1.235 |
| | C(25)-C(21) | | 1.499 | 1.465 |
| | C(25)-N(34) | | 1.402 | 1.401 |
| | O(26)-C(15) | | 1.212 | 1.235 |
| | C(15)-C(16) | | 1.494 | 1.454 |
| | C(15)-N(14) | | 1.415 | 1.431 |
| Bond Angle/° | ∠C(8)-N(7)-C(2) | 120.48 | | 127.63 |
| | ∠O(28)-C(25)-C(21) | | 128.87 | 131.75 |
| | ∠O(28)-C(25)-N(24) | | 126.35 | 123.43 |
| | ∠O(26)-C(15)-C(16) | | 127.69 | 124.04 |
| | ∠O(26)-C(15)-N(14) | | 126.37 | 130.34 |
| Dihedral Angle/° | ∠C(13)-C(8)-N(7)-H(20) | -38.83 | | 0.55 |
| | ∠C(9)-C(8)-N(7)-H(20) | 142.79 | | 177.57 |
| | ∠C(3)-C(2)-N(7)-H(20) | -41.72 | | -49.38 |
| | ∠C(1)-C(2)-N(7)-H(20) | 137.61 | | 124.27 |
| | ∠C(8)-N(7)-C(2)-C(1) | -89.61 | | -31.46 |
| | ∠C(6)-C(5)-N(14)-H(26) | -154.48 | | -138.06 |
| | ∠O(28)-C(25)-C(21)-C(22) | | -0.02 | -0.81 |
| | ∠O(26)-C(15)-N(14)-C(11) | | 0.48 | -0.68 |
| Total Energy (Hartrees) | | -573.948 | -1331.246 | -1905.343 |

Table. 5 Geometrical parameters of D(P)ANI, PI and D(P)ANI-PI structures optimized at B3LYP/6-31G* level of theory.

4. Results and Discussion

4.1. Experimental Study

Infrared Spectra

The FTIR spectra of PANI (a), PANI / PI blends with the weight ratio of 75:25

(b), 50:50 (c) and 25:75 (d) are shown in Fig.1. The IR main peaks of PANI / PI blends are identified and tabulated (Table 1). The conductive PANI (100:0) shows quinoid (Q) ring stretching at 1597 cm^{-1} , and benzenoid (B) ring stretching at 1502 cm^{-1} typical feature of a semiquinoid structure of emeraldine type [19]. The bands at 1371 cm^{-1} and 1345 cm^{-1} corresponds to B-N=Q and Car-N stretching modes respectively. The absorption peaks at 1175 cm^{-1} and 804 cm^{-1} are due to C-H in plane and out of plane bending vibrations of the aromatic ring respectively.

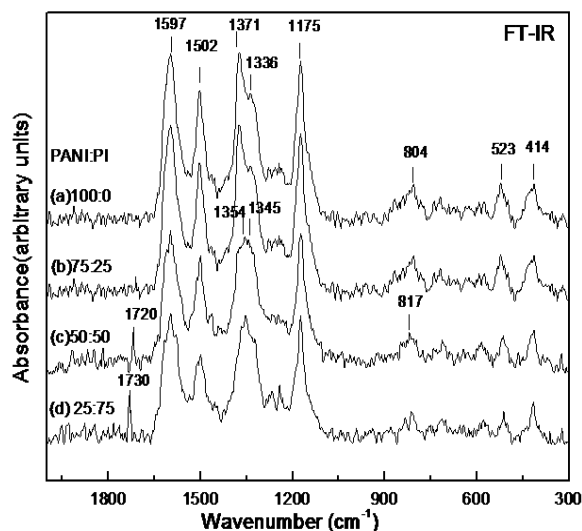


Figure 1: (a) FT-IR and (b) FT-Raman spectra of PANI, PANI /PI blend films.

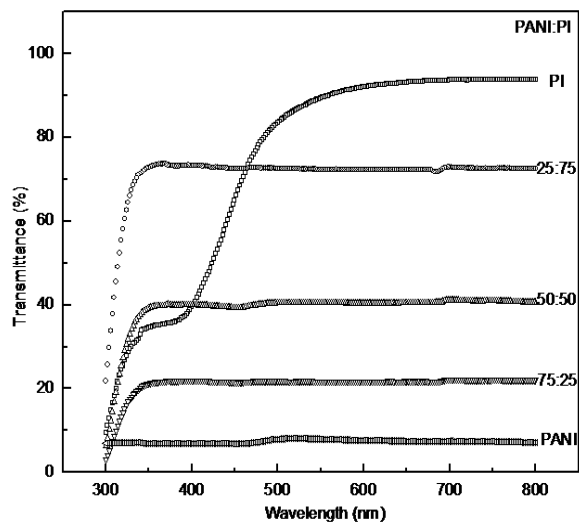


Figure 2: Transmittance spectra of PANI, PI and PANI /PI blend films.

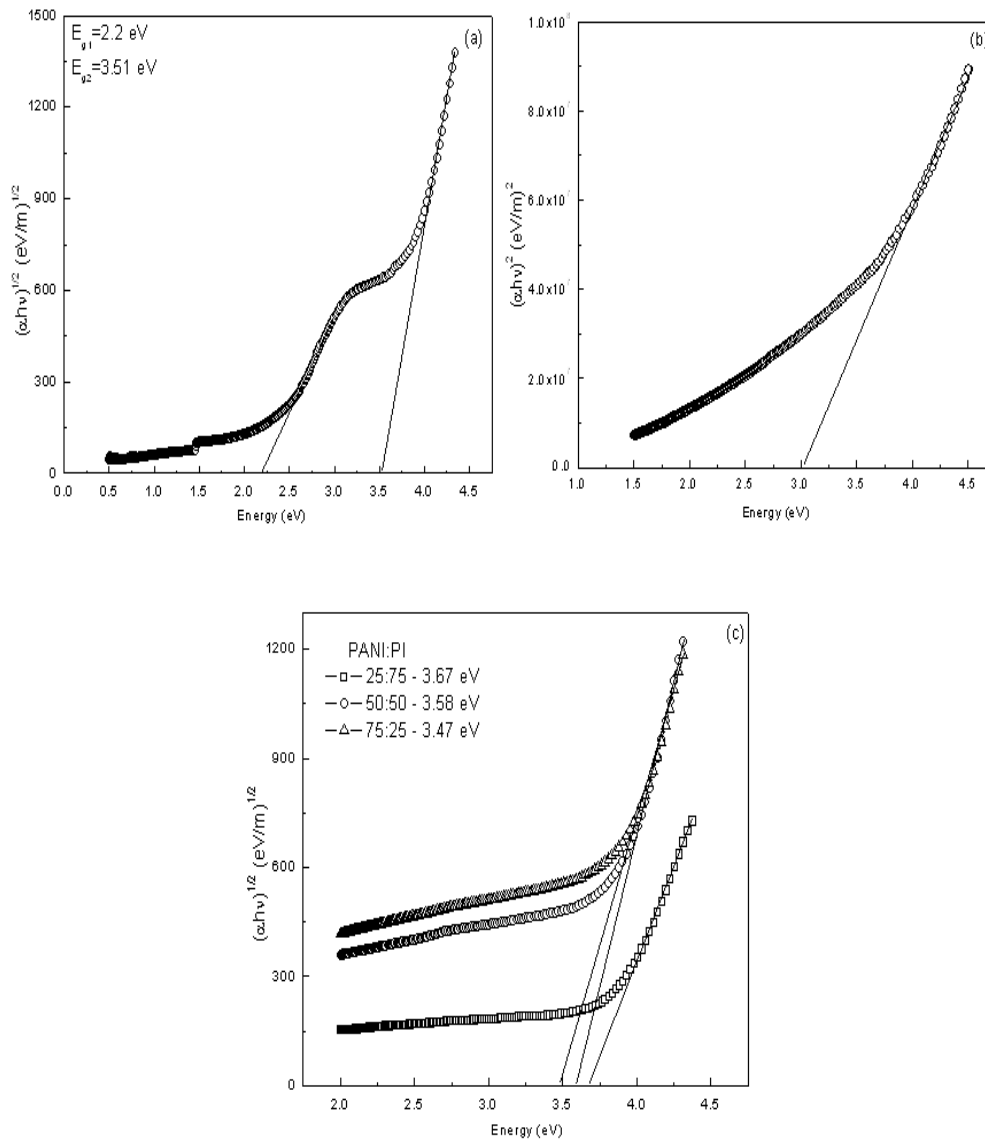


Figure 3: (a) Plot of $(\alpha h\nu)^{1/2}$ versus $h\nu$ show indirect allowed transition in PI, (b) Plot of $(\alpha h\nu)^2$ versus $h\nu$ show direct allowed transition in PANI and (c) Plot of $(\alpha h\nu)^{1/2}$ versus $h\nu$ show indirect allowed transition in PANI / PI blend films.

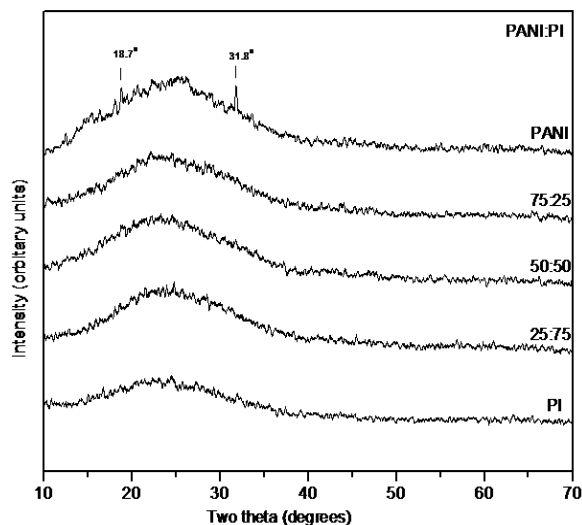


Figure 4: X-ray diffraction patterns of PANI, PI and PANI-PI blend films

The IR peaks of PANI / PI blend with the weight ratio of 75:25 are almost similar to conductive PANI. However, in the case of 50:50 and 25:75 weight ratio, the carbonyl C=O stretching band of PI seen at 1730 cm^{-1} shifts to 1720 cm^{-1} as the PANI content increases from 25% to 50% wt. As the content of PANI increases to 75%, the carbonyl band becomes smaller and its peak further shifts slightly towards the lower wavenumber. The observed red shift may be due to the formation of hydrogen bond between the C=O group of PI with the amine of PANI, without allowing the amine to participate in protonation. A similar observation has been reported for thermally imidized PANI / polyamic acid (PAA) blends [13].

Since O is highly electronegative, the hydrogen bonding to a carbonyl group lengthens the C=O bond and lowers the stretching force constant, which results in a lowering of the absorption frequency. The hydrogen bond between the C=O group of PI with the amine of PANI also affects the B-N=Q stretching mode. Because of this reason the band at 1371 cm^{-1} shift to 1354 cm^{-1} . The band at 1336 cm^{-1} is assigned to the characteristic band of $C_{ar} - N$ stretching indicate the doped state of PANI. This band almost disappears in the case of 25:75 weight ratio and this may due to the availability of more carbonyl group of PI that hampers the protonation. This fact is also seen as the intensity of the band at 1502 cm^{-1} decays where the band $C - NH^+ = C$ turns into $C - N = C$ characterizes the deprotonated structure.

Optical Spectra

The transmittance (T) data of polyaniline (PANI), polyimide (PI) and PANI / PI blend films (Fig.2) show the higher transmission in the higher wavelength region and

its decline at absorption edge. Analysis of the absorption coefficient (α) has been carried out to determine the nature of transitions involved and to obtain the optical band gap (E_g). Absorption coefficient data were elucidated from optical transmission measurements in the interference-free, strong absorption spectral region. The frequency dependence of the absorption coefficient can be described by an empirical relation,

$$\alpha h\nu = A(h\nu - E_g)^n$$

where A is a material constant, E_g a characteristic energy termed as optical band gap and n is the transition probability index, which has discrete values like $\frac{1}{2}$, $\frac{3}{2}$, 2 or more depending on whether the transition is direct or indirect and allowed or forbidden. The plots of $(\alpha h\nu)^2$ versus $h\nu$ and $(\alpha h\nu)^{1/2}$ versus $h\nu$ are linear function, indicating the existence of direct allowed and indirect allowed transition in PANI and PI, PANI / PI blends respectively. Extrapolation of linear dependence of the relation to abscissa yields the corresponding bandwidth E_g . The values of the optical energy gaps obtained from Fig. 3 (a), (b) and (c) are listed in Table 2.

From the table, it is observed that the percentage of transmittance (T) decreases with the increase of PANI concentration. At the same time the range of transparency almost remains same in PANI and its blends except for the polyimide film. The band gap evaluated for PANI (3 eV) almost matches with the reported result [20]. The band gap for PI film is calculated as 2.2, 3.51 eV. Yoo et al. [21] have recently reported the existence of only one optical band gap for polyimide (3.51 eV) matches with our result. However, there is an additional band gap (2.2 eV) obtained for PI film may be due to the formation of exciton. The exciton is a bound electron-hole pair, which can be formed in every insulating crystal, if the band gap is indirect. The energy of formation of an exciton is less than the band gap and so its energy level lies in the band gap. The optical band gap of the polyaniline blends shifts from 3.67 to 3.47 eV (bathochromic shift) when the PANI load (x) increases from 0.25 to 0.75. This bathochromic shift indicates the formation of hydrogen bonding between PI and PANI, which may result in weakening of bond strength in PANI. Similar results were reported for PANI - poly (vinyl alcohol) (PVA) and PANI - nylon 6 composites [4].

Structural and Electrical Conductivity

X-ray diffraction patterns of PANI, PI and PANI / PI blend films with the weight ratio of 75:25, 50:50 and 25:75 are shown in Fig.4. The CSA-doped PANI film has prominent diffraction peaks at $2\theta = 18.7^\circ$ and 31.8° in the background of amorphous shoulder around 25° , indicating that some part of the PANI sub chains become rigid and ordered. A model for the structure of CSA doped polyaniline film explains the presence of alternating layers of flat emeraldine salt chains and CSA- anion parallel (a,c) planes [22] grown parallel to the c axis. Here, polyaniline could be treated as a

polycation while CSA- acts as an anion that allows an increase in interchain packing and thus induces higher structural order. On the contrary, there are no pronounced diffraction peaks in the patterns of PANI / PI blends indicating the synergetic effect of the presence of large number of hydrogen bonding moieties (C=O group of PI and amine of PANI) in polyblend films reducing the interchain packing and hence resulting in the conformational hindrance of PANI sub chain. The disappearance of the characteristic peaks also suggests some kind of molecular mixing between two components [13]. However, the improvement of electrical conductivity from 10^{-8} to 10^{-5} S/cm in this blend films as shown in the Table(2) is due the enrichment of the conducting path in the amorphous regions of PANI / PI blends that reduces the tunneling/hopping distance between disordered regions results in the enhancement charge carrier motion.

Composition Analysis

X-ray Photoelectron Spectra of $(\text{PANI-CSA})_x-(\text{PI})_{1-x}$ blend films are shown in Fig. (5) for $x = 0, 0.25, 0.50, 0.75$ and 1. The survey scan spectrum of polyimide (Fig. 5a) consists of 3 main peaks: C1s around 285.65 eV, N1s around 402.04 eV and O1s around 531.76 eV. The survey scan spectrum of doped PANI (Fig. 5e) also consists of 3 main peaks: C 1s around 285.65 eV, N1s around 399.37 eV and O1s around 534.42 eV along with a peak at 158.59 eV corresponds to $\text{S}2_p$ element in SO_3 group of the doping material (CSA). The binding energy peak at 399.37 eV corresponds to the N 1s of the doped PANI and is from benzenoid amine. The doping material (CSA), which is used for protonation, protonates not only the imine nitrogen but also the amine nitrogen. Apart from these, one small contamination peak also appears at 104.39 eV and it corresponds to Si2p element which may be from the glass substrate.

Relative atomic percentage of PI, PANI and PANI / PI blends after correcting with the sensitivity factors are listed in Table 3. The protonation (doping) level of the PANI (S/N ratio) is determined from the sensitivity factor corrected $\text{S}2_p$ to N1s core-level spectra from the Table 3. It is found that the value of S/N is 0.23 in the case of PANI-CSA complex. This value gradually decreases with increasing PI concentration, though the level of CSA doping is the same for all compositions. This is due to the fact of the formation of hydrogen bond between the C=O group of PI with the amine of PANI, without allowing the amine to participate in protonation. This result is in accordance with the present studies on FTIR, optical and XRD analysis.

To understand the variation of binding energies of main peaks, the C1s and N1s core-level spectral lines (not shown) are deconvoluted into components and its values are presented in Table 4. The spectrum of PI has four species of C1s, 284.823, 286.076, 288.760 and 291.706 eV, respectively, for phenyl carbon bonded to hydrogen, C-C or C-N, C-O and the carbonyl carbon (C=O) species and one species of N1s at 400.742 eV

corresponds to imide nitrogen. The C1s spectrum of PANI-CSA can be deconvoluted into three environments: C-C or C-H at 284.941 eV, C-N or C=N at 286.722, and $C - N^+$ or $C = N^+$ at 288.708eV. The high bonding energy tail (288.708eV) is due to the $\pi - \pi^*$ bonding band coincide with the well-doped state [12]. The N1s spectrum has two environments: -NH from benzenoid amine is revealed at 399.819 eV and the imine -N+ species appeared at 401.625 eV. The PANI blends have four C1s components in which three C1s components are similar to PANI-CSA and the fourth components is carbonyl carbon (C=O) species of PI. The binding energy of carbonyl carbon species increases with increase of PI content in the blends indicate that the amine site of PANI-CSA prefers the formation of H bond than doping species.

The electronegativity of O in C=O gradually reduces, if the availability of N-H species of PANI increases, can be attributed to the reduction of displacement of electronic charge from the atom that lower the observed binding energies of the core electrons. Analysis of N1s components of blends revealed that $-NH$ and $-N^+$ species appeared only for 75% PANI blend, which suggest that the dopant species protonate not only the imine nitrogen but also the amine nitrogen, similar to the observations of Han et al.[12] in PANI/PAA and PANI/PI blends. However, the dominance of dopant is not seen for 25 and 50% PANI blends that clearly support the lower conductivity of those blends given in Table 2.

4.2. Theoretical Explanation

Geometrical Parameters

The two isolated structures were fully optimized and are depicted along with their atomic numbering schemes in Fig. 6 (a) & (b) followed by the D(P)ANI-PI structure shown in Fig 6 (c). The interacting D(P)ANI-PI structure shows hydrogen bonding between O(28) of PI and H(20) of D(P)ANI and between O(26) of PI and H(26) of D(P)ANI with bond lengths 1.950 \AA and 2.193 \AA respectively. The geometrical parameters of all the three structures and their respective energies are listed out in Table (5). The N(7)-H(20) and N(14)-H(26) bond lengths of isolated D(P)ANI structure are respectively 1.019 and 1.018 \AA . However the hydrogen bonding of O(28) and O(26) of PI with H(20) and H(26) has caused the elongation of N(7)-H(20) and N(14)-H(26) bond lengths to 1.021 and 1.020 \AA respectively. This elongation of N-H bond lengths due to the interaction of PI is thus expected to produce a shift in their vibrational frequencies. In the case of PI, hydrogen bonding has led to the increase in bond lengths of C(25)-O(28) and C(15)-O(26) from 1.211 to 1.235 \AA and 1.212 to 1.235 \AA respectively which in turn support well to our experimental part. The increase in bond lengths of the carbonyl group is also predicted to cause difference in CO vibrational frequencies from that of their isolated structure. The variation in bond lengths, angle and dihedral angles of the isolated structures due to the interaction of D(P)ANI and PI are listed in the Table. 5.

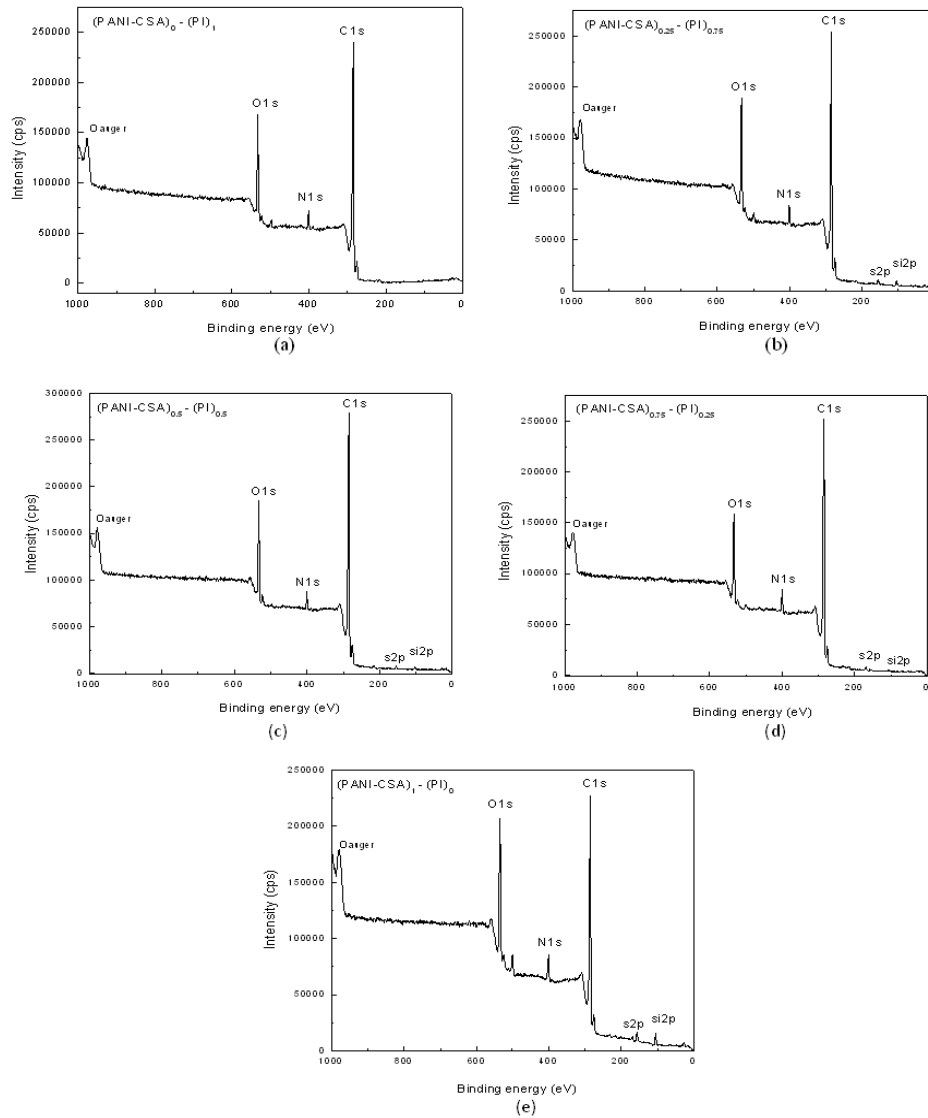


Figure 5: XPS spectra of (PANI-CSA) x - (PI) 1-x blend films

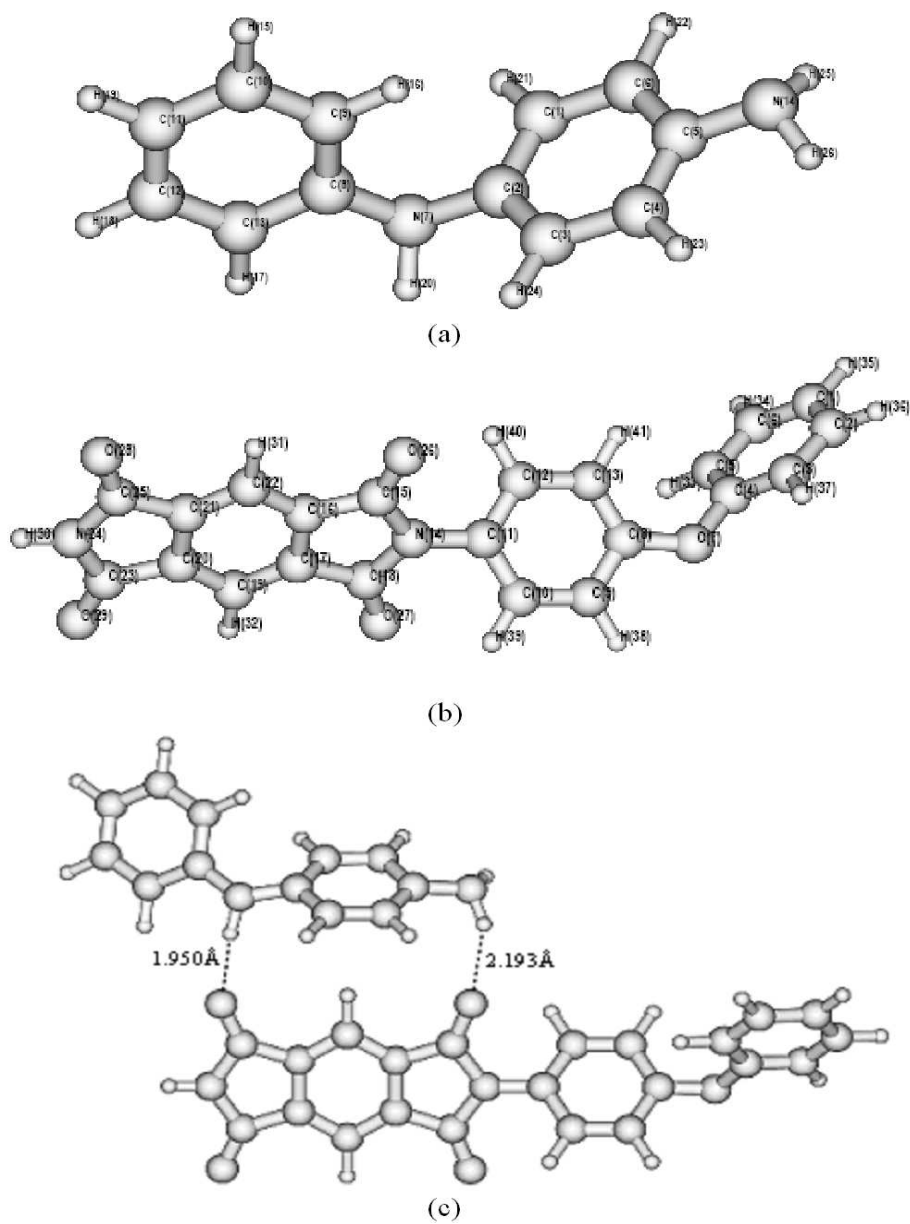


Figure 6: Three dimensional structure of (a) D(P)ANI (b) PI and (c) D(P)ANI-PI optimized at B3LYP/6-31G* level of theory.

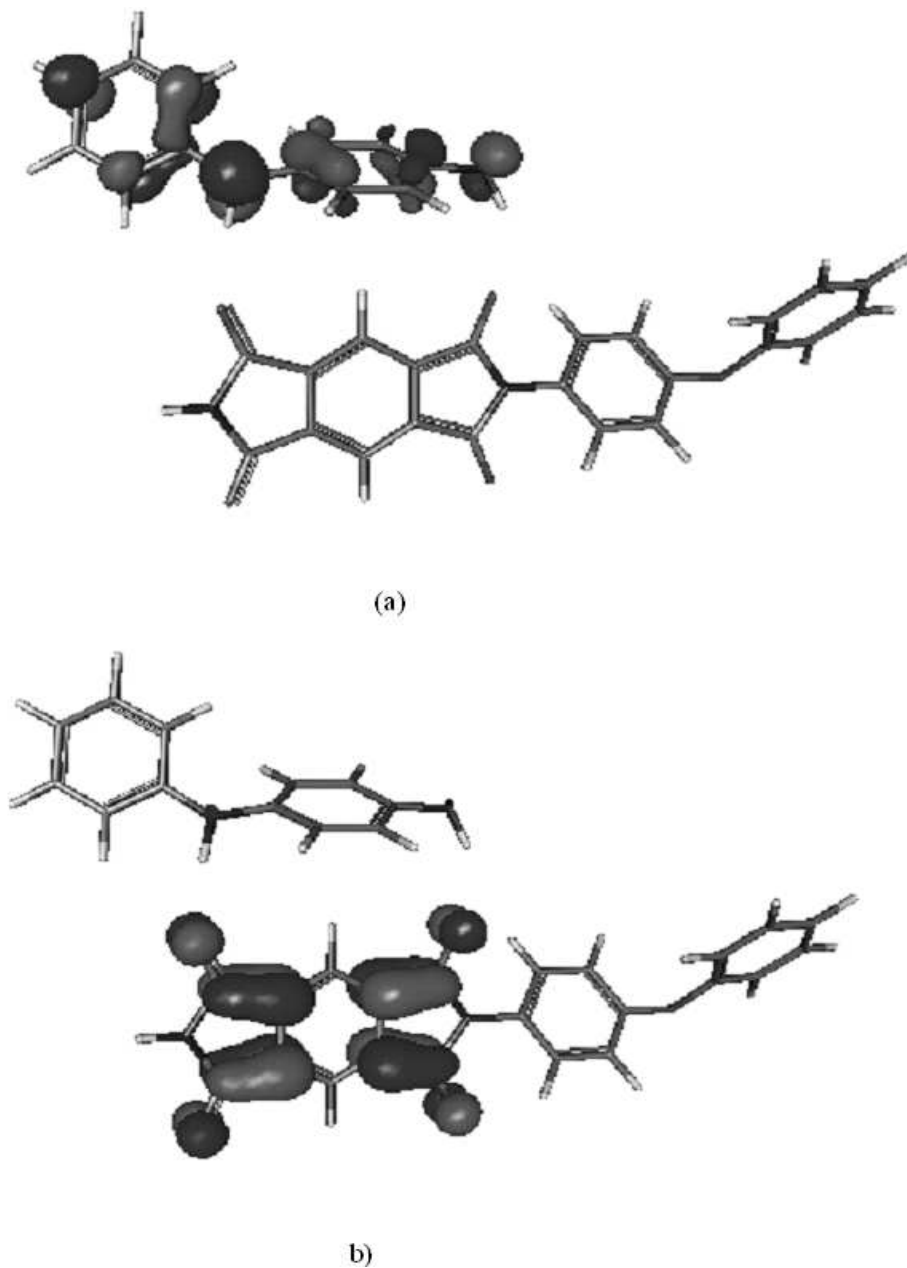


Figure 7: Pictorial representation of the Frontier molecular orbitals - (a) HOMO and (b) LUMO - of D(P)ANI-PI calculated at B3LYP/6-31G* level of theory.

Thermodynamic Properties

The occurrence of hydrogen bonding between D(P)ANI and PI will affect the strength of NH and CO bonds and hence shift in their vibrational frequencies are expected. The discrepancies in NH and CO stretching vibrational frequencies of the structures are listed in Table 1. It is evident from the data (Table 1) that the hydrogen bonding between carbonyl of PI and amine of D(P)ANI has influenced significant changes in the stretching NH and CO vibrational frequencies. In the case of isolated PI, a stretching vibrational frequency of 1805.77 cm^{-1} is calculated for the CO bond. Similar to the observed experimental result, the formation of hydrogen bond by O of the carbonyl group with the amine of D(P)ANI has predicted a considerable red shift by decreasing the frequency of CO bond to 1798.34 cm^{-1} . This lowering of frequency is due to the increase in the bond length of CO as shown in Table 5. In the same way, hydrogen bonding has led to the decrease in the vibrational frequency of NH bond from 3550.48 cm^{-1} to 3488.66 cm^{-1} thus predicting a significant red shift. The predicted discrepancy in the calculated frequencies is much comparable with our experimentally observation confirming that the presence of hydrogen bonding is responsible for the hindrance of protonation by the amine group of D(P)ANI.

Graphical Evaluation of Molecular Orbitals

The energy band gap for D(P)ANI, PI and D(P)ANI/PI structures were also calculated using density functional theory (DFT) and are listed in Table 2. The energy gap of isolated D(P)ANI and PI is found to be 1.01 eV and 2.81 eV respectively, which do not match with the experimental value because only one unit of polymer was taken for DFT calculations. However, the interaction of this D(P)ANI with PI increases its band gap to 2.42 eV. This conclude that the presence of PI decrease the conducting property of PANI and the shift in the energy gap of D(P)ANI/PI is mainly due to the formation of hydrogen bond between D(P)ANI and PI. The graphical evaluation of the Frontier molecular orbitals - the HOMO and LUMO - can provide much qualitative information on the nature and extent of interaction between PANI and PI. Fig. 5 depicts the HOMO and LUMO orbitals for the interacting D(P)ANI/PI structure. The molecular orbitals clearly show that the unshared pair (p orbitals) of oxygen (O) in the PI structure acts as the electron acceptor, thus occupying the LUMO orbitals. This further confirms the formation of hydrogen bond with D(P)ANI thereby reducing its conductivity as seen from Table 2.

5. Conclusion

Conductive films of PANI/PI blends with different compositions were prepared by solvent casting process. The molecular level interaction in these blend films

was experimentally characterized by Fourier transform infrared (FTIR), UV-Vis, X-ray diffraction (XRD) and X-ray photoelectron spectroscopic techniques. It was demonstrated that the conductive PANI can react with PI to form hydrogen bonds and thus keeping both as a miscible system. The interaction between O of the carbonyl group in PI and H of amine in PANI hampers the protonation of latter, in turn increasing its band gap. The optimized structure of D(P)ANI/PI shows the formation of hydrogen bonding between carbonyl and amine groups of PI and PANI respectively justifying further to the experimental observation. Calculated frequencies also predicts a red shift in the NH and CO stretching vibration of (D)PANI and PI due to the formation of the hydrogen bond. Similar to the experimental result, increase in the band gap of D(P)ANI is observed in the presence of PI thus weakening its conductivity. The race between dopant moieties and hydrogen bond moieties affect the protonation process in the PANI/PI blend system which in turn influence the structural, optical and electrical properties. Detailed studies on these properties are essential for device applications that are proposed for future work.

Acknowledgements

The authors thank Prof. Junsen Yi and M. Tamilselvan of the School of Information and Communication Engineering, *Sungkyunkwan University*, Suwan, South Korea for technical assistance and helpful discussions.

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Molecular Geometries and Spectral Analysis of Some Pyrazolo Quinoline Derivatives in Optoelectronic Devices

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Abstract

We present the results of quantum chemical simulation of pyrazolo [3,4-b] quinoline derivatives in the field of organic optoelectronics. Molecular geometries and spectral analysis in the absorption spectra are characterized by four strong absorption bands in the spectral range 200-500 nm. A substitution of the methyl groups by phenyl groups causes substantial changes of the absorption spectra mainly in the spectral range 250-1400 nm. From five classes of molecules about 29 derivatives were characterized for the study. The comparison of measured and calculated absorption spectra by quantum-chemical AM1 method manifests rather good agreement for all compounds in the part regarding the spectral positions. PAQ substituents are reported for the prediction of the integrated UV absorbance for a various set of positions using a quantitative structure-property relationship (QSPR) approach. At the same time, the measured spectra reveal the considerable broadening practically of all absorption bands. In order to gain more electronic examination, HOMO and LUMO energies gap (ΔE) have been calculated.

Keywords: Pyrazolo [3,4-b] quinoline, QSPR, AMI, HOMO-LUMO

1. Introduction

Organic optoelectronics devices are exploited in various applications that range from display and the lighting in the case of organic light emitting diodes (OLEDs)[1-2], solar cells, sensors and wearable electronics. The present generation is addicted to smartphone due to their high advantages and applications, rather because of low cost, light weight and flexible technology in the emerging field of material science. Among the large number of such materials, considerable interest is shown towards pyrazolo [3,4 b] quinoline [3] and its derivatives which recently have been found to possess a class of highly fluorescent materials in the blue spectral range [4] as well as promising materials for electroluminescent applications [5], particular displays and LED production.

Further improvement of their basic characteristics needs a detailed knowledge concerning the fundamental electronic and optical properties of organic molecules implemented into a polymer matrix which currently are not well established. Important information may be gained here by the absorption in UV and visible parts of the spectra applying appropriate experimental methods and quantum-chemical modeling.



Figure. 1 Pyrazoloquinoline (PAQ)

The general structure of pyrazoloquinoline derivatives and its positions

The central part of the PAQ molecule is an aromatic moiety with delocalized π -electronic system which is already discussed in the previous chapter makes indelible side substituents positions affecting the properties of HOMO and LUMO energy levels, the effect depending upon whether the substituent is electron-donating or electron-withdrawing, as well as whether it's electronic system can conjugate with the central part leading to further delocalization [6]. Main approach is usually focused on the interacting π -electrons which are not only the reason of the optical absorption, but also the basis of the relevant luminescent and electroluminescent properties of materials.

One of the most successful models for the calculation of UV spectra is the ZINDO modification of the Intermediate Neglect of Differential Overlap method [7]. Since most of the spectra are taken of molecules in solution, treatment of solvent effects on UV spectra has been an area of active research. The explicit consideration of solvent molecules in the quantum mechanical self-consistent field molecular orbital calculations is usually not feasible. Therefore, various continuum solvent models (CSM) that treat solvent as a simple dielectric continuum have been developed. Traditional CSM is the self-consistent reaction field (SCRF) model [8], that has been shown to reproduce the shifts of absorption peaks in aprotic solvents very well [9]. Another continuum when implemented in the framework of MOPAC reproduces solvatochromic shifts qualitatively in AM1 calculations [10]. Specific effects of protic solvents on the UV spectra of some PAQ derivatives have been studied using hybrid quantum chemical and molecular mechanics method [11]. Theoretical models have also been developed to approximate the band shape of molecular electronic transitions. Much of the

broadening of spectral lines occurs because there are many vibrational and rotational transitions with slightly different energies. Another cause of line broadening is the anisotropic interaction with the medium (solvent). An empirical method for reproducing the band shape from a single geometric structure has been developed [12] that is significantly faster than molecular dynamics approaches and potentially applicable for predicting the appearance of the spectra of large molecular systems. A new recently described parametrization of INDO is equally good for both geometry optimization and spectroscopy [13].

A combined treatment of the absorption intensities is further complicated by large differences in the oscillator strengths for transitions of different symmetry. Moreover, additional solvent-induced broadening of the spectral bands arises from the variation of the local environment of the chromophoric solute molecule in the condensed medium. The latter is caused by the thermal motion of the surrounding solvent molecules. At any given instant of time, there is a distribution of differently solvated solute molecules, each of which has characteristic transition energy to the excited state. The resulting distribution of the transition energies leads to the broadening of the spectral band. The theoretical assessment of the solvent-induced spectral broadening has thus to rely on a proper statistical treatment of the solvent distribution around the chromophoric solute molecule, both in the ground and in the excited state of the latter [14].

A QSPR approach has previously been applied to the prediction of absorption wavenumbers and molar absorptivities. [15] In this study various structure indices such as the integrated molecular transformation and normalized molecular moment indices were used to establish the correlation model. Modeling of molar absorptivity was not successful in this study evidently because absorptivity at a single wavelength (maximum) rather than the integrated area was used. The aim of the current study is to develop QSPR models for the rationalization and prediction of the ultraviolet integrated absorption for a diverse set of organic compounds at a precision level suitable for application to analytical work. The QSPR method is applied in the framework of the CODESSA program [16].

2. Methodology and Computational Studies

Molecular geometries of PAQ derivatives were studied through wave functions readout of an engine MOPAC with a basis set AM1. The calculation of optical absorption spectra has been carried out by (MM+) model (all atom force field models). Models are developed for the prediction of the integrated UV absorbance for a diverse set of molecular descriptors using a quantitative structure-property relationship (QSPR) approach. The calculations of optical absorption spectra were consequently performed within several semi-empirical quantum chemical models on available software's. However, the results will be calibrated through AM1 methods for generating geometrical and electronic structures. The electronic transition spectra were

calculated considering only the singly excited configuration interactions; the criterions' regarding the excitation energies considers either its upper limit of 12 eV for AM1-method). The UV spectroscopic studies along with molecular orbital theory ie., HOMO, LUMO analysis have been studied to elucidate information regarding charge transfer within the molecule were calculated in atomic units as parameters. The intensity of absorption bands are measured through probability of transitions from electronic states levels theory of approximation. The empirical parameters ΔE was chosen at reasonable value, which gives the best agreement in line shape of calculated spectral results.

3. Results and Discussion

Calculated wave functions of pyrazolo[3,4-b]quinoline derived from the structure refinement, with a set of 29 compounds are obtained from the quantum chemical calculations and are listed in the (Table 1), which are in accordance with the atom numbering scheme given in (Figure 1), geometrical wave functions were calculated through normal basis set as AM1 it was compared with derivatives vs Self-Consistent Field (SCF) energy graph in (Figure 2), it reveals that when the number of atoms increases, resulting the increase of molecular energy.

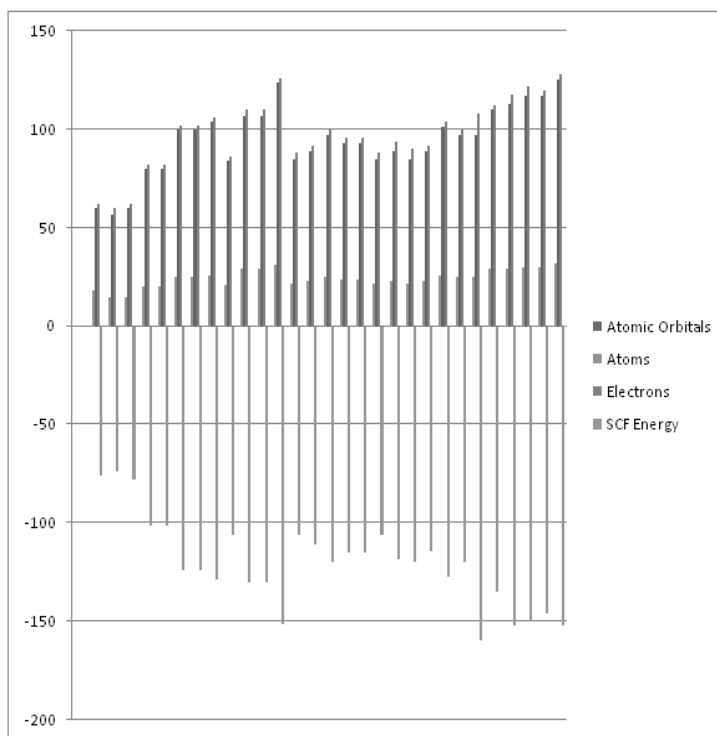


Figure. 2 Substituent's vs Atomic Orbitals, Atoms, Electrons SCF Energy

| Substituents | SCF Energy (Hartrees) | Dipole Moment | Heat of Formation (kcal/mol) |
|--------------|--------------------------|------------------|---------------------------------|
| 1. | - 75.7333 | 7.550 | 604.898 |
| 2. | - 73.9484 | 10.30 | 780.240 |
| 3. | - 77.8226 | 4.55 | 991.169 |
| 4. | -100.9970 | 6.52 | 1233.977 |
| 5. | -100.9300 | 6.57 | 1276.037 |
| 6. | -123.9450 | 2.74 | 1618.693 |
| 7. | -123.9450 | 2.74 | 1618.693 |
| 8. | -128.6350 | 4.71 | 1632.360 |
| 9. | -105.6740 | 4.80 | 1256.247 |
| 10. | -130.0820 | 1.80 | 1669.345 |
| 11. | -130.2380 | 5.92 | 1571.476 |
| 12. | -151.3690 | 0.68 | 2151.542 |
| 13. | -106.1870 | 9.79 | 1249.237 |
| 14. | -110.8210 | 13.31 | 1297.965 |
| 15. | -120.0140 | 18.61 | 1443.461 |
| 16. | -115.2130 | 13.34 | 1499.205 |
| 17. | -115.1350 | 4.94 | 1548.051 |
| 18. | -106.3150 | 14.96 | 1168.876 |
| 19. | -118.0550 | 19.68 | 1150.709 |
| 20. | -119.6250 | 7.13 | 1000.615 |
| 21. | -113.9190 | 9.70 | 1177.583 |
| 22. | -127.5810 | 13.17 | 1475.420 |
| 23. | -119.8730 | 15.74 | 1531.607 |
| 24. | -159.7730 | 7.07 | 1045.922 |
| 25. | -134.5850 | 3.02 | 1485.553 |
| 26. | -151.8300 | 3.25 | 1489.909 |

Table. 1 Calculated wave functions of pyrazolo[3,4-b]quinoline derivatives

3.1. HOMO & LUMO Energies

The analysis of the wave function (Table 2) indicates that the electron absorption corresponds to the transition from ground to first excited and it is mainly described by one electron excitation from the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital . The spectra dominated by the HOMO-LUMO

transition, at 12 eV are listed in ($\lambda_{\text{max}}^{\text{abs}}$) nm. The orbital energy of HOMO increased more than that of LUMO for PAQ derivatives with the methyl and phenyl groups at different positions. In the previous chapter, the main focus has been on the molecular structures. The properties that will be evaluated in this section can be used to determine the molecules reactivity. The HOMO and LUMO are very important aspects to consider for this type of observations. This is because the HOMO and LUMO are the most likely locations where a reaction will occur. The reaction is likely to occur there because the electrons in the HOMO have the most energy and therefore most willing to react. The LUMO is a likely location for a bond to occur as well because any invading electrons from another molecule will fill into the LUMO.

On comparing the energies of those orbitals one can create an idea of how much reactive a molecule is. Our results showed that the most similar HOMO and LUMO energies were between compound 22 and 28. The HOMO energy of compound 22 was -8.03602 eV, which is slightly more negative than methamphetamines HOMO energy of -8.21602 eV. The LUMO energy of compound 22 is -7.14802 eV and the energy of the compound 28 is -6.62002 eV. This indicates that compound 22 is slightly more stable than compound 28 because the lower the energy, the more stable the molecule. This assumption is in agreement with the overall energy of the molecule which was included in the calculation. The heat formation energy of compound was 1475.420 kcal/mol, while the overall energy of compound was 1672.486 kcal/mol. This proves that the energy of the HOMO and LUMO can predict the stability of the molecule, and the data here suggests that compound 28 is more reactive than compound 22.

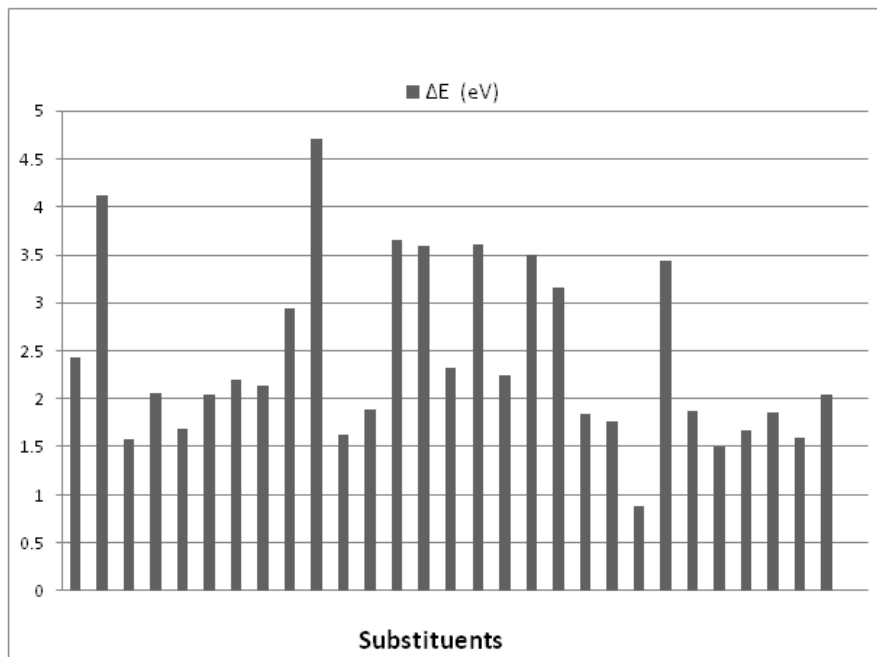


Figure. 3 Substituent vs ΔE

| Compounds | HOMO | LUMO | ΔE (eV) | $(\lambda_{\text{max}}^{\text{abs}})$ nm |
|-----------|----------|----------|-----------------|--|
| 1 | -8.33402 | -5.89702 | 2.43701 | 508.72 |
| 2 | -7.82702 | -3.70201 | 4.12501 | 300.54 |
| 3 | -7.75902 | -6.17802 | 1.58100 | 784.15 |
| 4 | -8.75902 | -6.70602 | 2.05301 | 603.87 |
| 5 | -8.75302 | -7.06102 | 1.69200 | 732.71 |
| 6 | -9.20802 | -7.16102 | 2.04701 | 605.64 |
| 7 | -8.43402 | -6.23402 | 2.20001 | 563.52 |
| 8 | -9.03202 | -6.90102 | 2.13101 | 581.77 |
| 9 | -8.70502 | -5.75901 | 2.94601 | 420.82 |
| 10 | -8.66302 | -3.95901 | 4.70401 | 263.55 |
| 11 | -7.43502 | -5.81702 | 1.61800 | 766.22 |
| 12 | -8.85202 | -6.95902 | 1.89300 | 654.91 |
| 13 | -8.69702 | -5.03901 | 3.65801 | 338.91 |
| 14 | -8.04202 | -4.45801 | 3.58401 | 345.91 |
| 15 | -7.46502 | -5.14901 | 2.31601 | 535.30 |
| 16 | -7.89202 | -4.27801 | 3.61401 | 343.04 |
| 17 | -7.67602 | -5.43801 | 2.23801 | 553.95 |
| 18 | -7.63502 | -4.14201 | 3.49301 | 354.92 |
| 19 | -7.39102 | -4.23201 | 3.15901 | 392.45 |
| 20 | -8.64702 | -6.81002 | 1.83700 | 674.88 |
| 21 | -8.67602 | -6.90902 | 1.76700 | 701.61 |
| 22 | -8.03602 | -7.14802 | 0.88800 | 1396.11 |
| 23 | -7.51402 | -4.07101 | 3.44301 | 360.08 |
| 24 | -8.76102 | -6.88702 | 1.87400 | 661.55 |
| 25 | -8.16802 | -6.66602 | 1.50200 | 825.40 |
| 26 | -8.40102 | -6.73102 | 1.67000 | 742.36 |
| 27 | -7.03302 | -5.17301 | 1.86000 | 666.53 |
| 28 | -8.21602 | -6.62002 | 1.59600 | 776.78 |
| 29 | -7.27402 | -5.22701 | 2.04701 | 605.64 |

Table. 2 Substituent Effect in PAQ Derivatives

3.2. Spectral Analysis

A substitution of the methyl groups by at least one phenyl group (Figure 3), causes the substantial changes of both calculated and measured spectra. A quantum

chemistry simulation reveals several additional absorption bands in the spectral range 250-1400 nm. There is a clear correlation between the intensities of these bands and the number of substituted phenyl groups. Most legibly they are observed in 1,3,4-triphenyl-1H-pyrazolo[3,4-b]-quinoline (see Figure 4) that contains three such groups, whereas in 1,3-dimethyl-4-phenyl-1Hpyrazolo[3,4-b] quinoline most of these bands are shown. An appropriate interpretation of this naturally refers to additional molecular double bonding segments C=C of the substituted phenyl groups. The corresponding absorption bands may be attributed to $\pi \rightarrow \pi^*$ electronic transition from the bonding to anti bonding molecular configuration.

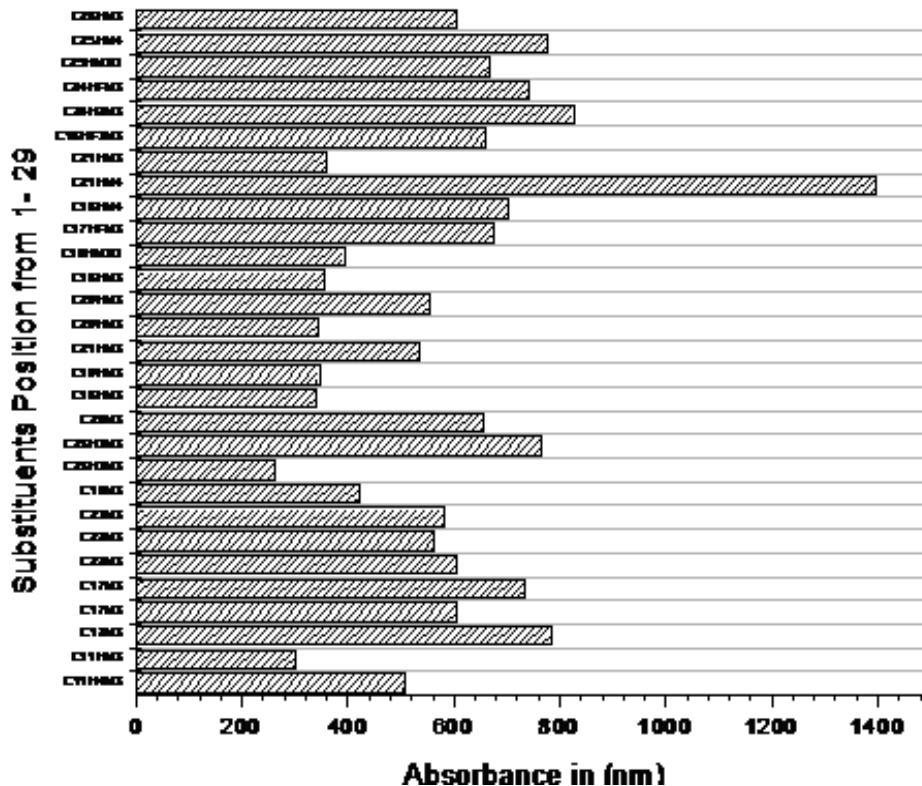


Figure. 4 Substituent vs Absorbance in (nm)

From comparisons of the raw output data of the excited state quantum descriptors with the graph of the UV-Visible spectrum graph, it was determined that the excited state with the greatest corresponding oscillator strength was very close to the wavelength of highest intensity in the absorption peak. Figures 5 to 9 shows the UV-Visible spectra of PAQ derivatives with its highest peak at 1396 nm and lowest at 263.55 nm. The collected oscillator strengths and wavelengths for all ten excited states calculated for each molecule can be found in (Table 2). It can be deduced that the oscillator strength value of the excited state is correlated with the intensity of the peak at its wavelength. The relationship between the largest oscillator strength value and absorption intensity value was determined to be linear as shown in (Figure 4).

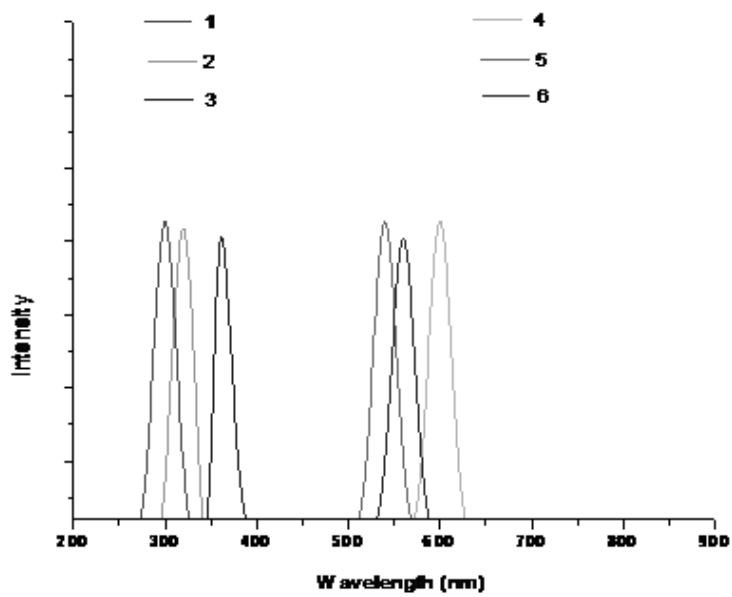


Figure. 5 Substituents 1 to 6

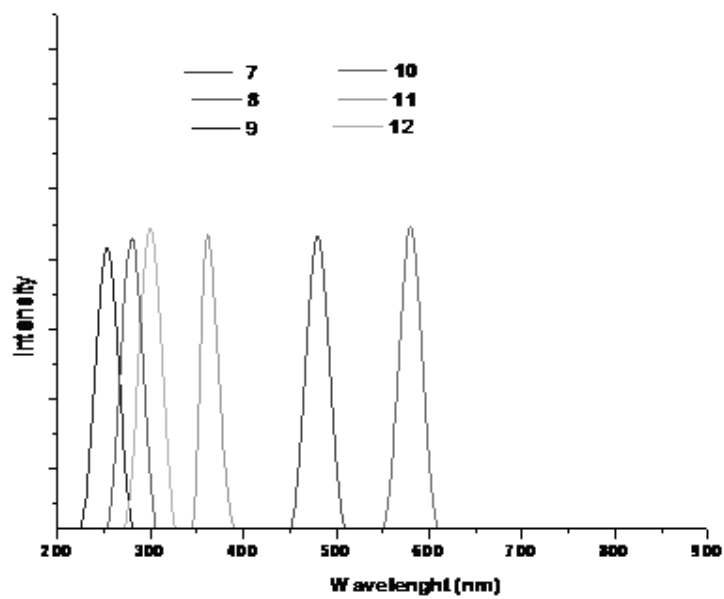


Figure. 6 Substituents 7 to 12

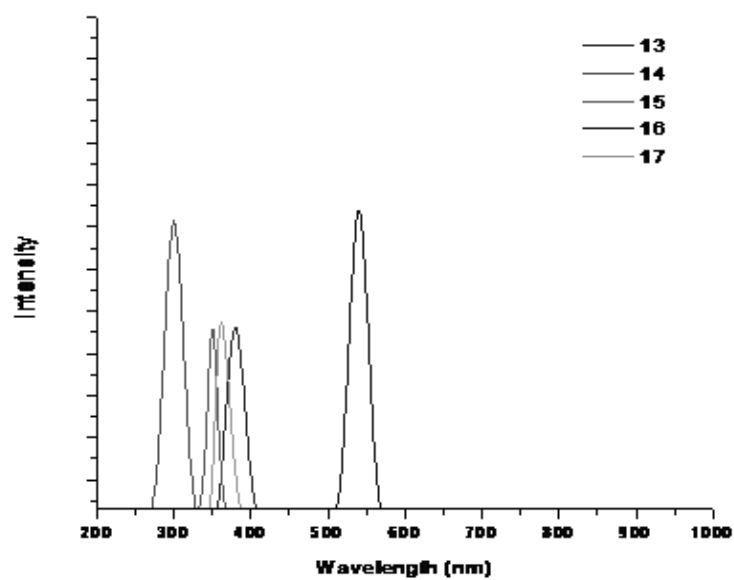


Figure. 7 Substituents 13 to 17

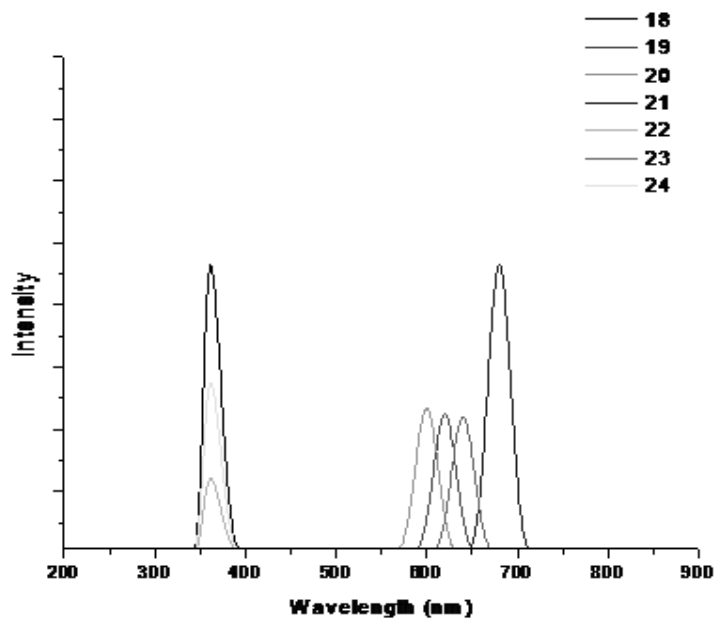


Figure. 8 Substituents 18 to 24

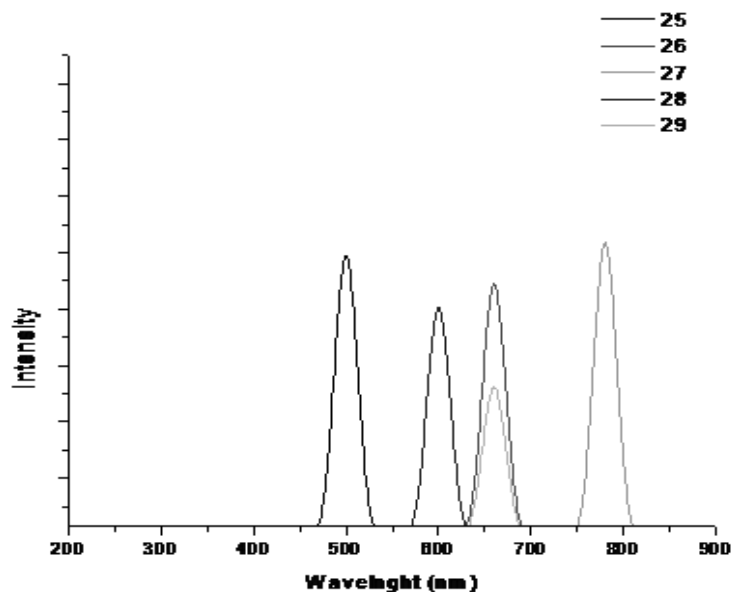


Figure. 9 Substituents 25 to 29

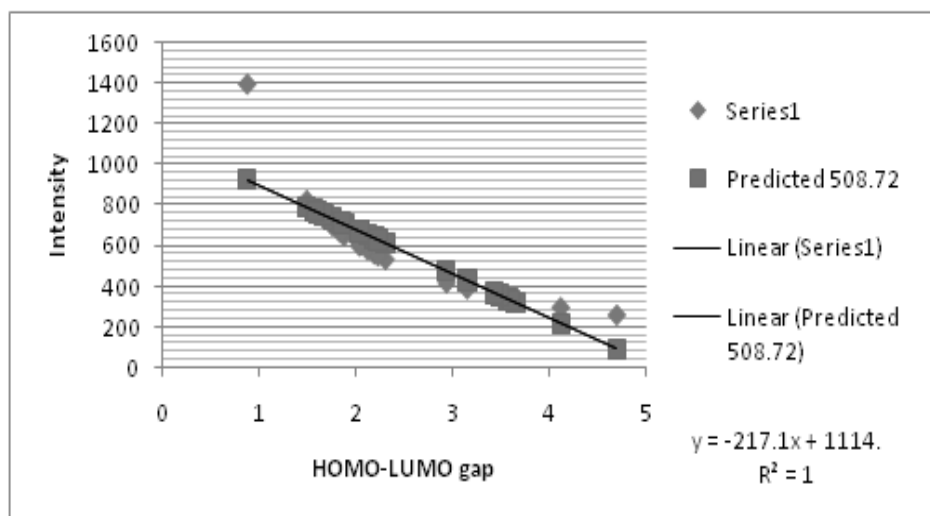


Figure. 10 Substituent vs Absorbance in (nm)

The strong correlation indicated by this set of data points supports the hypothesis that the intensity of the absorption peaks in the spectra are directly proportional to the oscillator strength of the excited state. From looking at the largest oscillator strength values, it was also determined that higher level excited states, rather than the first excited

state, contributed most to the peak intensity of the absorption peaks in the UV-Visible spectrum. Common excited state levels with the largest oscillator strengths ranged from $n=5$ to $n=9$. All the peak wavelengths ranged from approximately 263.55 nm to 1396 nm with excitation energies (EE) that ranged from 0.88800 eV to 4.1250 eV. The values for oscillator strengths ranged from 0.2271 to 1.9189 (f).

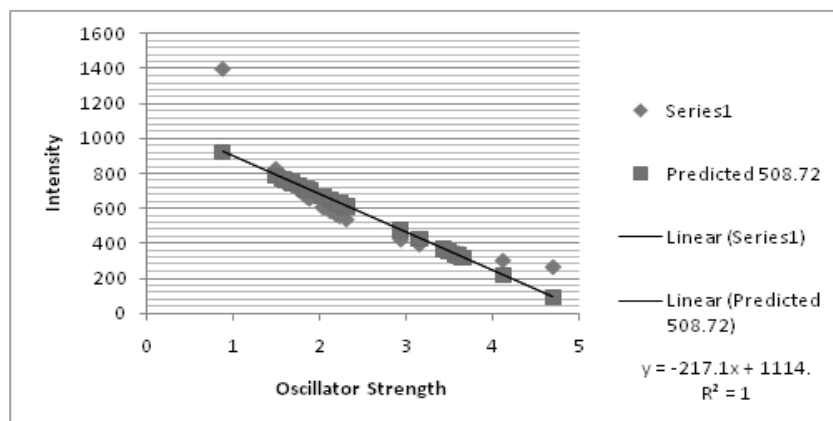


Figure. 11 Linear regression :Intensity Vs Oscillator Strength

4. Conclusion

The prediction of UV spectral intensity should be a useful computational tool in organic Chemistry. This capability would add to the armamentarium of spectroscopy for analytical chemists bring to the increasing need for data in support of high throughput organic synthesis. The development of highly significant QSAR or QSPR equations by extraction of molecular descriptors from large descriptor spaces has been successful for the prediction of many physical properties and biological activity of chemical compounds [20]. The present work demonstrates that analogous QSPR equations can be developed for the prediction of UV absorption area. Importantly, the descriptors employed in the best correlation equations are clearly relevant to the physical nature of UV absorption process. Various properties of excited state luminescent molecules were calculated including, HOMO-LUMO gap, oscillator strength, and peak wavelength and these quantum descriptors were paired with one another in order to find correlations. Strong linear regressions were found for intensity vs. LUMO-HOMO gap, oscillator strength vs. LUMO-HOMO gap. These relationships help to estimate any of these quantum descriptors for the prediction of these properties of other unknown luminescent compounds.

ACKNOWLEDGEMENTS

The authors are thankful to Vaniyambadi Muslim Educational Society for providing necessary facilities to carry-out this research work.

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Quantitative Structure Activity Relationship Analysis of N-nitroso-2,6-diarylpiperidin-4-one Semicarbazone Analogues

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Abstract

According to the *Similarity Principle* compounds with similar chemical structures usually possess similar physicochemical properties and biological activities. This is an underlying assumption when building Quantitative Structure Activity Relationship (QSAR) models and using them for making predictions for new compounds. Reported Biological activity measurements in terms of Inhibitive Concentration (IC_{50}) for a series of N-nitroso-2,6-diphenyl piperidin-4-one semicarbazones were obtained. QSAR analysis was performed on these compounds for variation in properties against the biological activity value. The results were in good agreement with the experimental values and a straight line was obtained when the two values were plotted on a 2D graph for the 13 molecules analysed.

1. Introduction

If a molecule displays interesting biological profile then it can very well be incorporated into a process starting from chemical synthesis to modulation of structure and finally ending up as a drug with better specificity. The process is started when the chemist conceives a hypothesis which relates the chemical features of the molecule to the biological activity. Without a detailed understanding of the biochemical process responsible for activity, the hypothesis generally is refined by examining structural similarities and differences for active and inactive molecules. Compounds are selected for synthesis based on features (or functional groups) that are believed to be responsible for activity.

The use of Quantum Chemical and Molecular Properties Descriptors has been widely accepted to account for the various types of activities of the molecule and is found useful in predicting the activities of other derivatives hitherto unknown [1]. The synthesis, in-vitro anti-aggregation and in-vivo anti-thrombosis activity of 20

hexahydropyrazino[10,20:1,6] pyrido [3,4-b]indole-1,4-dions (5a-t) as potential anti-thrombosis agents were reported in a study by Jiawang Liu et al. [2]. Two intermediates (tetrahydro-b-carboline-3-carboxy- L-amino acid benzylesters, 2-aminoacyltetrahydro-b-carboline-3-carboxylic acid benzylesters) were prepared and used for the cyclization to form cyclic molecules. A QSAR analysis was performed on these 20 compounds by using molecular descriptors generated by e-dragon server. Although the activities of these compounds are weakly correlated with the logP values, the QSAR analysis revealed that the anti-thrombotic activity of these compounds could be explained by their steric and electrostatic effects.

The ability of Projection Pursuit Regression (PPR) for the prediction of the binding affinities of some compounds to $\beta 1$ isoform of human thyroid hormone receptor (TR $\beta 1$) was carried out successfully using QSAR [3]. These compounds were of special interest because of their potential role in safe therapies for nonthyroid disorders while avoiding the cardiac side effects. Using the calculated structural descriptors by CODESSA (COmprehensive DEscriptors for Structural and Statistical Analysis) program, Principal Component Analysis (PCA) was performed on the whole compounds to assist the separation of the data into the training set and the test set in QSAR analysis. Six molecular descriptors selected by genetic algorithm (GA) were used as inputs for a PPR study to develop a more accurate QSAR model. The PPR model performed well both in the fitting and prediction capacity. For the test set, it gave a predictive correlation coefficient (R) of 0.9450, root mean square error (RMSE) of 0.4498, and absolute average relative deviation (AARD) of 4.19%, respectively.

In a slightly advanced technique of QSAR, a Genetic Algorithm-Kernel Partial Least Square (GA-KPLS), as a novel nonlinear feature selection method was performed by Mehdi et al. [4]. This technique combined Genetic Algorithms (GAs) as powerful optimization methods with KPLS as a robust nonlinear statistical method for variable selection. This feature selection method was combined with artificial neural network to develop a nonlinear QSAR model for predicting activities of a series of substituted aromatic sulfonamides as carbonic anhydrase II (CA II) inhibitors.

Another novel method called Molecular Maps of atom-level properties (MOLMAPs) was developed by Gupta et al. [5] to represent the diversity of chemical bonds existing in a molecule. Chemical relativity was primarily determined by the properties of bonds available in the molecule, as it related to the ability of bond breaking and bond making. In order to use physicochemical properties of individual bonds for an entire molecule, and at the same time having a fixed-length molecular representation, all the bonds of a molecule are mapped into a fixed-size 2D self-organizing map (MOLMAP). The application of MOLMAP descriptors to QSAR, with a study of the radical scavenging activity of 47 naturally occurring phenolic antioxidants was very well documented.

After designing some molecules based on structures of natural antioxidants, vitamin E (α -tocopherol) and uric acid, a series of substituted hydroxyphenylureas were synthesized [6]. As these compounds exhibited high inhibitory activity against lipid peroxidation, an insight into the mechanism of the inhibition reaction was obtained by analyzing their structure-activity relationships quantitatively. Electronic and steric effects of substituents on the phenolic hydroxyl group were shown to be of importance in governing the inhibitory potency. An increase in the electron donating property of substituents toward the phenolic hydroxyl group was found to enhance the antioxidative activity by the stabilization of an electron-deficient radical-type transition state. The steric shielding by ortho-substituents stabilized the phenoxy radicals formed following the transition state. Derivatives having the carboxyl group were found to be weakly active presumably because of an intermolecular ion-dipole interaction of the phenolic hydroxyl group with the carboxylate anion which could have retarded the formation of the transition state.

A QSAR toxicity analysis was performed by Malakhat et al. [7] for a series of 19 alkaloids with the lycoctonine skeleton. GA-MLRA (Genetic Algorithm combined with Multiple Linear Regression Analysis) technique was applied for the generation of two types of QSARs. The TPSA (Topological Polar Surface Area) and nC=O (number of -C(O)- fragments) parameters gave the best statistically significant mono- and bidescriptor models confirming the importance of H-bonding capability of the alkaloids for binding at the receptor site.

A multiple linear regression analyses was used to build QSAR models for nucleoside analogues [8] using Density Functional Theory (DFT) and Molecular Mechanics (MM+) based descriptors in both gas and solvent phases.

A few novel thiono and seleno phosphoramidate compounds with the general formula were prepared and characterized by Saeed et al [9] by ^1H , ^{31}P and ^{13}C NMR and IR spectroscopy and elemental analysis. ^{31}P chemical shift of thiono and seleno derivatives were not significant because of the little difference in electronegativity sulfur and selenium.

With enough studies on QSAR, a brief historical perspective was attempted by Schultz et al. [10]. The history of the use of QSARs in toxicology, both for environmental and human health effects was described. The 2,6-disubstituted piperidones form a biologically important class of compounds due to their pharmacological activities and their presence in a variety of alkaloids [11] and were also found to possess anticonvulsant property [12]. Based on the minimum inhibition values obtained, a linear regression analysis [13] is conducted with the calculated properties from semi empirical methods. The study may assist in exploring the energy landscape and free energy simulations can be used to compute the relative binding free energies of a series of drugs [14].

2. Theoretical Background

Various mathematical methods have been used to derive QSAR models but perhaps the most widely used technique is linear regression. The simplest type of linear regression equation has the following form:

$$y = mx + c$$

In this equation, y is called the dependent variable with x being the independent variable. In QSAR or QSPR y would be the property that one was trying to model (such as the biological activity) and x would be a molecular descriptor such as $\log P$ or a substituent constant. The aim of linear regression is to find values for the coefficient m and the constant c that minimise the sum of the differences between the values predicted by the equation and the actual observations. The values of m and c are given by the following equations [15] (in which N is the number of data values):

$$m = \frac{\sum_{i=1}^N [x_i - \langle x \rangle] [y_i - \langle y \rangle]}{\sum_{i=1}^N [x_i - \langle x \rangle]}$$

The line described by the regression equation passes through the point $(\langle x \rangle, \langle y \rangle)$ where $\langle x \rangle$ and $\langle y \rangle$ are the means of the independent and dependent variables respectively. If there is more than one independent variable then the method is referred to as multiple linear regression and when there is just one independent variable the term simple linear regression is applied.

Hansch was probably the first [16] to use QSARs to explain the biological activity of series of structurally related molecules. Hansch pioneered the use of descriptors related to a molecule's electronic characteristics and to its hydrophobicity. This led to the proposal that biological activity could be related to the molecular structure via equations of the following form:

$$\text{Log} \left(\frac{1}{C} \right) = K_1 \log P + K_2 \sigma + K_3$$

where C is the concentration of compound required to produce a standard response in a given time, $\log P$ is the logarithm of the molecule's partition coefficient between 1-octanol and water and σ is the appropriate Hammett substitution parameter. This formalism expresses both sides of the equation in terms of free energy. An alternative formulation of this equation uses the parameter π , which is the difference between the $\log P$ for the compound and the analogous hydrogen-substituted compound:

$$\log \left(\frac{1}{C} \right) = K_1 \Pi + K_2 \sigma + K_3; \quad \Pi = \log P_x - \log P_H$$

Another important breakthrough was Hansch's proposal that the activity was parabolically dependent on $\log P$:

$$\log \left(\frac{1}{C} \right) = K_1 (\log P)^2 + K_2 (\log P) + K_3 \sigma + K_4$$

Hammett and others had shown that for related compounds reaction rates and positions of equilibrium could be quantified using equations of the following form [17]:

$$\log \left(\frac{k}{k_\sigma} \right) = \rho \sigma$$

These equations express the rate (k) or equilibrium (K) constant for a particular substituent relative to that for a reference compound (indicated using the subscript 0 and typically that for which the substituent is hydrogen). The substituent parameter ρ is determined by the nature of the substituent and whether it is meta or para to the carboxylic acid or ester group on the aromatic ring. The reaction constant ρ is fixed for a particular process with the standard reaction being the dissociation of benzoic acids ($\rho = 1$).

A QSAR generally takes the form of a linear equation representing

$$\text{Biological Activity} = \text{Const} + (C_1^* P_1) + (C_2^* P_2) + \dots + (C_n^* P_n)$$

where the parameters P_1 through P_n are computed for each molecule in the series and the coefficients C_1 through C_n are calculated by fitting variations in the parameters and the biological activity. Variation in the data is quantified by the correlation coefficient, r , which measures how closely the observed data tracks the fitted regression line. Errors in either the model or in the data will lead to a bad fit. This indicator of fit to the regression line is calculated as:

$$r^2 = \frac{\text{Regression Variance}}{\text{Original Variance}}$$

where the Regression Variance is defined as the Original Variance minus the Variance around the regression line. The Original Variance is the sum-of-the-squares distances of the original data from the mean.

3. Methodology and Computational details:

The Geometry Optimisation was done using MOPAC 2007 [18]. The COSMO [19] (CONductor like Screening MOdel) values were tabulated. Since most of the drugs work with solvents the values of Cosmo Area and Cosmo Volume were taken as QM descriptors to predict the activity of the molecule [20]. The Molecular Modelling Programme used was Accelrys' Discovery Studio Viewer Pro [21]. The descriptors used in the analysis were Polarisability, Jurs Surface Area [22], Molecular Volume

and ALogP98 [23]. The Regression Analysis was done using the beta version of *Build* QSAR programme [24]. The other log P values have been calculated using the VCCLAB [25] and Molinspiration [26] programmes.

4. Result and Discussion

The general structure representing thirteen molecular systems is given in Fig.1 and details in Table 1. The geometry optimisation and the values obtained from the semi-empirical calculations are shown in Table 2, which contains the substituent details obtained from Nagarajan [27]. If all the values from Table 2 were taken for the generation of the model the following equation was obtained.

$$\begin{aligned} \text{MIC} = & -0.00280 (\pm 0.00763)\text{Heat} + 0.20618 (\pm 0.25952)\text{Dipole} \\ & -90.36277 (\pm 287.11583)\text{IP} - 90.79538 (\pm 287.12387)\text{HOMO} \\ & -0.92640 (\pm 0.73327)\text{LUMO} + 0.00221 (\pm 0.02304)\text{CosmoAr} \\ & -0.00184 (\pm 0.02021)\text{CosmoVol} - 0.03048 (\pm 11.108643) \end{aligned} \quad (1)$$

$$(n = 011; r = 0.957; s = 0.145; F = 4.653; Q2 = 0.617; SPRESS = 0.634)$$

This gave a very good r value of about 0.957. But, since the number of compounds taken were only 11, the number of descriptors had to be reduced. As per the requirements of the QSAR analysis the number of descriptors has to be in a proportion to get the best fit [28]. Hence only 4 descriptors were taken based on the highest r value [29]. This was done by removing a descriptor which produced lowest r value. The electronic descriptors like IP and Dipole Moment are useful in determining the effects of a drug on a substrate through electronic means [30]. LUMO is a state where electrons can be accommodated for any activity and COSMO values will indicate the behaviour of the molecule in a solution-like environment. The following equation was obtained with ($r = 0.941$).

$$\begin{aligned} \text{MIC} = & +0.14397 (\pm 0.12720)\text{Dipole} + 0.46390 (\pm 0.59589)\text{IP} \\ & -0.80622 (\pm 0.45125)\text{LUMO} + 0.00212 (\pm 0.00400)\text{CosmoAr} \end{aligned} \quad (2)$$

$$-0.97303 (\pm 6.837809)$$

$$(n = 011; r = 0.941; s = 0.120; F = 11.498; Q2 = 0.280; SPRESS = 0.299)$$

A commonly used method of cross validation in chemometrics is the *leave-one-out* method. The idea behind this method is to predict the property value for a compound

from the data set, which is in turn predicted from the regression equation calculated from the data for all other compounds. Using this method the following equation is obtained which has the best r value and a lower SPRESS value:

$$\begin{aligned} \text{MIC} = & +0.13112 (\pm 0.08926)\text{Dipole} + 0.42148 (\pm 0.41659)\text{IP} \\ & -0.77056 (\pm 0.31575)\text{LUMO} + 0.00127 (\pm 0.00288)\text{CosmoAr} \\ & -0.20730 (\pm 4.806874) \end{aligned} \quad (3)$$

($n = 010$; $r = 0.971$; $s = 0.081$; $F = 20.563$; $Q2 = 0.499$; $SPRESS = 0.238$)

The other set of descriptors were generated using the Discovery Studio Viewer Pro. The descriptors (Table 5) were chosen based on their activity related to these compounds. A Log P 98 is an implementation of the atom-type-based A Log P (the octanol / water partition coefficient) method using the latest set of parameters. Other descriptors that were generated using the online software, molinspiration are presented in the Table 3. These values were also included in generating models, but were ineffective. Only four of the above descriptors that include A LogP98, Polarisability, Molar Volume and Jurs Total Polar Surface Area were chosen for generating the model, since only 11 compounds were in the data set.

$$\begin{aligned} \text{MIC} = & +0.51003 (\pm 0.62276)\text{ALOGP98} - 0.00003 (\pm 0.00042)\text{Polzblty} \\ & -0.00332 (\pm 0.01559)\text{MolVol} - 0.00031 (\pm 0.00591)\text{JTPSA} \\ & +3.60403 (\pm 2.092566) \end{aligned} \quad (4)$$

($n = 011$; $r = 0.792$; $s = 0.215$; $F = 2.529$; $Q2 = 0.789$; $SPRESS = 0.472$)

The LOO method was again adopted to find out the best possible QSAR equation and the final equation was obtained as:

$$\begin{aligned} \text{MIC} = & +0.33131 (\pm 0.29458)\text{ALOGP98} - 0.00089 (\pm 0.00627)\text{MolVol} \\ & -0.00604 (\pm 0.00616)\text{JTPSA} + 3.51641 (\pm 1.279836) \end{aligned} \quad (5)$$

($n = 010$; $r = 0.911$; $s = 0.143$; $F = 9.752$; $Q2 = 0.574$; $SPRESS = 0.226$)

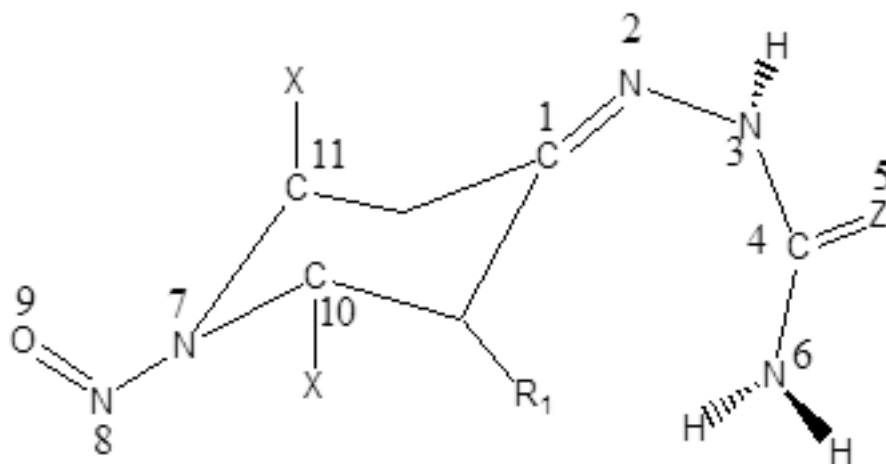


Fig. 1 Substituents and general Structure

Scheme .1: Substituents and numbering as in Fig. 1

3a. X=Ph; Z=O

3b. X=Ph; R₁=CH₃; Z=O

3h. X=Ph-Cl (ortho); R₁=CH₃; Z=O

3c. X=Ph-Cl (para); R₁=CH₃; Z=O

3g. X=Ph-F (para); R₁=CH₃; Z=O

3j. X=Ph-OCH₃ (para); R₁=CH₃; Z=O

3d. X=Ph; R₁=C₂H₅; Z=O

3f. X=Ph-OCH₃ (para); R₁=C₂H₅; Z=O

3i. X=Ph-Cl (para); R₁=C₂H₅; Z=O

3e. X=Ph; R₁=Iso Propyl; Z=O

4a. X=Ph; R₁=CH₃; Z=S

4b. X=Ph-OCH₃ (para); R₁=CH₃; Z=S

4c. X=Ph-OCH₃ (para); R₁=C₂H₅; Z=S

| S.No | Compd. | Molecular Formula | R | X | Z | IC (μM) | MIC ^a |
|------|--------|--------------------------|---------------|----------------------|---|----------------|------------------|
| 1 | 3a | $C_{18}H_{19}N_5O_2$ | H | C_6H_5 | O | 60 | 4.2218 |
| 2 | 3b | $C_{19}H_{21}N_5O_2$ | CH_3 | C_6H_5 | O | 92 | 4.0362 |
| 3 | 3h | $C_{19}H_{19}N_5O_2Cl_2$ | CH_3 | $C_6H_5Cl - o$ | O | 28 | 4.5528 |
| 4 | 3c | $C_{19}H_{19}N_5O_2Cl_2$ | CH_3 | $C_6H_5Cl - p$ | O | 18 | 4.7447 |
| 5 | 3g | $C_{19}H_{19}N_5O_2F_2$ | CH_3 | $C_6H_5F - p$ | O | 25 | 4.6021 |
| 6 | 3j | $C_{21}H_{25}N_5O_4$ | CH_3 | $C_6H_5 - OCH_3 - p$ | O | T1 | T1 |
| 7 | 3d | $C_{20}H_{23}N_5O_2$ | C_2H_5 | C_6H_5 | O | 75 | 4.1249 |
| 8 | 3f | $C_{22}H_{27}N_5O_4$ | C_2H_5 | $C_6H_5 - OCH_3 - p$ | O | 84 | 4.0757 |
| 9 | 3i | $C_{20}H_{21}N_5O_2Cl_2$ | C_2H_5 | $C_6H_5Cl - p$ | O | T2 | T2 |
| 10 | 3e | $C_{21}H_{25}N_5O_2$ | $-CH(CH_3)_2$ | C_6H_5 | O | 32 | 4.4948 |
| 11 | 4a | $C_{19}H_{21}N_5OS$ | CH_3 | C_6H_5 | S | 17 | 4.7695 |
| 12 | 4b | $C_{21}H_{25}N_5O_3S$ | CH_3 | $C_6H_5 - OCH_3 - p$ | S | 28 | 4.5528 |
| 13 | 4c | $C_{22}H_{27}N_5O_3S$ | C_2H_5 | $C_6H_5 - OCH_3 - p$ | S | 22 | 4.6575 |

^a Negative Logarithmic value of IC value

Table. 1 Compounds (numbered according to Fig. 1 & Scheme 1) and their molecular formulae, T refers to Test in the model

| S No. | Compd. | Heat of Formation (kcal) | Dipole Moment (Debye) | IP | Homo (eV) | Lumo (eV) | Cosmo Area (\AA^2) | Cosmo Vol. (\AA^3) | Mol. Weight |
|-------|---------|--------------------------|-----------------------|-------|-----------|-----------|-------------------------------|-------------------------------|-------------|
| 1 | 3a | 40.8467 | 1.5376 | 9.318 | -9.319 | 0.141 | 338.38 | 400.5 | 337.380 |
| 2 | 3b | 37.5087 | 1.8448 | 9.333 | -9.334 | 0.143 | 346.54 | 421.46 | 351.407 |
| 3 | 3h | 19.2580 | 2.6204 | 9.256 | -9.256 | -0.115 | 353.21 | 445.73 | 420.297 |
| 4 | 3c | 20.7082 | 1.8612 | 9.478 | -9.479 | -0.239 | 384.58 | 468.03 | 420.297 |
| 5 | 3g | -54.1100 | 1.7696 | 9.451 | -9.45 | -0.134 | 362.43 | 441.38 | 387.388 |
| 6 | 3j(T-1) | -39.5691 | 1.4205 | 8.891 | -8.891 | 0.177 | 404.39 | 485.28 | 411.460 |
| 7 | 3d | 27.0372 | 2.0309 | 9.236 | -9.236 | 0.268 | 371.2 | 443.31 | 365.434 |
| 8 | 3f | -50.0130 | 1.4509 | 8.808 | -8.809 | 0.311 | 429.2 | 507.01 | 425.486 |
| 9 | 3i(T-2) | 10.0812 | 2.7363 | 9.4 | -9.400 | -0.189 | 409.63 | 7489.7 | 434.324 |
| 10 | 3e | 30.0497 | 3.7038 | 9.22 | -9.227 | 0.250 | 379.71 | 460.83 | 379.461 |
| 11 | 4a | 85.6300 | 3.9955 | 8.845 | -8.846 | -0.243 | 372.16 | 439.35 | 367.468 |
| 12 | 4b | 8.5000 | 3.2684 | 8.814 | -8.814 | -0.217 | 429.8 | 503.15 | 427.520 |
| 13 | 4c | 4.2000 | 3.3412 | 8.802 | -8.802 | -0.202 | 443.49 | 526.99 | 441.547 |

Table. 2 The quantum chemical based descriptive properties of the the compounds under study

The MIC values were calculated for the compounds 3j and 3i based on the equations 3 and 6 and they are tabulated in Table 6: From the above values it is clear that QSAR equation generated through quantum chemical means gives closer values to experimental values of MIC. Hence the values were calculated as cross validation for all the compounds based on equation 3. They are given in Table 7.

| S.No | Emperical Formula | - 1/log MIC | GPCR ligand | Ion Channel | Kinase Inhibitor | Nuclear Rec. Lig | TPSA | Lipinski Violation |
|------|--------------------------|-------------|-------------|-------------|------------------|------------------|---------|--------------------|
| 1 | $C_{18}H_{19}N_5O_2$ | 4.2218 | -0.9 | -0.73 | -1.29 | -1.64 | 100.158 | 0 |
| 2 | $C_{19}H_{21}N_5O_2$ | 4.0362 | -0.89 | -0.72 | -1.29 | -1.58 | 100.158 | 0 |
| 3 | $C_{19}H_{19}N_5O_2Cl_2$ | 4.5528 | -0.82 | -0.76 | -1.28 | -1.35 | 100.158 | 0 |
| 4 | $C_{19}H_{19}N_5O_2Cl_2$ | 4.7447 | -0.83 | -0.67 | -1.19 | -1.52 | 100.158 | 0 |
| 5 | $C_{19}H_{19}N_5O_2F_2$ | 4.6021 | -0.78 | -0.64 | -1.14 | -1.43 | 100.158 | 0 |
| 6 | $C_{21}H_{25}N_5O_4$ | 4.0564 | -0.77 | -0.67 | -1.12 | -1.34 | 118.626 | 0 |
| 7 | $C_{20}H_{23}N_5O_2$ | 4.1249 | -0.87 | -0.72 | -1.37 | -1.5 | 100.158 | 0 |
| 8 | $C_{22}H_{27}N_5O_4$ | 4.0757 | -0.76 | -0.68 | -1.2 | -1.28 | 118.626 | 0 |
| 9 | $C_{20}H_{21}N_5O_2Cl_2$ | 4.7512 | -0.82 | -0.67 | -1.27 | -1.45 | 100.158 | 1 |
| 10 | $C_{21}H_{25}N_5O_2$ | 4.4948 | -0.81 | -0.65 | -1.16 | -1.54 | 100.158 | 0 |
| 11 | $C_{19}H_{21}N_5OS$ | 4.7695 | -1.2 | -1.14 | -1.52 | -1.66 | 83.087 | 0 |
| 12 | $C_{21}H_{25}N_5O_3S$ | 4.5528 | -1.03 | -1.03 | -1.33 | -1.41 | 101.555 | 0 |
| 13 | $C_{22}H_{27}N_5O_3S$ | 4.6575 | -1.02 | -1.03 | -1.4 | -1.35 | 101.555 | 0 |

Table. 3 Molecules and their drug-like properties generated from molinspiration website. GPCR is greater protein channel receptor and TPSA stands for total polar surface area.

| Eq. No. | r | r^2 | s | F | Q_2 | SPRESS |
|---------|-------|-------|-------|--------|-------|--------|
| 1 | 0.957 | 0.916 | 0.145 | 4.653 | 0.617 | 0.634 |
| 2 | 0.941 | 0.885 | 0.120 | 11.498 | 0.280 | 0.299 |
| 3 (loo) | 0.971 | 0.943 | 0.081 | 20.563 | 0.499 | 0.238 |
| 4 | 0.792 | 0.627 | 0.215 | 2.529 | 0.789 | 0.472 |
| 5 | 0.791 | 0.626 | 0.200 | 3.907 | 0.453 | 0.394 |
| 6 (loo) | 0.911 | 0.830 | 0.143 | 9.752 | 0.574 | 0.226 |

Table. 4 Some significant values from the statistical analysis

| S.No. | Compound | AlogP98 | Polarizability | Mol Volume | JTPSA | Mol Density |
|-------|----------|---------|----------------|------------|---------|-------------|
| 1 | 3a | 3.3746 | 13778.92 | 256.8 | 56.5366 | 1.31393 |
| 2 | 3b | 3.8371 | 14292.18 | 271.1 | 53.0101 | 1.29614 |
| 3 | 3h | 5.1659 | 17275.42 | 302.8 | 53.4552 | 1.38788 |
| 4 | 3c | 5.1659 | 17275.42 | 302.7 | 54.2154 | 1.38835 |
| 5 | 3g | 4.2481 | 14420.62 | 278.7 | 134.499 | 1.38987 |
| 6 | 3j (T-1) | 3.8043 | 16008.29 | 313.2 | 84.7694 | 1.31375 |
| 7 | 3d | 4.2933 | 14805.44 | 285.3 | 67.8341 | 1.28093 |
| 8 | 3f | 4.2605 | 16521.56 | 327.4 | 95.7096 | 1.29978 |
| 9 | 3i (T-2) | 5.6221 | 17788.68 | 316.9 | 67.1996 | 1.37048 |
| 10 | 3e | 4.5451 | 15318.71 | 299.6 | 64.8119 | 1.26641 |
| 11 | 4a | 4.7362 | 15609.98 | 284.2 | 15.5662 | 1.29307 |
| 12 | 4b | 4.7033 | 17326.09 | 327.8 | 34.7944 | 1.30443 |
| 13 | 4c | 5.1596 | 17839.36 | 341.9 | 42.3029 | 1.29149 |

Table. 5 Compounds and their molecular properties or constitutional descriptors

| S No | Compound | MIC | | |
|------|----------|--------|-------------|-------------|
| | | Exptl. | Calc (eq 3) | Calc (eq 6) |
| 1 | 3j (T-1) | 4.0564 | 4.1036 | 3.9861 |
| 2 | 3i (T-2) | 4.7512 | 4.7796 | 4.6911 |

Table. 6 Theoretical (by equations 3 & 6) and Experimental MIC Values

| SNo | Compound | MIC values (experimental) | MIC values (calculated) |
|-----|----------|------------------------------|----------------------------|
| 1 | 3a | 4.2218 | 4.2428 |
| 2 | 3b | 4.0362 | 4.2974 |
| 3 | 3h | 4.5528 | 4.5747 |
| 4 | 3c | 4.7447 | 4.6771 |
| 5 | 3g | 4.6021 | 4.5716 |
| 6 | 3j (T-1) | 4.0564 | 4.1036 |
| 7 | 3d | 4.1249 | 4.2168 |
| 8 | 3f | 4.0757 | 4.0008 |
| 9 | 3i (T-2) | 4.7512 | 4.7796 |
| 10 | 3e | 4.4948 | 4.4558 |
| 11 | 4a | 4.7695 | 4.7044 |
| 12 | 4b | 4.5528 | 4.6492 |
| 13 | 4c | 4.6575 | 4.6595 |

Table. 7 Calculated MIC values based on Quantum Chemical Descriptors

| SNo. | Comp | VCCLAB ^a Log P | VCCLAB Log S | Molinspiration ^b miLogP | DSV ^c AlogP98 |
|------|--------|------------------------------|-----------------|---------------------------------------|-----------------------------|
| 1 | 3a | 2.35 | -3.58 | 2.68 | 3.3746 |
| 2 | 3b | 2.75 | -3.78 | 3.15 | 3.8371 |
| 3 | 3h | 3.88 | -4.67 | 4.42 | 5.1659 |
| 4 | 3c | 3.84 | -4.66 | 4.51 | 5.1659 |
| 5 | 3g | 2.95 | -4.15 | 3.48 | 4.2481 |
| 6 | 3j -T1 | 2.77 | -3.91 | 3.27 | 3.8043 |
| 7 | 3d | 3.08 | -3.99 | 3.66 | 4.2933 |
| 8 | 3f | 3.15 | -4.12 | 3.77 | 4.2605 |
| 9 | 3i -T2 | 4.25 | -4.82 | 5.01 | 5.6221 |
| 10 | 3e | 3.68 | -4.23 | 4.65 | 4.5451 |
| 11 | 4a | 3.45 | -4.77 | 3.69 | 4.7362 |
| 12 | 4b | 3.42 | -4.73 | 3.81 | 4.7033 |
| 13 | 4c | 3.77 | -4.88 | 4.31 | 5.1596 |

^a <http://www.vcclab.org/lab/alogps/>

^b <http://www.molinspiration.com/services/logp.html>

^c Reference [23]

Table. 8 Different LogP values of all the molecules from different online methods

5. Conclusion

It can be seen from the study that quantum chemical descriptors are very useful in predicting the properties of molecules and their activity. The equations generated can be used to calculate the activity (MIC) of the molecule. The biological activity of unknown derivatives has been computed using the model generated from the QSAR fits for these type of compounds. Log P and Log S have been found to be essential in estimating the drug-likeness of the molecules. Moreover, web-based calculations of the drug-likeness of a molecule can be obtained and treated as reliable as they are generated based on huge database that is fed by many researchers across the globe.

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Kinetics of Oxidation of Pentaamminecobalt(III) Complexes of α -Hydroxy Acids and α -Amino Acids by Permonosulphuric Acid in Micellar Medium

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Abstract

The oxidation of pentaamminecobalt(III) complexes of α -hydroxy acids and α -amino acids by Permonosulphuric acid (PMS) in micellar medium yielding nearly 100% of carbonyl compounds and 100% Co(II) are ultimate products. In this reaction the rate of oxidation shows first order kinetics each in [Co(III)] and [PMS]. The unbound α -hydroxy acids and α -amino acids yield about 100% of carbonyl compounds in presence of micelles. The rate of oxidation of Co(III) complexes of both bound and unbound α -hydroxy acids and α -amino acids are enhanced more in the presence of cationic micelle of Cetyl trimethylammonium bromide (CTAB), when compared to the anionic micelle of Sodium laurylsulphate (NaLS) and non-ionic micelle of TRITON-X 100. The 1 mole of cobalt(III) complexes of α -hydroxy acids and α -amino acids reacts with nearly 0.5 mole of Permonosulphuric acid, similarly 1 mole of α -hydroxy acids and α -amino acids reacts with nearly 1 mole of Permonosulphuric acid. The reaction goes by free radical mechanism was proved by acrylonitrile polymerization. The appropriate methodology has been inducted.

Keywords: Permonosulphuric acid(PMS), α -hydroxy acids, α -amino acids, Micelles, Stoichiometry.

1. Introduction

The Kinetics studies[1-3] employing Permonosulphuric acid(PMS) is an efficient reagent for oxidation of primary and secondary alcohols to carbonyl compounds. Oxidation is an important process in organic chemistry. In recent years a variety of Permonosulphuric acid complexes have been prepared and tested to be effective oxidants [4-6]. Permonosulphuric acid is one of them. Introduction of PMS is economic and effective reagents for oxidation under mild and anhydrous conditions constitute a standing challenge. The anhydrous salt of PMS is white crystalline solid (m.p. 45° C). It is also known as Caro's acid. It is stable for some days but slowly loses ozonized

oxygen. It is strong oxidizing agent. It liberates Iodine almost instantaneously from KI. The little work has been done on PMS as oxidant in micellar medium.

A large class of organic compounds was oxidized by PMS has been reported. Since induced electron transfer in pentaamminecobalt(III) complexes of α -hydroxy acids and α -amino acids with various oxidants have been studied [7].

Induced electron transfer reactions in pentaamminecobalt(III) complexes of α -hydroxy acids and α -amino acids result in nearly 100% reduction at cobalt(III) centre with synchronous carbon-carbon bond fission and decarboxylation[8-10]. Such an electron transfer route seems to be unavailable for Permonosulphuric acid in its reaction with cobalt(III) bound and unbound α -hydroxy acids and α -amino acids to respective keto acid cobalt(III) complexes in Sodium laurylsulphate(NaLS)[11], Cetyl trimethylammonium bromide(CTAB)[12] and TRITON-X 100[13] possibly the transition state is more electron deficient. Such a transition state can be envisaged only when the C-H bond fission occurs in the slow step with hydride ion transfer. The absence of formation of cobalt(II) rules out the synchronous C-C bond fission and electron transfer to cobalt(III). The rate of PMS oxidation of cobalt(III) complexes of α -hydroxy acids and α -amino acids depends on the first power of PMS concentration. Similarly the reaction between PMS and unbound α -hydroxy acids and α -amino acids exhibits first order kinetics with respect to concentration of PMS[14]. The 1 mole of Co(III) complexes of α -hydroxy acids and α -amino acids consumes 0.5 mole of PMS, whereas 1 mole of unbound α -hydroxy acids and α -amino acids consumes 1.0 mole of PMS.

2. Experimental

The kinetics studies were carried out by allowing reactions in glass stopper corning glass vessels [15]. All ingredients of the reaction mixture were taken in separate flasks and the latter were suspended in a temperature controlled water bath. The solution of temperature pre-equilibrated Permonosulphuric acid of desired concentration was withdrawn and then immediately discharged into the reaction mixture. From this mixture 5ml of solution was titrated against sodium thiosulphate using starch as an indicator. Then this titration was continued at regular time intervals for about 75% of the reaction. The rate of the reaction ($-dc/dt$) in each kinetic run was determined by the slope of the tangent drawn at fixed concentration of Permonosulphuric acid which is written as [PMS]. The order of the reaction with respect to each reactant was determined by the relation between initial rate, that is, ($-dc/dt$) and initial [reactant].

The rate measurements were carried out on $60 \pm 0.2^\circ \text{C}$ in 100% aqueous medium for α -hydroxy acids and $27 \pm 0.2^\circ \text{C}$ for α -amino acids. The temperature was

controlled by electrically operated thermostat. The concentration of α -hydroxy acids and α -amino acids was varied in the range $[0.5 - 2.5] \times 10^2 \text{ mol dm}^{-3}$ at fixed concentrations of other reaction ingredients. A plot of initial rate versus [α -hydroxy acids] & [α -amino acids] yielded a straight line passing through the origin confirming first order dependence. The concentration of NaLS, CTAB and TRITON-X 100 was varied in the range of $[1 \times 10^{-3}, 10 \times 10^{-3}, 1 \times 10^{-4}, 5 \times 10^{-3}, 5 \times 10^{-4}] \text{ mol dm}^{-3}$ at concentrations of other reaction ingredients. A plot of initial rate versus [Micelles] yielded a straight line passing through the origin confirming first order dependence. The second order plots were also made for comparable concentrations of α -hydroxy acids, α -amino acids and micelles.

$$\begin{aligned} [\text{H}_2\text{SO}_4] &= 0.25 \text{ mol dm}^{-3} \\ [\text{NaLS}] &= 1.00 \times 10^{-3} \text{ mol dm}^{-3} \\ [\text{CTAB}] &= 1.00 \times 10^{-3} \text{ mol dm}^{-3} \\ [\text{TRITON} - \text{X100}] &= 1.00 \times 10^{-3} \text{ mol dm}^{-3} \\ \text{Temperature} &= 60 \pm 0.2^\circ \text{ C} \end{aligned}$$

| $10^3[\text{Compound}]$ mol dm^{-3} | $10^2 [\text{PMS}]_{\text{initial}}$ mol dm^{-3} | $10^2 [\text{PMS}]_{\text{final}}$ mol dm^{-3} | $\Delta 10^3 [\text{PMS}]$ mol dm^{-3} | [Compound]: $\Delta[\text{PMS}]$ |
|---|--|--|--|-------------------------------------|
| Mandelic acid | | | | |
| 1.0 | 1.0 | 0.89 | 1.10 | 1.00 : 1.10 |
| 2.0 | 2.0 | 1.80 | 2.00 | 1.00 : 1.00 |
| 4.0 | 2.0 | 1.60 | 4.00 | 1.00 : 1.00 |
| Lactic acid | | | | |
| 1.0 | 1.0 | 0.90 | 1.00 | 1.00 : 1.00 |
| 2.0 | 2.0 | 1.81 | 1.90 | 1.00 : 0.95 |
| 4.0 | 2.0 | 1.60 | 4.00 | 1.00 : 1.00 |
| Glycolic acid | | | | |
| 1.0 | 1.0 | 0.88 | 1.20 | 1.00 : 1.20 |
| 2.0 | 2.0 | 1.78 | 2.20 | 1.00 : 1.10 |
| 4.0 | 2.0 | 1.57 | 4.30 | 1.00 : 1.07 |

Table. 1 Stoichiometric data for PMS Oxidation of Co(III) bound & unbound α -hydroxy acids in the presence of NaLS, CTAB & TRITON-X 100

The reaction is first order with respect to the α -hydroxy acids and α -amino acids. The excess of the oxidant was used in kinetic runs. It gives pseudo first order rate constant. The pseudo first order rate constants calculated using the following integrated rate equations,

$$k = 2.203/t \log[a/a - x]$$

where a initial concentration of oxidant and $[a-x]$ concentration of oxidant at time t , are expressed in sec^{-1} . The values reported are averages of least two runs.

| | | |
|---------------------------------|---|---|
| $[\text{H}_2\text{SO}_4]$ | = | 0.25 mol dm^{-3} |
| $[\text{NaLS}]$ | = | $1.00 \times 10^{-3} \text{ mol dm}^{-3}$ |
| $[\text{CTAB}]$ | = | $1.00 \times 10^{-3} \text{ mol dm}^{-3}$ |
| $[\text{TRITON} - \text{X100}]$ | = | $1.00 \times 10^{-3} \text{ mol dm}^{-3}$ |
| Temperature | = | $27 \pm 0.2^\circ \text{ C}$ |

| $10^3[\text{Compound}]$ mol dm ⁻³ | $10^2 [\text{PMS}]_{\text{initial}}$ mol dm ⁻³ | $10^2 [\text{PMS}]_{\text{final}}$ mol dm ⁻³ | $\Delta 10^3 [\text{PMS}]$ mol dm ⁻³ | [Compound]: $\Delta[\text{PMS}]$ |
|---|--|--|--|-------------------------------------|
| Glycine | | | | |
| 1.0 | 1.0 | 0.89 | 1.10 | 1.00 : 1.10 |
| 2.0 | 2.0 | 1.80 | 2.00 | 1.00 : 1.00 |
| Alanine | | | | |
| 1.0 | 1.0 | 0.91 | 1.00 | 1.00 : 1.00 |
| 2.0 | 2.0 | 1.81 | 1.90 | 1.00 : 0.95 |
| Isoleucine | | | | |
| 1.0 | 1.0 | 0.88 | 1.20 | 1.00 : 1.20 |
| 2.0 | 2.0 | 1.78 | 2.20 | 1.00 : 1.07 |
| N-acetylglycine | | | | |
| 1.0 | 1.0 | 0.90 | 1.10 | 1.00 : 1.10 |
| 2.0 | 2.0 | 1.79 | 2.10 | 1.00 : 1.05 |
| N-benzoglycine | | | | |
| 1.0 | 1.0 | 0.89 | 1.10 | 1.00 : 1.10 |
| 2.0 | 2.0 | 1.79 | 2.10 | 1.00 : 1.05 |

Table. 2 Stoichiometric data for PMS Oxidation of Co(III) bound & unbound α -amino acids in the presence of NaLS, CTAB & TRITON-X 100

The stoichiometry was calculated from the ratio between reacted [oxidant] and [substrate]. The stoichiometric studies for the PMS oxidation of pentaamminecobalt(III) complexes of α -hydroxy acids and unbound ligand in the presence of micelles were carried out at $60 \pm 0.2^\circ \text{ C}$. It was observed that the cobalt(II) formation was negligibly small. The similar trends are followed in the bound & unbound ligand of α -amino acids. But the temperature was maintained at room temperature of $27 \pm 0.2^\circ \text{ C}$.

The stoichiometric results indicate that for one mole of cobalt(III) complex, about 0.5 mole of PMS is consumed, whereas with the unbound ligands for 1 mole of α -hydroxy acids & α -amino acids about 1.0 mole of PMS is consumed [16].

3. Results and Discussion

3.1. Dependence of Rate on α -Hydroxy Acids in Micellar Medium

$$\begin{aligned} [\text{PMS}] &= 0.08 \text{ mol dm}^{-3} \\ [\text{H}_2\text{SO}_4] &= 0.25 \text{ mol dm}^{-3} \\ [\text{Micelles}] &= 1.00 \times 10^{-3} \text{ mol dm}^{-3} \\ \text{Temperature} &= 60 \pm 0.2^\circ \text{ C} \end{aligned}$$

| 10^2 [α -hydroxy acids] mol dm^{-3} | $10^4 k_1$ (s^{-1}) | $10^2 k_2$ $\text{dm}^3 \text{mol}^{-1} s^{-1}$ | NaLS | | CTAB | | TRITON | |
|--|-------------------------|---|-------------------------|--|-------------------------|--|-------------------------|--|
| | | | $10^4 k_1$ (s^{-1}) | $10^2 k_2 \text{ dm}^3 \text{mol}^{-1} s^{-1}$ | $10^4 k_1$ (s^{-1}) | $10^2 k_2 \text{ dm}^3 \text{mol}^{-1} s^{-1}$ | $10^4 k_1$ (s^{-1}) | $10^2 k_2 \text{ dm}^3 \text{mol}^{-1} s^{-1}$ |
| Mandelic acid | | | | | | | | |
| 0.5 | 1.230 | 2.110 | 1.444 | 2.585 | 1.828 | 3.656 | 1.303 | 3.346 |
| 1.0 | 2.112 | 2.119 | 2.585 | 2.585 | 3.656 | 3.656 | 3.346 | 3.311 |
| 1.5 | 3.029 | 2.156 | 3.701 | 2.503 | 5.484 | 3.656 | 5.411 | 3.383 |
| 2.0 | 3.948 | 2.163 | 4.893 | 2.561 | 7.312 | 3.657 | 7.539 | 3.387 |
| 2.5 | 4.815 | 2.106 | 5.952 | 2.531 | 9.140 | 3.656 | 9.619 | 3.323 |
| Lactic acid | | | | | | | | |
| 0.5 | 1.825 | 2.776 | 2.106 | 3.235 | 2.986 | 4.926 | 2.201 | 4.420 |
| 1.0 | 2.709 | 2.775 | 3.235 | 3.265 | 4.926 | 4.926 | 4.420 | 4.431 |
| 1.5 | 3.601 | 2.706 | 4.414 | 3.276 | 6.908 | 4.958 | 6.618 | 4.461 |
| 2.0 | 4.512 | 2.708 | 5.475 | 3.217 | 8.775 | 4.937 | 8.856 | 4.467 |
| 2.5 | 5.436 | 2.706 | 6.571 | 3.228 | 10.631 | 4.912 | 10.996 | 4.409 |
| Glycolic acid | | | | | | | | |
| 0.5 | 0.999 | 1.862 | 1.133 | 2.263 | 0.808 | 2.455 | 0.605 | 2.302 |
| 1.0 | 1.862 | 1.863 | 2.263 | 2.263 | 2.455 | 2.455 | 2.302 | 2.391 |
| 1.5 | 2.778 | 1.802 | 3.340 | 2.226 | 3.874 | 2.402 | 4.091 | 2.303 |
| 2.0 | 3.628 | 1.836 | 4.460 | 2.230 | 5.548 | 2.424 | 6.005 | 2.334 |
| 2.5 | 4.509 | 1.839 | 5.561 | 2.224 | 7.259 | 2.403 | 7.883 | 2.317 |

Table. 3

The rate of permonosulphuric acid oxidation of α -hydroxy acids had been followed under pseudo first order condition by keeping excess of the α -hydroxy acids concentration than the reagent. The rate constants were calculated by the integrated rate equation. The graph of logarithm of concentration versus time was linear and the rate constants calculated from the slope of the graph agreed with the experimental value, which shows first order dependence on $[\alpha$ -hydroxy acids]. This was further substantiated from the study of changing the concentration of α -hydroxy acids from $[0.5 \text{ to } 2.5] \times 10^2 \text{ mol dm}^{-3}$ at a fixed concentration in micellar medium. The rate constants obtained for the different concentration of α -hydroxy acids were nearly a constant. Hence the rate of disappearance of α -hydroxy acids in this concentration range studied is given as (Table. 3), (Figure. 1).

$$-\frac{d}{dt}[\alpha\text{-hydroxy acids}] = k_1[\alpha\text{-hydroxy acids}] \quad (1)$$

All the kinetic runs were repeated and the rate constants were reproducible within $\pm 2\%$ range.

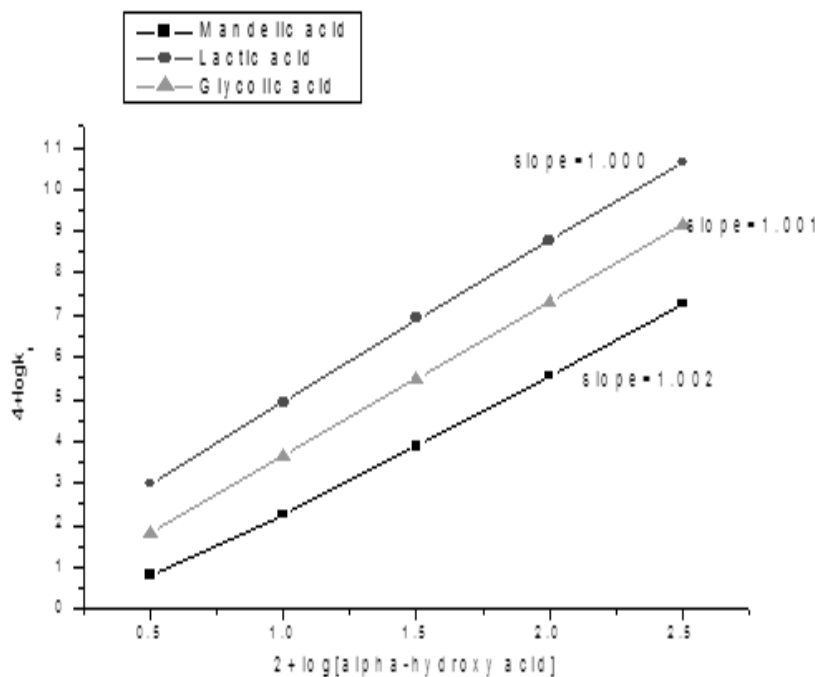


Fig. 1 Dependence of rate on $[\alpha$ -hydroxy acid] in CTAB

3.2. Dependence of Rate on Cobalt(III) Complexes of α -Hydroxy Acids in Micellar Medium

The rate of permonosulphuric acid oxidation of pentaamminecobalt(III) complexes of α -hydroxy acids had been followed under pseudo first order condition by keeping

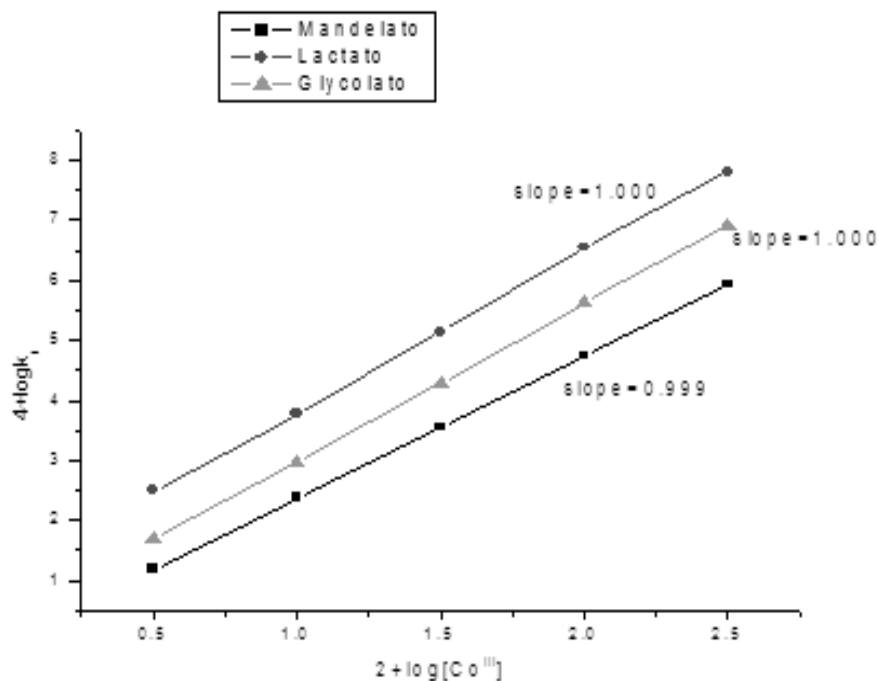


Fig. 2 Dependence of rate on [Co(III)] in NaLS

TABLE - 4

[PMS] = 0.08 mol dm⁻³
 [H₂SO₄] = 0.25 mol dm⁻³
 [Micelles] = 1.00 x 10⁻³ mol dm⁻³
 Temperature = 60 ± 0.2°C

| 10 ² [(NH ₃) ₅ Co(III) - L] mol dm ⁻³ | 10 ⁴ k ₁ (s ⁻¹) | 10 ² k ₂ dm ³ mol ⁻¹ s ⁻¹ | NaLS | | CTAB | | TRITON | |
|--|---|--|---|--|---|--|---|--|
| | | | 10 ⁴ k ₁ (s ⁻¹) | 10 ² k ₂ dm ³ mol ⁻¹ s ⁻¹ | 10 ⁴ k ₁ (s ⁻¹) | 10 ² k ₂ dm ³ mol ⁻¹ s ⁻¹ | 10 ⁴ k ₁ (s ⁻¹) | 10 ² k ₂ dm ³ mol ⁻¹ s ⁻¹ |
| Mandelato | | | | | | | | |
| 0.5 | 1.325 | 2.248 | 1.681 | 2.962 | 2.228 | 4.442 | 1.738 | 3.475 |
| 1.0 | 2.248 | 2.215 | 2.962 | 2.962 | 4.442 | 4.467 | 3.475 | 3.491 |
| 1.5 | 3.147 | 2.204 | 4.288 | 2.963 | 6.654 | 4.436 | 5.214 | 3.487 |
| 2.0 | 4.069 | 2.296 | 5.623 | 2.962 | 8.942 | 4.491 | 6.954 | 3.489 |
| 2.5 | 4.962 | 2.245 | 6.909 | 2.961 | 11.21 | 4.486 | 8.505 | 3.420 |
| Lactato | | | | | | | | |
| 0.5 | 2.102 | 3.014 | 2.486 | 3.762 | 3.956 | 6.232 | 3.059 | 5.118 |
| 1.0 | 3.014 | 3.079 | 3.762 | 3.762 | 6.236 | 6.278 | 5.118 | 5.198 |
| 1.5 | 3.948 | 3.063 | 5.144 | 3.762 | 8.558 | 6.238 | 7.136 | 5.182 |
| 2.0 | 4.804 | 3.014 | 6.552 | 3.768 | 10.852 | 6.298 | 9.037 | 5.124 |
| 2.5 | 5.702 | 3.043 | 7.801 | 3.728 | 13.051 | 6.222 | 10.884 | 5.137 |
| Glycolato | | | | | | | | |
| 0.5 | 1.025 | 1.907 | 1.183 | 2.375 | 1.131 | 3.021 | 1.102 | 2.703 |
| 1.0 | 1.907 | 1.916 | 2.375 | 2.371 | 3.021 | 3.012 | 2.705 | 2.778 |
| 1.5 | 2.814 | 1.936 | 3.560 | 2.376 | 4.924 | 3.023 | 4.308 | 2.716 |
| 2.0 | 3.748 | 1.902 | 4.750 | 2.386 | 6.933 | 3.002 | 6.002 | 2.728 |
| 2.5 | 4.602 | 1.915 | 5.935 | 2.342 | 8.959 | 3.020 | 7.516 | 2.716 |

excess of the complex concentration than the reagent. The rate constants were calculated

by the integrated rate equation. The graph of logarithm of concentration versus time was linear and the rate constants calculated from the slope of the graph agreed with the experimental value, which shows first order dependence on $[(NH_3)_5Co(III) - L]^{2+}$. This was further substantiated from the study of changing the concentration of pentaamminecobalt(III) complexes of α -hydroxy acids from $[0.5 \text{ to } 2.5] \times 10^2 \text{ mol dm}^{-3}$ at a fixed concentration in micellar medium. The rate constants obtained for the different concentration of $[(NH_3)_5Co(III) - L]^{2+}$ complexes of α -hydroxy acids were nearly a constant. Hence the rate of disappearance of complexes in this concentration range studied is given as (Figure. 2), (Table. 4).

$$-\frac{d}{dt}[(NH_3)_5Co(III) - L]^{2+} = k_1[(NH_3)_5Co(III) - L]^{2+} \quad (2)$$

All the kinetic runs were repeated and the rate constants were reproducible within $\pm 2\%$ range.

3.3. Dependence of Rate on α -Amino Acids in Micellar Medium

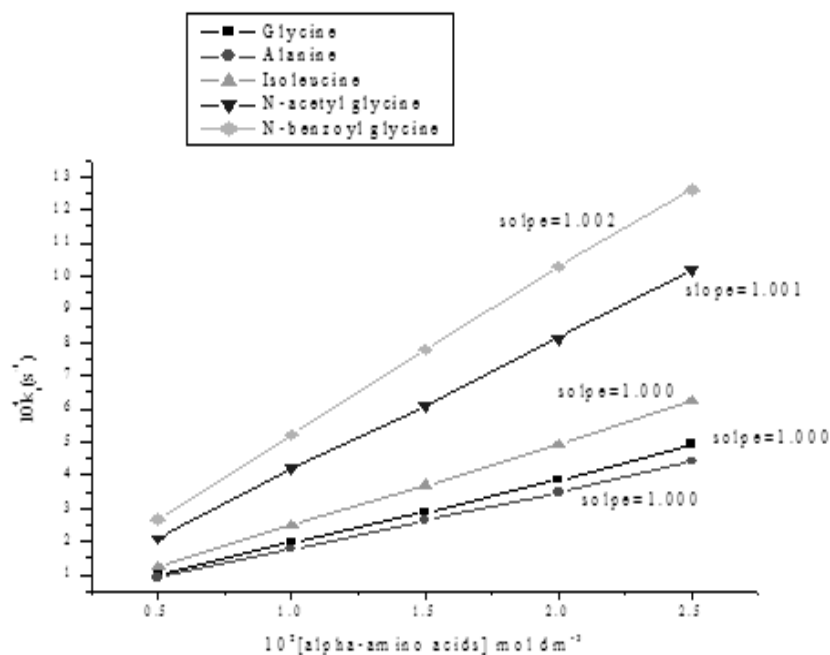


Fig. 3 Dependence of rate on $[\alpha\text{-amino acid}]$ in NaLS

TABLE - 5

| | | |
|-----------------------------------|---|--|
| [PMS] | = | 0.03 mol dm ⁻³ |
| [H ₂ SO ₄] | = | 0.25 mol dm ⁻³ |
| [Micelles] | = | 1.00 x 10 ⁻³ mol dm ⁻³ |
| Temperature | = | 27 ± 0.1°C |

| 10 ³ [α -amino acids] mol dm ⁻³ | 10 ⁴ k ₁ (s ⁻¹) | 10 ⁴ k _{obs} | NaLS | | CTAB | | TRITON | |
|--|--|----------------------------------|--|----------------------------------|--|----------------------------------|--|----------------------------------|
| | | | 10 ⁴ k ₁ (s ⁻¹) | 10 ⁴ k _{obs} | 10 ⁴ k ₁ (s ⁻¹) | 10 ⁴ k _{obs} | 10 ⁴ k ₁ (s ⁻¹) | 10 ⁴ k _{obs} |
| Glycine | | | | | | | | |
| 0.5 | 0.802 | 0.856 | 0.974 | 0.998 | 1.088 | 1.136 | 0.991 | 0.986 |
| 1.0 | 1.712 | 1.769 | 1.980 | 1.888 | 2.033 | 2.148 | 1.990 | 1.893 |
| 1.5 | 2.601 | 2.706 | 2.881 | 2.923 | 3.054 | 3.196 | 2.973 | 2.991 |
| 2.0 | 3.625 | 3.513 | 3.855 | 3.984 | 4.099 | 4.024 | 3.996 | 4.002 |
| 2.5 | 4.623 | 4.562 | 4.929 | 4.821 | 5.001 | 5.026 | 4.955 | 5.084 |
| Alanine | | | | | | | | |
| 0.5 | 0.723 | 0.869 | 0.896 | 0.923 | 0.956 | 0.942 | 0.920 | 0.891 |
| 1.0 | 1.604 | 1.568 | 1.763 | 1.836 | 1.927 | 1.956 | 1.856 | 1.894 |
| 1.5 | 2.502 | 2.601 | 2.647 | 2.726 | 2.848 | 2.938 | 2.761 | 2.632 |
| 2.0 | 3.402 | 3.488 | 3.454 | 3.526 | 3.820 | 3.986 | 3.689 | 3.768 |
| 2.5 | 4.302 | 4.416 | 4.401 | 4.498 | 4.751 | 4.882 | 4.638 | 4.592 |
| Isoleucine | | | | | | | | |
| 0.5 | 1.025 | 1.149 | 1.233 | 1.380 | 1.400 | 1.500 | 1.310 | 1.402 |
| 1.0 | 2.256 | 2.365 | 2.483 | 2.599 | 2.798 | 2.990 | 2.629 | 2.789 |
| 1.5 | 3.336 | 3.487 | 3.680 | 3.726 | 4.254 | 4.402 | 3.931 | 3.894 |
| 2.0 | 4.469 | 4.503 | 4.920 | 4.892 | 5.659 | 5.568 | 5.253 | 5.327 |
| 2.5 | 5.589 | 4.637 | 6.241 | 6.344 | 7.005 | 7.193 | 6.558 | 6.636 |
| N-acetyl glycine | | | | | | | | |
| 0.5 | 1.963 | 1.998 | 2.101 | 2.304 | 2.348 | 2.666 | 2.231 | 2.318 |
| 1.0 | 3.502 | 3.649 | 4.186 | 4.234 | 4.682 | 4.595 | 4.456 | 4.581 |
| 1.5 | 5.326 | 5.436 | 6.094 | 6.294 | 6.965 | 6.985 | 6.693 | 6.593 |
| 2.0 | 7.025 | 7.158 | 8.122 | 8.456 | 9.287 | 9.567 | 8.945 | 9.004 |
| 2.5 | 8.896 | 8.903 | 10.192 | 10.345 | 11.598 | 11.987 | 11.150 | 11.238 |
| N-benzoyl glycine | | | | | | | | |
| 0.5 | 2.314 | 2.369 | 2.665 | 2.998 | 2.984 | 3.045 | 2.831 | 2.789 |
| 1.0 | 4.199 | 4.213 | 5.199 | 5.538 | 5.890 | 6.025 | 5.665 | 5.789 |
| 1.5 | 6.256 | 6.301 | 7.778 | 7.993 | 8.760 | 8.999 | 8.403 | 8.038 |
| 2.0 | 8.256 | 8.946 | 10.292 | 10.489 | 11.487 | 11.739 | 11.312 | 11.489 |
| 2.5 | 10.236 | 10.347 | 12.604 | 12.904 | 14.401 | 14.893 | 13.913 | 14.036 |

The rate of permonosulphuric acid oxidation of α -amino acids had been followed under pseudo first order condition by keeping excess of the α -amino acids concentration

than the reagent. The rate constants were calculated by the integrated rate equation. The graph of logarithm of concentration versus time was linear and the rate constants calculated from the slope of the graph agreed with the experimental value, which shows first order dependence on $[\alpha\text{-amino acids}]$. This was further substantiated from the study of changing the concentration of $\alpha\text{-amino acids}$ from $[0.5 \text{ to } 2.5] \times 10^2 \text{ mol dm}^{-3}$ at a fixed concentration in micellar medium. The rate constants obtained for the different concentration of $\alpha\text{-amino acids}$ were nearly a constant. Hence the rate of disappearance of $\alpha\text{-amino acids}$ in this concentration range studied is given as (Table. 5), (Figure. 3).

$$-\frac{d}{dt}[\alpha\text{-amino acids}] = k_1[\alpha\text{-amino acids}] \quad (3)$$

3.4. Dependence of Rate on Cobalt(III) Complexes of $\alpha\text{-Amino Acids}$ in Micellar Medium

The rate of permonosulphuric acid oxidation of pentaamminecobalt(III) complexes of $\alpha\text{-amino acids}$ had been followed under pseudo first order condition by keeping excess of the complex concentration than the reagent. The rate constants were calculated by the integrated rate equation. The graph of logarithm of concentration versus time was linear and the rate constants calculated from the slope of the graph agreed with the experimental value, which shows first order dependence on $[(\text{NH}_3)_5\text{Co(III)} - \text{L}]^{2+}$. This was further substantiated from the study of changing the concentration of

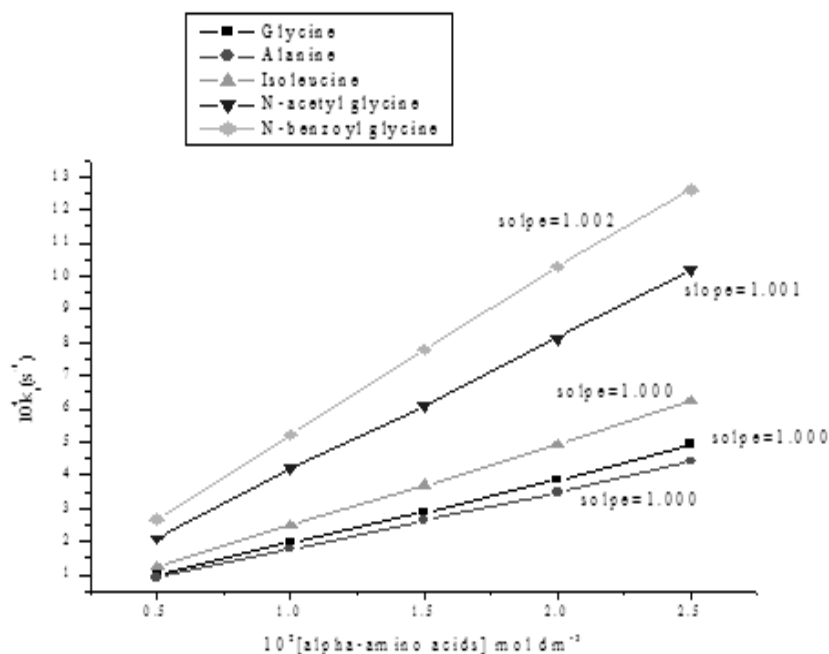


Fig. 4 Dependence of rate on $[\alpha\text{-amino acid}]$ in NaLS

TABLE - 6

| | | |
|-----------------------------------|---|--|
| [PMS] | = | 0.08 mol dm ⁻³ |
| [H ₂ SO ₄] | = | 0.25 mol dm ⁻³ |
| [Micelles] | = | 1.00 x 10 ⁻³ mol dm ⁻³ |
| Temperature | = | 27 ± 0.2°C |

| 10 ² [(NH ₄) ₂ Co(III)-L] mol dm ⁻³ | 10 ⁴ k ₁ (s ⁻¹) | 10 ⁴ k _{act} | NaLS | | CTAB | | TRITON | |
|--|---|----------------------------------|---|----------------------------------|---|----------------------------------|---|----------------------------------|
| | | | 10 ⁴ k ₁ (s ⁻¹) | 10 ⁴ k _{act} | 10 ⁴ k ₁ (s ⁻¹) | 10 ⁴ k _{act} | 10 ⁴ k ₁ (s ⁻¹) | 10 ⁴ k _{act} |
| Glycinato | | | | | | | | |
| 0.5 | 1.026 | 1.123 | 1.204 | 1.368 | 1.567 | 1.678 | 1.396 | 1.409 |
| 1.0 | 2.123 | 2.016 | 2.498 | 2.567 | 3.089 | 3.189 | 2.792 | 2.846 |
| 1.5 | 3.236 | 3.360 | 3.631 | 3.563 | 4.567 | 4.609 | 4.146 | 4.087 |
| 2.0 | 4.356 | 4.469 | 4.834 | 4.987 | 6.024 | 6.193 | 5.584 | 5.698 |
| 2.5 | 5.402 | 5.506 | 5.990 | 5.891 | 7.498 | 7.590 | 6.903 | 6.876 |
| Alaninato | | | | | | | | |
| 0.5 | 0.869 | 0.926 | 1.126 | 1.283 | 1.367 | 1.490 | 1.228 | 1.294 |
| 1.0 | 1.900 | 1.963 | 2.298 | 2.323 | 2.599 | 2.678 | 2.456 | 2.567 |
| 1.5 | 2.963 | 2.999 | 3.357 | 3.206 | 3.814 | 3.908 | 3.686 | 3.578 |
| 2.0 | 4.102 | 4.206 | 4.567 | 4.987 | 5.203 | 5.199 | 4.912 | 5.012 |
| 2.5 | 5.102 | 5.214 | 5.641 | 5.418 | 6.408 | 6.000 | 6.165 | 6.292 |
| Isoleucinato | | | | | | | | |
| 0.5 | 1.431 | 1.526 | 1.783 | 1.670 | 1.906 | 1.897 | 1.852 | 1.936 |
| 1.0 | 2.632 | 2.763 | 3.378 | 3.276 | 3.859 | 3.894 | 3.704 | 3.213 |
| 1.5 | 3.896 | 3.990 | 4.890 | 4.906 | 5.794 | 5.367 | 5.594 | 5.356 |
| 2.0 | 5.021 | 5.147 | 6.368 | 6.287 | 7.637 | 6.736 | 7.409 | 7.248 |
| 2.5 | 6.321 | 6.178 | 7.891 | 7.704 | 9.521 | 8.209 | 9.261 | 8.109 |
| N-acetylglycinato | | | | | | | | |
| 0.5 | 2.203 | 2.103 | 2.551 | 2.684 | 2.812 | 2.976 | 2.671 | 2.756 |
| 1.0 | 3.862 | 3.896 | 4.985 | 4.812 | 5.467 | 5.678 | 5.342 | 5.248 |
| 1.5 | 5.569 | 5.613 | 7.394 | 7.494 | 7.907 | 7.821 | 7.964 | 7.890 |
| 2.0 | 7.236 | 7.490 | 9.789 | 9.804 | 10.678 | 10.726 | 10.678 | 10.730 |
| 2.5 | 8.802 | 8.901 | 12.122 | 12.275 | 13.097 | 13.245 | 13.132 | 12.424 |
| N-benzoylglycinato | | | | | | | | |
| 0.5 | 2.963 | 2.996 | 3.295 | 3.398 | 3.504 | 3.670 | 3.401 | 3.513 |
| 1.0 | 4.856 | 4.963 | 6.399 | 6.489 | 6.842 | 6.829 | 6.708 | 6.789 |
| 1.5 | 6.789 | 6.846 | 9.458 | 9.563 | 10.001 | 10.176 | 9.789 | 9.876 |
| 2.0 | 8.621 | 8.703 | 12.569 | 12.678 | 13.274 | 13.356 | 12.804 | 13.536 |
| 2.5 | 10.236 | 10.364 | 15.674 | 15.784 | 16.594 | 16.601 | 15.603 | 15.146 |

pentaamminecobalt(III) complexes of α -amino acids from $[0.5 \text{ to } 2.5] \times 10^2 \text{ mol dm}^{-3}$ at a fixed concentration in micellar medium. The rate constants obtained for the different concentration of $[(\text{NH}_3)_5\text{Co}(\text{III}) - \text{L}]^{2+}$ complexes of α -amino acids were nearly a constant. Hence the rate of disappearance of complexes in this concentration range studied is given as (Table. 6), (Figure. 4).

$$-\frac{d}{dt}[(\text{NH}_3)_5\text{Co}(\text{III}) - \text{L}]^{2+} = k_1[(\text{NH}_3)_5\text{Co}(\text{III}) - \text{L}]^{2+} \quad (4)$$

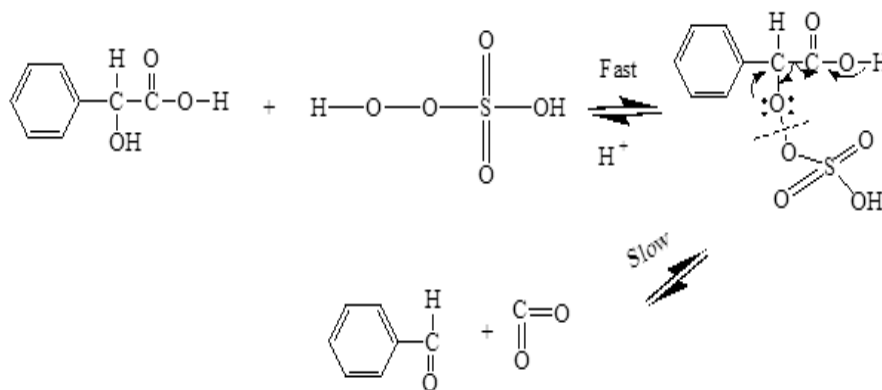
All the kinetic runs were repeated and the rate constants were reproducible within $\pm 2\%$ range.

4. Mechanism

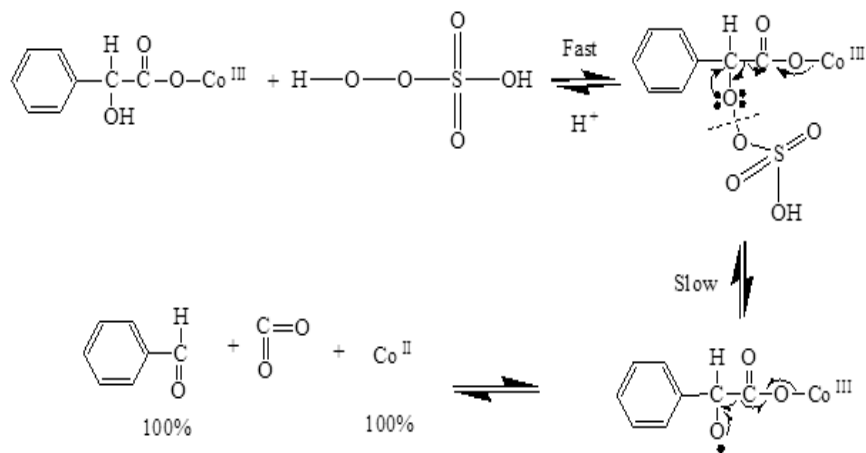
4.1. Mechanism of PMS oxidation of pentaamminecobalt(III) complexes of both bound and unbound α -hydroxy acids in micellar medium

PMS oxidizes OH centre of the α -hydroxy acids at a rate of comparable to that of the free ligand. There is 100% reduction at the Proton centre, forms a permonosulphuric acid ester which can decompose in a slow step, proceeds through C-C bond fission leading to the formation of carbonyl compounds with the evolution of carbon dioxide and H_2 gas.

Considering these facts and findings with these results, the following reaction schemes has been proposed for the PMS oxidation of pentaamminecobalt(III) complexes of both bound and unbound α -hydroxy acids.



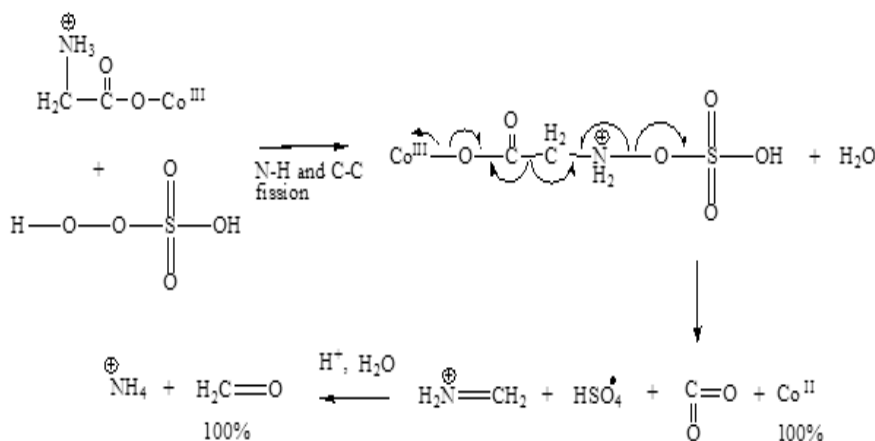
Scheme 1



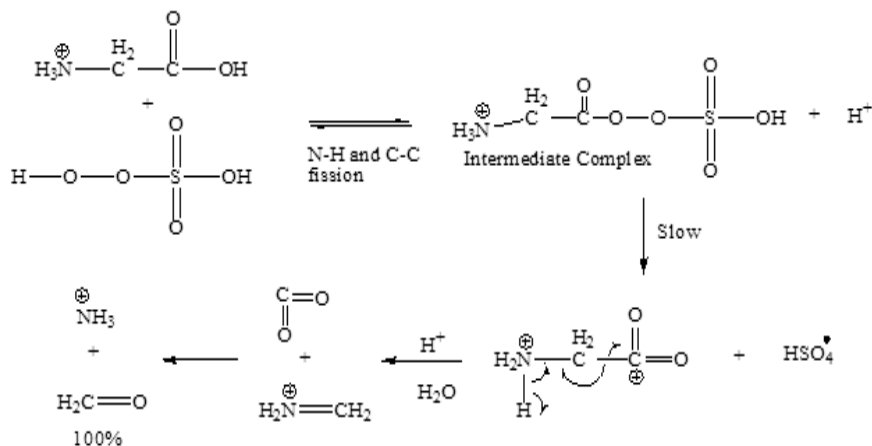
Scheme 2

4.2. Mechanism of PMS oxidation of pentaamminecobalt(III) complexes of both bound and unbound α -amino acids in micellar medium

The rate of PMS oxidation reaction depends on the first power of concentration of Co(III) complexes. The reaction exhibits first order dependence on the concentration of PMS. The electron transfer possibly occurs within the intermediate. The formation of binuclear complex with high association constant k , between PMS acetate and α -amino acids possibly due to the ligation of PMS acetate to free carbonyl end. The reaction between PMS oxidation of Co(III) complexes of α -amino acids exhibits total second order kinetics first order with respect to each reactant. The PMS attacks the $-NH_2$ or $-NH$ center in the slow step of the reaction leading to the formation of a radical $-NH$ or $-N\cdot$.



Scheme 3



Scheme 4

5. Ccoclusion

An induced electron transfer reaction has been attempted with Permonosulphuric acid and pentaamminecobalt(III) complexes of α -hydroxy acids and α -amino acids in the presence of NaLS, CTAB and TRITON-X 100 medium. The reaction exhibits second order kinetics. On comparing these two substrates with PMS oxidation of α -amino acids react faster than α -hydroxy acids. In these reaction the rate of oxidation shows first order kinetics each in [cobalt(III)] and [PMS]. Product and Stoichiometric analysis were carried out for the oxidation of complexes and free ligands in three different (Anionic, Cationic & Neutral) micellar medium with increasing micellar concentration and temperature an increase in the rate is observed. PMS oxidizes cobalt(III) bound and unbound α -hydroxy acids and α -amino acids through free radical. It explains the synchronous C-C bond fission, decarboxylation and electron transfer to cobalt(III) centre. For the α -amino acid complexes PMS attacks the $-\text{NH}_2$ or $-\text{NH}$ center in the slow step of the reaction leading to the formation of a radical $-\text{NH}$ or $-\text{N}$ -. The added CTAB enhances the rate of oxidation of a reaction much more than NaLS & TRITON-X 100. Among three different micelles TRITON-X 100 is react faster than NaLS but lesser than CTAB. But in the case of NaLS, it is reacting slowly than cationic and neutral micelles.

A mechanism involving the one electron transfer for the complex and two electron transfer for the ligand was proposed, that is, the 1 mole of Co(III) complexes of α -hydroxy acids and α -amino acids consumes 0.5 mole of PMS, whereas 1 mole of unbound α -hydroxy acids and α -amino acids consumes 1.0 mole of PMS. The reaction goes by free radical mechanism was proved by acrylonitrile polymerization. The appropriate methodology has been inducted.

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Attenuating Effect of *Phoenix Dactylifera L* on Cisplatin Induced Hepato Toxicity in Male Wistar Rats

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Abstract

Cisplatin (CP) is one of the most remarkable successes in "the war on cancer." Since the accidental discovery over four decades ago, cisplatin has been widely used for chemotherapy (Wang, D et al., 2005), and first member of a class of platinum-containing anti-cancer drugs which now also includes carboplatin and oxaliplatin.

These platinum complexes react in vivo, binding to and causing cross linking of DNA which ultimately triggers apoptosis (programmed cell death). Carboplatin and oxiplatin are second and third generation platinum drugs that have been introduced into clinical use because of their reduced toxicity.

In our present study, an attempt has been made to study the effect of Cisplatin on biochemical and histopathological parameters and ameliorating effects of the palm dates (*Phoenix dactylifera L.*) in male wistar rats. Adult male wistar rats were divided into four different groups. Group I Served as vehicle treated normal saline (Control), Group II Rats received single intra-peritoneal (Ip) injection of cisplatin (7mg/kg bw), Group III received *P. dactylifera L.* 200mg/kg/bw orally for 7 days beginning one day prior to cisplatin (CP) injection. Group IV Rats received alone *P. dactylifera* (200mg/kg bw) treated. Cisplatin exposure leads to adverse effects on hematological, hepatotoxic parameters including Erythrocytes (RBCs). Cisplatin induction leads to reduction in the levels of Enzymic and Non-Enzymic antioxidants levels. However, on treatment with *Phoenix dactylifera L.* normalized the levels of all the biochemical and hematological parameters. These findings highlight the efficacy of *Phoenix dactylifera L.* as protective effects Cisplatin induced hepatotoxicity.

Keywords: Cisplatin, *Phoenix dactylifera L*, Hepatotoxicity, Hepatoprotective, Free radicals, Antioxidants.

1. Introduction

Liver

Liver is one of the largest organs in human body and the chief site for intense metabolism and excretion. Weighing in at around 3 pounds, the liver is the body's second largest organ. It has a surprising role in the maintenance, performance and regulating homeostasis of the body. It is involved with almost all the biochemical pathways to growth, fight against disease, nutrient supply, energy provision and reproduction. The liver performs many essential functions related to digestion, metabolism, immunity, and the storage of nutrients within the body. These functions make the liver a vital organ without which the tissues of the body would quickly die from lack of energy and nutrients. The major functions of the liver are carbohydrate, protein and fat metabolism detoxification, secretion of bile and storage of vitamin. Thus, to maintain a healthy liver is a crucial factor for overall health and well-being. But when drug habits, alcohol infections and autoimmune disorders, prescribed (antibiotics, chemotherapeutic agents) cum over-the-counter drugs can eventually lead to various liver ailments like hepatitis cirrhosis and alcoholic liver disease. Liver has an incredible capacity for regeneration of dead or damaged tissues it is capable of growing as quickly as a cancerous tumor to restore its normal size and function. The liver is made of very soft, pinkish-brown tissues encapsulated by a connective tissue capsule. This capsule is further covered and reinforced by the peritoneum of the abdominal cavity, which protects the liver and holds it in place within the abdomen.

The liver performs multiple diverse functions essential for life. It receives processes, and stores materials absorbed from the digestive tract, including amino acids carbohydrates, fatty acids, cholesterol, lipids, vitamins, albumin, and minerals. Most of the proteins in plasma, including albumin, γ - and γ -globulins, clotting factors, and transport proteins, are synthesized by the liver. The liver is also the main site of detoxification of exogenous compounds such as drugs and toxins.

Free Radicals

In recent years there is an upsurge in the areas related to newer developments in prevention of disease especially the role of free radicals and antioxidants. The events of World War II (1939-1945) led directly to the birth of free radical biochemistry. The two atom bombs (6th August 1945 Hiroshima and 9th August 1945, Nagasaki) led to massive deaths to entire population, and the survivors had shortened life-span. In 1954, Gershan and Gilbert speculated that the lethal effects of ionizing radiation might be ascribed to formation of reactive oxygen species (ROS). Since then free radicals (atoms with an unpaired electron) such as ROS and reactive nitrogen species (RNS) have gained

notoriety (Gilbert et al., 1981).

The term *free radical* is used in a broad sense and also includes related reactive species such as 'excited states' that lead to free radical generation or those species that result from free radical reactions. In general, free radicals are very short lived, with half lives in milli-, micro-, or nanoseconds. Free radicals have been implicated in the etiology of several human diseases as well as ageing (Harman, 1958; Halliwell and Gutteridge 1997).

ROS and RNS are both produced in a well regulated manner to help maintain homeostasis at the cellular level in the normal healthy tissues and play an important role as signaling molecules. Most cells can produce superoxide ($O_2^{\circ-}$), hydrogen peroxide (H_2O_2) and nitric oxide (NO) on demand. The important beneficial roles of free radicals are given below.

1. Generation of ATP (Universal energy currency) from ADP in the mitochondria:oxidative phosphorylation
2. Detoxification of xenobiotics by Cytochromes P450 (Oxidizing Enzymes)
3. Apoptosis of effete or defective cells
4. Killing of micro-organisms and cancer cells by macrophages and cytotoxic lymphocytes
5. Oxygenases (eg.COX: cyclo-oxygenases, LOX: lipo-oxygenase) for the generation of prostaglandins and leukotrienes, which have many regulatory functions.

In recent years, it has become increasingly clear the ROS, such as O_2 and H_2O_2 may act as second messengers. ROS may play a role in modulating cellular function. Studies revealed that exogenous H_2O_2 could mimic the action of the insulin growth factor. The discovery of redox sensitive transcription factors and that *NO*, a free radical produced enzymatically, plays a physiological role in vasodilation and neurotransmission through activation of soluble guanylated cyclase further supported the concept that ROS and RNS act as second messengers to modulate signaling pathways. This led to the renaissance of the field of redox signaling and with the accumulation of data in various systems, a clearer picture is emerging of the signaling pathways and specific targets affected by ROS/RNS (Yoshikawa et al., 2000).

Other sources of free radicals include redox cycling of xenobiotics exposure to physiochemical agents like ionizing radiations such as X-rays and rays besides visible light or UV in the presence of oxygen and an endogenous compound or a drug that act as photosensitizer. Most of the damage induced by ionizing radiations in biological systems is indirect and is mediated by products of radiolysis of water including

hydrogen radical (*H), *OH, H_2O_2 , Peroxyl radical, (ROO*), O_2^* - etc., (Von Sonntag, 1987, Devasagayam and Kesavan, 1996). External sources of antioxidant nutrients that are essential for antioxidant protection include antioxidant vitamins C and E, vitamin A/provitamin A and the mineral selenium, a component of selenium-dependent glutathione peroxidase (Borek 1993).

Antioxidants

Antioxidants are substances that neutralize free radicals or their actions (Sies, 1996). Nature has endowed each cell with adequate protective mechanisms against any harmful effects of free radicals, superoxide dismutase, (SOD), glutathione peroxidase glutathione reductase, thioredoxin, thiols and disulfide bonding are buffering systems in every cell. α -Tocopherol (Vitamin E) is an essential nutrient which functions as a chain breaking antioxidant which prevents the propagation of free radical reactions in all cell membranes in the human body. Ascorbic acid (Vitamin C) is also part of the normal protecting mechanism. Other non-enzymatic antioxidants include carotenoids, flavonoids and related polyphenols, lipoic acid, glutathione etc.

Antioxidants, capable of neutralizing free radicals or their actions, act at different stages. They act at the levels of prevention, interception and repair. Preventive antioxidants attempt to stop the formation of ROS. These include superoxide dismutase (SOD) that catalyses the dismutation of superoxide to H_2O_2 and catalase that breaks it down to water (Sies, 1996; Cadenas and Packer, 1996). Interception of free radicals is mainly by radical scavenging, while at the secondary level scavenging of peroxyl radicals are effected. The effectors include various antioxidants like Vitamin C, Vitamin E glutathione, other thiol compounds, carotenoids flavonoids, etc., at the repair and reconstitution level, mainly repair enzymes are involved (Sies 1996; Cadensa and Packer 1996; Halliwell and Aruoma, 1993).

Concept of Oxidative Stress

The relation between free radicals and diseases can be explained by the concept of *oxidative stress* elaborated by Sies (1996). In normal healthy human body, the generation of pro-oxidants in the form of ROS and RNS are effectively kept in check by the various levels of antioxidant defense. However, when it gets exposed to adverse physiochemical, environmental or pathological agents such as atmospheric pollutants cigarette smoking, ultraviolet rays radiations, toxic chemicals, over-nutrition and advanced glycation end products (AGEs) in diabetes, this delicately maintained balance is shifted in favor of pro-oxidants resulting in *oxidative stress*. It has been implicated in the etiology of several 100s of human diseases and in the process of ageing.

Molecular Damage Induced by Free Radicals

All the biological molecules present in our body are at risk of being attacked by free radicals. Such damaged molecules can impair cell functions and even lead to death eventually resulting in diseases states. Membrane lipids present in sub-cellular organelles are highly susceptible to free radical damage. Lipids when reacted with free radical can undergo the highly damaging chain reaction of lipid peroxidation (LP) leading to both direct and indirect effects. During LP a large number of toxic byproducts are also formed that can have effects at a site away from the generation, behaving as *second messengers*. The damage caused by LP is highly detrimental to the functioning of the cell (Devasagayam et al., 2003).

Oxidative damage to DNA is a result of interaction of DNA with ROS or RNS. Free radicals such as $\cdot OH$ and $H\cdot$ react with DNA by addition to bases or abstractions of hydrogen atoms from the sugar moiety. This generates a spectrum of oxidative pyrimidine and purine damage products. Oxidation of proteins by ROS/RNS can generate a range of stable as well as reactive products such as protein that can generate additional radicals particularly upon interaction with transition metal ions. Although most oxidized proteins that are functionally inactive are rapidly removed, some can be gradually accumulate with time and thereby contribute to the damage associated with ageing as well as various diseases. Lipofuscin, an aggregate of peroxidized lipids and proteins accumulates in lysosomes of aged cells and brain cells of patients with Alzheimer's disease (Stadtman, 1992).

Significance of Antioxidant in Relation to Disease

Antioxidants may prevent and/or improve different diseases states (Knight, 2000). Zinc is an essential trace element, being a co-factor for about 200 human enzymes including the cytoplasmic antioxidant *Cu – Zn* SOD, isoenzyme of SOD mainly present in cytosol. Selenium is also an essential trace element and a co-factor for glutathione peroxidase. Apart from these carotenoids such as beta carotene, lycopene, lutein and other carotenoids function as important antioxidants and they quench $ROO\cdot$. Flavonoids mainly present as colouring pigments in plants also function as potent antioxidants at various levels (Sies, 1996 Cadenas and Packer, 1996, Kagan et al., 2002).

Antioxidant based drugs/formulations for prevention and treatment of complex diseases like atherosclerosis, stroke, Diabetes, Alzheimer's disease (AD), Parkinson's disease, Cancer etc. appeared over the past three decades. Free radicals theory has greatly stimulated interest in the role of dietary antioxidants in preventing many human diseases, including cancer atherosclerosis stroke, rheumatoid arthritis, neuro-degeneration and diabetes.

There is a considerable epidemiological evidence indicating association between diets rich in fresh fruits and vegetables and a decreased risk of cardiovascular disease and certain forms of cancer. It is generally assumed that the active dietary constituents

contributing to the protective effects are the antioxidants (vitamins, carotenoids polyphenols, sterols).

Oxidative Stress

Oxidative stress plays a critical role in the pathogenesis of cisplatin induced hepatotoxicity. Toxic liver failure induces the production of reactive oxygen species (ROS), which are responsible for the induction of tubular cells (Cetin, R et al., 2006). ROS are free radicals such as the hydroxyl radical (OH) and the superoxide anion (O_2^-) or molecules like hydrogen peroxide (H_2O_2). The production of ROS is a normal physiological event in various organs, including various tissues. However, the overproduction of ROS causes structural damage of biological macromolecules including nucleic acids, proteins and lipids, and those results in the formation of cytotoxic secondary products such as malondialdehyde (MDA).

Free radical oxidative stress has been implicated in the pathogenesis of a wide variety of clinical disorders, such as cancer, cardiovascular disease, Alzheimer's autoimmune disease diabetes, multiple sclerosis and arthritis (Halliwell and Gutteridge 1999). Free radicals are highly reactive particles with an unpaired electron and are produced by radiation or as by-products of metabolic processes. They initiate chain reactions, which lead to disintegration of cell membranes and cell compounds, including lipids, proteins, and nucleic acids (Leong and Shui, 2002). Sometimes, when we talk about the reactive oxygen species (ROS), we mean free radicals although the ROS can be classified into two groups: those that contain unpaired electrons (O_2^* and $*OH$) or those that have the ability to remove electrons from other molecules (H_2O_2 , $HOCl$). Biological systems protect themselves against the damaging effects of activated species by several means. These include free radical scavengers and chain reaction terminators enzymes such as SOD and CAT system (Proctor and McGinness, 1986). If human disease is believed to be due to the imbalance between oxidative stress and anti-oxidative defense it is possible to limit oxidative tissue damage and hence prevent disease progression by antioxidant defense supplements (Bhattacharya et al., 1999). In other words, if the balance sways in the direction of pro-oxidants, oxidative stress can arise, this under normal circumstances is controlled by a broad range of antioxidant enzymes, proteins and antioxidants provided by the diet.

2. Materials and Methods

Chemicals

All the fine chemicals were purchased from Sigma Chemical Co., USA. Cisplatin (CP) was procured from Dabur Pharma Ltd., New Delhi, India. All other chemicals used were of good quality and analytical grade.

Phoenix Dactylifera L. (Palm Dates) Extract Preparation

Fresh dates (*P.dactylifera* L) were collected from the local market. All dates were washed with tap water, and the seeds were removed. Fruit flesh was extracted two times with distilled water (1/10 w/v) by grinding with a mortar and pestle. It was centrifuged at 4°C for 20 min at 4000 g and the supernatant was collected. We selected an aqueous extract because most of the antioxidant components in dates are extracted in water (Vayalil PK, 2002, Al-Farsi M, 2007, Al-Showiman SS, et al., 1999). During the experience, the aqueous (date fruit) *P.dactylifera* L extract of was daily prepared and administrated to rats.

3. Methodology and Concept

Animal Model

Male albino rats of Wistar strain ($200 \pm 10g$) procured from Tamil Nadu University for Veterinary and Animal Sciences, (TANUVAS) Chennai, India were used for the study. Animals were fed with commercially available standard rat pelleted feed (M/s Pranav Agro IndustLtd., India) under the trade name Amrut rat/mice feed and water was provided ad libitum. The rats were housed under conditions of controlled temperature ($25 \pm 2^\circ C$) and acclimatized to 12-*h* light, 12-*h* dark cycle. Animal experiments were conducted according to the guidelines of institutional animal ethical committee.

4. Experimental Design

Seggregation of Groups

Experimental animals were divided into four groups of six rats each as follows.

- Group I : Served as vehicle treated normal saline (Control).
- Group II : Rats received single intra peritoneal (Ip) injection of cisplatin (7 mg/kg bw).
- Group III : Rats received Cisplatin (CP) (7mg/kgbw) as in group II and *P. dactylifera* (200 mg/kg bw) orally for 7 days beginning one day prior to cisplatin (CP) injection.
- GroupIV : Rats received alone *P. dactylifera* (200 mg/kg bw).

Collection of Samples for Biochemical Analysis

After the experimental period, the animals were anaesthetized by intra-peritoneal injection of phenobarbital sodium (30 mg/kg body weight) and were sacrificed. Blood was collected in sterile tubes. Liver tissues were immediately excised and immersed in ice-cold physiological saline. A section of the liver ventricle was set aside for the microscopic studies (Fig 2).

Serum Separation

The blood samples collected in plain centrifuge tubes were kept in inclined position to allow complete clotting of blood and then centrifuged at 2500 rpm for 10 min. The resultant clear supernatant was pipetted out and preserved in small vials in the freezer for the purpose of biochemical investigations.

Preparation of Tissue Homogenate

The liver tissue was excised, rinsed in ice-cold physiological saline and homogenized in 0.1 M Tris-HCl buffer (pH 7.4) using a tissue homogenizer with a teflon pestle at 4° C. The resultant supernatant was kept under refrigeration until further biochemical analysis. All the assay procedures were carried out within 48 hr of the sample collection.

Histopathological Study

Haematoxylin and Eosin Staining

A portion of hepatic (liver) tissue was fixed in 10 % formalin. The washed tissue was dehydrated in descending grades of isopropanol and cleared in xylene. The tissue was then embedded in molten paraffin wax. Sections were cut at 5- μ m thickness and stained (Fig 2) with haematoxylin and eosin (H&E).

Statistical Analysis

The values are expressed as mean \pm SD for six rats in each group. All of the grouped data were analyzed with SPSS/13.0 student software. Hypothesis testing method included one way analysis of variance (ANOVA) followed by post hoc testing performed with least significant difference (LSD) test. The *p* value of less than 0.05, 0.01, were considered to indicate statistical significance.

5. Results and Discussion

Cisplatin (CP) is one of the most remarkable successes in *the war on cancer*. Since the accidental discovery over four decades ago, cisplatin has been widely used for chemotherapy (Wang, D et al., 2005).

In our present study, an attempt has been made to study the effect of Cisplatin on biochemical and histopathological parameters and ameliorating effects of the palm dates (*Phoenix dactylifera* L.) in male wistar rats.

Cellular necrosis occurs as the result of an injurious environment and has been referred to as 'murder'. It is characterized by cellular swelling with loss of membrane integrity. Toxic injury from compounds such as carbon tetrachloride, aspirin, and acetaminophen occurs from the most part by necrosis. As the cell dies, it releases its contents, which evoke an inflammatory response, which causes further cell injury from cytokines and toxic oxygen species.

The causative factors appear to include cellular necrosis, metabolism of the drug and formation of free radicals. Reactive oxygen species (ROS) have been proposed as mediators of different diseases especially in toxic, ischemic or immunological conditions. *Phoenix dactylifera* L. (palm dates) might have a protective effect on the deteriorated liver function resulted from free radicals in the cisplatin induced hepatotoxicity. Our study/findings also provided evidence to suggest that *Phoenix dactylifera* L. had beneficial effect against cisplatin induced hepatotoxicity.

Changes in Lipid Peroxidation

The effect of cisplatin and *Phoenix dactylifera* L. on liver tissue lipid peroxidation in control and experimental group of rats. Cisplatin administration caused a significant increase in lipid peroxidation (LPO) in group II rats (Graph 1). Treatment with *Phoenix dactylifera* L. significantly prevented the rise in LPO induced by cisplatin (CP). The activity of *Phoenix dactylifera* L. is compared with antioxidants, and the result showed that it has more prominent effect than the antioxidants. Malondialdehyde, a stable lipid hydroperoxide, provides an index of the peroxidation of lipids in biological tissues. The acute administration of cisplatin (CP) increases lipid peroxidation (Zhong et al., 1998; Longoni et al., 1999). Cisplatin induced free radicals and in particular hydroxyl radical, leads to lipid peroxidation of cell membranes causing degradation of phospholipids. Cisplatin has been reported to increase malondialdehyde a stable product of lipid hydroperoxide, in isolated hepatic microsomes, and the major metabolic site for cisplatin (Inselmann et al., 1990). This observation suggested that cisplatin or its metabolites produce free radical species that attack lipid components leading to lipid peroxidation (Zhong et al., 1998) have shown that cisplatin induced local production of hydroxyl species, which play a pivotal role in nephrotoxicity caused by cisplatin. Consistent with this possibility, our data shows a significant increase in LPO which suggests the involvement of oxygen free radicals in the pathogenesis of cardiac injury

during cisplatin administration. Simultaneous Administration of Phoenix dactylifera L. to cisplatin induced rats significantly reduced the levels of hydroperoxides proving its potential antioxidant ability. The free radical inhibitory activity of Phoenix dactylifera L. is attributed to its antioxidant property, which effectively scavenges the reactive oxygen species and decreases lipid peroxidation end products. The antioxidant activity of phoenix dactylifera L (palm dates) towards hydroxyl radicals is considered to be due to chelating capacity of phoenix dactylifera L. several studies have shown that both phoenix dactylifera L. scavenges reactive oxygen species.

Changes in Antioxidant Enzymes

The effect of *Phoenix dactylifera L.* (palm dates) with that of cisplatin on hepatic antioxidant enzymes in control and experimental groups. Cisplatin induced rats show a significant decrease/decline in antioxidant enzymes. Phoenix dactylifera L. treatment to cisplatin fed rats shown to be sufficient in increasing the activities of these enzymes in Group III, when compared to cisplatin induced (Group II). Our results has shown that the SOD activity was significantly decreased in cisplatin treated rats, therefore this suggests the accumulation of superoxide anion radical, which might be responsible for decreased activity of SOD that might have depleted while scavenging the superoxide anion. The presently observed decrease in the catalase activity in cisplatin treated rats is due to the increased ROS, (Table 1), which that have inhibitory action on catalase (Kirman and Gaetani, 1984). Decrease in the activity of GPx during cisplatin administration indicates the reduction in the levels of GSH and increase in the levels of peroxides. The depletion of GSH causes a proportional decrease in H_2O_2 detoxification by GPx. The decreased activity of GR may be mainly due to depletion of GSH and NADPH levels in cisplatin induced rats, upon treatment with Phoenix dactylifera L. along with that of cisplatin resulted in maximal increase in GPx activity in renal tissues. The increased activity of GPx in response to Phoenix dactylifera L. is indicative of enhanced detoxification of H_2O_2 and lipid hydroperoxides. Phoenix dactylifera L. ability to prevent the changes in antioxidant enzymes could be attributed to its high scavenger potential, which would protect the tissues against free radicals generated by cisplatin, sparing antioxidant defenses (Kim et al., 2001). This protective measure might be attributed to the direct scavenging reaction of Phoenix dactylifera L. with superoxide radicals. Studies has reported that effective role of Phoenix dactylifera L. (palm dates) as scavenger of peroxide and superoxide radicals (Kim et al., 2001) which correlates with our study.

Changes in non-enzymic Antioxidants

The effect of cisplatin and Phoenix dactylifera L. on non enzymic antioxidant enzymes in control and experimental groups. A marked decline in the levels of non-enzymic antioxidants GSH, was noted in cisplatin treated rats. A significant increase in the levels of non-enzymic antioxidant towards control range was obtained

by treatment with *Phoenix dactylifera* L. (palm dates), indicating its protective effect against oxidative stress induced by cisplatin drug.

Antioxidants like, Vitamins C and E are the main lipid soluble rich antioxidant vitamins which plays a vital role in maintaining the integrity of the cells by preventing membrane peroxidation (Parra et al., 2003). The role of antioxidants in repairing oxidative renal toxicity after cisplatin administration has been reported (Papas, 1998). Decrease in the levels of GSH, and antioxidants during cisplatin administration leads to increased susceptibility of the tissues to free radical damage (Hagar et al., 2006). Consistent with the above concepts, decreased GSH level in cisplatin induced rats might be due to increased utilization of GSH for scavenging free radicals along with detoxification of cisplatin. *Phoenix dactylifera* L. (palm dates) administration increased the level of GSH, antioxidants towards normal values probably by modulating the oxidative stress.

Changes in Liver Marker Enzymes

Chronic administration of cisplatin is associated with pronounced oxidative stress and biochemical abnormalities. (Fig 2.B & C), shows the abnormal activities of liver marker enzymes that indicate cellular damage induced by cisplatin. The activities of AST and ALT were significantly elevated in the serum of cisplatin treated animals when compared with control values. Activities of these marker enzymes were restored to near control values by *Phoenix dactylifera* L. (Date Palm) co-administration. Cisplatin administration induced severe biochemical changes as well as oxidative damage.

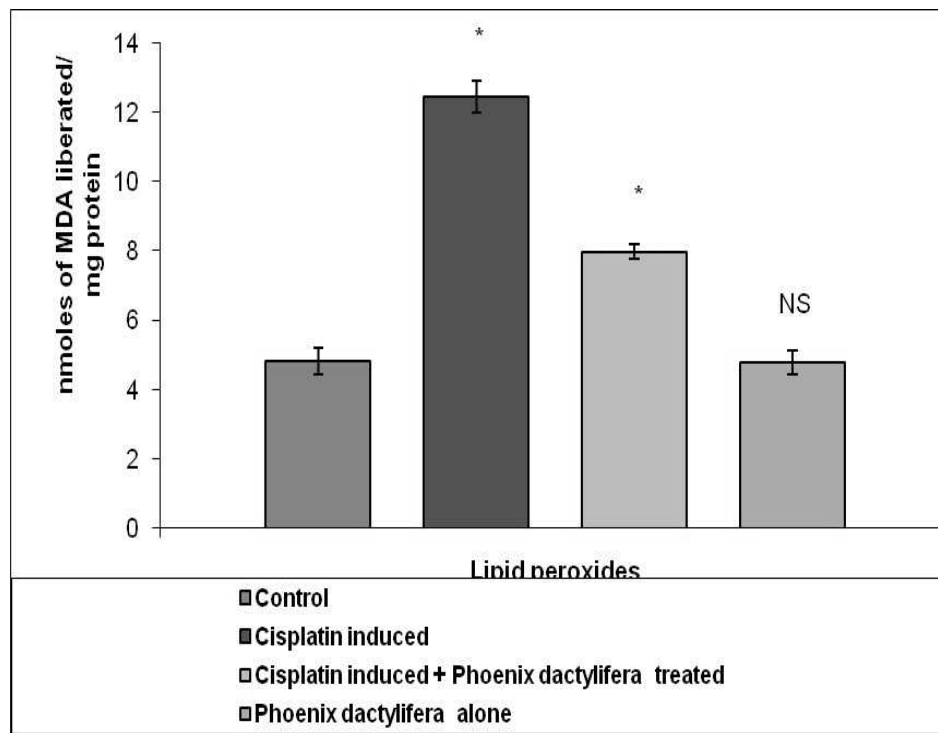
The present investigation revealed that administration of cisplatin resulted in typical functional disturbances, as evidenced by the marked elevations of liver marker enzymes ALT and AST in serum (Table 2) Consequently, there is much interest in developing new methods to abrogate hepatic damage by using a combination of various agents with cisplatin. AST and ALT enzymes released may be used as markers to diagnose the hepatic necrosis level (Levitsky, 2006). In recent years, some strategies have been proposed for hepato protective against oxidative stress. They are using natural antioxidants by eating fresh vegetables and fruits. Because they have antioxidants such as flavonoids, anthocyanin and polyphenol compounds (Zhang and Wang, 2002). In the present study, treatments with *Phoenix dactylifera* L (Date Palm) significantly lowered the levels of hepato marker enzymes to near normal value, highlighting the hepato protective role of cisplatin.

SDS PAGE

The SDS PAGE (Fig 1) pattern of the hepatic tissue of control and experimental groups, upon induction of cisplatin resulted in prominent change in protein pattern when compared to control group (lane 2). Treatment with *Phoenix dactylifera* L. (lane 3) prevent the protein fragmentation compared to cisplatin induced group, *Phoenix dactylifera* L. alone (lane 4) shows similar protein profile when compared to control group.

Attenuation of Phoenix Dactylifera L. (Palm Dates) on Cisplatin induced Histopathological Study

Histopathological studies (Fig 2) proved that cisplatin causes damage the liver. These degenerative changes involved the size, shape and organization of the liver tissues. cisplatin administration, a greater disorganization of the focal necrosis and cellular infiltration. However we showed the changes in different proteins related to cytoplasmic, extracellular matrix. cisplatin induced oxidative stress leads reactive radicals formed during hepatic tissues damage with the depletion of enzymatic and nonenzymatic antioxidants. When altered metabolism in hepatic tissues increased the generation of superoxide anions and lipid peroxidation upon reperfusion. Therefore the properties of biological membranes were affected allowing cellular macromolecules to be released. During Phoenix dactylifera L. treatment alters the histopathological changes induced by cisplatin. Phoenix dactylifera L. (palm dates) offered better protection to the hepatocytes, and may be due to rich antioxidants, free radicals scavenging and hepato protective effect.



Graph 1. Effect of cisplatin and Phoenix dactylifera on the activities of lipid peroxidation in the serum of control and experimental group of rats

Results are expressed as mean \pm SD for 6 different sets of experiments. Values are considered significantly different at $P < 0.05$ with post-hoc LSD test.

| Particulars | Control | Cisplatin induced | Cisplatin induced + Phoenix dactylifera L. treated | Phoenix dactylifera L. alone |
|-------------|-------------------|-------------------|--|------------------------------|
| SOD | 3.56 \pm 0.07 | 1.65 \pm 0.04 | 2.96 \pm 0.05 | 3.68 \pm 0.03 |
| CAT | 14.563 \pm 6.75 | 95.63 \pm 3.54 | 124.63 \pm 4.534 | 149.35 \pm 5.85 |
| GPx | 4.676 \pm 0.23 | 2.74 \pm 0.35 | 3.64 \pm 0.33 | 4.26 \pm 0.63 |
| GST | 0.98 \pm 0.012 | 0.39 \pm 0.014 | 0.74 \pm 0.02 | 0.97 \pm 0.019 |
| GR | 1.75 \pm 0.06 | 1.15 \pm 0.03 | 1.54 \pm 0.04 | 1.78 \pm 0.06 |

Table 1. Effect of cisplatin and Phoenix dactylifera L. on the activities of SOD, CAT, GPx, GST and GR in the serum of control and experimental rats.

Results are expressed as mean \pm SD for 6 different sets of experiments. Values are considered significantly different at $P < 0.05$ with post-hoc LSD test.

| Particulars | Control | Cisplatin induced | Cisplatin induced + Phoenix dactylifera L. treated | Phoenix dactylifera L. alone |
|-------------|-------------------|--------------------|--|------------------------------|
| ALP | 4.63 \pm 0.12 | 9.36 \pm 0.08 | 3.43 \pm 0.09 | 4.35 \pm 0.42 |
| SGOT | 167.83 \pm 6.86 | 278.344 \pm 8.65 | 196.65 \pm 3.86 | 173.63 \pm 6.54 |
| SGPT | 87.65 \pm 4.63 | 146.65 \pm 6.53 | 106.45 \pm 3.63 | 88.45 \pm 4.34 |

Table 2. Effect of cisplatin and Phoenix dactylifera L. on the hepatic marker enzymes in control and experimental group of rats.

Results are expressed as mean \pm SD for 6 different sets of experiments. Values are considered significantly different at $P < 0.05$ with post-hoc LSD test.

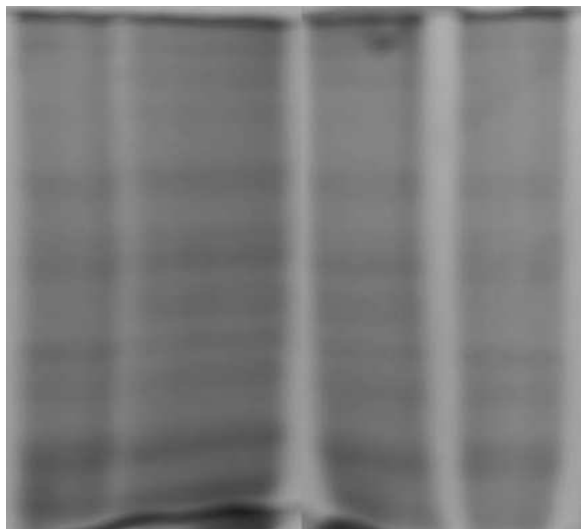


Fig 1. Effect of cisplatin and Phoenix dactylifera L. on the SDS-PAGE pattern of the hepatic tissue of control and experimental groups

Protein fragmentation analysis by SDS-PAGE electrophoresis in rat liver tissue homogenate.

Lane 1: Control

Lane 2: Cisplatin- Induced

Lane 3: Cisplatin + Phoenix dactylifera

Lane 4: Phoenix dactylifera.

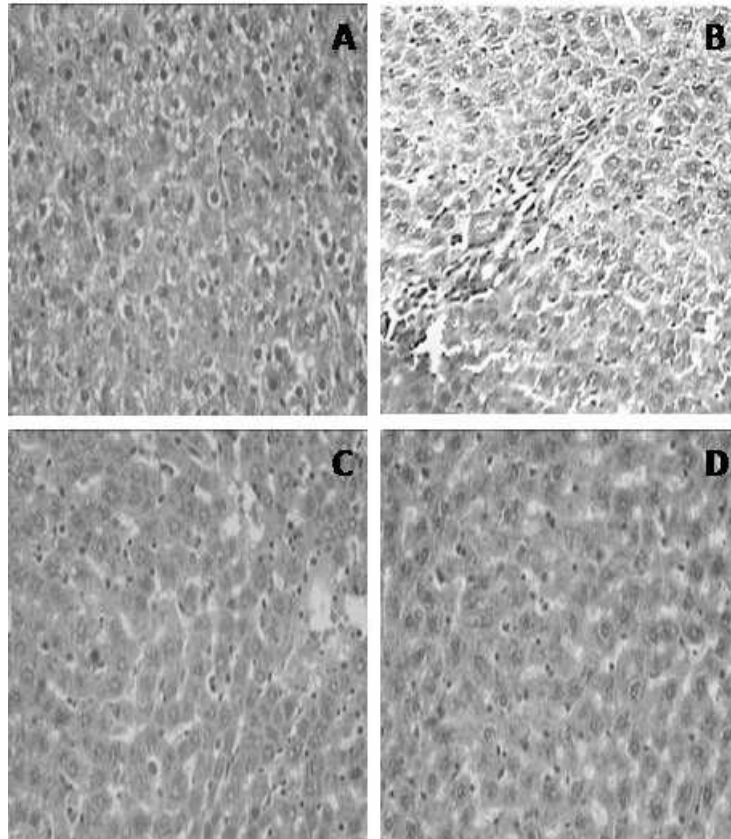


Fig 2. Effects of Cisplatin and Phoenix dactylifera L. on Histopathological analysis of rat liver stained with Haematoxylin and Eosin (H&E) viewed at original Magnification (10X).

Fig 2. (A) Effect of cisplatin and Phoenix dactylifera L. on rat liver histopathological alterations in control and experimental group of rats. The liver of control rats (Fig.2A) (H&E) and P.dactylifera L. (Fig.2D) alone treated rats showed a normal architecture of liver. cisplatin exposure resulted in changes in liver architecture as indicated by focal necrosis and inflammatory cell infiltration (Fig.2B,C) (H&E) cisplatin along with P.dactylifera L. administration (Fig. 2C) (H&E) showed near normal hepatocytes with mild portal inflammation.

6. Conclusion

The liver in normal physiological conditions is resistance to oxidative damage because of their efficient protective mechanisms. However, under oxidative stress, the liver (hepatocytes) and their mechanisms are very sensitive to oxidative damage due

to their content of enzymes which are continuously exposed to high concentration of oxygen. The work was designed to evaluate the protective effect of Phoenix dactylifera L. (Palm Dates) against cisplatin induced oxidative damage/injury in hepatocytes.

In our present study, Cisplatin induced shows the decrease in the levels of antioxidants and Non-Enzymic antioxidant Enzymes levels, (Graph 1) increase in the levels of lipid peroxidations. Cisplatin exposure alters the biochemical parameters viz., liver antioxidant and Non-Enzymic antioxidants. However, Phoenix dactylifera L. (Palm Dates) normalized the levels of antioxidant and non enzymatic antioxidant Enzymes.

Our findings highlight the efficacy of Phoenix dactylifera L. as protective effects against cisplatin induced oxidative damage to the hepatic cells which induced toxicity. Thus it is concluded that Phoenix dactylifera L. (Palm Dates) provide a protective effect in the cisplatin induced hepatotoxicity.

Cisplatin exposure leads to adverse effects on hematological, hepatotoxic parameters including Erythrocytes (RBCs). Cisplatin induction leads to reduction in the levels of Enzymic and Non-Enzymic antioxidants levels (Table 2) However, on treatment with Phoenix dactylifera L. normalized the levels of all the biochemical and hematological parameters. These findings highlight the efficacy of Phoenix dactylifera L. as protective effects Cisplatin induced hepatotoxicity.

ACKNOWLEDGEMENTS

We are thankful to the faculty members of the Department of Biochemistry. The authors would like to thank the Secretary & Correspondent and the Principal of Islamiah College (Autonomous) for their encouragement, providing the necessary facilities and support in carrying out the work.

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Cyclosporine - A induced oxidative stress mediated cardiac mitochondrial apoptosis through up-regulation of Bax and down-regulation of Bcl₂ in male wistar rats, potential attenuation by S-allyl cysteine

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Abstract

Cardiac apoptosis is potentially important in cardiac disorders. Pro-apoptotic (Bax), anti-apoptotic (Bcl-2) proteins and mitochondrial dysfunction are key regulators of apoptosis. In this study, we characterized the regulation of Bax, Bcl-2 and caspase proteins during cyclosporine-A [CsA] induced oxidative stress mediated mitochondrial apoptosis and modulating effect of S-allyl cysteine [SAC]. Male Wistar rats were divided into four groups. Group-I control, group-II received CsA at dose of 25 mg/kg BW orally for 21 days, group-III received CsA as group-II and SAC at dose of 100mg/kg BW for 21 days intraperitoneally; group-IV SAC alone. CsA-induced apoptosis was evidenced by release of cytochrome-C into the cytosol, up-regulation of Bax and down-regulation of Bcl-2, caspase family protein expressions. SAC administration inhibited apoptosis through the reserve of cytochrome-C release, inhibition of caspase-3, down-regulation of Bax and up-regulation of Bcl-2. Further CsA- induced cardiotoxicity was evident by decreased activities of TCA cycle enzymes and mitochondrial antioxidants, along with increased activities of lipid peroxidation, serum creatine phosphokinase, lactate dehydrogenase, aspartate transaminase, and alanine transaminase. However, SAC administration normalized all the above parameters to normal level. The results suggest that administration of SAC reduced incidence of cardio vascular disease. A diet containing garlic could prove beneficial to the heart.

Keywords: Cyclosporine, Cardiac apoptosis, Oxidative stress, S-allyl cysteine, Antioxidant.

1. Introduction

Cyclosporine- A [CsA] is a potent immunosuppressive drug used for organ transplantation and also in the treatment of autoimmune diseases [1]. CsA have

wide range of biological activities including anti-parasitic, fungicidal, and anti-inflammatory effects. But the clinical value is limited due to adverse side effects including nephrotoxicity, cardiotoxicity, hepatotoxicity [2], increased blood pressure [3, 4], hypertension [5], lympho-proliferative diseases [6], atherosclerosis and interstitial myocardial fibrosis [7]. FDA and social media reported in July 2014, 24,393 people who have side effects while taking cyclosporine among them 31 % have cardiotoxicity in America alone [8]. Nevertheless, CsA remains used as a valuable therapeutic agent and is frequently used in clinical practice. There are many hypotheses to elucidate the mechanism of CsA-induced adverse effects, including free radical formation, oxidative stress lipid peroxidation, disturbances of respiratory chain mitochondrial enzymes and cellular injury, apoptosis [9].

CsA induced Oxidative stress can be assessed by assaying the products such as TBARS, malondialdehyde which indicate membrane lipid peroxidation and cellular injury [9]. The deleterious effects of ROS on cardiac tissue can be blocked by antioxidant enzymes. Antioxidants are capable of scavenging ROS, including reactive oxygen free radicals such as superoxide, hydroxyl, and peroxy radicals, could have therapeutic advantages over CsA induced cardiac toxicity. A large dose of consumption of drugs like CsA causes depletion of cellular antioxidants level which consequently exacerbates oxidative stress in conjunction with mitochondrial dysfunction [10].

Mitochondria are the most important source of cellular energy in our body their dysfunction is a major mechanism for CsA-induced cardiac toxicity. Prolonged oxidative stress in myocardium results in specific morphological changes in heart mitochondrial lipids, proteins, DNA and disturbs the function of the mitochondrial respiratory chain, thereby affecting the cellular ATP production and leads to abnormalities in cardiac marker enzymes and TCA cycle enzymes [11]. Recent studies have reported that the reactive oxygen species, mitochondrial permeability transition pore, Bcl-2 family, caspases, and cytochrome C might be involved in regulating the apoptosis [12]. Mitochondria play a central role in triggering apoptosis. Several studies have demonstrated that consumption CsA results in cardiac remodeling and impaired ventricular function through increased oxidative stress, apoptosis and inflammation [13]. Apoptosis is an active mode of cell death can be a feature of both acute and chronic pathological diseases including cardio vascular diseases. In apoptosis, a biochemical cascade activates proteases that destroy molecules that are required for cell survival [14]. Members of the Bax/Bcl-2 family are pro-apoptotic and anti-apoptotic. The balance between pro-apoptotic and anti-apoptotic signals from the Bcl-2 family has a crucial role in the release of cytochrome c [15]. Cytochrome C is a member of the mitochondrial electron transport chain that is required for the generation of ATP. Cytochrome C is an important trigger of the caspase cascade and it is released from the mitochondria into the cytoplasm. In the cytoplasm, it binds to Apaf-1 to form the apoptosome. The

apoptosome activates caspase an upstream initiator of apoptosis [14].

Diet plays an important role in the modulation of various human diseases, including cardiovascular disease. Epidemiological studies have shown that diets rich in fruits, herbs, spices, garlic and onion are associated with a low risk of cardiovascular disease [16]. Studies have shown that the impairment of mitochondrial function and programmed cell death pathways can be inhibited by antioxidants. Garlic is one of the most popular food ingredients consumed worldwide and the bioactive ingredients mainly S-allyl cysteine have been shown to be protective against various diseases including cardiovascular diseases. S-Allylcysteine [SAC], an organosulphur constituent of garlic, has been reported to have hypocholesterolemic, hypolipidemic, anti-hypertensive, anti-diabetic, antithrombotic and anti-hyperhomocysteinemia effects, and to possess many other biological activities including antimicrobial, antioxidant, inhibition of lipid peroxidation [17], anticarcinogenic, antimutagenic, antiasthmatic, immunomodulatory and prebiotic activities, anti-inflammatory [18], anti-cancer, antihepatotoxic [19] nephro protective [20] and neuro protective activity [21]. In view of these findings, in the present study we investigated the preventive effect of SAC on CsA induced mitochondrial oxidative stress mediated apoptosis.

2. Materials and Methods

2.1. Chemicals

Cyclosporine A [Sandimmun - neoral, Novartis pharma AG, Basle, Switzerland]. S-allylcysteine was purchased from Sigma-Aldrich Co. [St. Louis, MO, USA]. All other chemicals used were of analytical grade.

2.2. Animal Model

Wistar male albino rats weighing between 200 g - 240 g were housed in animal cages with food and water ad libitum. Six animals were housed per cage, and maintained on 12/12 hr day and night cycle. The animals were fed with commercial pellet diet [Hindustan lever Ltd., Bangalore, India]. The experiments were conducted according to ethical norms approved by the Ministry of Social Justices and Empowerment, Government of India and Institutional Animal Ethics Committee Guidelines.

3. Experimental Design

The rats were divided into four groups [six rats in each group] as follows:

- Group I - Control rats [Rats received no treatment normal diet and pure drinking water].
- Group II - Rats induced with CsA 25 mg/kg BW orally for three week [21 days].
- Group III - Rats administered with CsA 25mg/kg BW orally and simultaneously administered 100mg/kg BW of SAC dissolved in water for 21 days intraperitoneally.
- Group IV - Drug alone rats [100 mg/kg BW of SAC alone dissolved in water for 21 days intraperitoneally].

After the experimental period, the animals were fasted overnight, anaesthetized with sodium Pentothal and were sacrificed. Blood was collected from venous orbital plexus with capillary tubes and kept in inclined position to allow complete clotting of blood and then centrifuged at 600g for 30 min. Serum was separated and were used for biochemical investigations. The heart tissue was excised, rinsed in ice-cold saline and homogenized in 0.1 M Tris-HCl buffer [pH 7.4] using a tissue homogenizer with a Teflon pestle at 4°C and kept under refrigeration until further biochemical analysis.

3.1. Histological Examination

A portion of the heart tissue was fixed in 10% neutral buffered formalin and embedded in paraffin wax for histological evaluation. Sections with thickness 5 μm were stained with hamatoxylin and eosin [H&E], examined under high power light microscope.

3.2. Isolation of Heart Mitochondria

Mitochondria were isolated from the heart tissue by the method of Jhonson and Lardy [22]. The heart was washed, minced well in ice-cold saline and homogenized in 0.25 M ice-cold sucrose solution at 4°C. This homogenate was centrifuged at 500 g for 10 min to remove nuclear fraction and the broken cell debris. The supernatant was then centrifuged in a refrigerated REMI C-24 centrifuge at 12,000 g for 12 min. The pellet was taken as the mitochondrial pellet and suspended in 0.25 M sucrose containing 10 mM Tris-HCl buffer, pH 7.4 and 1 mM EDTA to a known volume. This was gently homogenized and used to assess the activities of mitochondrial enzymes.

3.3. Biochemical Estimations

Heart mitochondrial thio barbituric acid reactive substances TBARS were estimated by the method of Fraga et al. [23]. The activities of heart mitochondrial enzymes such as isocitrate dehydrogenase ICDH [24], succinate dehydrogenase SDH [25],

malate dehydrogenase MDH [26], α -ketoglutarate dehydrogenase α -KGDH [27], NADH dehydrogenase [28] and cytochrome C oxidase [29] were assayed. The activities of antioxidant enzymes such as superoxide dismutase SOD [30], catalase CAT [31], glutathione peroxidase GPx [32], glutathione reductase GR [33], Glutathione-S-transferases GST [34] estimated in isolated mitochondria. The serum was used to measure cardiac marker enzymes such as aspartate transaminase AST [35], alanine transaminase ALT [36], creatinine kinase CK [37], Lactate dehydrogenase LDH, was measured by the method of [38].

3.4. Immunoblotting

Western blot technique was employed to quantify the abundance of the cytochrome c, caspase-3, caspases-9, Bax and Bcl-2. Heart of control and experimental rats were homogenized in buffer containing 135 mM NaCl, 20 mM Tris-HCl, 2 mM EDTA and 1 mM PMSF [pH 7.4]. The volume of homogenization buffer was 1 ml per 100mg tissue sample. The homogenates were centrifuged [15 min, 10,000 rpm at 4° C] and the protein content of the supernatant was determined according to method of Lowry et al. [39] with BSA as standard. Supernatant aliquots [20g total protein] were boiled for 5 min in sample buffer [0.2 M Tris-HCl buffer, 10 % glycerol, 2 % SDS, 0.02 % β -mercaptoethanol]. Proteins were separated by Tris glycine SDS discontinuous 10% polyacrylamide gel and electroblotted on to nitrocellulose membrane [Amersham Biosciences, NJ, USA] using a semidry transfer system [40]. After protein transfer, the membrane was incubated for 2h at room temperature in blocking buffer [0.05 % Tween-20, 5% non-fat dried milk, Tris-buffered saline [TBS pH 7.5]. After blocking, the membrane was rinsed for 5 min with washing buffer [TBS containing 0.05 % Tween-20 [TBST], then incubated for 16 h at 4°C with primary antiserum diluted [1:1,000] with TBS containing 0.05 % Tween-20 and 1.0 % non-fat dried milk. After overnight incubation of primary antibody, the membrane was washed thrice [5 min each] with TBST. Then it was incubated with respective secondary antibodies with horse raddish peroxidase [1:50,000 dilution] for 1 h at room temperature. Protein antibody complexes were detected by the addition of diaminobenzidine [DAB] as the substrate.

3.5. Statistical Methods

All the results were expressed as mean \pm SD for six rats in each group. All the grouped data were statistically evaluated with SPSS/12.0 software. Hypothesis testing method included one-way analysis of variance [ANOVA], followed by least significant difference [LSD] test; $P < 0.05$ was considered to indicate statistical significance.

4. Results

4.1. Effect of SAC on CsA-induced Lipid Peroxidation

Effect of SAC on the levels of TBARS during CsA-induced lipid peroxidation in the control and experimental groups of rats was shown in Fig .1. TBARS levels were found to be significantly increased in CsA-induced rats, whereas it was significantly reduced in SAC treated groups. However, no significant difference was observed between control and drug control groups.

4.2. Effect of SAC on CsA-induced Endogenous Antioxidant Enzyme Levels

Table 1 shows the activities of enzymic [SOD, CAT, GPx, GR and GST] antioxidant levels in the control and experimental group of rats. A significant decrease in the levels of antioxidant enzymes were observed in the rats administered with CsA. The adverse changes in antioxidant enzyme profile were restored to near normal levels in SAC treated groups of rats. However, no significant changes were observed between control and drug control groups.

4.3. Effect of SAC on CsA-induced Cardiac Marker Enzymes

Table 2 shows the activities of cardiac markers AST, ALT, CK, LDH of control and experimental groups of rats. A significant increased level of cardiac marker enzymes was found in CsA-induced animals when compared to control. Whereas, SAC treated rats shown the levels remained near the control group. However, no significant changes were observed between control and drug control groups.

4.4. Effect of SAC on CsA-induced Mitochondrial TCA Cycle Enzymes

The activities of the TCA cycle and respiratory enzymes in the control and experimental groups are presented in Table 3. The activities of the ICDH, α -KGDH, SDH, MDH, NADH dehydrogenase and cytochrome-c-oxidase were found to be significantly lower in the mitochondria of rats subjected to CsA induction when compared with control group. However, administration of SAC significantly increases the above enzyme activities to near normal level.

4.5. Effect of SAC on CsA-induced Histological Examination of Rat Heart

A histopathological analysis of control and experimental groups of rats were shown in [Fig. 2]. Myocardium of control rats showed normal cardiac fibers without any infarction and orderly arrangement of myocytes [Fig. 2a]. Histopathological findings of the CsA-induced myocardial fibers showed infarcted cardiac muscle fibers with oedema, enlarged interstitium disorganization of myocardial fibers [Fig. 2b]. CsA-induced with SAC administered rat myocardium showed only mild oedema without infarction and

the myocardial fibres were within normal limits, normal cardiac muscle bundles with minimal interstitial fibrosis in tissues [Fig. 2c]. Rats supplemented with SAC alone showed normal cardiac muscle bundles without any damage [Fig. 2d].

4.6. Measurement of CsA- induced Apoptosis Related Proteins by Western Blotting

Bax/Bcl2: Bcl-2 a family of apoptotic proteins plays central role in upstream signaling of cytochrome C release. In particular, among the entire Bcl-2 family, Bax and Bcl-2 have been well examined and that the relative content of Bax/Bcl-2 provides a tight control in promoting the execution of apoptotic cascades. In this present study we observed CsA induction rats shown decrease expression of Bcl-2 and increased expression of Bax [Fig. 3 A, B]. Oral administration of SAC to CsA- induced rats significantly decrease the Bax expression and increase the Bcl-2 expression toward control rats. Following SAC treatment the level of Bcl-2 is up-regulated and Bax expression appeared to be down-regulated. These results show that the anti-apoptotic property of SAC was achieved possibly through regulating the levels of pro and anti-apoptotic protein expressions.

Cytochrome c release from the mitochondria is a critical step in the apoptotic cascade, because it activates downstream caspases. To examine the release of cytochrome c in CsA- induced rats, we conducted Western blotting of the cytosol fraction. The findings demonstrate that CsA- induced rats shown increased cytosolic cytochrome C expression compared to control rats [Fig 3C]. Oral supplementation of SAC to CsA intoxicated rats reduces the cytosolic cytochrome C content possibly by protecting mitochondrial membrane integrity. Caspases are known to play a central role in various apoptotic responses, including mitochondrial mediated apoptosis. To identify the CsA-induced apoptosis by assessed the expression of caspase -3 and 9. Western blot analysis revealed that the levels of caspase- 3 and 9 were increased [Fig 3 D, E]. These results suggest that CsA-induced apoptosis is associated with the activation of caspase-3 and 9. SAC administration prevented the CsA - induced activation of caspase-3 and 9. β -actin served as a positive control [Fig 3F].

5. Discussion

CsA administration results in excess formation of hydroxylradicals, leading to lipid peroxidation and thus increase in associated with cardiac dysfunction and structural deterioration. The data obtained from the present study indicate the involvement of free radicals, oxidative stress in the pathogenesis of CsA-induced cardiac injury. The increased levels of free radicals and lipid peroxidation products following CsA have been reported in many experimental studies in vitro and in vivo [41,42]. Simultaneous

administration of SAC to CsA- induced rats showed a significant reduction in peroxidative levels, which highlights the antioxidant efficacy of SAC. The protective efficacy of SAC is directly linked with the scavenging activity of peroxy radicals. SAC has been reported to inhibit lipidperoxide formation and free radical production [43]. The free radical inhibitory activity of SAC is attributed to its antioxidant property, which effectively scavenges the reactive oxygen species and decreases lipid peroxidation and its products [44].

The endogenous antioxidant enzymes SOD, CAT, GPx, GR and GST are considered to be the primary defense agent that protects biological macromolecules from free radicals induced oxidative damage. In this study, significantly decreased activities of antioxidant enzymes were observed in mitochondrial fraction of heart tissues of CsA-induced rats when compared to control rats. The observed decrease in the activities of these enzymes might be due to their increased utilization for scavenging ROS, lipid peroxidation and thus providing more evidence for the involvement of oxidative damage in CsA-induced toxicity [45]. A relationship between oxidative stress cardiotoxicity has been speculated in many experimental animal models. Co-supplementation of SAC significantly increase the levels of enzymatic antioxidants compared to CsA-induced rats. This might indicate that SAC, as an excellent source of antioxidants, in modulating CsA-induced oxidative stress [46].

The diagnostic marker enzymes of cardiac damage are AST, ALT LDH and CK. The present investigation revealed that administration of CsA resulted in typical functional disturbances of cardiac muscle, as evidenced by the marked elevations of cardiac marker enzymes in serum. CsA induction leads to leakage of enzymes from the damaged heart to the serum because of their tissue specificity and catalytic activity, which was evidenced by the decreased activity of these enzymes in heart tissue and increased activities in serum, when compared with control [47]. In the present study, treatments with SAC significantly lowered the levels of these marker enzymes to near normal value, highlighting the cardio protective role of SAC. In previously reports shown that SAC has restored the activities of these marker enzymes in serum of ISO-induced rats [48].

The mitochondrial respiratory chain marker enzymes ICDH, α -KGDH, SDH, MDH, NADH dehydrogenase and cytochrome-c-oxidase were significantly decreased in the CsA treated rats. Reduction in mitochondrial metabolism enzymes [Krebs cycle and oxidative phosphorylation] was accompanied by increased ROS production by CsA [49] indicating that mitochondrial enzymes play a crucial role in the pathogenesis of CsA-induced cardiac damage. CsA induced mitochondrial dysfunction causes deleterious complications for cellular function, leading to impaired energy production, impaired cellular calcium buffering, activation of proteases and phospholipases, activation of nitric oxide synthase, and generation of free radicals [50]. These pathways can

lead to either apoptotic or necrotic cell death depending upon the severity of the insult. SAC supplementation restored the activities of these enzymes to near normal in the myocardial mitochondria. SAC is an antioxidant [51] and has the potential to inhibit lipid peroxidation, free radicals and oxidative stress ultimately resulting in increase in the activities of these TCA cycle enzymes. Thus, the capacity of SAC to restore the mitochondrial membrane components from oxidative insults would have proven essential in preserving these enzymes against lipid peroxidative damage and deterioration. Histopathological findings of the CsA-induced myocardium showed infarcted cardiac muscle fibers with oedema, enlarged interstitium disorganization of myocardial fibers and inflammatory cells. CsA-induced with SAC administered rat myocardium showed mild oedema but no infarction and the myocardial fibres were within normal limits and normal cardiac muscle bundles. Rats supplemented with SAC alone showed normal cardiac muscle bundles without any pathological changes.

Apoptosis is generally regulated by complex proteins called pro-apoptotic [Bax] and anti-apoptotic [Bcl2] proteins. The Bax/Bcl-2 ratio is an index of cellular apoptosis, which determines whether a cell will undergo apoptosis or to survive in pathophysiology [14]. The balance between pro-apoptotic and anti-apoptotic signals from the Bcl-2 family has a crucial role in the release of cytochrome C [15]. In this present study, we found that CsA induction up-regulate the expression of bax, while down-regulate the bcl-2 protein expression. In mitochondria CsA induction cause severe oxidative stress, which turns to activate Bax protein expression and creates mitochondrial permeability transition pores and subsequent release of cytochrome C [52]. The anti-apoptotic bcl-2 protein protects cells from a variety of stimuli that induce apoptosis by its antioxidant and cyto-protective properties. The death repressing activity of bcl-2 may be counteracted by dimerization with bax. It has been proposed that the relative ratio of bcl-2 and bax determines cell survival following an apoptotic stimulus. However, SAC treatment modulates the expression of Bax and Bcl2, it up-regulates Bcl2 and down-regulates Bax protein expression. Cytochrome C is a member of the mitochondrial electron transport chain that is required for the generation of ATP. Cytochrome C is an important trigger of the caspase cascade [53]. Cytochrome C mediated activation of cell death pathways occurs if cytochrome C is released from the mitochondria into the cytoplasm. In the cytoplasm, cytochrome C binds to Apaf-1 to form the apoptosome a molecular complex consisting of cytochrome c, Apaf-1, ATP, and procaspase 9. The apoptosome activates caspase 9, an upstream initiator of apoptosis. This mechanism makes regulation of the release of cytochrome C a key step in the initiation of apoptosis. Furthermore, there is a close relationship between Bax/bcl-2, cytochrome expression and caspase activity.

Caspases plays a significant role in the apoptotic progression and activation of caspase-3 the execution of apoptosis [54]. In the present study, we observed that CsA

induction activate caspase-3 in the rat cardiac tissues. When the CsA-induced rats were treated with SAC prevents the activation of caspase-3. Recent studies have demonstrated that mitochondria may play a key role in apoptosis by releasing cytochrome C and activating caspase-9, which activates caspase-3 that is responsible for DNA-cleavage action and myocyte death. In this study, we also found that CsA induction apparently increased the caspase-9. However, SAC treatment decreased the activation of caspase-3 and caspase-9 which were induced by CsA. Previous study reported that SAC decreased caspase-3 activity and inhibits cardiac apoptosis through its antioxidant potential [55].

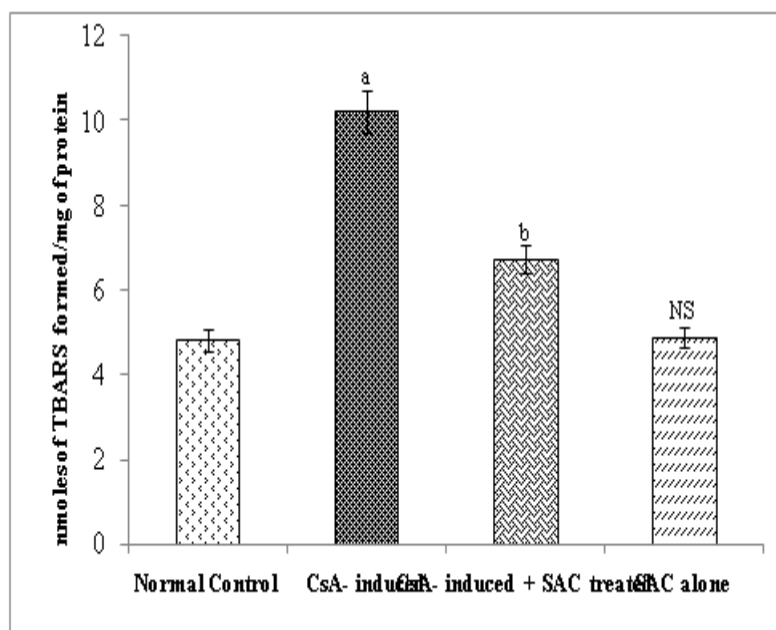


Figure 1: Effect of CsA and SAC on the Level of Lipid Peroxides in Cardiac Mitochondria of Control and Experimental Rats

Results are expressed as mean + SD for 6 different sets of experiments. Values are considered significantly different at $p < 0.05$ with post-hoc LSD test. Statistically significant variations are compared as follows:

^a CsA-induced vs. control.

^b CsA-induced + SAC treated vs CsA-induced.

^{NS} SAC Vs Normal control

^{a,b} indicates $p < 0.05$ and NS indicates Non-significant.

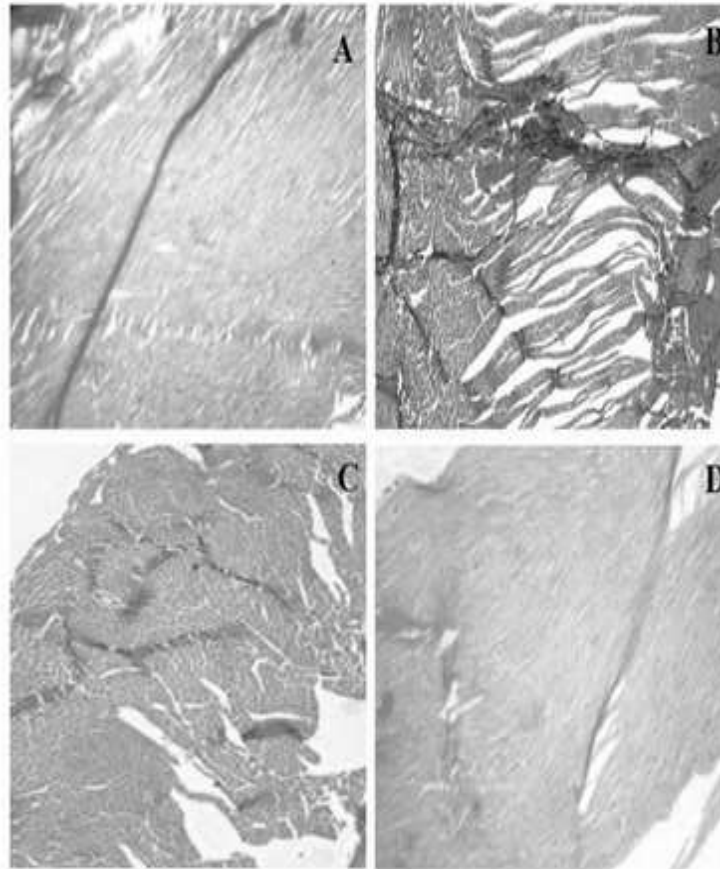


Figure 2: Effect of CsA and SAC on Rat Cardiac Histopathological Alterations in Control and Experimental Group of Rats

Effects of CsA and SAC on histopathological analysis of rat heart stained with H&E viewed under light microscope (10 x).

- (A) Myocardium of control rats showed normal cardiac fibers without any infarction and orderly arrangement of myocytes.
- (B) CsA-induced myocardial fibers showed infarcted cardiac muscle fibers with oedema, enlarged interstitium disorganization of myocardial fibers.
- (C) CsA-induced with SAC treated rat myocardium showed only mild oedema without infarction and the myocardial fibres were within normal limits, normal cardiac muscle bundles.
- (D) Rats supplemented with SAC alone showed normal cardiac muscle bundles without any damage.

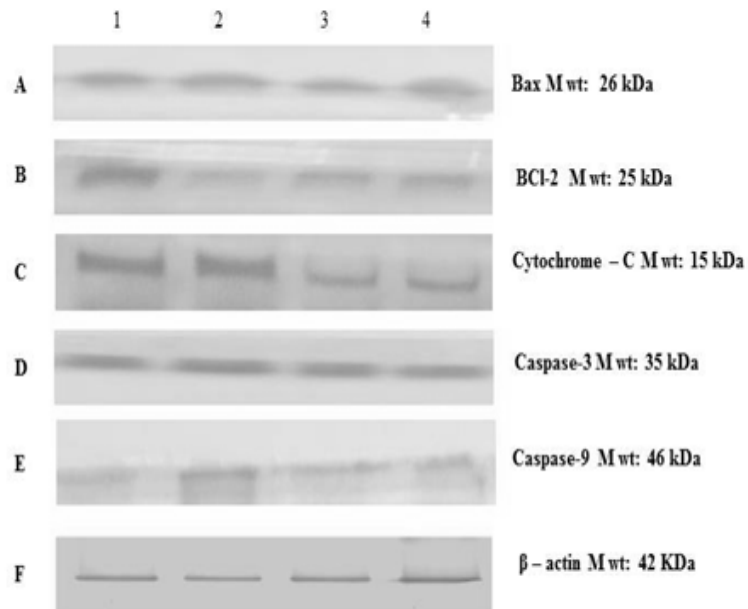


Figure 3: Effect of CsA and SAC on the Levels of Bcl-2, Bax, cytochrome c, Caspase -3, 9 Protein Expression

- (A) Immunoblot expression of Bax (26 kDa)
- (B) Immunoblot expression Bcl2 (25 kDa)
- (C) Immunoblot expression of Cytochrome C (15 kDa)
- (D) Immunoblot expression of Caspase 3 (35 kDa)
- (E) Immunoblot expression of Caspase 9 (46 kDa) in control and experimental groups of rats.
- (F) β -actin as positive control in the cardiac tissue of control and experimental animals.

Lane 1: control; Lane 2: CsA-induced group; Lane 3: CsA + SAC; Lane 4: SAC alone.

CsA-induced vs. control

CsA-induced + SAC treated vs CsA-induced.

| Particulars | Control | CsA – induced | CsA – induced + SAC treated | SAC alone treated |
|-------------|----------------|----------------|-----------------------------|-------------------|
| SOD | 5.76 ± 0.056 | 3.48 ± 0.042 | 4.85 ± 0.048 | 5.82 ± 0.052 |
| CAT | 172.87 ± 16.34 | 126.63 ± 12.97 | 158.73 ± 14.68 | 168.65 ± 16.76 |
| GPx | 16.65 ± 1.57 | 9.754 ± 1.12 | 14.87 ± 1.48 | 15.98 ± 1.63 |
| GR | 2.88 ± 0.18 | 1.37 ± 0.08 | 2.45 ± 0.12 | 2.75 ± 0.16 |
| GST | 26.87 ± 2.85 | 12.45 ± 1.57 | 20.85 ± 2.54 | 24.78 ± 2.86 |

Table. 1 Effect of CsA and SAC on the activities of SOD, CAT, GPx, GR and GST in the cardiac mitochondria of control and experimental rats.

SOD: superoxide dismutase; CAT: catalase; GPx: glutathione peroxidase; GR: glutathione reductase; GST: Glutathione-S-transferases; Enzyme activities are expressed as SOD: units/min/mg protein (One unit is equal to the amount of enzyme that inhibits pyrogallol auto-oxidation by 50%). CAT: μ moles of H_2O_2 hydrolyzed/min/mg protein. GPx: moles of NADPH oxidized/min/mg protein. GST: nmol of CDNB conjugated/min/mg protein. GR: moles of NADPH oxidized/min/mg protein.

Results are expressed as mean \pm SD for 6 different sets of experiments. Values are considered significantly different at $p < 0.05$ with post-hoc LSD test. Statistically significant variations are compared as follows:

CsA- induced vs. control.

CsA- induced + SAC treated vs CsA- induced. NS SAC vs Normal control

indicates $p < 0.05$ and NS indicates Non-significant.

| Experimental Groups | AST | ALT | LDH | CK |
|---------------------------|--------------|--------------|-------------|--------------|
| Control | 42.86 ± 3.76 | 26.86 ± 2.45 | 5.86 ± 0.68 | 10.67 ± 1.76 |
| CsA-induced | 28.78 ± 2.44 | 12.67 ± 1.35 | 9.62 ± 0.88 | 6.86 ± 1.12 |
| CsA-induced + SAC treated | 38.23 ± 2.23 | 22.86 ± 1.77 | 7.15 ± 0.76 | 8.89 ± 1.34 |
| SAC alone treated | 41.46 ± 3.43 | 25.57 ± 2.56 | 5.78 ± 0.61 | 10.34 ± 1.45 |

Table. 2 Effect of CsA and SAC on the activities of cardiac marker enzymes in serum of control and experimental group of rats

AST: Aspartate aminotransferase; ALT: alanine aminotransferase; LDH: Lactate dehydrogenase; CK: creatinine kinase. Enzymes activities are expressed as IU/L.

Results are expressed as mean + SD for 6 different sets of experiments. Values are considered significantly different at $p < 0.05$ with post-hoc LSD test. Statistically significant variations are compared as follows:

CsA- induced vs. control.

CsA- induced + SAC treated vs CsA- induced.

SAC vs Normal control

$p < 0.05$ and Non-significant.

| Particulars | Control | CsA- induced | CsA- induced + SAC treated | SAC alone treated |
|--|----------------|----------------|----------------------------|-------------------|
| Isocitrate dehydrogenase (ICDH) | 818.63 ± 66.93 | 578.46 ± 48.86 | 751.34 ± 46.45 | 808.93 ± 44.93 |
| α -Ketoglutarate dehydrogenase(α -KGDH) | 86.58 ± 8.54 | 48.94 ± 5.24 | 72.72 ± 7.32 | 82.34 ± 8.24 |
| Succinate dehydrogenase (SDH) | 326.83 ± 22.14 | 182.56 ± 12.64 | 289.67 ± 17.34 | 318.44 ± 12.34 |
| Malate dehydrogenase (MDH) | 413.34 ± 34.38 | 267.32 ± 21.43 | 386.57 ± 28.29 | 408.78 ± 33.44 |
| NADH dehydrogenase (NADH-DH) | 182.54 ± 16.53 | 112.43 ± 10.16 | 157.87 ± 12.34 | 178.52 ± 16.34 |
| Cytochrom- c-oxidase | 12.96 ± 2.13 | 7.34 ± 1.84 | 10.13 ± 1.72 | 12.26 ± 1.89 |

Table. 3 Effect of CsA and SAC on the activities of heart mitochondrial TCA cycle enzymes in control and experimental group of rats

Units: **ICDH** - nmoles of ketoglutarate formed / hr / mg protein; α - **KGDH** - nmoles of ferrocyanide formed / hr / mg protein; **SDH** - nmoles of succinate oxidaised / min / mg protein; **MDH** -nmoles of NADH oxidaised / min / mg protein; **NADH-DH** - nmoles of NADH oxidaised / min/ mg protein and **Cytochrom- C-oxidase** - nmoles of cytochrome / min / mg protein. Results are expressed as mean + SD for 6 different sets of experiments. Values are considered significantly different at $p < 0.05$ with post-hoc LSD test. Statistically significant variations are compared as follows:

CsA- induced vs. control.

CsA- induced + SAC treated vs CsA- induced.

SAC vs Normal control

indicates $p < 0.05$ and Non-significant.

6. Conclusion

In view of these findings, it is possible to conclude that prolonged consumption of CsA results severe oxidative stress, increase lipid peroxidation in cardiac mitochondria leads to activation of apoptosis and cardiac damage. SAC supplementation almost

ameliorated the cardiac dysfunction by protecting the cardiac marker enzymes, TCA cycle enzymes, decreasing the lipid peroxide products and improving the antioxidant status of the cell. These interesting data facilitate us to conclude that SAC administration might be an appropriate approach to prevent CsA-induced cardiac toxicity. SAC seem to be promising tools to explore therapeutic alternatives in cardiovascular diseases. A diet containing garlic compounds such as SAC could prove beneficial to the heart. Further investigations should be focused in exploring the beneficial effects of these drugs and the mechanisms underlying their action.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Occurrence of Alien Ascidiens in V.O. Chidambaranar Port, Thoothukudi

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Abstract

There is growing awareness that many marine sessile organisms are highly invasive and can spread rapidly to new habitats through ballast water and hull of ships. There are 12 major ports and numerous minor ports along the 7,500 km long Indian coastline, which may act as gateway for marine bio-invasion. V.O. Chidambaranar port, formerly Thoothukudi port, is one among the 12 major ports in India with regular services to United States, Europe, China, Red sea port and Mediterranean countries and may facilitate bioinvasion. Ascidiens belonging to the Class Ascidiacea of sub-Phylum Tunicata are abundant in many ports around the world and most of them are non-indigenous. They are one of the key ecological groups because of their invasive potentials. The distribution and impact of invasive ascidiens in India are less well documented and hence the present study was aimed to document the invasive ascidiens in V.O.C. port. Out of 23 species of ascidiens reported in the present study, 19 ascidiens have been believed to be alien species, with mostly from Australian origin. Seven ascidiens are found as established invasive. Their arrival has been mainly due to shipping and ballast waters and some that have arrived recently may have significant future impact. Presence of large number of invasive ascidiens in this harbour reinforces the need for continued and periodic monitoring of population expansion of these species and also for establishment of control programme. Utilization of non - indigenous ascidiens for the betterment of humankind may be considered one of management strategies of non - indigenous species.

Keywords: Ascidiens, Conservation, Distribution, India, Invasive

1. Introduction

Bioinvasion is one of the leading marine environmental issues in the world and represents a serious global threat to marine biodiversity, survival of native species and the economy (Campbell, et al., 2007). International Union for Conservation of Nature and Natural Resources (IUCN) defines Alien Invasive Species as an alien species

which becomes established in natural or semi natural ecosystems or habitat, an agent of change, and threatens native biological diversity. These invasive species are widely distributed in all kinds of ecosystems throughout the world, and include all categories of living organisms such as animals, plants, fungi and microorganisms. For an alien species to become invasive, it must arrive, survive and thrive. The Indian coast, being dotted with 12 major ports and a number of minor ports is susceptible for bioinvasion and hence warrants a close watch. Little information exists from marine ecosystems of India regarding the presence and distribution of invasive alien species including ascidians.

Ascidians belonging to the Class Ascidiacea of sub-Phylum Tunicata are abundant in many ports around the world and most of them are non-indigenous. They are one of the key ecological groups because of their invasive potentials. It has been reported that in India, 8% of the total 828 native species is represented by ascidians (www.sealifebase.org). Taxonomical studies on ascidians in India have been expanded with a report of more than 400 species. However, distributional information of alien ascidians is lacking. Subba Rao (2004) reviewed the records of Indian ascidians and reported that 6% of the total 205 non - indigenous taxa introduced into Indian seas in the post - 1960 period was represented by ascidians. The first report on alien ascidians in India was published by Abdul Jaffar Ali and Sivakumar (2007) and revealed that out of 33 species, 31 were alien ascidians in Vizhinjam Bay (southwest coast of India). Tamilselvi (2008) reported the occurrence of 18 alien ascidians in Thoothukudi coast (North Break Waters). Abdul Jaffar Ali et al. (2009) observed the 34 invasive ascidians along the southern coasts of peninsular India. The purpose of this publication is to document the known distribution of invasive ascidians in the V.O. Chidambaranar port, Thoothukudi coast.

2. Materials and Methods

Area description

V.O. Chidambaranar port is within the Gulf of Mannar ($8^{\circ} 44' 53.82''$ N Latitude, $78^{\circ} 12' 15.77''$ E Longitude) in the southeast coast of India (Fig 1). This port is one of the important and major ports in south India with year round heavy traffic by number of ships and other mechanised boats. This port is provided with many man-made structures such as hull of boats as well as ships, oyster cages, cement blocks, small stones, other harbour installations, etc., which facilitate the recruitment of alien ascidians.

Methods of collection

Intertidal sites were visited at low tides and a variety of collection methods were used to obtain the organisms. Hand tools were used to remove animals from solid surfaces like bumper tires, docks, small rocks, stones and marina floats. Snorkeler and SCUBA diver were engaged to collect materials from the undersides of floating docks at marinas.

Methods of identification

All materials collected were narcotized and then preserved in 10% buffered formalin in seawater. The specimens were sorted and identified to species or the lowest practicable taxon, with dissection, compound and stereo microscopes using taxonomic keys (Kott, 2004).

After an extensive review of literature on global invasive species, their spread based on history, species origin, species behavior and field observations at Indian coastal areas, a list of invasive alien ascidians was prepared. The following websites were also examined extensively for background information

<http://www.marinespecies.org>,
<http://www.catalogueoflife.org> and
[http:// www.sealifebase.org](http://www.sealifebase.org).

All the species were categorized based on the 10 criteria proposed by Carlton (1989).

3. Results

A total of 23 ascidians which includes 13 genera belonging to eight families were encountered in the study area. Of these, four were native (*Distaplia nathensis*, *Polyclinum indicum*, *P. madrasensis* and *Diplosoma swamiensis*) and remaining 19 ascidians were considered as alien species. Categorized 23 ascidians along with family were shown in Table 1.

Among the 23 species, 15 were categorized as invasive ascidians. Seven species such as *Phallusia nigra*, *Styela canopus*, *Herdmania pallida*, *Eudistoma viride*, *Didemnum candidum*, *D. psammathodes* and *Lissoclinum fragile* were identified as established invasive species. Since the origin of two species such as *Symplegma oceania* and *Microcosmus propinquus* were uncertain, they were recognized as cryptogenic (Carlton, 1989). In earlier report (Abdul Jaffar Ali et al., 2009), *Styela canopus* and *Eudistoma viride* have been categorized as invasive and cryptogenic respectively, but the present study revealed that these species have established their population and breed throughout the year and hence they were categorized as established invasives.

Microcosmus exasperates, *H. pallida*, *D. candidum* and *D. psammathodes* were most abundant species occurred on every substrate type indicating that these common species were able to colonize all the available substrata. Of the 8 families, Didemnidae is the most dominant family with 6 species followed by Ascidiidae and Pyuridae (4 each), Polyclinidae (3), Styelidae and Polycitoridae (2 each), Rhodosomatidae and Stomozoidae (1 each) (Figure 2).

According to the available literature, maximum number of ascidians was from Australian region followed by North Pacific Ocean and Indian Ocean. The other regions, which contribute less, were Caribbean Sea, South Pacific Ocean and Mediterranean Sea.

Table 1. List of ascidians collected from different habitats of the study area

| S. No. | Ascidians | Type | Status | Substrates | | | | | |
|-------------------------------|--|------|--------|------------|----|----|----|----|----|
| | | | | S1 | S2 | S3 | S4 | S5 | S6 |
| Family: RHODOSOMATIDAE | | | | | | | | | |
| 1 | <i>Rhodosome luteolum</i> (Savigny, 1816) | C | I | x | - | - | x | x | x |
| Family: ASCIDIIDAE | | | | | | | | | |
| 2 | <i>Phallusia arabica</i> Savigny, 1816 | S | I | x | - | - | x | x | x |
| 3 | <i>P. rigida</i> Savigny, 1816 | S | EI | x | - | - | x | x | x |
| 4 | <i>Ascidia gemmata</i> Sluiter, 1895 | S | I | - | - | - | x | x | x |
| 5 | <i>A. rufocincta</i> Stimpson, 1885 | S | I | - | - | - | x | x | x |
| Family: STYELIDAE | | | | | | | | | |
| 6 | <i>Synglyma oceanica</i> Tokioka, 1961 | C | C | - | - | - | x | - | - |
| 7 | <i>Styela canopus</i> (Savigny, 1816) | S | EI | x | - | - | x | x | x |
| Family: PYURIDAE | | | | | | | | | |
| 8 | <i>Microcosmus nasutus</i> Heller, 1878 | S | I | x | - | - | x | x | x |
| 9 | <i>M. propeus</i> Herdman, 1881 | S | C | x | - | - | x | x | x |
| 10 | <i>M. squamiger</i> Michaelson, 1927 | S | I | x | - | - | x | x | x |
| 11 | <i>Herdmania manni</i> (Savigny, 1816) | S | EI | x | x | x | x | x | x |
| Family: HOLOZOIDAE | | | | | | | | | |
| 12 | <i>Detrigla nakaeana</i> (Matsukishi, 1998) | C | N | - | x | x | x | x | - |
| Family: POLYCITORIDAE | | | | | | | | | |
| 13 | <i>Eudiroena mucronum</i> Kott, 1990 | C | I | - | x | x | x | - | - |
| 14 | <i>E. viridis</i> Tokioka, 1955 | C | EI | - | x | x | x | - | - |
| Family: POLYCLINIDAE | | | | | | | | | |
| 15 | <i>Polychinum indicum</i> Sebastian, 1954 | C | N | - | - | x | x | - | - |
| 16 | <i>P. madrasense</i> Sebastian, 1952 | C | N | - | - | x | x | - | - |
| 17 | <i>P. nudum</i> Kott, 1992 | C | I | - | - | - | x | - | - |
| Family: DIDEMNIDAE | | | | | | | | | |
| 18 | <i>Didemnum candidum</i> Savigny, 1816 | C | EI | x | x | x | x | x | x |
| 19 | <i>D. prasinokoder</i> (Sluiter, 1895) | C | EI | x | x | x | x | x | x |
| 20 | <i>Diploroma macdowaldi</i> Herdman, 1886 | C | I | - | x | x | x | - | - |
| 21 | <i>D. swamloensis</i> Ranganathan, 1986 | C | N | - | x | x | x | - | - |
| 22 | <i>Littorichium bistratum</i> (Sluiter, 1905a) | C | I | - | - | - | x | - | - |
| 23 | <i>L. fragile</i> (Van Name, 1902) | C | EI | x | x | x | x | x | x |
| Total | | | | 11 | 9 | 11 | 23 | 14 | 13 |

Note: S - Simple; C - Colonial; N - Native; I - Invasive; C - Cryptogenic;

EI - Established Invasive

x - Present; - - Absent

S1 - Large cement blocks; S2 - Granite stones; S3 - Small embedded rocks

S4 - Pearl oyster cages; S5 - Hull of ship; S6 - Old barges



Figure. 1 Satellite view of study area - V.O.Chidambaram Port, Thoothukudi coast

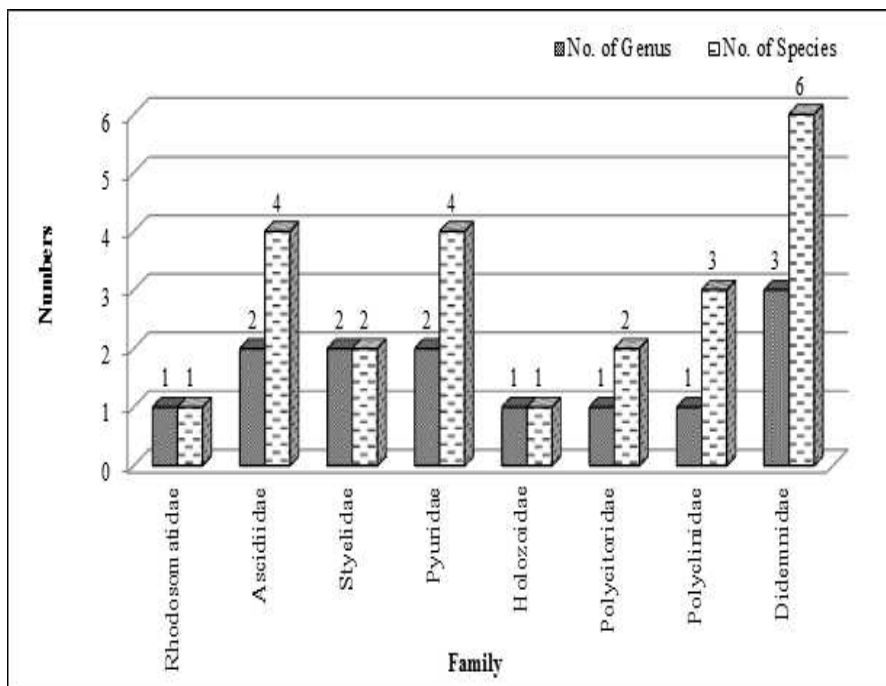


Figure. 2 Members of the various families of ascidians recorded in the present study

4. Discussion

As expected, increased number of alien ascidians (19) along with four native species at study area was observed. It is well known that availability of artificial substrates, such as buoys, ropes and floats, near and in marinas often have large numbers of introduced ascidians (Lambert and Lambert, 2003). Generally non-indigenous species (NIS) are abundant in harbour areas. An alternative factor that may enhance invasion in harbour and marina areas is environmental degradation commonly found in these habitats that favours the establishment of NIS, as native species are poorly adapted to these altered conditions (Preisler, et al., 2009). Introduced organisms may also be favoured by a change in resources available, such as space for colonization when pollution intolerant species die and increasing space for tolerant invasive species (Herbert, 1999). The above reports strongly evident the recruitment of large number of alien ascidian in Thoothukudi harbour.

The exhaust review of literature revealed that maximum alien ascidians might have probably migrated from Australian region because out of 19 alien ascidians, 12 species were reported at Australia, which is followed by North Pacific Ocean and Indian Ocean. The other regions, which contribute less, are Caribbean Sea, South Pacific Ocean and Mediterranean Sea but this is yet to be authenticated with complete ship traffic schedule of both Thoothukudi and other countries. Occurrence of more number of alien ascidians at study area could also be justified by the fact that Thoothukudi port harboured 1026 foreign ships from North East countries and 210 from other ports of India (Personal communication from Port Authorities of Central Document Centre, Thoothukudi Port Trust). Number of evidences supports this fact that worldwide shipping has introduced exotic species into many ports (Hewitt, et al., 2004). Introductions of non-indigenous ascidians into harbours in both tropical and temperate waters are now with the increasing rate of introductions yearly (Lambert, 2002).

In the present survey, three species such as *Diplosoma macdonaldi*, *Lissoclinum bistratum*, and *Eudistoma muscosum* were considered as new arrivals to this port. These species have never been reported in study area previously. These species might have transported through ships and/or ballast waters from Australia and South Pacific Ocean (Kott, 2004).

In Thoothukudi coastal water, 14 ascidians were identified as new species by various authors (Renganathan, 1986; Renganathan and Monniot, 1984; Meenakshi, 2013). According to the criteria proposed by Carlton (1989), these 14 new species may be considered as native to India. Out of 14, 10 native ascidians were not encountered for the past 10 years and these species might be either overlooked by alien ascidians or migrated to some other areas.

Alien ascidians are recognized as one of the leading threats to biodiversity and also inflict enormous costs on fishing and fisheries. In contrast, many ascidians are used as food in the form of various preparations in many parts of the world such as Chile,

France, Korea, Italy, Japan etc. Many novel compounds including anticancer drug such as, ET 743, etc. obtained from different species of colonial ascidians (Valoti, et al., 1998). Tyrosine derived bactericidal compound was isolated from the alien species *Phallusia nigra*, native to the Red sea (Abdul Jaffar Ali, et al. 2008). Pickle was prepared from the mantle bodies of non-native simple ascidian *H. pallida*, native to Red sea (Tamilselvi, et al., 2010).

Since there is no concrete solution to prevent or eradicate the alien ascidians, they can be better utilized from the natural conditions for value added products in order to preserve or restore of native species. By applying positive strategy to these ascidians, invasiveness may be controlled as well as native species can be protected against local eradication or extinction of species.

Acknowledgements

Our deep sense of gratitude to Department of Biotechnology, Government of India for the financial support (BT/PR6801/AAQ/3/609/2012) and also to our College Secretary and Principal for their motivation.

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In Silico Analysis of COI Gene Sequences of Two Colonial Ascidians *Polyclinum Indicum* and *Didemnum Candidum* from Gulf of Mannar

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Abstract

COI gene sequences of 670 and 737 bps in length were obtained two colonial ascidians, *Polyclinum indicum* and *Didemnum candidum* respectively using universal primer. Lengths of the obtained sequences were in mitochondrial cytochrome c oxidase subunit I gene range. Maximum GC content was observed in the *Didemnum candidum* compared to *Polyclinum indicum*, although both were GC rich. The translated product of these COI genes resulted amino acids sequences of length 215 and 183 amino acids, with molecular weight of 23707.4 and 20073.9 Daltons for *Polyclinum indicum* and *Didemnum candidum* respectively. Theoretical pI values and aliphatic index values supported the instability index values, which proved the stability of the mitochondrial COI. Two amino acids cysteine and glutamate were absent in *Polyclinum indicum* and *Didemnum candidum* correspondingly. Further studies using amino acids of COI gene from different ascidians may aid in developing a molecular key for the identification of ascidians.

Keywords: *Polyclinum indicum*, *Didemnum candidum*, COI gene, amino acids.

1. Introduction

Advances in computational technology and sequencing have made DNA sequence the major source of new information for advancing our knowledge of evolutionary and genetic relationship. The animal mitochondrial genome is a better target for analysis than the nuclear genome because of its lack of introns, limited exposure to recombination and its haploid mode of inheritance (Saccone et al 1999). The choice of mitochondrial gene as a universal marker was mostly driven by the fact that mitochondria is maternally inherited, avoiding problems with recombination. Mitochondrial genome has a high mutation rate when compared with the nuclear genome, which results in high degree of intra-specific polymorphism and divergence, important in evolutionary studies (Williams and Knowlton 2001, Wheat and Watt 2008,

Hlaing et al 2009). The mitochondrial cytochrome c oxidase subunit is a protein coding gene, where indels are rare, since most may lead to a shift in the reading frame. The phylogenetic signal in COI gene is much higher than in any other mitochondrial genome. A high incidence of base substitutions is observed in the third position nucleotide, leading to a rate of molecular evolution that is about three times greater than that of 12s or 16s rDNA (Knowlton and Weigt 1998). Other mitochondrial genes may match with COI gene in resolving cases of recent divergence but a deeper phylogenetic insight is provided than its alternatives such as cytochrome b (simmons and Weller 2001) because the slow changes in its amino acid sequence than any other mitochondrial genome (Lynch and Jarrel 1993). This feature may make it possible to assign any unidentified organisms to a higher taxa (eg. Phylum, order) by examining the amino acid substitutions before determining its species identity with nucleotide substitution. In this context, an in-silico approach was made in the present investigation to analyse the mitochondrial COI gene and its translated products of the two colonial ascidians.

2. Materials and Methods

Two species of colonial ascidians were collected from Gulf of Mannar (south east coast of India). They were identified using taxonomic keys (Sebastian 1954, Kott 1990)

Genomic DNA Isolation

Genomic DNA was isolated using DNeasy Blood and Tissue Kit (Qiagen) following manufacturer's animal tissue protocol.

PCR Amplification and Sequencing

COI gene was amplified using Universal primer (Folmer et al, 1994). PCR amplifications were carried out in 100.0 μ l reaction volumes containing; 1 μ l of AmpliTaq Gold DNA polymerase enzyme, 400 ng of both primers and 1 μ l of template DNA. Thermocycling conditions consisted of: 94° C for 5 minutes, one cycle; 94° C for 30 seconds, 55° C for 30 seconds, 72° C for 30 seconds; 35 cycles; 72° C for 3 minutes, one cycle. Amplified products were purified and sequenced in both directions using BigDye Terminator v3.1 Cycle sequencing Kit (Applied Biosystems, USA) by a commercial lab. PCR products were sequenced in both the reverse and forward direction using the appropriate PCR primer to prime the sequencing reaction. Sequence quality was checked using Sequence Scanner Software v1 (Applied Biosystems). Sequence alignment and required editing of the obtained sequence was carried out using BioEdit (Hall 1999).

Data analysis

GC% was calculated using BioEdit (Hall 1999). Translation of COI gene sequences were done by ExPASy Translate using ascidian mitochondrial as the genetic code. All the amino acid studies of the COI genes were done using ExPASy. The transmembrane helix corresponding to the obtained COI sequence was analysed with the TMPred software (Hofmann and Toffel S, 1993).

3. Results and Discussion

Amplification using universal primer obtained a 670 bp sequence (Fig.1) for *Polyclinum indicum* and 737 bp sequence (Fig.2) for *Didemnum candidum*. Both these sequences were in the mitochondrial COI gene range. Maximum GC content (63%) was observed in *Didemnum candidum* COI sequence (Table.2). Translation of these COI sequences for undisrupted and long open reading frames obtained two amino acid sequences of length 215 and 183 amino acids, with a molecular weight of 23707.4 and 20073.9 Daltons for *Polyclinum indicum* and *Didemnum candidum*. These two amino acid sequences in 5'3' directions were the best frames among the other frames generated in 3' 5' and 5'3' directions (Figs 3 and 4). These amino acid sequences with long open reading frames are indispensable, since the long open reading frames are used in along with other evidence, to initially identify candidate protein coding regions in a DNA sequence (Deonier et al 2005). The amino acids Phenylalanine (F) with 12.1% and Leucine (Leu) with 12.0% (Table 1) were the dominant amino acids in the translated product of *Polyclinum indicum* and *Didemnum candidum*. *Polyclinum indicum* was rich in negatively charged amino acids, whereas *Didemnum candidum* had equal number of negatively and positively charged residues (Table 2). The instability index values of these amino acid sequences proves the stability of the mitochondrial COI protein. Moreover the stability of this protein was supported by the theoretical pI values the aliphatic index values (Table 2), which is a positive factor for the thermostability of proteins. The amino acid sequences of the corresponding 5'COI gene regions comprised five transmembrane helix for *Polyclinum indicum* and four transmembrane helix for *Didemnum candidum*. These helices were joined by two external and two internal loops (Figs 5 and 6). This result is in agreement with the COI protein topographical model (Saraste 1990). An interesting observation made from this in-silico analysis of the translated product of COI gene was the absence of amino acids Cysteine (C) and Glutamate (E) in *Polyclinum indicum* and *Didemnum candidum* respectively. This result reveals the absence of coding sequence for these amino acids in the COI gene of this species.

```

>IGTTTTTGGGA ATTTTGGCGC TATCAIGTIT TTTATTGGTG GGGCGATGGC
GATGGTTATT CGTGCGGAGT TGTITCAGCC GGGTTTGCAA TATGTAGAGC
CCCAGTTTTT TAACTCCAIG ACAACGGTGC ATGCGCTGGT GATGATTTTT
GGCCTGTTA TGCCGGCAGG TGTGGGICTT GCCAACTGGA TGATTCCGAT
GATGATTGGT GCTCCGATA TGGCCAIGCC TCGTATGAAT AATATGAGTT
TCTGGATACT GCCGTTTGCT TTTGCGTIGC TGTATCCAC CTTCITTTATG
CAGGGTGGTG CGCCGGAIGG TGGCTGGACT ATGTATCCAC CGTIGGTATT
ACAGCTTGGG GACGGATTTT CGTTTTTGAT TTTGCGAGTA CATTTCCTCG
GTATTCGTC AATATATGGG GCGATTAATA TTATTGCTAC GGCCTTTAAT
ATGCGGGCGC CAGGCATGAC TTTTATGAGG TTGCCITTTAT TTGCTGGAC
CTGGGTATT ACAGCGTTTT TGCTGATAGC CGCTATGCCA GTACTGGCAG
GCGGTGTTAC CATGTTGCTG ACAGATCGTT ATTTTGGGAC GGCATTCTTT
GATGCCGCGG GTGGTGGCGA TCCAGTAAATG TTTTCCAGATA TATCTGGTT
TTTTGGTCAT CCATGAAAGT

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Fig. 1 COI gene sequence of *Polyclinum indicum*

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>CGAATTTTC CCTGCCTGGC CATGTAGAT TAGACTGGAT GGGGGGCGAC
CTGCAGGGCC TGGTCCTTIG GGAAGTGGCC TAGCCGGGAA TCCAGGTGTT
CTCCGACACC GGCCTGCTGG CCCAGCTGGG CATCTTCCAG GGCAAGCACG
GCTATAACGC CGTGGTCACC GCCCAGGCC TGATCATGAT CTTCTTCATG
GTCATGCCCC CCATGGTCGG CGGGTTTGGC AACTGGTTCG TGCCGATCAT
GATCGGCGCG CCGGACATGG CCTTCCCGCG CATGAACAAC ATTTTCGTCT
GGCTGCTGGT CGCCGCCTGG TGCCTGCTGA TCCTGTCGAT GTTCACCGAC
GGCGGACCGG GCAAGGGCTT CGGCGGAGGC TGGACGGCCT ATCCGCGCT
ATCGACCACG GGCCACGTCG GCCCCGCCCT CGACCTGGCG ATCTTCACGC
TGCACGTCGC GGGCGCCAGC TCGATCCTGG GCGCGATCAA CTTCAICACC
ACCATTTTGA ACATGCGC GC CCGGGCATG ACGCTTACC GGATGCCGCT
GTTGCGCTGG TCGGTGCTGA TCACGGCCTT CCTGCTGCTG CTGTCGCAGC
CCGTGCTGGC CGGCGCCATC ACCATGCTGC TGACGGACCG CAACTTCCAC
ACCCACTTCT TCGATCCCGC CGGCGGCGGC GACCCGATCA TGTACCAGCA
CCTGTTCTTG ATTTTTTGGT CACCCTGAAA GTTTTAA

```

Fig. 2 COI gene sequence of *Didemnum candidum*

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MFFIGGAMAM VIRAEFQPG LQYVEPQFFN SMTTVHALVM IFGAVMPAGV GLANWMIPMM
IGAPDMAMPR MDMMSFWMLP FAFALLSTF FMQGGAPDGG WMYPPFLVLQ LGDGFPLIF
AVHFLGISSI MGAINIATA FMRAPGMTF MGLPLFVWTV VITAFLLMAA MPVLGGVTM
LLTDRYFGTA FFDAAAGGDF VMFQHMFWFF GHFWK

```

Fig. 3 Amino acid sequence of *Polyclinum indicum*

```

MIFFMVMPAM VGGFGNWFVP IMIGAPDMAF PRMNNISFWL LVAAWCLLIL SMFTDGGPGK
GFGGGWTAYP PLSTTGHVGP AFDLAIFTLH VAGASSILGA INFITILNM RAPGMTLHRM
PLFAWSVLIT AFLLLSQPV LAGAITMLLT DRNFHTHFFD PAGGGDFIMY QHLFLIFWSP
WKF

```

Fig. 4 Amino acid sequence of *Didemnum candidum*

4. Conclusion

In this primary study, a molecular level approach was made to study the structure of COI gene and its translated product. This study made it evident that the two colonial ascidians are GC rich. This result may help in further studies, since the GC content of the COI region is a very strong predictor of genomic shifts in nucleotide (Filipe.O et al 2007). Absence of two amino acids cysteine and glutamate in *Polyclinum indicum* and

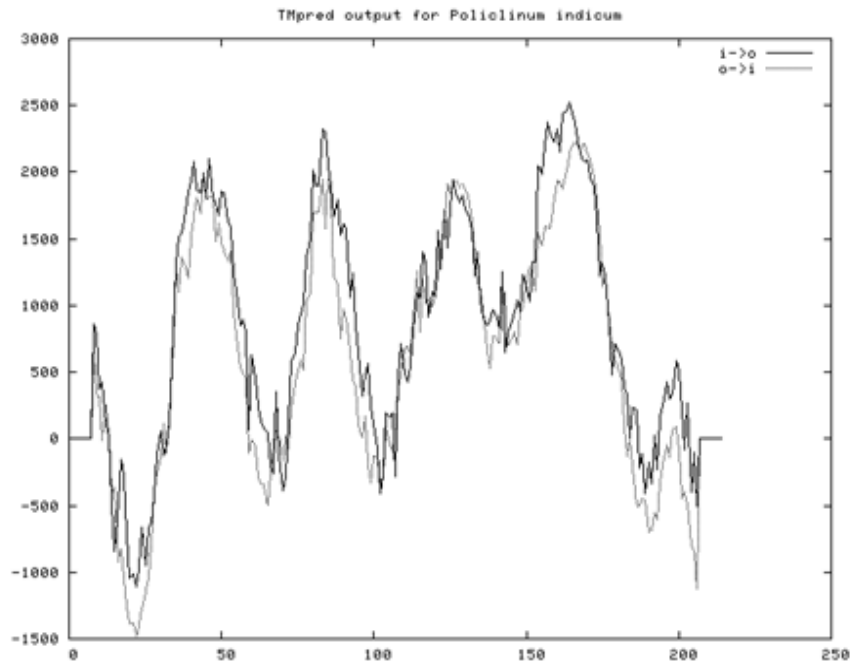


Fig. 5 Hydropathy plot of *Polyclinum indicum* 5' COI region.

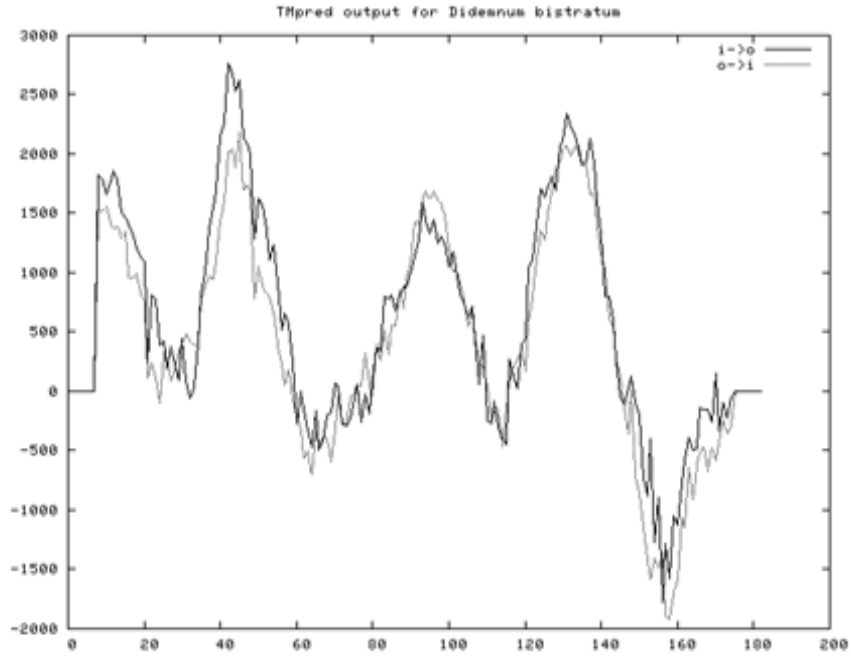


Fig. 6 Hydropathy plot of *Didemnum candidum* 5' COI region.

Didemnum candidum may serve as an additional supportive molecular information in species identification apart from the phylogenetic information. Further studies on COI genes and its amino acid compositions from different ascidians may assist in developing a key for the identification of ascidians and also to understand genetic diversity among ascidians.

| Amino acid | Number | | % of Amino Acid | |
|------------|----------|----------|-----------------|----------|
| | Spices 1 | Spices 2 | Spices 1 | Spices 2 |
| Ala (A) | 24 | 17 | 11.20% | 9.30% |
| Arg (R) | 4 | 4 | 1.90% | 2.20% |
| Asn (N) | 6 | 6 | 2.80% | 3.30% |
| Asp (D) | 6 | 6 | 2.80% | 3.30% |
| Cys (C) | 0 | 1 | 0.00% | 0.50% |
| Gln (Q) | 6 | 2 | 2.80% | 1.10% |
| Glu (E) | 2 | 0 | 0.90% | 0.00% |
| Gly (G) | 24 | 20 | 11.20% | 10.90% |
| His (H) | 4 | 6 | 1.90% | 3.30% |
| Ile (I) | 12 | 14 | 5.60% | 7.70% |
| Leu (L) | 20 | 22 | 9.30% | 12.00% |
| Lys (K) | 1 | 2 | 0.50% | 1.10% |
| Met (M) | 25 | 13 | 11.60% | 7.10% |
| Phe (F) | 26 | 19 | 12.10% | 10.40% |
| Pro (P) | 16 | 14 | 7.40% | 7.70% |
| Ser (S) | 5 | 8 | 2.30% | 4.40% |
| Thr (T) | 11 | 12 | 5.10% | 6.60% |
| Trp (W) | 7 | 7 | 3.30% | 3.80% |
| Tyr (Y) | 3 | 2 | 1.40% | 1.10% |
| Val (V) | 13 | 8 | 6.00% | 4.40% |

Table. 1 Amino acid composition of *Polyclinum indicum* and *Didemnum candidum*

| Parameters | Polyclinum indicum | Didemnum candidum |
|--|--------------------|-------------------|
| Length of COI gene (bp) | 670 | 737 |
| GC% | 47 | 63 |
| No of amino acids | 215 | 183 |
| Molecular weight | 23707.4 | 20073.9 |
| Theoretical pI | 5.63 | 7.01 |
| Total number of negatively charged residues (Asp +Glu) | 8 | 6 |
| Total number of positively charged residues (Arg +Lys) | 5 | 6 |
| Instability index | 37.56 | 35.84 |
| Aliphatic index | 86.74 | 98.69 |
| Grand Average of | 0.867 | 0.782 |
| Hydropathicity (GRAVY) | | |
| Transmembrane heices | 5 | 4 |

Table. 2 In-silico analysis of *Polyclinum indicum* and *Didemnum candidum*

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Phytochemical Screening of leaves of *Punica granatum* and its Antibacterial Activity

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Abstract

Phytochemical screening and invitro antimicrobial activity of leaves of *Punica granatum* was investigated. Phytochemical screening of leaves of *P. granatum* was carried out by using ethanol as solvent and its analysis was focused to investigate the presence of five important phytochemicals namely alkaloids, flavonoids, glycosides, tannins and saponins. Results showed the presence of flavonoids and glycosides, whereas Alkaloids, Tannins and Saponins were found to be absent in ethanolic extract. Ethanolic crude extract of leaves of *P. granatum* was tested against four clinically isolated pathogenic bacteria namely *Escherichia coli*, *Pseudomonas sp.*, *Klebsiella sp.*, and *Streptococcus sp.* The antibacterial assay was performed by disc diffusion method. The ethanolic extract showed tremendous antibacterial potentiality that was determined by zone of inhibition against all the pathogens subjected to this study. However, the crude extract showed maximum activity against *Streptococcus sp.*, and minimum activity against *Pseudomonas sp.*, among the above mentioned species. Results are encouraging enough to deduce the importance of some Phytochemicals of this plant particularly flavonoids and glycosides. Further investigation is required to identify, validate the active compounds and determine the dose to formulate the antibacterial drug.

1. Introduction

The practice of using plant as a source of medicine is as old as human civilization. With several trials and experiments, scholars and doctors for several centuries, have utilized different plants, fruits and herbs to cure ailments and relieve the patient from pain. These have often been described as medicinal plants. Its ingredients, proportion, parts of the plant used for the preparation of medicine has been documented well in literature and practiced in different parts of the world. Medicinal plants contain different bioactive ingredients used to cure diseases or relieve pain¹. The remedial properties

of medicinal plants could be based on the antioxidant, antimicrobial, antipyretic or analgesic effects of different phytochemicals present in them². The prominence of medicinal plant gained importance with the outcome of side effect associated with allopathic drugs.

The widespread use of commercially available antimicrobial drugs led to the emergence of resistance against pathogens leading to a threat to global public health. Since 1980, the introduction of new antimicrobial drugs has declined due to the huge expense of developing and testing new drugs. All commercially available antibiotics with prolonged use may have side effect on human health. They kill gut flora and patients need probiotics to replace gut flora.

Punica granatum L., commonly known as pomegranate, is a fruit-bearing deciduous shrub or small tree, native to Asia and belongs to the family Lythraceae³. The pomegranate is native to the region of Armenia, Iran and the western Himalayan range, and has been cultivated in Iran, Iraq, Armenia, Afghanistan, Pakistan, India, Russia, and the Mediterranean region for several millennia⁴. The leaves are shiny and about 7.6 cm long⁵. *P. granatum* has been extensively used as a traditional medicine in many countries for the treatment of dysentery, diarrhea, helminthiasis, acidosis, hemorrhage and respiratory diseases⁶. Further, this plant is reported to have excellent antibacterial, antifungal, antiprotozoal and antioxidant properties⁷⁻⁹.

Numerous phytochemical constituents have been found in different parts of the pomegranate plant making it pharmacologically precious¹⁰. Therefore, the present study was undertaken with the objectives to assess the antibacterial properties and to screen the phytochemical contents of the leaf extracts of *P. granatum L.*

2. Materials and Methods

Collection of Plant material

The leaves of *P. granatum* were collected from the available plant in and around Vaniyambadi, and the specimens were identified and confirmed by experts in Department of Biotechnology, Islamiah College (Autonomous), Vaniyambadi.

Preparation of Plant Extracts

Ethanollic Extract

Fresh leaves of *P. granatum* were washed thoroughly with water to remove the impurities on the surface of leaves and shade dried. The dried plant material was powdered using blender. 10 g of powdered material was added with 100 ml of absolute ethanol in a conical flask and kept in an orbital shaker for 48 hours. The extract was filtered using Whatmann No: 1 filter paper and stored at 2 - 8° C. The condensed extracts were used for preliminary screening of phytochemicals and antibacterial assay.

Phytochemical analysis of different Crude extracts

Extracts were tested for the presence of Phytochemicals such as glycosides, saponins, alkaloids, flavonoids and tannins by following the standard procedures.

Test for Glycosides

This experiment was carried out by Keller Killiani Test¹². Test solution was treated with few drops of glacial acetic acid and Ferric chloride solution and mixed. Concentrated sulphuric acid was added, and observed for the formation of two layers. Lower reddish brown layer and upper acetic acid layer which turns bluish green would indicate a positive test for glycosides. Bromine water test - Test solution was dissolved in bromine water and observed for the formation of yellow precipitate to show a positive result for the presence of glycosides.

Test for Saponins

Foam Test - Test solution was mixed with water and shaken and observed for the formation of froth, which is stable for 15 minutes for a positive result¹².

Test for Alkaloids

Hager's Test - Test solution was treated with few drops of Hager's reagent (saturated picric acid solution). Formation of yellow precipitate would show a positive result for the presence of alkaloids¹².

Test for Flavonoids

Ferric chloride test - Test solution when treated with few drops of Ferric chloride solution would result in the formation of blackish red color indicating the presence of flavonoids¹².

Test for Tannins

Gelatin Test - Test solution when treated with gelatin solution would give white precipitate indicating the presence of tannins¹².

Antibacterial Assay**Collection of bacterial species**

Four clinical isolates namely *Escherichia coli*, *Pseudomonas sp*, *Klebsiella sp* and *Streptococcus sp* were collected from Diagnostic Laboratory, Christian Medical College (CMC), Vellore and sub cultured in nutrient broth and streak plate technique and kept in refrigerator for performance of assays and future use.

Preparation of extract concentration

Ethanol extract was subjected to antibacterial activity. 10g of powdered material prepared from leaves of pomegranate (*Punica granatum*) was taken in 250 ml of conical

flask and 100ml of absolute Ethanol was added. The extract was filtered, dried and was used to prepare different concentration such as 40 mg / ml, 60 mg / ml and 80 mg / ml to perform antibacterial assay.

Preparation of Nutrient Agar

2.8 g of Nutrient agar was added with 100ml distilled water and sterilized in Autoclave at 120° C for 15 - 20 minutes. The media was poured in petri plates and kept for few minutes for solidification. After solidifying, the agar was used to carry out the antibacterial assay.

Disc Diffusion Method

The antibacterial activity was performed by disc diffusion method. Whatmann No: 1 Filter paper was used to prepare small disc of size 5mm in diameter. These discs were dipped in different concentrations of extract. Four clinical isolates *Escherichia coli*, *Pseudomonas sp*, *Klebsiella sp* and *Streptococcus sp* were transferred to different petriplates separately using spread plate technique and left for few minutes to dry in laminar air flow. Discs containing different concentration of extracts were kept on the surface of the agar along with a control. The petri plates containing the extract and microbial inoculum were kept in an incubator at 37° C for 48 hours.

3. Results

| S.No. | Phytochemicals | Ethanollic Extract |
|-------|----------------|--------------------|
| 1 | Flavonoids | + |
| 2 | Alkaloids | - |
| 3 | Saponins | - |
| 4 | Tannins | - |
| 5 | Glycosides | + |

Table. 1 Screening of phytochemicals in Ethanollic Extract of *Punica granatum*

| Clinical Isolates | Zone of inhibition (mm in diameter) | | | |
|--------------------------|-------------------------------------|------------|-----------|-----------|
| | Ctrl | 40 mg / ml | 60 mg /ml | 80 mg /ml |
| <i>E.coli</i> | 0 | 12 | 18 | 26 |
| <i>Pseudomonas sp.</i> | 0 | 11 | 17 | 23 |
| <i>Klebsiella sp.</i> | 0 | 15 | 19 | 28 |
| <i>Streptococcus sp.</i> | 0 | 10 | 20 | 30 |

Table. 2 Antibacterial activity in ethanollic extract of *P. granatum*

Three different concentration of *Punica granatum* extract for antibacterial activity (40 mg /ml, 60 mg / ml and 80 mg / ml)

Ctrl - Control (Distilled Water)

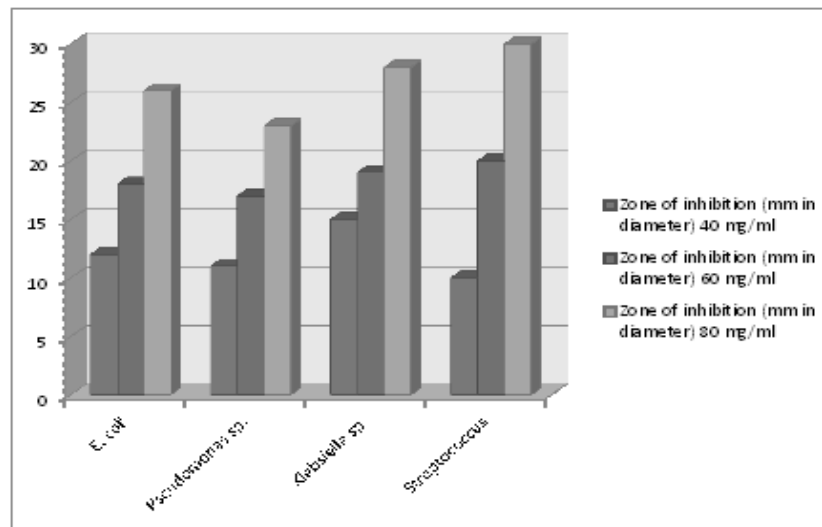


Figure 4: Data representing Antibacterial activity of Ethanolic leaves extract of *P. granatum* in a dose dependent manner

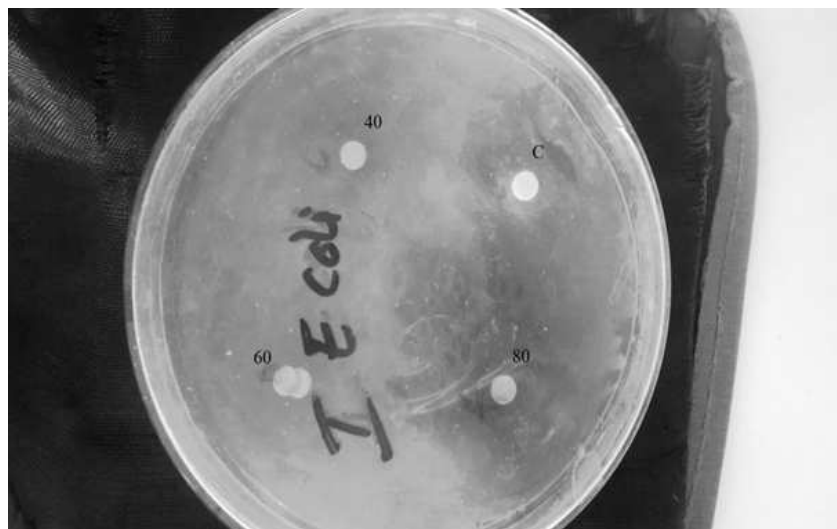


Figure 5: Antibacterial activity of Extract against Escherichia coli species

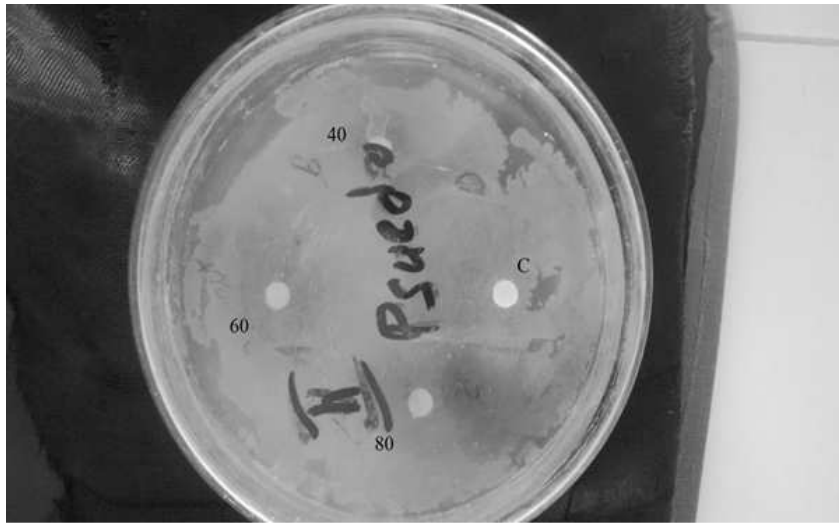


Figure 6: Antibacterial activity of Extract against *Pseudomonas* species

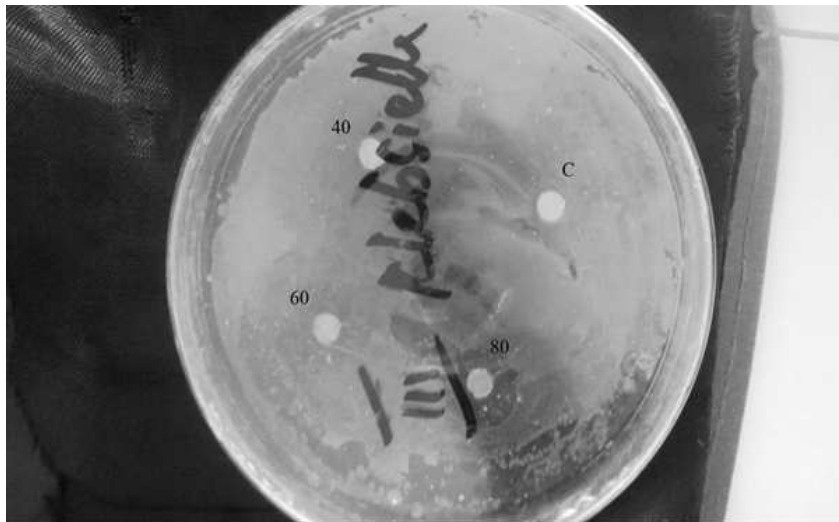


Figure 7: Antibacterial activity of Extract against *Klebsiella* species

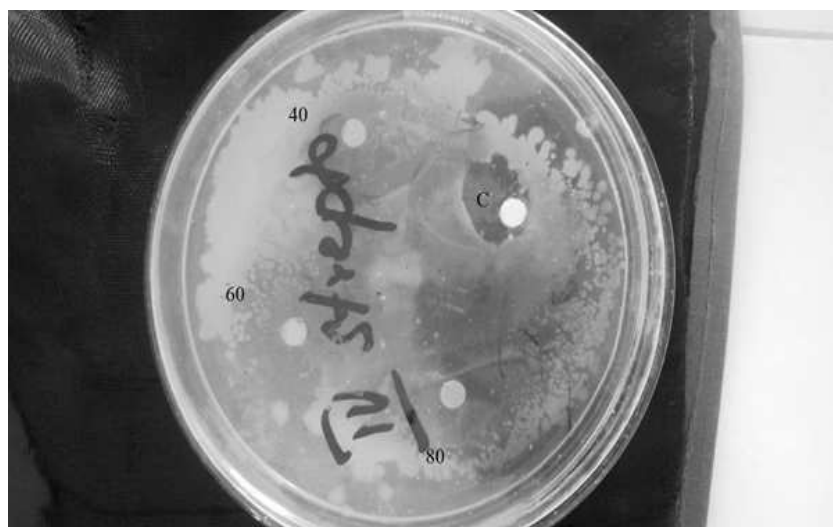


Figure 8: Antibacterial activity of Extract against Streptococcus species

4. Discussion

The Phytochemical analysis of the ethanolic extract of leaves of *P. granatum* showed that flavonoids and glycosides were present when subjected to ferric chloride test and Keller Killiani's test respectively, whereas Alkaloids, Tannins and saponins are found to be absent in ethanolic extract (Table - 1). However, it has been reported that tannins and saponins are found to be present in the methanolic leaves extract of *Punica granatum*¹¹. Flavonoids and Glycosides are reported to be present in leaves, fruits and peels of *Punica granatum* when subjected to phytochemical screening solvents such as Ethanol, Methanol, Aqueous, Ethyl acetate and Chloroform^{11,12}. *P. granatum* is popularly known for containing abundance of flavonoids that makes them potential antioxidant and anticancer agent. It has been reported that pomegranate leaves, seed oil and peel extracts showed tremendous antioxidant property^{11,13,14}. The Peel extracts of pomegranate reportedly contains potential anticancer property¹³.

Ethanolic extracts of leaves of *P. granatum* was tested against four clinically isolated pathogenic bacteria namely Escherichia coli, Pseudomonas sp., Klebsiella sp., and Streptococcus sp. The ethanolic extract exhibited maximum inhibition against Streptococcus sp., (30 mm @ 80 mg / ml) followed by Klebsiella sp., (28 mm @ 80 mg / ml) E.coli (26 mm @ 80 mg / ml) and Pseudomonas sp. (23 mm @ 80 mg / ml). The significant results of the ethanolic extract have been presented well in (Table 2) and

zone of inhibition is clearly shown in Figure 2, Figure 3, Figure 4 and Figure 5. The graphical data representing antibacterial activity of extract at different concentration clearly demonstrated the effectiveness of the crude extract of leaves of *P. granatum* (Figure 1). The extract showed best antibacterial capacity in all the concentration (40 mg /ml, 60 mg / ml and 80 mg / ml) against *Klebsiella* sp., followed by *Streptococcus* sp., and *E. coli*. The ethanolic extract showed better inhibition against gram positive bacteria than gram negative bacteria. It has been confirmed from previous study with methanolic leaves extract 11. It has also been reported that the methanolic and aqueous peel extracts showed antibacterial activity 13, 15 - 18. According to reported study on antibacterial activity of leaves extract of *P. granatum*, *E. coli* 11 was subjected to antibacterial assay which has given encouraging results. This study also confirmed the effective antibacterial capacity of leaves extract of pomegranate against *E. coli*.

5. Conclusion

The potential antibacterial property of the leaves of *P. granatum* is due to the presence of phytochemicals such as flavonoids and Glycosides. These phytochemicals also possess antifungal, antioxidants, anticancer and hypolipidemic properties according to previous study 13, 18, 19. These phytochemicals can be fractionated and investigated for exploring its diverse medicinal property. This may lead to identification of active compounds, essential for making of drug molecule. This study is of utmost importance since phytochemical screening of ethanolic extract of leaves of *Punica granatum* has not been reported widely and most of the research focused on peel and fruit extracts. This study is also significant because the antibacterial activity of ethanolic extract of *P. granatum* demonstrates its capacity to restrict the growth of all the pathogens subjected to this study. The bactericidal activity of *P. granatum* was shown to inhibit bacterial growth in maximum at 80 mg / ml. This study also demonstrates the increase in antibacterial activity of extract with increase in concentration which clearly indicates dose dependent activity of this plant extract. The above mentioned concentration may further be tested in isolated specific phytochemicals for identifying active components with GC - MS and NMR.

Acknowledgements

We are thankful to The Christian Medical College, Vellore, for providing us clinical samples for this study.

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Hierarchical Access Control in Organizations using Software Agents

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Abstract

In this research, a novel attempt is made to implement hierarchical access control (HAC) with the help of software agents that aid in dual encryption and decryption. Symmetric polynomials and Diffie Hellman protocols work in collaboration to achieve the HAC. The proposed scheme is secure, scalable and adaptable to any hierarchy with less cost.

1. Introduction

Hierarchical Access Control refers to the control procedures that allow employees in ancestral /superior role access the information held by the employees in descendant / subordinate role while denying the vice versa. Many researchers have attempted to find solution for the problem of hierarchical access control in a user hierarchy.

A scalable complex system can be managed when it is represented as a hierarchy. It is based on an abstraction that the entities in each group have some attributes which are similar and are henceforth grouped. Hierarchical systems are usually composed of related subsystems linked according to their relationship.

Present day organizations use cryptographic based schemes to achieve control over business activities involving information security. In this paper, a scalable deterministic key management scheme based on symmetric polynomials (SP) and group Diffie-Hellman (DH) schemes is presented for realizing HAC. The proposed model is called DEHAC (Dual Encryption Hierarchical Access Control) as HAC is achieved by the process of dual encryption. The proposed approach can be implemented for a large group of users with the added advantage of less storage cost, communication cost and computation cost.

The efficiency of the scheme is due to the ability of the Trusted Intermediary Software Agent (TISA) in every ancestor security class to derive the key of the

descendant security classes, perform dual encryption, decryption and multicasting of the encrypted messages. The presence of the TISA makes it feasible to implement HAC.

The proposed approach performs in a scalable manner managing a large number of users, in spite of the high instability exhibited by the users. Symmetric polynomials are polynomials in which the value of the symmetric polynomial remains the same for different permutations of the parameters. This property is used when an ancestral class (Zou, X & Bai, L 2008) TISA derives the key of its descendant security class. It is an unconditionally secure scheme. Both class level dynamics and user level dynamics can be taken care while preserving the confidentiality requirement. Only one key is needed in each and every class of users which is a local key formed using any one of the following Diffie- Hellman schemes namely

- Group Diffie- Hellman Scheme (GDH)
- Tree Based Group Diffie- Hellman Scheme (TGDH)
- Group Elliptic Curve Diffie- Hellman Scheme (GECDH)
- Tree based Group Elliptic Curve Diffie-Hellman Scheme (TGECDH)

According to the infrastructure and communication capabilities of the participants in a particular security class or network, any one of the scheme can be used for the primary key formation. In addition to this key, all TISA's of the respective security classes hold one more key called the SP key with the help of the symmetric polynomial approach. All security classes are managed separately and do not affect each other. The central authority's role is very minimal. It takes care to distribute the polynomials to all TISA's and also helps in managing the issues concerning the class dynamics. This dual encryption scheme reduces the number of rekeying messages, communication cost, computation cost and memory cost.

The proposed scheme is highly adaptable, as the hierarchical administration can be applied according to the organization chart of any corporate. Enterprises should implement a layered approach to secure high risk internet-based systems. The dual encryption scheme provides effective controls in a layered approach and enables a timely response. Improved controls over account activities can be performed locally within a security class and tools based on the status of the participants can be administered to block connection from employees who are suspected to be associated with fraudulent activities.

2. Software Agents

In the proposed scheme, there is a need for an entity which is not a member of a class but should be entrusted with the responsibility for performing dual encryption

and decryption and also to take part in key formation in the local groups. Chalupsky et al (2002) discussed that teams of software agents can aid humans in accomplishing tasks, facilitating the organization's coherent functioning and rapid response to crises and reducing the burden on humans. Iftikar Ahmed (2004) discussed about the creation of subsystems that are autonomous in nature and perform a specified task independently irrespective of the disturbances occurring in the system. Okamoto et al (2008) discussed about software personal assistant (SPA). It is an agent that acts to support a user in a human organization by automating individual tasks and facilitates coordination with other members of the organization. Recent and current research has looked at developing SPAs for a diverse range of domains, including emergency response and military teams, office environments, factory floors, and even outer space. This motivated to use a software process agent as an intermediary to realize HAC.

3. Motivation and the Research

The detailed analysis of the above prevalent schemes led to the research problem of finding a method by which each user in the hierarchy should be able to have access to his resources and to the resources held by its descendents with less number of computation, storage and communication. The main motivation could be a reality only if the hierarchical access group can be visualized as consisting of different security classes and each class having any number of users. The main idea in the research is to let the user use the own group key to access the messages of its juniors. This is possible only with a two layered approach. Presence of TISA helps in creating the link between the two layers. The presence of a routine task that involves dual encryption, decryption and key derivation motivated the use of a software agent in each security class.

4. Architecture of TISA

The architecture of TISA is discussed in this section .In any organization, there are dozens of small, cumbersome tasks that every individual performs on a daily basis, such as scheduling meetings, arranging lunch, and locating other people. Many of these tasks require looking up information, monitoring information and keeping people informed. As such, they are well suited to software agents. In the case of agent-oriented systems, their hallmark is the ability to operate in highly dynamic and incompletely specified environments, handle tasks that may not be known a priori, etc. The agents collaborate with their users to improve the accomplishment of the users' tasks. The TISA has the following functionality with the help of the various units which work in coordination for achieving HAC.

Credibility Checker Unit This unit provides authorization service, which includes an authorization decision function that checks the database to decide whether a user is a

valid user for the corresponding security class.

DH- Keyshare donor unit This unit participates in the contributory key agreement to form the local key of their class. The unit involves in giving a random contribution just like any other user in the security class and helps in the key formation. This feature adds an extra security to the system and makes the process of guessing of contributions difficult.

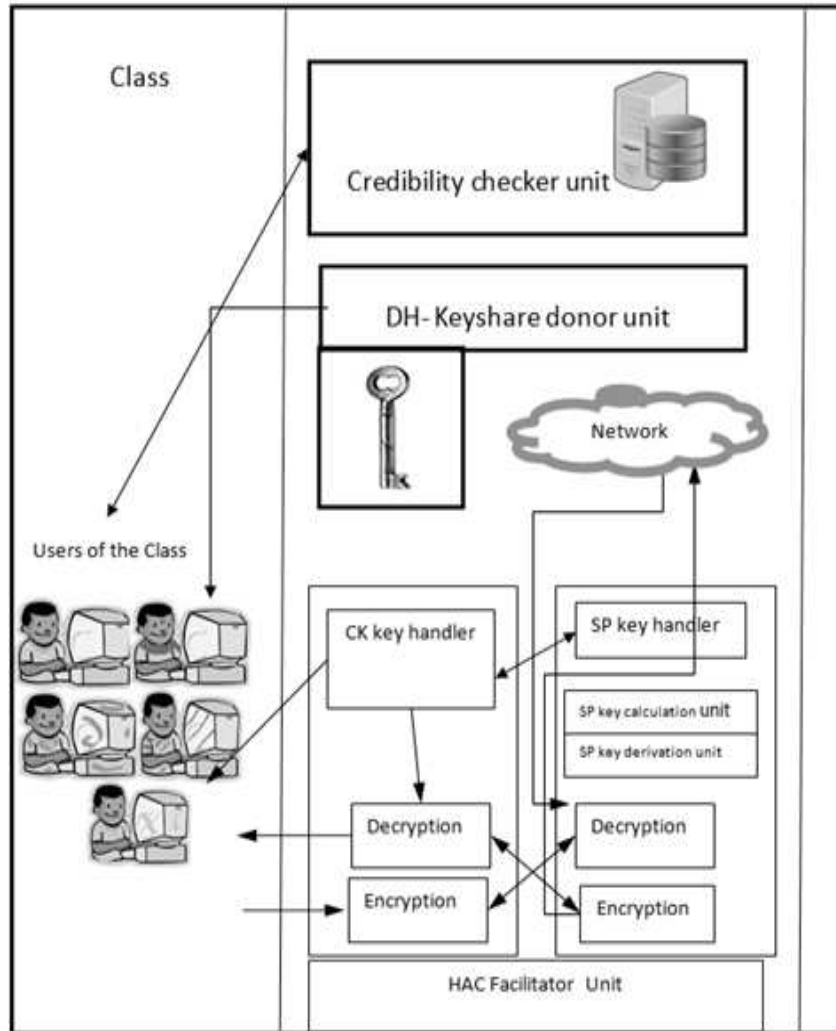


Figure 1: Architecture of TISA

HAC Facilitator Unit

- i SP - key handler

1. If the message is from the peer TISA s, it derives the symmetric polynomial key of descendant class. It decrypts the message using the derived key and passes the message to the CK-key handler.
2. If the message is from the CK-key handler, it derives the symmetric polynomial key of its own class and encrypts the message with the symmetric polynomial key and multicasts the encrypted message to the Peer TISA s.

ii CK- key handler

1. If the message is from the SP-key handler, it encrypts the message with the Diffie-Hellman key formed by the local group and transmits to the users of its security class.
2. If the message is from the users of the class, The CK-key handler sends the message after decrypting using its class key to the SP-key handler.

5. Working of Symmetric Polynomial Layer

The working of the proposed scheme is explained here for an educational institution by taking a small hierarchy consisting of only three classes as shown in Figure 2.

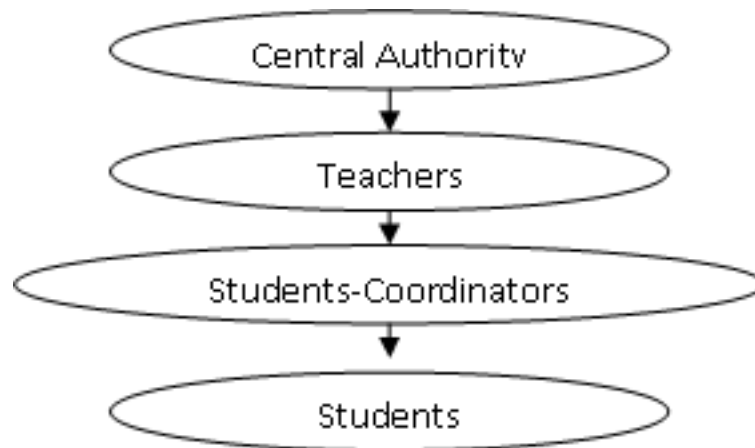


Figure 2: A Simple School Hierarchy

One possible deployment model is shown in the Figure 3. The proposed solution should allow teachers and student coordinators to access the messages which are transmitted

between the students whereas the students should not be allowed to see the messages that get transferred between the teachers or student - coordinator. This is achieved by using a dual encryption method. Each class has two keys namely the symmetric polynomial key and class key. The class key is formed by any one of the group Diffie Hellman schemes namely GDH, TGDH, GECDH and TGECDH. The central authority distributes a symmetric polynomial to the classes. There is a software agent in each and every class called the Trusted Intermediary Software Agent (TISA). It participates in the formation of the class key. The symmetric polynomials are polynomials which give same value for different permutations of the parameters or variables.

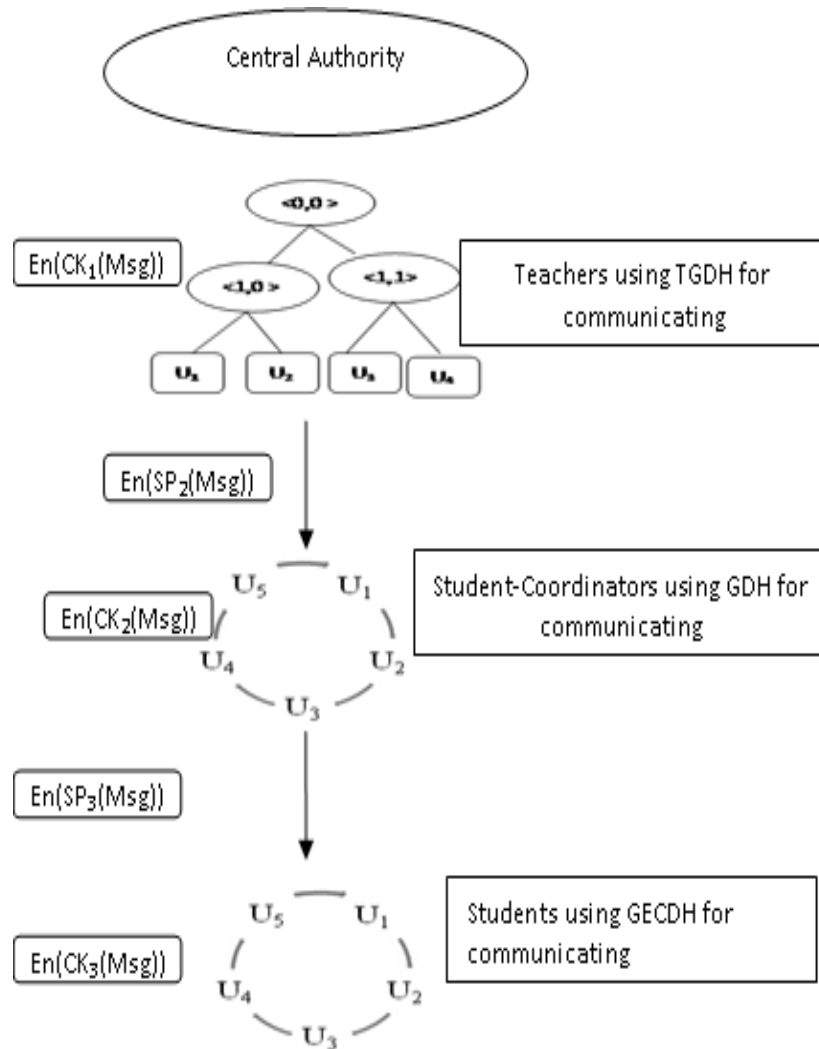


Figure 3: A possible Deployment Model for the Simple School Hierarchy

The formation of the symmetric polynomial key and the mechanism by which the ancestor class TISA generates the key of the descendant class is explained below for the simple school hierarchy. The set of classes = $\{SC_1, SC_2, SC_3\}$ and set of ancestor classes = $\{SC_1\}$. There are two ancestor classes in the hierarchy. SC_1 is the immediate ancestor of SC_2 and SC_2 is the immediate ancestor of SC_3 . The hierarchical access control has to be implemented for the following cases (a) $SC_1 \geq SC_2$. (b) $SC_1 \geq SC_3$ (c) $SC_2 \geq SC_3$. The permissible class for each class due to the hierarchical relationship they possess with the other security classes is shown in the Table 1.

The $TISA_1$, $TISA_2$ and $TISA_3$ calculate the symmetric polynomial key SP_1 , SP_2 and SP_3 respectively for their classes. To enable the calculation and derivation of symmetric polynomial keys, a value m which identifies the level of hierarchy that may be supported is to be calculated. The value of m can be greater than or equal to maximum of $\{m_1, m_2, m_3\} + 1$. m_i is the number of ancestors in the security class SC_i .

| S.No | m_i | Computation | Value |
|------|-------|---|-------|
| 1 | m_1 | number of ancestor classes for the security class $SC_1 = \{\Phi\}$ | 0 |
| 2 | m_2 | number of ancestor classes for the security class $SC_2 = \{SC_1\}$ | 1 |
| 3 | m_3 | number of ancestor classes for the security class $SC_3 = \{SC_1, SC_2\}$ | 2 |

Table. 1 Calculation of m_i

The value of m should be greater than or it can be equal to maximum (0 , 1 , 2) + 1, that is, 3 . The value of $m = 3$ is suffice for the hierarchy shown above, as there are only maximum of two ancestors in the hierarchy. However a large value of m makes class dynamics easier when more security classes need to be added. In this illustration m is chosen as 4 so that up to 4 levels of ancestors can be used in the hierarchy. The additional parameters for the hierarchy are $s_1, s_2, s_3, s_4, s'_1, s'_2, s'_3$. The Central Authority CA randomly generates a polynomial function $P(x_1, x_2, x_3, x_4)$ with four parameters. The CA can then compute three polynomial functions for classes SC_i . Once the polynomial functions are obtained, they are securely transmitted to every TISA respectively. The calculation of the symmetric polynomial key by the TISA of the respective classes is shown below for the example hierarchy.

1. Calculation of SP1 by $TISA_1$
Ancestor classes of $SC_1 = \{\Phi\}$

$$m_1 = 0, m - m_i - 1 = 3$$

$$\begin{aligned} SP_1 &= g_1(s'_1, s'_2, \dots, s_{m-m_i-1}) \\ &= P(s_i, s_{i_1}, s_{i_2}, \dots, s_{i_m}, \dots, s'_1, s'_2, \dots, s'_{m-m_i-1}) \end{aligned}$$

$$SP_1 = g_1(s'_1, s'_2, s'_3) = P(s_1, s'_1, s'_2, s'_3)$$

2. Calculation of SP2 by TISA₂

Ancestor classes of $SC_2 = \{SC_1\}$

$$m_2 = 1, m - m_i - 1 = 2$$

$$\begin{aligned} SP_2 &= g_2(s'_1, s'_2, \dots, s_{m-m_i-1}) \\ &= P(s_i, s_{i_1}, s_{i_2}, \dots, s_{i_m}, \dots, s'_1, s'_2, \dots, s'_{m-m_i-1}) \end{aligned}$$

$$SP_2 = g_2(s'_1, s'_2) = P(s_2, s_1, s'_1, s'_2)$$

3. Calculation of SP3 by TISA₃

Ancestor classes of $SC_3 = \{SC_1, SC_2\}$

$$m_3 = 1, m - m_i - 1 = 1$$

$$\begin{aligned} SP_3 &= g_3(s'_1, s'_2, \dots, s_{m-m_i-1}) \\ &= P(s_i, s_{i_1}, s_{i_2}, \dots, s_{i_m}, \dots, s'_1, s'_2, \dots, s'_{m-m_i-1}) \end{aligned}$$

$$SP_3 = g_3(s'_1) = P(s_3, s_1, s_2, s'_1)$$

1. Key derivation of the subordinate classes is done by the ancestor

$$j = 2 \quad i = 1$$

$$\begin{aligned} H_{j/i} &= S_2/S_1 \cup SC_1 \\ &= \{SC_1\}/\{\Phi \cup SC_1\} = \{\Phi\} \end{aligned}$$

$$r_j = 0$$

$$m - m_i - 2 - r_j = 4 - 0 - 2 - 0 = 2$$

$$AC_{1,2} = P(s_1, s_2, s'_1, s'_2)$$

$$SP_2 = P(s_2, s_1, s'_1, s'_2)$$

$$AC_{1,2} = SP_2 \quad (\text{same parameters in different permutation})$$

2. Key derivation of SC_3 by TISA₁

$$j = 3 \quad i = 1$$

$$\begin{aligned} H_{j/i} &= S_3/S_1 \cup SC_1 \\ &= \{SC_1, SC_2\}/\{\Phi \cup SC_1\} = \{SC_2\} \end{aligned}$$

$$r_j = 1$$

$$m - m_i - 2 - r_j = 4 - 0 - 2 - 1 = 1$$

$$AC_{1,3} = P(s_1, s_3, s_2, s'_1)$$

$$SP_3 = P(s_3, s_1, s'_2, s'_1)$$

$$AC_{1,3} = SP_3 \quad (\text{same parameters in different permutation})$$

3. Key derivation of SC_3 by $TISA_2$

$$j = 3 \quad i = 2$$

$$\begin{aligned} H_{j/i} &= S_2/S_2 \cup SC_2 \\ &= \{SC_1\}/\{SC_1 \cup SC_1\} \\ r_j &= 0 \\ m - m_i - 2 - r_j &= 4 - 1 - 2 - 0 = 1 \\ AC_{2,3} &= P(s_3, s_2, s_1, s'_1) \\ SP_3 &= P(s_3, s_1, s_2, s'_1) \\ AC_{1,3} &= SP_3 \quad (\text{same parameters in different permutation}) \end{aligned}$$

The following cases shown in Table 2 are non-permissible privileges for the example hierarchy in Figure 1. When a TISA of a class which is not an ancestor tries to derive the key of a security class, it results in a polynomial with different parameters or mismatch in parameters ,hence the symmetric polynomial key of the class cannot be derived by a TISA of a Non ancestral Class.

| Class | Non Permissible Privileges |
|--------|----------------------------|
| SC_1 | – |
| SC_2 | SC_2 |
| SC_3 | SC_1, SC_2 |

Table. 2 Non Permissible Privileges

A few Examples for the key derivation by the non ancestral classes shown above is discussed below.

1. Key derivation of SC_1 by $TISA_2$

$$j = 1 \quad i = 2$$

$$\begin{aligned} H_{j/i} &= S_1/S_2 \cup SC_2 \\ &= \{\Phi\}/\{SC_1 \cup SC_2\} = \{\Phi\} \\ r_j &= 0 \\ m - m_i - 2 - r_j &= 4 - 1 - 2 - 0 = 1 \\ NAC_{2,1} &= P(s_2, s_1, s_1, s'_1) \\ SP_1 &= P(s_1, s'_1, s'_2, s'_3) \\ NAC_{2,1} &\neq SP_1 \quad (\text{different parameters give wrong key value}) \end{aligned}$$

2. Key derivation of SC_1 by $TISA_2$

$$j = 1 \quad i = 3$$

$$\begin{aligned} H_{j/i} &= S_1/S_3 \cup SC_3 \\ &= \{\Phi\}/\{SC_1, SC_2 \cup SC_3\} = \{\Phi\} \end{aligned}$$

$$r_j = 0$$

$$m - m_i - 2 - r_j = 4 - 2 - 2 - 0 = 0$$

$$NAC_{3,1} = P(s_3, s_1, s_1, s_2)$$

$$SP_1 = P(s_1, s'_1, s'_2, s'_3)$$

$$NAC_{3,1} \neq SP_1 \text{ (different parameters give wrong key value)}$$

3. Key derivation of SC_2 by $TISA_3$

$$j = 2 \quad i = 3$$

$$\begin{aligned} H_{j/i} &= S_2/S_3 \cup SC_3 \\ &= \{\Phi\}/\{SC_1, SC_2 \cup SC_3\} = \{\Phi\} \end{aligned}$$

$$r_j = 0$$

$$m - m_i - 2 - r_j = 4 - 2 - 2 - 0 = 0$$

$$NAC_{3,2} = P(s_3, s_1, s_1, s_2)$$

$$SP_2 = P(s_2, s_1, s'_1, s'_2)$$

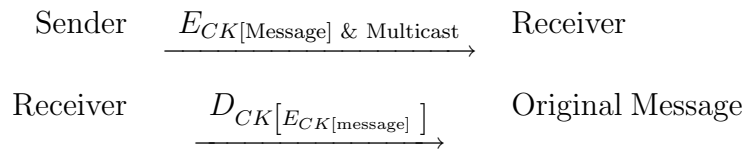
$$NAC_{3,2} \neq SP_2 \text{ (different parameters give wrong key value)}$$

The above example shows the key calculation and key derivation process by the TISA's. It establishes the fact that the correct symmetric polynomial key will be arrived only when a TISA belongs to a valid ancestor. The TISA aids in the communication semantics and helps in achieving the HAC.

6. Communication Semantics

The communication semantics in the Upper Layer and Lower Layer is explained below.

a. Communication semantics within the security class



b. Communication semantics for ancestor classes

| | | |
|---------------------------------------|--|--------------------------------------|
| Sender | $\xrightarrow{E_{CK}[\text{Message}] \& \text{Multicast}}$ | TISA |
| TISA | $\xrightarrow{D_{CK}[E_{CK}[\text{Message}]] \& \text{Multicast}}$ | Original Message |
| TISA _{descendants} | $\xrightarrow{E_{SP}[\text{Message}] \& \text{Multicast}}$ | TISA _{ancestor} |
| TISA _{ancestors} | <u>applies symmetric polynomial derivation</u> | Symmetric Polynomial |
| TISA _{ancestors} | $\xrightarrow{D_{SP}[E_{SP}[\text{Message}]]}$ | OriginalMessage |
| TISA _{ancestors} | $\xrightarrow{E_{CK}[\text{Message}] \& \text{Multicast}}$ | Members of the Class |
| Members of the Class(ancestor groups) | $\xrightarrow{D_{CK}[E_{CK}[\text{Message}]] \& \text{Multicast}}$ | Original Message of descendant users |

7. GDH Key formation - Numerical Illustration

The following section explains how the primary key is formed in the student coordinator class SC_2 . DO-L represents student coordinator of the LAW department and When the users are exchanging messages, the group key agreement protocols provide a good solution to the problem of managing keys in large networks as they provide the ability to generate the group key which adapts well to the dynamic nature of network groups. In the security class SC_2 , consider initially User - 1 (DO-L) joins. A key is formed between DO-L and TISA₂. If a new student coordinator wants to join in the security class, first it should broadcast the join request message. After receiving the join request message, class controller sends the intermediate key to the new member for generating the new class key. If a member wants to leave the security class, first it should send the leave request to the class controller to generate the new class key. DO-L and TISA₂ generate the Class key

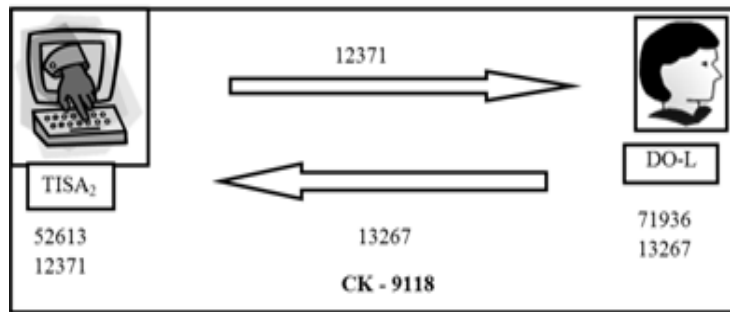


Figure 4: Architecture of TISA

TISA₂

$$K_1 = 52613$$

$$PK_1 = 53^{52613} = 12371$$

DO - L

$$K_2 = 71936$$

$$PK_2 = 53^{71936} = 13267$$

Class key calculation

TISA₂

$$CK = PK_2^{K_1} \pmod{13713}$$

$$CK = 13267^{52613} \pmod{13713} = 9118$$

DO - L

$$CK = PK_1^{K_2} \pmod{13713}$$

$$CK = 12371^{71936} \pmod{13713} = 9118$$

8. Hierarchical Access Control Cost

The HAC cost is the number of keys to be transmitted to make the higher class users to see the resources or messages of the lower class users. For a class , assume that there are m ancestor classes SC_1, SC_2, SC_m for the Class SC_k . The number of users in the ancestor classes are denoted by H_1, H_2, \dots, H_m . Thw HAC Cost is shown in Table 3.

| Scheme | No. of Keys to be transferred for HAC |
|-----------------------------|---------------------------------------|
| Single Tier GDH Scheme | $\sum_{i=1}^m H_i$ |
| Single Tier GECDH Scheme | $\sum_{i=1}^m H_i$ |
| Single Tier TGDH | $\sum_{i=1}^m H_i$ |
| Single Tier TGECDH | $\sum_{i=1}^m H_i$ |
| Symmetric Polynomial Scheme | $\sum_{i=1}^m H_i$ |
| Proposed Scheme using TISA | One |

Table. 3 Hierarchical Access Control Cost

8.1. Rekeying Cost: Illustration

Using the single tier symmetric polynomial approach the number of changes that might be made on the user’s key based on user join/leave is calculated. The key must be changed when a new user joins or leaves from their respective classes in the example hierarchy (Figure 5). Suppose that there are 50 classes in the hierarchy and each class consists of hundred users each, then a unique key for every class is calculated under the assumption that fifty classes of eight levels and each class consisting of 4 users exist.

From the hierarchy the total number of key changes to be made for the first sixteen Classes is tabulated in Table. It is seen that the number of rekeys is equal to Number of descendent class + 1 in the case of symmetric polynomial and in GDH each class contains four users and hence the key has to be transmitted to all the users . In Two tier approach , the key change is restricted to that class only.

| User Dynamics in Class | Single Tier-Symmetric Polynomial Approach / GDH / GECDH / TDGH / TGDH Approach | DEHAC Approach |
|------------------------|--|----------------|
| SC_{42} | 800 | 1 |
| SC_{36} | 700 | 1 |
| SC_{30} | 600 | 1 |
| SC_{23} | 500 | 1 |
| SC_{17} | 400 | 1 |
| SC_{12} | 300 | 1 |

Table. 4 Rekeying Cost

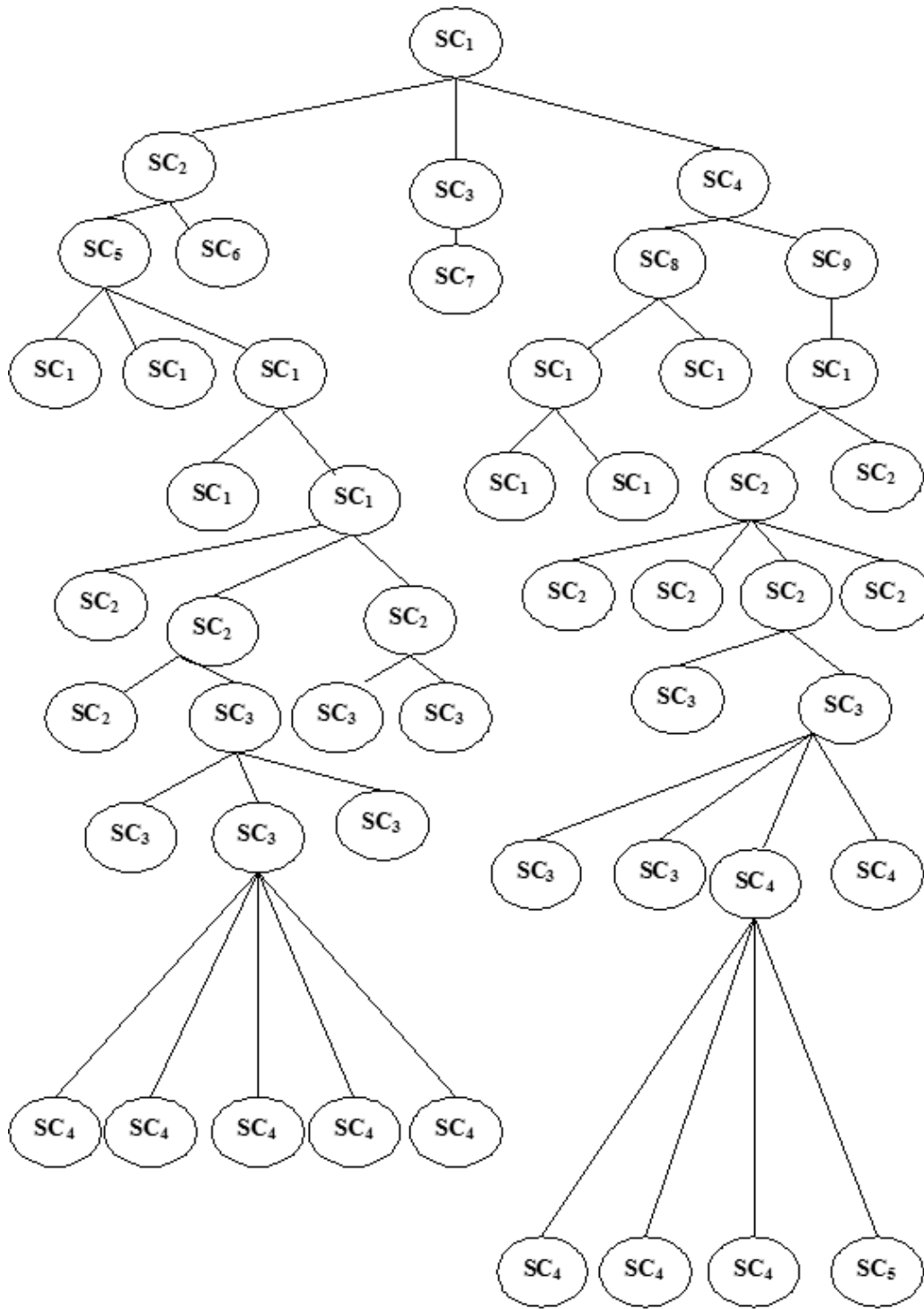


Figure 5: Hierarchy Analyzed for Calculating the No. of Re-keys

9. PERFORMANCE FEATURES

This section explains some performance features of the proposed scheme.

9.1. Exterior Collecting Attack

An intruder cannot generate the secret key from a lower security class by accessing public parameters. The proposed model resists intrusion from outsiders. If an attacker ATT_x is outside the system wants to access the Security class SC_x , it means it has no idea about what are the parameters to evaluate the polynomial SP_x or the Diffie-Hellman Key and how the mapping between the parameters and the credentials has been performed. Even users belonging to a security class are not aware as the symmetric polynomial value is completely screened for them and hence the attacker fails to conquer.

9.2. Collaborative Attacks

The collaborative attack is a type of attack where several users collaborate to launch the attack. Suppose SC_j and SC_k are the immediate successors of SC_i ; the relationship will not allow for a collaborative attack. It is assumed that if there is a higher privileged user belonging to class SC_2 and there are two descendant classes SC_4 and SC_5 . Users of SC_4 and SC_5 cannot perform a collaborative attack as both the primary key CK_2 and Secondary Key SP_2 cannot be derived by SC_4 or SC_5 .

9.3. t - Collusion Attacks

The proposed scheme is built on the

- (i) Polynomial function which consists of m parameters, threshold t and the number of classes
- (ii) the Diffie-Hellman Key agreement scheme used for the key formation within the class.

It is seen that other schemes like (Blundo et al 1993) are unconditionally secure to t user's collusion attacks. In other words, when t or fewer users no matter which classes they come from work together they cannot make public any small piece of information of the polynomial function or their ancestral class keys. However more than t users cannot only rebuild their parent's keys but also entirely determine the polynomial function so that all keys can be exposed. In summary the previous schemes are unconditionally secure and are capable of defending against upto t - users' collusion attacks. However in the proposed scheme, the users belonging to the different classes or same class are aware of only their class key CK_x which is a volatile key that changes as and when users join and leave the class. The polynomial key is not known to any of the user. Hence the proposed scheme can work with the same stringent security for $t = 1$ or

$t = 10$ or $t = 100$, that is, the t is not a security deciding parameter, any value of t can be used. Hence the proposed scheme is free to collusion attack by any number of users.

9.4. Polyinstantiation

Polyinstantiation refers to a scenario in which different subjects of a same application see different forms of a single entity in real world. This is a very important feature that endorses secure communication. In the proposed DEHAC, Polyinstantiation is observed. In the example hierarchy Msg_9 is the message transmitted within the Security Class SC_9 . In SC_9 , it is transmitted as $Encrypt(CK_9(Msg))$. The same message is transmitted as $Encrypt(CK_4(Msg))$ within the security class SC_4 and as $Encrypt(CK_2(Msg))$ within the security class SC_2 and as $Encrypt(CK_1(Msg))$ within the Security Class SC_1 .

10. Conclusion

The proposed scheme provides an efficient solution to the problem of changing secret keys of a security class in the hierarchy. In addition, this scheme has the ability to efficiently support other dynamic properties, just as adding a new security class to the hierarchy and deleting an existing security class from the hierarchy. The class dynamics are taken care by the symmetric polynomial module and the group dynamics in the respective classes by the group Diffie- Hellman scheme.

11. Future Work

Hierarchical Access Control is an emerging, important application and research area because of the presence of infinite number of situations which have a hierarchical structure. Even though there have been exciting achievements in HAC key management, much work still remains to be done.

The Future work is envisaged towards some of the research avenues in HAC are

- Wireless environments
- Cloud environments
- Adhoc environments
- It is believed that more researchers and professionals will benefit from, and join the area of HAC.

The future of HAC is very promising due to its application in almost all organizations.

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Steganography - Seeing the Unseen

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Abstract

In this article, we first give some preliminaries about the basic working principle of the steganographic technique. We give a review of some steganographic techniques for hiding data in certain different text, audio and video files.

1. Introduction

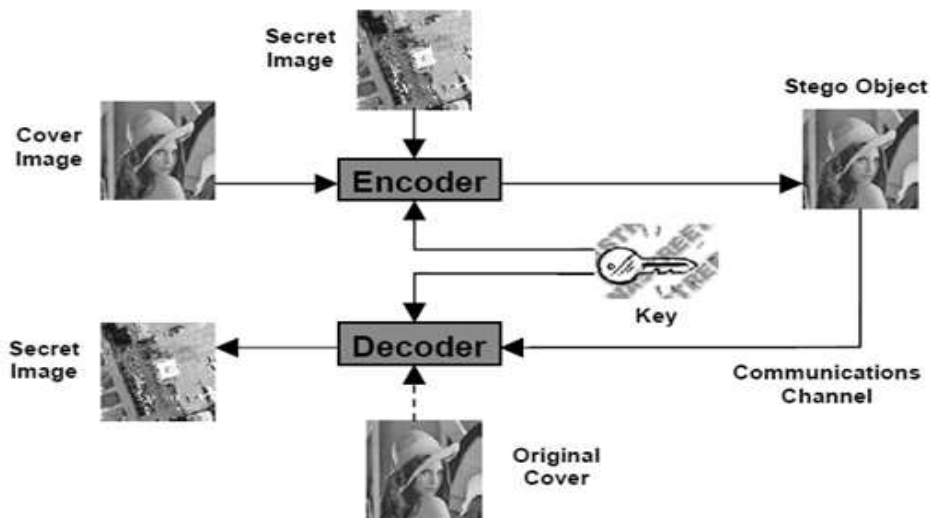
Steganography is derived from the Greek for covered writing and essentially means *to hide in plain sight*. Simple steganographic techniques have been in use for hundreds of years, but with the increasing use of files in an electronic format, new techniques for information hiding have become possible. Steganography provides a means of secret communication which cannot be removed without significantly altering the data in which it is embedded. The embedded data will be confidential unless an attacker can find a way to detect it.

2. Requirements of Hiding Information Digitally

There are many different protocols and embedding techniques that enable us to hide data in a given object. However, all of the protocols and techniques must satisfy a number of requirements so that steganography can be applied correctly. The following is a list of main requirements that steganography techniques must satisfy:

- The integrity of the hidden information after it has been embedded inside the stego object must be correct.
- The secret message must not change in any way, such as additional information being added, loss of information or changes to the secret information after it has been hidden.

If secret information is changed during steganography, it would defeat the whole point of the process. The stego object must remain unchanged or almost unchanged to the naked eye. If the stego object changes significantly and can be noticed, a third party may see that information is being hidden and therefore could attempt to extract or to destroy it. The manipulations can be simple processes such as resizing, trimming or rotating the image. The secret message inside the image must survive these manipulations, otherwise the attackers can very easily remove it and the point of steganography will be broken.



Steganography Techniques By taking advantage of human perception it is possible to embed data within a file. For example, with audio files frequency masking occurs when two tones with similar frequencies are played at the same time. The listener only hears the louder tone while the quieter one is masked. Similarly, temporal masking occurs when a low-level signal occurs immediately before or after a stronger one as it takes us time to adjust to the hearing the new frequency. This provides a clear point in the file in which to embed the mark. However many of the formats used for digital media take advantage of compression standards such as MPEG to reduce file sizes by removing the parts which are not perceived by the users. Therefore the mark should be embedded in the perceptually most significant parts of the file to ensure it survives the compression process. Clearly embedding the mark in the significant parts of the file will result in a loss of quality since some of the information will be lost. A simple technique involves embedding the mark in the least significant bits which will minimise the distortion. However it also makes it relatively easy to locate and remove the mark. An improvement is to embed the mark only in the least significant bits of randomly chosen data within the file. **Binary File Techniques** If we are trying to hide some secret

information inside a binary file, whether the secret information is a copyright watermark or just simple secret text, we are faced with the problem that any changes to that binary file will cause the execution of it to alter. Just adding one single instruction will cause the executing to be different and therefore the program may not function properly and may crash the system. Text Techniques While it is very easy to tell when you have committed a copyright infringement by photocopying a book, since the quality is widely different, it is more difficult when it comes to electronic versions of text. Copies are identical and it is impossible to tell if it is an original or a copied version. To embed information inside a document we can simply alter some of its characteristics. These can be either the text formatting or characteristics of the characters. You may think that if we alter these characteristics it will become visible and obvious to third parties or attackers. The key to this problem is that we alter the document in a way that it is simply not visible to the human eye yet it is possible to decode it by computer. Line Shift Coding Protocol In line shift coding, we simply shift various lines inside the document up or down by a small fraction. The shifted lines are undetectable by humans because it is only a small fraction but is detectable when the computer measures the distances between each of the lines. Differential encoding techniques are normally used in this protocol, meaning if you shift a line the adjacent lines are not moved. By finding out whether a line has been shifted up or down we can represent a single bit, 0 or 1. And if we put the whole document together, we can embed a number of bits and therefore have the ability to hide large information.

Word Shift Coding Protocol The word shift coding protocol is based on the same principle as the line shift coding protocol. The main difference is instead of shifting lines up or down, we shift words left or right. This is also known as the justification of the document. The codebook will simply tell the encoder which of the words is to be shifted and whether it is a left or a right shift. Again, the decoding technique is measuring the spaces between each word and a left shift could represent a 0 bit and a right bit representing a 1 bit. Without having the original for comparison it is likely that this may not be noticed and the shifting could be even smaller to make it less noticeable.

Feature Coding Protocol In feature coding, there is a slight difference with the above protocols, and this is that the document is passed through a parser where it examines the document and it automatically builds a codebook specific to that document. It will pick out all the features that it thinks it can use to hide information and each of these will be marked into the document. This can use a number of different characteristics such as the height of certain characters, the dots above i and j and the horizontal line length of letters such as f and t. Line shifting and word shifting techniques can also be used to increase the amount of data that can be hidden.

White Space Manipulation One way of hiding data in text is to use white space. If done correctly, white space can be manipulated so that bits can be stored. This is done by adding a certain amount of white space to the end of lines. The amount of white space corresponds to a certain bit value. Due to the fact that in practically all text

editors, extra white space at the end of lines is skipped over, it won't be noticed by the casual viewer. In a large piece of text, this can result in enough room to hide a few lines of text or some secret codes.

XML is becoming a widely used standard for data exchange. The format also provides plenty of opportunities for data hiding. This is important for verifying documents to see if they have been altered and also for copyright reasons. You can embed a code for example, which can be traced back to the source. Many different files can exist when XML is used. There is the XML file itself but there can be transformation files (.xsl), validation files (.dtd) and style files (.css). All of these files can be used to hide data but the main XML file is usually the best due to its larger size. This technique concentrates on just the XML file, more elaborate techniques could use a combination of all four files to increase robustness. One way of hiding data in XML is to use the different tags as allowed by the W3C. For example both of these image tags are valid and could be used to indicate different bit settings Stego key:

```
< img >< /img > - > 0
< img/ > - > 1
```

LSB - Least Significant Bit Hiding (Image Hiding) This method is probably the easiest way of hiding information in an image and yet it is surprisingly effective. It works by using the least significant bits of each pixel in one image to hide the most significant bits of another. So in a JPEG image for example, the following steps would need to be taken

1. First load up both the host image and the image you need to hide.
2. Next chose the number of bits you wish to hide the secret image in. The more bits used in the host image, the more it deteriorates. Increasing the number of bits used though obviously has a beneficial reaction on the secret image increasing its clarity.
3. Now you have to create a new image by combining the pixels from both images. If you decide for example, to use 4 bits to hide the secret image, there will be four bits left for the host image. (PGM - one byte per pixel, JPEG - one byte each for red, green, blue and one byte for alpha channel in some image types)

Host Pixel: 10110001

Secret Pixel: 00111111

New Image Pixel: **10110011**

4. To get the original image back you just need to know how many bits were used to store the secret image. You then scan through the host image, pick out the

least significant bits according the number used and then use them to create a new image with one change - the bits extracted now become the most significant bits.

Host Pixel: 10110011

Bits used: 4

New Image: **00110000**

This method works well when both the host and secret images are given equal priority. When one has significantly more room than another, quality is sacrificed. Also while in this example an image has been hidden, the least significant bits could be used to store text or even a small amount of sound. All you need to do is change how the least significant bits are filled in the host image. However this technique makes it very easy to find and remove the hidden data.

Direct Cosine Transformation Another way of hiding data is by way of a direct cosine transformation (DCT). The DCT algorithm is one of the main components of the JPEG compression technique. This works as follows:

1. First the image is split up into 8 x 8 squares.
2. Next each of these squares is transformed via a DCT, which outputs a multi dimensional array of 63 coefficients.
3. A quantizer rounds each of these coefficients, which essentially is the compression stage as this is where data is lost.
4. Small unimportant coefficients are rounded to 0 while larger ones lose some of their precision.
5. At this stage you should have an array of streamlined coefficients, which are further compressed via a Huffman encoding scheme or similar.
6. Decompression is done via an inverse DCT.

Hiding via a DCT is useful as someone who just looks at the pixel values of the image would be unaware that anything is amiss. Also the hidden data can be distributed more evenly over the whole image in such a way as to make it more robust.

One technique hides data in the quantizer stage. If you wish to encode the bit value 0 in a specific 8 x 8 square of pixels, you can do this by making sure all the coefficients are even, for example by tweaking them. Bit value 1 can be stored by tweaking the coefficients so that they are odd. In this way a large image can store some data that is quite difficult to detect in comparison to the LSB method.

This is a very simple method and while it works well in keeping down distortions, it is vulnerable to noise.

Wavelet Transformation While DCT transformations help hide information or general data, they don't do a great job at higher compression levels. The blocky look

of highly compressed JPEG files is due to the 8 x 8 blocks used in the transformation process. Wavelet transformations on the other hand are far better at high compression levels and thus increase the level of robustness of the information that is hidden. This technique works by taking many wavelets to encode a whole image. They allow images to be compressed so highly by storing the high frequency "detail" in the image separately from the low frequency parts. The low frequency areas can then be compressed which is acceptable as they are most viable for compression. Quantization can then take place to compress things further and the whole process can start again if needed.

3. Sound Techniques

Spread spectrum systems encode data as a binary sequence which sounds like noise but which can be recognized by a receiver with the correct key. The technique has been used by the military since the 1940s because the signals are hard to jam or intercept as they are lost in the background noise.

MIDI

MIDI files are good places to hide information due to the revival this format has had with the surge of mobile phones, which play MIDI ring tones. MIDI files are made up of a number of different messages. Some of these messages control the notes you hear while others are silent and make up the file header or change the notes being played. The message we are interested in is one called Program Change (PC). A PC basically changes the type of instrument being played on a certain channel. If there are multiple PC messages in succession the instrument played will be the one selected at the very end of the message chain and due to the fact these messages occur so frequently, there are no noticeable side effects to the sound.

Each PC message can contain a number from 0 to 127, which corresponds to the number of different instruments that can be played. So all you need to do is string together the necessary number of PC messages to contain the hidden data.

Obviously this method doesn't allow for huge amounts of data to be stored nor is it a very good way of hiding data as it can be easily seen.

MP3

The MP3 format is probably the most widespread compression format currently used for music files. Due to this, it also happens to be very good for hiding information in. The more inconspicuous the format, the more easily the hidden data may be overlooked. As the sound file is being compressed during the Layer 3 encoding process, data is selectively lost depending on the bit rate the user has specified. The hidden data is encoded in the parity bit of this information. As MP3 files are split up into a number

of frames, each with their own parity bit, a reasonable amount of information can be stored. To retrieve the data all you need to do is uncompress the MP3 file and read the parity bits as this process is done. This is an effective technique which leaves little trace of any distortions in the music file.

Video

For video, a combination of sound and image techniques can be used. This is due to the fact that video generally has separate inner files for the video (consisting of many images) and the sound. So techniques can be applied in both areas to hide data. Due to the size of video files, the scope for adding lots of data is much greater and therefore the chances of hidden data being detected is quite low.

4. Conclusion

As steganography becomes more widely used in computing there are issues that need to be resolved. There are a wide variety of different techniques with their own advantages and disadvantages. Many currently used techniques are not robust enough to prevent detection and removal of embedded data. The use of benchmarking to evaluate techniques should become more common and a more standard definition of robustness is required to help overcome this. For a system to be considered robust it should have the following properties:

- The quality of the media should not noticeably degrade upon addition of a mark.
- Marks should be undetectable without secret knowledge, typically the key.
- If multiple marks are present they should not interfere with each other.
- The marks should survive attacks that don't degrade the perceived quality of the work.

As attacks are found that work against existing techniques, it is likely that new techniques will be developed that overcome these deficiencies. The continuing use of digital media will drive development of new techniques and standards for steganography are likely to be developed. Meanwhile techniques used by law enforcement authorities to detect embedded material will improve as they continue to try and prevent the misuse of steganography.

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Part B :

HUMANITIES

Hollywood illustrated in Scott F. Fitzgerald's *The Last Tycoon*

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Abstract

F. Scott Fitzgerald was born Francis Scott Key Fitzgerald on September 24, 1896, in St. Paul, Minnesota. He attended the St. Paul Academy, and when he was 13, he saw his first piece of writing appear in print: a detective story published in the school newspaper. The novel's new incarnation, *This Side of Paradise*, was published in 1920. Fitzgerald, at the age of 24, supported himself financially by writing great numbers of short stories for popular publications such as *The Saturday Evening Post* and *Esquire*. Some of his most notable stories include *The Diamond as Big as the Ritz*, *The Curious Case of Benjamin Button*, *The Camel's Back* and *The Last of the Belles*. With its beautiful lyricism, pitch-perfect portrayal of the Jazz Age and searching critiques of materialism, love and the American Dream, *The Great Gatsby* is considered Fitzgerald's finest work. After another two years lost to alcohol and depression, in 1937 Fitzgerald attempted to revive his career as a screenwriter and freelance storywriter in Hollywood, and he achieved modest financial, if not critical, success for his efforts. He began work on another novel, *The Love of the Last Tycoon*, in 1939, and he had completed over half the manuscript when he died of a heart attack on December 21, 1940, at the age of 44, in Hollywood, California. Even in its incomplete form, *The Love of the Last Tycoon*: has achieved a reputation as the best Hollywood novel. The novel's tragic tycoon hero is Stahr. Caught in the crossfire of his own effortless cynicism and his silent, secret vulnerability, Stahr inhabits a world dominated by business, alcohol and promiscuity. If there is a moral or social necessity to film-making in this West Coast never-never land, Stahr does not always believe in it. If there is love he does not always see it. The sharpness of Fitzgerald's prose, the steely simplicity of his style, give a cutting edge to this study of Hollywood in the thirties, from which Fitzgerald draws a painfully bitter-sweet love affair and bids his own poignant farewell to the Great American Dream.

Introduction

Francis Scott Fitzgerald was an American author of novels and short stories, whose works are the paradigmatic writings of the Jazz Age. He is widely regarded as one of

the greatest American writers of the 20th century. Fitzgerald moved to Hollywood in 1937. He finished four novels: *This Side of Paradise*, *The Beautiful and Damned*, *The Great Gatsby* and *Tender Is the Night*. A fifth, unfinished novel, *The Love of the Last Tycoon*, was published posthumously in 1941. As edited by the literary critic Edmund Wilson, it contained six completed chapters, an abridged conclusion, and some of Fitzgerald's notes. The work is an indictment of Hollywood, where Fitzgerald had had a disappointing career as a screen writer. Richard D. Lehan in his essay titled *Count of Darkness, The Last Tycoon, and The Pat Hobby Stories* comments on the nature of the novel.

As in The Great Gatsby and Tender Is the Night, The Last Tycoon spirals out from a story of an individual to a story of history, from the personal to the public. The story of Monroe Starh is the story of Hollywood - and, by implication, the story of America as well. (pp 163)

Inspired by the life of film mogul Irving Thalberg, on whom protagonist Monroe Stahr was based, *The Last Tycoon* centers on Stahr, Hollywood's first wunderkind studio executive in the 1930s as he climbs to the height of power pitting him against his mentor and current head of the studio Pat Brady, a character based on Louis B. Mayer. With Stahr as a focal point, the series delves into the true violence, sex and towering ambition of Hollywood in the '30s. The issue of social statuses is also raised in *The Love of the Last Tycoon*. However, the main focus of Fitzgerald's commentary is on Hollywood. He writes that *Hollywood is a perfectly zoned city so you know exactly what kind of people economically live in each section from executives and directors, through technicians in their bungalows right down to extras*. In *Scott Fitzgerald's Last Novel* by J. Donald Adams says,

So, too, is The Last Tycoon an ambitious book, but, uncompleted though it is, one would be blind indeed not to see that it would have been Fitzgerald's best novel and a very fine one. Even in this truncated form it not only makes absorbing reading; it is the best piece of creative writing that we have about one phase of American life-Hollywood and the movies.

The novel opens with Cecilia, daughter of a Hollywood producer, flying home from her college in New York. Rose Adrienne Gallo in his essay, *Hollywood Revisited: The Last Tycoon* speaks about Cecilia thus,

Cecilia Brady is described in Fitzgerald's outlines as a pretty, modern girl, neither good nor bad, tremendously human. Cecilia has been sent by her father, a self-made man, to an eastern college to acquire the polish worthy of a Hollywood princess. (pp 114)

Across the aisle from Cecilia are two Hollywood people, one of whom she recognizes as a visitor to her home. When a stewardess sits with Cecilia and addresses her by name, the gentleman she recognized immediately introduces himself and his companion. Wylie White is a screenwriter and his friend is a failed producer, though this is not explained to Cecilia immediately. When the plane is grounded in Nashville, the three companions decide to ride out to Andrew Jackson's historic home, Hermitage. The ride is long and quiet. Mr. Schwartz falls asleep for the first restful sleep in weeks, while Wylie flirts with Cecilia.

They arrive at Hermitage at dawn; however, they are unable to go inside because it is not open yet. Instead, Wylie and Cecilia talk on the front steps while Mr. Schwartz sleeps. When it is time to go, the newly awakened Schwartz says they should go on without him that he no longer wishes to return to Las Angeles. Wylie agrees to take a note to a fellow traveler and he and Cecilia leave. It is the next day before they learn that Mr. Schwartz committed suicide soon after their departure.

Cecilia Discovers Monroe Stahr

Back on the plane, Cecilia discovers that the mystery passenger that Mr. Schwartz was concerned with earlier is *Monroe Stahr*, her father's partner. Rose Adrienne Gallo in his essay, *Hollywood Revisited: The Last Tycoon* justify the name given to the protagonist of the novel.

The name Stahr suggests his destiny. The sound proclaims his role-STAR of an unparalleled era in an industry in which the phenomenal, the spectacular, is the norm. the spelling of Stahr retains the suggestion of foreignness, of alienation, of otherworldliness, perhaps. Is he, as Cecilia adoringly describes him, a luminous being who has chosen to be for a while a super-star among the other lesser star of Hollywood ?

Cecilia has had a crush on Stahr since childhood and hopes that this summer break from school will lend them an opportunity to explore those feelings. Rose Adrienne Gallo in his essay, *Hollywood Revisited: The Last Tycoon* further emphasis on the character of Cecilia.

Cecilia is intelligent, cynical, but understanding and kindly toward the people, great or small, who are of Hollywood. It is through Cecilia that we see the marvelously drawn minor characters who are woven into the backdrop of an ordinary day in a Hollywood studio . . . (pp 115)

A few days after returning to California, Cecilia goes to the studio in order to bring her father home for his birthday. While trying to convince him to leave his work, an

earthquake strikes. Cecilia, her father, and his business companions go into Stahr's office. Here they learn that the earthquake has caused a water main to burst and the back lot is flooded. Stahr calls a fix-it man and they all rush out to see the damage for themselves. After a few moments, two women come floating down the flood on the head of a prop statue. Stahr is instantly infatuated with one of the women because of her resemblance to his deceased wife. Rose Adrienne Gallo in his essay, *Hollywood Revisited: The Last Tycoon* brings to limelight about deceitful Hollywood thus,

Reality is antithetical to Hollywood, a world that thrives on artifice, illusion, deceit. In the episode of Kathleen on the head of Shiva, illusion reigns. (pp 119)

The next day, Stahr spends a busy, though typical, day at work. Throughout the day, Stahr encourages his secretary to track down the girls, finally getting one of them on the phone. Stahr asks to meet her in a public place and she reluctantly agrees to meet him at a local drugstore. The moment Stahr sees her he knows he has made a mistake. This girl looks nothing like his wife. Stahr drives her home. The girl insists that he meet a girlfriend of hers. The moment the second girl opens her front door, Stahr knows she is the woman he remembers from the night before.

The second girl refuses to agree to meet Stahr anywhere and refuses to tell him her name. Stahr goes away dejected. However, Stahr runs into the girl at a party and convinces her to meet him the next day for coffee. Stahr and Kathleen drive to Santa Monica and find their way to a house Stahr is building out there. Kathleen seems reluctant to be with Stahr, though when he takes her home she insists he take her back to the house and there they become intimate. It is not until later that Stahr learns from a letter Kathleen wrote at the beginning of the date that she is engaged to marry another man.

Kathleen calls Stahr and asks to see him. Kathleen explains about a difficult relationship she recently left thanks to the help of her fiancé. Kathleen gives Stahr a chance to tell her not to marry her fiancée, but he does not take it. The next day Stahr receives a telegram to let him know Kathleen has been married.

Cecilia's Wish Fulfilled

A week later, Stahr asks Cecilia to arrange a meeting between him and a Communist who Stahr blames for organizing a union at the studio. Stahr takes Cecilia and this man to dinner and drinks too much, getting into a physical altercation with the Communist afterward. It is after this that Cecilia finally gets her wish and she and Stahr begin seeing each other.

Mr. Brady, Cecilia's father, has become unhappy with his partnership with Stahr. The relationship of Patrick Brady and Monroe Stahr is a perfect example of how friendships work in Hollywood. There were no superficial signs of animosity and all seemed well in their picture-perfect world, they served as a paragon for friendship. They worked together and throughout the story the author never mentions any roadblocks in their journey as partners in their ventures, but the true character of Brady is only revealed when Stahr leaves the industry to attend to some business. Brady begins plotting against Stahr in order to force him out of the company, going as far as blackmailing Stahr over his affair with Kathleen, which has continued despite her marriage, and hiring a man to kill Stahr. In retaliation, Stahr hires a man to kill Brady. Richard D. Lehan in his essay titled *Count of Darkness, The Last Tycoon, and The Pat Hobby Stories* wrote about the how the novel has been linked with Hollywood.

Fitzgerald paralleled the destruction of Stahr with the destruction of Hollywood. He identified Stahr with the vital and romantic Hollywood of the past ; (pp 161)

Critical Comments on *The Last Tycoon*

In that small period of time, Brady goes behind Stahr's back and makes administrative changes in terms of pay cuts which he knew (beforehand) wouldn't go well with Stahr's ideologies. Stahr was a paternalistic employer and Brady making fifty percent pay cuts and promising the labor unions that the same would be implemented to the executives as well, and then employing a sick double standard and going back on his promise naturally do not go well with Stahr. This kind of cutthroat scheming is only prevalent in Hollywood. Nowhere else will you see two contemporaries going head to head to bring the other down for no apparent reason other than absolute authority in their respective spheres. The *Dog eats Dog* philosophy is followed only in the highest circles in Hollywood.

However, Stahr has second thoughts, though he cannot cancel the order because the plane he is flying on the New York crashes. Brady dies soon after Stahr leaving Cecilia without both the most important men in her life.

The Last Tycoon deserves serious consideration in the Fitzgerald canon. Despite its brevity, the fragment has attracted favorable critical attention. J. Donald Adams stated:

The Last Tycoon (is) an ambitious book, but, uncompleted though it is, one would be blind indeed not to see that it would have been Fitzgerald's best novel and a very fine one. Even in this truncated form, it not only makes

absorbing reading; it is the best piece of creative writing that we have about one phase of American life-Hollywood and the movies (pp 124)

In *A Note on Fitzgerald* which is reprinted in *The Crack-Up*, John Dos Passos discusses *The Last Tycoon* thus,

*This establishment of a frame of reference for common humanity has been the main achievement of writing which in other times and places has come to be called great. It requires as well as the necessary skill with the tools of the trade, secure standards of judgment that can only be called ethical. Hollywood, the subject of *The Last Tycoon*, is probably the most important and the most difficult subject for our time to deal with. Whether we like it or not it is in that great bargain of five and ten cent lusts and dreams that the new bottom level of our culture is being created. The fact that at the end of a life of brilliant worldly success and crushing disasters Scott Fitzgerald was engaged so ably in a work of such importance proves him to have been the first-rate novelist his friends believed him to be. In *The Last Tycoon* he was managing to invent a set of people seen really in the round instead of lit by an envious spotlight from above or below. *The Great Gatsby* remains a perfect example of this sort of treatment at an earlier, more anecdotic stage, but in the fragments of *The Last Tycoon*, you can see the beginning of a real grand style.*

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Eugene O’Neill’s *ILE*: A Materialistic Reading

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Abstract

Materialism refers to the preoccupation with the material world as opposed to intellectual or spiritual values. This doctrine appears to be prevalent in western society today. It also refers to the term, Cultural Materialism. Materialism is the desire to own and consume material goods. There is a growing trend of increasing materialism in the world in order to lead the comfortable life. People who are more materialistic cannot lead a happy life. Moreover materialism leads to psychological issues.

Introduction

Materialism refers to the preoccupation with the material world as opposed to intellectual or spiritual values. This doctrine appears to be prevalent in western society today. It also refers to the term, *cultural materialism*. Materialism is the desire to own and consume material goods. There is a growing trend of increasing materialism in the world in order to lead the comfortable life. People who are more materialistic cannot lead a happy life. Moreover, materialism leads to psychological issues.

O’Neill’s View

Money served as the ticket for social advancement and the standard of self-esteem. The literary works written during the late 1800’s illustrated the corrupt nature of American society. *The Gilded Age*, a novel written by Mark Twain (1835-1910) dealt with materialism, corruption in business and getting rich through ruthless business deals. *Sister Carrie*, a novel written by Theodore Drieser was concerned with Carrie’s desire for a fine house, clothes and money. Through these plays, O’Neill criticizes the American society, in which the human values are replaced by the new values of the materialistic and competitive society. The characters are imposed great pressures by the society in order to achieve prosperity. According to Travis Bogard,

O’Neill’s plays present the American society which distorts and deforms the individual’s spirit, destroying man’s creative potential by divorcing him from those qualities of humanity which give him dignity and the sense of man hood. The materialistic system is him enemy and core conflict of the fable is his battle with the exponents of that system (249).

Eugene O’Neill’s play *Ile* focuses on the lust for fame. O’Neill’s own experience at sea provided material for many of his early plays. It was Strindberg who gave him the vision of what modern drama could be. His early sea plays - *Bound East for Cardiff* (1916), *Ile* (1917) and *Moon of the Caribbees* (1918) were realistic.

Ile's Background

Ile is the story of a whaling captain Keeney and his desire for fame and social status. O'Neill has presented the sea as the centre of the play. Keeney is a man of strong will and cruelty. His main motive is the pursuit of whale oil. In those days whale-seeking was viewed as valuable as gold-prospecting. When the play opens, we see The Atlantic Queen being locked in ice for a year and that is the last day ending the two year contracts signed by the crewmen. The playwright portrays the serious atmosphere of the setting as follows, . . . *the light which comes through the skylight is sticky and faint, indicating one of those gray days of calm when ocean and sky are alike dead* (O'Neill 118).

There is nothing except *Ice, ice, ice!* (O'Neill 119). The ship is compared to a fly which has got stuck in molasses. The sea is so quiet and the silence is so thick. One feels afraid to hear his own voice. The steward remarks, *You are afraid to hear our own voice* (O'Neill 122). The steward of the ship starts damning the ice and the captain. He infers that the quality of hardness is found both in the ice and the captain Keeney. He further remarks about captain that *he's hard man - as hard a man as ever sailed the seas* (O'Neill 120). The condition of sea workers is described through the words of the steward as follows,

Blessed Christ! Two years of this dog's life and no luck in the fishing and the hands half starved with the food runnin' low, rotten as it is; and not a sign of him turnin' back for home (O'Neill 120).

Even though the contract ends that day he begins to doubt if he will ever set foot on land again.

Keeney's Craze for Oil

For Keeney, he is nothing without Whale oil. He will destruct anybody or anything which seeks to oppose his pride. We can smell his brutal nature from the dropping of the dish by the Steward as an agitation at the arrival of the Captain. Keeney shouts at the Steward and Ben for their indulgence in gossiping. Then he fiercely orders Ben to go out and clean up the chartroom and asks the Steward to pick up the broken dish. He threatens the Steward about the consequence if he breaks the next dish by saying,

The next dish you break, Mr. Steward, you take a bath in the Bering Sea at the end of a rope (O'Neill 124).

The Steward tremblingly continues his work after hearing the frightening words of the Captain. The only comfort for the crewmen is the presence of captain's wife, Annie. Without her it would have been hell. Annie is a school teacher with romantic thoughts of the sea. She married Captain Keeney and after four years, has got the permission to accompany her husband on a voyage. She ventures with her husband, imagining her husband's life at sea as free. There is also a mouth organ to comfort her journey.

But they have meager luck during the first year and then the ship Atlantic Queen is completely ice-locked in the Arctic Ocean. Though the way is clear towards the South, the Captain is waiting for the North to clear.

Annie starts hating the sea and the organ as they remind her home in land. She is not even allowed to get a breath of fresh air. She gets bored to live inside the walls of the ship. When she saw the water through the curtain she shouted

Ah, water! Clear water! As far as I can see! (O'Neill 125)

Her romantic thoughts about the sea and the sea life are shattered now. When Keeney convinces her to wait for the day when the Sun shines, Annie replies that the Sun never shines in this terrible place. Keeney sends her back to the cabin saying that he has to discuss the ship's business with Slocum, the Mate.

The captain tells Slocum that he doesn't allow his wife on deck because he expects trouble from the crew. He inspects his own revolver and makes sure Slocum has his. They are keeping the revolvers just to frighten the crew. He wants the crewmen to be too submissive like dogs to rebel against their master. He says,

Not that we'll have to use 'em - - not if I know their breed of dog - - jest to frighten 'em up a bit (O'Neill 126).

Slocum cites that the ship's store of food is running low and that Keeney might be subject to legal action for damages if he keeps the ship out beyond the crew's contractual obligation. Keeney mocks him, suggesting that he might join in a mutiny against him. But Slocum absolutely denies it. Slocum has been with him for ten years and Keeney has trained him in the whaling business. He merely considers Slocum, a better breed of dog than the rest of the crew. He reveals to Slocum why he will not turn back, and his admission brings forth an excessive outpouring of primitive emotions. He would feel humiliated before rival captains to return to port without a full consignment of oil and says

I ain't never come back home in all my days without a full ship. Ain't that truth? (O'Neill 128).

He also suggests that he has seen evidence that the ice northward of the ship is breaking up.

Crewmen's Mutiny

Four hundred barrels of oil is not enough for his social status. The poor crewmen are ready to go home and they hold a meeting against Keeney. On behalf of the crew, Joe speaks to Captain Keeney. He says that the time they signed up for is over and today they want to go home. But Keeney is not ready to allow them till the ship is full of oil. Keeney says that the ice will break up soon. Joe points out that the food they eat is

rotten and running low. When Joe says that law is in their side, Keeney fiercely shouts that he is the law on this ship.

Joe then declares that the men have no choice except to mutiny and take the ship home themselves. It is at this moment that Mrs. Keeney reemerges from her room, although none of the other characters notice in the excitement of their heated argument. She sees her husband shooting Joe. The other crewmen seem likely to attack and overpower the captain, but they are cowed before Keeney and Slocum's pistols. They meekly withdraw, dragging Joe's unconscious body with them. Keeney believes he has triumphed over them and sends Slocum up on deck to keep order. After the incident Keeney hears his wife's hysterical sobs and turn to attend her.

The sea makes both the captain and his wife mad. In the beginning the ice and the mutiny make Captain Keeney mad because of the fear of loss reputation. Then the clear water to the North makes Keeney mad and crazy even to forget his promise to Annie to return home. On the other hand, the cleared way to towards South increases the madness of Annie to return home quickly. Both are eager but their eagerness has different directions. The captain is eager to see the melting ice to continue his journey to hunt oil. Annie is also eager to see the melting ice to return home.

Keeney's strongest impetus is the pursuit of whale oil. As whale is highly prized, whale-seeking is to seek for profit. The reality of *Ile* is that the possession of money is a symbol of power. He is running after his purely materialistic goals. He is governed by his own pride and masculinity. At last Captain Keeney gets the whales but he loses what he cannot recover again.

Conclusion

At the cost of loss of his family and happiness, he breaks the promise given to Annie and continues his journey. He goes to the extreme level to fulfill his American Dream. He even knocks the crew chief, who raises a mutiny against him. O'Neill depicts the common social value of the capitalistic society and criticizes the dark side of American Dream.

Annie couldn't convince her husband to turn South ward. She could do nothing but pleading him. But she comes out of her dream about sea and realizes herself. It is only the captain who never comes out of his American dream of prestige and money. It is the sea which opens Annie's eyes and leaves Keeney in darkness.

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Demographic Factors and Job Satisfaction -A Study with Reference to Public Sector Bank Employees

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Abstract

This study was conducted to examine the relationship between various demographic factors and job satisfaction of public sector bank employees. The sample consisted of 120 clerical level employees working in public sector banks in Vellore District, Tamilnadu. The main objective of the study was to find out the relationship between job satisfaction and other demographic factors like age, educational level, experience, income, and family size etc. Gangulie's job satisfaction scale was used to measure the degree of job satisfaction of nationalized bank employees. The findings showed that except educational level, no other demographic variables showed a significant relationship with job satisfaction. So, Job satisfaction of public sector bank employees was not found to be affected by demographic factors.

Keywords: Job Satisfaction

Introduction

The success of any business activity depends on the competent, motivated and effective human resources available in the organization. It is a fact that the efficient and profitable use of all other factors of production is vested with the labour force. So it is the most important duty of the management to create an environment in which the human resources perform effectively so as to achieve the goals of organization.

The effectiveness of an organization is measured by various indicators like job satisfaction, productivity and labour turnover. It is natural that in an effective organization, job satisfaction and productivity will be high and turnover and absenteeism will be low. A worker who is more satisfied in his job will be highly productive and will not leave the organization or absent himself unnecessarily.

Concept of Job Satisfaction

Before discussing the factors related to job satisfaction, it would be desirable to clarify the concept which seems to have acquired a degree of ambiguity because of its frequent use in a rather general and loose manner. A clarification of the meaning of words *job* and *satisfaction* is therefore necessary. According to Vroom (1964) the term *job* referred to worker's immediate work task and work role in a particular work organization.

As a generic concept, satisfaction may be described in a behavioural perspective. Individual or organizational behaviour is believed to be goal directed. Each human action, then, has a primary motivation and most actions are attempts to maximize satisfaction by fulfilling multiple motivations, some of which are identified by Maslow (1954). Accordingly, the meaning of satisfaction in common usage, encompasses the degree to which goals, desires, needs, wants or motivations are accomplished. In other words, satisfaction occurs when one gets what he needs, desires, wants, expects, deserves or deems to be his entitlement. According to Hoppock (1935) *Job satisfaction is any combination of psychological, physiological and environmental circumstances that causes a person truthfully to say I am satisfied with my job.*

Bullock (1952) conceptualized job satisfaction as *an attitude which results from a balancing and summation of many specific likes and dislikes experienced in connection with the job.*

Arnold and Feldman (1986) defined job satisfaction as *the amount of overall affect (or feelings) that individuals have toward their jobs.*

In the present study job satisfaction is conceptualized as *a positive attitude or a pleasurable emotional state which results from specific work-related experiences.*

Review of Literature

Age

Srivastava (1978) investigated the relationship between age and job satisfaction in a study conducted on underground colliery workers. The results showed a negative relationship between age and job satisfaction.

Arya (1984) studied the relationship between job satisfaction and age on a sample of 375 workers from two public sector undertakings. His study revealed that there is no significant relationship between age and job satisfaction. (Chi - Square value 1.4553; df = 4).

Diliprai Janatilal Bhat (1987) examined the relationship of job satisfaction to age on a sample of 250 male and female college teachers. The findings showed non-significant job satisfaction difference between the young age and the middle age college teachers and also there was non-significant job satisfaction difference between the young age and the old age college teachers.

White and Specter (1987) studied the relationship between age and job satisfaction. Their study revealed that job satisfaction increases in positive linear fashion with respect to age. The authors concluded that employees become more satisfied as chronological age increases.

Baldev et al. (1991) studied the relationship between job satisfaction and age in 30 public sector enterprises with the help of specially-designed questionnaire completed by 5184 managerial personnel. Their findings showed that there is significant relationship between age and job satisfaction.

Sinha et al. (1995) examined the relationship between job satisfaction and age. 248 managers and 1795 workers participated in the study. The study revealed that age was positively correlated with job satisfaction.

Panda et al. (1996) investigated the relationship between job satisfaction and age. Their sample consisted of 102 teachers working in twelve secondary schools. The RCE Mental Health Scale and job satisfaction scale developed by Anand (1992) were administered to the respondents. The result of the study revealed that there is a significant effect of interaction between mental health and age on secondary school teachers job satisfaction ($F = 12.08; p < 0.01$).

Nazir (1998) interviewed 245 bank employees to study the relationship between job satisfaction and age. The result showed insignificant relationship between the two variables.

Kalpna Srivastava (1999) studied the relationship between job satisfaction and age on a sample of 393 working women in Rajasthan. The study revealed that there was no significant association between job satisfaction and age of working women.

Deosthalee (2001) examined the relationship between age and job satisfaction in a sample consisting of 302 employees from Mumbai. The results showed a significant relationship between age and job satisfaction ($F = 2238.58; P < 0.001$).

Sayadain et al. (2004) investigated the relationship between job satisfaction and age

on a sample of 120 Mongolian and 100 Ugandan employees. The result showed that there are significant differences between countries as far as country by age difference is concerned. The Ugandans have higher average ($M = 16.75$) as compared to Mongolians ($M = 14.54$). The differences in various age groups within the country are also significant ($F = 3.83$; $df = 1/126$; $p < .01$). Age wise differences show that Mongolian of the ages of 25 and below are most satisfied ($M = 17.07$) while in case of Ugandan sample, those between the age group of 31 - 35 are most satisfied with their job ($M = 18.36$). The interaction effect failed to reach the level of significance.

The picture that has been established in this section is one of a conflict between studies showing insignificant differences among age groups and those that found an increase in job satisfaction as individuals get older.

Sex

The findings regarding sex are also conflicting. Hulin and Smith (1964) used Job Description Index (JDI) to measure satisfaction of 295 male workers and 163 female workers from four different plants. The data indicated that the female workers tend to be somewhat less satisfied with their job than their male counterparts. But, they highlighted two main points which merit further examination. Firstly, sex must not be understood as crucial factor which leads to either high or low satisfaction. It is rather the entire constellation of variables which consistently co-varies with sex (e.g. pay, promotion, social norms, etc.) and causes the differences in job satisfaction. Secondly, situational factors play a significant role in determining job satisfaction.

Diliprai Janatilal Bhat (1987) investigated the relationship between job satisfaction and sex on a sample of 250 college teachers consisting of 125 male and 125 female teachers. The findings showed a significant job satisfaction difference between the female and male college teachers.

Swaran Prasad (Mrs.) et al. (1988) investigated the influence of sex on job satisfaction. 25 male and 25 female employees from various nationalized banks were the respondents of her study and t test was computed to see the differences between male and female employees. The result showed that female employees are more satisfied than male employees ($t = 4.64$; significant at .01 level).

Sivajirao (1995) examined the relationship between sex and job satisfaction in a study conducted on 120 school teachers. He found significant relationship between sex and job satisfaction.

Weeks and Nantel (1995) focused on gender difference from the point of view of job satisfaction. Results revealed that female sales personnel were in reality very similar to

their male counterpart regarding job satisfaction and performance behaviour.

Panda et al. (1996) studied the relationship between job satisfaction and sex on a sample of 102 secondary school teachers. The study revealed that sex has no significant effect on secondary school teachers job satisfaction ($F = 0.34$; $1/98$; $p > 0.05$)

Shailaja (2003) studied 50 male and female teachers to determine the relationship between sex and job satisfaction. The findings showed no significant relationship between the two variables ($F = 1.5882$; $p < 0.05$).

It is clear from the above studies that more number of studies in this area will be able to establish the nature of relationship between sex and job satisfaction.

Education

Inconsistent findings have been reported regarding the relationship between educational level, intelligence and job satisfaction. Singh (Mrs.) (1974) studied 521 teachers to determine the relationship between educational level and job satisfaction. The findings showed that level of education was not significantly related to level of job satisfaction.

Sharma et al. (1991) studied the relationship between job satisfaction and level of education on a sample of 5184 managerial personnel taken from 30 public sector enterprises. The findings showed a moderately significant relationship between the two variables ($r = +.609$; $p < 0.001$).

Singh et al. (1995) on a sample of 1795 workers and 248 managers drawn from a large manufacturing organization located in the Eastern part of India studied the relationship between job satisfaction and level of education. Their findings showed that educational level of the workers was statistically significant ($r = -.08$; $p < 0.01$). The author concluded that the more educated the workers or the higher their position, the more dissatisfied they were with the organization.

Nazir (1998) investigated the relationship between job satisfaction and level of education. The study was carried out in a private bank in Jammu and Kashmir having branches throughout the State. 193 workers participated in the study. The findings showed that level of education was positively related to the overall job satisfaction of the model respondents (IZI value 5.58; $p < 0.010$).

Kalpna Srivastava (1999) studied the relationship between job satisfaction and level of education on a sample of 393 female workers. The findings showed that post graduate respondents are more satisfied (Mean score 20.7063) than the undergraduate respondents (Mean score 21.5118).

Deosthalee (2001) investigated the relationship between education and job satisfaction on a sample of 302 employees. The study revealed a positive relationship between education and job satisfaction ($F. 728.05; p < 0.001$).

Studies reviewed in this section had mixed results in investigating the relationship between education and job satisfaction.

Marital Status

Wild and Dawson (1972) examined the influence of marital status on the relationship between specific job attitude and overall job satisfaction on a sample of 2543 female manual workers engaged in 10 plants in U.K. The results indicated that marital status had significant effect on the relationship of a specific job attitude and overall job satisfaction.

Diliprai Janatilal Bhat (1987) studied the relationship between job satisfaction and marital status on a sample of 222 college teachers. The findings revealed that there is non-significant job satisfaction difference between the unmarried and married college teachers.

Nazir (1998) studied 245 clerks to determine the relationship between job satisfaction and marital status. The findings showed that marital status was not found to be associated with the overall job satisfaction.

Kalpna Srivastava (1999) examined the relationship between job satisfaction and marital status on a sample of 393 working women. The study revealed a significant relationship between job satisfaction and marital status.

Job Experience

Wild and Dawson (1972) studied the relationship between job satisfaction and job tenure on a sample of 2543 female manual workers in U.K. The findings revealed a significant relationship between job satisfaction and job tenure.

Mary (1987) conducted a study to determine the job satisfaction of principals and vice principals. The sample consisted of 504 female principals and 331 vice principals in Texas public schools. The author found that principals are more significantly satisfied than vice principals and job tenure and job level did not show any significant effect on job satisfaction.

Pond III (1987) investigated the relationship between organizational tenure and job satisfaction on a sample of 226 employees. The findings revealed no significant

relationship between job tenure and job satisfaction.

Sinha et al. (1995) studied the relationship between job satisfaction and work experience on a sample of 248 managers and 1795 workers. Their findings revealed that there is statistical significance between job satisfaction and years of service.

Saiyadain et al. (2004) investigated the relationship between job satisfaction and length of service on a sample of 120 Mongolian and 100 Ugandan workers. The findings showed that while Mongolians with 1-15 years of experience are more satisfied with their job ($M = 15.57$), Ugandans with 6-10 years experience showed greater satisfaction with their job ($M = 17.07$).

In addition to the above studies, Saiyadain and Mirza (1996) and Sokoya (2000) have found a positive relationship. On the other hand, Kalandhan et al. (1999) found a negative relationship between job satisfaction and length of service.

Statement of the problem

In the liberalized economy, trade and industry have to confront with many challenges to enhance their competitive strength domestically and globally, which in turn require these organizations to perform better in terms of productivity, quality, time and service. In this context, human behaviour seems to play an important role in the maximization of organizational effectiveness. The satisfaction of employees in their job casts its shadow on their behaviour and response at work which ultimately results in organizational effectiveness. Productivity in an organization is directly linked to employee satisfaction and quantum of attention paid to their physical and mental needs. Whether or not an employee will render his or her services whole heartedly for the organization and produce up to his/ her optimum potential depends, to a large extent, on the way the worker feels about the work, fellow workers and supervisors.

Objectives of the Study

In the light of the above research problem, the following objectives are framed for the present research study:

1. To measure the degree of job satisfaction among the bank employees.
2. To ascertain the relationship between various demographic variables and the bank employee's job satisfaction.

Hypothesis Tested

To achieve the above objectives, the following general hypothesis was formulated:

H_1 : There exists significant relationship between Job satisfaction level and the demographic factors of bank employees.

Research Methodology

To achieve the objectives and to test the hypotheses of the study, a two part questionnaire consisting of personal information and job satisfaction was developed.

Personal Data

Part I of the questionnaire consists of self styled questions relating to personal data which were necessary for the analysis of study to determine the relationship between job satisfaction and various demographic variables.

Job Satisfaction Questionnaire

In part II of the questionnaire, the job satisfaction inventory standardized by Gangulie and Rita Shresthya (1994) was adopted. The questionnaire had 23 questions to be filled by the respondents on a five point Likert scale ranging from *very much satisfied* to *very much dissatisfied* as well as *strongly agree* to *strongly disagree*. The scoring pattern was 1 to 5 in positive direction of the job satisfaction giving a minimum score of 23 and a maximum score of 115. Those respondents who scored below 33 percent were considered as with low level satisfaction and those who scored between 33 and 66 percent were classified as moderately satisfied and those respondents whose scores were above 66 percent were classified as highly satisfied.

Methodology of the Study

Pilot Study and Pre Testing

A pilot study was undertaken by the researcher to find out the feasibility of collecting the required information by administering the Gangulie's job satisfaction questionnaire on 20 clerical level employees of public sector banks. Based on the pilot study, the questionnaire was modified to suit the requirements of the present study. To test the reliability and validity of the questionnaire, Cronbach-Alpha reliability test was applied and the result was more than 0.7. There fore it was found that the questionnaire used for assessing the satisfaction level of the bank employees was reliable.

Sample

The study covered clerical level employees working in the nationalized commercial banks of Vellore District. According to the National Bank for Agriculture and Rural Development (NABARD) District Office, Vellore and the Lead Bank (Indian Bank, Vellore), as on 31st March, 2005 there are 166 branches of public sector commercial banks functioning in Vellore District. So the clerical level employees working in the above said 166 banks formed the population for the present study. As the researcher was not able to get data on the total number of clerical level employees working in Vellore District, through simple random sampling method, 50% of the total number of banks i.e. 83 banks from the above list were selected. The researcher personally visited all randomly selected banks and explained the purpose of study to the respective branch managers and requested them to provide the names of those employees who are working at the clerical level. From the list of names provided by the manager, two names were selected in each bank at random. Thus by the above process 166 employees were selected for the study and they were given the questionnaire with a request to fill up and hand over personally or send it by post. The researcher was able to receive responses only from 126 respondents. Out of 126 filled in questionnaire, six of them were found to be incomplete and were rejected. Thus the final sample for the present study consisted of 120 respondents.

Analysis of Data

Based on the data collected through questionnaire, analysis was carried out. The researcher used statistical techniques like frequency distribution, percentages and Chi-Square test for analyzing the data.

Significance of the Study

Studies relating to job satisfaction have been scanty in banking industry. The present study is one of the very few attempts to study the various demographic factors affecting the job satisfaction of bank employees. Commercial banks play an important role in the economic development of the country. The Government can achieve its development target like employment generation, alleviation of rural poverty and development of cottage and rural industries only with the active participation of commercial banks. Trade, industry, agriculture and all other activities depend on services of commercial banks for their successful survival. So it becomes necessary that the commercial banks must have a work force which is very much satisfied in their job. The highly satisfied workers in the commercial banks are very much essential to carry out their work with dedication so as to achieve the target and goals. Though a total commitment, dedication and sincerity are highly desirable in all types of organizations and institutions, it is very much important in the case of service institutions like banking

industry.

In a globalized world, the entire business sectors including banking industry faces severe competition. Unless they have a highly motivated and committed work force, they cannot compete both at the national and international level. In this scenario, the researcher makes an attempt to find out the demographic factors which increases the level of job satisfaction among bank employees. The findings of the study may provide an insight for banking policy makers to take appropriate measures so as to increase the satisfaction level of employees which in turn will make them happy, productive, sincere and dedicated employees.

Results and Discussion

The findings show (Table-1) that nearly 75 percent respondents are highly satisfied and 25 percent are moderately satisfied in their job. It is interesting to note that there is no one with low level of satisfaction.

| Degree of Satisfaction | Frequency | Percentage |
|---------------------------|-----------|------------|
| Low Job Satisfaction | Nil | – |
| Moderate Job Satisfaction | 31 | 25.8 |
| High Job Satisfaction | 89 | 74.2 |
| Total | 120 | 100.0 |

Table 1 Level of Satisfaction of Public sector Bank Employees

Relationship between Level of Satisfaction and the Age of Bank Employees

In order to test the relationship between job satisfaction and age of the respondents, the following hypothesis is framed.

H_0 There exist no significant relationship between level of job satisfaction and the age of bank employees

H_1 There exist significant relationship between level of job satisfaction and the age of bank employees

| Age of Respondents | Level of Satisfaction | | Total |
|--------------------|-----------------------|------|-------|
| | Moderate | High | |
| 21 - 30 years | 3 | 4 | 7 |
| 31 - 40 years | 8 | 22 | 30 |
| 41 - 50 years | 18 | 45 | 63 |
| 51 years and above | 2 | 18 | 20 |
| Total | 31 | 89 | 120 |

$$\chi^2 = 3.933 \text{ (df = 3; } p = 0.05)$$

Table 2 Relationships between Age and Job Satisfaction

The chi-square test reveals (Table- 2) that the calculated value is less than the table value at 0.05 levels of significance ($3.933 < 7.81$). So the null hypothesis that there is no relationship between age and level of job satisfaction of public sector bank employees is proved. The findings of the present study agree with the findings of Diliprai Janatilal Bhat (1987) and Nazir (1998).

Relationship between Education and Level of Satisfaction of Bank Employees

The following hypothesis was formulated to test the relationship between educational level and job satisfaction of public sector bank employees

H_0 Educational level and job satisfaction are not significantly related

H_1 Higher the educational level, higher the job satisfaction among bank employees.

| Education Level | Level of Satisfaction | | Total |
|-----------------|-----------------------|------|-------|
| | Moderate | High | |
| SSLC | – | 12 | 12 |
| HSC | 2 | 6 | 8 |
| Degree | 27 | 56 | 83 |
| Post Graduate | 2 | 15 | 17 |
| Total | 31 | 89 | 120 |

$$\chi^2 = 7.882 \text{ (df = 3; } p = 0.05)$$

Table 3 Relationship between Education and Level of Satisfaction

The chi- square test reveals (Table-3) that the calculated value is more than the table value ($7.882 > 7.81$). So the alternate hypothesis that there is relationship between education and level of job satisfaction of public sector bank employees is accepted. The finding of the present study is in confirmation with the findings of Volmer and Kinnery (1955), Nazir (1998) and Kalpana Srivastava (1999).

Relationship between Sex and Job Satisfaction

In order to test the relationship between gender difference and job satisfaction, the following hypothesis was framed.

H_0 Gender difference and level of job satisfaction of bank employees are not significantly related

H_1 There is significant relationship between sex and level of job satisfaction of bank employees

| Sex | Level of Satisfaction | | Total |
|--------------|-----------------------|------|-------|
| | Moderate | High | |
| Male | 17 | 59 | 76 |
| Female | 14 | 30 | 44 |
| Total | 31 | 89 | 120 |

$$\chi^2 = 1.299 \text{ (df = 1; } p = 0.05)$$

Table 4 Relationship between Sex and Level of Job Satisfaction

The Chi-Square test for the above table reveals (Table-4) that the calculated value is 1.299 which is less than the table value ($1.299 < 3.86$). So the null hypothesis is accepted and it can be concluded that there is no relationship between sex and job satisfaction level of public sector bank employees. The study of Panda, et. al (1996) and Shailaja (2003) also showed the similar result as in the present study.

Experience and Level of Job Satisfaction

To test the relationship between experience and job satisfaction of the public sector bank employees, the following hypothesis was formulated.

H_0 Experience and level of job satisfaction are not positively related

H_1 Experience and level of job satisfaction are positively related

| Experience | Level of Satisfaction | | Total |
|----------------|-----------------------|------|-------|
| | Moderate | High | |
| 1 - 10 years | 3 | 9 | 12 |
| 1 - 20 years | 7 | 35 | 42 |
| 21 - 30 years | 18 | 37 | 55 |
| Above 30 years | 3 | 8 | 11 |
| Total | 31 | 89 | 120 |

$$\chi^2 = 3.933 \text{ (df = 3; } p = 0.05)$$

Table 5 Relationships between Experience and Level of Job Satisfaction

The calculated chi-square value is 3.233 (Table-5) which is less than the table value (3.233 < 7.81). So the alternate hypothesis that there is positive relationship between experience and job satisfaction is not proved. The finding of this study is in confirmation with the findings of Pritpaul Kaur (1984) and Kalandhan et.al (1999).

Family Size and Level of Job Satisfaction

The relationship between family size and level of job satisfaction of bank employees are tested by framing the following hypothesis

H_0 There is no significant relationship between family size of the bank employees and their job satisfaction

H_1 Higher the family size, higher will be the level of satisfaction.

| Family Size | Level of Satisfaction | | Total |
|---------------|-----------------------|------|-------|
| | Moderate | High | |
| 1 - 3 Persons | 8 | 36 | 44 |
| 4 - 6 Persons | 16 | 40 | 56 |
| 7 - 9 Persons | 7 | 13 | 20 |
| Total | 31 | 89 | 120 |

$$\chi^2 = 2.441 \text{ (df = 2; } p = 0.05)$$

Table 6 Relationship between family size and level of satisfaction

The chi-square for the above table reveals (Table-6) that the calculated value is 2.441 which is less than the table value at 0.05 levels ($2.441 < 5.99$). Hence it is concluded that that family size of the bank employees has no relevance to their job satisfaction and hence the H_0 is accepted. As in the present study, Diliprai Janatilal Bhat (1987) and Sinha et.al (1995) also had the same findings.

Income and Level of Job Satisfaction

The relationship between job satisfaction and income level of the public sector bank employees are tested by formulating the following hypothesis.

H_0 There is no significant relationship between income level and job satisfaction of public sector bank employees.

H_1 There exists significant relationship between income level and job satisfaction.

| Income Level | Level of Satisfaction | | Total |
|---------------|-----------------------|------|-------|
| | Moderate | High | |
| 5001 - 10000 | 5 | 10 | 15 |
| 10001 - 15000 | 5 | 26 | 31 |
| 15001 - 20000 | 17 | 37 | 54 |
| Above 20000 | 4 | 16 | 20 |
| Total | 31 | 89 | 120 |

$$\chi^2 = 3.28 \text{ (df = 3; } p = 0.05)$$

Table 7 Relation hips between income Level and Job Satisfaction

Table-7 shows the relationship between income level and job satisfaction of public sector bank employees. The chi-square test reveals that the calculated value at 0.05 levels is less than the table value ($3.218 < 7.81$). So the null hypothesis there is no relationship between income level and job satisfaction of public sector bank employees hold good.

Findings of the Study

The researcher analyzed the data to study the various aspects of job and measure the extent of job satisfaction. The data showed that 74.2% of public sector bank employees are *highly satisfied* and 25.8% are *moderately satisfied*. It was interesting to note that there was no respondent in the *low satisfaction* classification. So it was found that the

public sector bank employees are either *highly satisfied* or *moderately satisfied* in their jobs.

The researcher made an attempt to study the various demographic factors of the respondents and the relationship between the demographic factors and the level of job satisfaction of public sector bank employees.

Testing of Hypotheses

Different hypotheses were formulated to study the relationship between job satisfaction and other variables. The findings are summarized as follows.

- There is no significant relationship between job satisfaction and age of public sector bank employees.
- There is significant relationship between job satisfaction and educational level of bank employees
- There is no relationship between job satisfaction and sex difference.
- There is no significant relationship between job satisfaction and experience of bank employees.
- There is no significant relationship between job satisfaction and family size of the respondents.
- There is no significant relationship between job satisfaction and income level of bank employees.

Conclusion

The findings of the present study showed that except educational level, all other demographic factors like age, sex, experience, family size showed no significant relationship with job satisfaction at 0.05 levels. Income level of the bank employees also showed no significant relationship with job satisfaction. So it can be concluded that except educational level, all other demographic factors have no relationship with the level of job satisfaction of public sector bank employees.

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Corporate Culture and Organisational Effectiveness (A Study Based on the Managerial Perceptions in Tamil Nadu)

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Abstract

In today's liberalized, privatized, globalized and competitive business environment, a most common question frequently comes to our mind is why some organizations are flourishing while others are perishing? Umpteen number of research studies have been carried out on this and have proved that success and failure of the organizations are mostly due to its own organizational cultures. Because of this organizations has become an important tool for the management to steer the organization towards success. On this background, the researcher has attempted to study the success and failure of the organization by examining the impact of organization culture on the effectiveness of the organization. While carrying out this objective the researcher has developed a new patternization of organizational culture namely, progressive and regressive cultures which is rooted on psycho-analytical study of individuals. The researcher selected 225 business executives from south India and the study found that there is a significant impact of organization culture on organizational effectiveness.

1. Introduction

Emphasis on the study of corporate culture originally began from western countries, which attempted to know secrets of phenomenal success of the Japanese organizations since Second World War. Studies have shown that the organizational cultures of Japanese firms are entirely different from that of the western companies. These cultural differences in organizations across the countries attracted the management researchers towards the study of organizational culture. But only after 1980's organizational culture became a central concern in the study of organizational behavior. The upsurge of interest in organizational culture reflected on the back-to-back commercial success of three bestsellers that spoke of organizational cultures under various guises: Ouchi's (1981)¹ *Theory Z*, Peters and Waterman's (1982)² *In Search of Excellence*, and Deal and Kennedy's (1982)³ *Corporate Cultures*. These publications made organizational culture a hot topic of discussion among organizational theorists and management practitioners. Hundred of researches began to work in this area. Numerous books

were published. Most important academic journals dedicated entire issues to the discussion of organizational culture. Interest in organizational culture was not limited to academic researchers alone but business concerns expressed more interest in the studies of organizational culture. The concept of organizational culture also referred as *corporate Culture* or *company culture* has become increasingly popular and attained the status of dominant idea in the field of organizational behavior in a relatively very short period of time.

In India, the post 1991 economic reforms made corporate culture as most relevant topic. The reforms accelerated the change process in organizations. The new, dynamic environment pushed the organizations towards radical transformation, not only to sustain profitability but also even for the survival in the new liberalized and globalize era. Business need to develop a planned strategy, that could entail redesigning, reorganizing or innovating current activities and organizational structure in order to improve organization's competitive strength, customer focus and customer satisfaction. These radical changes can be brought to the organizations by developing appropriate organizational cultures. Organizational cultures act as vehicles to bring these changes to organizations and it will the organizations to face the challenges of global competition effectively and efficiently.

2. Organizational Culture - Concept

Organizational culture represents the common perception and values held by the organization's members. Individuals with different backgrounds or at different levels in the organization will tend to have different perceptions that finally gives birth to organizational cultures. It is the moral, social and behavioral norms of an organization based on the beliefs, attitudes, and priorities of its members. Earlier organizations were seen as rational means to plan, organize, coordinate and control a group of people and its strategy and structure helped to carry out its activities. Organizational theorists in recent years began to acknowledge that organizations just like individuals have personalities and possess a unique character which distinguishes them from others. Every organization has its own culture, which grows and develops as organizational culture.

It has also been proved by umpteen studies that success and failures of the organizations is mostly due to its own culture, even though other factors like marketing, finance, planning, production, production etc. acts as facilitators. Corporate culture has become an important tool for the executives to introduce and manage organizational change. They realized that significant strategic or structural alignment couldn't occur if the organization's values and behavioral norms do not support it. Organization members create and or are indoctrinated into unique beliefs and assumptions that form the basis for acting together. These beliefs and assumptions may operate at a conscious level.

Studies have found amazing results on the impact of organizational culture on their productivity. Moore Head and Griffer⁴ in their study has pointed out that 1 to 2 hours of additional work can be extracted per employee per day by infusing strong culture in the organization and concluded that organizations with strong cultures do perform well. The research work of Peter and Waterman (1982)⁵ has clearly proved that highly successful companies in America have the similarities of Japanese culture. Many other studies have also contributed to the belief that corporate culture is a highly significant factor and real contributor to the success of the organizations.

3. Organizational Culture - Definition

It is difficult to define culture and still difficult to specify or delineate it. It exists despite one's desire to have it or not, whether noticed or ignored. Whether articulated or not. It is reflected in how things are done and how problems are solved. The culture metaphor is derived originally from agriculture and the process of growing things but the concept of organizational culture was arrived through its analogy with national culture. The notion that the different national or ethnic grouping has different culture. The analogy is now extended to the notion that different organization also has different cultures, which grow and develop as organizational culture.

In biological terms, culture is like the DNA of an organization, invisible to the naked eye, but critical to the shaping its behavior. One culture could be distinguished from another in terms of how some commonly shared human problems are sought affecting the performance of employee in positive or negative ways. Organizational culture is a set of values held by individuals in a firm. These values define what is good or acceptable behavior and what is bad or unacceptable behavior.

Webster New Collegiate Dictionary defines culture as *The integrated pattern of human behavior that includes thought, speech, action and artifacts and depends on man's capacity for learning and transmitting knowledge to succeeding generations.* On the background of these basic definitions, for the purpose of this study organizational culture has been conceptualized as a common set of beliefs, values and attitudes that the members perceives in an organization. It helps the members of organization to understand which actions are considered acceptable and unacceptable, what is desirable and undesirable to the organization what is expected by the organization from its employees.

4. Statement of Research Problem

In today's competitive business environment, a common question comes frequently to our mind is *why some organization more successful than others?* Why, while some organizations are flourishing others are perishing? Even though the success and failures of the organizations are the results of so many factors, nobody has considered that *cultural factors* of the organization is important element. During late 1970's and early 1980's the term *culture* is widely used in the studies of organizational behavior, because of growing realization among behavioral scientists and management consultants that the culture of an organization has much influence on *organizational effectiveness*. The publication of books - Theory Z (Ouchi-1981); The Art of Japanese Management (Pascale and Athos-1981); In search of excellence (Peter and Waterman-1982)- presented a different picture of management, which is usually consist of strategy, finance, marketing. These authors have concentrated on *behavior side* of management. They have argued that the difference between successful organizations rests with the values, beliefs, attitudes and principles that form the culture of an organization. For the past twenty-five years western management scientists have concentrated and still they continue to concentrate on the concept. These studies have proved beyond any doubt that there is a strong relationship between corporate culture and organizational effectiveness. But in our country research on organizational culture is still in nascent stage and only few studies have concentrated on this aspect. This prompted the researcher, to study the concept and to ascertain the validity of findings relating to corporate culture and organizational effectiveness in Indian context.

Further on closer interaction with the different section of the industry and extensive review of organizational cultures present in the organizations it was found that the values, attitudes and beliefs held by the members of a successful organization is entirely different from that an un successful or sick organization. It gave birth to the notion that organizations are successful mainly due to their healthy organizational cultures and organizations are sick and unsuccessful because of their poor organizational cultures. Therefore, on this premise organizational cultures have been classified as progressive cultures and regressive cultures. The successful, innovative and effective organizations develop and follow *Progressive Culture* whereas sick, unsuccessful organizations nurture *Regressive Culture*. By inculcating progressive culture an organization becomes more innovative and successful and by adopting regressive culture an organization becomes further sick and start decaying. This classification of typology is based on characterization of human psychology Further, the typologies developed so far by both Western and Indian researchers falls between these two extremes - progressive and regressive cultures. Thus, in the proposed study, this typology of organizational culture is being used to the study the relationship between organizational cultures and organizational effectiveness.

In short the present study proposes firstly, to investigate the relationship between organizational culture and organizational effectiveness, secondly to validate the above typology of organizational cultures and lastly to find out predominant cultural patterns in corporate of Tamil Nadu.

5. Significance of the Study

A fundamental assumption in organizational psychology is that it is impossible to understand the behavior in organization, without understanding the characteristics, behavior of individuals operating within organizations. Based on current knowledge and conceptual developments in the field of human psychology, it should no longer be acceptable to treat culture as somehow opposed to or independent of human nature. And it should no longer be acceptable to ignore evolutionary psychological foundations through which culture is created and transmitted. It is also unreasonable to expect that human culture delineate from its foundations when it enters organizations. Therefore, it is the firm belief of the researcher, which is rooted, in the understanding of human nature, and his studies from psychology, socio- psychology and psychoanalysis that corporate culture should be rooted in characteri-structure of human being. After all, culture is derived from the shared values or beliefs of a society. Corollary to it organizational culture reflects the shared values of the members of the organization. Organizational culture cannot be discussed in isolation from the totality of the human nature.

Further, several studies have been carried out to study the impact of organizational culture on various organizational aspects such as organizational performance, organizational effectiveness, involvement and satisfaction of employees etc. These studies have concluded beyond any doubt that organizational culture is the major contributor to the success of the organization. But majority of these studies concentrated and studied only successful organizations and has attributed its phenomenal success and effectiveness to organizational culture. Surprisingly none of the study has so far concentrated either sick or unsuccessful companies and has attributed their failures and sickness to organizational cultures. In an attempt to study the impact of culture on effectiveness further deeper, few studies even carried out the patternization of organizational cultures and developed typologies. But, these typologies, while neglecting the individuals have given over emphasis to organizational factors and it cannot be a comprehensive view about human nature in organizations. Typologies advanced by western authors such as clan, hierarchy, market and adhocracy cultures (Cameron and Ettington, 1989); Tough - guy, macho, work hard or play hard, bet your company and process culture (Deal and Kennedy, 1982); strong and weak cultures (Peters and Waterman, 1982) are seems to be biased towards organizational structure.

these typologies seems to be unrealistic and incongruent to the understanding of human psychology. Similarly typologies developed by Indian authors are full of its own contradictions and are not rooted in the study of human psychology. Jai P.B.Sinha's classification of culture in to autocratic, bureaucratic, participative, and nurturant task culture is not a comprehensive view of human nature. Autocratic, bureaucratic, technocratic and entrepreneurial patterns of corporate culture developed by Udai Pareek is also too much empirical and widening the gap between the culture and human psychology. Amarchand and Jayaraj typology of corporate culture in to work, strong, and weak culture is not grounded in any systematic thought about human nature and again emphasizing on organizational factors. This study is hence significant on the ground that, it tries to address the lacuna and fills the gap in the field organizational culture studies. Firstly, on this background the researcher has adopted a new typology i.e. progressive and regressive corporate culture based on the totality of human nature. This is more comprehensive view of human nature. This typology got its roots from the psychoanalytical studies of human being and influenced by the works of Erich Fromm and Sigmund Freud.

Secondly, an attempt has been made to study the impact of organizational cultures classified on the basis of above typology on the effectiveness of the organization.

Thirdly, in this study a maiden attempt has been made to study sick and unsuccessful organizations hitherto neglected apart from studying successful organizations.

Lastly, the present study tries to find out the dominant organizational cultures present in the organizations. Thus the present study will address the pitfalls of previous studies, diagnose the suitability of patterns of culture to the emerging organizational challenges and if need be suggest changes in organizational cultures to suit changing organizational tasks.

6. Objectives of the Study

The central theme of this proposed study is to analyze the impact of corporate culture on organizational effectiveness. Thus the prime objective of the study is to analyze the relationship between organizational culture and organizational effectiveness. While analyzing this relationship, the other objectives of the study are to examine the relationship between individual factors of executives and their perceptions of organizational culture, to study the relationship between organizational factors of executives and their perceptions of organizational culture, to identify prevalence of dominant organizational culture, Thus following are the specific objectives of study.

- To analyze the relationship of organizational culture and organizational effectiveness.
- To examine the impact of individual factors of executives on their perceptions of organizational culture.

- To examine the impact of organizational factors of executives on their perceptions of organizational culture.
- To identify the prevalence of dominating cultural pattern of corporate in Tamil Nadu.

7. Hypotheses of the study

To study the above objectives totally thirteen hypotheses are formulated for being tested. Among this eight hypotheses have been formulated to analyze the relationship between individual factors of executives and organizational culture. It is based on commonly held lay notion and on the intuition of the researcher himself that personal factors influence the perception of organizational culture. Another four hypotheses are related to organizational factors to examine the relationship between organizational factors and organizational cultures and the last one is to test the relationship between organizational culture and effectiveness.

- H 1: Young executives perceive their organizational culture to be regressive and older executives perceive their organizational culture to be progressive.
- H 2: The more the educational level of the executives the more will be the perception towards progressive culture.
- H 3: The higher the annual income of an executive the more will be the perception towards the progressive culture.
- H 4: Experienced executives will perceive their organizational culture to be progressive, where as executives with less experience perceives regressive culture.
- H 5: An executive with more outside experience will perceive his organizational culture to be regressive.
- H 6: Top level executives perceive their organizational culture to be progressive whereas as low-level executives perceive regressive culture.
- H 7: A married executive perceives his organizational culture to be progressive and an un-married executive perceives it to be regressive.
- H 8: Executives with rural background perceives their organizational culture to be progressive, whereas urban executives perceive it to be regressive.
- H 9: Executives of manufacturing industry perceive their organizational culture to be more regressive than the executives of service industry.

- H 10: Executives from private limited companies perceive their organizational culture as more progressive comparing to their counterparts in public sector and private sector undertakings.
- H 11: Executives of family managed organizations perceive their organizational culture to be more regressive than that of professionally managed organizations.
- H 12: An executive of MNC perceives his organizational culture as more progressive comparing to an executive of Indian organization.
- H 13: progressive culture leads an organization to effectiveness and regressive culture leads the organization towards ineffectiveness.

8. Scope and Limitations of the Study

The study adopts the concept of organizational culture as the property of the employee and hence organizational culture is taken to mean the psychological organizational culture or the perceived organizational culture. Hence the data relating to organizational culture perception score are not aggregated at organizational level. The organizational culture perception score speaks of psychological opinion of the executives of the different categories. Hence, the study is limited to understanding organizational culture as a subjective psychological phenomenon from executives' perception. The organizational culture from the standpoint of organization is not the concern of this study. The psychological perceived organizational culture is considered to be more scientific, valid and useful than an objective measure of organizational culture as viewed by Sharma⁶. Further more the positive or negative reactions of executives to their organizational environment, however subjective the same might be, can be taken to have quite substantial repercussions for organizational effectiveness.

Further perceptions of organizational effectiveness inquired in to are restricted to dimensions developed by T sui classification of organizational effectiveness. This classification seems to be more reliable and scientific as it covers the interests of all stakeholders namely shareholders, employees, management, suppliers, creditors, customers, government and society at large. Thus perceptions of effectiveness relating to other than those covered by Tsui's classification fall beyond the scope of this study.

9. Methodology of the Study

This study on organizational culture is an empirical investigation based on the perceptions of executives employed in organizations. The methodology of research followed is described below.

10. Geographical Area of the Study

This study covered entire area of Tamil Nadu by selecting organizations from industrial cities covering Chennai, Ranipet, Ambur, Hosur, Coimbatore, Thrippur, Trichy and Nagarkoil. Totally 40 organizations were selected from these cities comprising five public sector undertakings, fifteen private limited organizations and twenty public limited organizations. While selecting these 40 organizations care was taken to include organizations having variety of backgrounds with respect to their origin, management, type of industry such as MNC, joint ventures, manufacturing industries, service industries, family managed organizations, professionally managed organizations. For the purpose of the study organizations employing more than 200 employees alone were selected as responding units. A complete description of sample profile of organizations taken for the study is given in the following tables

| Type of ownership | No. of Organizations |
|-------------------------------|----------------------|
| Public Sector Organizations | 5 |
| Private Limited Organizations | 15 |
| Public Limited Organizations | 20 |
| Total | 40 |

Table. 1 Sample profile of organizations on the basis of ownership of organizations

Executives for the study were selected from both predominant industries namely manufacturing and service. Care was taken to have representation from both the types of industries in each segment of organizations as presented in table 2.

| Type of Industry | Pub. Sector | Private Ltd. | Public Ltd. | Total |
|------------------|-------------|--------------|-------------|-------|
| Manufacturing | 4 | 10 | 12 | 26 |
| Service | 1 | 5 | 8 | 14 |
| Total | 5 | 15 | 20 | 40 |

Table. 2 Sample profile of organizations On the basis of type of industry

Table 3 gives the details of the organizations selected for the study on the basis of the type of management.

| Type of Industry | Pub. Sector | Private Ltd. | Public Ltd. | Total |
|------------------------|-------------|--------------|-------------|-------|
| Family Managed | — | 12 | — | 12 |
| Professionally Managed | 5 | 3 | 20 | 28 |
| Total | 5 | 15 | 20 | 40 |

Table. 3 Sample profile of organizations On the basis of type of management

The details of organizations with respect to their origination like MNC or Indian or Joint Venture has been given in Table 4.

| Type of Industry | Pub. Sector | Pvt. Ltd. | Pub. Ltd. | Total |
|------------------------------|-------------|-----------|-----------|-------|
| Multi National Organizations | — | 3 | 5 | 8 |
| Indian Companies | 5 | 5 | 15 | 25 |
| Joint Ventures | — | 3 | 4 | 7 |
| Total | 5 | 15 | 20 | 40 |

Table. 4 Sample profile of organizations on the basis of origin of organization

11. Sample Population of the Study

The sample population for the study was chosen by convenient sampling technique. Finding and contacting female executives in the above mentioned organizations was proved to be very difficult, further it is presumed that there is no gender bias in higher hierarchical postings like top level and middle level executives. Hence female executives were not selected for the study and the sample consists only male executives.

| | | A | B | C | D | TOTAL |
|-----|--------------------------------|-----|-----|----|----|-------|
| 1. | Age | 25 | 80 | 76 | 36 | 217 |
| 2. | Education | 75 | 99 | 43 | — | 217 |
| 3. | Annual Income | 69 | 99 | 49 | — | 217 |
| 4. | Experience in the organization | 38 | 88 | 70 | 21 | 217 |
| 5. | Total Executive Experience | 31 | 77 | 71 | 38 | 217 |
| 6. | Designation | 72 | 145 | — | — | 217 |
| 7. | Marital Status | 195 | 22 | — | — | 217 |
| 8. | Nativity | 42 | 175 | — | — | 217 |
| 9. | Type of Organization | 121 | 96 | — | — | 217 |
| 10. | Ownership of Organization | 48 | 119 | 50 | — | 217 |
| 11. | Type of Management | 46 | 171 | — | — | 217 |
| 12. | Origin of Organization | 47 | 140 | 30 | — | 217 |

Table. 5 Sample profile of respondents

Table 6 deliberates on the parameters of respondents and organizations in each class.

| | | A | B | C | D |
|-----|--|---------------|--------------|------------|------|
| 1. | Age (in Years) | < 30 | 31 - 40 | 41 - 50 | > 51 |
| 2. | Education | UG | PG | PROF. | — |
| 3. | Annual Income (Rs.in Lacs) | < 3 | 3 - 5 | > 5 | — |
| 4. | Experience in the organization (in yrs.) | < 5 | 5-10 | 10 -20 | > 20 |
| 5. | Total Executive Experience(in yrs.) | < 5 | 5-10 | 10 -20 | > 20 |
| 6. | Designation | Top | Middle | — | — |
| 7. | Marital Status | Married | Unmarried | — | — |
| 8. | Domicile Area | Rural | Urban | — | — |
| 9. | Type of Organization | Manufacturing | Service | — | — |
| 10. | Ownership of the Organization | Pvt. Ltd. | Pub.Ltd. | Pub. Sect. | — |
| 11. | Type of Management | Family | Professional | — | — |
| 12. | Origin of Organization | MNC | Indian Co. | JV. | — |

Table. 6

The executives selected for the study are top level and middle level managerial staff. The top-level executives consist of CEO, managing directors, general managers and middle level executives consist of departmental heads, and functional heads. Totally 225 executives were selected, out of which 150 were middle level executives and 75 were top-level executives. From the responses of these executives seven filled up questionnaires are found to be in complete and could not be used for analysis and so, remaining 217 responses were taken for analysis. A complete profile of respondents selected from different organizations and having different personal backgrounds are given in the following table (Table .5)

12. Instruments used for Data Collection

The researcher for the purpose of collecting data developed a three-part questionnaire. First part of the questionnaire was designed to collect information about the individual

factors of executives and about organizational factors. This information is useful in examining the type of relationship between individual factors and organizational factors with organizational cultures.

Second part of the questionnaire was designed to understand the overall effectiveness of the organization from the perceptions of the executives. Respondents are requested to give yes or no responses to twenty statements prepared on the basis five dimensions, which represents the interests of stakeholders. This information provides vital insight to ascertain the impact of organizational culture on organizational effectiveness.

Third part of the questionnaire deals with typology of the organizational culture. Totally 54 statements constitutes this part, out which 30 statements represents progressive culture of the organization which is prepared on the basis of eight dimensions of progressive culture. Remaining 24 statements of the questionnaire represents regressive culture, which is prepared on the basis of the dimensions of regressive cultures. Detailed descriptions of the dimensions of progressive and regressive culture have been given in the chapter of conceptualization of the study.

13. Analysis of the Study

The total OC perception score of each respondent formed the basis for analyzing and interpreting the data. With respect to organizational effectiveness in Part-B of the questionnaire, each statements having *yes* has been awarded two marks and one mark for *no* response. The maximum positive score for this part of the questionnaire is 40 and the minimum score is 20. On this basis the overall effectiveness of the organization has been classified as under:

| Total score | Classification of effectiveness |
|-------------|---------------------------------|
| 0 – 20 | In effective organization |
| 21 – 30 | Somewhat effective organization |
| 31 – 40 | Most effective organization |

Table. 7 Table showing the extent of overall effectiveness of the organizations

With respect to respondent's perceptions relating cultural patterns presents in the organizations, a maximum score of 4 for strongly agree, 3 for agree, 0 for undecided or not applicable and 2 for disagree and 1 for strongly disagree have been assigned. Accordingly a maximum score for this part questionnaire is 216 and the minimum score is 54. On the basis of total perception score of the executives, the pattern of organizational culture has been classified as given in the table 1.8

| Total score | Classification of organizational culture |
|-------------|--|
| 0 – 54 | Strong feelings of regressive culture |
| 55 – 108 | Less feelings of regressive culture |
| 109 – 162 | Less feelings of progressive culture |
| 163 – 216 | Strong feelings of progressive culture |

Table. 8

Summary of the Findings about Organizational Culture (OC) and Organizational Effectiveness (OE) Relationship

The vital relationship between organizational culture and organizational effectiveness was examined by Chi Square test of significance and the results indicated a significant relationship. Further the results fall in line with the contention of the study that progressive culture leads an organization towards the effectiveness and regressive culture leads to in effectiveness. The results revealed a clear pattern on the relationship that the regressive cultured organizations are *in-effective* organizations and progressive cultured organizations are *most effective* organizations.

The results indicated that 98.9% of *most effective organizations* have progressive culture and only 1.1% of the *most effective organizations* have regressive culture. Similarly in the case of *effective organizations* 70% of them have progressive culture and 30% have regressive culture. In the case of *ineffective organizations* 81.5% of them have regressive culture and the remaining 18.5% have progressive culture. Further the findings revealed that 77.42% of the respondents have indicated the presence of progressive culture in their organizations where as only 22.58% have indicated regressive pattern of organizational culture. So it is concluded that the predominant culture in the organizations of Tamil Nadu is progressive culture.

OC and OE Relationship in Manufacturing Industry

The relationship between organizational culture and organizational effectiveness in manufacturing industry has been statically proved by Chi- square test. The statistical results also points out the presence of a pattern that regressive culture leads to in-effectiveness and progressive culture converts an organization into *most effective organization*. In manufacturing sector 88.9% of *in effective organizations* have indicated the presence of regressive culture and 11.1% of them have progressive culture. In the case of *effective organizations* of manufacturing sector 45.2% have opined to have regressive culture and remaining 54.8% have indicated the presence of progressive culture. Similarly in the case of *most effective organizations* of manufacturing sector 65.7% have indicated the presence of progressive culture and only 34.3% have indicated the presence of regressive culture. Further it is found that 57.85% of the manufacturing

sector organizations have progressive pattern where as only 42.15% have regressive pattern of organizational culture. Hence it is concluded that majority of manufacturing organizations have progressive pattern of organizational culture.

OC and OE Relationship in Service Sector Industry

Findings revealed a significant relationship between organizational culture and organizational effectiveness in service sector industry. It is found that all *ineffective organizations* (i.e. 100% of the sample) in service sector have regressive culture. Similarly 80% of the *most effective* service sector organizations are found to have progressive culture and only 20% have regressive pattern of culture.

Further the results shows that service sector industries predominantly (57.29%) have regressive culture and only 42.71% have indicated progressive pattern of organizational culture.

OC and OE Relationship in Family Managed Organization

In the case of family managed organization the results indicated a significant relationship between organizational culture and organizational effectiveness. it shows that that 76.75% of family managed organizations have regressive culture and only 23.25% of them have progressive culture and hence it is concluded that the predominant culture in family managed organizations is regressive culture. The results further reveals that 44.2% of family managed organizations are *ineffective organizations*, 65.2% are *effective organizations* and only 2.3% are *most effective organizations*.

Therefore it is concluded that the family managed organizations which is predominantly following regressive culture are mostly ineffective in terms of its overall effectiveness.

OC and OE Relationship in Professionally Managed Organization

The Chi- Square test of significance has proved that there is a significant relationship between organizational culture and organizational effectiveness in professionally managed organization. The findings revealed that only 4.6% of the professionally managed organizations are *ineffective organizations*, 51.1% of them are *most effective organization* and the remaining 44.3% are *effective organizations*. Further it was found that 79.32% of professionally managed organizations have progressive pattern of culture and only 20.68% have regressive organizational culture. Therefore it is concluded that almost 80% of the professionally managed organizations have progressive pattern of culture. Hence it is concluded that the predominant culture in professionally managed organization is progressive culture and majority of them are *most effective organizations*.

OC and OE Relationship in Private Limited Organization

The relationship between OC and OE in respect of private limited organization has been disproved by statistical tests. But, while observing the predominant culture in the private limited organization it is found that 66.66% of them have regressive pattern of culture where as only 33.33% have progressive pattern of culture. Further the results show that regressive culture has led to in-effectiveness in private limited organizations, which indicates that 84.21% of *in-effective organizations* have regressive culture. Further it is found from the findings that only 2% of private limited organizations which predominantly have regressive pattern of culture are *most effective organizations* in terms of over all effectiveness.

OC and OE Relationship in Public Limited Organization

The findings show a significant relationship between culture and effectiveness in Public Limited organizations. Further the results points out that 72% of the public limited organizations have progressive culture and hence it has been concluded that the predominant culture public limited organizations is progressive culture. Further it is revealed that 44.1% of the public Limited organizations are *most effective organizations*, 51.7% are *effective organizations* and only 4.2% of them are *in-effective organizations*. In the case of *in-effective organizations* all (100%) the in-effective organizations in public limited sector are found to have regressive culture only. Therefore the results clearly point out and further validate the contention this study that regressive culture in an organization renders the organization as *in-effective organization* where as progressive pattern converts an organization in to a *most effective organization*.

OC and OE Relationship in Public Sector Organization

The relationship between OC and OE with respect to public sector undertakings is failed the statistical test of significance and hence it is concluded that there is no significant relationship between OC and OE in public sector undertakings. Further it is revealed from the findings that 70% of public sector undertakings have progressive pattern of culture and only 30% have regressive pattern of culture, so it is concluded that the predominant culture in PSU is progressive culture. Similarly the results further indicates that 74% of the public sector undertakings are found to be *most effective organizations*, 20% are *effective organizations* and only 12% of them are *in-effective organizations*.

OC and OE Relationship in MNCs

The statistical results shows a insignificant relationship between OC and OE in MNCs. However the results clearly indicate that the predominant culture in these MNCs is progressive culture, which shows that 76.59% of MNCs have progressive culture and only 23.41% have regressive culture. While probing the relationship between culture

and effectiveness in MNCs, it is observed 62.5% of the *ineffective organizations* found to have regressive culture and remaining 37.5% have progressive culture. In the case of *effective organizations* 28.57% have regressive culture and remaining 71.13% have progressive culture. In the case of *most effective organizations* all (100%) of the *most effective MNCs* are having progressive culture only and none of them have regressive culture.

OC and OE Relationship in Joint Venture organization

The relationship between organizational culture and organizational effectiveness in JV has been statistically proved with Chi- Square test of significance. It is observed that all (100%) the *ineffective JVs* found to have regressive culture and none of them had progressive culture. In the case of *effective organizations* 46.15% of them have regressive culture and remaining 53.85% have progressive pattern of organizational culture. Similarly in the case of *most effective organizations* 91.7% have progressive culture and only 8.3% have regressive culture. All these findings point out that progressive culture leads to effectiveness and converts an organization in to *most effective one*.

With respect to the predominant culture of JVs the findings revealed that 40% of JVs have regressive culture and 60% have progressive culture, and hence it is concluded that the predominant culture of JVs is progressive culture.

OC and OE Relationship in Organization having Indian Origin

The relationship between culture and effectiveness in organizations having Indian origin has been proved statistically. With respect to the dominant culture in Indian organizations it is found that 55.71% have progressive pattern of culture and 44.29% have regressive culture. The relationship between OC and OE in Indian corporate, revealed that all (100%) *ineffective organizations* have regressive pattern of culture. In the case of *effective organizations* 63.63% have indicated the presence of regressive culture and 36.37% have progressive pattern of culture in their organizations. Similarly with respect to *most effective organizations* it is found that 63.33% of them have progressive culture and only 36.67% have regressive pattern of culture.

14. Conclusions Drawn from the Study

From the detailed findings of the study the following conclusions emerge. With respect to the relationship between personal factors of executives and perceptions of organizational culture it is found that

- ⇒ Age of the executive seems to have no influence on the perception of either progressive culture or regressive culture of the organization.

- ⇒ Educational qualifications of executives clearly influences the perceptions of progressive culture, whereas in the case of regressive culture it is having very little influence
- ⇒ Annual income of executives does not seem to influence the perceptions of progressive culture, but cause a definite difference in the perceptions of regressive culture.
- ⇒ Experience of the executive in the organization seems to have clear and concrete influence on the perception of both progressive and regressive culture of the organization.
- ⇒ Total executive experience, designation and marital status and domicile area of the executives seems to have no influence on the perceptions of both progressive and regressive cultures of the organization.

With respect to the influence of organizational factors of executives on the perceptions of organizational culture, it is found that

- ⇒ Type of industry in which the executives work influences the perceptions of progressive culture, where as in the case of regressive culture it seems to have very little influence.
- ⇒ Type of management of the organization where the executive is employed seems to have great influence on the perceptions of both progressive and regressive cultures.
- ⇒ Ownership of organization such as private limited, public limited and public sector seems to cause great difference in the perceptions of executives with respect to both progressive and regressive culture.
- ⇒ Origin of the organization like Multi National Companies, Joint Ventures, and Indian Companies where the executives employed, seems to influence the perceptions of progressive culture but do not have influence on the perceptions of regressive culture.

With respect to the core relationship between organizational culture and organizational effectiveness it is found that

- ⇒ There is a significant relationship between organizational culture and organizational effectiveness in manufacturing sector and service sector industries, family and professionally managed organizations, public limited organizations, joint venture companies and companies of Indian origin. In the case of private limited organizations, public sector organizations and MNCs the results failed to prove a significant relationship.

⇒ However the findings of the study clearly pointed out that progressive pattern of culture converts an organization in to either *effective* or *most effective* organization and regressive pattern of culture renders an organization in to a *in-effective* organization. As proved by this study, this contention holds well in all types of organizations irrespective of their nature, origin, management, and ownership.

15. Suggestions of the study

Most of the organizations in our country have included the codes of their corporate culture in every facet of their functional areas and try to imbibe its values among employees, to reap its benefits. But to reap further benefits and increase the effectiveness of organization with the help corporate culture, organizations needs to develop a unique progressive pattern of culture by incorporating dimensions of progressiveness along with following aspects:

- The organizational culture should permeate in to every decision and everyday lives of organization and as well as its employees.
- The organization should have an effective mechanism to enforce the value system of its culture.
- The organization should ensure fairness, equality, integrity and accountability in enforcing and implementing its value system.
- The organization should have a well-defined support system to encounter moral and ethical dilemmas while implementing its culture.
- The organizational parameters like performance, involvement, satisfaction etc should encourage, reinforce and tied to its own corporate cultures.

This mechanism will translate and transform the progressive organizational culture in to organizational effectiveness.

Further, the researcher feels that similar studies linking organizational culture with organizational effectiveness may be carried out in other type of organizations like agro based industries, cooperative type of organizations, which have not been covered in this study, to find whether the findings replicate there too.

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Tourism and its Prospects in India

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Abstract

Tourism is recognized as a major global service industry governed by the laws of supply and demand. It has advanced as a concomitant to general development. It touches not only the economic fabrics of the society but also has deep-rooted effects on social norms and moral values. The ramification of tourism has reached out to many sectors of the economy. The explosion of global tourism has occurred because of its commercial expediency and of human community into an increasingly leisure-oriented society. That is why more and more companies involved themselves in the highly skilled business of transporting, accommodating and catering for tourists all over the world.

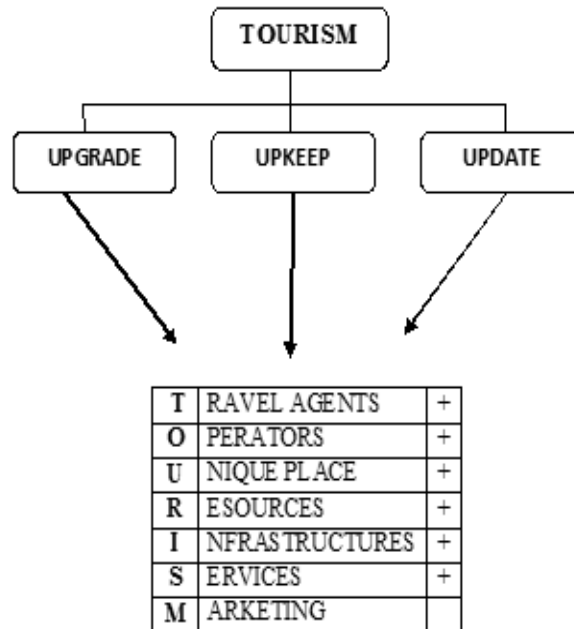
Introduction

Tourism is no longer a joy ride but a regular and reoriented promising industry having a flow of human contacts. The entire gamut of trade and travel activities seems to have combined adventure with the element of tourism. Tourism was recognized as a means of economic expansion after the Second World War and was perceived as a renewable resource. Government has recognized tourism industry as a consuming industry and not simply a passive one that generates economic benefits. Proponents of tourist expansion visualize tourism as a harbinger of economic growth and modifier of socio economic inequalities, while the critics have highlighted various social strains which are caused by tourist development, examples being, distortion of indigenous cultural expressions, conversion of small farmers into wage labour due to high land cost and associated alienation of land, perpetuation of racial inequalities and erosion of dignity.

Tourism in India

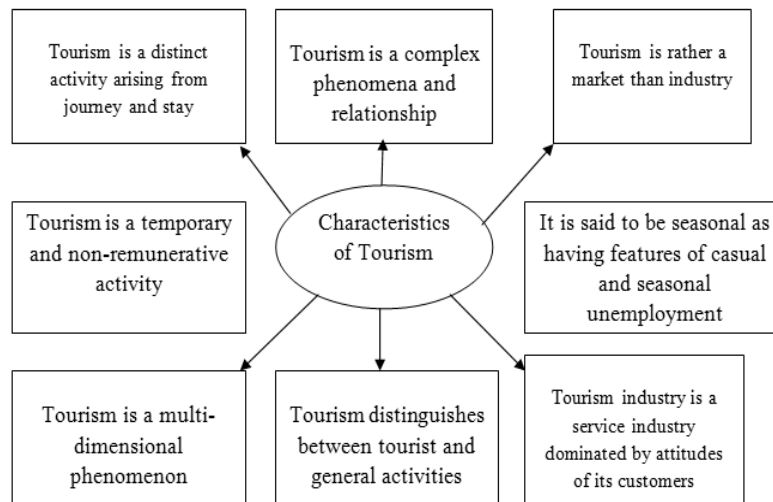
India is a land of contrasts-from tropics to snows. It is vast, varied and strikingly beautiful and the second most populated and the seventh largest country in the world. India has the most ancient cultural heritage. More than thousand million people diverse in many ways inhabit over 32, 87,782 square kilometers of the Indian Soil. The variety of its scenery, its intensive and equally varied agriculture, it's extremely diversified

New Dimension of Tourism



(Raina A.K. and Lodha. R.C., Fundamental of Tourism system, Kanishka publishers, New Delhi, 2004, p.7)

Characteristics of Tourism



(Raina A.K. and Lodha. R.C., Fundamental of Tourism system, Kanishka publishers, New Delhi, 2004, p.7)

industry, its big cities and thickly populated areas, its vast open country side, its ports, its variety of languages and finally its manifest to relations with other nations of the world all of these make India an exciting and fascinating destination. Physically, the mainland comprises of four well-defined regions, namely the great mountain zone, the extensive middle section of Indo-Genetics plain together with the Brahmaputra valley of Assam, the desert region and the Southern Peninsula. The Himalayas comprise of three almost parallel ranges interspersed with large plateaus and valleys some of which like the Kashmir and Kalu valleys are very fertile, extensive and extremely rich in scenic beauty. Some of the highest peaks in the world are found in these ranges.

There are four main seasons in India.

- (i) Winter Season (December-February),
- (ii) Hot weather Summer season, (March-May)
- (iii) Rainy season, South-West monsoon period (June-September)
- (iv) Post-monsoon period, known as north-east monsoon period in the South Peninsula, (October-November).

| Month | Foreign Tourist Arrivals (Nos.) | | | Percentage Change | |
|--------------|---------------------------------|---------|---------|-------------------|---------|
| | 2011 | 2012 | 2013 | 2012/11 | 2013/12 |
| January | 568719 | 622713 | 681002 | 9.5% | 9.4% |
| February | 552152 | 627719 | 681193 | 13.7% | 8.5% |
| March | 512152 | 535613 | 606456 | 4.6% | 13.2% |
| April | 371956 | 446511 | 447581 | 20.0% | 0.2% |
| May | 332087 | 383439 | 374476 | 15.5% | -2.3% |
| June | 384642 | 405464 | 433390 | 5.4% | 6.9% |
| July | 466715 | 475544 | 485808 | 1.9% | 2.2% |
| August | 422173 | 428490 | 445632 | 1.5% | 4.0% |
| September | 369821 | 417478 | 411562 | 12.9% | -1.4% |
| October | 507093 | 559641 | 556488 | 10.4% | -0.6% |
| November | 608178 | 669767 | 701185 | 10.1% | 4.7% |
| December | 680004 | 736843 | 752972 | 8.4% | 2.2% |
| Total | 5775692 | 6309222 | 6577745 | 9.2% | 4.3% |

(Source: India Tourism Statistics 2013)

Table 1 Foreign Tourist Arrivals (FTAs) from Tourism in India during December 2013 and comparative figures of 2012 and 2011

Apart from its snow-covered northern fringe, India is generally a hot country. North and Central India experience the two extremes of climate. In December and January, in spite of bright sunshine it can be extremely cold and frosty. On the other hand in Western and Eastern India, the cold season is less pronounced, while south India basks under a tropical climate all the year round.

Performance of Tourism Sector during April 2013

The Ministry of Tourism compiles monthly estimates of Foreign Tourist Arrivals (FTAs) and Foreign Exchange Earnings (FEE) from tourism on the basis of data received from major airports. Following are the important highlights regarding FTAs and FEE from tourism in India during the month of April 2013.

| Month | Foreign Exchange Earnings (in Rs. Crore) | | | Percentage Change | |
|-----------|---|-------|-------|-------------------|---------|
| | 2011 | 2012 | 2013 | 2012/11 | 2013/12 |
| January | 5593 | 5777 | 8623 | 3.3% | 49.3% |
| February | 6646 | 7653 | 8502 | 15.2% | 11.1% |
| March | 5507 | 5522 | 7843 | 0.3% | 42% |
| April | 4518 | 5724 | 6745 | 26.7% | 17.8% |
| May | 4358 | 5047 | 5562 | 15.8% | 10.2% |
| June | 4751 | 5440 | 6485 | 14.5% | 19.2% |
| July | 5444 | 7116 | 8389 | 30.7% | 17.9% |
| August | 4620 | 5734 | 7260 | 24.1% | 26.6% |
| September | 4678 | 5748 | 6652 | 22.9% | 15.7% |
| October | 5219 | 7019 | 8154 | 34.5% | 16.2% |
| November | 6516 | 7941 | 9723 | 21.9% | 22.4% |
| December | 7039 | 8870 | 10549 | 26.0% | 18.9% |
| Total | 64889 | 77591 | 94487 | 19.6% | 21.8% |

(Source: India Tourism Statistics 2013)

Table 2 Foreign Exchange Earnings (FEE) from Tourism in India during December 2013 and comparative figures of 2012 and 2011

Promotion for Twelfth Five Year Plan (2012-2017)

1. To review the present status of Tourism Sector.

2. To review the implementation of ongoing programme in Tourism.
3. To formulate the objectives and to suggest strategies and programmes to boost tourism activities and its overall development in the state for the Twelfth Five Year Plan.
4. To identify the various tourist destinations in the State and suggest measures for improvement of infrastructure facilities in these areas.
5. To suggest policy package for encouraging private sector involvement in tourism promotion like hotels, restaurants, transport, etc.
6. To identify the neglected areas and groups; gaps, weaknesses and bottlenecks and to take note of the persisting and emerging problems/ situations related to the sector.
7. To identify priority areas for development of tourism during the Twelfth Plan period based on a master plan and to assess prospects of tourism of new tourism products.
8. To review connectivity requirements to tourist destinations and suggest measures to improve connectivity to existing and potential destinations.
9. To suggest measures for increasing the period of stay/spending by tourists so as to create more employment and income generating opportunities and selected destinations.
10. To make an assessment of the accommodation requirements, both in the star and budget category and the requirements transportation and other facilities commensurate with the projected volume of tourist traffic.
11. To identify constraints which impede the growth of tourism and make recommendations for their removal.
12. To promote tourism awareness among the people by developing district excursion centers, hill stations, opening of amusement parks, etc. by providing infrastructure facilities for the benefit of the low budget tourists.
13. To identify need for schemes to promote tourism development.
14. To suggest measures for development of water sports and adventure sports.
15. To take up any other important issue pertaining to this sector and suggest suitable action plan to achieve the desired objectives.

Tourist Destinations in Tamilnadu State

The State of Tamil Nadu, situated in the southern part of the Indian Peninsula has over 20 centuries of cultural heritage and historic significance as some of the most dynamic dynasties like the Cholas, the Pandayas, the Cheras and the Pallavas had ruled this region. Tamil Nadu has been bestowed by nature with a long Coramandel coast line, as well as hilly regions of Eastern and Western Ghats, very rich in diverse plant and animal life besides scenic beauty. With water resources from the several east flowing rivers, TamilNadu has the advantage of several water bodies in the form of lakes, waterfalls and others besides having some of world's most beautiful natural beaches along its coastline.

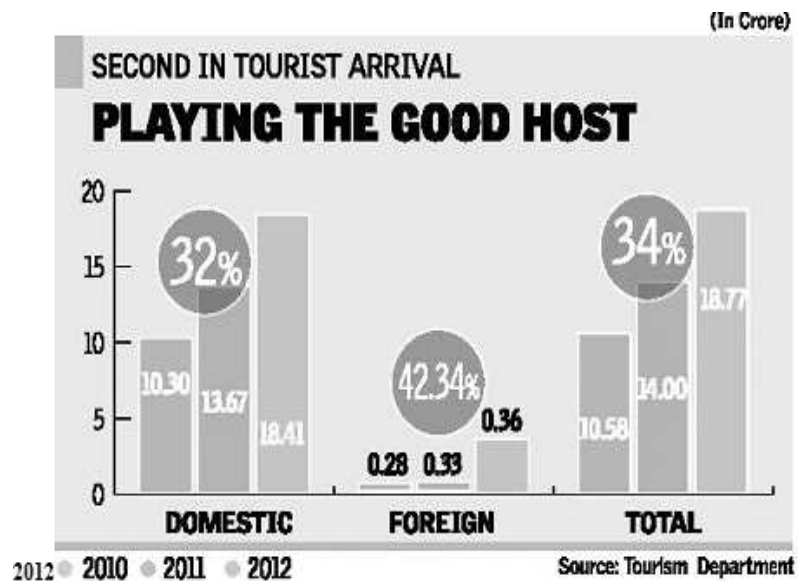
General public in Tamil Nadu is hospitable and communicates well with outsiders' in spite of the language barrier. Tamil, the Dravidian language which is the language of the land in Tamil Nadu is one of the oldest languages in the world, perhaps even older than Sanskrit.

The foremost of important tourist attractions in Tamil Nadu are its impressive temples, which are true edifices of a great and ancient culture vibrant and lively even today. Next only to the pilgrimage and heritage locations in Tamil Nadu comes the scenic beauty of nature in and around the state in the form of forests, wildlife sanctuaries, hill stations and the long bio-diverse coastline. These locations provide immense opportunities for sightseeing, pleasure and leisure, to the visitors of various categories including adventure tourists. Tamilnadu Tourism is provided a significant number of service such as -

1. Hotels, Restaurants, resorts and other tourists complexes providing accommodation and / or catering and food facilities to tourists.
2. Travel agencies, tour operators and tourist transport operators.
3. Units providing facilities for cultural, adventure and wildlife experiences to tourists.
4. Surface, water and air transport facilities for tourists.
5. Leisure, entertainment, amusement, sports and health units for tourists and convention/ seminar unit and organization.

34 per cent jump in tourist arrivals compared to previous year. Tamil Nadu occupied the second slot in the country in terms of domestic as well as foreign arrivals by attracting over 18.77 crore tourists during 2012, 34 per cent jump over the previous year, when it played host to 14 crore people.

Interestingly, Andhra Pradesh led the pack in domestic tourists with 20.68 crore arrivals, but did not make it to the top 10 States in receiving foreign nationals, according to an official statement issued by the Union Tourism Department. Maharashtra was favourite among foreign tourists with 51 lakh arrivals, whereas it attracted 6.63 crore domestic visitors.



Tamil Nadu rose from the third rank in domestic arrivals in 2011 to second slot by replacing Uttar Pradesh, which has moved down from the first position to third with the arrival of 16.8 crore visitors.

The top 10 States in terms of domestic arrivals are Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Rajasthan, Uttarakhand, Gujarat and West Bengal. They contributed 84.5 per cent of domestic tourists' arrivals in 2012. Tamil Nadu, New Delhi, Uttar Pradesh, Rajasthan, West Bengal and Bihar attracted over one million foreign tourists in 2012. The top 10 States attracted 90 per cent of total foreign tourists into the country.

Talking to The Hindu, the tourism department official said: *If Tirupati was the star attraction for Andhra Pradesh, Chennai, Mamallapuram, Kancheepuram, Udhagamandalam, Thanjavur, Kodaikanal, Madurai and Rameswaram attracted both domestic and foreign visitors for us.* According to him, most of the foreign tourists came from USA (3.26 lakh), Sri Lanka (3 lakh), UK (2.90 lakh), France (1.50 lakh), Malaysia (2 lakh), Singapore (1.9 lakh), Australia (1.4 lakh) and Cannada (1 lakh).

Conclusion

The Earth with all its beauty is for the people to enjoy and explore new things. Travel for the purpose of pleasure is fascinations to mankind from the prehistoric time. Leisure with guest for pleasure and recreations the force for the development of tourist travel. The increasing material wealth as a result of industrialization and the development of various modes of the transport facilities and organization of travel paid holidays and leave travel benefits are the basic motives for the development of tourism in recent years. The impact of tourism a national economy is becoming increasingly important due to its share in the earnings of foreign exchange, and generates employment opportunities by the way of promoting handy craft and small scale industries etc. it is concluded that any tourism development are based on three important things, namely attraction, accommodation and other tourist facilities and services. Finally infrastructure should be made in the world class model. Arranging transportation (air, road, rail and water), water supply, electric power, sewerage and solid waste disposal and telecommunication. .

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Organizational Role Stress and Job Satisfaction - A Study of Information Technology Professionals

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Abstract

Stress is a subject which is hard to avoid. The term is discussed not only in our everyday conversation but has become enough of a public issue to attract widespread media attention whether it be radio, television, newspapers or magazines, the issue of stress figures everywhere. It is a common myth that stress comes from various sources and it is comparatively more from occupation. These organizational stresses have its impact on Job Satisfaction of the employees. It also perceived that the job with less stress normally results in good amount of Job Satisfaction. But, all the occupations are not alike. Therefore, occupation is an important factor to be considered. It is assumed that the quantum of stress faced by the employees of Information Technology Industry is much more than the others connected to any other profession and occupation. The researchers have targeted six major firms in the IT sector. The researchers by adopting Quota Sampling method has selected twenty five employees from each of the six companies mentioned above in two cities constituting 300 respondents. The sampling technique adopted for this study is 'Quota Cum Accidental Sampling' Method. The factor analysis reveals that at the first level Role Stagnation (RS) and Role Expectation Conflict (REC) are contributing to ORS of IT Professionals; Personal Inadequacy (PIn), Role Ambiguity (RA) and Resource Inadequacy (RIn), Inter-Role Distance (IRD), Role Overload (RO), Role Erosion (RE), Role Isolation (RI), Self Role Distance (SRD), Role Overload (RO-5) and Role Overload (RO-1) are contributing at second, third, fourth, fifth, sixth, seventh, eighth, ninth and tenth levels respectively and the factor matrix analysis reveals that at the first level 'Job Content, Freedom and Opportunities' and at the second level, 'Industrial Relations, Working Conditions and Recognition' are contributing to Job Satisfaction of IT Professionals.

Introduction

The modern world, which is said to be a world of achievements, is also a world of stress. One finds stress everywhere, whether it be within the family, business

organisation or enterprise or any other social and economic activity. Right from the time of birth till the last breath, an individual is invariably exposed to various stressful situations. Thus, it is not surprising that interest in the issue has been rising with the advancement of the present century which has been called the *Age of Anxiety and Stress*.

Stress is a subject which is hard to avoid. The term is discussed not only in our everyday conversation but has become enough of a public issue to attract widespread media attention whether it be radio, television, newspapers or magazines, the issue of stress figures everywhere. Different people have different views about it as stress can be experienced from a variety of sources. If we ask the opinions of five different people, we may likely to get at least five different definitions for the term stress. The businessperson views stress as frustration or emotional tension; the air traffic controller sees it as a problem of alertness and concentration; the biochemist thinks of it as pure chemical event.

The concept of stress was first introduced in the life sciences by Hans Selye in 1936. It is a concept borrowed from the natural sciences. Derived from the Latin word *Stringere*, stress was popularly used in the seventeenth century to mean hardship, strain, adversity or affliction. It was used in the eighteenth and nineteenth centuries to denote force, pressure, strain or strong effort with reference to an object or person. In engineering and physics, the term implies an external force or pressure exerted on something with the intention to distort and being resisted by the person or object on which it is exerted. In psycho-physiology, stress refers to some stimulus resulting in a detectable strain that cannot be accommodated by the organism and which ultimately results in impaired health or behavior. In common parlance, however, the terms 'stress' and 'strain' are used synonymously in a non-scientific manner. The popularity of this concept has dwindled in the physiological field where it was first introduced but the use of stress terminology continues to flourish in psychological and social sciences. (Pestonjee D M, 2009) [1].

The common man today faces stress every now and then, in every walk of life. Stress accompanies us wherever we are, wherever we go, like a shadow it follows us. Stress is so close to each of us that its presence is barely perceived. It has become an inbuilt ingredient of today's life and this does not mean that in those earlier days, people had no stress; perchance, they were not aware of it and its impact.

The researcher has observed that the stress is identified in every individual's life irrespective of age, sex, marital status, education level and designation. It is a common myth that stress comes from various sources and it is comparatively more from occupation. These organisational stresses have its impact on Job Satisfaction of the employees. It also perceived that the job with less stress normally results in good amount of Job Satisfaction. But, all the occupations are not alike. Therefore, occupation is an important factor to be considered. It is assumed that the quantum of stress faced by the employees of Information Technology Industry is much more than the others connected to any other profession and occupation.

Today, people from all walks of life are attracted towards stress and hence this era is called as *Stress Era* or *Stress Age*. This era is also called as *Information Technology Era* (IT Era) or *Information Technology Age* (IT Age) (Rupashree Khubalkar, 2008) [2].

Hence, the researchers wish to explore the relationship of Work-Role Stressors with the Job Satisfaction of IT Professionals.

Significance of the Study

The researchers have observed that Indian IT Professionals, in contrast to similar professionals in other parts of the world (where the single parent family or the nuclear-family system is a more common way of life) must be facing and confronting lot more pressures and conflicts in their attempts to meet the varying and contrasting demands of work and family roles. The pressures are likely to be high, primarily because of the Indian socio-cultural context, where the joint-family-structure and the extended family system, with its emotionally loaded familial bonds and close-knit character, is the dominant way of life. Hence, the researchers have found that the IT Professionals in India, about whom not enough data and information is generated and available, as interesting source materials for exploring and furnishing new insights into the problems of organizational role. Indian IT Professionals were considered an interesting study material for one other reason also. It is a commonly known fact that the socio-cultural ethos in the sub-continent is quite different because of its strong social and family support system. In the face of industrialisation, modernisation, urbanisation, globalisation and growth in the standards of education and economy levels, rapid transformation is taking place in the social fabric and social structure of the nation. The typical joint-family structure, especially in urban areas and amongst the educated lot, is rapidly getting destroyed and substituted by nuclear and close single families.

In such a situation, how do IT Professionals in India, within this kind of organisational structure, respond to and cope with the conflicts and pressures (and resultant stress) from work? Do these work role stressors, have a say in the level of Job Satisfaction? These are some very pertinent questions that triggered the interest and attention of the researchers to carry out such a study which will be helpful to IT Professionals, Employers, IT Industry and the society as a whole.

Research Problem

It has been observed that present large segment of young educated youth - both men and women in India including other countries show preference to IT industry over other sectors in the society. This may be due to its attractive monetary benefits, respectability in the society, pleasant and ever young work environment, inherent challenging feature, tour and travel opportunities, medical reimbursement, holiday packages and quick opportunity for career development.

IT profession that is likely to provide the above mentioned benefits draws the

maximum number of educated youth both men and women towards it (the growing demand of institutions offering IT industry based courses and the increasing number of enrolments in them, is sufficient evidence to support the claim). Thus, it is no wonder, that most Indian family as also its prospective employees regard IT Profession to be one of the most suited and respectful profession for both the genders. This is more with respect to the middle-class segment of the population (that probably constitute the largest chunk of the literate and educated population of the country) which, in its attempt to meet economic challenges and acquire the mantle of a modern, liberal and forward class, is increasingly allowing its youth irrespective of the gender bias to join the work force, but without enough will or courage (or probably preferring the status quo) to break the traditionally assigned differential roles of a gender stratified social system.

However, the IT Profession seems to be much attractive, one cannot deny the level of stress experienced by IT Professionals, particularly the Indian IT Professionals.

Though many researches carried out earlier to study the stress among IT Professionals, many of them have failed to prove only work role related stress in them. Few studies were done to measure the social as well as family stressors and many researches proved the work-family conflicts and family-work conflicts among them. But none of the study took place so far by correlating organisational role stress with the job satisfaction that too particularly in the field of IT Profession. In short, the present study intends to explore the relationship of Work Role Stressors with the job satisfaction of IT Professionals. This Research Problem has raised the following questions.

1. What are the levels of Work Role Stress and Job Satisfaction?
2. What is the relationship of demographic factors with organisational role stress and job satisfaction?
3. What is the relationship of Work Role Stress and Job Satisfaction of IT Professionals?

Important Concepts

Organisational Role Stress or Work Role Stress

Work Role Stress or Job Stress or Organisational Role Stress is generally defined as the person-environment misfit. When there is misfit of an individual's skills and abilities or needs in the environment, it threatens the individual's well being. Strain and tension occur and stress is the natural result (French, Rogers & Cobb, 1974) [3]. Work related stress (produced by such factors such as role ambiguity, role overload and career frustration) can provide such strain symptoms as irritability, fatigue, preoccupation, depression, and anxiety (Brief, Schuler & Van Sell, 1981) [4].

The U.S. Department of Health has defined Job Stress or Occupational Stress or Work Role Stress as *the harmful physical and emotional responses that occur when the*

requirements of a job do not match the capabilities, resources or needs of the worker. Under this definition it is clear that one can be stressed at work, not just if he/she is not fully able or trained to do a job, but also if the nature of the job is such that it does not meet his/her emotional or psychological needs. If specific high demands are also being placed on him/her, then, this can lead to considerable pressure and stress. In relation to organisational roles, ten stresses are worth considering, namely, Inter-Role Distance (IRD), Role Stagnation (RS), Role Expectation Conflict (REC), Role Erosion (RE), Role Overload (RO), Role Isolation (RI), Personal Inadequacy (PIn), Self-Role Distance (SRD), Role Ambiguity (RA) and Resource Inadequacy (RIn).

Job Satisfaction

Job satisfaction is an attitudinal concept central to work psychology (Bass and Barnett, 1972). [5] Bullock (1952) [6] defined job satisfaction as an attitude, which results from a balancing and summation of many likes and dislikes experienced in connection with one's job. Locke (1969) [7] defined job satisfaction as 'a pleasurable or positive emotional state resulting from the appraisal of one's job values or job experience.' According to Wexley and Yukl (1977) [8] job satisfaction is the way an employee feels about his job. Ilies and Judge (2004) [9] have defined job satisfaction as a latent evaluative tendency of one's job that accounts for the co-variation between work stimuli and responses is manifested through discrete evaluative states during the working day.

Seybolt (1976) [10] supported the idea that job satisfaction is a function of the person-environment interaction. Although a number of factors (such as wages, opportunity for achievement and advancement, security, company, management, social aspects of job, communication and benefits) are related to the job satisfaction, it is the interaction among these factors rather than any one of them in isolation that accounts for job satisfaction.

In simple terms, Job Satisfaction is the way how people feel about their job and its various aspects. It has to do with the extent to which people like or dislike their job. That is why job satisfaction and job dissatisfaction can appear in any given work situation.

Objectives of the Study

The main objective of the research study is to determine the relationship between the stressors of Work Roles and Job Satisfaction of IT Professionals. For this, the researchers have framed the following objectives.

- To study the level of Work-Role Stress and Job Satisfaction of IT Professionals.
- To study the relationship of demographic factors with that of Work-Role Stress and Job Satisfaction.

- To study the relationship of Work-Role Stress with that of Job Satisfaction of IT Professionals.

Hypothesis

Based on the above objectives, the following hypotheses were framed.

- There is no significant relationship between Demographic Factors and Work-Role Stress and Job Satisfaction.
- There is no significant relationship between Work-Role Stress and Job Satisfaction.

Research Methodology

Population

The researchers have targeted six major firms in the IT sector namely 1) Tata Consultancy Services (TCS) 2) Cognizant Technology Solutions (CTS) 3) Infosys 4) Wipro 5) HCL and 6) Microsoft Corporation India (Pvt.) Ltd., having offices both at two major cities (to have uniformity) namely Bengaluru (Karnataka) and Chennai (Tamilnadu) as the former is considered as the IT Hub of India and the later is equivalently having major IT firms. All categories of IT Company employees are included in the population.

Sample

The researchers by adopting Quota Sampling method has selected twenty five employees from each of the six companies mentioned above in two cities constituting 300 respondents. The researchers have not differentiated respondents based on their designation. The researchers have personally visited the above mentioned IT Companies and the required data was collected from the IT Professionals who voluntarily came forward to respond to the questionnaire. Hence, the sampling technique adopted for this study is 'Quota Cum Accidental Sampling' Method.

Questionnaire

The researchers have designed a questionnaire with the following three parts

Part I - Personal Information;

Part II - Organisational Role Stress Scale (ORS; Udai Pareek) [11];

Part III - Job Satisfaction Questionnaire (Shailendra Singh) [12];

Part I - Personal information

This part of the questionnaire consists of questions relating to Demographic Factors and few other personal factors relevant for the study.

Part II - Organisational role stress scale (ORS Scale)

In this part, the researchers have attempted to gather information in connection with the Organisational Role Stress. For this purpose, a scale called Organisational Role Stress Scale (ORS Scale) containing fifty statements developed in 1983 and standardised by Udai Pareek was adopted with a slight modification in scaling.

The researchers have adopted only four point likert scale as Strongly Agree, Agree, Disagree and Strongly Disagree. As the respondents are well educated there is no room for not answering to any statement. Hence, the scale representing "Neither Agree nor Disagree" i.e., "neutral" is considered irrelevant and hence not included. However, all the fifty questions were adopted with slight modifications to suit the present study but grouped under ten classifications as Inter-Role Distance, Role Stagnation, Role Expectation Conflict, Role Erosion, Role Overload, Role Isolation, Personal Inadequacy, Self-Role Distance, Role Ambiguity and Resource Inadequacy. Udai Pareek himself suggested these ten classifications.

Part - III Job satisfaction questionnaire (JSQ)

This is the third and last part of the questionnaire. This part is to measure the Job Satisfaction level of the respondents. For this, the researchers have used the questionnaire called the Job Satisfaction Questionnaire consisting of 20 statements developed and standardised by Shailendra Singh. The original questionnaire have five points namely 1, 2, 3, 4 and 5 to represent the agreement with respect to satisfaction about the statements as Very Dissatisfied, Dissatisfied, Neutral, Satisfied and Very Satisfied respectively. But the researchers have made a small change with respect to the scaling though he has adopted all the statements as it is. Four point likert scale is adopted to measure the responses as Very Much Satisfied, Satisfied, Dissatisfied and Very Much Dissatisfied. There is no scale to represent *Neutral* so as to obtain compulsorily the responses for all the statements.

Reliability Test

In order to test the reliability of the questionnaire cronbach alohpa test was carried out and the value came to 0.761. Hence it can be concluded that the tool designed and used for this study is reliable.

Analysis of Data

For the purpose of analysis chi-square test, correlation analysis, factor analysis has been used. The detail of analysis is as follows.

Level of Organisational Role Stress and Job Satisfaction

The following table shows the level of organisational role stress and job satisfaction of IT Professionals.

| Levels | Organizational Role Stress | | Job Satisfaction | |
|----------|----------------------------|-----|------------------|-----|
| | Frequency | % | Frequency | % |
| High | 51 | 17 | 258 | 86 |
| Moderate | 249 | 83 | 36 | 12 |
| Low | — | — | 6 | 2 |
| TOTAL | 300 | 100 | 300 | 100 |

Table. 1 Level of Organisational Role Stress and Job Satisfaction of IT Professionals

It is clear from the above table that 4/5th of the respondents, that is, 83 % are experiencing moderate level of organisational role stress and only less than 1/5th, that is, 17% of the respondents were found to be experiencing high level of organisational role stress. It is to be noted that there is no one experiencing low level of organisational role stress.

The above table indicates that more than 4/5th of the respondents are highly satisfied and only 12% of the respondents come under the category of moderately satisfied with their job. Though not considerable, 2% of respondents were experiencing low level of job satisfaction.

Testing of Hypothesis

To study the relationship of demographic factors with that of Work Role Stress and Job Satisfaction, the following hypothesis is formulated.

There is no significant relationship between Demographic Factors and Work-Role Stress and Job Satisfaction.

Chi-Square Test

The above mentioned hypothesis is tested using the chi-square test in the following discussions.

The chi-square analysis showed that there exist a significant relationship of age, gender, marital status, family type, family size, designation, experience, remuneration, working shift, spouse working status and nature of spouse work with that of organisational Role stress of IT Professionals. But there exist no significant relationship of educational qualification and working hours with that of organisational Role Stress of IT professionals.

The chi-square analysis showed that there exist a significant relationship of age, gender, family type, family size, educational qualification, designation, working hours, and nature of spouse work with Job Satisfaction of IT Professionals. But there exist no significant relationship of marital status, experience, remuneration, working shift and spouse working status with Job Satisfaction of IT Professionals.

| S No. | Factors Compared | Value Value | Degrees of Freedom | Significance |
|-------|---------------------------------|-------------|--------------------|--------------|
| 1 | Age & ORS | 42.145 | 3 | 0.000 |
| 2 | Gender & ORS | 6.065 | 1 | 0.014 |
| 3 | Marital Status & ORS | 10.461 | 3 | 0.015 |
| 4 | Family Type & ORS | 19.954 | 1 | 0.000 |
| 5 | Family Size & ORS | 17.374 | 2 | 0.000 |
| 6 | Educational Qualification & ORS | 3.160 | 5 | 0.675 |
| 7 | Designation & ORS | 16.191 | 4 | 0.003 |
| 8 | Experience & ORS | 27.540 | 4 | 0.000 |
| 9 | Remuneration & ORS | 23.753 | 4 | 0.000 |
| 10 | Working Hours & ORS | 4.923 | 2 | 0.085 |
| 11 | Working Shift & ORS | 21.233 | 4 | 0.000 |
| 12 | Spouse Working Status & ORS | 2.594 | 1 | 0.107 |
| 13 | Nature of Spouse Work & ORS | 11.073 | 3 | 0.010 |

Table. 2 Demographic Factors and Organisational Role Stress

| S. No. | Factors Compared | Chi-Square Value | Degrees of Freedom | Significance |
|--------|--------------------------------|------------------|--------------------|--------------|
| 1 | Age & JS | 49.512 | 6 | 0.000 |
| 2 | Gender & JS | 7.022 | 2 | 0.030 |
| 3 | Marital Status & JS | 9.831 | 6 | 0.133 |
| 4 | Family Type & JS | 7.089 | 1 | 0.029 |
| 5 | Family Size & JS | 25.129 | 4 | 0.000 |
| 6 | Educational Qualification & JS | 44.149 | 10 | 0.000 |
| 7 | Designation & JS | 39.171 | 8 | 0.000 |
| 8 | Experience & JS | 11.742 | 8 | 0.163 |
| 9 | Remuneration & JS | 14.959 | 8 | 0.060 |
| 10 | Working Hours & JS | 10.185 | 4 | 0.037 |
| 11 | Working Shift & JS | 12.373 | 8 | 0.135 |
| 12 | Spouse Working Status & JS | 7.311 | 2 | 0.026 |
| 13 | Nature of Spouse Work & JS | 15.578 | 3 | 0.001 |

Table. 3 Demographic Factors and Job Satisfaction

Correlation Analysis

Relationship between Organisational Role Stress (ORS) and Job Satisfaction (JS)

This is another important objective of the present study to find the relationship between organisational role stress (ORS) with job satisfaction (JS) of the IT Professionals. For this objective the following hypothesis was formulated.

There is no significant relationship between organisational role stress and job satisfaction.

In order to test the above mentioned hypothesis, correlation analysis and paired sample *t*-test was applied. The following table shows the summary of correlation and *t*-test. Since the level of significance in case of *t*-test is less than 0.05 H_0 is rejected. Therefore it can be concluded that there is a difference in the mean value between Organisational Role Stress (ORS) and Job Satisfaction (JS).

As far as correlation between Organisational Role Stress and Job Satisfaction is concerned there exist a correlation ($r = 0.129$) at 0.05 significance level and as the significance level is less than 0.05, H_0 is rejected. Hence, it can be concluded that there exist a significance relationship between Organisational Role Stress and Job Satisfaction.

| S.No | Variables | Mean | SD | r | | <i>t</i> (df 299) | |
|------|----------------------------------|--------|-------|----------------|------------|-------------------|------------|
| | | | | <i>r</i> value | Sig. Level | <i>t</i> value | Sig. Level |
| 1 | Organizational Role Stress (ORS) | 125.01 | 6.77 | 0.129 | 0.026 | -81.396 | 0.000 |
| 2 | Job Satisfaction (JS) | 63.27 | 12.05 | | | | |

Table. 4 Relationship between ORS Segments and Job Satisfaction

Factor Analysis

In order to analyse the data further, factor analysis was carried out to know the inter correlations between factors studied and to analyse among the factors which of the factors contribute to the maximum.

Factor Analysis was carried out for Organisational Role Stress consisting of 50 factors and Job Satisfaction consisting of 20 factors. Factor Analysis for Organisational Role Stress.

Table. 5 shows the result of factor analysis for organisational role stress. Table. 5 shows that the extraction of *Initial Eigen Value* by adopting Principal Component Factoring Method. It is clear from the above table that among the 50 variables, only ten factors whose Eigen values are more than one is selected. The factors are Inter-Role Distance (IRD) - 1, Role Ambiguity (RA) - 1, Resource Inadequacy (RIn) - 4, Resource Inadequacy (RIn) - 2, Role Ambiguity (RA) - 2, Personal Inadequacy (PIn) - 1, Role Erosion (RE) - 1, Personal Inadequacy (PIn) - 4, Role Ambiguity (RA) - 5 and Personal Inadequacy (PIn) - 2.

Factor matrix called *Rotated Component Matrix* was used to know that among the ten variables, which variable correlates very much and thus considered as contributing factors for the organisational role stress of IT Professionals on hierarchy basis.

Table. 6 shows 10 different levels consisted of group of factors which contribute to the Organisational Role Stress (ORS) of IT Professionals. The following table explains in detail these group of factors classified in 10 levels which are named based on some common feature exist among the factors come under each group.

Total Variance Explained

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|-----------|---------------------|---------------|--------------|-------------------------------------|---------------|--------------|-----------------------------------|---------------|--------------|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 20.026 | 40.053 | 40.053 | 20.026 | 40.053 | 40.053 | 6.388 | 12.777 | 12.777 |
| 2 | 3.765 | 7.530 | 47.583 | 3.765 | 7.530 | 47.583 | 6.038 | 12.076 | 24.852 |
| 3 | 2.948 | 5.895 | 53.478 | 2.948 | 5.895 | 53.478 | 6.032 | 12.065 | 36.917 |
| 4 | 2.343 | 4.686 | 58.164 | 2.343 | 4.686 | 58.164 | 4.122 | 8.244 | 45.161 |
| 5 | 1.722 | 3.444 | 61.608 | 1.722 | 3.444 | 61.608 | 3.691 | 7.381 | 52.542 |
| 6 | 1.568 | 3.135 | 64.743 | 1.568 | 3.135 | 64.743 | 3.244 | 6.489 | 59.031 |
| 7 | 1.410 | 2.819 | 67.563 | 1.410 | 2.819 | 67.563 | 2.590 | 5.181 | 64.212 |
| 8 | 1.264 | 2.529 | 70.091 | 1.264 | 2.529 | 70.091 | 2.148 | 4.295 | 68.507 |
| 9 | 1.138 | 2.276 | 72.368 | 1.138 | 2.276 | 72.368 | 1.626 | 3.251 | 71.758 |
| 10 | 1.103 | 2.205 | 74.573 | 1.103 | 2.205 | 74.573 | 1.407 | 2.814 | 74.573 |
| 11 | .954 | 1.908 | 76.481 | | | | | | |
| 12 | .905 | 1.810 | 78.291 | | | | | | |
| 13 | .816 | 1.632 | 79.923 | | | | | | |
| 14 | .763 | 1.527 | 81.449 | | | | | | |
| 15 | .685 | 1.371 | 82.820 | | | | | | |
| 16 | .665 | 1.330 | 84.150 | | | | | | |
| 17 | .612 | 1.224 | 85.373 | | | | | | |
| 18 | .567 | 1.134 | 86.507 | | | | | | |
| 19 | .534 | 1.069 | 87.576 | | | | | | |
| 20 | .480 | .960 | 88.536 | | | | | | |
| 21 | .469 | .938 | 89.474 | | | | | | |
| 22 | .451 | .903 | 90.376 | | | | | | |
| 23 | .412 | .825 | 91.201 | | | | | | |
| 24 | .394 | .789 | 91.989 | | | | | | |
| 25 | .384 | .769 | 92.758 | | | | | | |
| 26 | .364 | .729 | 93.487 | | | | | | |
| 27 | .336 | .672 | 94.159 | | | | | | |
| 28 | .304 | .607 | 94.766 | | | | | | |
| 29 | .267 | .534 | 95.300 | | | | | | |
| 30 | .264 | .529 | 95.828 | | | | | | |
| 31 | .248 | .497 | 96.325 | | | | | | |
| 32 | .221 | .442 | 96.768 | | | | | | |
| 33 | .179 | .358 | 97.126 | | | | | | |
| 34 | .178 | .355 | 97.481 | | | | | | |
| 35 | .172 | .344 | 97.825 | | | | | | |
| 36 | .147 | .295 | 98.119 | | | | | | |
| 37 | .138 | .276 | 98.396 | | | | | | |
| 38 | .127 | .253 | 98.649 | | | | | | |
| 39 | 9.831E-02 | .197 | 98.846 | | | | | | |
| 40 | 9.473E-02 | .189 | 99.035 | | | | | | |
| 41 | 8.414E-02 | .168 | 99.203 | | | | | | |
| 42 | 8.054E-02 | .161 | 99.364 | | | | | | |
| 43 | 7.085E-02 | .142 | 99.506 | | | | | | |
| 44 | 5.695E-02 | .114 | 99.620 | | | | | | |
| 45 | 4.900E-02 | 9.800E-02 | 99.718 | | | | | | |
| 46 | 4.197E-02 | 8.394E-02 | 99.802 | | | | | | |
| 47 | 3.651E-02 | 7.303E-02 | 99.875 | | | | | | |
| 48 | 3.519E-02 | 7.038E-02 | 99.945 | | | | | | |
| 49 | 2.184E-02 | 4.367E-02 | 99.989 | | | | | | |
| 50 | 5.450E-03 | 1.090E-02 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

Table. 5 Factor Analysis (Initial Eigen Value) - (ORS)

Rotated Component Matrix^a

| | Component | | | | | | | | | |
|-------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| ROLE STAGNATION (RS) - 1 | -.657 | -.345 | -9.87E-02 | -.159 | -.127 | 2.724E-02 | -.225 | -6.80E-02 | -2.14E-02 | 2.209E-02 |
| ROLE EXPECTATION CONFLICT (REC) - 1 | .655 | .215 | -.166 | .112 | -1.19E-02 | -2.54E-02 | .247 | 1.645E-02 | .154 | -5.06E-02 |
| ROLE EXPECTATION CONFLICT (REC) - 4 | -.679 | -.156 | -.279 | -6.60E-02 | -.175 | -.140 | .122 | -6.24E-02 | 6.555E-02 | -.121 |
| ROLE EROSION (RE) - 1 | .645 | .215 | .202 | .252 | -.140 | -.215 | 1.602E-02 | -4.26E-02 | .202 | 7.620E-02 |
| ROLE STAGNATION (RS) - 2 | -.552 | -2.62E-02 | -.222 | -.127 | .114 | .169 | -.212 | -.116 | 6.229E-02 | -.205 |
| ROLE STAGNATION (RS) - 3 | -.562 | .262 | .261 | .225 | -5.96E-02 | -.221 | 6.571E-02 | -.146 | .160 | -7.72E-02 |
| ROLE EXPECTATION CONFLICT (REC) - 2 | -.547 | .229 | .215 | 6.924E-02 | -.259 | -.126 | .102 | 2.622E-02 | .257 | -2.19E-02 |
| INTER-ROLE DISTANCE (IRD)-1 | -.536 | .296 | .212 | .292 | -2.05E-02 | -.166 | -.167 | -6.72E-02 | 2.520E-02 | -3.59E-02 |
| ROLE STAGNATION (RS) - 4 | -.522 | .200 | -.194 | .452 | -.262 | .117 | .152 | .147 | -.162 | -.116 |
| ROLE STAGNATION (RS) - 5 | .461 | .105 | .145 | .295 | -4.41E-02 | -.176 | 5.924E-02 | -1.22E-02 | .446 | 2.242E-02 |
| PERSONAL INADEQUACY (PI) - 4 | -.252 | -.757 | -.142 | -.226 | .105 | 6.207E-02 | -.166 | -5.64E-02 | -1.16E-02 | -6.47E-02 |
| PERSONAL INADEQUACY (PI) - 5 | -.199 | -.750 | -.295 | -5.22E-02 | .220 | 6.216E-02 | -.156 | -6.21E-02 | 9.215E-02 | .172 |
| PERSONAL INADEQUACY (PI) - 2 | -.206 | -.722 | -.256 | -3.25E-02 | .172 | .149 | 7.212E-02 | -.122 | -.112 | -4.92E-02 |
| PERSONAL INADEQUACY (PI) - 3 | -.160 | .626 | .165 | 6.410E-02 | -.222 | 6.721E-02 | .212 | .110 | .122 | -.159 |
| PERSONAL INADEQUACY (PI) - 1 | .295 | .622 | .225 | 9.700E-02 | -2.76E-02 | -9.62E-02 | .154 | -4.05E-02 | .117 | .106 |
| SELF-ROLE DISTANCE (SRD) - 2 | -.219 | .622 | .225 | 6.272E-02 | .126 | -5.99E-02 | 6.406E-02 | .251 | .261 | 4.270E-02 |
| RESOURCE INADEQUACY (RI) - 1 | .202 | .455 | .472 | .409 | .105 | -.104 | .125 | .122 | 5.425E-02 | 7.976E-02 |
| ROLE AMBIGUITY (RA) - 2 | .266 | .452 | .455 | .151 | -6.22E-02 | -.165 | .161 | .161 | -7.29E-02 | .221 |
| ROLE AMBIGUITY (RA) - 4 | .127 | .262 | .796 | -1.02E-02 | -6.77E-02 | -2.26E-02 | .127 | 2.625E-02 | .172 | .166 |
| ROLE AMBIGUITY (RA) - 5 | .407 | .122 | .726 | .145 | -7.67E-02 | -.110 | .141 | .160 | -6.96E-02 | -9.96E-02 |
| RESOURCE INADEQUACY (RI) - 4 | -.212 | -.257 | -.691 | -.210 | .229 | -.101 | -6.54E-02 | -.122 | -.109 | .162 |
| RESOURCE INADEQUACY (RI) - 2 | .159 | .500 | .614 | .162 | -2.09E-02 | -.205 | 9.060E-02 | .120 | 6.574E-02 | -.121 |
| ROLE AMBIGUITY (RA) - 1 | .477 | .262 | .597 | -5.20E-02 | 4.054E-02 | -5.99E-02 | .155 | .220 | -7.24E-02 | .202 |
| ROLE AMBIGUITY (RA) - 2 | .456 | .262 | .562 | 2.662E-02 | 6.212E-02 | -.105 | .202 | .214 | -2.12E-02 | .170 |
| SELF-ROLE DISTANCE (SRD) - 3 | -.290 | -.225 | -.562 | -9.07E-02 | 1.723E-02 | -.116 | -.165 | -.220 | -.227 | .116 |
| RESOURCE INADEQUACY (RI) - 3 | .174 | .515 | .524 | .204 | -6.09E-02 | -.229 | 7.924E-02 | 7.472E-02 | .120 | -.109 |
| SELF-ROLE DISTANCE (SRD) - 1 | -.269 | -.406 | -.475 | -.246 | .121 | -.121 | -.155 | -2.41E-02 | -.257 | -.229 |
| RESOURCE INADEQUACY (RI) - 5 | 2.946E-02 | -.165 | -.461 | -.461 | .267 | .261 | 2.702E-02 | -4.70E-02 | .140 | .260 |
| INTER-ROLE DISTANCE (IRD) - 2 | .172 | 6.754E-02 | 6.507E-02 | .622 | .109 | -2.61E-02 | 1.912E-02 | .222 | .125 | .120 |
| INTER-ROLE DISTANCE (IRD) - 4 | -.212 | -9.55E-02 | -.295 | -.720 | .225 | 2.926E-02 | -1.69E-02 | .102 | .164 | 5.704E-02 |
| INTER-ROLE DISTANCE (IRD) - 5 | -1.11E-02 | 6.407E-02 | 4.626E-02 | .725 | -.242 | 2.624E-02 | -1.22E-02 | 9.755E-02 | .156 | .159 |
| INTER-ROLE DISTANCE (IRD) - 3 | .261 | .156 | 1.344E-02 | .679 | -.110 | -6.82E-02 | .154 | -7.25E-02 | .175 | -3.50E-02 |
| ROLE OVERLOAD (RO) - 2 | -6.05E-02 | -.146 | 4.622E-02 | -6.22E-02 | .760 | .155 | -.151 | -6.22E-02 | -7.20E-02 | -9.09E-02 |
| ROLE OVERLOAD (RO) - 3 | .115 | .120 | .152 | -.225 | .640 | .229 | -.256 | -.212 | -1.42E-02 | -.202 |
| ROLE OVERLOAD (RO) - 4 | -.156 | -.270 | -.296 | -.275 | .625 | 7.746E-02 | -9.25E-02 | 2.944E-02 | -.152 | 6.216E-02 |
| ROLE EXPECTATION CONFLICT (REC) - 5 | -.470 | -.171 | -.252 | -5.76E-02 | .507 | .219 | .125 | -.122 | -6.92E-02 | .162 |
| ROLE ISOLATION (RI) - 5 | .220 | .219 | .126 | -2.75E-02 | -.466 | -.129 | .411 | .220 | -.116 | -.160 |
| ROLE EXPECTATION CONFLICT (REC) - 3 | .422 | .174 | .424 | .144 | -.444 | 1.472E-02 | .204 | -.176 | 2.746E-02 | .162 |
| ROLE EROSION (RE) - 4 | -9.92E-02 | 2.012E-02 | -6.69E-02 | -7.89E-02 | .120 | .794 | -.199 | -5.21E-02 | 9.462E-02 | -.122 |
| ROLE EROSION (RE) - 5 | -1.72E-02 | -.176 | -7.62E-02 | -9.16E-02 | 6.144E-02 | .750 | -.224 | -.126 | -.221 | 2.675E-02 |
| ROLE EROSION (RE) - 2 | -.242 | -.122 | -.127 | .101 | .140 | .779 | -.126 | -2.25E-02 | 4.267E-02 | 2.415E-02 |
| ROLE EROSION (RE) - 2 | -.486 | -.126 | -2.55E-02 | -4.05E-02 | .267 | .559 | 1.674E-02 | -.100 | -2.97E-02 | -.160 |
| ROLE ISOLATION (RI) - 4 | .162 | .247 | 6.256E-02 | 5.255E-02 | -5.64E-02 | -.262 | .704 | .117 | 2.924E-02 | 5.220E-02 |
| ROLE ISOLATION (RI) - 2 | .140 | .146 | .266 | 6.922E-02 | -.262 | -.165 | .672 | 6.464E-02 | 5.122E-02 | .106 |
| ROLE ISOLATION (RI) - 3 | -.127 | -6.55E-02 | -.254 | -9.16E-02 | .295 | .251 | -.555 | -.264 | -.209 | .200 |
| ROLE ISOLATION (RI) - 1 | -.402 | -.412 | -.175 | -4.21E-02 | .115 | .245 | -.415 | 7.675E-02 | .126 | -.257 |
| SELF-ROLE DISTANCE (SRD) - 4 | -4.26E-02 | -.290 | -.164 | -7.21E-02 | .161 | 1.761E-02 | -.179 | -.176 | .112 | 2.756E-02 |
| SELF-ROLE DISTANCE (SRD) - 5 | 1.615E-02 | 4.012E-02 | .222 | .122 | -.127 | -.262 | 9.012E-02 | .734 | .129 | .106 |
| ROLE OVERLOAD (RO) - 5 | -.172 | -.162 | -.250 | -.215 | .460 | 2.691E-02 | -9.15E-02 | 1.422E-02 | -.614 | 2.197E-02 |
| ROLE OVERLOAD (RO) - 1 | .141 | -.129 | -1.22E-02 | .276 | -.475 | -.275 | 4.540E-02 | .112 | 4.847E-02 | .627 |

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.
^a . Rotation converged in 17 iterations.

Table. 6 Factor Matrix (Rotated Component Matrix) (ORS)

| Level 1 [Role Stagnation (RS) and Role Expectation Conflict (REC)] | | |
|--|--------|--|
| Contributing Factor | Value | Factor Explanation |
| ROLE STAGNATION (RS) - 1 | -0.687 | No learning scope in the present job to hold higher positions. |
| ROLE EXPECTATION CONFLICT (REC) - 1 | 0.685 | Inability to satisfy conflicting demands of people. |
| ROLE EXPECTATION CONFLICT (REC) - 4 | -0.679 | Variation in the expectations of seniors and juniors. |
| ROLE EROSION (RE) - 1 | 0.648 | Reduction of importance of the Present Role. |
| ROLE STAGNATION (RS) - 2 | -0.583 | Preoccupancy in the present role hinder in accepting higher responsibility. |
| ROLE STAGNATION (RS) - 3 | 0.560 | Non-Availability of time and opportunities for self-preparation to face future challenges of the role. |
| ROLE EXPECTATION CONFLICT (REC) - 2 | 0.547 | Inability to satisfy conflicting demands of peers and juniors. |
| INTER-ROLE DISTANCE (IRD)-1 | 0.536 | Interference of work role in family role. |
| ROLE STAGNATION (RS) - 4 | 0.502 | Scope for personal growth. |
| Level 2 [Personal Inadequacy (PIn)] | | |
| Contributing Factor | Value | Factor Explanation |
| PERSONAL INADEQUACY (PIn) - 4 | -0.787 | Preparedness pertaining to role. |
| PERSONAL INADEQUACY (PIn) - 5 | -0.750 | Required training and preparation for the present role. |
| PERSONAL INADEQUACY (PIn) - 2 | -0.733 | Required skills to discharge responsibilities. |
| PERSONAL INADEQUACY (PIn) - 3 | 0.638 | Required training for the role. |
| PERSONAL INADEQUACY (PIn) - 1 | 0.632 | Required knowledge to discharge responsibilities. |
| SELF-ROLE DISTANCE (SRD) - 2 | 0.603 | Lack of opportunity to use the obtained training and expertise. |
| RESOURCE INADEQUACY (RIn - 3) | 0.515 | Lack of required no. of colleague to work with. |
| RESOURCE INADEQUACY (RIn - 2) | 0.500 | Lack of resources to be effective in the present role. |

| Level 3 [Role Ambiguity (RA) and Resource Inadequacy (RIn)] | | |
|--|--------|---|
| Contributing Factor | Value | Factor Explanation |
| ROLE AMBIGUITY (RA) - 4 | 0.796 | Vagueness and unclarity exist in role |
| ROLE AMBIGUITY (RA) - 5 | 0.726 | Lack of priorities in the role |
| RESOURCE INADEQUACY (RIn) - 4 | -0.691 | Worry with regard to lack of necessary facilities |
| RESOURCE INADEQUACY (RIn) - 2 | 0.614 | Lack of resources to be effective in the present role |
| ROLE AMBIGUITY (RA) - 1 | 0.597 | Unclarity about scope of role |
| ROLE AMBIGUITY (RA) - 2 | 0.583 | Unclarity about responsibilities of role |
| SELF-ROLE DISTANCE (SRD) - 3 | -0.583 | Doing work without interest |
| RESOURCE INADEQUACY (RIn) - 3 | 0.534 | Lack of required no. of colleague to work with |
| Level 4 [Inter-Role Distance (IRD)] | | |
| Contributing Factor | Value | Factor Explanation |
| INTER-ROLE DISTANCE (IRD) - 3 | 0.822 | Role Interference in Family |
| INTER-ROLE DISTANCE (IRD) - 4 | -0.730 | Interference of organisational responsibilities in extra-organisational roles |
| INTER-ROLE DISTANCE (IRD) - 5 | 0.725 | Lack of time for family and friends due to heavy work role |
| INTER-ROLE DISTANCE (IRD) - 2 | 0.679 | Lack of time to spare with society and religion |
| Level 5 [Role Overload (RO)] | | |
| Contributing Factor | Value | Factor Explanation |
| ROLE OVERLOAD (RO) - 2 | 0.760 | Impact of work load on quality of work |
| ROLE OVERLOAD (RO) - 3 | 0.640 | Burdened with too much responsibility |
| ROLE OVERLOAD (RO) - 4 | 0.608 | Need for role reduction |
| ROLE EXPECTATION CONFLICT (REC) - 5 | 0.507 | Non-fulfillment of contradictory expectations of different people |

| Level 6 [Role Erosion (RE)] | | |
|---|--------|--|
| Contributing Factor | Value | Factor Explanation |
| ROLE EROSION (RE) - 4 | 0.794 | Under utilisation of capabilities |
| ROLE EROSION (RE) - 5 | 0.780 | Non-challenging role |
| ROLE EROSION (RE) - 3 | 0.779 | Under responsibility in the present role |
| ROLE EROSION (RE) - 2 | 0.559 | Many functions of the present role wrongly delegated to others |
| Level 7 [Role Isolation (RI)] | | |
| Contributing Factor | Value | Factor Explanation |
| ROLE ISOLATION (RI) - 4 | 0.704 | Non-participation in decision making and problem solving |
| ROLE ISOLATION (RI) - 2 | 0.672 | Lack of interaction between different roles |
| ROLE ISOLATION (RI) - 3 | -0.558 | No consultation between different roles |
| Level 8 [Self-Role distance (SRD)] | | |
| Contributing Factor | Value | Factor Explanation |
| SELF-ROLE DISTANCE (SRD) - 4 | -0.776 | Lack of freedom in defining present role as per employees wish |
| SELF-ROLE DISTANCE (SRD) - 5 | 0.734 | Conflict between values and role |
| Level 9 [Role Overload (RO)] | | |
| Contributing Factor | Value | Factor Explanation |
| ROLE OVERLOAD (RO) - 5 | -0.614 | Feeling of overburden in role |
| Level 10 [Role Overload (RO)] | | |
| Contributing Factor | Value | Factor Explanation |
| ROLE OVERLOAD (RO) - 1 | 0.607 | Feeling of heaviness in workload |

Table. 7 Factor Matrix for ORS - 10 Levels Explained

The above table reveals that at the first level Role Stagnation (RS) and Role Expectation Conflict (REC) are contributing to ORS of IT Professionals; Personal Inadequacy (PI_n), Role Ambiguity (RA) and Resource Inadequacy (RI_n), Inter-Role Distance (IRD), Role Overload (RO), Role Erosion (RE), Role Isolation (RI), Self Role Distance (SRD), Role Overload (RO-5) and Role Overload (RO-1) are contributing at second, third, fourth, fifth, sixth, seventh, eighth, ninth and tenth levels respectively.

Factor Analysis for Job Satisfaction (JS)

The following table shows the result of factor analysis for Job Satisfaction.

Total Variance Explained

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|-----------|---------------------|---------------|--------------|-------------------------------------|---------------|--------------|-----------------------------------|---------------|--------------|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 11.781 | 58.907 | 58.907 | 11.781 | 58.907 | 58.907 | 7.706 | 38.529 | 38.529 |
| 2 | 1.126 | 5.628 | 64.535 | 1.126 | 5.628 | 64.535 | 5.201 | 26.008 | 64.535 |
| 3 | .908 | 4.540 | 69.075 | | | | | | |
| 4 | .839 | 4.193 | 73.268 | | | | | | |
| 5 | .871 | 3.355 | 76.623 | | | | | | |
| 6 | .597 | 2.986 | 79.609 | | | | | | |
| 7 | .523 | 2.614 | 82.222 | | | | | | |
| 8 | .477 | 2.383 | 84.606 | | | | | | |
| 9 | .434 | 2.171 | 86.776 | | | | | | |
| 10 | .411 | 2.056 | 88.832 | | | | | | |
| 11 | .378 | 1.891 | 90.723 | | | | | | |
| 12 | .344 | 1.721 | 92.444 | | | | | | |
| 13 | .282 | 1.409 | 93.853 | | | | | | |
| 14 | .266 | 1.330 | 95.184 | | | | | | |
| 15 | .236 | 1.181 | 96.364 | | | | | | |
| 16 | .214 | 1.072 | 97.436 | | | | | | |
| 17 | .163 | .815 | 98.251 | | | | | | |
| 18 | .128 | .639 | 98.890 | | | | | | |
| 19 | .120 | .602 | 99.492 | | | | | | |
| 20 | .102 | .508 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

Table. 8 Factor Analysis (Initial Eigen Value) - (Job Satisfaction)

Table. 8 shows that the extraction of *Initial Eigen Value* by adopting Principal Axis Factoring Method. It is clear from the above table that among the 20 variables, only two factors whose Eigen values are more than one is selected. The factors are JSQ-2 (Freedom in Work) and JSQ-14 (Variety of Task in the Job).

Factor matrix called *Rotated Component Matrix* was used to know that among the two variables, which variable correlates very much and thus considered as contributing factors for the job satisfaction of IT Professionals on hierarchy basis.

Table. 9 shows 2 different levels consisted of group of factors which contribute to the Social and Family Role Stress (SFRS) of IT Professionals. The following table explains in detail these group of factors classified in 2 levels which are named based on some common feature exist among the factors come under each group.

Table. 10 showing the factor matrix analysis reveals that at the first level *Job Content, Freedom and Opportunities* and at the second level, *Industrial Relations, Working Conditions and Recognition* are contributing to Job Satisfaction of IT Professionals.

Rotated Component Matrix *

| | Component | |
|--------------------------------------|-----------|------|
| | 1 | 2 |
| JOB SATISFACTION QUESTION (JSQ) - 18 | .812 | .270 |
| JOB SATISFACTION QUESTION (JSQ) - 17 | .782 | .299 |
| JOB SATISFACTION QUESTION (JSQ) - 15 | .765 | .244 |
| JOB SATISFACTION QUESTION (JSQ) - 12 | .750 | .290 |
| JOB SATISFACTION QUESTION (JSQ) - 19 | .738 | .385 |
| JOB SATISFACTION QUESTION (JSQ) - 20 | .701 | .283 |
| JOB SATISFACTION QUESTION (JSQ) - 10 | .700 | .406 |
| JOB SATISFACTION QUESTION (JSQ) - 11 | .699 | .338 |
| JOB SATISFACTION QUESTION (JSQ) - 14 | .674 | .468 |
| JOB SATISFACTION QUESTION (JSQ) - 13 | .661 | .351 |
| JOB SATISFACTION QUESTION (JSQ) - 16 | .646 | .454 |
| JOB SATISFACTION QUESTION (JSQ) - 8 | .611 | .520 |
| JOB SATISFACTION QUESTION (JSQ) - 7 | .590 | .555 |
| JOB SATISFACTION QUESTION (JSQ) - 1 | 6.560E-02 | .787 |
| JOB SATISFACTION QUESTION (JSQ) - 4 | .426 | .711 |
| JOB SATISFACTION QUESTION (JSQ) - 2 | .501 | .710 |
| JOB SATISFACTION QUESTION (JSQ) - 5 | .359 | .708 |
| JOB SATISFACTION QUESTION (JSQ) - 3 | .479 | .681 |
| JOB SATISFACTION QUESTION (JSQ) - 6 | .471 | .652 |
| JOB SATISFACTION QUESTION (JSQ) - 9 | .480 | .494 |

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.
 a. Rotation converged in 3 iterations.

Table. 9 Factor Matrix (Rotated Component Matrix) (Job Satisfaction)

Recommendations

It is a known fact that very few IT companies have done anything substantial to tackle the problems of stress at the workplace, family environment and society in general. Overemphsising the achievement oriented work cultures and simply linking employee motivation with material incentives may not always increases job satisfaction among employees. The stress factor is intangible and cannot be quantified so easily, and thus neglected. It is a great hidden cost for the companies. In recent times, many companies are waking up and are taking stress as a serious concern for their employees. Traditionally, organisations used to either conduct exclusive stress management workshops or just generally integrate it with employee training and development programmes apart from redesigning of human resource policies,

| Level 1 - [Job Content, Freedom and Opportunities] | | |
|--|-------|--|
| Contributing Factor | Value | Factor Explanation |
| JOB SATISFACTION QUESTION (JSQ) -18 | .812 | Power and prestige in the job. |
| JOB SATISFACTION QUESTION (JSQ) -17 | .782 | Chances to learn new things. |
| JOB SATISFACTION QUESTION (JSQ) -16 | .763 | Job security. |
| JOB SATISFACTION QUESTION (JSQ) -12 | .750 | Attention paid to employees suggestions. |
| JOB SATISFACTION QUESTION (JSQ) -19 | .738 | Opportunities to make decisions. |
| JOB SATISFACTION QUESTION (JSQ) -20 | .701 | Opportunities to achieve something worthwhile. |
| JOB SATISFACTION QUESTION (JSQ) -10 | .700 | Chances of promotion. |
| JOB SATISFACTION QUESTION (JSQ) -11 | .699 | Management style. |
| JOB SATISFACTION QUESTION (JSQ) -14 | .674 | The amount of variety in the job. |
| JOB SATISFACTION QUESTION (JSQ) -13 | .661 | Working Hours |
| JOB SATISFACTION QUESTION (JSQ) -18 | .646 | Opportunity to help others with personal problems at work. |
| JOB SATISFACTION QUESTION (JSQ) -8 | .611 | Relationship between Management and Employees. |
| JOB SATISFACTION QUESTION (JSQ) -7 | .590 | Opportunities to use abilities. |
| JOB SATISFACTION QUESTION (JSQ) -2 | .501 | Freedom in choosing working method. |
| Level 2 - [Industrial Relations, Working Conditions and Recognition] | | |
| Contributing Factor | Value | Factor Explanation |
| JOB SATISFACTION QUESTION (JSQ) - 8 | .520 | Relationship between Management and Employees. |
| JOB SATISFACTION QUESTION (JSQ) -7 | .555 | Opportunities to use abilities. |
| JOB SATISFACTION QUESTION (JSQ) -1 | .787 | The physical work conditions. |
| JOB SATISFACTION QUESTION (JSQ) -4 | .711 | Recognition for good work. |
| JOB SATISFACTION QUESTION (JSQ) -2 | .710 | Freedom in choosing Working Method. |
| JOB SATISFACTION QUESTION (JSQ) -6 | .708 | Satisfaction with Immediate Boss. |
| JOB SATISFACTION QUESTION (JSQ) -3 | .681 | Satisfaction with Colleagues. |
| JOB SATISFACTION QUESTION (JSQ) -8 | .652 | Amount of given responsibility. |

Table. 10 Factor Matrix for Job Satisfaction - 2 Levels Explained

training programmes exclusively for women employees to cope with their traditional roles, medical examination, redesigning and redistribution of roles to reduce overload, time-management techniques, work-life and family-life integration programmes, work autonomy to knowledge workers, breaks during working hours, providing non-pressure environment, helping the employees in career planning, presenting clear roles and responsibilities, encouraging participation in decision making, providing opportunities for social interaction, providing moral education, holding family day, job enrichment and supportive supervision (immediate boss or team lead). Today, the need for continuous monitoring and implementation of new and updated intervention techniques has been widely recognised. Infosys Technologies Ltd., has already adopted a 24 hour hotline for its employees who are suffering from depression to access and get counseling from psychiatrists. Infosys has also developed a specially designed program

for employees' well-being, called 'HALE' (Health Assessment Lifestyle Enrichment). The programme helps in reducing absenteeism and psychological stress in workplace. Wipro runs a programme called 'Mitr' (Friend), which takes care of physical and emotional well-being of its employees. The programme involves formation of trained workgroups offering counseling and assistance to the employees in need. Other such programmes are as under.

De-stressing programmes like yoga, gym and spa sessions. SumTotal Systems, a global provider for learning and talent management systems based at Hyderabad, has initiated this. It is a practice there that every alternate Wednesday a masseur comes to the office to give a neck and shoulder massage to all those registered for the service. The total cost of service is borne by the company.

Infogain Corp., a California based business consulting firm which provides product engineering and IT solutions has an enclosed area, called 'the hut', on the terrace of its offices in Noida, near New Delhi, where its 650 plus employees can do aerobics, yoga or listen to music thrice a week. Infogain has also tied up with a concierge service which takes care of bill payments, movie ticket bookings, travel plans, gift deliveries and so on, for the employees at a nominal rate. For most of the services Infogain Corp. reimburse the amount.

Xansa, the UK based outsourcing and technology firm which has offices in Noida, Kolkata and Chennai has meditation, counseling, yoga and online games on its intranet as stress bursting tools. These games are designed to enhance some skills and increase concentration.

Directi Group has introduced dance as a way to de-stress. Salsa instructor takes the session with 70-80 members. Participating with friends and families as trekking group in treks, in and around Mumbai to de-stress.

In today's organisations, the knowledge workers are not merely satisfied by monetary aspects like high salary, incentives and perks. For example, in case of IT industry, non-monetary aspects like working environment and career prospects are not only crucial but critical for employee satisfaction and motivation. An organisation's working environment and culture are highly reflected by the stress levels among its employees.

Few other organisational level offerings in connection with stress management include flexible leave arrangement (career breaks, part-year employment, marriage leave, parental leave, maternity leave, paternity leave and bereavement leave), flexi working hours (including flexi working day and flexi work place i.e. flexible location and e-working concept using telecommunication facility and virtual teams), compressed work week (which allows employees to complete their task in a fewer days than a full week), job sharing (facilitates two or more people sharing one full time position so that each is working part-time), part-time work, child care arrangements (vacation child care programmes, child care referral services, child care network, work-based child care for nursing mothers, family room and telephone access), library access to

read light, non-work oriented fiction and poetry, providing elder care, gym subsidies, in-house store/services, arranging vacation trips, conducting stress audit in the work place, biofeedback in which electronic monitoring of physiological processes such as heart rate, body temperature, blood pressure and muscle tension, brain waves and stomach acid, imagery (by imagination of a scene, place or event that is peaceful, restful, beautiful and happy), hypnosis by expert and improving working conditions and ergonomics (Ergonomics is related to the physical and psychological relationships between people and their working environment. Ergonomically designed components and devices such as, office furniture, key boards and computers helps in reducing number of work related disorders). It is recommended that the IT Companies at their level should try to diagnose the root cause of stress and then try to rectify the problem from its origin. Unrealistic targets, communication gap, and negative motivation which are some of the root causes, should be avoided. It is advised not to stick with one or two techniques known to them or practiced in their firm rather it is suggested to try other alternatives mentioned above depending on the basic nature and root of stress. It will work out and as an organisation it can manage the said stress. However, all the factors that cause stress among employees may not be controllable for the organisation like recession, social demands or other employees' personal lives. Moreover, the causes and effects of stress are often different for different employees. So, along with the organisational level programmes, it is important for the organisations to build awareness and encourage employees to adopt stress management techniques at their own individual levels. It is also quite evident that any organisational level intervention technique is not without limitations in terms of ensuring a long term healthy stress-free work environment for its employees. Infact, the role of organisations in stress management is more of a facilitator than anything else. Therefore, managing stress should be an equal responsibility of the individuals as well.

An individual cannot change the world, but he can change his reactions to situations by changing himself. Understanding the individual stress level is the first step towards successful stress management. It involves recognising the stressors or the factors that causes stress and affects health. Employees have to identify certain stress symptoms and relate it with the stress situation they are going through. Difficulty in sleeping, frequent burst of anger and depression are common stress symptoms related to various stress situations. Recognising the stress symptoms can help people to keep stress from snowballing to chronic from an acute stage. It may also prompt them to adopt life styles techniques of stress management and seek medical help when it becomes necessary. So, once the stress level is understood, next step is to select a suitable stress management technique. There are several techniques of stress management today which includes anything from yoga to aromatherapy. Yoga includes postures (asana), breathing (pranayama), and meditation (dhyana). It helps to increase the body awareness, releases muscular tension and increases coordination between mind and body. Another technique getting popular is the 'laughter therapy'. No one can deny that 'laughing is

the best medicine'. In this 21st century life has become too fast, too mechanical and somewhat over materialistic, people often forget to laugh. We must adopt humor as a part of our life to reduce stress. Simply, inculcating a general habit of being organised and managing time by prioritising tasks according to their importance takes a lot of pressure out of our daily lives. Besides, every individual has to understand his own strengths and limitations and should not strive beyond his capacity. Adopting a healthy lifestyle means proper diet, routine sleep, regular exercises, and taking some time out for ourselves for the things that we like. But on the other hand, taking to smoking or drinking may temporarily help one to cope with stressful situations but at the same time they do serious damage to our health in the long run.

Use of simple stress busters like listening to music, deep breathing, drinking sufficient water, indulging in leisurely activities and hobbies, stop worrying and remain positive, taking breaks, talking with closed ones, playing simple games on computer or cell phones, reading and sharing jokes with colleagues and friends, taking a shower, if possible, body massage and meditation (Mantra/Prayer/Recitation of Holy Books, Recitation of Sacred Books) provides quick relief in stressful situations. It is recommended that the IT Professionals as individuals can adopt any one or more of the above mentioned techniques to reduce the stress level. It is a fact that the above mentioned techniques are though simple stress management techniques and are very helpful and effective at most of the times, still it is recommended and advisable to seek medical and specialist's intervention in severe cases of chronic stress.

Conclusion

The most important thing for individuals to remember is that stress is created by people's reactions to situations, rather than the situations themselves. The growing stress among IT employees in recent times has reached to an alarming level as indicated by various studies. Workplace stress is not only a threat to the individual health of employees working in IT companies but also brings down the organisational productivity in the long run. Managing stress in growing economies like India that too in a sector like IT industry has become quite a challenge as there is a mismatch between existing health infrastructure and the pace at which IT industry is expanding. The Government and the policy makers have to assist the IT companies in bringing stringent rules and guidelines for the organisations and develop adequate health infrastructure inside the companies as well as outside the company's compound. The thrust should be more towards promoting preventive healthcare practices.

The IT companies should consider its employees as its valuable asset. Each and every employee working at different capacities plays an important role in the development of the organisation. Therefore, understanding, accommodating and giving sympathetic approach to manage the IT employees' stress will certainly increase the job satisfaction among them and in turn organisational productivity and effectiveness will

improve.

No organisation and individual remain silent under stressful situation. The study will help the IT firms to realise the relationship exist between organisational role stress and job satisfaction. Similarly, no organisation especially an IT company can attain the milestones without a satisfied workforce. Hence, it is a right time to introduce suitable stress management programmes at the organisational level and bringing improvement in the existing stress management programmes and thereby increasing job satisfaction that will lead to increased productivity, improved relationships both on and off the job, better team work and communication, improved morale, retention of valued employees and what not? At the individual level, employees working in IT companies should be much aware of their stress levels, be more concerned about their health and practice healthier lifestyle so as to be a part of developing India. India's competitive advantage in the global economy is substantially dependent on its young and productive working population. But this advantage may not remain sustainable, if stress and its implications are not addressed immediately with seriousness.

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Relationship between Academic Achievement and Cognitive Development Levels of High School Students

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Abstract

The purpose of this study is to determine the relationship between High School students' cognitive development levels and their profiles (age, gender, and academic achievement) using the Cognitive Development Test (CDT) in Thirupattur Educational District of Vellore Revenue District in Tamil Nadu. The subjects (N = 600) were drawn from 9th and 10th standard students of government, government aided and private schools in this district. While significant relationships were not found between students' cognitive developments and their genders and ages, a relationship was found with academic achievement.

Introduction

Cognitive growth is considered as a highly desirable educational goal, and many curricula are designed to develop students' particular cognitive skills. The meaning of cognitive development can be defined as students' understanding levels of the concepts or principles, students' operational stages; the concrete operational stage or the formal operational stage, and thinking abilities. Several researchers have studied different subjects such as planning and developing instructional programs, classroom activities, laboratory activities, teaching materials, measurement-assessment methods and pre-service teacher education strategies for the purpose of developing students' cognitive thinking abilities.

Aim of the Study

The aim of the study is to determine 9th and 10th standard high school students' cognitive development levels by using standard test based on Piagetian theory and

to reveal the relationships between students' cognitive development levels and their profiles (age, gender, and science achievement) in Thirupattur educational district of Vellore revenue district.

Subjects

The subjects were 600 ninth and tenth standard students in schools chosen to reflect a cross-section of middle to high socio-economic levels at government, government aided and private high schools in Thirupattur educational district of Vellore revenue district in Tamil Nadu, India. Within these schools, the participating students were chosen using random selection from the classes. While 300 (50 %) subjects were males, 300 (50 %) subjects were females. Students' ages are between 160 and 185 months, mean = 170 months, and standard deviation = 16.5 months. All participants live in the rural areas. The economies of these cities are mostly based on agriculture. Private schools are also different from the government schools with some points. Students in these schools come from socially and economically high class and pay quite high tuition fee. Technical and physical environments of these schools are well designed, classrooms are not crowded and teachers are employed for every class. They follow the same curriculum (samacheer kalvi) with the government and government aided schools developed by the government of Tamil Nadu.

Although government schools are very common all over the study area, there are also private schools. However, the government tries to improve the numbers of these schools in village by financially supporting all successful students.

The reasons for this particular selection of high school students are:

- According to the Piaget's theory, 9th and 10th grade middle school students should be in transition between concrete and formal operational level such that instructional strategies in schools have substantial effect on their cognitive development.
- Students come across many new concepts for the first time at 9th and 10th grade and their knowledge is limited. Therefore, they could be expected to directly use their thinking abilities while answering the questions.

Developing and validating the instrument

The questionnaire comprises of 20 context questions. The first 20 questions were multiple choice and the 21st and 22nd questions are open-ended. The concrete operational part consists of 7 questions: seriation, 3 questions; classification, 2 questions and conservation, 2 questions. The formal operational part comprises 15 questions: probability reasoning, 5 questions; proportional reasoning, 1 questions; combinatorial

reasoning, 2 questions; correlational reasoning, 2 questions; controlling variables, 2 questions and hypothetical reasoning, 3 questions.

Data Analysis

The questionnaire comprises of 20 context questions. The first 20 questions were multiple choice and the 21st and 22nd questions are open-ended. The concrete operational part consists of 7 questions: seriation, 3 questions; classification, 2 questions and conservation, 2 questions. The formal operational part comprises 15 questions: probability reasoning, 5 questions; proportional reasoning, 1 questions; combinatorial reasoning, 2 questions; correlational reasoning, 2 questions; controlling variables, 2 questions and hypothetical reasoning, 3 questions.

| | | | | | | |
|----|---|----|--------|---|----------|-----|
| 0 | – | 6 | points | = | concrete | 2A; |
| 7 | – | 14 | points | = | concrete | 2B; |
| 15 | – | 20 | points | = | formal | 3A; |
| 21 | – | 22 | points | = | formal | 3B |

In this way, each class and school's score was calculated. Descriptive and basic statistical methods were then used to determine the distribution of students' development levels regarding stage and sub-stages, gender and stage cross tabulation, percentage of students' answers in the concrete and formal questions by school type.

Findings

In this part, the distribution of subjects' gender, developmental levels in respect of stages and sub-stages, gender and stages cross tabulation and percentage of students' correct answers in the concrete and formal questions regarding school type, is given. Relationships between cognitive development and students' profiles were investigated by means of SPSS. Table 2 shows the participant's cognitive development levels and sub-levels.

One-way ANOVA was used to determine differences between students' cognitive development levels and their ages. F ratio ($F(4, 437) = 0.491, p > 0.05$) shows that there is not a significant difference between their age and their cognitive development levels. Subjects' science achievement scores were determined using the standard test results.

In the study area, almost all science teachers do not set their own papers for their students' assessments. Since the purpose of these teachers is to prepare their students for the board exams, they usually use the model / revision exams. Reading ability, validity and reliability of these standard tests are done professionally by the experts. Therefore,

government, government aided and private school teachers use these types of tests to assess their students' achievements in schools. For this study, we obtain students' academic achievement test results from each course teacher in the samples. Subjects' academic achievements in the schools and their cognitive development levels in the CDT were investigated with one-way ANOVA test. Students' cognitive development levels and science achievement scores showed that significant difference ($F(4, 437) = 39.05, p < 0.001$) were found.

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Social Reform Movement in Andhra Region (1848-1919)

A Brief Historical Study

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The social reform movement got vigorous in the later part of 19th century in Andhra region under Kandukuri Veeresalingam Pantulu - the crusader of women rights. He advocated the rights of women in widow remarriage and citing the examples of Vedas, Smritis and Puranas. The research article critically analyzes the services rendered by Veeresalingam to women in particular and society general. It also examines the challenges faced by him in organizing the widow marriages and other social reforms.

He was a pioneer in social reform, in journalism and literature. He had much distinction to his credit. He was born in Rajahmundry in 1848 in a fairly prosperous middle class family of Niyogi Brahmins. He started his career as Junior Assistant in the Government School at his birth place Rajahmundry and reached up to the fellow of the University of Madras. As a first step in social reform Veeresalingam and his youthful friends tried their hand at comparatively minor measures of social reform like post puberty marriages for girls, inter dining and inter marriage among the different sects of the Brahmin community and disposal of dead bodies in more hygienic way. The results were too encouraging.

The unnatural practice of enforced widowhood had led the society in to evils like abortion and infanticide. He invoked the authority of Vedas, Smritis and the Puranas and cited the story of Arjuna marrying the widow. The students and the youth of the locality gave a hearty response to his exposition of the problem and rallied vigorously in his support, even though the social pressure against such attempts were there. He and a few of his trusted friends formed themselves into an active group called the Widow Remarriage Association (WRA). Two liberal minded gentlemen by name Baru Raja Rao Pantulu and Pydah Ramakrishnaiah of Kakinada visited Rajahmundry and promised to help them up to Rs. 30,000 when the need arose. This gives a great boost to the crusader. Veeresalingam plunged in to vigorous propaganda campaign in 1879 in favour of widow remarriage began which had its effect on the youth of Andhra. Parents and guardians of young virgin widows from different places approached him to see if he could do something. The forward looking sections of the community hailed his initiative and courage [1].

The idea of widow marriage was first applied by him to the higher castes, the Brahmins and the Vaisyas in particular. One reason for it might be that it was most needed among them. Enforced widowhood was practically unknown among many of the lower castes. The first widow remarriage took place in Bengal in the year 1856 shortly after the passing of the Widow Remarriage Act of 1856. It was followed by Bombay and Rajahmundry in 1869 and 1881 respectively because of the initiatives taken by the great reformers like Ishwar Chandra Vidyasagar, M.G. Ranade and Veeresalingam [2]. There was a near total boycott by all the functionaries of the marriage ceremonies; like Vedic priests, Brahmin cooks, the drummers, trumpet -blowers and others. Due to lack of cooperation from the orthodox people, there was a fear of outbreak of violence and disorder at the time of wedding procession. But everything went off according to the expectations, with no untoward incidents due to courageous steps taken by him.

Veeresalingam depended on two friends who stood by him through thick and thin - Pydah Ramakrishnaiah, a merchant prince of Kakinada and Basavaraju Gavarraju, a close companion of his, who were ready to face any consequence for Veeresalingam sake. The local government, despite the British tradition of non-interference in religion and social matters, were helpful to Veeresalingam in maintaining law and order. The District superintendent of Police a British Officer was present in person at the function, beside posting a posse of sixty constables to guard the house and the procession. This, was of course, in addition to the battalion of local students who were already there to take care of their *Master*.

Letters of ex-communication went out from the Sankaracharya to all his *erring* disciples. Some of them promptly expressed their regret and promise to behave in accordance with the social order. Over thirty families were affected this way. No less a person than Pydah Ramakrishnaiah, who had virtually financed these marriages and provided for the upkeep of these couples, lost his nerve and went through the Prayaschittam ceremony. Following these incidents, there was a lull on this front for some months. The general atmosphere was not very conducive to new marriages. In the late summer of 1882, Veeresalingam visited the city of Madras, with his wife and the newly married couples, on the invitation of Chentsal Rao. Apart from meeting like-minded friends and presenting the young couples to them at social parties, he gave a few lectures. It was a passionate address that he delivered in the Anderson Hall of Madras Christian College [3].

Veeresalingam returned to Rajahmundry in 1882 itself to look after teaching at the Government School by day and the poor boys' school at night. His other works includes the editing of Viveka Vardhini (a mouth piece to propagate his ideas started as a monthly in 1874 later converted in to fortnightly and monthly, discontinued in 1890) and the writing of books. By the middle of 1884 he had the satisfaction of arranging ten

widow remarriages including two Vaisyas couples and Brahmins. He had the unstinted cooperation of his wife, Rajyalakshamma who worked as his right hand in all these matters. In one of the marriages, she had even to fetch drinking water from the Godaveri, at a distance of a mile from their residence. The message of Brahma Samaj from Bengal reached Andhra region through the speeches of Keshab Chandra Sen and the teachings of Raja Ram Mohan Roy, a group of young men formed Prarthana Samaj at the residence of Veeresalingam in 1878. It was under the Samaj the first night school for poor boys was started in Rajahmundry. Acts of charity for the blind, duff and dumb and other physically challenged persons were encouraged by the Samaj. He also started a girl's school at Innispet in Rajahmundry, understanding the need to create awareness and self confidence among the young girls that could change their social outlook. Educational opportunity for women was very limited in the early 20th century in India [4].

While the Widow Marriage Association was not very active for some years after the death of two of his trusted friends, Gavarraju and Pydah Ramakrishnaiah, he could not help suspending the publication of the journal, **Vivekavardhini** in 1890. The idea of raising an assembly hall, which could conveniently be used for the meetings in connection with the widow marriage movement had been on his mind, ever since the year 1879. The idea was revived during the golden jubilee year of Queen Victoria's reign in 1877. The town hall reputedly the first of its kind in the Andhra districts, came into existence in October 1890. He added a reading room to it and a billiards table for recreation. The hall was declared open by prof.M.Rangacharya, Head of the Department of Sanskrit in Presidency College, Madras, a distinguished scholar of those days. In his speech, he paid a high tribute to Veeresalingam for his public work.

After **Vivekavardhini** had ceased publication, Veeresalingam was persuaded by his friend Nyayapati Subba Rao Pantulu, to look after the journal, **Chintamani**. This was recently started by him in 1891, and was being printed at the Vivekavardhini Press. Besides the friends journal, Veeresalingam was helping it substantially by contribution through its writings. On behalf of the local Prarthana Samaj, he started a new journal called **Satyasamvardhini**.

In 1893, Veeresalingam was awarded the title of *Rao Bahadur*. What used to be the coveted reward for *loyalty* to the crown, among the *native* leaders of some political importance, and become an official tribute to the courage, conviction and social awareness of a private individual. He was a mere schoolmaster, a poor Telugu Pandit chosen for this high honor by the state.

He shifted his residence to Madras to publish the collected works in several volumes. Some three years earlier, he had purchased a small house for himself in Purasawakkam,

near to his friend, Mannava Butchaiah Pantulu , a leader of the Brahma Samaj movement in the city of Madras [5].

Veerasingam in his autobiography states that a total of 27 widow marriages had been conducted by him before his departure for Madras. Soon after his arrival Veerasingam was elected President of the Social Reform Society, as well as the south Indian Brahma Samaj. These placed new responsibilities on his shoulders. He purchased at his own expense a small building, suitable for housing both the societies. His residence, which had the press on the premises, also provided shelter to a few of the young widows studying in the Egmore Girls' School. A little later, he purchased a site on the city's outskirts, in the midst of a casuarina's plantation. He cut it down to raise a modest structure to locate the widows' home, hostel as well as School. He spent a pretty penny on it. This included the bulk of his own modest savings, and the donations he was able to collect through his initiative [6].

In the year 1898, he was invited to preside over the Indian Social Conference, whose session was held along with the Indian National Congress meeting in Madras. It was at this session that M. G. Ranade, who inaugurated it, publicly hailed Veerasingam as the *Vidyasagar of the south*. This was only the public recognition of a position which had long been accepted by the people of the South, Andhra in particular. He came to be associated with many of the academic bodies and official committees. On his arrival in his home-town in 1905, he found little or no follow-up action in any of the programmes of social work he had helped to activate earlier. His absence of eight years from the scene seemed to have had its adverse effect on many of the institutions with which he had identified himself. He noted with regret that those in charge of the reading room attached to the Victoria Jubilee Town Hall, which he had been responsible for starting, had not taken any interest in it, during his absence.

There were two objects in view for Veerasingam to work for on his return to Rajahmundry. The first was to start a school for girls, whose education had always been uppermost in his mind. He decided to name it after Queen Victoria. This school was meant to serve the needs of the inmates in the widow's home, as also others outside, and prepare them for admission to higher classes in the high school. To get over the problem of building construction and the like, he located the school in his own ancestral house in the town, leaving the small portion of it for himself and his wife as residential quarters. The response from the public was quite encouraging; despite his limited means he paid the salaries of the teachers, which came to nearly Rs. 1,700 in the first year, out of his own pocket. The second object was the starting of a weekly to serve as an effective vehicle of publicity for his views in support of the work that needed to be done.

The **Vivekavardhini**, along with the **Hasya Sanjeevani** (magazine devoted to

humor) started in 1876 as also the **Chintamani** (edited by Veeresalingam, sponsored by his friend and published from Madras) had all ceased publication, with no organ of his own to influence public opinion. The new Journal Satyavadini (devoted to the discussion of social and religious themes, opposed to the orthodox Arya Matabodhini) started in 1905 was able to make its appearance on March 1, 1906. It contained sections in English as well as in Telugu. The Satyavadini like its predecessor, **Vivekavardhini**, was fearless and outspoken. Wealth or influence, social status or official position, were not enough to protect one from its criticism. None was spared. Certainly not those who fell from the ethical standards set for themselves or expected of them by those who looked up to them for leadership. During the years 1905-1906 there were two important events in the life of Veeresalingam. One was his decision to become an **Anushthanic Brahamo** (an active ardent to the practice of Brahma Samaj) and the other formation of **Hitakarini Samaj** (Widow Home). After the Samaj was formed he shifted all his activities to city's outskirts to be fully developed in due course. The widow home run by Veeresalingam was situated in his own house, for want of a separate building.

Veeresalingam said, *I am prepared hereafter to sacrifice all my resources - monetary, mental and physical, my life itself if necessary, in the cause of improving the lot of women in general and widows in particular.*

Despite local cooperation at all levels, Veeresalingam was faced with the problems of inadequate resources of the Samaj for improving its ways-and-means position. He undertook a fund-raising campaign which took him to many places in and out of Andhra, Kakinada, Berhampur, Bombay, Poona and Secunderabad.

He had also acquired a small house in the city of Bangalore. It was in this house that the seeds of social reform in Mysore were sown by him in the years 1908-1909. The first widow marriage in this city was performed by him in 1910. It had, of course, to be done in the Cantonment, in view of the laws then in force in the princely state of Mysore [7].

The sizable number of *reformed families*, who owed their existence and well-being to him, were either unable or reluctant to come to his aid. The families that lived on the premises of the Hitakarini Samaj, beneath his extended roof, as it were, did not prove very helpful in talking care of him, as he needed at his age.

During the years, 1910 to 1913, the important literary work completed by Veeresalingam was his autobiography in two volumes. He took the trouble of bringing out the revised edition of the first part of his Lives of the Telugu Poets.

The seventy-first birthday of Veeresalingam was celebrated quietly in his home town on 16th April 1919. Three days later he set out on his journey to Madras, where he wanted to look up some references in the original sources available in the Oriental Manuscripts Library for working on the Lives of the Telugu Poets. He told to his friends, who met him on the eve of his departure, about some of his hopes and fears. Three

objects yet to be realized by him were:

- The establishment in Rajahmundry of a well- equipped library in the name of the classical Telugu poet, Nannaya Bhattu
- The completion of his work on the lives of the poets and
- The preparation of a comprehensive grammar of the Telugu language.

That was the message he left for the citizen of Rajahmundry and the people of Andhra in general, before he entrained for Madras. On 27 the May 1919 the great social reformer breathed due to illness and the last rites were held at Veda Vilas at Egmore in Madras [8].

The evaluation of outstanding contribution done by Kandukuri Veeresalingam Pantulu to women could be seen to be derived from the percept of Raja Ram Mohan Roy, Ishwar Chandra Vidyasagar and M.G.Ranade. He was a tireless crusader for sanity in social life and purity in public life. He undertook the challenging task of widow remarriage that was strongly resisted by the society, finally he succeeded. He constructed schools for girls and homes for widows. The lack of education among women in the early 20th century observed the situation and he tried to empower them. He never bothered about the threats of ex- communication and stood like a lighthouse to eradicate the evils of orthodoxy. He opened a new chapter in the life of young widows. One must remember the selfless services of Veeresalingam in the upliftment of women.

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A Clarion Call for Islamic Feminism and Muslim Women's Rights in India

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Indian Muslim Citizens and the Quest for Modernity

For quite some time, the renewed orientation of many Muslims worldwide towards the normative sources of their religion has been equated with a perceived quest for the legitimacy of an *anti-Western, dogmatic* or *rigid* Islam. That this is not necessarily the agenda behind it becomes very clear when one looks at recent developments in India. Faced with enormous political, social and economic challenges, more and more active *lay* Muslims in India are engaging in fresh interpretations of the Islamic tradition, which for them as citizens of a modern nation-state could help to build bridges towards the majority community or society in general and not detach them from it any further. This effort is not restricted to a tiny minority of Muslim intellectuals, as it is supported, for example, by sections of the newly emerging Muslim middle class in India and many grass-root movements all over the country. One could even argue that the discussion of burning questions, such as education, the political representation of Indian Muslims, and above all the legal and social status of Muslim women, have led to the emergence of a new public sphere in India in recent years which, in turn, is linked to many other transnational and or local Muslim publics (see Eickelman and Anderson 1999 and Salvatore Eickelman 2004). As Sikand points out, the language of this new Muslim public sphere is English, not Urdu, which may be one of the reasons why it has gone largely unnoticed by the academic community so far, since Urdu is still regarded by many as the preferred language of Indian Muslim discourse (Sikand 2006).

These new Muslim actors in local, national, and transnational spaces argue that ardent Muslims do not depend on religious authorities to understand the Koran, but they can read and interpret the Koran for themselves. Thus, like other contemporary reform movements within Islam, their efforts can be seen as an answer to the perceived crisis of religious authority as well as the crisis of (political) representation, on the local, national and global level

Especially with regard to India, not much attention has been paid to this discursive movement so far. This holds true also with regard to the emerging Muslim women's rights movement in India that came to life in the aftermath of the heated controversy on the religion-based personal laws for Muslims in India in the 1980s (Muslim Personal

Law). Much more than in its initial phase, this emancipatory movement seems to draw a lot of inspiration from the global discourse of Islamic feminism, which gained momentum in the 1990s. Hence, the claim to reform gender unjust laws within Muslim Personal Law is not necessarily based on the Indian Constitution or the Universal principle of Human rights, but first and foremost on the authority of the Koran. The central argument of Islamic feminism is that the Koran guarantees a number of rights to women, which are constantly denied to them as a consequence of prevailing patriarchal interpretations.

As a perceived singular movement, Islamic feminism is often distinguished from *Muslim feminism* and *Islamist feminism*. With regard to India these ideal types are not very helpful as analytical categories, since the growing influence and reference to Islamic feminism simply cannot be associated with one distinct group of proponents or one movement exclusively. Therefore, a distinction should rather be made between Islamic feminism as a discursive movement, and the distinct organizations or movements that are all increasingly referring to it.

Islamic Feminism: Discourse or Social Movement ?

According to Moghadam, Islamic feminism is first and foremost a discourse whose strategy and praxis is primarily script - related. Nevertheless, there seems to be a clear tendency among observers to equate this discursive strategy or praxis with an ideology that generates or is expected to generate a transnational social or political movement, or - as the critics of Islamic feminism maintain. Accordingly, it is often stated that the Islamic feminist movement is confronted with *ideological divisions*, a *weak interconnectedness*, *internal conflicts* among Islamic feminists and *divisions weakening the movement as a whole* or with *frictions inside the movement*. These observations are obviously based on the idea of a more or less coherent, singular movement grounded in Islamic feminism. In the specific Indian context, the very recent emergence of Islamic feminism can be best understood as a discursive praxis that is adapted by women's rights activists who, in many cases, have already been associated with local or regional or national women's movements and by actors within Islamic or *Islamist* movements and organizations alike, such as the Jamaat-e-Islami Hind (JIH). As we can observe in India and elsewhere, the increased turning of certain groups within these distinct movements to the global discourse of Islamic feminism does not mean that they become sort of [*natural allies*]. Nor does it necessarily imply that these actors and different local movements feel the need to build networks or develop a common agenda.

Hence, rather than conceptualizing Islamic feminism as an ideology or category for a transnational social or political movement, it is considered as a discursive movement or strategy that is adapted by certain actors. This argument is corroborated by the fact that many Muslim women's rights activists who draw upon this discourse would never accept the label *feminist* or *Islamic feminist* as it still has a negative or ambiguous connotation in non-Western contexts.

Critical Absence of Muslim Women in the Grand Historical Narratives

Until very recently, observers were not at all convinced that Islamic feminism would ever come to light in India. In the eyes of Asghar Ali Engineer and Zarina Bhatti, two essential preconditions for the long overdue appearance of an Islamic gender critique in India were missing. According to Aftab, South Asian Muslim women are generally represented as *oppressed*, "backward" and *victims of the double tyranny* of their religion and the specifically the South Asian form of patriarchy which is grounded in the traditional Hindu view of femininity. Historians like Gail Minault, Barbara Metcalf and Azra Asghar Ali - have shown that Muslim women and men alike have constantly striven for new or re-definitions of existing women's rights since the second half of the 19th century. Among them were and are until today many eminent writers and poetesses of the 20th and 21st century, such as Ismat Chughtai, Qurratulain Hyder⁸, and Jilani Bano⁹. At present, the poetic voices of Tamil author and poet Telugu poet, Shajahana¹¹ and Urdu poet and social activist, Jamila Nishat¹² among others, are getting some attention, not only in India or South Asia, but also on an international level. But in spite of the manifold attempts to counter the essentialist construction of the Muslim woman as a *passive victim* by putting forward differentiated narratives and alternative images, the stereotypes seem to persist, especially in India. As Nigar Ataulla, editor of India's largest-selling English-language Islamic Magazine *Islamic Voice* (Bangalore), puts it, in the Indian context, whenever one talks of the status of Muslim women, the focus invariably falls on the notorious form of repudiation known as *triple talaq*, the question of polygamy and the veil. She calls this essentialist perception of Muslim women a "dangerous triangle" and her observation is confirmed by a study on the perception of the Muslim minority in India. Especially when compared to women of other denominations, Muslim women are perceived as *submissive, fragile* and *too weak to fight for their rights*.

Inscribing Muslim women into the grand narratives or making them more visible as social actors remains a very difficult undertaking. What makes it even more problematic is the fact that Muslims in India are still seen as an obvious community that draws its specificity from an inherent nature of its religion. On one hand, it is overlooked in this perspective that, as members of the Indian society, Indian Muslims are naturally involved in processes of economic change, nation-building and secularization just like any other section of the population. On the other hand, the role of the state is often neglected, especially with regard to the relationship between the State and patriarchal structures in society. The Indian state, however, has always been actively involved in the definition and construction of the family and private sphere. This can be best exemplified with regard to the history and post-colonial interventions of the Indian state in Muslim Personal Law.

A Watershed Moment for the Secular Women's Movement in India: The Controversy over Muslim Personal Law

The long controversy surrounding the question whether religious family laws form an obstacle to democracy, national unity and progress of Indian society or rather a warrant for legal pluralism as a basis for the plurality of Indian society, reached its climax in the course of the oft-cited Shah Bano case in the mid-1980s. The fiercely disputed question of maintenance for repudiated or divorced Muslim wives was exploited, among others, by Hindu nationalist actors who called for the substitution of existing religion based personal laws by a Uniform Civil Code as envisaged by the Indian constitution. In the course of the debate, it became clear that this *secular* civil code would in fact resemble more or less the already existing Hindu Code. Moreover, the avowed commitment to an overarching civil law code was increasingly equated with a *commitment to the nation*. Muslim groups and individuals who argued for the retention of Muslim Personal Law as an integral part of their cultural rights were subsequently not only branded as *backward* and *misogynist* but increasingly also as *anti-national* and *unwilling to integrate*.

Faced with the growing polarization about this question, the Congress Government under Prime Minister Rajiv Gandhi somewhat-hastily adopted the so-called Muslim Women Bill in 1986. The law gave Muslim Personal law priority over criminal law. By adopting this law, the Indian State also had put an end to the repeated attempt of Muslim women since the 1980s to obtain maintenance under secular jurisdiction. Regarding the development in India, one could rather argue that it is above all due to this entanglement between state intervention and patriarchal claims to power on the part of Muslim Organizations like the All-India Muslim Personal Law Board, that Muslim women's right activists were forced to look for new ways to engage with religious and political discourse and to seek legitimacy within Islamic discourse. It is from this point of departure that recent feminist thinking in India stresses the necessity and possibility of reform within the framework of existing family laws as a viable way to achieve gender-just laws.

For the secular women's movement, which had gained strength since the 1970s, the Muslim Women Bill marked a watershed-moment in its postcolonial history. For secular women's rights activists, the whole agitation over Muslim women's rights on maintenance contained a series of bitter lessons of experience women's movement in India had been united by the idea that the State should encourage the society's cultural, social and political progress through legislation and thereby strengthen *national integration*. This is also the reason for the movement's longstanding support for the claim for an overarching Civil Law Code in India. And this, on, explains the appearance of a very peculiar argumentative alliance with regard to Muslim personal law in the 1980s, which was, among others, supported by extremist Hindu nationalist organizations such as the Shiv Sena in Maharashtra and the Rashtriya Swayamsevak

Sangh (RSS) Initial doubts with respect to the secular nation-state came up only in the context of the general critique of secularism from the mid-1980s onwards. Following this critique, the elitist assumption that social change and progress were inherent to the process of nation-building, was now more and more challenged. Faced with the appropriation of their claim for an overarching Civil Law Code by Hindu nationalist actors, these doubts grew stronger in the aftermath of the Shah Bano case. Especially the critique of wellknown women's rights activists such as Madhu Kishwar and Flavia Agnes & were very important in this context. The disillusionment with the state and the realization that Hindu nationalist actors had more or less seized a genuine feminist demand led to a growing dissociation of feminist actors from this agenda. As a result of this, the claim for a Uniform Civil Code seems to be no longer supported by major women's organizations in India. It remains a debated issue, however, which strategies should be best followed in order to achieve greater gender equality under the existing religion-based laws, i.e. Hindu, Muslim, Christian and Parsi Laws.

Increasing Visibility of Muslim Women in Public Spheres

Contrary to the experience of the secular women's movement in India, the Shah Bano case and the adoption of the Muslim Women Bill represent a point of departure for the emerging Muslim women's rights movement in postcolonial India and a very recent phenomenon that is labeled as Islamic feminism. Many local Muslim women's right groups and initiatives were founded in the late 1980s, such as the Goa Muslim Women's Association or Awaaz-e-Niswan in Mumbai. Although many of these & organizations have been active for more than 20 years, the English-Language Press in India, has only started to cover their activities and agenda to a significant extent from the late 1990s onwards. Especially during the last three years, quite a number of reports and interviews with Muslim women's rights activists have been published. Many of these articles put a focus on Muslim women's Organizations and activists who question religious authorities, especially the Ulama

- (1) Strive for reforms of existing laws within the framework of Muslim Personal Law in order to strengthen, the rights of Muslim women,
- (2) Are planning to establish a mosque for women,
- (3) Point out that Islam as a religion does not discriminate or oppress women but rather the patriarchal system that has been established on the basis of a highly selective interpretation of the normative sources, especially the Koran.

Against the background of the absence of Muslim women from media discourse and their cliched representation as *passive victims* of violence and discrimination within their religious community, the increasing visibility of self-conscious Muslim women's rights' activists in Indian public spheres may indeed be seen as a surprise. one of

the basic principles of modern mass media is that they always rely on what has been publicized before and thus concentrate on specific variations of what is already known. The sudden representation of Muslim women's rights activists in the Indian English-Language media may well be regarded as a media-specific surprise since they are depicted as an *unexpected and new variation* in the all too well known narrative on Muslim women in India that has persisted for decades.

It becomes quite clear that very few organizations were initially founded in order to pursue the goal of legal reforms, nor to create more publicity for the Islamic feminist agenda. Most of them rather seem to have emerged from local grassroots initiatives, which are so typical for the vital civil society in India. The main activities of the largest and best-known Organization led by Muslim women, Awaaz-e-Niswan (AeN), concentrate around the professional education of poor women with the goal of enabling them to make a living for themselves and their children. In addition to that, AeN offers marriage counseling on a weekly basis.

The increasing cooperation and networking of Muslim women's Organizations on a national and even on an international level seems to be a more recent phenomenon. In these new contexts, the focus is not so much laid on help for individual women, but rather on a dialogue within the Muslim community, especially with the Ulama. As mentioned before, media campaigns and public relation strategies play a significant role on this level of activism. These organizations and networks often coordinate demonstrations in cooperation with secular women's Organizations.

The All-India Muslim Women's Rights Network (MWRN), which was established in 1999 by activists from AeN and from the Mumbai-based Women's Research and Action Group (WRAG), is the most successful network with a nationwide radius. Every one or two years, they hold conferences, which at the same time serve as a meeting point for all the Organizations which are active in this network. For instance, in 2005, about 300 delegates met in Lucknow and discussed questions such as the role of the State with respect to women's rights, the effects of communal violence on Muslim women and the challenges that Muslim women's rights activists are facing in India. Between 1994 and 98, WRAG conducted an extensive study titled *Women & Law in the Muslim Community*, with the declared aim of collecting, documenting and analyzing the diverse civil or family laws that are applied to Muslims in India. It is often overlooked that the term *Muslim Personal Law* does not refer to a codified or unified family law code and that laws may differ more or less significantly from region to region. One of the findings of this research project was that Muslim women in India clearly support the demand for reform of Muslim Personal Law in India. As WRAG describes on its homepage, it was this claim, which among other things, led to an increase in awareness-raising campaigns, which shall help to inform Muslim women about the rights that are guaranteed to them in the Koran and thereby encourage new impulses for debate on reform of MPL.¹⁸ In 2006, a new organization by name Bhartiya Muslim Mahila Andolan was founded for this specific goal. It claims to be the first pan-Indian movement

uniting Muslim women across the various existing castes and classes in Muslim Indian society. It is this organization that most explicitly states its reference to the global discourse of Islamic feminism in the formulation of goals by declaring that BMMA strives to *explore possibilities of reforming personal laws based on male dominance*¹⁹.

From the self-description and development of Muslim women's organizations in Mumbai, it becomes very clear that they are increasingly influenced by the discourse of Islamic feminism. At the same time, many of them remain firmly rooted in local grassroots initiatives and they also regard themselves as an integral part of the National Women's Movement in India.

A very similar development can be observed with regard to the well-known South Indian women's Organization which was founded by Daud Sharifa Khanam in Pudukottai in Tamil Nadu in 1987. Like the Mumbai-based Organization Awaaz-e-Niswan, STEPS was not founded for Muslim women exclusively. Interestingly, STEPS dedicates a lot of space on its website to the self-description of the organization, its origins, motives and goals. It was originally founded to fight against the discrimination and violence against young girls and women. In 2003, the organization announced its intention to establish a monthly jamaat assembly for Muslim women to provide them with a public space for articulation and information about the patriarchal interpretation of Islamic principles by male religious authorities.

This idea of a jamaat for women also seems to be a reaction to the growing frustration among Muslim women in Pudukottai about the decisions that are made by the Jamaat members regarding issues of dowry, divorce, domestic violence, custody or child abuse. As Muslim women can even go to the local police station and seek help there, most of their complaints are transferred by police officers to the local Jamaat to which women have no access. It means that the Jamaats decide of their own accord without even listening to the women and as a result of this, the judgements passed by them are often biased and one - side STEPS fundamentally questions the authority of the traditional Jamaat system as well as the legitimacy of its claim to exert control on the Muslim community.

What attracted a remarkable amount of media attention in this context, was the plan of these jamaat members to build a mosque exclusively for women. The mosque is to be erected on a site that had been donated to them especially for this purpose. Besides the prayer room and a coordination office for issues related to education or job vacancies for women, the jamaat activists are also planning to set up a center for education and research. Access to mosques for women, not only in the sense of a place for prayer but as a public space where women are allowed to actively engage in, discussing remains a very controversial issue among Indian Muslims. Following role models such as Sharifa Khanam and others, similar plans to erect mosques for women can be observed in different regions of the country.

Conclusion

Despite the fact that they are faced with severe opposition and financial problems, the women activists in Pudukottai stick to their plan to build a mosque and Sharifa Khanam herself coordinates a big network of Muslim women in Tamil Nadu. Various local Muslim women's rights-movements are clearly moving towards the global discourse of Islamic feminism, but this does not mean that they do not consider themselves as an integral part of a national women's movement any longer, nor does it mean that they don't function as grass-roots organizations on the local or regional level any more. Thus, even if the same actors are involved, the concept of a movement may refer to very different settings, frameworks, forms of organization and communication. The discursive strategy or praxis of Islamic feminism indeed seems to be only one, albeit increasingly important, among other discursive strategies that are involved by Muslim women's right activists in India in their pursuit of gender-justice.

Seen in this perspective, recent developments in India clearly seem to underline Ahmed-Ghosh's argument that feminism in Muslim contexts cannot and should not be conceptualized in terms of mutually exclusive analytical categories such as *secular* or *Islamic* feminism but should rather be seen as a hybrid construction - in theory and practice. From the literature that has been published on Islamic feminism in India so far, it seems that a twofold dilemma manifests itself on a theoretical-conceptual level. Firstly, it has to be taken into account that many social actors who are subsumed under the category *Islamic feminist*, would not necessarily accept this label for themselves, and this holds true not only with respect to India but also Muslim women's rights activists in other countries. A clear distinction should be made between Islamic feminism as a discursive movement whose strategy is first and foremost based on texts, and the local, national or transnational movements that are now making use of this discursive praxis, actually precede the emergence of Islamic feminism in the 1990s. It is an indisputable fact that Islamic feminism as a discourse and strategy has become a very important point of reference for different groups and contexts in India. achievement of gender equality within the framework of Muslim Personal Law in India is certainly not in Ever since the foundation of the All-India Muslim Women's Personal Law Board (AIMWPLB) in February 2005, however, which attracted a lot of media attention in India and hardly be ignored any longer that Muslim women in India have an increasingly audible voice in the newly emerging Muslim public sphere. Like many of their male counterparts, they encourage believing Muslims to read and to interpret the Koran for themselves and to find new ways to bring their religious belief in accordance with the prerequisites of today's life. And perhaps even more pronounced, Muslim women argue that the *modernization* and future of the Muslim minority heavily depend on the achievement of gender equality within the community and on the recognition of Muslim women as active Indian citizens by the majority community.

Compilation of Online Resources Gateway for Learning and Research: with Special Reference to Islamic Communities

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Abstract

This paper aims to describe development of Muslim community Higher Education and research. Education is the Lighthouse for the universe. This article focused the list of reputed higher educational and research opportunities available in India for the Muslim community. Methodology of this study is to collect all the Educational and research institutions, open educational resources from different websites, and from reference books then sorted out according to the title provided in the subject gateway. This online resource gateway is designed by a free website called *Webnode*. The main purpose of this study is to provide open access resources like e-books, e-journals, e-theses, subject gateways , institutional repositories and Research gateway in a single window. This paper also focused on number of Funding agencies available in India, and very specific on Muslim community scholarship, funding organizations for higher education and research. Findings of this study Reputed research institutions in India and Tamil Nadu, Open Access Resources such as e-books, e-journals, Theses & Dissertations sites, Subject gateways, Funding agencies, Bibliography styles, Google Scholar profile, News Paper Directory, Institutional Repositories, Free online Libraries and Research Gateway which is given in morethan 200 sites.

Keywords: Higher Education, Open Access Resources, Subject Gateways, Funding Agencies and Research gateway

1. Introduction

Education is the key to success and empowering the economy of a Nation. India has before it the global challenge of drawing large numbers into the stream of higher education in the twenty-first century. Higher Educational Research Institutions has

spread over in India. Among this Muslim Minority Institutions also included and their service for the minority students. The Union Government also taking initiatives for the development of minority education. Due to Information Technology Revolution the Education sector has tremendous development in India. Education is recognized as one of the critical elements of the national development effort and higher education, in particular, is of vital importance for the Nation, as it is powerful tool to build a knowledge based society of the 21st Century.

There were only 2 Muslim Universities in India at the time of independence. Osmania University, Hyderabad and Aligarh Muslim University. After that gradual development of more than 10 universities established for the Higher Education and Research. During the long period of Muslim rule in India a network of thousands of educational Institutions had been built up across the country. These institutions, generally known as Madrasas, included maktabas, Madrasas and Jamiats. Maktabas were at the lowest range of the education system. Now in India around 300 universities are offering research education and out of which 20 universities are especially focused on muslim community.

Online Resources plays vital role for the Higher Education and research. Especially Books, Journals, Theses, patents, standards, dissertations etc. are available in digital format, and it can be accessed by Internet. The electronic resources are available in two forms that is Open Access and Paid resources. The Open access resources can be accessed by anyone without paying any amount, But paid resources can be accessed by the permission of Publishers.

Subject Gateways

Subject Gateways are also called Information Gateways or Resource Gateways or online tools or Information services, which gives access to the best available Internet sources on a specific subject area. *Subject gateways are online services and sites that provide search and browse catalogues of internet based resources. Subject gateways will typically focus on a related set of academic subject areas.* Subject gateways are those value-added services which select, evaluate, catalogue and classify Internet resources with the aim to help users in the information retrieval, being a very useful resource for the respective user communities.

Funding Organizations

In India there is only a minimum level of awareness among the students/Research scholars regarding scholarship facilities. The Indian Government taking remedial measures to reach higher education for each and every person, but due to un awareness of funding agencies in India Students/Research scholars are dropping their education.

Particularly Muslim Minority students un aware of funding agencies. So, the researcher Identify and collect what are the funding agencies for research and scholarships facilities available in India. There are three types of funding organizations available in India. They are as follows:

- Governmental Funding Organizations
- Non Governmental Organizations
- Islamic Funding Organizations

Under the Government Funding agencies there are Autonomous bodies also included. In this study the researcher collected the information and address of each funding agencies and what type of funding/scholarship they providing to higher education/research. Each funding agencies will provide the funding assistance according to their subject.

Review of Literature

Shashikant C.Gudodagi etc.,(2004) discussed in their paper explains in brief about information gateways, their need and salient features of them, further they explains the role of librarians with regards to gateways and list out some of the well-known gateways. Zhang Xiya etc.,(2004) discussed in their paper compare several differences with other subject information gateway systems, such as embody scope, resource types, organization system, resources description, retrieval function, appreciation service, renewal and maintenance, cooperation model, amount of data etc., and also put forward some good ideas of developing subject gateway system. Neelakandan,B, Malatesh N, Surulinathi M and Srinivasa Ragavan S (2010)discussed in this paper explains the need and scope of creating a subject based gateway related to domain specific content such as Biotechnology, Nanotechnology etc. there are several resources coming up for the emerging fields both in open sources and in conventional methods. In the recent decades subject based content collection gateways are increasing around the globe, this paper explains about one such gateway related to Biotechnology. Tramullas, Jesus (2006) discussed in his paper ” Constructing Web subject gateways using Dublin core, the resource description framework and topic maps” that specialized subject gateways have become an essential tool for locating and accessing digital information resources, with the added value of organization and previous evaluation catering for the needs of the varying communities using these. Within the framework of a research project on the subject, a software tool has been developed that enables subject gateways to be developed and managed. Watwood, Carol (2006) discussed in his article that NLM Gateway, a Web-based meta search engine for many resources of the National Library of Medicine (NLM), searches MEDLINE/PubMed, the NLM catalog, TOXLINE Special etc., Developed by the library’s Lister Hill national Centre for Biomedical

Communications, the Gateway debuted in October 2000 as part of the migration from the older ELHILL fee-based search system to free access on the web.

Research Methodology

The Investigator before starting the research, collected the information from Islamic community institutions regarding the requirement of higher education and research. The researcher checked their knowledge of Open access resources and Funding agencies available in India, particularly for the Muslim community. Based on the requirement the researcher identified the various online resources and funding agencies for the study. After identified, the researcher organized the resources based on the categories like books, journals, theses, dissertations and funding agencies such as Governmental, Non Governmental, Islamic organizations. Finally researcher has selected the free website called *webnode* based on its features. Under this website the researcher has created online resources gateway namely *Gateway for Islamian Education*.

This gateway can be accessed by Internet and it is available for 24/7 hours/days. This site is regularly updated.

Online Resources Gateway



Figure 6: gatewayformuslimminority.webnode.com

The above homepage provides the following information in left side of the screen shot. Higher Educational and Research Institutions available in India for Muslim

communities, Open Access Resources, Theses & Dissertations, Subject Gateways, Funding Agencies, Different styles of Bibliography Writing, Google scholars Profile, News Paper Directory, Institutional Repositories, Online Libraries and Research Gate (website for Research topic and project proposal writing) available for the Research Scholars. Funding organizations/Agencies is also additional bonanza for the students/Research Scholars particularly Muslim community.

Webpage of Research Institutions

This webpage provides information about the Research Institutions available in India for Muslim Minority students. There are Nineteen reputed Higher educational and research institutions available, among this some of them Arabic and Urdu Institutions. In this Institutions some of them providing open access resources and scholarship facility and research grants to the respective students/scholars. Under this site a separate table given for Arabic Institutions websites. They providing higher education from basic to Doctorate level and each of the address hyperlinked with concerned website.

Webpage for Open Access Resources

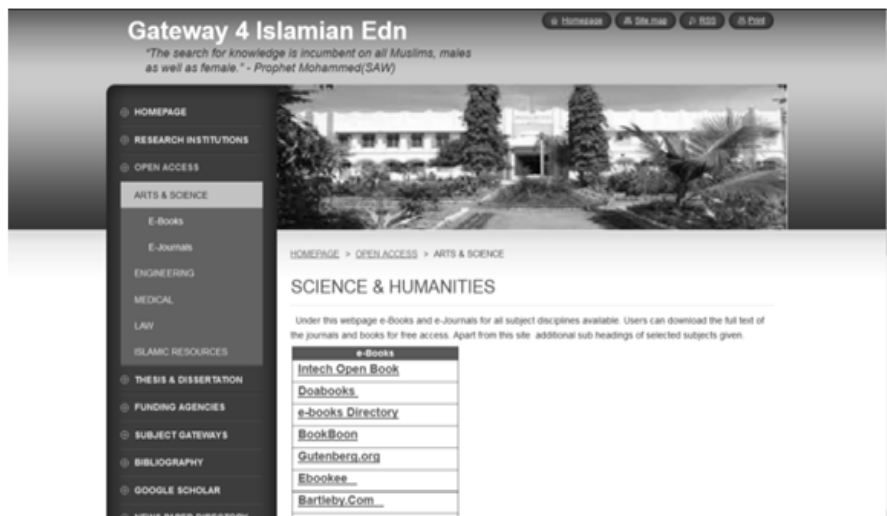
This webpage provides information about the open access resources of Arts, Science, Medical, Engineering & Technology e-books, e-Journals and other databases for the Research Scholars. Under the main title three subdivisions are given. Students/Scholars according to their subject can browse the site and download the e-Books and e-Journals and references.



Open Access Resources-Arts & Science

In this screen shot there are two subdivision given under this title one is e-Books and another one is e-Journals. Under this screen shot e-books & e-journals subjects are

listed and given in the separate table, apart from this table five category of subjects are given they are Physics, chemistry, Mathematics, Computer science and life science.



Open Access Engineering Resources

This screen shot provides information about the engineering subjects. Under the open access resources. In this site open access journals and books are available for the engineering students and scholars.

Open Access Medical Resources

This webpage provides Medical resources books, journals, databases, references and different types of Indian medical treatments. They are Ayurveda system of medicine, Siddha, Homeopathy and Unani medicine apart from this medical databases, e-journals and e-books are also available.

Open Access Law Resources

This webpage provides Indian law and British law related books, journals and important cases and references databases. This site is useful for the Law students and research scholars.

Open Access Islamic Resources

Under this webpage information about the Islamic open access resources given and also each site is hyperlinked and they providing resources of Arabic and urdu subjects. Free e-books and e-journals and other related literature available in each of

the subdivision of the titles. Some of the sites providing full text urdu & Arabic books and journals in PDF format.



Gateway for Open Access Theses & Dissertation



In this Screen shot one separate table given with five headings they are individual sites each one of them hyperlinked. They are provides open access theses and dissertations for all subject disciplines. This site allows you to access the full text of Thesis and dissertations in all subjects.

Open Access Theses & Dissertation - Science & Humanities

Apart from the above this Screen shot provides the open access Theses and dissertations of Science and Humanities subjects. Indian and foreign Institutions providing full text of theses and dissertations available in this site for all subject Disciplines. Under this site more than hundred National and International Institutions providing online theses in pdf format.

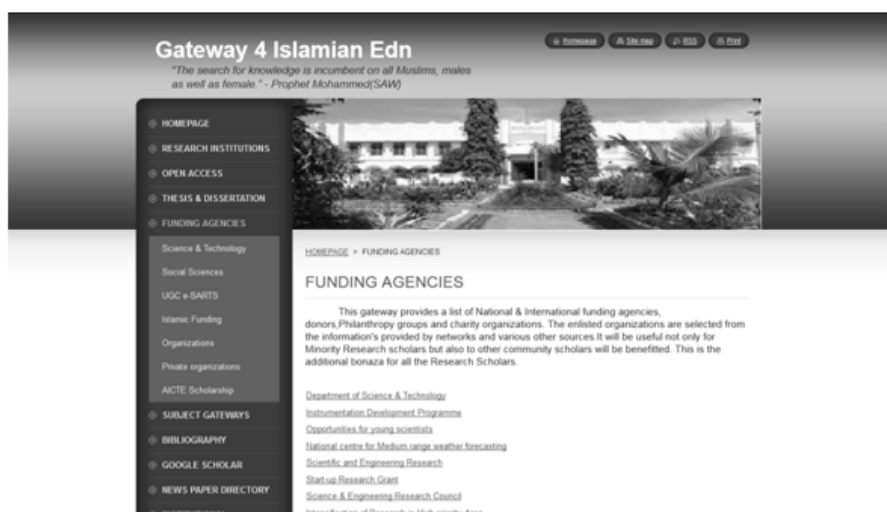
Subject Gateways

This webpage provides detailed information of all subjects. Each subject will be given in full details of e-books, e-journals, references, abstracts, citations and databases. These details will be useful for all the research scholars and faculties.

Webpage for Languages Gateway

Under the subject gateways site three language gateways are given. These webpage will give information of Arabic, Urdu and Tamil languages. They provide research articles, books, journals, poems, Essays etc.,

Webpage for Funding Agencies



This webpage provides a list of National & International funding agencies, donors, Philanthropy groups and charity organizations. The enlisted organizations are selected from the information's provided by networks and various other sources. Especially Islamic funding organizations provided here for Muslim community students/ Research scholars and also other funding organizations provide for the General. This is an additional bonanza for all the under graduate, post graduate students, Research Scholars and faculties. This site also provides grants for minor and major research projects.

Funding Agencies for Science & Humanities

This webpage provides information to the research scholars/faculties of science and humanity subjects. More than hundred funding agencies available in this site.

Funding agencies UGC e-SARTS

In this screen shot provides information of University Grants commissions e-SARTS funds for research. The links will be given separately hyperlinked for easy to search. Research scholars according to their subject may apply to the concerned department.

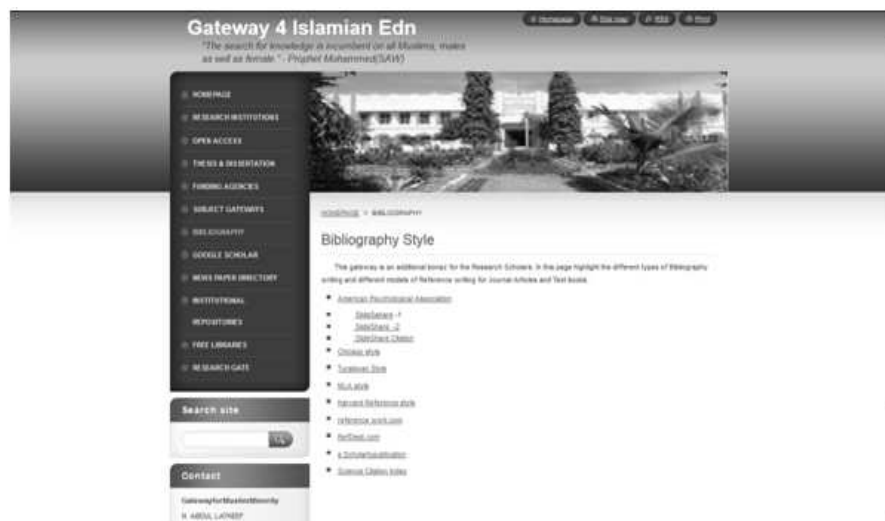
Webpage for Islamic Funding Agencies

This site provides scholarship assistance to economically disadvantaged students of muslim community. There are twenty islamic organizations/agencies providing scholarships to the underpriviledged students/Research scholars. Each title will be hyperlinked to the concerned homepage. This funding agencies assisting to undergraduate, Postgraduate students and research scholars.

Webpage of Google Scholars

This screen shot provides information about the Scholars of Bharathidasan University Maths, physics, chemistry, Bio-medical science, Industrial Biotechnology and Library science. In this Google scholars site providing their individual publications, Paper presentations , Journal articles and research reports.

Webpage for different styles of Bibliography



This gateway is an additional bonanza for the Research Scholars. In this page highlight the different types of Bibliography writing and different models of Reference writing for Journal Articles, Text books, Theses and Dissertation. According to the requirement scholars apply this style for their research work.

Webpage for News Paper Directory

This page provides three different online Newspaper directories, Namely Online News paper Directory, Mediaworld.info and Press Display. This directory covers around the world News papers and provides updated in PDF format.

Webpage for Institutional Repositories

This site provides National and International Institutions and their publications, programmes, question papers, research reports of their faculties.

Webpage for Free online Libraries

This webpage provides the online Free Libraries available in the universe. This libraries providing the free e-books and e-journals and other information sources. There are Nine Online free libraries provided in this page.

Webpage for Research Gate

This site provides the research informations like project proposal writing, research funding assistance, research topics, tools & techniques and completed research reports to support the research activities.

Some of the Important Open Access Resources Sites given in this Gateway**E - Books:**

| | |
|-------------------|--|
| Intech Open Book | www.intechopen.com |
| Doabooks | www.doabooks.org |
| Orielly Open Book | www.orielly.com/open book/ |
| BookBoon | www.bookboon.com |
| EBookee | http://ebookee.org/ |

E - Journals:

| | |
|--------------------------|--|
| Benthamsience | www.benthamsience.com |
| DOAJ | www.doaj.com |
| IEEE | www.ieee.org/open-access/ |
| Interscience Open Access | www.interscience.in |
| Springer Open | www.springeropen.com/journals |
| Bioline International | www.bioline.org.br/journals |

E - Thesis:

| | |
|---------------------------|--|
| NDLTD | www.ndltd.org |
| MIT Thesis | www.dspace.mit.edu/handle/1721.1/7582 |
| Shodhganga | www.shodhganga.inflibnet.ac.in |
| Australian Digital Theses | http://www.adt.edu.au/ |
| Canada Theses Portal | http://amicus.collectionscanada.gc.ca |

Subject Gateways:

| | |
|---------------------|--|
| Arab Gateway | www.arabgateway.edu.au |
| Urdu | www.khitaabghar.org/dir/ |
| Tamil | www.ulakaththamizh.org/ |
| Arts and Humanities | www.ahds.ac.uk |
| Chemistry | www.chemdex.org |
| Maths | www.mathforum.org/library/ |
| Biogate | www.life-sciences-germany.com |

Some of the Scholarship/Funding Organisations

| | |
|---|--|
| B S A Zakat Foundation | http://www.bsazakat.org |
| Maulana Azad Education Foundation | http://maef.nic.in |
| Kalaskar Educational Services | http://www.kesstudent.com |
| Progressive Muslim Education Trust | http://www.pmet.org |
| Opportunities for young scientists | http://www.dst.gov.in/aboutus |
| Indian council of social science research | http://www.csir.res.in |
| UGC e-SARTS | www.ugc.ac.in |
| J.N.TaTa Endowment Loan scholarship | http://www.dorabjitatatrust.org |
| K.C.Mahindra Education Trust | www.mahindra.com/How-We-Help/Foundations/ |

| S.No. | Type of Resources | Number of sites |
|-------|------------------------------|-----------------|
| 1 | E-Books sites | 15 |
| 2 | E-Journals sites | 50 |
| 3 | Theses & Dissertation sites | 120 |
| 4 | Subject Gateways | 15 |
| 5 | Funding Agencies 100+ sites | |
| | Governmental Organisations | 58 |
| | Islamic Organisations | 20 |
| | Foreign Agencies | 20 |
| | NGO's | 8 |
| 6 | Free online Libraries | 9 |
| 7 | Research information gateway | 4 |

Statistical Table for Open Access Resources

Findings

In this study there are Nineteen Muslim Minority Research Institutions provided. These are selected institutions only. They are providing research programmes of all subject disciplines for all category of People, Apart from this thirteen Government Aided muslim minority colleges of Tamil Nadu also given. Among these some of them have Arabic Research Institutions. The Arabic institutions providing education from basic to Ph.D level. Under this institutions some of them open access resources and scholarship facilities. This site provides more than 15 open access e-books free sites and 50+ online free Journals sites given. The investigator also identified and provided 120+ sites for open access Theses & Dissertations. There are 17+ Subject Gateways identified and added separately in this study.

The Investigator provided more than hundred funding agencies, among this Ninety eight funding Agencies are selected and separated in to three categories. They are Governmental Funding Agency, Non Governmental organization and Islamic funding organizations. According to this Fifty eight Governmental, twenty Islamic funding agencies and Eight Non-Governmental organizations and twelve Foreign Governmental organizations. Apart from this some of the Funding Agencies categorized as subject wise like Arts & Science, Engineering and Medical.

Under this gateway Selected Institutional Repositories also compiled and three sites for News paper directory, Nine Free online Library websites and Research Gate (site for Research scholars & faculties) also given in this study. This is added advantage for the research scholars. The investigator also given 7 types of Bibliographical styles in this study. This styles will provides different types of reference and bibliography writing. The data collected from different internet resources as well as reference books. Research gate is one of the subdivision it provides four individual sites for research aid, collaboration and sharing of research publications/ reports.

Conclusion

Influence of Information technology there is a drastic development of online resources which can be accessed by Internet for the free of cost. Now since the enormous growth of online literature the researchers and educators are getting confused to choose the right resource for their research. Researchers and Educators from the Islamic communities have access to these neatly arranged resources, based on the categories for their academic activities and also this gateway useful for the researchers and educators in general. This will also enable the library professionals to develop the further subject gateway for their Respective users without any financial support.

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- Sumangala Jha, Encyclopedia of Research on Digital Libraries: Design and development.(2013)

Urdu Gateways

<http://www.minhajbooks.com/english/index.html>

<http://www.besturdubooks.wordpress.com>

<http://www.islamicbook.ws/urdu/>

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Mobile : 0091 98840 55569

