ज्ञान-विज्ञान विमुक्तये

PROCEEDINGS OF THE NATIONAL SEMINAR ON

"EMERGING NANO SCIENCE AND ITS FUTURE IN BIOLOGY"

21st to 23rd August 2012



Organized by

DEPARTMENT OF ZOOLOGY AND AQUACULTURE

ST. ALOYSIUS' COLLEGE, EDATHUA

Alappuzha- 689 573, Kerala

(Affiliated to Mahatma Gandhi University, NAAC Re-accredited)

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Collaboration with

Centre for Nano Science & Nano Technology, M.G. University, Kottayam &

Department of Chemistry, St. Thomas College, Pala

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Bottom - Calcium carbonate particles for drug delivery

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Message

The ability to see nano-sized materials has opened up a world of possibilities in a variety of industries and scientific endeavors. Nanotechnology is essentially a set of techniques that allow manipulation of properties at a very small scale which can have many applications. It is a new frontier of knowledge and this National Seminar is a humble tribute from the Aloysian family to all the scientific initiatives to explore the potential of this technology.

Science, being a systematic body of knowledge, is ever growing. The academia at the service of this body has to share this dynamism. Hope this proceedings serves as a testimony of this commitment. I congratulate all in the Department of Zoology, Dr. N. Suja, the HOD and Dr. Shibu George, the Convener for their sincere hard work.

DR. P. C. ANIYANKUNJU

Principal



Preface

Science is not static but ever changing. The brain behind the changes is not the nature itself but a specific intellectual group called the scientific community. Their dedicated, untiring and continuous intrusions into the nature result in the amazing findings on her enigma. When they share their inventions and findings, scientific knowledge expands and the science is defined to be subjected to evolution.

Research activities for finding the ultimate truth are inevitable in this modern era of science and technology. Sharing of research findings is the duty of each and every researcher which not only improves his knowledge but also adds a great contribution to the existing world of science. "Publish or Perish" is the current slogan of the scientific community and it shows how much important is the publication of a research finding.

Today, there are several opportunities for publication. 'National Seminar' is a good venue for publishing and sharing the research findings. The Department of Zoology and Aquaculture, St.Aloysius' College, Edathua is fortunate enough to organize a U.G.C. sponsored National Seminar on "Emerging Nano Science and its Future in Biology" from 21st to 23rd of August 2012.

Nano Science is one of the recent branches of the science with greatest attention from scientists. The opportunities of Nano Science in Biology, especially in Medicine is surprising. A National Seminar on this topic is relevant and it helps the Nano Science researches to share their technical and practical knowledges.

I would like to take this opportunity to extend our gratitude to the U.G.C. for sponsoring the seminar and also to the resource persons and paper contributors.

I also acknowledge the efforts given by the collaborating institutes; Centre for NanoScience and Nano Technology, M.G.University, Kottayam and Department of Chemistry, St. Thomas College, Pala.

I would also like to thank Dr. P.C. Aniyankunju (Principal), Dr. N.Suja (HOD, Zoology) and other teaching and non teaching staff of our college for their interest and support given for the success of this seminar.

I hope this publication will be a source for improving your cognitive thinking on Nano Science and help you to do more research on it for the ultimate beneficial of the society.

Dr. Shibu George

(Assistant Professor, St. Aloysius' College, Edathua)

Editor

NATIONAL SEMINAR- SUMMARY

The Department of Zoology and Aquaculture, St. Aloysius' College (Mahatma Gandhi University, Kottayam), Edathua in collaboration with Centre for NanoScience and Nanotechnology, M.G University, Kottayam and Post Graduate and Research Department of Chemistry, St. Thomas College (Mahatma Gandhi University, Kottayam), Pala, Kottayam organized UGC sponsored three days National Seminar on "Emerging NanoScience and its Future in Biology" during August 21-23, 2012.

Inaugural session

The inaugural session was held on August 21, at 10:00 AM with a meaningful prayer song. The session was inaugurated by Rt. Rev. Dr. Selvister Ponnumuthan, Bishop of Punalur Diocese. Distinguished guests present in the occasion included Very Rev. Fr. Kurian Puthenpura, Manager, St. Aloysius' College, Edathua, Dr. P. C. Aniyankunju, Principal, St. Aloysius' College, Edathua, Dr. Nandakumar Kalarikkal, Joint Director, Centre for Nano Science and Nanotechnology,M.G.University, Kottayam and Dr. Varghese Mathew, Head, Department of Physics, St.Aloysius' College, Edathua and Dr. N. Suja, Head, Department of Zoology and Aquaculture, St.Aloysius' College, Edathua.

The seminar observed the participation of over 102 personnel including distinguished scientists, academicians and researchers from various Universities and colleges of Kerala and other states. During these three days of national seminar six lectures were delivered by expert professors from different parts of the country and 16 research papers were presented by scientists, academicians and research scholars.

During the inaugural session, Dr. P. C. Aniyankunju, Principal of the college put forward the welcome address. He highlighted the objective of holding the seminar and also emphasized the importance of Nanoscience and Nanotechnology for all round national development. This was followed by presidential address by Very Rev. Fr. Kurian Puthenpura, manager of the college. In his speech, he pointed out the role of an academic institution in understanding and promoting newer areas of learning. He also suggested exploring studies on how the recent scientific innovations are going to affect the common man and environment now and in the future.

Thereafter, the occasion was felicitated by Dr. Nandakumar Kalarikkal, Dr. Varghese Mathew and Dr. N. Suja. Finally Dr. Shibu George, Convener of the National Seminar proposed the vote of thanks. The welcome address, presidential address, inaugural address, felicitations and vote of thanks by respective persons are included in the proceedings.

Technical Sessions

After the Inaugural Session, six main Technical Sessions were held, two on the first day, three on the second day and one on the third day. Paper presentations were held on the third day. The sessions were chaired by Academicians Dr. –C. K. Mahadevan, Dr. M. R. Anatharaman and Dr. Sunny Kuriakose. Each session was followed by interaction period of 5 -10 minutes.

I st Day (21-8-2012)

Technical Session I (11.30 am -1.00pm) was chaired by Dr. Sunny Kuriakose, during which Dr. Nandakumar Kalarikkal -Joint Director, Centre for NanoScience and Nanotechnology, M.G.University, Kottayam presented a paper on Nano-materials and

Biomedical Applications. Following massive discussion and interaction by the participants, the report was endorsed.

Technical Session II (2.00pm to 4.00pm) was chaired by Dr. C. K. Mahadevan. Dr. Vidhya Ramaswami- Chairperson, International Centre for Intellectual Training and Empowerment presented a talk on Nanotechnology as Trend Setter – Dreaming the Future for Big Consequences. Following completion of the technical session, group discussion session was organized.

II day – 22-8-2012

Technical Session III (10.00 am -11.30 am) was chaired by Dr. M. R. Anantharaman. During this session, Dr. Sunny Kuriakose- Associate Professor, Department of Chemistry, St.Thomas College, Pala delivered a lecture on Nanotechnology and Environment. There was a group discussion session after the lecture.

Technical Session IV (11.30 am-1.00pm) was chaired by Dr. C. K. Mahadevan. Dr. M. R. Anantharaman, Head, Department of Physics, Cochin University of Science and Technology presented a talk on Magnetic Nanoprobe for Biomedical Applications. This was followed by group discussion.

Technical Session V (2.00 pm-4.00pm) was chaired by Dr. Sunny Kuriakose. During this session, Dr. C. K. Mahadevan, Associate Professor, Department of Physics, S.T. Hindu College, Nagercoil. Tamilnadu talked on Quantum Dots for Lifescience Applications. After completion of the talk, group discussion was organized.

III Day – 23-8-2012

Technical Session VI (10.00am-11.30 am) was chaired by Dr. C. K. Mahadevan. During this session, Dr. Deepthi Menon, Associate Professor, Amrita Centre for

Nanosciences, Kochi presented a lecture on Nanomaterials in Biology. Following completion of the talk, group discussion was conducted.

The technical papers by resource persons are included in the proceedings.

Paper presentation

This session was held from 11. 30 am to 1.00 pm and also from 2.00 pm to 2.30 pm. A total of 16 papers were presented by scientists, academicians and research scholars on various aspects of Nanoscience and Nanotechnology. The session was chaired by Dr. Deepthi Menon. A feedback session was organized from 2.30pm to 3.00 pm.

Valedictory function started at 3.00 pm which was presided over by the Principal of the college, Dr. P. C. Aniyankunju. In this function, Rev. Fr. Thomas Kanjiravelil, Bursar of the College was the Chief Guest. The function started with prayer. After the prayer, Dr. Shibu George, Convener of the seminar presented welcome address to the gathering. Dr. P. C. Aniyankunju presented the presidential address. Rev. Fr. Thomas Kanjiravelil proposed the keynote address. Dr. Kuriachen George, Associate Professor, Department of Commerce felicitated the programme. Certificates were distributed to the participants. Dr. N. Suja, Head of the Department of Zoology and Aquaculture proposed the vote of thanks.

CONTENTS

1.1. Objectives of the seminar 1

1.2. Organizing Committee 4

1.3. List of Invited Speakers 5

1.4. Programme 6

1.5. Inaugural Ceremony

1.5.1. Welcome Speech 10

1.5.2. Presidential Address 12

1.5.3. Inaugural address 14

1.5.4. Vote of Thanks 18

2. Technical Sessions (Abstracts)

2.1. Nanotechnology as Trendsetter – Dreaming the Future for Big Consequences

Dr. Vidhya Ramaswamy 22

2.2. Magnetic Nanoprobes for Biomedical Applications

Dr. M. R. Anantharaman 30

2.3. Nanotechnology and Environment

Dr. Sunny Kuriakose 34

2.4. Nanomaterials in Medicine

Dr. Deepthi Menon 37

2.5. Quantum Dots for Life Science Applications

Dr. C.K.Mahadevan 45

3. PAPERS PRESENTED- ABSTRACTS

3.1 Preparation and Properties of Medically Important Amorphous Iron Oxide Nanoparticles

S.I. Srikrishna Ramya and C.K. Mahadevan 52

3.2. Synthesis and Characterization of Nano Sizediron Oxide for Biological Applications

Malu Somaraj, P.P.Sharmila, Chithra P.G and Nisha.J.Tharayil 53

3.3 Influence of Preparation Methods on the Crystallite Size and Structure of Titanium Dioxide Nanoparticles

Saisy K. Esthappan, and Rani Joseph 54

3.4. Synthesis of Biomedically Important Nanocrystalline Nickel Sulphide

S. Nagaveena and C.K. Mahadevan 55

3.5. Modification of Polypropylene/Polystyrene blends using Vinyl silane modified Kaolin Clay

Asha Krishnan K, Tresa Sunitha George, K.E George 56

3.6. Utilization of Endophytic Bacteria for Silver Nanoparticle Biosynthesis

Jasim B, Roshmi Thomas, Jyothis Mathew and Radhakrishnan EK 58

3.7. Preparation and Characterization of Rice Husk Ash filled High Density Polyethylene Composites

Ayswarya E.P and Eby Thomas Thachil 59

3.8. Synthesis and Structural Characterization of a Transparent Conducting Oxide Thin Film

Nancy John, P.P. Sharmila, Chithra P.G and Nisha J.Tharayil 60

3.9 Synthesis of Nanocrystalline CoSe by Chemical Bath Deposition

Jaise Maria George, Jewel Jyothi Jose, Jose James and George V Thomas 61

3.10 Synthesis and Characterisation of Polyethyleneglycol Stabilized Silver Nanoparticles and their Antibacterial Activity

Cincy George and Sunny Kuriakose 62

3. FULL PAPERS

3.1. Carbon Nanoparticles Isolated from Natural Sources: An Effective Antibacterial System against Pathogenic Gram Negative and Gram Positive Bacteria

Sheena Varghese, Sunny Kuriakose and Soumya Jose 64

3.2. An Investigation of Adhesive Strength of Nanolayered Silicate Clay Reinforced Epoxy in Aluminium and Styrene Butadiene Rubber Substrate

Bindu Sharmila.T.K, Ebi Thomas Thachil, P.M., Sabura Begum 74

4.3. Synthesis of Calcium and Iodine doped ZnO Nano-Structured Thin Films for Antimicrobial Applications using Silar Method

Sunil C Vattappalam, Deepu Thomas , Simon Augustine , Sunny Mathew 88

4.4. Silica-coated CdSe Quantum Dots for Bioimaging Applications

Vinayakan R, Vibin M and Annie Abraham 95

4.5. Textured Grain Growth in ZnO nano Flowers by Tin Doping

Deepu Thomas, Sunil C. Vattappalam, Sunny Mathew and Simon Agustine 105

4.6. Carboxylated Carbon Nanotube filled NBR / NR Composites for High Dielectric Devices

Shaji.P.Thomas, Saliney Thomas, E.J.Mathew , Marykutty C.V 115

5. NATIONAL SEMINAR PHOTOS 133

1.1. OBJECTIVES OF THE SEMINAR

Nano-science is well recognized as a revolutionary step in various fields of science and a logical field of study for the researchers in the coming years as it is the study of fundamental principles of molecules and structures between one nanometer and hundred nanometers in size. Nano-materials are structurally and functionally prevalent in the organic, inorganic and biological fields. Their unique size dependent properties make these materials superior and indispensible in many areas of human activity. The benefits of nanotechnology are almost unlimited. Nanotechnology has created a growing sense of excitement due to the ability to create and utilize materials, devices and systems to through the control of matter on the nanometer scale. This technology aims tinier and faster instead of bigger and slower.

The biological application of nano- particles is a rapidly developing area of nanotechnology that raises new possibilities in the diagnosis and treatment of various diseases. Current and near future developments in medicine are of interest, because it can be projected beyond them to perceive what will be possible once inexpensive nano- scale manufacturing of highly functional products become a reality. Scientists and engineers believe nanotechnology can be used to benefit human health now and in the future through applications such as better filters for improving water purification, more effective methods of delivering drugs in medicine and new ways of repairing damaged tissues and organs. Applications of nanotechnology during the next few decades can result a very large increase in computer speed, enormous storage capacity, efficient battery storage, reduction in the cost of pure water, stainless clothes and therapies for different types of ailments.

Manufacturing with nanotechnology can solve many of the world's current problems. Nano-scale materials are now in electronic, cosmetics, automotive and medical products. New concepts of regenerative medicine give hope to many patients with organ failure or severe injuries. Nano-particle reinforced polymers, orally applicable insulin, artificial joints made from nano-particulate materials,

surgical blades and suture needles and low calorie food with nano-particulate taste enhancers are the miracles of nanotechnology. Nanotechnology has endless string of application in biotechnology. Nano-biotechnology presents a promising research and development frontier with a tremendous future impact in many areas. Bio engineered nano-particles are used in drug delivery as transport vehicles of diagnostic or therapeutic agents. Nucleic acid ligands or aptameres are used in nano-biomedical applications for targeting diseases or as therapeutics. Magnetic nao-particles function at the cellular or molecular level of biological interactions. Nanotechnology, using advanced polymers as a delivery mechanism may revive genetic therapy as a tool for curing diseases. Nano-biosensors and DNA nano- chips can recognize genetic and molecular events and have reporting abilities, thereby offering the potential to detect rare molecular signals associated with malignancy. Nanotechnology is effective in the diagnosis, treatment and prevention of disease especially by enabling early disease detection and diagnosis, as well as precise and effective therapy. It approaches in surgery, cancer diagnosis and therapy, bio detection of molecular disease markers, molecular imaging, implant technology, tissue engineering and devices for drug, protein, gene and radionuclide delivery. Recent advances in nano-technology have led several groups to recognize the promise of recruiting nano- materials to the ongoing battle against pathogenic bacteria. Direct, real time electric detection of viral particles can be achieved with high selectivity using nano-wire field effect transistors.

Nano- medicine, an offshoot of nanotechnology refers to highly specific medical intervention at the molecular level for curing diseases or repairing damaged tissues such as bone, muscle, nerve chronic pulmonary diseases or coronary artery diseases. Research in nano-medicine will allow for a better understanding of the functioning of the human body at the molecular and nano-metric level and it will thus give us the possibility to intervene beter at pre-symptomatic, acute or chronic stage of illness. Molecular imaging in nano-oncology has considered as a high area in cancer diagnosis. Nano-particles offer a new

method of tumor targeting, which can concomitantly improve the efficacy and decrease the toxicity of existing anti-cancer agents.

1. To update the academic community and enlighten the public about the recent advancements in

1.1. The application of Nanotechnology in agriculture,industry, healthcare, biosensors etc.

1.2. To understand how nanostructures interact with DNA, proteins, membranes, and ultimately with cells

1.3. To understand the fundamental design principles for nanoscale drug delivery methods and enhance understanding of potential nano-toxicological effects

2. To identify the immediate needs of Kerala, Tamil Nadu and Karnataka for the applications of Nanotechnology in various sectors.

3. To create a forum for interaction between potential users of Nanoscience and technology providers

1.2. ORGANIZING COMMITTEE

Very Rev. Fr. Kurian Puthenpura (Manager)

Dr. P. C. Aniyankunju (Principal)

Rev. Fr. Thomas Kanjiravelil (Burzar)

Prof. Jerome P. V. (College Council Member)

Dr. Jochan Joseph (College Council Member)

Shri. Poly Thomas (President, Alumni Association)

Shri. Shaji Thottukadavil (Vice President, PTA)

Dr. Varghese Mathew (HOD, Dept. of Physics)

Prof. Joseph Edward (Former HOD, Dept. of Zoology)

Prof. Joice Joseph (HOD, Dept. of English)

Prof. Mathew Gregory (Dept. of Chemistry)

Prof. Johnson K. Joice (Dept. of Economics)

Dr. Suja N. (HOD, Dept. of Zoology)

Dr. Shibu George (Assistant Professor and Convener, Dept. of Zoology)

1.3 INVITED SPEAKERS

1. **Dr. Vidya Ramaswami**
   Chairperson,
   International Centre for Intellectual Training and Empowerment (INCITE)
   Sri Rams, N.H.Road, Kazhakuttom, Trivandrum, Kerala.

2. **Dr. Nandakumar Kalarikkal**
   Joint Director, Centre for Nanoscience and Nanotechnology
   M.G. University, Kottayam, Kerala.

3. **Dr. Sunny Kuriakose**
   Associate Professor,
   Dept. of Chemistry,
   St. Thomas College, Pala,
   Kottayam, Kerala

4. **Dr. M. R. Anantha Raman**
   Head, Department of Physics
   Cochin University of Science and Technology, Kochi, Kerala.

5. **Dr. C. K. Mahadevan**
   Associate Professor, Department of Physics,
   S.T. Hindu College
   Nagercoil, Tamil Nadu.

6. **Dr. Deepthi Menon**
   Associate Professor
   Centre for Nanosciences,
   Amrita centre for Nanosciences, Kochi, Kerala.

1.4. P R O G R A M M E

DAY – I

21-08-2012

Registration 9.00 – 10.00 am

Inauguration 10.00 – 11.30 am

Prayer

Welcome Speech : **Dr. P.C.Aniyankunju**

(Principal, St.Aloysius' College, Edathua)

Presidential Address : **Very.Rev.Fr.Kurian Puthenpura**

(Manager, St. Aloysius' College, Edathua)

Inaugural Address : ***Rt. Rev. Dr. Selvister Ponnumuthan***

(Bishop of Punalur Diocese)

Felicitations : **Dr. Nandakumar Kalarikkal**

(Joint Director, Centre for Nano Science and Nanotechnology,M.G.University, Kottayam)

: **Dr. Varghese Mathew** (Head, Dept. of Physics, St.Aloysius' College, Edathua)

: **Dr. N. Suja** (Head, Dept. of Zoology, St.Aloysius' College, Edathua)

Vote of Thanks : **Dr. Shibu George** (Assistant Professor & Convenor, St. Aloysius' College, Edathua)

Technical Session- 1

*11.30 – 1.00 pm **Nano-materials and Biomedical Applications**

(**Dr. Nandakumar Kalarikkal** -Joint Director, Centre for Nano Science and Nanotechnology,M.G.University, Kottayam).

*1.00 – 2.00 pm Lunch break

Technical Session- 2

*2.00 – 4.00 pm **Nanotechnology as Trend Setter – Dreaming the Future for Big Consequences**

(Dr**. Vidhya Ramaswami**- Chairperson, International Centre for Intellectual Training and Empowerment).

DAY – II

22-08-2012

Technical Session- 3

*10.00 – 11.30 am **Nanotechnology and Environment**

(**Dr. Sunny Kuriakose**- Associate Professor, Department of Chemistry, St.Thomas College, Pala).

Technical Session- 4

*11.30 – 1.00 pm **Magnetic Nanoprobe for Biomedical Applications**

(**Dr.M. R. Anantharaman** – Head, Department of Physics, Kochin University of Science and Technology)

*1.00 – 2.00 pm Lunch break

Technical Session- 5

*2.00 – 4.00 pm **Quantum Dots for Lifescience Applications**

(**Dr. C. K. Mahadevan**- Associate Professor, Department of Physics, S.T. Hindu College, Nagercoil. Tamilnadu)

DAY – III

23-08-2012

Technical Session- 6

*10.00 - 11.30 am **Nanomaterials in Biology**

(**Dr. Deepthi Menon**- Associate Professor, Amrita Centre for Nanosciences, Kochi)

*11.30 – 1.00 pm Oral Presentation

*1.00 – 2.00 pm Lunch break

*2.00 – 2.30 pm Oral Presentation

*2.30 – 3. pm Feed Back Session

*3.00 – 4.00 pm Valedictory Function and Certificate Distribution

INAUGURAL SESSION

1.5.1. WELCOME SPEECH

Dr.P.C.Aniyankunju

Principal, St.Aloysius College, Edathua.

Respected chair of this inaugural session, Very Rev.Fr. Kurian Puthenpura,the Manager of this college, honorable guest of this morning, Rt. Rev. Dr.Selvister Ponnumuthan,Bishop of Punalur Diocese, Dr.Nandakumar Kalarikkal, Dr.Varghese Mathew, Dr.N.Suja, Dr.Shibu George, participants from other institutions, faculty members and my dear students, special greetings of this day to all!

Small is beautiful, at the same it is powerful also. Atom is small but can be powerful positively as well as negatively. It all depends on our attitude to life and future. The immense potential of nanotechnology can be tapped subject to the concern for life and future. Thus, it involves moral issues. This national seminar on "Emerging Nano Science and its Future in Biology" is a humble attempt on our part to join with the interests and the efforts of the academia at large.

I take this opportunity to congratulate the Department of Zoology in conceiving and conducting this seminar. The respected Manager of our College, Very Rev.Fr. Kurian Puthenpura is on the chair of the session, keeping a close watch on all the proceedings. He has always been a source of guidance and inspiration for us in serving the youth through higher education. I most cordially welcome him.

Honorable guest, Rt.Rev. Dr. Selvister Ponnumuthan is the Bishop of the Catholic Diocese of Punalur. He is the new Bishop of the Diocese with great experience in the field of research in theology and in small Christian communities/Human communities. He has been a professor in a major seminary and faculty member of great institutions. We have close association at CANA, where the John Paul II Higher Institute for Marriage and Family is housed. We were together in the Institute Council. He is very much interested in Music. It is for the

first time Bishop comes to our College. I with all respect extend you a warm and cordial welcome.

I welcome Dr.Nandakumar Kalarikkal, Joint Director of the Centre for Nanoscience and Nanotechnology, one of the collaborators of this National seminar.

I greet and welcome Dr.Varghese Mathew, Head of the Department of Physics.

I extend my sincere congratulation and appreciation to two persons who laboured much for the actualization of this great academic exercise, Dr.N.Suja and Dr.Shibu George, hearty welcome to both.

Faculty members, Scholars and Students from other institutions took all the pain to be here in joining us. It is only with you that the seminar finds its fruits, hearty welcome to all.

I welcome all my fellow teachers, PTA representatives and my dear students.

Welcome to one and all.

Dr.P.C.Aniyankunju

Principal

1.5.2. PRESIDENTIAL ADDRESS

Rev. Fr. Kurian Puthenpura

Manager, St. Aloysius' College, Edathua

Your excellency Rt.Rev.Dr. Selvister Ponnumuthan, Bishop of Punalur Diocese, Respected Dr.Nandakumar Kalarickkal, Dr. P.C. Aniyankunju, Prof. V.T. Thomas, Dr. Varghese Mathew, Dr.N. Suja, Dr.Shibu George invited guests and participants of the seminar..

Edathua church has a long standing history in the promotion of educational and technical ventures and thus it became the educational hub of Kuttanadu. The first educational institution of Kuttanadu began in Edathua towards the end of the 19^{th} century. There is a story behind it. The people approached the Apostolic Vicar of Kottayam (Changanassery) Dr.Charles Laveange S.J. for constructing a big flag post. He guided them to begin an English school to keep their heads high. And thus in 1895 the St. Aloysius English School began. It grew in years and now the 46 year old St. Aloysius College continues the legacy. The college cannot be behind in understanding and promoting newer areas of learning. The three day seminar on "Emerging Nano Science and its Future in Biology" organized by the department of Zoology is a step in this direction.

The world is in urgent need of people of solid and deep knowledge, of a serious culture, a genuine human and social sensitivity and deep faith. Dues Caritas Est, the first encyclical letter of Pope Benedict XVI (2005) underscores the importance of professional formation. At the same time it states that professional competence is not of itself sufficient; there is a need for a formation of heart. It begins with a discontentment of the existing state of affairs and calls for a restorative justice that goes beyond distributive justice. Faith in the power of resurrection will make it possible what appears impossible. It calls for a discerning heart as King Solomon asking Yahweh "give thy servant therefore an understanding

mind … that I may discern between good and evil". Above all dreams speak the language of the heart. A dream however beautiful remains a dream until it is shared; a shared dream gets transformed into a vision. Jesus' work among the dispirited people of Israel did last only a short while; yet he succeeded to share his dream of Reign of God with the small band of companions, and it flourished in a vision of global proportions. We are sharers of that vision.

I hope that the eminent persons who present papers here will take you on the wings to the world of Nano materials and the laws govern them, its application in different fields especially in the field of biology. You need to look into the pros and corns with a discerning heart. How is it going to affect the common man and environment now and in the future? May the papers presented here enlighten you. I wish you all the best. Thank you.

Rev. Fr. Kurian Puthenpura

Manager

1.5.3. INAUGURAL SPEECH

Rt. Rev. Dr. Selvister Ponnumuthan

Bishop of Punalur Diocese

Respected Principal Dr.P. C. Aniyankunju, Very Rev.Fr. Kurian Puthenpura, Dr. Nandakumar Kalarikkal, Dr.Varghese Mathew, Dr.N.Suja, Dr.Shibu George, Distinguished Scientists who are here to present scientific papers, teachers and friends,

When my friend Dr. Aniyankunju, Principal of this college, invited me to visit this prestigious college I was very happy. But when he told me that I should inaugurate a National Seminar of highly scientific nature I was rather perplexed. The reason is simple- I am a lay person in the field of Nano Science and I am not discouraged because you do not expect from me a scientific paper but only benediction.

Let me bring to your attention that in the Holy Scripture where Jesus explains the working of "yeast"(Mt.13,31-33), he brings out how even a very minute addition can bring out a changed /totally changed outcome.

- And so, I do take this opportunity with pleasure to address this seminar specially assembled to consider, the emerging opportunity and influence of nanotechnology.
- Nanotechnology, with its essence of size and control, has already made its gigantic influence and impact in the field of telecommunication, making the size of the world, in the rooming of the pocket or mobile phone.
- I am sure, that the experts of nanotechnology, who are sitting here, shall no doubt assert as Niels Bohr once famously remarked: "it is always difficult to make predictions, especially when they concern the future!" All enthusiasts of nanotechnology assert that it will create revolutions, in every branch of human endeavor.
- Nanotechnology has both indirect and direct applications, in human life. And as we dream, and as these experts sitting here shall avow – nanotechnology shall leap…and should leap surely, with its precision, accuracy and robustness – but for

the security of mankind, for the goodness of a healthy and brighter future; yes, I pray to make this world better and more serene as God designed.

- I am much concerned about the people – both as a spiritual leader and as a social leader.
- Where I am more sensitive is, about the direct application of nanotechnology: the chief direct domains are that of medicine, and chemical synthesis and analysis where the impact of medicine may be debated in forums after forums.
- We should also consider and consider with robustness – the cosmetic formulation – which will be formulated, marketed and widely used in free trading.

Let me just highlight an example:

Eg: In cosmetic formulations – active ingredients in the form of nanoparticles retain the functionality of microparticles – such as the ability to absorb ultraviolet light. Here, since the process is absorption light is not scattered, hence the application of cosmetics does not influence the appearance of the skin.

IMPACT:-The drawback should be noted that the minuteness of the particle can freely penetrate through the skin into the body – and so far, the after effects are unknown!

This can be, or more of this can be the case with direct domains – such as medicine, biology and chemical synthesis and analysis.

- The experts and the exponents of nanotechnology should therefore be the watchdogs also not only of the present society, but that of the generations to come! And so, we should think together – about the increasingly reporting renal problems today, that were not there some 5-10 years back as in the quantum and in the age group as we see today. Why man's major organs get weaken and marred decade by decade, in the midst of all that science, technology and facilities have attained! Where have we lost the measures?
- We should analyse together – the probable cause for – whether it is a direct or indirect impact of a Technology that aided human comfort! Or is it a mere impact of a lifestyle that man welcomed? In any case it is the obligation of the experts and exponents to take remedial steps and to set stops.

- We should foresee together – what should be accepted both in the dynamics and metrics – because LIFE is particular and HEALTH is the supreme concern, in the long run, that cannot be compromised, and if compromised shall end up in nothing but death!
- It is understood that in medicine, nanotechnology may ultimately develop quasiautonomous robots or "nanobots" and microsurgical techniques, where by the said nanobots can be released in to the blood, through which they travel to locate the affected site that need intervention, and carryout the required repair work. This would be a great blessing if adapted, and carried out with the vision of both human wholeness and human freedom.
- Human freedom (Gen 1, 26: Sir 15,15) is unique and shall be upheld in every aspect of life and culture. He does not yield his freedom to anybody as he so uniquely yields his freedom of mind and body to a physian /surgeon. Yes, this he does with the great hope that he shall be saved from the impending deterioration of health or death. There by it becomes the obligation of the physian / surgeon to uphold and safeguard this faith which alone makes the bond. And hence there should be transparency in the administration and in the process as well.
- The Bible clearly states that the human being is an organic whole (Gen 1,26/2,7) and allows him free dominion (Gen 1,26) and that becomes the nature of man. Solomon, the ever most wise man in the history exclaims about this belonging and relationship (Eccl. 3,11-15)
- Science and psychology upholds this WHOLENESS today. It is well accepted that man is a psychosomatic spiritual entity. So to do anything unto man either in supplementing, complimenting or as remedial, should always be aware of this trio-wholeness. An ailing spirit is seen when there is the advice to take the pangs away from mind, to be relieved from the pain of the body (Eccl 11,10), and is attuned not only to the modern neuro/psycho treatment, but to the whole ambience of health care today.
- Man cannot be helped/treated merely in his body – which in turn will affect his psychological self and spiritual tranquility: he cannot be helped/treated merely in his psychic system because it is his self himself and may spoil the other two that are automated by the self : he cannot be helped / treated his spiritual tranquility –

because it is his inner self, the very life that shall affect both his body and mind(1 Thes 5,23/ 3 Jn 2)

- To sum anything done unconcerning this trio-wholeness will end up first in tribulations and then in death. So let us do good, in the doing process, concerning the entity of human, and that entity is the WHOLENESS of man.
- Now in inaugurating, let me feel myself that I am doing something good to mankind, that the experts and exponents sitting here shall do things for the WHOLENESS of man. I feel sure that nanotechnology may achieve it as the medical approach of nanotechnology is not like the pharmaceutical based therapy: but with molecular precision and nano-sensors.

Best of Luck for mankind, in prayers!

Rt.Rev.Dr.Selvester Ponnumuthan

Bishop of Punalur Diocese

1.5.4. VOTE OF THANKS

Dr. Shibu George

Assistant Professor & Convener

St. Aloysius' Colleger, Edathua

Very Rev. Fr.Kurian Puthenpura, our Manager, His Grace, Rt. Rev. Dr. Selvister Ponnumuthan, Bishop of Punalur Diocese, Dr. P.C. Aniyankunju, our Principal, Dr. Nandakumar Kalarikkal, Joint Director, Centre for Nano Science and Nano Technology, M.G.University, Kottayam, Dr. Varghese Mathew, HOD, Physics, St. Aloysius' College, Edathua, Dr. N. Suja, HOD,Zoology, delegates from various institutions research scholars, my colleagues and dear students..

I am very happy to stand in front of you at this great occasion because the Department of Zoology is organizing a seminar at National Level. First of all, I thank the Almighty God for giving the strength for organizing this seminar.

In recent years, UGC has been given more importance for teaching inter-disciplinary subjects in Arts and Science Colleges. When we thought of a topic for the present seminar, we decided to choose an interdisciplinary topic. This is the reason for why we have selected "Nano Science" as the seminar topic. I hope, this National Seminar will inspire your research mind towards Nano Science.

Let me do my duty of proposing gratitude to each and every one of you.

First of all, I thank **Very Rev. Fr.Kurian Puthenpura**, our Manager. Rev Fr. is the Vicar of St.George Forane Church, Edathua. In addition to his busy duties of the Church, he always finds time for guiding the College. He never hesitates whatever demands we put forward him for the development of the College. Respected Father, on behalf of our College, Collaborating institutes and all those who are gathered here, I extend you a deep gratitude. Thank you Father, for your precious presence.

When we thought about the chief guest of the inaugural session, with no substitute, the face came to our mind is the **His Grace Rt. Rev. Dr.Selvister Ponnumuthan**, Bishop of

Punalur Diocese. He is not only a spiritual pacemaker, but also a well known academician. Through his words in key note address, we are really inspired. His Grace, you blessed us with your presence. We are thankful to you for accepting our invitation and also for the pain you took to come over here from Punalur to Edathua. Taking words from heart, on behalf of our Manager, Principal, our department and all the participants, I extend you a deep, sincere gratitude. Thank you Your Excellency.

We the Aloysian family is always agreed one fact that our Principal **Dr. P.C. Aniankunju** is a man of 'Action' rather than words. Because of his untiring, hard work, UGC has sanctioned more than a crore of rupees in the last year for improving the infrastructure facilities of the College. One of his great visions on our College is to develop our College as a Centre for Excellence. The Department of Zoology is always felt a paternal affection from him. Words are more to tell about him, but due to the time limit, I extend a sincere gratitude to Dr. P.C. Aniyankunju. Thank you sir for your all supports and inspiration for organizing this seminar.

Dr. Nandakumar Kalarikkal, is the Joint Director of Centre for Nano Science and Nano Technology, M.G. University, Kottayam. When we contacted him for collaborating with us, he accepted our invitation with pleasure, and he also accepted to serve as a resource person in this seminar. On behalf of each and every one of you, I extend you a deep gratitude. Thank you sir for your presence and also for collaborating with us.

It is my pleasure to propose a vote of thank to **Dr. Varghese Mathew**, HOD of Physics of our College. We have consulted several times for his advice in connection with this seminar. Under his leadership, a national seminar was conducted by the Department of Physics in the last year and all his past experiences helped us a lot for the easy conduct of the present seminar. Sir, on behalf of each one assembled here, I extend you a sincere gratitude. Thank you sir.

Dr.N Suja, the HOD of Zoology is an efficient and dedicated person who always works hard for uplifting our department in all respects. Without her active participation, this seminar would not be possible. She has given an extra care for planning and organizing this seminar. Madam, on behalf of each and every one here, I extend you a sincere gratitude.

The success of the seminar is depending on the active participation of the participants. We have faculty members from various colleges, research scholars, my

colleagues and the students of St. Aloysius, and other Colleges. I take this opportunity to give my thank to each and every one of you.

I extend special thank to the faculty members and research scholars of other institutions for the interest shown to take part in this seminar.

Special thanks go to Prof. Jogi Jose and Dr. Indulal G of Mathematics for helping us for the success of the seminar.

I also thank the non-teaching staff for their support.

Last, but not least, I thank media people, refreshment team, photographers and all others, who helped directly or indirectly for the success of this seminar

Once again, taking words from heart, I thank each and every one of you. Thank you very much.

Dr. Shibu George

Convener

TECHNICAL SESSIONS (ABSTRACTS)

2.1. NANOTECHNOLOGY AS TRENDSETTER – DREAMING THE FUTURE FOR BIG CONSEQUENCES

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Today nanotechnology is still in a formative phase--not unlike the condition of computer science in the 1960s or biotechnology in the 1980s. Yet it is maturing rapidly. Between 1997 and 2005, investment in nanotech research and development by governments around the world soared from $432 million to about $4.1 billion, and corresponding industry investment exceeded that of governments by 2005. By 2015, products incorporating nanotech will contribute approximately $1 trillion to the global economy. About two million workers will be employed in nanotech industries, and three times that many will have supporting jobs. Descriptions of nanotech typically characterize it purely in terms of the minute size of the physical features with which it is concerned--assemblies between the size of an atom and about 100 molecular diameters. That depiction makes it sound as though nanotech is merely looking to use infinitely smaller parts than conventional engineering. But at this scale, rearranging the atoms and molecules leads to new properties. One sees a transition between the fixed behavior of individual atoms and molecules and the adjustable behavior of collectives. Thus, nanotechnology might better be viewed as the application of quantum theory and other nano-specific phenomena to fundamentally control the properties and behavior of matter.

Over the next couple of decades, nanotech will evolve through four overlapping stages of industrial prototyping and early commercialization. The first one, which began after 2000, involves the development of passive nanostructures: materials with steady structures and functions often used as parts of a product.

These can be as modest as the particles of zinc oxide in sunscreens, but they can also be reinforcing fibers in new composites or carbon nanotube wires in ultraminiaturized electronics. The second stage, which began in 2005, focuses on active nanostructures that change their size, shape, conductivity or other properties during use. New drug-delivery particles could release therapeutic molecules in the body only after they reached their targeted diseased tissues. Electronic components such as transistors and amplifiers with adaptive functions could be reduced to single, complex molecules.

Starting around 2010, workers will cultivate expertise with systems of nanostructures, directing large numbers of intricate components to specified ends. One application could involve the guided self-assembly of nanoelectronic components into three-dimensional circuits and whole devices. Medicine could employ such systems to improve the tissue compatibility of implants, or to create scaffolds for tissue regeneration, or perhaps even to build artificial organs. After 2015-2020, the field will expand to include molecular nanosystems--heterogeneous networks in which molecules and supramolecular structures serve as distinct devices. The proteins inside cells work together this way, but whereas biological systems are water-based and markedly temperature-sensitive, these molecular nanosystems will be able to operate in a far wider range of environments and should be much faster. Computers and robots could be reduced to extraordinarily small sizes. Medical applications might be as ambitious as new types of genetic therapies and anti-ageing treatments. New interfaces linking people directly to electronics could change telecommunications.

Over time, therefore, nanotechnology should benefit every industrial sector and health care field. It should also help the environment through more efficient use of resources and better methods of pollution control. Nanotech does, however, pose new challenges to risk governance as well. Internationally, more needs to be done to collect the scientific information needed to resolve the ambiguities and to install the proper regulatory oversight. Helping the public to perceive nanotech soberly in a big

picture that retains human values and quality of life will also be essential for this powerful new discipline to live up to its astonishing potential.

Two main approaches are used in nanotechnology. In the 'bottom-up' approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition. In the 'top-down' approach, nano-objects are constructed from larger entities without atomic-level control. The impetus for nanotechnology comes from a renewed interest in Interface and Colloid Science, coupled with a new generation of analytical tools such as the atomic force microscope (AFM), and the scanning tunneling microscope (STM). Combined with refined processes such as electron beam lithography and molecular beam epitaxy, these instruments allow the deliberate manipulation of nanostructures, and lead to the observation of novel phenomena. Examples of nanotechnology include the manufacture of polymers based on molecular structure and the design of computer chip layouts based on surface science. Despite the promise of nanotechnologies such as quantum dots and nanotubes, real commercial applications have mainly used the advantages of colloidal nanoparticles in bulk form, such as suntan lotion, cosmetics, protective coatings, drug delivery, and stain resistant clothing.

Nanotechnology offers exciting opportunities and unprecedented compatibilities in manipulating chemical and biological materials at the atomic or molecular scale for the development of novel functional materials with enhanced capabilities. It plays a central role in the recent technological advances in biomedical technology, especially in the areas of disease diagnosis, drug design and drug delivery. In this review, we present the recent trend and challenges in the development of nanomaterials for biomedical applications with a special emphasis on the analysis of neurotransmitters. Neurotransmitters are the chemical messengers which transform information and signals all over the body. They play prime role in functioning of the central nervous system (CNS) and governs most of the metabolic functions including movement, pleasure, pain, mood, emotion,

thinking, digestion, sleep, addiction, fear, anxiety and depression. Thus, development of high-performance and user-friendly analytical methods for ultra-sensitive detection of neurotransmitters remain a major challenge in modern biomedical analysis. Nanostructured materials are emerging as a powerful mean for diagnosis of CNS disorders because of their unique optical, size and surface characteristics.

Applications of Nanotechnology ↓

The biological and medical research communities have exploited the unique properties of nanomaterials for various applications (e.g., contrast agents for cell imaging and therapeutics for treating cancer). Terms such as biomedical nanotechnology, bionanotechnology, and nanomedicine are used to describe this hybrid field. Functionalities can be added to nanomaterials by interfacing them with biological molecules or structures. The size of nanomaterials is similar to that of most biological molecules and structures; therefore, nanomaterials can be useful for both in vivo and in vitro biomedical research and applications. Thus far, the integration of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles.

1. Diagnostics

Nanotechnology-on-a-chip is one more dimension of lab-on-a-chip technology. Biological tests measuring the presence or activity of selected substances become quicker, more sensitive and more flexible when certain nanoscale particles are put to work as tags or labels. Magnetic nanoparticles, bound to a suitable antibody, are used to label specific molecules, structures or microorganisms. Gold nanoparticles tagged with short segments of DNA can be used for detection of genetic sequence in a sample. Multicolor optical coding for biological assays has been achieved by embedding different-sized quantum dots into

polymeric microbeads. Nanopore technology for analysis of nucleic acids converts strings of nucleotides directly into electronic signatures.

2. Drug delivery

The overall drug consumption and side-effects can be lowered significantly by depositing the active agent in the morbid region only and in no higher dose than needed. This highly selective approach reduces costs and human suffering. An example can be found in dendrimers and nanoporous materials. They could hold small drug molecules transporting them to the desired location. Another vision is based on small electromechanical systems; NEMS are being investigated for the active release of drugs. Some potentially important applications include cancer treatment with iron nanoparticles or gold shells. Nanotechnology is also opening up new opportunities in implantable delivery systems,' which are often preferable to the use of injectable drugs, because the latter frequently display first-order kinetics (the blood concentration goes up rapidly, but drops exponentially over time). This rapid rise may cause difficulties with toxicity, and drug efficacy can diminish as the drug concentration falls below the targeted range.

3. Tissue engineering

Nanotechnology can help to reproduce or to repair damaged tissue. This so called 'tissue engineering' makes use of artificially stimulated cell proliferation by using suitable nanomaterial-based scaffolds and growth factors. Tissue engineering might replace today's conventional treatments like organ transplants or artificial implants. On the other hand, tissue engineering is closely related to the ethical debate on human stem cells and its ethical implications.

4. Chemistry and Environment

Chemical catalysis and filtration techniques are two prominent examples where nanotechnology already plays a role. The synthesis provides novel materials

with tailored features and chemical properties: for example, nanoparticles with a distinct chemical surrounding (ligands), or specific optical properties. In this sense, chemistry is indeed a basic nanoscience. In a short-term perspective, chemistry will provide novel "nanomaterials" and in the long run, superior processes such as 'self-assembly' will enable energy and time preserving strategies.

5. Filtration

A strong influence of nanochemistry on wastewater treatment, air purification and energy storage devices is to be expected. Mechanical or chemical methods can be used for effective filtration techniques. One class of filtration techniques is based on the use of membranes with suitable hole sizes, whereby the liquid is pressed through the membrane. Nanoporous membranes are suitable for a mechanical filtration with extremely small pores smaller than 10 nm (nanofiltration) and may be composed of nanotubes. Nanofiltration is mainly used for the removal of ions or the separation of different fluids. On a larger scale, the membrane filtration technique is named ultrafiltration, which works down to between 10 and 100 nm. One important field of application for ultrafiltration is medical purposes as can be found in renal dialysis. Magnetic nanoparticles offer an effective and reliable method to remove heavy metal contaminants from waste water by making use of magnetic separation techniques. Using nanoscale particles increases the efficiency to absorb the contaminants and is comparatively inexpensive compared to traditional precipitation and filtration methods.

6. Energy

The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving (by better thermal insulation for example), and enhanced renewable energy sources.

7. Reduction of energy consumption

A reduction of energy consumption can be reached by better insulation systems, by the use of more efficient lighting or combustion systems, and by use of lighter and stronger materials in the transportation sector. Currently used light bulbs only convert approximately 5% of the electrical energy into light. Nanotechnological approaches like light-emitting diodes (LEDs) or quantum caged atoms (QCAs) could lead to a strong reduction of energy consumption for illumination.

8. Increasing the efficiency of energy production

Today's best solar cells have layers of several different semiconductors stacked together to absorb light at different energies but they still only manage to use 40 percent of the Sun's energy. Commercially available solar cells have much lower efficiencies (15-20%). Nanotechnology could help increase the efficiency of light conversion by using nanostructures with a continuum of bandgaps. The degree of efficiency of the internal combustion engine is about 30-40% at the moment. Nanotechnology could improve combustion by designing specific catalysts with maximized surface area. In 2005, scientists at the University of Toronto developed a spray-on nanoparticle substance that, when applied to a surface, instantly transforms it into a solar collector.

9. Use of more eco-friendly energy systems

An example for an environmentally friendly form of energy is the use of fuel cells powered by hydrogen, which is ideally produced by renewable energies. Probably the most prominent nanostructured material in fuel cells is the catalyst consisting of carbon supported noble metal particles with diameters of 1-5 nm. Suitable materials for hydrogen storage contain a large number of small nanosized pores. Therefore many nanostructured materials like nanotubes, zeolites or alanates are under investigation. Nanotechnology can contribute to the further reduction of

combustion engine pollutants by nanoporous filters, which can clean the exhaust mechanically, by catalytic converters based on nanoscale noble metal particles or by catalytic coatings on cylinder walls and catalytic nanoparticles as additive for fuels.

10. Information and Communication

Current high-technology production processes are based on traditional top down strategies, where nanotechnology has already been introduced silently. The critical length scale of integrated circuits is already at the nanoscale (50 nm and below) regarding the gate length of transistors in CPUs or DRAM devices.

11. Quantum Computers

Entirely new approaches for computing exploit the laws of quantum mechanics for novel quantum computers, which enable the use of fast quantum algorithms. The Quantum computer will have quantum bit memory space termed qubit for several computations at the same time.

12. Optics

The first sunglasses using protective and antireflective ultrathin polymer coatings are on the market. For optics, nanotechnology also offers scratch resistant surface coatings based on nanocomposites. Nano-optics could allow for an increase in precision of pupil repair and other types of laser eye surgery.

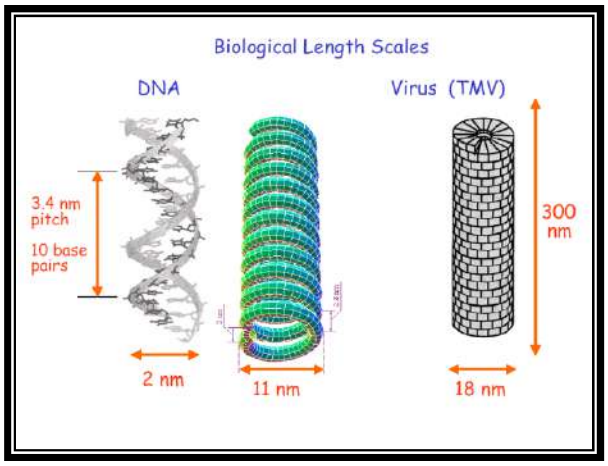
2.2. MAGNETIC NANOPROBES FOR BIOMEDICAL APPLICATIONS

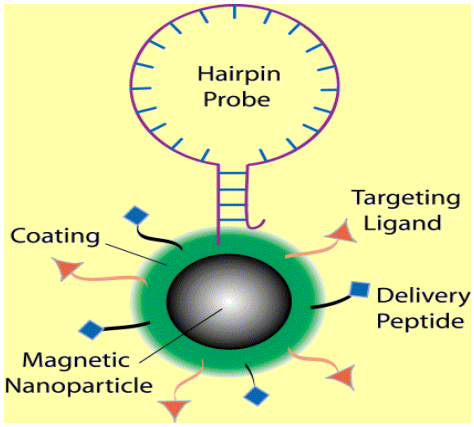
M. R. ANANTHARAMAN

Head, Department of Physics, Cochin University of Science and Technology, Cochin-22, India

Nano magnetic materials are increasingly being investigated as nanoprobes for various applications. In principle, any material compatible with cell size, RNA /DNA/virus and which can easily be sent intravenously are good magnetic probes. They must also be biocompatible with minimum side effects. Thus any ferromagnetic or ferrimagnetic material serve this purpose. The first and foremost criterion of a magnetic nano probe is its dimension**,** stability, biocompatibility and its magnetic characterization like saturation magnetization, coercivity, hysteresis loop. Two forms of iron oxides which are ferrimagnetic and inexpensive, namely, Fe_3O_4 and γFe_2O_3 are biocompatible and sought after for bio medical applications. These forms of Iron oxide when synthesized in the nano form exhibit super paramagnetism and they are found to be ideal for various bio medical applications. Super paramagnetic Iron oxides nanoparticles or commonly called SPIONs are thus unique and can find applications in wide areas such as cell separation, contrast enhancing agents in MRI, drug targeting, drug delivery and also for treatment of cancer. The employment of SPIONs for cancer treatment is called magnetic hyperthermia where in a SPION is functionalized with an appropriate moiety and sent through the blood stream. The advantage of employing these particles for treatment of cancer is that they lock on to the malignant cells and the application of an alternate magnetic field heats the cell or tissue beyond 42^0C inside the body and thus leaving the benign cells intact. Similarly Iron oxide particles can be tagged with appropriate functional groups and could be dragged to the required target site. This could be for drug delivery.

SPIONs are also good candidate for contrast enhancing in Magnetic Resonance Imaging. SPIONs are considered superior to Gd based salts which are presently used for contrast enhancing. SPIONs can be made multifunctional and made fluorescent and can be used for detection and treatment of diseases. The various biomedical applications of SPIONs are illustrated below.





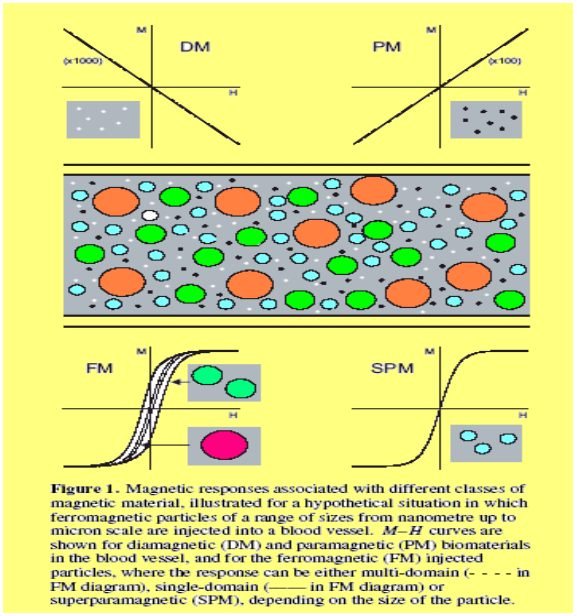


Figure 1. Magnetic responses associated with different classes of magnetic material, illustrated for a hypothetical situation in which ferromagnetic particles of a range of sizes from nanometre up to micron scale are injected into a blood vessel. *M*–*H* curves are shown for diamagnetic (DM) and paramagnetic (PM) biomaterials in the blood vessel, and for the ferromagnetic (FM) injected particles, where the response can be either multi-domain (- - - - in FM diagram), single-domain (—— in FM diagram) or superparamagnetic (SPM), depending on the size of the particle.

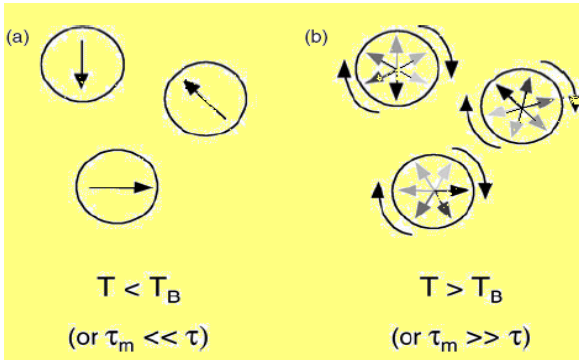


Figure 2. Illustration of the concept of superparamagnetism, where the circles depict three magnetic nanoparticles, and the arrows represent the net magnetization direction in those particles. In case (*a*), at temperatures well below the measurement-technique-dependent blocking temperature T_B of the particles, or for relaxation times τ (the time between moment reversals) much longer than the characteristic measurement time τ_m, the net moments are quasi-static. In case (*b*), at temperature well above T_B, or for τ much shorter than τ_m, the moment reversals are so rapid that in zero external field the time-averaged net moment on the particles is zero.

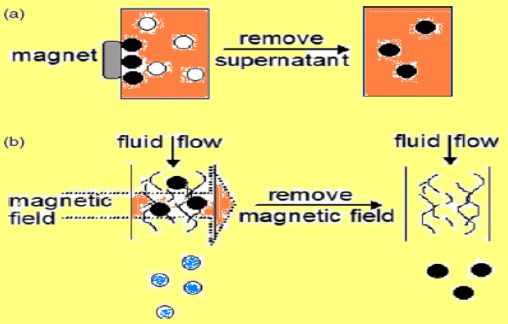


Figure 3. The standard methods of magnetic separation: in (*a*) a magnet is attached to the container wall of a solution of magnetically tagged (●) and unwanted (○) biomaterials. The tagged particles are gathered by the magnet, and the unwanted supernatant solution is removed. In (*b*) a solution containing tagged and unwanted biomaterials flows continuously through a region of strong magnetic field gradient, often provided by packing the column with steel wool, which captures the tagged particles. Thereafter the tagged particles are recovered by removing the field and flushing through with water.

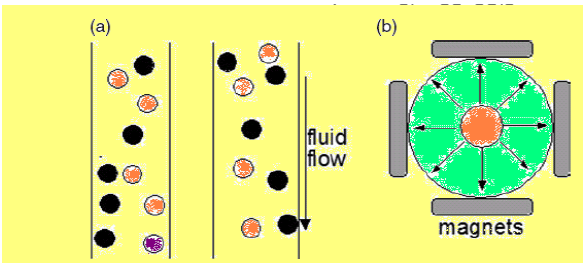
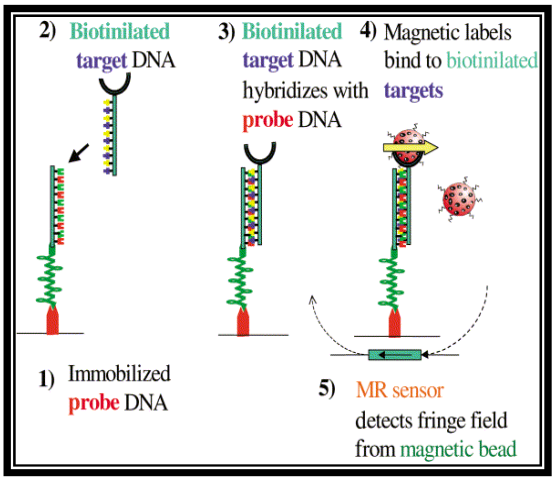


Figure 4. A rapid throughput method of magnetic separation, in which an annular column containing a flowing solution of magnetically tagged (●) and unwanted (○) biomaterials is placed within a set of magnets arranged in quadrature: (*a*) longitudinal cross-section of the annular column; (*b*) transverse cross-section of the four magnets with the resulting magnetic field lines. Under the action of the magnetic field gradient the tagged particles move to the column walls, where they are held until the field is removed and they are recovered by flushing through with water. The central core of the column is made of non-magnetic material to avoid complications due to the near-zero field gradients there.



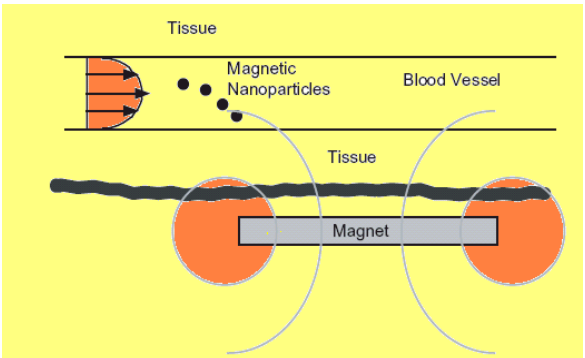
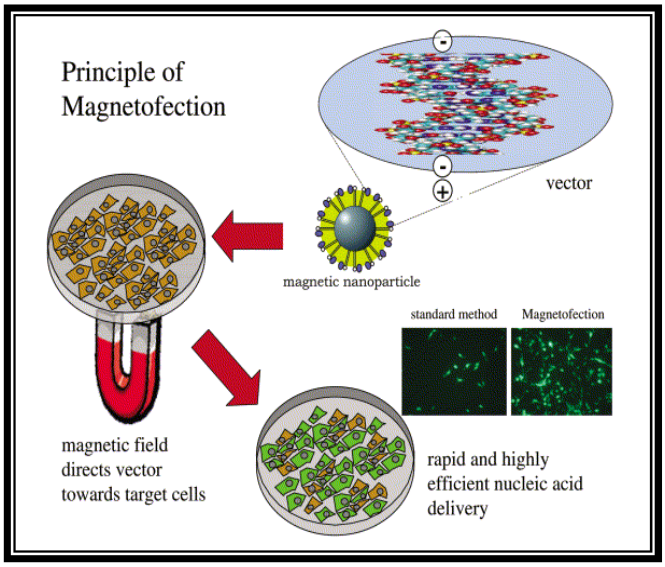
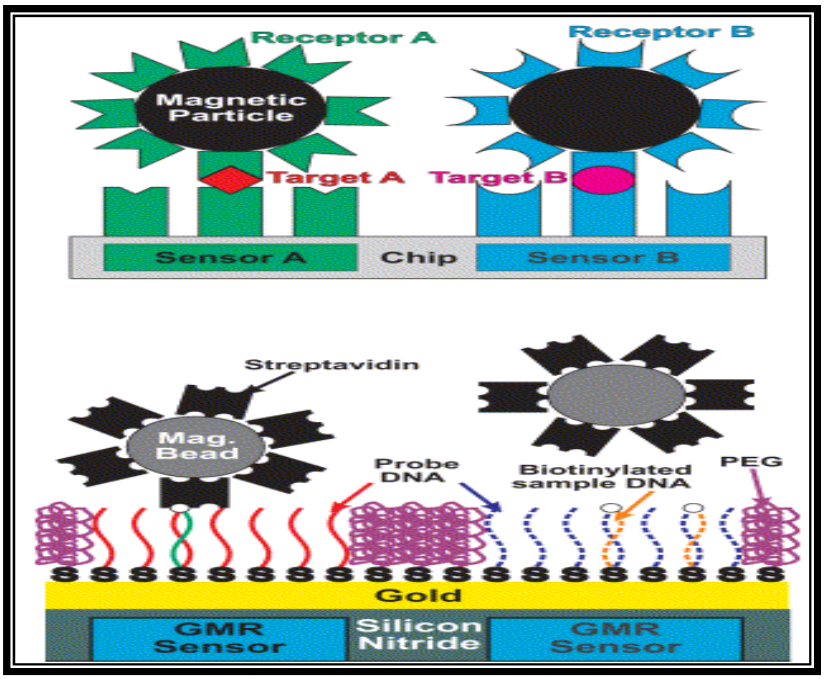


Figure 5. A hypothetical magnetic drug delivery system shown in cross-section: a magnet is placed outside the body in order that its magnetic field gradient might capture magnetic carriers flowing in the circulatory system.





References

(1) An-Hui, L.; Salabas, E. L.; Ferdi, S. *Angew. Chem. Int. Ed.* **2007**, *46*, 122 -1244.

(2) Pankhurst, Q. A.; Connolly, J; Jones, S. K.; Dobson, J. *J. Phys. D: Appl. Phys.* **2003**, 36,167-181.

(3) Omid, V.; Jonathan, W. G.; Miqin, Z. *Adv. Drug Deliv. Rev.* **2010,** 62, 284-304.

(4) Jin, X.; Gang, L.; Henry, S. E.; Hua, A.; Xiaoyuan, C. *Acc. Chem. Res.* **2011,** DOI: 10.1021/ar200044b.

(5) Narayanan, T. N.; Reena Mary, A. P.; Anas Swalih, P. K.; Sakthi Kumar, D.; Makarov, D.; Albrecht, M.; Jayesh, P.; Abdul aziz, A.; Anantharaman, M. R. *J. Nanosci. Nanotechnol.* **2010**, 10, 1-10.

2.3. NANOTECHNOLOGY AND ENVIRONMENT

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Nanotechnology is an emerging field which connects Chemistry, Physics, Biology and Medicine and there is great debate regarding to what extent industrial and commercial use of nanomaterials will affect the environment and ecosystems. The environmental impact of Nanotechnology can be broadly classified into two aspects: the potential for nanotechnologcal innovations to help to minimize the pollution and to improve the environment, and the possibly novel type of pollution that nanotechnological materials might cause if released into the environment.

Nanotechnology could potentially have a great impact on clean energy production. Research is underway to use nanomaterials for purposes including more efficient solar cells, practical fuel cells, and environmentally friendly batteries. The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving (by better thermal insulation for example), and enhanced renewable energy sources. Nanotechnology may find great applications in the field of batteries. Because of the relatively low energy density of conventional batteries, the operating time is limited and a replacement or recharging is needed, and the huge numbers of spent batteries represent a disposal problem. The use of nanomaterials may enable batteries with higher energy content or supercapacitors with a higher rate of recharging, which could be helpful for the battery disposal problem. Current commercially available solar cells have low efficiencies of 15-20%. Research is ongoing to use nanowires and other nanostructured materials with the hope of to create cheaper and more efficient solar cells than are possible with conventional planar silicon solar cells. It is believed that these nanoelectronics-based devices will enable more efficient solar cells, and would have a great effect on satisfying global energy needs. Another example for an environmentally friendly form of energy is the use of fuel cells powered by hydrogen. Probably the most prominent nanostructured material in fuel cells is the catalyst consisting

of carbon supported noble metal particles with diameters of 1-5 nm. Suitable materials for hydrogen storage contain a large number of small nanosized pores.

A strong influence of nanochemistry on waste-water treatment, air purification and energy storage devices is to be expected. Mechanical or chemical methods can be used for effective filtration techniques. One class of filtration techniques is based on the use of membranes with suitable hole sizes, whereby the liquid is pressed through the membrane. Nanoporous membranes are suitable for a mechanical filtration with extremely small pores smaller than 10 nm ("nanofiltration") and may be composed of nanotubes. Nanofiltration is mainly used for the removal of ions or the separation of different fluids. Magnetic nanoparticles offer an effective and reliable method to remove heavy metal contaminants from waste water by making use of magnetic separation techniques. Nanoscale particles increases the efficiency to absorb the contaminants and is comparatively inexpensive compared to traditional precipitation and filtration methods. Some water-treatment devices incorporating nanotechnology are already on the market, with more in development. Low-cost nanostructured separation membranes methods have been shown to be effective in producing potable water in recent researches. Nanoscale iron particles have also shown potential as a detoxifying agent for cleaning environmental contaminants.

The second most important aspects of the environmental impact of nanotechnology are the threats caused by the nanomaterials in new type of environmental pollution. **Nanopollution** is a generic name for all waste generated by nanodevices or during the nanomaterials manufacturing process. This kind of waste may be very dangerous because of its size. It can float in the air and might easily penetrate animal and plant cells causing unknown effects. Most human-made nanoparticles do not exist in nature, so living organisms may not have appropriate mechanisms to deal with nanowaste compared to other kinds of wastes which are degraded by the microbes to harmless materials. This is probably the greatest challenge to nanotechnology: how to deal with its nanopollutants and nanowaste and how to convert them to harmless, non-toxic materials. Environmental assessment is justified as nanoparticles present novel (new) environmental impacts. The most dangerous thing is that it is not currently possible to "precisely predict or control the ecological impacts of the release of these nano-products into the environment." Ecotoxicological impacts of nanoparticles and the potential for bioaccumulation in plants and microorganisms remain under-researched. The capacity for nanoparticles to function as

a transport mechanism also raises concern about the transport of heavy metals and other environmental contaminants. Not enough data exists to know for sure if nanoparticles could have undesirable effects on the environment. Two areas are relevant here: (1) In free form nanoparticles can be released in the air or water during production or as waste by-product of production, and ultimately accumulate in the soil, water or plant life. (2) In fixed form, where they are part of a manufactured substance or product, they will ultimately have to be recycled or disposed of as waste. It is not known yet whether certain nanoparticles will constitute a completely new class of non-biodegradable pollutant. In case they do, it is not known how such pollutants could be removed from air or water because most traditional methods are not suitable for such tasks since their pores are too big to catch nanoparticles.

To properly assess the health hazards of engineered nanoparticles the whole life cycle of these particles needs to be evaluated, including their fabrication, storage and distribution, application and potential abuse, and disposal. The impact on humans or the environment may vary at different stages of the life cycle.

The questions frequently raised by environmental activists and the public related to the safety of nanomaterials are yet to be addressed. Nanotechnology is believed to be the science and technology of the next century or the next millennium which can touch every act and every moment of human life. There is no doubt about the immense possibility of this new technology in making the human life more beautiful and more comfortable. But the potential hazards caused by the products of this new technology and their impact on the environment cannot be left without proper consideration and evaluation.

2.4. NANOMATERIALS IN MEDICINE

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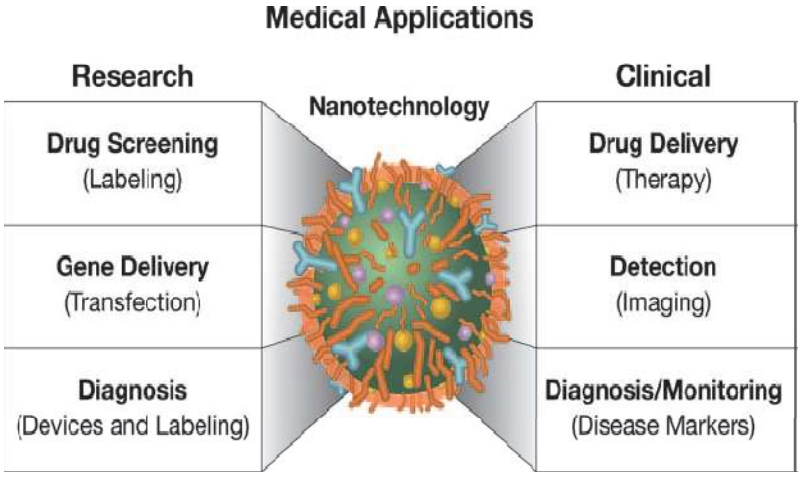
Nanotechnology refers to research and technology development at the atomic, molecular, and macromolecular scale, leading to the controlled manipulation and study of structures and devices with length scales in the 1- to 100-nanometers range. Objects at this scale, such as "nanoparticles," take on novel properties and functions that differ markedly from those seen in the bulk scale. The small size, surface tailorability, improved solubility, and multifunctionality of nanoparticles open many new research avenues for biologists. The novel properties of nanomaterials offer the ability to interact with complex biological functions in new ways—operating at the very scale of biomolecules. This rapidly growing field allows cross-disciplinary researchers the opportunity to design and develop multifunctional nanoparticles that can target, diagnose, and treat diseases such as cancer.

INTRODUCTION

Nanotechnology has achieved the status as one of the critical research endeavors of the early 21st century, as scientists harness the unique properties of atomic and molecular assemblages built at the nanometer scale. Nanoscale structures and materials (e.g., nanoparticles, nanowires, nanofibers, and nanotubes) have been explored in many biological applications (e.g., biosensing, biological separation, molecular imaging, and/or anticancer therapy) because their novel properties and functions differ drastically from their bulk counterparts. Particularly, their high volume/surface ratio, surface tailorability, improved solubility, and multifunctionality open many new possibilities for biomedicine. Moreover, the intrinsic optical, magnetic, and biological properties of nanomaterials offer remarkable opportunities to study and regulate complex biological processes for

biomedical applications in an unprecedented manner. Since life itself, fundamentally, is a collective of processes at nanoscale within cells, it is unavoidable and necessary to understand the impacts of the presence of nanomaterials inside the cells when one explores the advantages and promises of nanomaterials for biomedical applications.

The confluence of these newly acquired capabilities, coupled with advances in imaging, bioinformatics, and systems biology, holds tremendous promise for answering some of biology's most challenging biochemical and genetic questions. By operating in the nanoscale realm, at the very scale of biomolecules, nanotechnology offers a wide range of tools and applications (see Table 1). Near-term applications include drug-delivery platforms, enhanced image contrast agents, chip-based nanolabs capable of monitoring and manipulating individual cells, and nanoscale probes that can track the movements of cells and individual molecules as they move about in their environment. Such an unprecedented ability to observe and influence complex systems *in vivo* and in real time provides detailed information about the fundamental mechanisms involved in the progression of disease and greatly extends the existing toolset for drug delivery and noninvasive drug monitoring.



By providing constructs capable of combining multiple functionalities into a single nanoscale entity, nanotechnology also offers the opportunity to monitor and

detect molecular and cellular changes associated with disease states. Given this multifunctional capability, one can imagine building a nanoparticle that can target a specific tissue or cell type, delivering a contrast agent that allows for noninvasive imaging and a therapeutic payload to the target. A nanoparticle might even contain a reporter, such as an apoptotic marker, which signals that the payload has been delivered and is having the desired therapeutic effect. Clever combinations of different nanostructured materials will support the development of multifunctional nanomedical platforms. Recently, extensive researches have focused on multifunctional nanomedicines for multimodal imaging and simultaneous diagnosis and therapy. For example, MRI contrast agent and fluorescent dye have been simultaneously incorporated into nanostructured materials for the construction of multimodal imaging probes. MRI or optical imaging contrast agent and therapeutic agent have been incorporated in nanostructured matrix for simultaneous diagnostic and therapeutic applications. Such combinatorial nanostructures may eventually provide the means to achieve "personalized medicine" by tailoring drug delivery to individual response. Although this may seem futuristic, several groups have already created multifunctional nanodevices and are testing them in *in vitro* and *in vivo* systems.

Obviously, the successful applications of the nanomaterials in biology and medicine sometimes require them to enter cells. The entry of the nanomaterials into the cell have to cross a major barrier, that is, the ***cell membrane*** that consists of a nanometer-thin lipid bilayer with embedded or peripherally attached proteins. Although it is not a trivial matter, nanomaterials can enter cells via several known processes, including (i) non-specific uptake by endocytosis, where the nanomaterials often end up in endocytic compartments; (ii) direct microinjection of nanoliter of dispersion of nanomaterials, which is a tedious procedure and only applicable to a limited number of cells; (iii) electroporation, which uses charges to physically ''push'' nanomaterials across the membrane; and (iv) mediated/targeted uptake based on the surface functionalization of nanomaterials by using known biological interactions or promoters. Among these processes, the last one holds the

great promises and offers convenient flexibility because nanomaterials themselves normally need a compatible surface to interact with the cells before realizing their own functionalities. Usually, the nanomaterials should be compatible with biological systems, in addition to the required good water solubility. Although there are several developed strategies to coat the nanomaterials for conferring good water solubility and desired functions, an ideal surface coating should satisfy the following basic requirements: (i) preventing the nanomaterials from unwanted aggregation during the long-termstorage; (ii) maintaining good water solubility; (iii) retaining the functionalities of the nanomaterials; and (iv) ensuring the biocompatibility before the nanomaterials interact with their targeted subjects.

QDs as fluorescent dyes

One of the most advanced and exciting forefronts of nanobiotechnology is the applications of quantum dots (QDs) in biology and medicine. QDs are semiconductor nanocrystals with size in the nanorange less than 20 nm. QDs find many applications in biology because the mere change of their diameters significantly shifts their emission spectra. Several useful applications, in the study of subcellular processes of fundamental importance in biology, have highlighted the potential of QDs in nanobiotechnology. As now well recognized, besides their narrow, tunable, and symmetric emission spectra, QDs have much greater temporal stability and resistance to photobleaching than fluorescent dyes do. Furthermore, assisted by appropriate surface functionalization, fluorescent QDs are able to bind to biomolecules to facilitate selective imaging of specific subcellular structures. Moreover, the simultaneous use of QDs with a variety of emission spectra opens the way to use multiplexed optical coding for studying complex biological systems as depicted in Fig.1a. Indeed, the ability to make QDs water-soluble and target them to specific biomolecules has led to promising applications in cellular labeling, deep tissue imaging, assay labeling, and as efficient fluorescence resonance energy transfer (FRET) donors.

Cellular imaging

Cellular labeling using QDs has made the most advanced progress, attracted the greatest interest, and also reached certain stage of commercialization. Recently, numerous reports have appeared describing the use of biofunctionalized QDs that have different sizes to label cells, which permits extensive visualization of cells under continuous illumination to achieve multicolor imaging. Such applications highlighted the advantages offered by QDs as a unique type of fluorophores. For example, the antibody conjugated QDs show capability of multicolor labeling of live cells based on endocytotic uptake and selective labeling of cell surface proteins. By monitoring the QD emission over a week of cellular development, cells were reported to tolerate QDs for extended periods of time. As shown in Fig. 1b, after the QDs functionalized with different antibodies were uptaken by cells or bound to surface receptors, the human epithelial cells were stained by five-color QDs (525-QDs, orange; 565-QDs, green; 605-QDs, magenta; 655- QDs, Cyan; and 705-QDs with red color). Moreover, QDs have been used for *in vivo* biological imaging. Researchers have demonstrated the cancer targeting and imaging by using CdSe@ZnS core—shell QDs that give red emission. After being linked with tumor-targeting antibodies, *in vivo* studies in mice expressing human cancer showed that these QD probes accumulated at the tumor sites. Our research group at Amrita has developed a heavy-metal-free luminescent QD based on Manganese doped zinc sulfide (ZnS), conjugated with a cancer-targeting ligand, folic acid (FA), as a promising bio-friendly system for targeted cancer imaging [Fig. 2].

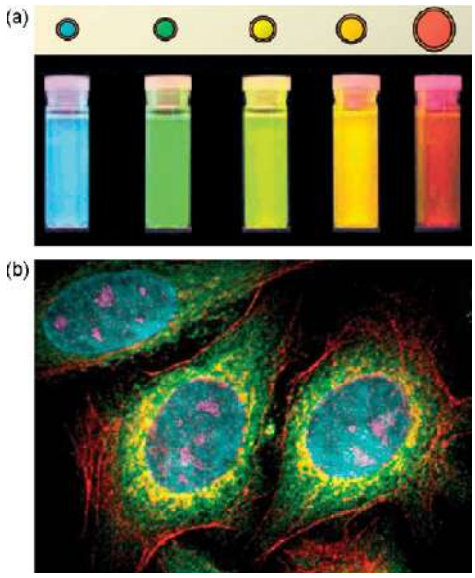


Figure 1 Cellular multicolor imaging using the QDs. (a) The fluorescent emission (from red to blue) of QDs with different sizes excited by a hand-held UV lamp (ex = 365 nm). (b) The multicolor imaging of fixed human epithelial cells using five different color QDs. Cyan corresponds to 655-QDs labeling the nucleus, magenta 605-QDs labeling Ki-67 protein, orange 525-QDs labeling mitochondria, green 565-QDs labeling microtubules, and red 705-QDs labeling actin filaments. (courtesy of Quantum Dot Corp.)

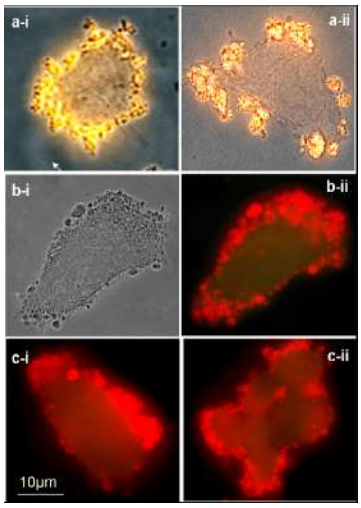


Figure 2. Fluorescent microscopic image showing the interaction of FA–ZnS:Mn QDs with FR+ KB cells: imaging experiment carried out with 10 μM yellow emitting 20% FA (II)–ZnS:Mn: (a-i) imaging carried out with 2 × 10^4 cells/well (24-well plate), (a-

ii) 2 × 10^3 cells/well (24-well plate), (b-i) bright-field image of KB cells with QDs attached to the cell membrane, (b-ii) corresponding true color FL image showing a large aggregation of red-emitting QDs on the cell membrane, (c-i) FL image of another single cell, and (c-ii) FL image showing decoration of a colony of cancer cells with QDs.

For *in vivo* biological imaging applications of QDs, the fluorescent emission wavelength ideally should be in a region of the spectrum where blood and tissue absorb minimally, but is still detectable by the instruments. Thus, the QDs should emit at approximately 700—900nm in the near-infrared (NIR) to minimize the problems of indigenous fluorescence of tissues. Moreover, the spectroscopic properties of NIR QDs would allow imaging deeper penetration than conventional near-infrared dyes. The development of NIR QDs is progressing rapidly. Several cadmium based materials with near infrared emission, such as CdTe@CdSe core-shell Type II QDs hold great promise in several applications. However, the non-cadmium, near-infrared emitting QDs may become a better choice for biomedical applications owing to their enhanced biocompatibility.

SUMMARY AND PERSPECTIVE

Although there are many exciting potential biological applications of nanomaterials reported recently, one needs to discern genuine scientific promises from hypes and constantly improve the fundamental understanding of the interactions of nanomaterials with intracellular structures and process. Unlike the conventional studies in molecular biology, the molecular precision of the interaction between nanomaterials and the intracellular subjects still remains at a rather primitive level. Although it is important to focus on *in vivo* biomedical applications of the nanomaterials and on transforming proof-of-concept into the state-of-the-art technology, which is the major goal for the development of nanobiotechnology, there are many issues and challenges to be addressed. For example, the monodispersity of QDs in water phase remain an issue that hampers the success of single QD imaging. Despite recent progresses on the surface modification of the nanomaterials, many works are to be done to achieve reasonable reproducibility, robust surface coating, and convenient functionalization and bioconjugation

procedures because of the complexity of nanomaterials surface chemistry. Comparing with small molecules, the sizes of nanoparticles sometimes are too big to monitor the intracellular events without causing interferences. For *in vivo* applications, the physiological stability of nanomaterials and their ability to extravasate blood vessels and penetrate into the interstitial spaces is of high concern. The toxicity of nanomaterials to the live subjects and even the whole environment has to be dealt with more and more attentions. The collaboration of the scientists in the fields of materials science, chemistry, physics, biology, as well as medicine would be essential for the successful exploration of the applications of nanomaterials inside cells.

2.5. Quantum Dots for Life Science Applications

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ABSTRACT

The nanostructured materials are known for their unique mechanical, chemical, physical, thermal, electrical, optical, magnetic, biological and also specific surface area properties. Quantum dots are small inorganic nanocrystals / nanoparticles that possess unique properties. Inorganic nanoparticles such as noble metal nanoparticles, magnetic metal oxide nanoparticles and semiconductor nanocrystals are used for bio – conjugation. A variety of remarkable applications in biology / life sciences such as in the field of biosensors, magnetic resonance imaging, drug delivery and magnetic fluid hyperthermia can be obtained by the synergy of magnetic nanocrystals and biomolecules. Herein we present the meaning, synthesis, properties and applications (especially in life sciences) of quantum dots. In addition, we will describe a simple method to prepare the quantum dots with specific examples.

1. INTRODUCTION

Nanoscale science, engineering and technology are concerned with the manipulation of matter on the nanometer length scale which is now generally taken as the 1 to 100nm range. Although nanoscience might simply be seen as a natural and a necessary progression from the (sub) micro-scale engineering that has driven the microelectronics and computing industries thus far, it is not merely the trend towards higher levels of miniaturization but the wealth of novel physical, chemical and biological behaviour that occurs on the nanometer scale that makes nanoscience such a fundamentally exciting and technologically relevant area of research [1].

Fluorescent semiconductor nanoparticles, or quantum dots have been developed for use in imaging and have been employed as markers for biological processes. These nanoparticles offer several advantages over fluorescent dye molecules, as they photobleach much more slowly and their emission wavelength can be finely tuned. Key challenges for further development of quantum dots related to their encapsulation with a biocompatible layer and the need to avoid nonspecific absorption. The size dependent properties of these nanomaterials/nanoparticles have been exploited for this biological labeling. Hence, it is extremely important to control the size and also shape of the nanoparticles / nanocrystals in order to obtain the desired physical property. Therefore, the field of functionalization is almost endless and represents an enormous space to explore. This in combination with molecular imaging can provide a new branch of science, viz. nanobiotechnology imaging research. So, a major challenge in the nanomaterials science is the accurate control of the size and shape, which in turn is directly linked with the nanomaterials processing method [2].

The meaning, synthesis and properties of quantum dots along with a simple method proposed by us for the preparation of semiconductor nanocrystals and magnetic nanoparticles are provided here in some detail.

2. QUANTUM DOTS

Engineered nanomaterials, either by way of a top-down approach (a bulk material is reduced in size to nanoscale pattern (or a bottom-up by atom or molecule by molecule), go beyond just a further step in miniaturization. They have broken a size barrier below which quantization of energy for the electrons in solids becomes relevant. The so-called " quantum size effect" describes the physics of electron properties in solids with great reductions in particle size.

When the reduction from the bulk material (in three dimensions) is in all three dimensions, the material reduces to a point which is well known as quantum dot. The state of matter around this size is referred as mesoscopic state. It is called a nanoparticles or cluster. A nanoparticle is considered as the one whose dimensions

are large enough to exhibit properties that are significantly different from those in bulk state.

Tremendous progress has been made to understand the quantum-size behaviours and to investigate the size and morphology dependent properties. Numerous methods have been developed for the fabrication of such materials. The important methods used are: microwave assisted heating, sonochemical synthesis, sonoelectrochemical synthesis, photochemical synthesis, γ-irradiation method, low temperature solid-state synthesis, solvothermal synthesis, electrochemical template synthesis, microemulsions route, sol-gel synthesis, etc.

Highly fluorescent nanoparticles like the ones derived from group II-VI and III-V semiconductors, usually called quantum dots (QDs), are very appealing for application as labels in cell biology and bioassays development, providing advantages over lanthanides and organic dye probes. The most used semiconductors are CdS, CdTe, ZnSe and CdSe- core / ZnS-shell and ZnSe nanocrystals capped with small organic molecules; the size of these nanocrystals, ranging from 1 to 10nm, may be tuned during their synthesis and their size dispersion is usually moderate.

Interesting features of such nanosized semiconductors are their broad absorption and their narrow, symmetrical, photoluminescence spectra (typical full width at half maximum about 20nm). The photoluminescence maximum position, usually occurring in the visible – near IR, is strongly size dependent, and their fluorescence quantum yield ranges from 10% to 40-50% depending on preparation. The conjugation with biologically interesting molecules is generally achieved adopting a covalent or self-assembling approach.

3. MAGNETIC NANOPARTICLES

Magnetic nanoparticles exhibit unusual behaviours as a result of size effects. Several uses of these nanoparticles have been proposed on high density information storage and a number of biomedical applications like magnetic resonance imaging

(MRI), hyperthermia, targeted drug delivery, cellular imaging [3-5], etc. Also, several clinical applications like detection of liver metastases, metastatic lymph nodes and inflammatory and / or degenerative diseases have been carried out. It is very important that the particles be superparamagnetic for drug delivery systems. Hence, the synthesis of magnetic nanoparticles is an important subject of study in nanomaterials science and technology. Several magnetic nanoparticles based on ferrites and perovskites (such as manganates) are in use for such applications, among them iron oxide (α-Fe_2O_3, γ- Fe_2O_3), cobalt oxide and cobalt iron oxide are the most important ones.

4. A SIMPLE METHOD FOR THE PREPARATION

Microwaves are electromagnetic waves containing electric and magnetic field components. It is well known that the interaction of dielectric materials, liquids or solids with microwave leads to what is generally known as dielectric heating. The frequencies allotted for microwave assisted heating are 918 MHz and 2.45 GHz with the latter frequency being most often used. The latter is also applied in domestic microwave ovens.

Compared with conventional heating methods, microwave assisted heating presents a more rapid and simultaneous environment for the formation of nanoparticles due to the fast and homogeneous heating effects of microwave irradiation.

Therefore, microwave assisted heating method has the advantages of short reacting time, high energy efficiency, and the ability to induce the formation of particles with small size, narrow size distribution, and high purity. When materials are irradiated with microwaves they absorb energy from the microwave field.

Power absorbed, P, is given by

$$P = 2\pi f \varepsilon_0 \varepsilon_r \tan\delta |E_i|^2 .$$

The frequency, f, and the amplitude, $|E_i|$, of the microwaves are instrumental parameters (controllable) while the dielectric constant, ε_r , and the loss tangent,

tanδ, are material parameters. In a given experimental setup ($|E_i|$ and f are held constants), P is determined by ε_r and tanδ.

Therefore, when a mixture of two materials A and B of different dielectric constants, ε_A and ε_B , is exposed to microwave field, the material with higher values of ε_r absorbs energy preferentially and gets heated rapidly compared to the other. A precursor material can be chosen such that it has a high value of ε_r and decomposes by preferential microwave absorption to yield the desired materials. The liquid chosen should be one which does not decompose before the normal boiling temperature. Also, the resulting material should not be soluble in it. The insoluble material product, however, should be prevented from growing into large particles. This is accomplished by the addition of a suitable capping agent to the initial solution. Also, it is necessary to control the microwave power that the solvent does not boil violently.

Water has a very high dipole moment, which makes it one of the best solvents for microwave assisted reactions.

e.g. $CdCl_2 + H_2S \rightarrow CdS + 2HCl$

$Zn(Ac)_2 + H_2S \rightarrow ZnS + 2HAc$

During the formation of the nanoparticles under microwave irradiation, solvents have important influence on the size and morphology of the final products. In different solvents, the collision rate between reactant molecules, the heating rate, and the temperature of the reaction are different. As a result, nanocrystalline particles with different sizes and morphologies could be obtained by using different solvents.

THE ACTUAL METHOD

The required amount of the precursors are dissolved in the solvent and kept in the domestic microwave oven. The oven is operated normally with a frequency of 2.45 GHz and power 840W.

Microwave irradiation is done till the solvent is evaporated completely. The colloidal precipitate obtained is cooled and washed several times with distilled water and then with acetone to remove the organic impurities present, if any. The sample is then dried in atmospheric air and collected as the yield. If necessary

annealing at the required temperature for the required duration can be done to achieve the required result.

ILLUSTRATIONS

CADMIUM SULPHIDE (CdS)

Band gap energy ≈ 2.40 eV

$Cd(ac)_2 + 2$ thiourea $\rightarrow [Cd(thiourea)_2](ac)_2 \rightarrow CdS$ + others

Water and ethylene glycol can be used as solvents

Ethylene glycol gives good yield

Annealing not required

Average crystallite size observed ≈ 2.5 nm

HEMATITE(α- Fe_2O_3)

α- Fe_2O_3 nanocrystals have unique characteristics such as superparamagnetism, high saturation fields and extra anisotropy contributions which arise from the effects of finite size and large surface area. These characteristics lead them into many application areas such as magnetism, catalysis, electrochemistry, biotechnology, etc.

$FeCl_3$ + Urea $\rightarrow$ α- Fe_2O_3 + others

Solvent $\rightarrow$ Ethylene glycol

Annealing the as-prepared sample at 700°C for 1 hour will give α- Fe_2O_3 in the pure form.

Average crystallite size observed is 24.8nm.

References

1. P.Moriarty (2001) *Rep.Prog.Phys*. **64** ,297
2. K.Byrappa, S.Ohara and T.Adschiri (2008) *Adv.Drug Deliv. Rev*. **60** ,299
3. D.E.Speliotis (1999) *J.Magn.Magn.Mater*.**193**(1-3), 29.
4. T.Osaka, T.Matsunaga, T.Nakanishi, A.Arakaki, D.Niwa and B.Lida (2006) *Anal.Bioanal.Chem*. **384**, 593.
5. C.Corot, .Robert, J.M.Idee and M.Port (2006) *Adv.Drug Deliv.Rev*.**58**, 1471.

PAPERS PRESENTED

ABSTRACTS

3.1. Preparation and Properties of Medically Important Amorphous Iron Oxide Nanoparticles

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ABSTRACT

Iron oxide nanoparticles are of considerable interest due to their wide range of applications in fields such as magnetic storage, medicine, chemical industries and water purification. Amorphous iron oxide nanoparticles have been found to be used as magnetic pigments in recording and information-storage media catalysis, magnetic fluids, magneto optical devices and studies of macroscopic quantum tunneling. It is worthwhile mentioning that nanocrystalline iron oxides have been found to be effective as image-intensifying agents for nuclear magnetic resonance imaging, magneto-caloric refrigeration, medical diagnosis, controlled drug delivery and magnetic-induced cancer therapy. Although, there have been a number of studies made on the preparation of crystalline iron oxide nanoparticles, there have been only limited studies on the preparation of amorphous iron oxide nanoparticles. In the present study, we have made an attempt to prepare amorphous iron oxide nanoparticles by a simple solvothermal method using a domestic microwave oven. The prepared sample has been characterized structurally, optically and magnetically by carrying out the relevant measurements. The X-ray powder diffraction measurements indicate clearly the amorphous nature. The average particle size has been found to be 19 nm. The band gap was found to be 1.87 eV**.** The magnetic measurements indicate a super paramagnetic nature with a blocking temperature of $T_B \approx 32$ K. Details will be presented.

Key Word: Iron oxide nanoparticle

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3.2. Synthesis and Characterization of Nano Sizediron Oxide for Biological Applications

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ABSTRACT

Fe_2O_3 is the most common oxide of iron. Among the various forms of iron oxides, maghemite (γ- Fe_2O_3) and hematite (α-Fe_2O_3) are of great importance in technological and industrial applications. They are widely used in applications such as magnetic recording media, optical devices, magnetic resonance imaging, electromagnetic devices medical diagnosis, controlled drug delivery and photo-anode for photo assisted electrolysis of water. Nanoparticles of Fe_2O_3 were prepared by chemical precipitation method using PEG(200) as the stabilizer. Different size of Fe_2O_3 naoparticles were obtained by annealing the precursors at different temperatures. The size and crystal structure of these particles were determined using XRD. The optical characterization of the samples was done using UV-Visible absorption spectroscopy. The samples were also analyzed using FTIR and Micro-Raman spectroscopy. Transformation of γ- Fe_2O_3 to α-Fe_2O_3 was studied by annealing the precursor in the range of 400 to 600°C. DC electrical conductivity of pellets of nanopartiicles of Fe_2O_3 were also studied.

Keywords: Iron oxide, chemical precipitation, DC electrical conductivity

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3.3. Influence of Preparation Methods on the Crystallite Size and Structure of Titanium Dioxide Nanoparticles

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ABSTRACT

Titanium dioxide nanoparticles were prepared by sol gel method and wet synthesis. XRD was used to study the crystallite size and phase of TiO_2 nanomaterials. TiO_2 prepared by sol gel method showed anatase crystal structure when it was calcined at 500^0C and rutile structure when it was calcined at 1000^0C, but the crystallite size was very high compared to anatase form. TiO_2 prepared by wet synthesis method showed rutile form with lower particle size at a cacination temperature of 400^0C. SEM photographs indicated formation of spherical nanopaticles of rutile TiO_2 by wet synthesis. Elemental analysis was done by energy dispersive X-ray atomic spectrum.

Key Word: Titanium dioxide, Nanoparticle

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3.4. Synthesis of Biomedically Important Nanocrystalline Nickel Sulphide

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ABSTRACT

Magnetic nanoparticles exhibit unusual behaviours as a result of size effects and have been proposed to be used in a number of biomedical applications like MRI, hyperthermia, targeted drug delivery, cellular imaging, etc and several clinical applications like detection of liver metastases, metastatic lymph nodes and inflammatory and/or degenerative diseases. Uniform spherical assembled structures with diameters ranging from nano to microscale structures are of great interest because of their high specific surface area. However, the development of simple, mild and effective methods for creating spherical superstructures composed of nanocrystal building blocks still remains a key research challenge. Nanostructured nickel sulphide is one among the useful magnetic nanoparticles. In the present study we have made an attempt to prepare nanocrystalline nickel sulphide by a simple microwave assisted solvothermal method. The prepared nanocrystals have been characterized structurally, chemically and magnetically. The average crystallite size obtained is 20nm. The prepared material exhibits weak ferromagnetism with coercivity 155 Oe and retentivity 0.00012 emu/g. Details will be presented.

Key Word: Nanocrystal, nickel sulphide

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3.1. Modification of Polypropylene/Polystyrene blends using Vinyl silane modified Kaolin clay

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ABSTRACT

Polymer blending is an effective way to combine the properties of individual components together. Polypropylene (PP) and polystyrene (PS) are two of the widely used plastics and their blends have also received considerable attention. However, PP and PS are widely regarded as immiscible due to lack of interfacial adhesion between the components. Several problems of these blends may be caused by poor compatibility of the components. Kaolin clay, potential nanofiller, is not widely used for polymer modification. In this work it is proposed to modify kaolin clay by using triethoxy vinyl silane. XRD, TGA and BET surface area is used to characterize the modified kaolin clay. The results show that property of unmodified clay is improved by adding triethoxy vinyl silane. The modified kaolin nanoclay was added as a modifier in PP/PS blend. Polypropylene and polystyrene / clay Nanocomposites were prepared through melt intercalation technique using Thermo Haake Rheochord mixer at 180^0Cwith a rotor speed of 50 rpm and mixing time was fixed at 8 min. After mixing the melt was pressed in a hydraulic press cut into pieces. Samples for mechanical studies were prepared using Injection mould. The mechanical properties like tensile properties and flexural properties were studied. PP/ PS Nanocomposites were characterized using XRD, TGA. The flow properties were evaluated using MFI. Results show that nanoclay can be used to improve various mechanical and thermal properties of PP/PS blend. XRD result shows a slight increase in d spacing which confirms partial intercalation.TGA studies show that the thermal stability of PP/PS clay nanocomposites is improved by modification. SEM images show good dispersion of modified kaolin in PP/PS blend.

This study shows that polymer nanocomposites can be developed from PP/PS blends using modified kaolin clay.

Key Words: Kaolin clay, Nanocomposites

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3.2. Utilization of Endophytic Bacteria for Silver Nanoparticle Biosynthesis

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ABSTRACT

Nanoparticles based research is well known for its application in variety of areas. Among the various methods for nanoparticle synthesis biological methods is environment-friendly and is a promising way to synthesis particles with desired physio-chemical properties. Due to its interaction with metals, microbes have the innate potential to synthesis of metal nanoparticles and so they can be considered as potential bio factories for nanoparticle synthesis. Many microorganisms can aggregate inorganic material within or outside the cell to form nanoparticles (NPs) through diverse which makes studies on microbial synthesis mechanisms much promising. Biosynthesis of nanoparticles using various plants has been elucidated since bacteria with this property can be greatly expected in association with these plants. Also silver nanoparticles have a number of applications in nonlinear optics, biolabelling, high-sensitivity biomolecular detection and diagnostics, antimicrobials and therapeutics, catalysis and microelectronics. In the current study describes synthesizing potential of endophytic bacterial isolates from selected medicinal plants for the isolation, identification and screening of silver nanoparticle.

Key Word: Nanoparticle

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3.3. Preparation and Characterization of Rice Husk Ash filled High Density Polyethylene Composites

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ABSTRACT

This paper presents the results of a study on the use of rice husk ash (RHA) for property modification of HDPE. Rice husk is a waste product of the rice processing industry. It is used widely as a fuel which results in large quantities of RHA. Here, the characterization of RHA has been done with the help of XRD, ICPAES, light scattering based particle size analysis, FTIR and SEM. Most reports suggest that RHA when blended directly with polymers without polar groups does not improve the properties of the polymer substantially. In this study RHA is blended with HDPE in the presence of a compatibilizer. The compatibilized HDPE-RHA blend has a tensile strength about 18% higher than that of virgin HDPE. The elongation-at-break is also higher for the compatibilized blend. TGA studies reveal that uncompatibilized as well as compatibilized HDPE-RHA composites have excellent thermal stability. The results prove that RHA is a valuable reinforcing material for HDPE and the environmental pollution arising from RHA can be eliminated in a profitable way by this technique.

Key Words: Rice husk ash, RHA

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3.4. Synthesis and Structural Characterization of a Transparent Conducting Oxide Thin Film

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ABSTRACT

There has been a great deal of interest in the preparation of inexpensive thin films of SnO_2 during the last three decades. This is because tin oxide thin films are n-type semiconductors with a large band gap (Eg = 3 eV) having high transparency and very good electrical conductivity. The films are chemically inert, mechanically hard and can resist high temperature. Several potential applications have been reported previously, such as varistors , solar cell applications, electrochromic displays and nanobelts for electrical and sensing properties as well as chemical microsensor applications.Transparent conductive tin oxide thin films have been prepared by vacuum thermal evaporation. The films were characterised by X- ray diffraction (XRD), scanning electron microscopy (SEM), atomic force microscopy (AFM), fourier transform infrared spectroscopy (FTIR), UV- visible spectroscopy. The effects on grain size and band gap are studied with annealing temperature. DC electrical conductivity measurements of nanostructured SnO_2 thin films deposited at different pressures were carried out at different temperatures.

Key words: Transparent conducting oxide, annealing , surface morphology, band gap

3.5. Synthesis of Nanocrystalline CoSe by Chemical Bath Deposition

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ABSTRACT

CoSe have many industrial applications including IR detection and imaging. It is used in the production of standard grades of foods, reagents, agricultural and pharmaceuticals. In this research work, CoSe nanocrystls were prepared by Chemical Bath Deposition technique. This nanocomposite was characterized by UV and XRD. The UV-visible spectrum showed a peak at 207nm, characteristics of cobalt nanoparticles. X-ray diffraction pattern of CoSe nanoparticle indicated the presence particles in the size 1.033nm.

Key Word: CoSe, Nanocrystls

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3.6. Synthesis and Characterisation of Polyethyleneglycol Stabilized Silver Nanoparticles and their Antibacterial Activity

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ABSTRACT

Silver nanoparticles were synthesized in an inexpensive, versatile and reproducible method and the nanoparticles were successfully encapsulated into PEG aggregates. The antibacterial activity of the newly developed system against *E. Coli* was investigated. The most promising result that deliver here is a new outlook to the antibacterial activity exhibited by an encapsulated silver nanoparticle. The results obtained here clearly demonstrate the efficient antibacterial activity of silver nanoparticle encapsulated PEG. The proficient bactericidal activity of silver nanoparticle embedded PEG suggest the use of the system in future biological and biomedical applications.

Key Words: Silver nanoparticles, PEG, antibacterial

PAPERS PRESENTED

FULL PAPERS

4.1. Carbon Nanoparticles Isolated from Natural Sources:

An Effective Antibacterial System against Pathogenic Gram Negative and Gram Positive Bacteria

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ABSTRACT

The carbon nanoparticles (CNPs) were isolated from kitchen soot by physical methods. The nanoparticles obtained were characterized by UV/visible spectroscopy, SEM and XRD. The antibacterial activity of the isolated carbon nanoparticles was tested against various pathogenic bacterial strains such as Gram negative *Proteus vulgaris, Vibrio parahaemolyticus,* and Gram positive *Streptococcus haemolyticus.* The inhibition zones were measured and it was found that the carbon nanoparticles isolated from natural sources are active against these Gram negative and Gram positive bacterial strains.

Keywords: Carbon nanoparticle, Antibacterial, Micro organisms, Gram negative bacteria, Gram positive bacteria

1. INTRODUCTION

Nanotechnology is emerging as a rapidly growing field with its application in science and technology for the purpose of manufacturing new materials at the nanoscale level. Nanotechnology is a field that is burgeoning day by day making an

impact in all spheres of human life. Nanoscience and nanotechnology include the areas of isolation, characterization and application of nanostructured and nanosize materials. Nanoparticles are defined as particles with size in the range of 1 to 100 nm at least in one of the three dimensions. Because of this very small size scale, they possess an immense surface area per unit volume, a high proportion of atoms in the surface and near surface layers, and the ability to exhibit quantum effects [1- 3]. Nanoparticles serve as the fundamental building blocks for various nanotechnology applications.

Micro organism like bacteria, fungi and protozoa produces a wide range of diseases. Latest investigations revealed that most of the microbes are resistant to antibiotics. Biomedical nanotechnology presents revolutionary opportunities in the fight against many diseases caused by pathogenic bacterial and fungal strains. An area with near-term potential is detecting molecules associated with diseases such as cancer, diabetes mellitus, neurodegenerative diseases, as well as detecting microorganisms and viruses associated with infections, such as pathogenic bacteria, fungi, and HIV viruses.

Due to the emergence of infectious diseases caused by different pathogenic microbes the pharmaceutical companies and the researchers are searching for new antimicrobial agents. The emergence and increase of micro-organisms resistant to antibiotics is a serious problem to public health. Some of antimicrobial agents are extremely irritant and toxic to humans. Thus, the formulation of new effective, resistance-free and low -cost and natural origin antimicrobial agents is of great interest [4-7]. It has been previously reported that nano sized antimicrobial formulation could be used as effective bactericidal materials [6-8].

Carbon is one of the most abundant elements in nature. A wide variety of carbon –based nano materials have been prepared, such as carbon nanotubes [9, 13], fullerenes, nanofibers, nanodiamond, carbon nanoonions and other carbonaceous nanomaterials. The unique chemical and physical properties of carbon nanoparticles are largely attributed to their high surface area, special

morphology, unique electronic, optical and thermal characteristics, biocompatibility and chemical inertness [1, 2].

Carbon based nano materials have high antimicrobial activity [8, 9]. Single-walled CNTs exhibit a strong antimicrobial activity and can pierce bacterial cell walls [10-14]. As the size of carbon particles decreases down to nanoscale range their antimicrobial activity increases because of their larger surface area per unit volume and high proportion of atoms in the surface and near surface layers [1- 3]. On the basis of this enhanced effectiveness, carbonaceous nanomaterials aptly employed to fight to human pathogens. The present work deals with the isolation of carbon nanoparticles from natural sources and the analysis of the antimicrobial activity of these nanoparticles against selected bacterial strains.

2. MATERIALS AND METHODS

Isolation of Carbon Nanoparticles from Natural Sources

Glass plates of uniform sizes were hung above the hearth in a chimney so that smoke from this hearth will stick on the glass plate. These were labelled as day 1, day 2 etc and the corresponding glass plates were removed from the smoke hood after 1 day, 2 day etc up to 7 days. The particles sticking on the glass plates were scratched off and collected. The soot after six month duration was also collected and it was labelled as sample 'infinity'. The collected carbon particles were stored for further use by wrapping in aluminium foil with out exposure to sunlight. The crude kitchen soot was dissolved in acetone- water (3:1) mixture. The undissolved residue was discarded after centrifugation or filteration.The clear solution was collected and the solvent was evaporated off on a vacuum rotary evaporator. The carbon nanoparticles (CNP) were collected and the solubility of the carbon nanoparticles was tested and was found to be soluble in acetone, methanol, chloroform, water, DMF and DMSO.

Preparation of Culture Media for Incubation of Micro organisms

1.3 gm nutrient broth powder was dissolved in 100 ml water by gently

boiling in a 250 ml conical flask stoppered by cotton plug. The broth was sterilized by autoclaving at 15 lbs pressure at 121^0C for 15 minutes. It was cooled in a laminar hood, which was disinfected by cleaning thoroughly with absolute alcohol followed by UV irradiation for 20 minutes. A disinfected wire loop size stock micro organisms was transferred into the cold medium under laminar flow. 7.6gm Miller Hinton Agar (M.H. Agar) and 1.2gm Agar Agar were dissolved in 200ml water in a capped bottle. The agar solution was sterilized by autoclaving at 15 lbs pressure at 121^0C for 15minutes. Then it was cooled to 40-45^0C in a laminar hood, which was disinfected by cleaning thoroughly with absolute alcohol followed by UV irradiation for 20 minutes. The medium was then poured into Petri dishes with almost equal agar thickness (2.5mm). The dishes were cooled for sufficient time to solidify the agar medium.

M.H. Agar plates were launed with bacteria using sterile cotton swabs dipped in the nutrient broth culture of bacterial strains. The disc dipped in a solution of carbon nanoparticles was applied in the launed plate. The covered dishes were kept in an incubator oven at 37^0C for 24 hr to test. The entire handling was done inside the laminar hood in front of a flame of a spirit lamp. After the test inhibition zone diameter was measured from the clear zone of agar dish. Sterile disc impregnated with solvent as water alone was also used as control [6, 7, 16, 17].

3. RESULTS AND DISCUSSION

Carbon nanoparticles were isolated by collecting kitchen soot from chimney. It is one of the inexpensive, versatile and reproducible methods for isolation of carbon nanoparticles. Soot is general term refers to impure carbon particles resulting from the incomplete combustion of a hydrocarbon. The impure soot collected were dissolved in (3:1) acetone - water mixture and the carbon nanoparticles collected was dried and characterised.

Characterization of Carbon Nanoparticles

The carbon nanoparticles were characterized by UV/visible spectroscopy, X-ray diffraction and Scanning Electron Microscopy [14, 15]. Carbon nanoparticles were dissolved in acetone- water (3:1) mixture and subjected to UV/visible analysis.

The spectrum showed peaks at 345nm, and 412nm (Figure 1) due to various π – π* transition.

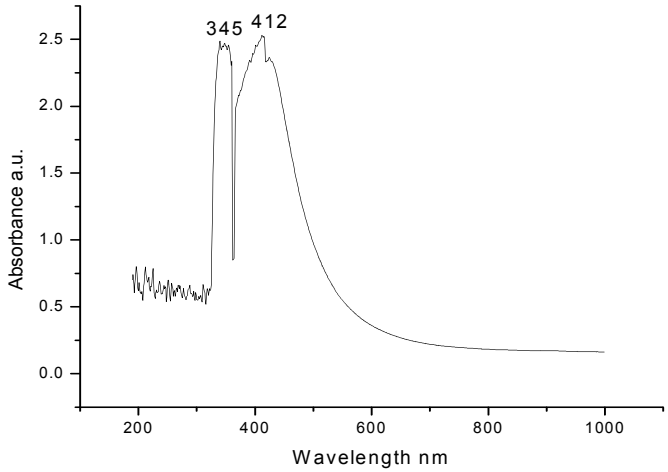


Figure 1. UV/visible absorption spectrum of carbon nanoparticles (sample infinity)

Scanning Electron Microscopy (SEM) was used in this project for high magnification imaging and elemental analysis. Surface analysis of the carbon nanoparticles was carried out by scanning electron microscopy in order to investigate the morphology of the particle. The samples were coated with a thin film of platinum to make their surface conducting. The SEM image of the carbon nanoparticle sample infinity is shown in figure 2.

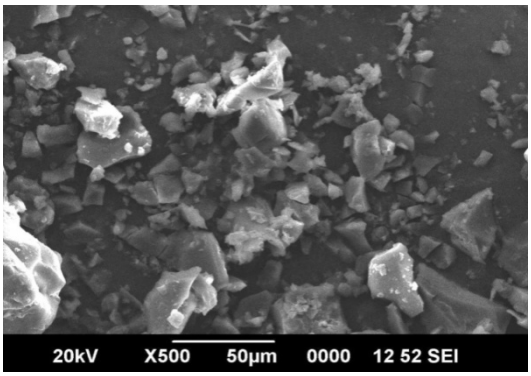


Figure 2. SEM image of carbon nanoparticle (sample infinity)

X-ray crystallography was used as a method of determining the arrangement of atoms within a crystal and also the size of the carbon nanoparticle and it was found to be

29nm. The result of the X-ray diffraction (XRD) analysis of sample infinity are plotted in the fig: 3

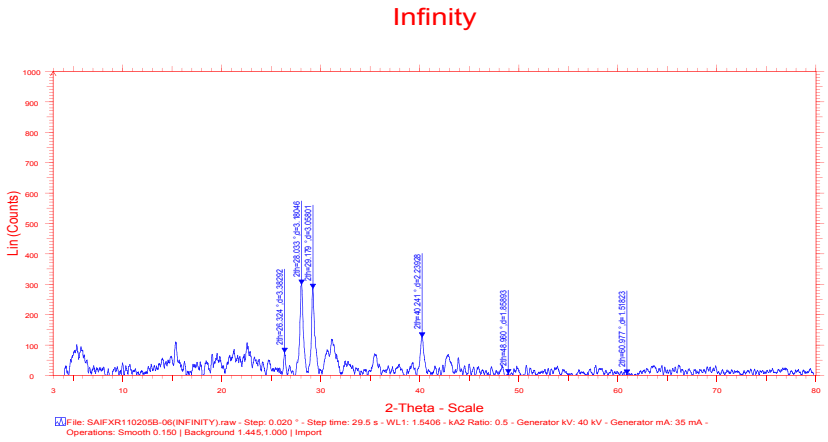


Figure 3. XRD pattern of carbon nanoparticles (sample infinity

Antibacterial Activity of Carbon Nanoparticles

The antibacterial activity of isolated carbon nanoparticle was tested by disc diffusion method.

Bacterial Strains

For *in vitro* screening, bacteria, such as *Proteus vulgaris, Vibrio parahaemolyticus,* and *Streptococcus haemolyticus* were selected. The strains were collected and were sub cultured and stocked on the semi solid nutrient Agar slants and kept at 4^0C in the refrigerator. The micrograms were transferred to the Nutrient Broth prior to inoculation. The antibacterial activity of carbon nanoparticles isolated from carbon soot was investigated against various pathogenic bacteria of Gram negative strains using disc diffusion method. Two samples were prepared. The solution of CNP isolated from acetone as sample I and the solution of CNP from (3:1) acetone- water mixture as sample II. Using sterile micro pipette 200µlts of the samples of carbon nanoparticles solutions were poured into the discs. After incubation times the different levels of zone (200 µl) were measured. The diameter

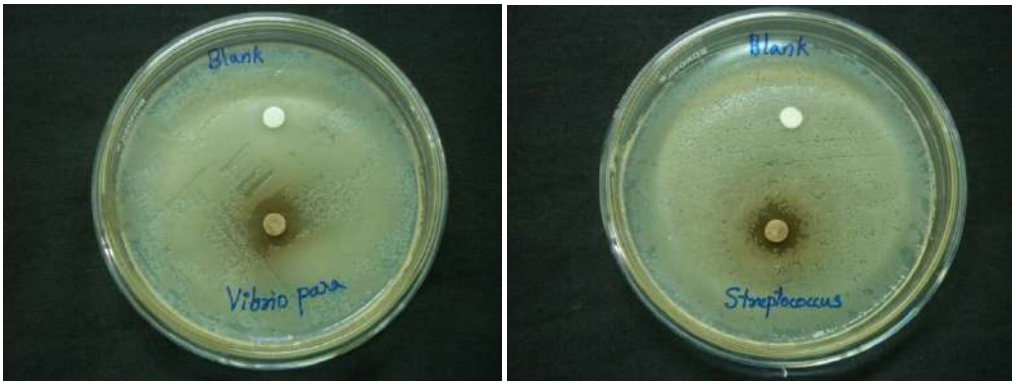
of inhibition zone for *Proteus vulgaris* was 16 mm. The inhibition zone for *Vibrio parahaemolyticus and Streptococcus haemolyticus* was found to be 20 mm and 17 mm respectively. The results are summarized in table 1.

Table 1: Antibacterial activity of carbon nanoparticles

Sl.No	Bacterial strain tested	Diameter of zone of inhibition (in mm)
1	*Proteus vulgaris*	16
2	*Vibrio parahaemolyticus*	20
3	*Streptococcus haemolyticus*	17



Figure 4. Antibacterial effects of carbon nanoparticles against *Proteus vulgaris*



(a) (b)

Figure 5. Antibacterial effects of carbon nanoparticles against (a) *Vibrio parahaemolyticus* and (b) *Streptococcus haemolyticus*

4. CONCLUSION

The carbon nanoparticles were isolated from natural sources such as kitchen soot. The carbon nanoparticles were characterized by UV/visible spectroscopy, SEM and XRD. This work integrates nanotechnology and microbiology, leading to possible advance in the formulation of new types of bacterial strains. One of the most promising applications of carbon nanoparticles that we determined from our study is its antibacterial activity. An antibacterial drug in medication is used to treat bacterial infections. The antibacterial properties of carbon nanoparticles collected from sample infinity were studied and found to be effective against bacterial strains such as *Proteus vulgaris, Vibrio parahaemolyticus,* and *Streptococcus haemolyticus* . The inhibition zone measured in millimeter clearly demonstrated the potential activity of carbon nanoparticles against Gram negative bacterial strains such as *Proteus vulgaris, Vibrio parahaemolyticus* and Gram positive *Streptococcus haemolyticus.* The kitchen soot was employed as an antimicrobial agent since ancient times, and was called the "old woman's remedy". This is nature friendly, inexpensive and can be scaled up to any quantity. Due to the outbreak of the infectious diseases caused by different pathogenic bacteria and the development of antibiotic resistance the pharmaceutical companies and the researchers are

searching for new antibacterial agents. In the present scenario nanoscale materials have emerged up as novel antimicrobial agents owing to their high surface area to volume ratio and its unique chemical and physical properties. So carbon nanoparticle is a boon to pharmaceutical industry. The work presented in this paper can be extended further to develop a series of antimicrobial agents of natural origin and this work explores the immense possibilities of our natural resources as biomedical and therapeutic agents if these are formulated into nanosized and nanostructured materials.

6. ACKNOWLEDGEMENT

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7. REFERENCES

1. Pradeep T.. NANO: The Essentials. *Tata McGraw-Hill Education, New Delhi*; 2, 2007.

2. Chen, H. and Roco, M. Mapping Nanotechnology Innovations and Knowledge, Global and Longitudinal Patent and Literature Analysis Series. *Springer; U.S.* 2009.

3. Kyriacou, S.V., Brownlow, W.J., Xu, X.H.N. Biochemistry. 43; 140-147, 2004.

4. Abarca, M., Bragulat, M., Castellá, G. and Cabañes, F. Appl. Environ Microbial, 60 (7), 2650–2652, 1994.

5. Schuster, E., Dunn-Coleman, N., Frisvad, J. and Van Dijck, P. Applied microbiology and biotechnology, 59 (4-5), 426–435, 2002.

6. Cincy George., Sunny Kuriakose, Prakashkumar B. and Tessymol Mathew. Supramolecular Chemistry, 22 (9), 511–516 (2010).

7. Cincy George., Sunny Kuriakose., Shibumon George and Tessymol Mathew., Supramolecular Chemistry, iFirst article, 1–6 (2011).

8. Ramadi, Muntaha, Ph.D., Study of the nanomaterials and their antimicrobial activities, Texas Southern University, 3447362, 2009.

9. Liu S., Wei L., Hao L. et al., "Sharper and faster "Nano darts" kill more bacteria: a study of antibacterial activity of individually dispersed pristine single-walled carbon nanotube," *ACS Nano*, vol.3, no.12, pp. 3891–3902, 2009. View at Publisher · View at Google Scholar · View at PubMed· View at Scopus.

10. Jia G., Wang H., Yan L. et al., "Cytotoxicity of carbon nanomaterials: single-wall nanotube, multi-wall nanotube, and fullerene," Environmental Science & Technology, vol. 39, no. 5, pp. 1378–1383, 2005. View at Publisher · View at Google Scholar · View at Scopus.

11. Yang C., Mamouni J., Tang Y., and Yang L., "Antimicrobial activity of single-walled carbon nanotubes: length effect," Langmuir, vol. 26, no. 20, pp. 16013–16019, 2010. View at Publisher ·View at Google Scholar · View at PubMed · View at Scopus.

12. Arias L. R. And Yang L., "Inactivation of bacterial pathogens by carbon nanotubes in suspensions,"Langmuir, vol. 25, no. 5, pp. 3003–3012, 2009. View at Publisher · View at Google Scholar · View at PubMed · View at Scopus.

13. Kang C.S., Herzberg M., Rodrigues D. F., and Elimelech M., "Antibacterial effects of carbon nanotubes: size does matter," Langmuir, vol. 24, no. 13, pp. 6409–6413, 2008. View at Publisher· View at Google Scholar · View at Pub Med · View at Scopus.

14. Prabhakar Misra and Dubinskii, Editors, Marcel Dekker, *Ultraviolet Spectroscopy and UV Lasers*, New York, 2002.

15. Goldstein, G. I., Newbury, D. E., Echlin, P., Joy, D. C., Fiori, C. and Lifshin, E., *Scanning electron microscopy and X-ray microanalysis*. New York: Plenum Press, 1981.

16. Laboratory Procedures for Microorganisms, http://www.cabri.org/guidelines/micro-organisms/M203Ap1.html.

17. http://www.scribd.com/doc/28514268/Microbiology-Culture-Media-Manual.

4.2. An Investigation of Adhesive strength of Nanolayered Silicate Clay Reinforced Epoxy in Aluminium and Styrene Butadiene Rubber Substrate

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ABSTRACT

Nano composite adhesives based on epoxy resin Araldite GY 250 (Bisphenol A) and modified nanoclay,Closite 93 A were prepared by mechanical stirring followed by sonication.Aradur HY 951 was used as the hardener. A series of these composites were prepared with varying compositions,viz 1,2,3,4 and 5 phr of nanoclay.The major objective was to examine the role of epoxy nano composite in the area of epoxy bonding against two substrates having different surface characteristics ,Aluminium (Al) and Styrene Butadiene Rubber (SBR) . 3 amino propyl triethoxy silane was used as the adhesion promoter.The adhesive performance was studied by measuring lapshear strength and peel strength. The result shows a substantial increase in the adhesive strength by the addition of nano clay in the case of Al/Al bonding.There is a 50% increase in Al/Al lap shear strength at 0.99 wt% of nanoclay. Peel strength also shows improvement with nanoclay. The improvement in adhesive properties in the case of SBR/SBR bonds was nominal. The morphology of nanocomposite was investigated by XRD studies. X ray diffraction shows that clay distribution in the polymer matrix is of the exfoliated kind at lower level loading and partially exfoliated at higher loading.

Key Words : Epoxy resins ,Organo clay,Adhesive strength ,SBR substrate

1. INTRODUCTION

Epoxy resins are among the most important base materials for high performance adhesives and in structural applications as the matrix materials of fiber- reinforced composites [1]. They have been widely used in packaging of electronic components, making of industrial coverings, and adhesive industry because of mechanical strength, good thermal resistance and great stickiness to most of materials. However, since they are usually brittle and vulnerable to crack, ductile thermoplastic materials such as micro- sized rubber or nylon particles are added to the polymers to increase their fracture toughness, which compromises the strength of thermoset polymers [2]. Much work has been carried out to improve the properties of epoxy resins and nano particle seem to be attractive compounds for the reinforcement [3]. Due to their small size and large surface area, nano reinforcements would be able to provide unique combination of properties with only small amounts which are not possible to be reached for conventional fillers with sizes in the micrometer range. Nano particles have already been components of most adhesive formulations including epoxy based adhesives [4] .The nanoparticles have included fumed silica for the adjustment of rheological properties ,carbon black as a black pigment or to give antistatic properties and organically modified clay for tuning the rheological behavior of the adhesives. Nanotechnology also provides improvements in the mechanical, thermal, and permeation properties of epoxy adhesives [5]. In addition, the use of nanoparticles such as nanofibers, nanotubes and graphite, various forms of nanosilicates offer promising improvements in the above mentioned adhesive properties with practicality and low cost.

Most epoxy resins that are used in adhesives are based on bisphenol A diglycidyl ether or Bisphenol F diglycidyl ether. Curing is carried out in most cases by using amines, anhydrides or dicyandiamide as curing agent. Recently epoxy reinforced with nano-scale layered silicate clay have drawn significant attention and have been extensively studied [6-28]. Clays find wide range of applications, in various areas of science, due to their natural abundance and the propensity with

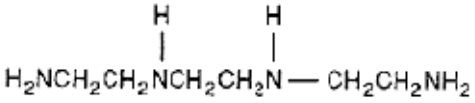
which they can be chemically and physically modified to suit practical technological needs. The most commonly studied nanoclays are modified layered clays, especially montmorillonite,due to its high cation exchange capacity (CEC), excellent ability to swell, high platelet aspect ratio and ease with which their surface can be modified [29]. Presence of inorganic cations on the basal planar surface of montmorillonite layers makes it hydrophilic in nature and hence renders the clay ineffective for absorption of aliphatic and relatively hydrophobic compounds. Modification of clays changes the hydrophilic nature of clay to hydrophobic and increases the interlayer distance between their layers [30]. Therefore, it assures better dispersion in the organic polymer matrix with expanded interlayer spacing. These organic cations also increase its wettability and thermodynamically favorable interactions with organic molecules. Due to its nanoscale dispersion, increased mechanical, thermal, barrier properties are observed in the nano composites. Depending on the nature of the layered clay, polymer matrix and level of interaction between them, 3 different types of polymer nanocomposite morphology are observed .They are conventional, intercalated and exfoliated nanocomposites [31]. If the clay layers and polymer are not compatible, clay layers forms separate phases. Therefore the clay will provide little mechanical reinforcement in conventional composites. In intercalated nanocomposites, polymer molecules penetrate into the galleries of clay and interlayer spacing is increased. Exfoliated nanocomposits are obtained when the clay layers are completely delaminated by the polymer matrix and homogenously dispersed in the polymer matrix. Due to this homogenous distribution of the layers exfoliated nanocomposites exhibit superior properties compared to intercalated and phase separated ones [32]. The potential of using nano fillers for enhancement of adhesive properties is possible only if agglomeration between the particles is avoided and good interfacial bonding between particle surface and resin matrix is obtained.

The primary objectives of the current study were to investigate epoxy nano clay composite formation through its morphological examination and to document macro adhesion strengths (lap shear and peel) in two different substate such as

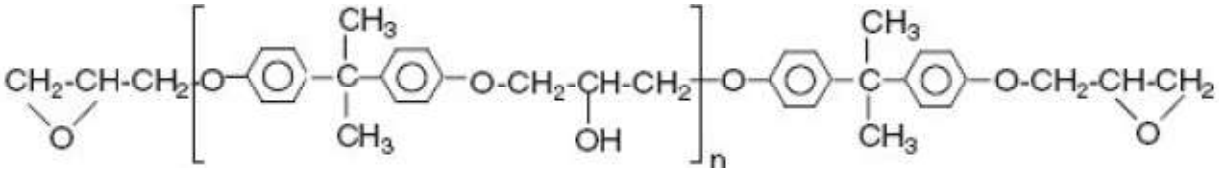
Aluminium (Al) and Styrene Butadiene Rubber (SBR). This study attempts to discover benefits of adding different amount of nano clay to adhesive systems.

2. MATERIALS AND METHODS

The matrix used in the present study was epoxy resin Araldite GY 250 based on diglycidyl ether bisphenol A and Triethylene tetramine hardener under the commercial name HY 951 and was purchased from Emax glass fibre and accessories (P) Ltd Chennai. The reinforcing clay nano particle was Cloisite 93 A, an organoclay, from Southern Clay Corp. It is a methyl dihydrogenated tallow ammonium montmorillonite. The cation exchange capacity is 90 mequiv/100g of clay. The weight loss of Cloisite 93A on ignition is 40 wt %. Table 1 shows physical properties of Cloisite 93A. The adhesion promoter, an amino silane (3 Aminopropyl triethoxy Silane) was purchased from Sigma Aldrich Banglore, India and was used as received .The Aluminium substrate used in this study was extruded aluminium alloy AA 6060-T6.It was supplied by Hindalco Industries Ltd., Mumbai,India . Styrene Butadiene Rubber (SBR 1502) was obtained from Japan Synthetic Rubber Co.Ltd.Tokyo.



Triethylene tetramine



Diglycidylether bisphenol A(DGEBA)

Table 1 Physical properties of Cloisite 93A

Density (g/cm3)	**1.88**
Surface area (m^2/g)	**800**
Crystalline particle size from XRD (nm)	**10.78**
d-spacing, d_{001} (Å)	**23.72**

Preparation of epoxy nano clay composite adhesive

The preparation consists of mixing of clay 1, 2,3,4,5 phr in the epoxy resin. Firstly, the clay and the epoxy resin were carefully weighed and mixed together manually in a suitable beaker followed by mixing with a mechanical stirrer for 45 minutes. Then the mixing was carried out through high intensity ultrasonic irradiation for another 30 mts with pulse mode 07 sec on and 03 sec off. To avoid the temperature rise during the sonication process, external cooling was employed by submerging the beaker containing the mixture in an ice bath. Mixture was degassed under vacuum for 30 mts. Afterwards 10% hardener was added to the epoxy resin, followed by mixing with a mechanical stirrer for about 5 mts. Again the mixture was degassed for about 5 minutes. Add 2 phr 3-Amino propyl triethoxy silane It is then pasted on Aluminium and SBR substrate to find out the adhesive strength.

Metal to Metal bonding –Substate preparation

Metal strips of size 100 × 25 mm were machined from plain sheets of 1.6 mm thickness to serve as the metal substrates for lap shear studies on metal to metal bonds. Mechanical cleaning (surface roughening) was done with a No.100 emery paper. Solvent degreasing was done by trichloroethylene followed mechanical cleaning.

SBR to SBR bonding -Substrate preparation

The rubber compounding for the preparation of elastomeric substrate was done on laboratory size (15 × 30 cm) two roll mills at a friction ratio of 1:1.25 as per ASTM D 3186. The compounding recipe for the substrate is given in the table 2 below. The compounding ingredients were added in the following order: activators, fillers, processing aids, accelerators and curing agents. After complete mixing the compound was homogenised and finally sheeted out. The time of cure was in accordance with the results of cure studies initially performed on a Rubber Process Analyser (RPA 2000, supplied by Alpha Technologies, USA). A cure time of 11.9 minutes is obtained .Optimum cure time is the time required for the torque value of $[(T_{max} - T_{min}) \times 0.9 + T_{min}]$, where T_{max} is the maximum torque and T_{min} is the minimum torque.

The compound was subsequently moulded in an electrically heated hydraulic press employing a pressure of 200 Kg/cm^2 and a temperature of 150^0 C to form strips of 100 × 25 ×2mmsize. Mechanical cleaning (surface roughening) was done with a No.100 emery paper. The roughened rubber strips were further cleaned with a soft cloth.

Table-2 SBR substrate Compounding Recipe

Ingredient	phr
SBR 1502	100
Zinc Oxide	5
Stearic acid	1
HAF	50
Aromatic oil	10
Vulcanox HS	1
Vulcanox 4020	1
MBTS	0.5
TMTD	0.5
Sulphur	1

Characterization and property studies

X-ray powder diffraction Analysis

X-ray powder diffraction patterns were obtained by busing a Bruker AXS D8 Advance X-ray powder diffractometer equipped with Cu Kα radiation. The samples were scanned in the range of 2-25 at increment step of scanning 0.020^0 at a wavelength of 1.541 A^0 operating at 40KV and 35 mA.

Scanning electron microscopy

The fracture surface of lapshear and organo clay was examined using a JOEL Model JS M 840A scanning electron microscope. The fracture surface was gold coated prior to SEM investigation to avoid charging.

Tests for Adhesive joints

Lap shear tests

The lap shears test measures the strength of the adhesive in shear .It is done as per ASTM D 1002. This is the most commonly used shear test for structural adhesives. Testing is carried out by pulling the two ends of the overlap in tension causing the adhesive to be stressed in shear. This test is called tensile shear test. It is expressed in force per unit bond area.

Peel Tests

Peel tests involves stripping away a flexible adherend from another adherend that may be flexible or rigid**.**The specimen is usually peeled at an angle of 90 or 180 degrees. The most common types of peel tests are the T-Peel, 180^0 peel, the floating roller peel and the climbing drum methods. Peel values are recorded in Newton / mm of width of the bonded specimen. The most popular of all peel tests is the T peel test and it is carried out as per ASTM D 1876. This test is used when both adherends are flexible.

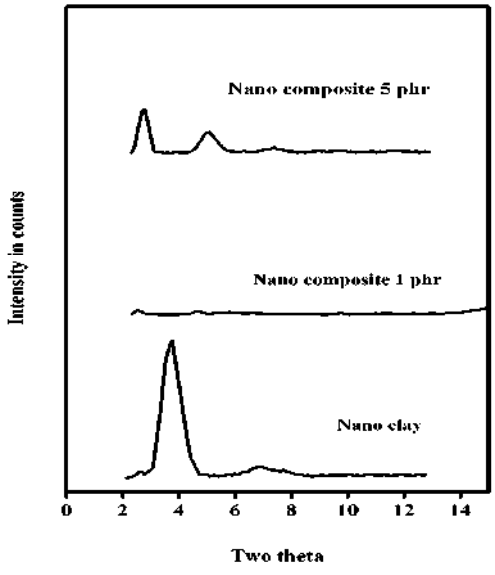
The peel and shear strength tests were performed on Shimadzu Universal testing machine (10KN) with a grip separation rate of 50 mm /min.

3. RESULTS AND DISCUSSIONS

X-Ray diffraction measurements

It is known that structure and morphology has a significant influence on the final properties of nanocomposites. X-ray diffraction measurements are used to characterize the morphology of nanocomposites.If there are reflections in the low angle region this indicates intercalated nanocomposites. However if the peaks are broad or disappeared completely this signifies complete exfoliation [19]. The XRD pattern for the organo clay and epoxy nano clay composite is shown in Figure-1. It is seen that the basal spacing and diffraction peak of d_{001} plane of organo clay is 23.72 A^0 at 3.722 2θ value. For the sodium montmorillonite clay it is about 13 A^o [30]. The presence of organo ion in the interlayer gallery region of organo clay causes higher d-spacing than the unmodified clay.Besides its presence changes hydrophilic nature of Na^+ in the interlayer region and makes more compactibility with the the polymer matrix.

Figure-1



By using the Debye-Scherrer formula $d = \frac{0.9\lambda}{\beta \cos\theta}$ (Where λ is the wavelength of X ray 1.5418 A^0 and β is Full Width at half maximum of diffraction peak (FWHM) and θ is the angle corresponding to the peak) for calculating crystalline particle size, it is found that the particle size is 10.78 nm for FWHM 0.738 and 3.122 two theta . The absence of (001) diffraction peak is significant at 1 phr nano clay loading which suggests good dispersion of clay layers in the epoxy matrix indicating some extent of exfoliation. At higher loading (5 phr) presence and shift of (001) diffraction peak and increase in basal spacing indicate that intercalated structure and exfoliated structure coexist in epoxy nano clay composites.

Scanning electron microscopy

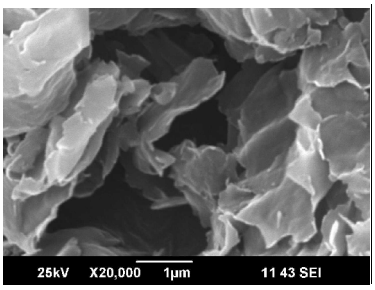


Figure 2

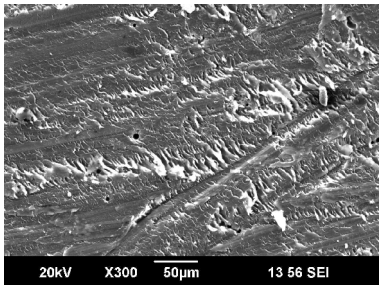


Figure 3

Figure 2 is the SEM micrograph of organo modified nanoclay. This confirms the layered structure of nanoclay. Figure 3 shows the fracture pattern after lap shear test of Aluminium substrate when the formulation contains 1 phr nano clay loading. The striations on the surface caused by layer by layer failure indicate a more emphatic cohesive failure of the substrate.

Adhesive Strength

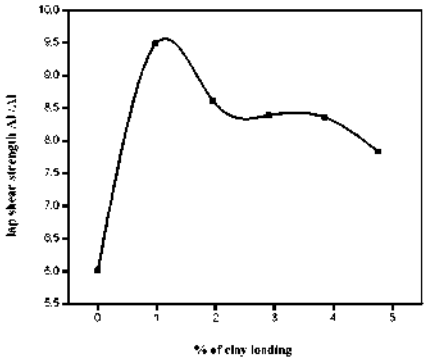


Figure -4

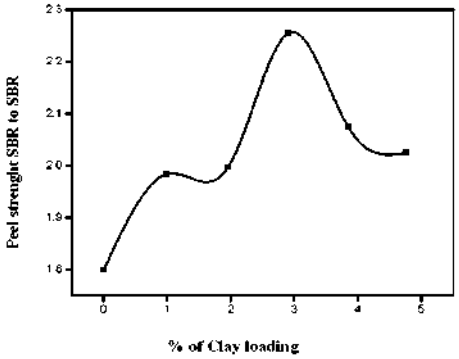


Figure -5

Figure- 4 shows the variation of lap shear strength with nano clay loading in the case of Al to Al bond.The highest lapshear strength was obtained when the adhesive formulation containing 1 phr nanoclay loading. There is a 50% increase in Al/Al lap shear strength at that nanoclay loading.

The shear strength of SBR –SBR bonds was high enough to cause fracture of the substrate irrespective of the type of epoxy resin nanoclay composite and it is not reproduced here. Figure 5 shows the effect of adding nanoclay on peel strength of SBR to SBR specimens. It can be seen that peel strength of SBR-SBR bonds slowly increases with increase in nanoclay concentration. The addition of nano clay improves both peel and shear strengths. The improvement in property may due to the change of failure mode. The joints bonded with neat adhesives present failure at the interface while for nanoclay reinforced adhesives failure is cohesive. Finally, at relative high contents of nanoreinforcement, the failure mode of the joints is interfacial again. Another reason for the increase in the bond strength on addition of clay may be higher wettability of nanoclay reinforced adhesives than the neat epoxy resins. The worsening of the joint properties at relative high nano clay contents can be explained by the increase of the adhesive viscosity or the appearance of agglomerations due to dispersion problems.

4. CONCLUSION

In the present study, the adhesive properties of the epoxy organo clay nanocomposites (1-5 phr of cloisite 93 A) prepared by mechanical stirring followed by sonication, have been studied by lapshear and peel tests. A marked improvement in adhesive properties was found with epoxy nano clay composite compared to neat epoxy. There is a 50% increase in Al/Al lap shear strength at 1 phr nanoclay loading. XRD of nano clay reveals that the presence of organo ion in the intergallery region of OC causes higher d spacing than the unmodified clay. Xray diffraction of nano composite shows that clay distribution in the polymer matrix is of the exfoliated kind at lower level loading and partially exfoliated at higher loading.Scanning electron micrograph shows that nano reinforced adhesives shows cohesive failure at optimum clay loading.

5. REFERENCES

1. Ke Wang, Ling Chen, Jingshen Wu, Mei Ling Toh,| Chaobin He, and Albert F. Yee. Epoxy Nanocomposites with Highly Exfoliated Clay: Mechanical Properties and Fracture Mechanisms ,*Macromolecules* 2005, *38,* 788-800.

2. Byung Chul Kim, Sang Wook Park, Dai Gil Lee, Fracture toughness of the nano-particle reinforced epoxy composite, *Composite Structures* 86 (2008) 69–77.

3. Silvia G Prolongo, Maria R.Gude and Alejandro Urena ,Nanoreinforced adhesives,*Nanofibers, Book edited by Ashok Kumar*,ISBN 978-953-7619-86-2 pp 438 .

4. Andreas Hartwig, Andreas Luhring, Jasmine Trautmann. Spheroidal Nanoparticles in Epoxide -Based Adhesives .*Macromolecular materials and engineering* 2009 ,294,363-379.

5. Erol Sancaktar , JasonKuznicki ,Nanocomposite adhesives: Mechanical behavior with nanoclay, *International Journal of Adhesion & Adhesives* 31 (2011) 286-300.

6. Akbari, B. and R. Bagheri. 2007. Deformation mechanism of epoxy/clay nanocomposite.
European Polymer Journal 43:782-788.

7.Wang, L., K. Wang, L. Chen, Y. Zhang and C. He. 2006. Preparation, morphology and thermal/ mechanical properties of epoxy/nanoclay composite. *Composites: Part A*

37: 1890-1896.

8. Yasmin, A., J. L. Abot and I. M. Daniel 2003. Processing of clay/epoxy nanocomposites
by shear mixing. *Scripta Materialia* 49: 81-86.

9. Yasmin, A., J. Luo, J. L. Abot and I. M. Daniel, 2006. Mechanical and thermal behavior
of clay/epoxy nanocomposites. *Composites Science and Technology* 66: 2415-2422.

10. Wang, J. and S. Qin. 2007. Study on the thermal and mechanical properties of epoxy–
nanoclay composites: The effect of ultrasonic stirring time: *Materials Letters* 61: 4222-4224.

11.. Basara C., U. Yilmazer and G. Bayram. 2005. Synthesis and characterization of epoxy
based nanocomposites. *Journal of Applied Polymer Science* .98:1081-1086.

12. Dean, D., R. Walker, M. Theodore, E. Hampton and E. Nyairo. 2005. Chemorheology
and properties of epoxy/layered silicate nanocomposites. *Polymer* 46:3014-3021.

13. Tjong, S.C. 2006. Materials Science and Engineering. *Structural and Mechanical Properties of Polymer Nanocomposites* 53(3-4) : 73-197.

14. Isik, I., U. Yilmazer and G. Bayram. 2003. Impact Modified Epoxy/ Montmorillonite
Nanocomposites: Synthesis and Characterization. *Polymer* 44: 6371-6377.

15. Lu, H. J., G. Z. Liang, X. Ma, B. Y. Zhang and X. B. Chen. 2004. Epoxy/clay nanocomposites: further exfoliation of newly modified clay induced by shearing force of ball milling. Polymer International 53: 1545-1553.

16. Yasmin, A., J. L. Abot and I. M. Daniel. 2003. Processing of clay/epoxy nanocomposites with a three-roll mill machine. *Materials Research Society Symposium Proceedings* 740:75-83.

17. Zilg, C., R. Thomann, J. Finter and R. Mulhaupt. 2000. The influence of silicate modification and compatibilizers on mechanical properties and morphology of anhydride-cured epoxy nanocomposites. *Macromolecular Materials & Engineering.* 280(81):41-46.

18. Zhou, Y., F. Pervin, M.A. Biswas, V.K. Rangari and S. Jeelani, 2006. Fabrication and characterization of montmorillonite clay-filled SC-15 epoxy. *Materials Letters*. 60:869-873

19. Gilman, J. W. 1999. Flammability and Thermal Stability Studies of Polymer Layered
Silicate Clay/ Nanocomposites. *Applied Clay Science* 15: 31-49.

20. Nigam, V., D. K. Setua, G.N. Mathur and K.K. Kar. 2004. Epoxy-Montmorillonite Clay
Nanocomposites: Synthesis and Characterization. *Journal of Applied Polymer Science* 93:2201-2210.

21. Park, J. H. and S.C. Jana. 2003. Mechanism of Exfoliation of Nanoclay Particles in Epoxy-Clay Nanocomposites. *Macromolecules* 36:2758-2768.

22.Wang, K., L. Chen, M. Kotaki and C. He. 2007. Preparation, microstructure and thermal
mechanical properties of epoxy/crude clay nanocomposites. *Composites: Part A*. 38: 192-197.

23. Kotsilkova R. 2005. Processing–Structure–Properties Relationships of Mechanically
and Thermally Enhanced Smectite/Epoxy Nanocomposites. *Journal of Applied Polymer Science* 97(6):2499–2510.

24. Wang, S., Y. Hua, Q. Zhongkaic, Z. Wang, Z. Chen and W. Fan. 2003. Preparation and
flammability properties of polyethylene/clay nanocomposites by melt intercalation method from Na_+ montmorillonite. *Materials Letters* 57 : 2675-2678.

25. Le Pluart, L., J. Duchet, H. Sautereau, P. Halley and J. F. Gerard. 2003. Rheological properties of organoclay suspensions in epoxy network precursors. *Applied Clay Science* 25(3-4): 207-219.

26. Gu, A. and G. Liang. 2003. Thermal degradation behaviour and kinetic analysis of epoxy/montmorillonite nanocomposites. *Polymer Degradation and Stability* 80: 383-391.

27. Qi, B., Q.X. Zhang, M. Bannister and Y. W. Mai. 2006. Investigation of the mechanical
properties of DGEBA-based epoxy resin with nanoclay additives. *Composite Structures*. 75: 514-519.

28. Ratna, D., N. R. Manoj, R. Varley, S. Raman and G. P. Simon. 2003. Clay-reinforced epoxy nanocomposites. *Polymer International* 52: 1403-1407.

29. Xi, Y., Frost, R.L., He, H., Kloprogge, T., Bostrom, T., 2005. Modification of Wyoming montmorillonite surfaces using a cationic surfactant. *Langmuir* 21, 8675–8680.

30. T. P. Mohan, M. Ramesh Kumar, R. Velmurugan, Mechanical and barrier properties of epoxy polymer filled with nanolayered silicate clay particles ,*Journal of Material Science*
41 (2006) 2929–2937.

31. Hackman and L.Hollaway ,Durability and Mechanical properties of polymer-layered Silicate nano composites, *Proceedings of the International symposium on Bond Behaviour of FRP in Structures* (BBFS 2005)

32. Becker,O.,R.VarleyandG.Simon.2002.Morphology,thermal relaxations and mechanical properties of layered silicate nano composites based upon the functionalitity epoxy resins .*polymer* 43 ,4365-4373.

4.3. Synthesis of Calcium and Iodine Doped ZnO Nano-Structured Thin Films for Antimicrobial Applications Using Silar Method

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ABSTRACT

Sodium Zincate solutions of different concentrations were prepared from Specific concentrations of Sodium Hydroxide and Zinc Sulphate solutions. Calcium and Iodine at 3, 5 and 7 atomic percentages were doped independently to the solution. Zinc Oxide nano structured thin films were prepared from this solution by chemical Successive Ionic Layer Adsorption and Reaction technique [SILAR]. The samples were then annealed at 450 ^{0}C for one hour in the presence of air. The X-Ray diffraction pattern and Scanning Electron microscopy (SEM) of the samples were taken to study the structural parameters and grain size of the particles. Anti microbial activities of the thus prepared films were studied and the results were compared with that of the activity of standard drugs. And it was found that inhibitory zone diameter increases in the case of ZnO mixed antibiotics to that of pure antibiotics.

Key words: ZnO thin film, SILAR method, textured, annealing ZnO thin films, Calcium - doping, Iodine doping.

1. INTRODUCTION

A nano material is a material whose any one of the dimensions will be ranging from 1 nm to 100 nm. Nano technology is the study of manipulating

matter on an atomic or molecular scale. The concept of nano technology was introduced by Richard Feynman in 1959. Nano medicine is an emerging field in nano technology that potentially changing the way to treat diseases through drug delivery and tissue engineering. Nano medicine involves the use of a nano particle in surgical and medical treatment of patients. This highly selective approach reduces coasts and human suffering.

Zinc Oxide in physical aspect is a compound semiconductor with a wide and direct band gap of 3.37eV. Is it a white adhesive material and has many applications in the field of electronics as well as in medical field. ZnO can act as a mild antiseptic and and anti -irritant. So it is widely used to treat a variety of skin diseases. Mitra *et al* (1998) has prepared ZnO thin films using chemical deposition technique. They have used ZnO salts as precursor and successfully synthesized ZnO thin films. The structural and morphological properties of the synthesized films were characterized using XRD and SEM. They have received considerable attention due to unique anti bacterial anti fungal and UV filtering properties, high catalytic and photochemical activities.

It was demonstrated that resin-based dental composites containing ZnO shows antimicrobial activity and reduce the growth of bacterial biofilm (Fang M *et al*, 2006). Smaller particles of ZnO have been found more effective than larger particles against both gram positive and gram-negative bacteria (Jones N *et al*, 2006, Adams LK *et al*, 2008).

Previous studies carried out in *streptococcus sorbrinus* planktonic culture explain the antimicrobial properties of ZnO. These particles generate active Oxygen species such as H_2O_2, which inhibit the growth of planktonic microbes. The nano particles of TiO_2 are unable to inhibit bacterial growth in absence of light but in presence of UV light, they attribute the production of active Oxygen species. Like TiO_2, ZnO particles can be photocatalytic under UV light leading to the

production of antimicrobial active Oxygen species. (Gho G *et al* 2008, Sunanda K *et al*., 2003)

An antimicrobial effect of Iodine is also well known. Iodent is a potent broad-spectrum antiseptic agent. Iodine is effective and quiet economical in the treatment of many chronic wounds. Iodine medicated ointments absorbs fluids, remove exudates, pus and debris from the wound surface. Iodine is effective in treating mixed skin infections; wound cleansing, treatment of burns and ulcers in dental and oral conditions and in skin antisepsis. (George Rodeheaver, William Bellamy *et al*., 1982)

2. EXPERIMENTAL DETAILS

Thin film requires a substrate to support itself. The substrate provides necessary strength and rigidity needed for the thin film and it has adequate thermal ability to ensure at room temperature and withstand a high temperature. The substrate used here microscope glass slide. It is necessary to remove the contaminant that would otherwise affect the properties of thin film. The glass substrate is cleaned with Chromic acid followed by cleaning with acetone. The well cleaned substrate is immersed in chemical bath (Sodium Zincate solution) for a known standard time followed by immersion in hot water for the same tome for hydrogenation (second dip). In this way thin layers of Sodium Zincate complexes re formed during first dip, which decomposes into ZnO when subsequently dipped in hot water. The equations for the formation of ZnO thin films can be written as follows.

$$Zn\ SO_4 + 4NaOH \rightarrow Na_2ZnO_2 + Na_2SO_4 + 2H_2O$$

$$Na_2ZnO_2 + H_2O \rightarrow ZnO\ + 2NaOH$$

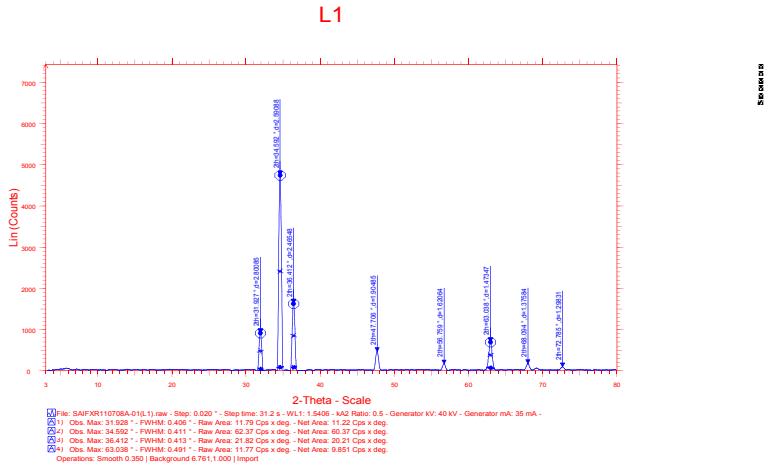
Deposition of thin film is not possible at all concentrations of Zinc Sulphate and Sodium Hydroxide. The Zinc Oxide film deposition is fount ideal at 4 molar concentration of Sodium Hydroxide and 0.75 to 0.1 molar concentrations of Zinc

Sulphate. Part of thus-formed ZnO was deposited onto the substrate as a strongly adherent film and remaining ZnO forms precipitate in the solution. ZnO films deposited with 100 drippings were dried in air and subsequently annealed at a temperature of 450 ^{0}C for one hour.

Iodine doping is done by adding Iodine into Sodium Zincate solution. Doping concentrations selected were 3, 5 and 7 atomic percentages of Iodine. Calcium doping is done by adding Calcium Sulphate to the solution of Sodium Zincate. The XRD analysis of the thus prepared samples was taken to study the structure of the film.

3. RESULTS AND DISCUSSION

Iodine and Calcium doped ZnO nano-structured thin films were prepared by Silar method at different concentrations of Zinc sulphate and Sodium hydroxide. The films were then annealed at 450 0C for one hour in the presence of air. The XRD of the samples were taken to determine the structural parameters. The XRD patterns of the samples are given below.



The synergic effect of Iodine and Calcium doped Zinc Oxide films with antibiotics are studied and are compared with that of existing pure antibiotics. The synergic effect of Iodine doped Zinc Oxide and its comparison with that of existing

antibiotics is given in the table below. Inhibitory zone diameter at varying concentrations of Iodine doped ZnO in millimeter.

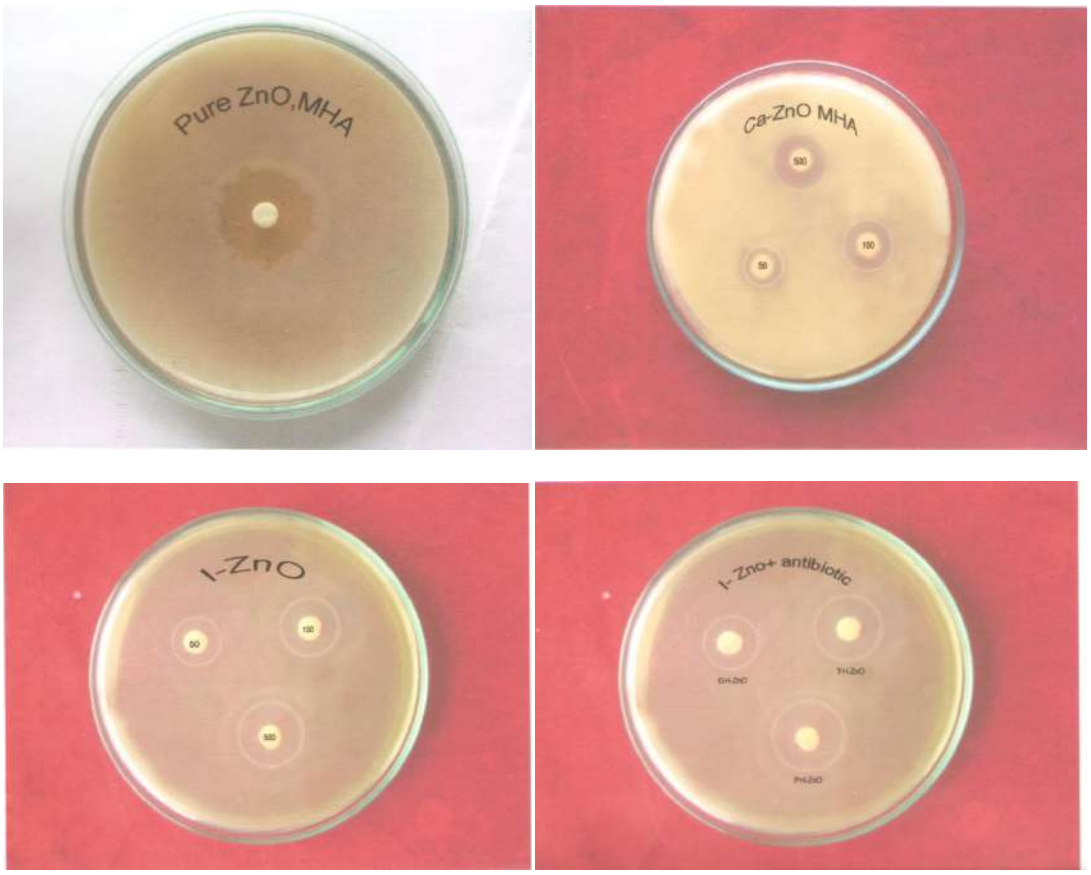
Isolates	Gentamycin	Gentamycin and Iodine doped ZnO	Pencilin	Pencilin and Iodine doped ZnO	Tetracyaline	Tetracyaline ns Iodine doped ZnO
Pseudomonas sps.	10	13	18	21	11	13

Inhibitory zone diameter at varying concentrations of Calcium doped ZnO in millimeter.

Isolates	Gentamycin	Gentamycin and Calcium doped ZnO	Pencilin	Pencilin and Calcium doped ZnO	Tetracyaline	Tetracyaline ns Calcium doped ZnO
Pseudomonas sps.	10	13	18	20	11	13

From the above tables it is clear that Iodine and Calcium doped ZnO has synergic effect on common anti biotics.

The pictures of Inhibitory zone are given below.



4. CONCLUSION

The synergic effect of Iodine and Calcium doped ZnO prepared by silar method is rested and is found that the inhibitory zone diameter increases when the Iodine or Calcium doped ZnO is mixed with pure antibiotics.

5. REFERENCES

1. R. Chandramohan, V Dhanasekharan, S Ezhilvizhiyan, T A Vijayan j Matterial Si: mater electron (2012) 23, 390-397

2. Adams Lk, Lyo DY, Mcintosh A , Alvares P, j (2006) comparative toxicity of nano scale TiO2
3. Ananthanarayanan and Panickers (2009) text book of microbiology 204-207
4. Binning G Robert H , (1986) Scanning tunneling microscopy IBM journal research and development 30.4
5. Chou Tl, Ting JM (2005) Deposition and charecterisation of novel integrated ZnO nano rods.

4.4 Silica-coated CdSe Quantum Dots for Bioimaging Applications

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ABSTRACT

The toxicological effects of silica-coated CdSe quantum dots (QDs) were investigated systematically on human cervical cancer cell line. Trioctylphosphine oxide capped CdSe QDs were synthesized and rendered water soluble by overcoating with silica, using aminopropyl silane as silica precursor. The cytotoxicity studies were conducted by exposing cells to freshly synthesized QDs as a function of time and concentration by Lactate dehydrogenase assay, MTT assay and morphological examination of cells using phase contrast microscope. The in vitro analysis results showed that the silica-coated CdSe QDs were nontoxic even at higher loadings. The florescence imaging studies were conducted using silanised QDs and the images obtained confirmed the potential of QDs as bioimaging tags.

Keywords: Quantum dots, Cytotoxicity, Silica-coating, Imaging

1. INTRODUCTION

Quantum dots (QDs) offer variety of applications in biomedical science, particularly for the detection of ions and molecules, drug and gene delivery, cellular imaging, diagnosis and treatment of diseases [1,2]. The unique photophysical properties of QDs such as broad absorption band, high two photon absorption cross section, and narrow emission band with high tunability as function of size and long lived luminescence [3], make them superior to conventional fluorophores. However, there are limiting factors which include toxicity, poor water solubility and also

larger size compared to organic fluorophores, which lead to the poor expulsion of QDs from the body after in vivo analysis [4,5,6]. It is seen that the toxicological effects of CdSe quantum dots arise mainly due to the leakage of core constituents by surface oxidation [7,8]. Therefore, the surface modification of QDs with biocompatible ligands, which can also prevent the leakage of core constituents, is of importance when the application of QDs in biomedical applications is concerned.

Most of the QD synthesis methods yield QDs which are soluble only in non-polar organic media [9]. Among various approaches to make these QDs aqueous soluble, overcoating with silica is one of the most preferred methods [10, 11, 12]. Overcoating with silica shell prevents escape of the core constituents, thereby decreasing toxicity effects and also renders the QD surface cytocompatible [13, 14, 15]. Another advantage is the elimination of ZnS overcoating step as it is a tedious process and uses precursors which are extremely toxic, pyrophoric, expensive and unstable. Even after ZnS coating, further step is required to make QD water soluble. This will result in an overall increase in the hydrodynamic radius of QD, which is not acceptable when the in vivo applications of QDs are concerned.

In the present study, we have synthesized silica coated CdSe QDs using aminopropyl silane (APS) as silica precursor and its toxicological effects on human cervical cancer cell line (SiHa) have been investigated. QDs cytotoxicity was evaluated by morphological examination of cells and by MTT assay. Also, we have demonstrated that the silica-coated CdSe QDs exhibit strong fluorescence behavior under aqueous biological conditions and this optical property is used for fluorescence imagining in cancer cell lines

2. MATERIALS AND METHODS

All chemicals and reagents used were purchased from Sigma 泡 ldrich, USA. The human cervical cancer cell lines were procured from National Centre for Cell Sciences, Pune, India, and maintained at 37 ⍰C and 5% CO_2 in DMEM (Dulbecco's

modified Eagle's medium) supplemented with 10% fetal bovine serum and antibiotics.

The electronic absorption spectra were recorded on a Shimadzu Model UV-3101 scanning spectrophotometer; emission spectra were collected using SPEX-Fluorolog F112X spectrofluorimeter. For HRTEM and EDS studies, a drop of nanoparticle solution was placed on a carbon coated Cu grid and the solvent was allowed to evaporate. Specimens were imaged on a FEI Tecnai G^2 S-TWIN 300 kV high resolution transmission electron microscope.

Synthesis of quantum dots

QDs were synthesized by following a reported procedure [9,16]. A pot mixture containing CdO (0.067 g, 0.52 mmol), dodecylamine (3.8 g, 20.72 mmol), TOPO (2.7 g, 6.9 mmol) and tetradecylphosphonic acid (0.40 g, 1.44 mmol) was heated to 300 ?C under vacuum. At this temperature, an injection mixture containing TOPSe [selenium coordinated to trioctylphosphine (TOP), 83 μL, 0.083 mmol) in TOP 5.2 mL] was introduced. After desired crystal growth, the reaction was arrested by reducing the reaction temperature down to ambient conditions. The QDs thus obtained was purified by reprecipitation with methanol and redispersed in dry chloroform for silica overcoating.

Silica overcoating after modifying a reported procedure [12] as follows; A mixture CdSe QDs in chloroform (400 μL) and APS (0.075 g) was vortexed for 30 min, in an inert atmosphere. This mixture was added to Igepal CO-520 (1.3 mL) in cyclohexane (10 mL) and stirred for 30 min under dry conditions. Again ammonia solution (150 μL, 33 wt%) was added drop wise and the stirring was continued for 24 h. The silica-coated QDs thus obtained was purified by washing repeatedly with dry chloroform and redispersed in PBS buffer (pH 7.3). Dots were stored in a cool and dark place.

Cell culture

The cells were dispersed in 96 well plates ($5x10^4$ cells per well) and incubated with different concentrations (250, 500, 750 and 1000 nM) of silica-coated CdSe QDs for 24, 48 and 72 h at identical environment. Of note, the concentration of QDs was calculated from the first absorbance maximum of QD according to the previously reported method [17]. After the treatment period, cytotoxicity was evaluated by morphological examination and MTT assay. Freshly synthesized QDs were immediately tested for cytotoxicity on cancer cells

MTT ASSAY

The MTT assay is used to measure mitochondrial activity. After the treatment of cells with silica-coated CdSe QDs, with different incubation time, 10 µL stock MTT ((3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide), 5 mg/mL) was added to each well, and cells were incubated at 37 °C for 3 h. Cells were lysed with acidulated sodiumdodecyl sulfate. Absorbance was measured at 570 nm using microplate reader (Biorad, USA).

Morphological examination

Cells were dispersed in 96 well plates and treated with QDs as described above, with different incubation time like 24, 48 and 72 h, at 37 °C in a 5% CO_2 humidified environment and kept in the dark. After incubation, the cell morphology was examined with a phase contrast microscope (20 x magnifications) (Leica DM IL, Germany).

Cellular Imaging Experiments - Fluorescence microscopy

For cellular imaging experiments, cells were cultured on coverslips, and the medium was changed on every 2 days, till 85% cell confluence was achieved. Then the cells were incubated at 37 °C with 5% CO_2 for 3 h after adding with silica-coated CdSe QD solution (100 nM) in PBS. After incubation, the cover slips were taken out, rinsed thrice at 37 °C using pre-heated PBS, fixed with 3.7%

paraformaldehyde and fluorescence cellular images were observed using a DM 6000 fluorescence microscope (Leica, Germany, 20 x objectives, equipped with DFC 300 FX digital camera).

3. RESULTS AND DISCUSSION

The CdSe QDs before and after silanisation was characterised using various spectroscopic techniques and electron microscopy. The silica-coated CdSe QDs synthesized showed a broad absorption profile with an excitonic absorption at 550 nm. The photoluminescence obtained was narrow with an emission maximum at 560 nm in PBS buffer (pH 7.3). High resolution transmission electron microscope (HRTEM) image showed that, silica-coated CdSe QDs obtained were monodisperse with an average size 5.5 nm (Figure 2). The silanisation was further characterised by EDS and FTIR analysis (Results not shown). A proposed mechanism is the formation of siloxane bond by the hydrolysis and condensation of two aminopropyl silane molecules, so that one amino group is coordinated to CdSe surface, while other on the periphery, resulting in a three dimensional network structure. The QDs were found to be readily soluble in aqueous medium, stable and luminescing.

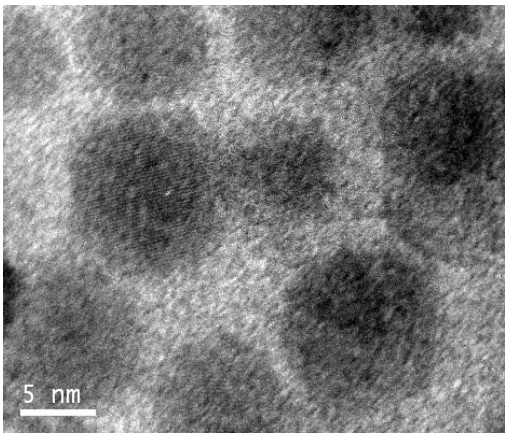


Figure. 2. HRTEM image of Silica-coated CdSe QDs

Further, the toxicological effects of silica-coated CdSe QDs were performed systematically on Human cervical cancer cells (SiHa) by means of morphological

examination and MTT assay. For morphological analysis, the cells were treated with QDs (1 μM) and the cell morphology was examined using a phase contrast microscope at time intervals 24, 48 and 72 h. Interestingly, the morphology of SiHa cells incubated with QDs remained almost the same as that of untreated cells even up to 72 h, without affecting cell proliferation (Figure 3). These observations indicate that the silica shell provides a highly stable and inert passivation layer for QDs, so that the core constituents are well retained in within the shell.

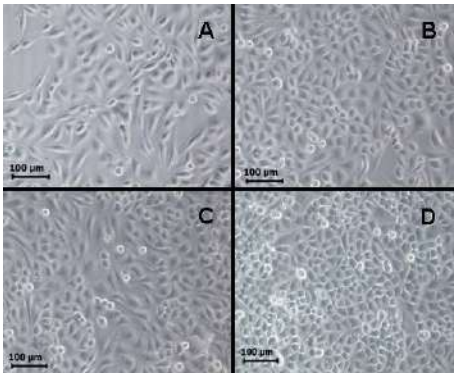


Figure 3. Morphology of SiHa cells (a) before treatment and (b-d) after incubated with silica-coated CdSe QDs (1 μM) for 24, 48 and 72 h respectively (x20 magnification). The morphology of SiHa cells incubated with (1 μM) silica coated CdSe QDs for 72 h was almost the same as that of untreated cells.

Further, MTT assay was used to evaluate the mitochondrial activity in living cells. MTT assay quantifies the enzymatic conversion of tetrazolium into a soluble brown formazan product by mitochondrial dehydrogenase. For this the cells were treated with silica coated CdSe QDs as a function of time (0-72 h) and QD concentration (0-1 μM). As is evident from Figure 4, the silica-coated CdSe QDs showed no significant dose-dependent cytotoxic effects even at higher concentrations. More than 85% cells were viable when compared to the control.

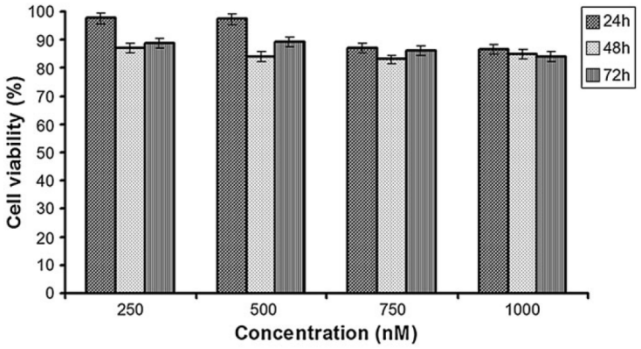


Figure. 4. Results of the MTT assay of mitochondrial activity of SiHa cells exposed to silica-coated CdSe QDs as a function of concentration and incubation time. The cell viability was calculated as a percentage from the viability of the control (untreated) cells. The viability of the control cells was considered 100%. The results are means ± SD from four independent experiments

The morphology analysis and MTT assay based on QD concentration and treatment duration highlighted the excellent biocompatibility of the silica-coated CdSe QDs. Earlier reports have shown that QDs toxicity is mainly due to Cd^{2+} ions being released and affecting cells, so that the cytotoxicity of QDs is greatly dependent on their surface molecules [7,8]. Herein the results showed that the silica overcoating effectively prevented the leakage of core materials, thereby decreasing the toxic effects of CdSe QDs providing good biocompatibility

Further, we have applied these QDs for cellular imaging applications by growing the cancer cells (HeLa) for 3 h in the presence of QDs. Our cellular imaging results showed that silica-coated CdSe QDs were significantly internalized into cytoplasmic vesicles and produce the good fluorescence in and around the cells (Figure 5). These images obtained confirmed the excellent cytocompatibility and potential of silica coated QDs as noval fluorescent tags.

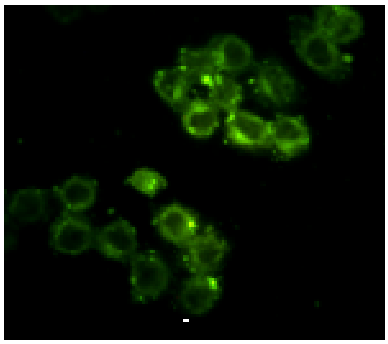


Figure 5. Cellular imaging-Fluorescence microscopy. Micrographs showed the effective cellular imaging behaviour of HeLa cells on exposure with silica-coated CdSe QDs.

4. CONCLUSIONS

Silica-coated, water soluble CdSe quantum dots were successfully synthesized and it's in vitro cytotoxicity analysis and fluorescence behavior were systematically studied. From cell viability (MTT) assay and morphological studies, it has been confirmed that the silica-coated CdSe QDs have least cytotoxicity, even at higher concentrations. In addition, fluorescence study confirmed that these QDs are very useful for cellular imaging owing to their relatively stable fluorescence emission under biological conditions.

5. ACKNOWLEDGMENTS

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6. REFERENCES

1. Biju V., Itoh T., Anas A., Sujith A., Ishikawa M. Semiconductor quantum dots and metal nanoparticles: syntheses, optical properties, and biological applications. Anal Bioanal Chem: 2008 (391) 2469-95.

2. De M., Ghosh P.S., Rotello V.M.: Applications of nanoparticles in biology. Adv Mater: 2008: (20) 4225-41.

3. Smith A.M., Nie S. Chemical analysis and cellular imaging with quantum dots. Analyst: 2004 (129) 672-7.

4. Klostranec J.M., Chan W.C.W. Quantum dots in biological and biomedical research: recent progress and present challenges. Adv Mater: 2006 (18) 1953-64.

5. Hardman R. A toxicological review of quantum dots: toxicity depends on physicochemical and environmental factors. Environ Health Perspect: 2006 (114:2) 165-72.

6. Choi H.S., Liu W., Misra P. et al. Renal clearance of quantum dots. Nat Biotechnol: 2007 (25) 1165-70.

7. Kirchner C., Liedl T., Kudera S., Pellegrino T., Javier A.M., Gaub H.E. et al. Cytotoxicity of colloidal CdSe and CdSe/ZnS nanoparticles. Nano Lett: 2005 (5) 331-38.

8. Derfus A.M., Chan W.C.W., Bhatia S.N. Probing the cytotoxicity of semiconductor quantum dots. Nano Lett: 2004 (4) 11–18.

9. Peng X.A., Peng X.G. Formation of high-quality CdTe, CdSe, and CdS nanocrystals using CdO as precursor. J Am Chem Soc: 2001 (123) 183-84.

10. Pellegrino T., Kudera S., Liedl T., Javier A.M., Manna L., Parak W.J. On the development of colloidal nanoparticles towards multifunctional structures and their possible use for biological applications. Small: 2005 (1) 48–63.

11. Darbandi M., Thomann R., Nann T. Single quantum dots in silica spheres by microemulsion synthesis. Chem Mater: 2005 (17) 5720-25.

12. Selvan S.T., Patra P.K., Ang C.Y., Ying J.Y. Synthesis of silica-coated semiconductor and magnetic quantum dots and their use in the imaging of live cells. Angew Chem Int Ed: 2007 (46) 2448-52.

13. Chen F., Gerion D. Fluorescent CdSe/ZnS nanocrystalpeptide conjugates for long-term, nontoxic imaging and nuclear targeting in living cells. Nano Lett: 2004 (4) 1827-32.

14. Han R., Yu M., Zheng Q., Wang L., Hong Y., Sha Y. A facile synthesis of small-sized, highly photoluminescent, and monodisperse CdSeS QD/SiO_2 for live cell imaging. Langmuir: 2009 (25) 12250-55.

15. Bakalova R., Zhelev Z., Aoki I., Ohba H., Imai Y., Kanno I. Silica-shelled single quantum dot micelles as imaging probes with dual or multimodality. Anal Chem: 2006 (78) 5925-32.

16. Vinayakan R., Shanmugapriya T., Nair P.V., Ramamurthy P., Thomas K.G. An approach for optimizing the shell thickness of core-shell quantum dots using photoinduced charge transfer. J. Phys. Chem. C: 2007 (111) 10146-49.

17. Yu W.W., Qu L., Guo W., Peng X. Conjugation chemistry and bioapplications of semiconductor box nanocrystals prepared via dendrimer bridging. Chem Mater: 2003 (15) 3125-33.

4.5. Textured Grain Growth in ZnO Nano Flowers by Tin Doping

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ABSTRACT:

ZnO thin films were prepared by Successive Ionic Layer Adsorption Reaction (SILAR) method. The textured grain growth along c-axis in pure ZnO thin films and doped with Sn were studied. The structural analysis of the thin films was done by X-ray diffraction and surface morphology by scanning electron microscopy. Textured grain growth of the samples was measured by comparing the peak intensities. Textured grain growth in ZnO thin films is found to be enhanced by doping with Sn. ZnO thin films having good crystallinity with preferential (002) orientation is a semiconductor with photonic properties of potential benefit to biophotonics .A possible mechanism for the textured grain growth is also investigated. From energy dispersive X-ray analysis, it is inferred that oxygen vacancy creation is responsible for the enhanced textured grain growth in ZnO thin films.

Key words: ZnO thin film, SILAR method, textured grain growth, annealing ZnO thin films, Sn- doping

1. INTRODUCTION

For nearly half a century, the synthesis and characterization of ZnO thin film is an active area of research. ZnO with wurtzite structure [1] is an n-type semiconductor with direct band gap of 3.37eV [2, 3] and high electronic mobility. As a wide and direct band gap semiconductor, nanostructred ZnO thin films have attracted more attention in optoelectronic devices [4]. The transparent conductive oxide (TCO) electrodes using Al-doped ZnO have attracted much attention as

powerful candidate materials for ITO transparent electrodes. ZnO thin films have attracted considerable attention because they can be tailored to possess high electrical conductivity, high infrared reflectance and high visible transmittance upon applying different techniques [5, 6, 7, and 8]. Different methods have been applied to obtain ZnO thin films. These include magnetron sputtering [6], chemical bath deposition [9], sol-gel [10], spray pyrolysis [11] etc. Chemical deposition techniques are relatively low cost processes and can be easily scaled up for industrial application. Among the thin films deposition methods, double dip technique from aqueous solutions is the simplest and the most economical one. Double dip method otherwise called SILAR method (Successive Immersion Layer Adsorption Reaction) [5, 12, and 13] also offers the opportunity of doping the host ions with impurities on different kinds, shapes and sizes on substrates with ease. Zinc oxide crystallites with preferential grain growth along c-axis are desirables for applications such as UV diode lasers, piezoelectric surface acoustic wave or acoustic-optic devices and gas sensors [4].There are reports that textured grain growth along c-axis in ZnO thin films is enhanced by doping and annealing. Controllable n-type doping is easily achieved by substituting Zn with group IV elements such as Sn [5, 6]. Moreover, the band gap of the material can be tuned from 3.37 to 3.11 eV if it is doped with group IV metal ions.

In course of the present investigations, textured grain growth in Sn- doped ZnO thin films were studied. A possible mechanism for the textured grain growth is also investigated. Such studies are not yet reported.

2. EXPERIMENTAL

ZnO thin films were prepared by Successive Ionic Layer Adsorption Reaction (SILAR) method. In which, the ZnO thin film was coated on the glass substrate (26 *76 mm) by alternately dipping the substrate in Sodium Zincate bath at room temperature and then in hot water maintained at 90- 95^{o}C . Rostov et al [14] had already used this method for preparing Cu_2O thin films. Sodium Zincate bath was prepared by using 1 M Zinc Sulphate [$ZnSO_4 .7H_2O$] and 2 M Sodium

Hydroxide [NaOH]. Tin doping was done by adding Stannous Chloride (Tin Chloride) in Sodium Zincate bath. The doping concentration of was 10 atm%. Before deposition, the glass substrates were cleaned by chromic acid followed by cleaning with acetone. The well-cleaned substrates were immersed in the chemical bath for 10sec followed by immersion in hot water for the same time and it was repeated for 100 times. These samples were annealed at 450^{o}C for half an hour in air. The structural analysis of the thin films was done by X-ray diffraction (XRD) and surface morphology by scanning electron microscopy (SEM). X-ray diffraction was performed on Bruker AXS-8 using CuK_{α} radiation and SEM micrographs were taken by using JEOL -JSM6490. Chemical elemental stoichiometry was examined from energy dispersive X-ray analysis (EDAX) linked with SEM unit. The resistance of ZnO thin film at room temperature is measured by Keithley 2100 6 1/2 Digital Multimeter.The optical absorbance was measured in the wavelength range of 190-1100 nm by means of a UV-VIS spectrophotometer.

Textured grain growth of the samples was measured by using a texture index (T.I.), which is the ratio of the intensities of (002) reflection ($2\theta = 34^{o}$) to (101) reflection ($2\theta = 36^{o}$) in the XRD. i.e., T.I. = I_{002}/I_{101}

3. RESULTS AND DISCUSSION

3.1 Structural and morphological characterization

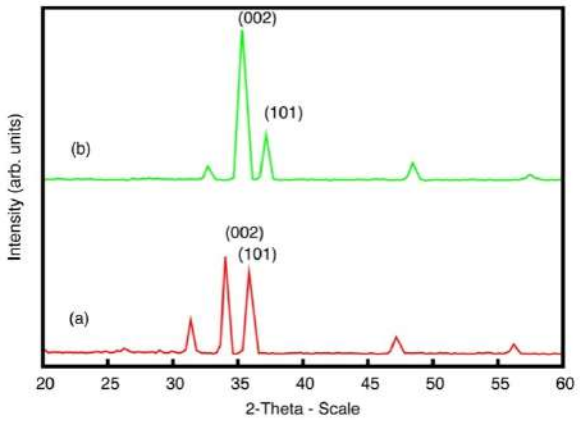


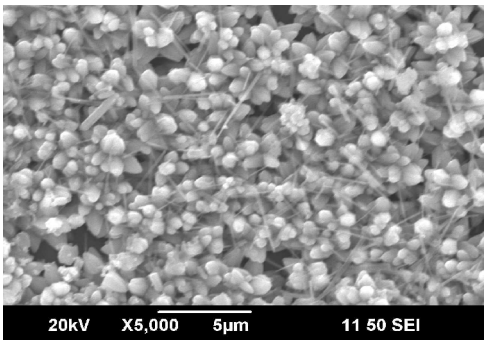
Figure 1. (a-b) shows the XRD pattern of pure and doped sample

XRD patterns of ZnO thin films of pure and doped samples are depicted in fig1. (a-b). It is seen from figures that the (002) peak appears with maximum intensity at $2\theta = 34^{o}$. The other peaks at 31^{o}& 36^{o} can be associated with (100), (101) reflections of ZnO, as expected for wurtzite hexagonal ZnO structure (JCPDS no.36-1-1451). In particular, it is clearly observed that the intensity of the (002) peak enhanced by doping with Sn.The (002) diffraction peak exhibited a higher intensity, showing a fact that the textured grain growth is along (002) direction.

Table-1 gives the textured index (T.I), resistance, and band gap of pure & doped samples.

Sample No.	Sample details	T.I	Grain size in nm	Resistance in MΩ	Band Gap in eV
1.	Pure Sample	1.21	18	8.5	3.3
2.	Sn-Doped	4.61	27.35	2.25	3.11

Figure 2 & 3 show the SEM micrographs of the pure sample and doped sample. From the fig1. - (a-b) and from table-1, it's clear that there is significant textured grain growth in Sn-doped sample. The needle like as well as flowered structure of ZnO is evident in the SEM micrograph of the pure sample (fig.2). But when sample doping with Sn the needle like structure is found to be disappeared and flowered structure become more prominent. The average grain size of the ZnO crystals in the films was calculated by using Scherrer's formula: $D = 0.9\lambda / \beta \cos\theta$, where D is the grain size, λ- the wavelength of X-ray used, β- the FWHM(Full width half maximum) and θ- Bragg diffraction angle of the XRD peak. From the studies, the grain size of the Sn-doped sample was found to be in the range 27.35nm (Table-1). The dislocation density $\delta = 1/ D^2$, where D is the grain size. Dislocation density gives the degree of crystallinity. Therefore, the larger values of D indicate better crystallization of the films. Therefore grown thin films having good crystallinity with preferential (002) orientation is a semiconductor with photonic properties of potential benefit to biophotonics.



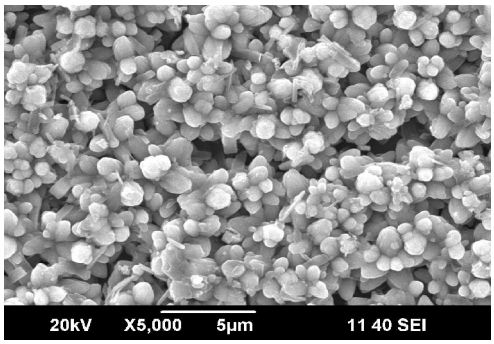


Fig 2. (Pure sample) **Fig 3. (Sn-Doped sample)**

From the figuress 1 (a-b), 2 and 3& from the table-1 it is clear that textured grain growth in Sn- doped sample is increased significantly. The SEM micrographs confirm the textured grain growth in the sample.

3.2 Resistance Measurements

The thin film resistivity strongly influenced by the interaction of the conduction electrons with the surface. In other words, it is a measure of the material's surface inherent resistance to current flow. The grain size and resistance of ZnO thin films measured at room temperature is given in table-1. It shows that as the grain size increases, the resistances of the film decreases *i.e.*, resistance is inversely proportional to the grain size. One of the reasons for this is due to the decrease in grain boundary when the grain sizes increase. Another is due to the contribution from Sn ions on the substitutional site of Zn ions and Sn- interstitial atoms.

3.3 Optical Properties of Nanocrystalline ZnO Films

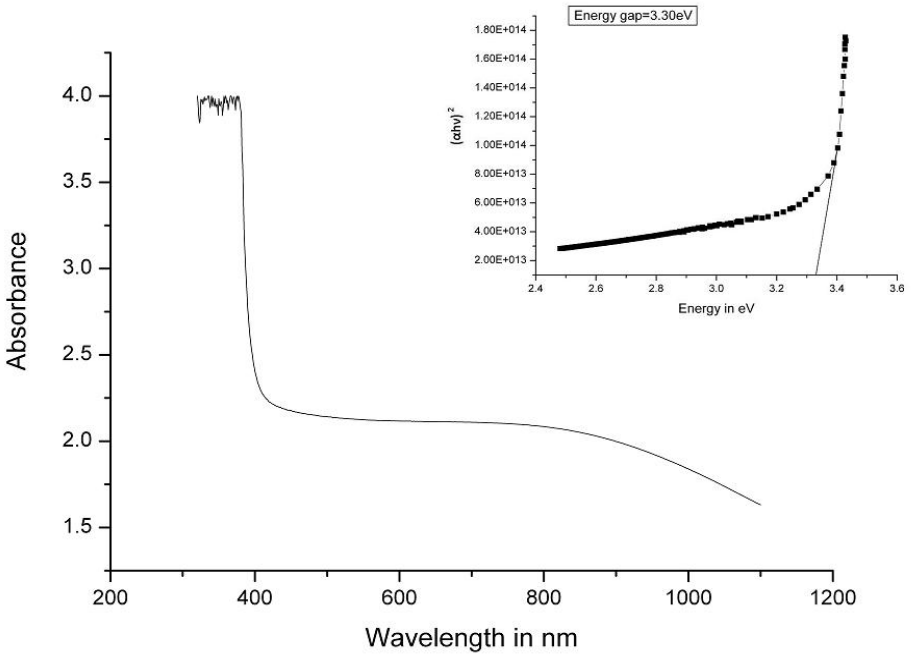


Figure 4. Absorbance for the sample annealed in air. The inset indicates optical band gap energy of the sample.

The figure 4 shows the optical absorbance spectrum of noncrystalline ZnO thin films annealed at 450^0C in air for half an hour using UV-visible region from 200 nm - 800 nm. The corresponding optical band gap of ZnO thin film is estimated by extrapolation of the linear relationship between $(\alpha h\upsilon)^2$ and $h\upsilon$ according to the equation $h\upsilon = A (h\upsilon - Eg)^{1/2}$ where α is the absorption coefficient, $h\upsilon$ is the photon energy, Eg is the optical band gap and A is a constant. Figure 4 (inset) the plot of $(\alpha h\upsilon)^2$ versus energy $h\upsilon$ .The values of direct band gap; Eg are calculated from the intercept $(\alpha h\upsilon)^2$ vs. $h\upsilon$ curve is also been plotted. The presence of a single slope in the plot suggests that the film has direct and allowed transition. The band gap value of ZnO thin film is found to be 3.30 eV which is slightly smaller than that of bulk ZnO (3.37 eV). This difference is due to the fact that the values of band gap Eg depend on many factors like the granular structure, the nature and concentration of

precursors, the structural defects and the crystal structure of the films etc. Moreover, departures from stoichiometry form lattice defects and impurity states. It is reported that the band gap difference between the thin film and crystal is due to the grain boundaries and imperfections of the polycrystalline thin films [15]. The band gap is calculated for the sample doped with tin and annealed in air. The corresponding values are reported in the table-1. It shows that as band gap decreases with increase in the grain size of film i.e. band gap is inversely proportional to the grain size. The resistance decrease with the increase in the grain size, as the grain boundary decreases. As the grain size increases band gap decreases.

3.4 Elemental analysis by EDAX

Energy-dispersive X-ray spectroscopy (EDS or EDX) is an analytical technique used for the elemental analysis or chemical characterization of a sample. Theoretically expected stoichiometric mass% of Zn and Oxygen are 80.3 and 19.7. The atomic percentage of oxygen in the pure and doped samples is 27.54 and 24.20 respectively.

From the above values, it is clear that as the texture index increases, the oxygen content of the samples decreases. This means that, oxygen vacancy is more in samples, which has more textured grain growth.

3.5 Mechanism behind the oriented grain growth

Native or intrinsic defects are imperfections in the crystal lattice that involve only the constituent elements. They include vacancies (missing atoms at regular lattice positions), interstitials (extra atoms occupying interstices in the lattice) and anti sites (a Zn atom occupying an O lattice site or vice versa) [16].

It is reported that Sn- doping will create oxygen vacancies due to the substitution of Zn by Sn. This confirms that, oxygen vacancy creation is the mechanism behind the enhanced textured grain growth.

4. CONCLUSION

From the studies following conclusions can be drawn. Textured grain growth in ZnO thin films enhanced significantly by Sn-doping. From the SEM micrographs it is found that as the textured grain growth increases the needle like structure disappears and flowered structure become prominent. When the textured grain growth increases, crystallinity of the thin film improves, resistance & band gap decreases. ZnO thin films having good crystallinity with preferential (002) orientation is a semiconductor with photonic properties of potential benefit to biophotonics. A possible mechanism for the textured grain growth is also investigated. From energy dispersive X-ray analysis, it is inferred that oxygen vacancy creation is responsible for the enhanced textured grain growth in ZnO by Sn- doping.

5. ACKNOWLEDGEMENT

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6. REFERENCES

[1] Xiangdong G, Xiaomin L, Weidong Y. Preparation and characterization of highly oriented zno film by ultrasonic assisted silar method. Journal of Wuhan University of Technology–Materials Science Edition

[2] 2005; 20:23– 6. [2] Zhou B, Rogachev AV, Liu Z, Piliptsou DG, Ji H, Jiang X. Effects of oxygen/argon ratio and annealing on structural and optical properties of zno thin films. Applied Surface Science 2012; 258(15):5759 –64.

[3] Shelke V, Sonawane B, Bhole M, Patil D. Electrical and optical proper-ties of transparent conducting tin doped zno thin films. Journal of Materials Science: Materials in Electronics 2012; 23:451–6.

[4] Yen T, Strome D, Kim SJ, Cartwright A, Anderson WA. Annealing studies on zinc oxide thin films deposited by magnetron sputtering. Journal of Electronic Materials 2008; 37:76499.

[5] Park JH, Pak HK, Cho CR. Deposition-temperature effects on AZO thin films prepared by rf magnetron sputtering and their physical properties. Journal of the Korean Physical Society 2006; 49(1):S584–8.

[6] Chandramohan R, Dhanasekaran V, Ezhilvizhian S, Vijayan T, Thirumalai J, Peter A, et al. Spectral properties of aluminium doped zinc oxide thin films prepared by silar method. Journal of Materials Science: Materials in Electronics 2012; 23:390–7. .

[7] Son J, Shim J, Cho N. Variations in electrical and physical proper-ties of al: zno films with preparation conditions. Metals and Materials International 2011; 17:99–104.

[8] Murmu P, Kennedy J, Ruck B, Williams G, Markwitz A, Rubanov S,et al. Effect of annealing on the structural, electrical and magnetic properties of gd-implanted zno thin films. Journal of Materials Science 2012; 47:1119–26.

[9] Zhu H, Hpkes J, Bunte E, Gerber A, Huang S. Influence of working pres-sure on zno ;al films from tube targets for silicon thin film solar cells. Thin Solid Films 2010; 518(17):4997 – 5002.

[10] Luo WH, Tsai TK, Yang JC, Hsieh WM, Hsu CH, Fang JS. Enhancement in conductivity and transmittance of zinc oxide prepared by chemical bath deposition. Journal of Electronic Materials 2009; 38:2264–9.

[11] Kokubun Y, Kimura H, Nakagomi S. Preparation of zno thin films on sapphire substrates by sol-gel method. Japanese Journal of Applied Physics 2003; 42(Part 2, No. 8A):L904–6.

[12] Lee Y, Kim H, Roh Y. Deposition of zno thin films by the ultra- sonic spray pyrolysis technique. Japanese Journal of Applied Physics2001; 40(Part 1, No. 4A):2423–8.

[13] Pathan H, Lokhande C. Deposition of metal chalcogenide thin films by successive ionic layer adsorption and reaction (silar) method. Bulletin of Materials Science 2004; 27:85–111.

[14] Ristov M, Sinadinovski G, Mitreski M. chemically deposited cu_2o thin film as an oxygen pressure sensor. Thin Solid Films 1988; 167(12):309.

[15] Saleem M, Fang1 L, Wakeel A, Rashad M, Kong C. Y. Simple preparation and characterization of nano-crystalline zinc oxide thin films by sol-gel method on glass substrate. WorldJournal of Condensed Matter Physics 2012; 2(6):10–5.

[16] Jannotti A, G C. Fundamentals of zinc oxide as a semiconductor. Re- ports on Progress in Physics 2009; 72(126501):126501a–126506a30.

4.6. Carboxylated Carbon Nanotube filled NBR / NR Composites for High Dielectric Devices

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ABSTRACT

Acrylonitrile butadiene rubber (NBR) / natural rubber (NR)-carboxylated carbon nanotube composites were prepared on a laboratory type two-roll mill. Different quantities of carbon nanotubes (CNT) starting from 1to 7 phr were incorporated into the polymer matrix and the resulting compounds were vulcanized using N-benzylimine aminothioformamide (BIAT) / N-cyclohexyl benzthiazole sulfenamide (CBS) binary accelerator system. The vulcanizates in standard dimensions were used for investigating dielectric properties. The dielectric properties increased with increase in dosage of the modified CNT. This was due to the maximum filler-polymer interaction and the resultant maximum dispersion of filler particles in the matrix. As the concentration of CNT increased, more polar groups were incorporated. The overall polarizability of the resulting nanocomposite was increased leading to higher dielectric constant. XRD and electron microscopy have been used for morphological analysis.

Key words: Carboxylated CNT, nanocomposites, dielectric properties, capacitors

1. INTRODUCTION

The exceptional properties of CNTs, like high mechanical strength, flexibility, and impressive electrical and thermal conductivity make them attractive and potential candidates for various applications[1-3]. Despite these outstanding properties, there are two main limitations which prevent its easy use. The surface energy of CNTs is significantly different from that of the matrix of polymer or similar organic compounds and as a result, the finer dispersion of CNTs into the matrix is quite a difficult task[4].

Also, the seamless surface of CNTs cannot provide physical interaction between CNTs and the matrix[5]. The modification of CNTs using suitable compounds makes them interesting and apt candidates for a plethora of applications including nanoelectronics[6]. Owing to processability, resistance to oils and chemicals, NBR is widely used in many industries. However, neat NBR exhibits only poor tensile properties and oil resistance. A considerable amount of research has been made over the last several years with a view to obtaining new polymeric materials with enhanced specific attributes for specific applications. Much attention was devoted to the simplest route for combining outstanding properties of different existing polymers, i.e., by blending polymers. Sirisinha et al.[7] proved that oil resistance of 20 / 80 NR / NBR blend depended strongly on the phase morphology of the blend. The smaller the size of the NR dispersed phase was, the higher was the resistance to oil. Mathai et al.[8] investigated that the equilibrium solvent uptake decreased with an increase in the concentration of NBR.

Now-a-days binary accelerators are increasingly popular among scientists and industrialists owing to the fact that such systems (i) allow vulcanization to be carried out at lower temperature in a shorter time (ii) produce vulcanizate with superior physico-mechanical properties compared with those obtained using single accelerator. Though enough studies are available on mechanism of vulcanization using single accelerators, only few studies are available on the chemistry of vulcanization with binary accelerator systems. Dogadkin et al[9] and Skinner and

Watson[10-11] investigated number of binary accelerator systems and observed synergic activation.

Since only very few studies are available on the use of binary accelerator systems in the vulcanization of NBR/NR blends and also on the use of carboxylated CNT in NBR / NR blends, efforts have been made in this study to investigate electrical properties of 80/20 NBR/NR-CNT composites vulcanized with BIAT-CBS binary accelerator system[12]. XRD and electron microscopy have been used for morphological analysis.

2. EXPERIMENTAL

Acrylonitrile-butadiene rubber (NBR) (33 % acrylonitrile content, grade N-684) was supplied by Eliokem Pvt Ltd., Gujrat, India. NR of grade ISNR-5 was supplied by Rubber Research Institute of India, Kottayam. Carboxylated multiwalled carbonnanotubes (MWCNT) was supplied by Nanocyl S.A, Belgium with average diameter 9.5 nm, length < 1.5 μm and –COOH functionalization < 4 wt. % and purity > 97 %. Stearic acid, zinc oxide, CBS, and sulfur (commercial grade) were supplied by Cimpson Scientific Ltd, Kerala. BIAT was synthesized by us as reported earlier[12].

2.2.1. Compounding

Nanocomposites were prepared on a two-roll mill (15.3 x 30.5 cm, Indian Expeller) as per ASTM designation D3182-89. During the blend preparation, the component rubbers were masticated separately for 2 min and then together for 5 min. The overall mixing time including the time for ingredient mixing was kept constant for all mixes (18 min). All the fillers were pre-heated in air oven at 80^0C for 5 hrs to remove moisture. The formulations are given in table.1. All the mixes from $NBCNT_1$ to $NBCNT_4$ contain NBR and NR in 80: 20 proportions, 5 phr of stearic acid-coated zinc oxide (ZOS), 5 mmols of CBS, 7.5 mmols of BIAT, 1.5 phr of S and 1, 3, 5 and 7 phr respectively of CNT.

2.2.2. Cure characteristics

The curing behaviour of rubber compound was measured using automated Goettfert elastograph; model Vario 67.98 (German) at 150^0C. It is a rotorless rotational shear vulcameter with chamber in which the rubber compound is placed. The cure properties were directly obtained with the help of software.

2.2.3. Vulcanization

Vulcanization of the rubber compounds was done in an electrically heated laboratory type hydraulic press (Indian Expeller) at 150^0C at a pressure of 120 $Kg.cm^{-2}$ up to the optimum cure time in respective moulds. The moulded samples were kept in a cold and dark place for 24 hrs and then used for various measurements

2.2.4. Fourier transforms infrared spectroscopy

FTIR spectra were taken on Shimadzu spectrophotometer in the range 4000 – 500 cm^{-1}.

2.2.5. X-ray diffraction studies

X-ray diffraction patterns of the samples were taken on Bruker AXS D_8 advance model XRD instrument at STIC, Cochin University campus with source Cu, wavelength 1.5406 A^0 and Si (Li) PSD detector.

2.2.6. Scanning electron microscopy

Scanning electron microscopic images of the samples were taken using Jeol SEM (10 KV) at School of Chemical Sciences, Mahatma Gandhi University, Kottayam.

2.2.7. Transmission electron microscopy

Transmission electron microscopic images of the samples were taken on Jeol JEM-2100 HRTEM (200 Kv, beam current 104.2 μA) at Indian Institute of Technology, Kharagpur. The TEM of vulcanized rubber samples were taken after

preparing ultrathin sections of samples using ultramicrotome (Leica EM FCS ultra cut) with cryo-system.

2.2.8. Atomic force microscopy

AFM images of the vulcanized rubber samples were taken on Multiview-1000™ SPM (Nanonics Imaging Ltd. Malcha, Jerusalem), in tapping mode, at Indian Institute of Technology, Kharagpur.

2.2.9. Dielectric studies

Dielectric measurements were carried out at room temperature using LCR meter. The test samples were coated with conductive graphite paint on either side and copper wires were fixed on both the sides of the sample as electrodes. Circular samples of diameter 10 mm and thickness 0.3 mm were punched out from vulcanized sheet and used at frequency range 500 Hz- 15 MHz.Dielectric permitivity (ε') can be calculated from the capacitance using the equation[13] (2.1)

$$\varepsilon' = ct / A\,\varepsilon_0 \qquad (2.1)$$

where c is the capacitance of the material, t is the thickness of the sample, ε_0 is the permitivity of free space (8.85×10^{-12} F m^{-1}) and A is the area of the sample under electrode. Volume resistivity (ρ) is calculated from,

$$\rho = RA / t \qquad (2.2)\backslash$$

where R is the resistance of the test sample.

Electrical conductance is the reciprocal of volume resistivity. The dielectric loss (ε") is obtained from the equation,

$$\varepsilon'' = \tan\delta\,\varepsilon' \qquad (2.3)$$

3. RESULTS AND DISCUSSION

3.1. FTIR spectroscopy

The FTIR spectrum of CNT is given in fig.3.1. The peak at 1738 cm^{-1} is due to carbonyl group. The peak at 3650 cm^{-1} can be assigned to –OH group. The peaks at 2857 and 2928 cm^{-1} are due to C-H stretching of aromatic ring attached to CNT by modification[14].

3.2. XRD analysis

In the XRD spectra of all the CNT filled NBR/NR blend vulcanizates (fig.3.2) less intense peak at 24.7^0 is due to the intercalated CNT. Khairurrijal et al. reported intense peak at 25.5^0 for (002) planes of CNT fabricated using spray pyrolysis[15]. Li et al. also reported intense peak at 25.9^0 for CNT[16]. The reduction in intensity and also the shift from the expected angle 25.9^0 to 24.7^0 in the present case could be due to intercalation as evident from the SEM and TEM images (fig.3.3.& 3.4). The peak at 24.7^0 becomes more broad and intense as the concentration of CNT increases due to more intercalation.

3.3. Microscopic analysis

The morphological analysis of representative vulcanizates of NBR / NR blend mixes were done using microscopic methods like SEM, TEM and AFM and the micrographs are given in fig.3.3,3.4 & 3.5) The foldings found in the SEM image of $NBCNT_1$ (fig.3.3(a) could be due to the lower NBR-NR miscibility. The white patches are due to agglomerated nanoparticles of ZnO and BIAT. This type of foldings are not found in the SEM image of $NBCNT_4$ (fig.4.7.b), due to the enhanced compatibilizing action of carboxylated CNT as its concentration increases. The TEM image of $NBCNT_1$ (fig.3.4.a) shows well dispersed curled CNTs. As the concentration of CNTs reaches 7 phr in $NBCNT_4$, fracturing and agglomeration of CNTs occur as shown in the TEM image (fig.3.4.b).

The AFM topographic phase images were taken in tapping mode. The phase images (fig.3.5) reveal the microstructure of the composites. The phase image of $NBCNT_4$ (fig .3.5.b) shows more roughness, indicating greater rubber-filler interaction in $NBCNT_4$[17-21].

Table.1. NBR / NR blend formulations containing CNT

Ingredients (Parts per hundred)	Mixes			
	$NBCNT_1$	$NBCNT_2$	$NBCNT_3$	$NBCNT_4$
NR	20	20	20	20
NBR	80	80	80	80
ZOS	5	5	5	5
TDQ	1	1	1	1
CNT	1	3	5	7
CBS	1.32	1.32	1.32	1.32
n-BIAT	1.3425	1.3425	1.3425	1.3425
S	1.5	1.5	1.5	1.5

Table.2. Cure properties of NBR / NR blend mixes(CNT-filled)

Mixes	optimum cure time t_{90} min	scorch time ts_2 min	minimum torque dNm	maximum torque dNm	cure reate index CRI
$NBCNT_1$	8.20	1.38	0.2	5.1	14.66
$NBCNT_2$	6.95	1.37	0.3	5.5	17.92
$NBCNT_3$	6.71	1.20	0.4	5.7	18.15
$NBCNT_4$	5.74	1.11	0.8	6.2	21.60

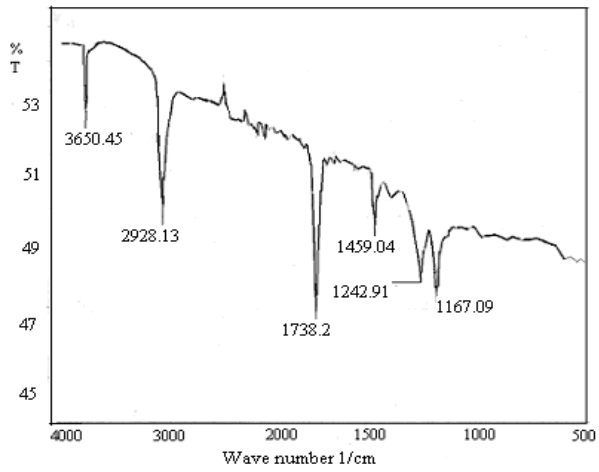


Fig.3.1. FTIR spectrum of modified MWCNT

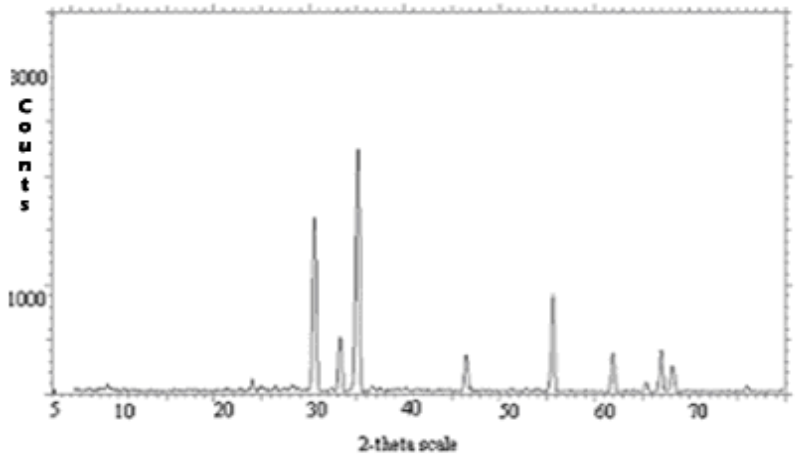


Fig. 3.2 (a). XRD of $NBCNT_1$

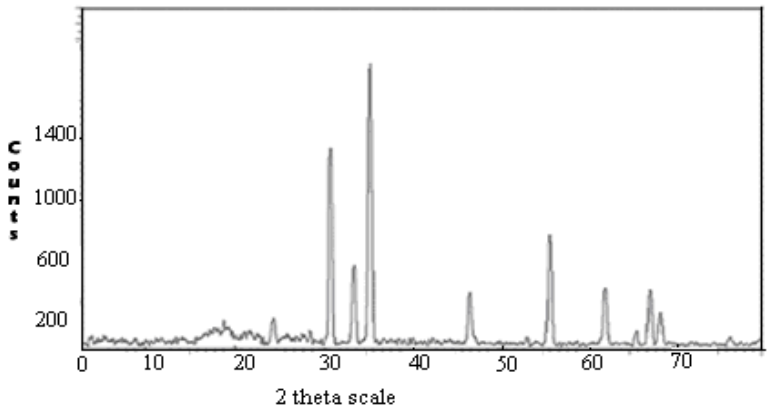


Fig. 3.2 (b). XRD of $NBCNT_2$

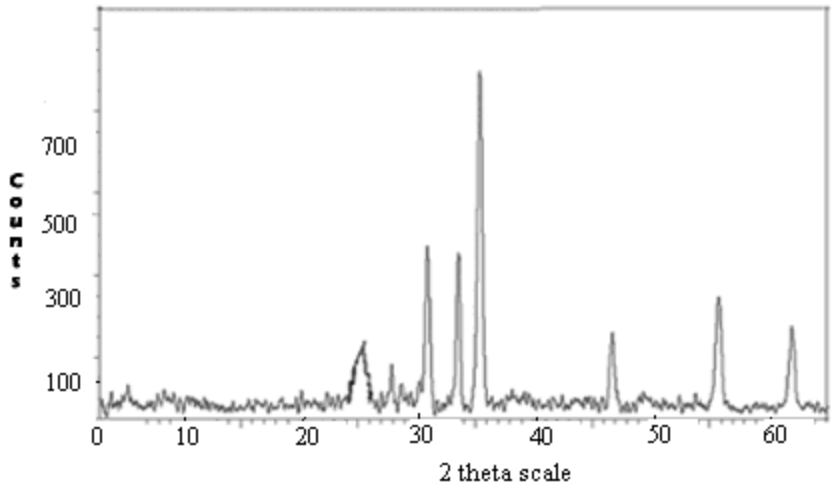


Fig.3.2 (c) XRD of $NBCNT_4$

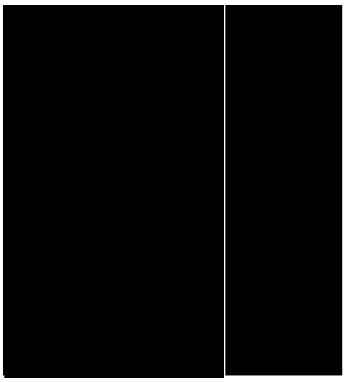


Fig.3.3(a) SEM image of $NBCNT_1$

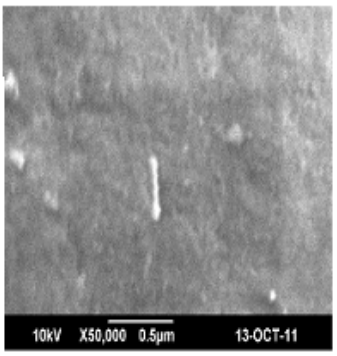


Fig.3.3(b) SEM image of $NBCNT_4$

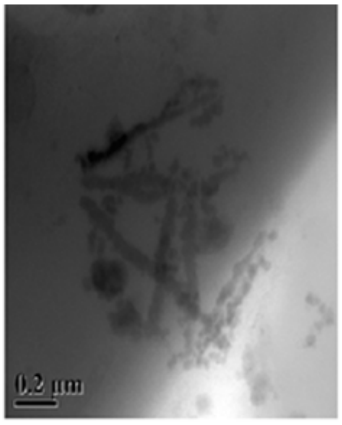


Fig.3.4(a)TEM image of $NBCNT_1$

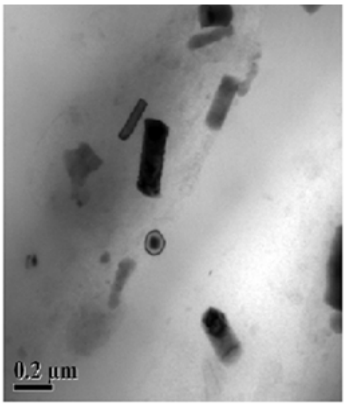
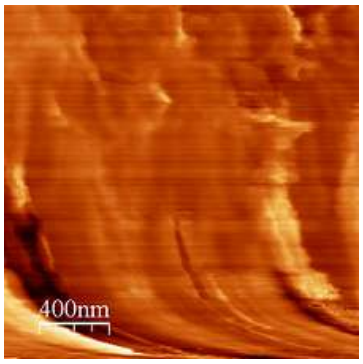


Fig.3.4(b)TEM image of $NBCNT_4$



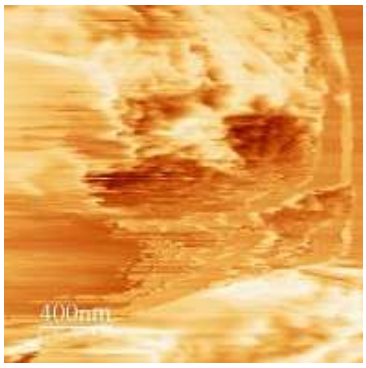


Fig.3.5(a) AFM phase image of $NBCNT_1$ Fig.3.5(b) AFM phase image of $NBCNT_4$

3.4. **Electrical properties**

Electrical conductivity of polymer nanocomposites is due to the formation of continuous conductive network in the polymer matrix[22]. This network consists of specific spatial arrangement of conductive elements so that low resistance electrical paths are developed for free movement of electrons. The conductivities of CNT-filled NBR / NR vulcanizates at different frequencies are represented as plotes of conductivity versus log frequency in fig.3.6. The CNT-filled vulcanizates exhibited higher conductivity. This could be due to (i) the special geometry and large surface area of CNTs increased filler-polymer interaction and created low resistance electrical paths for free movement of electrons (ii) the incorporation polar groups present on CNTs could further increase conductive interaction. The increased dispersion of CNTs in the matrix compared to spherical with lower aspect ratio enhanced the conductivities of CNT-filled vulcanizates[23].

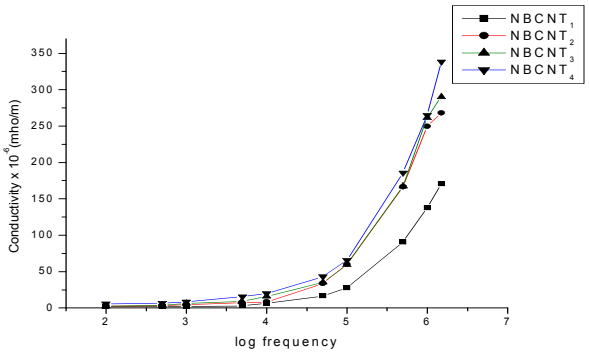


Fig.3.6. Variation of conductivity with log frequency

The conductivities of the CNT-filled vulcanizates increased with increase in the dosage of CNT from 1 phr in $NBCNT_1$ to 7 phr in $NBCNT_4$ indicates the enhanced degree of formation of percolating network of MWCNTs in the NBR / NR matrix[24]. The conductivities of all the vulcanizates showed an increase with increase in frequency. This increase can be due to the increase in segmental mobility of the polymer matrix at higher frequency level.

The variation of dielectric constant with frequency at room temperature is given in fig.3.8. The dielectric constant of filled systems depends on the size, shape, distribution pattern, polar groups on filler, and the filler-polymer interaction[25]. As the aspect ratio of the filler becomes high, conductive contacts will also increase, which results in enhanced dielectric constant. There was increase in dielectric constant on the increase in the dosage of CNT (fig.3.7).The mix $NBCNT_4$ exhibited maximum values for dielectric constant. This is due to the maximum filler-polymer interaction and the resultant maximum dispersion of filler particles in the matrix, leading to maximum percolation. Also, as the concentration of CNT increased, more polar groups were incorporated. The overall polarizability of the resulting nanocomposite was increased resulting in higher dielectric constant. It is evident from the fig. 3.8 that dielectric constant of the vulcanizates decreased with increase in frequency at a fixed temperature. It is also evident that the decrease in dielectric constant is much prominent at low frequencies. The decrease in dielectric constant with increase in frequency is an expected behaviour in the case of most

dielectric materials. This is due to dielectric relaxation, which involves the orientation polarization. The orientation polarization in turn depends on the molecular arrangement. Consequently, at higher frequencies, the rotational motion of the polar molecules in the dielectric substance is not sufficiently fast for attaining equilibrium with the field. Hence, dielectric constant decreases with increasing frequency[26].

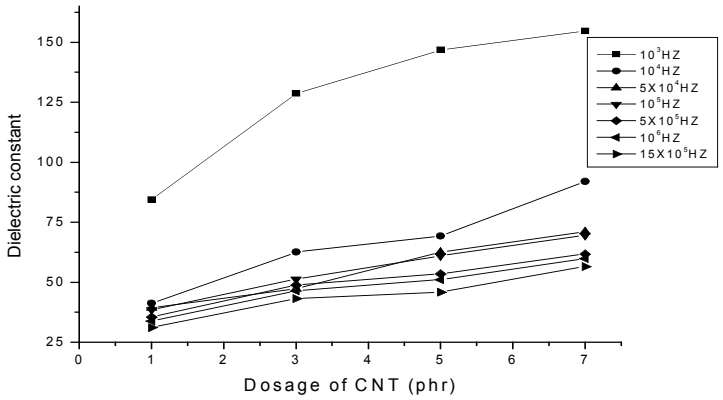


Fig.3.7. Variation of dielectric constant with dosage of CNT (at different frequencies)

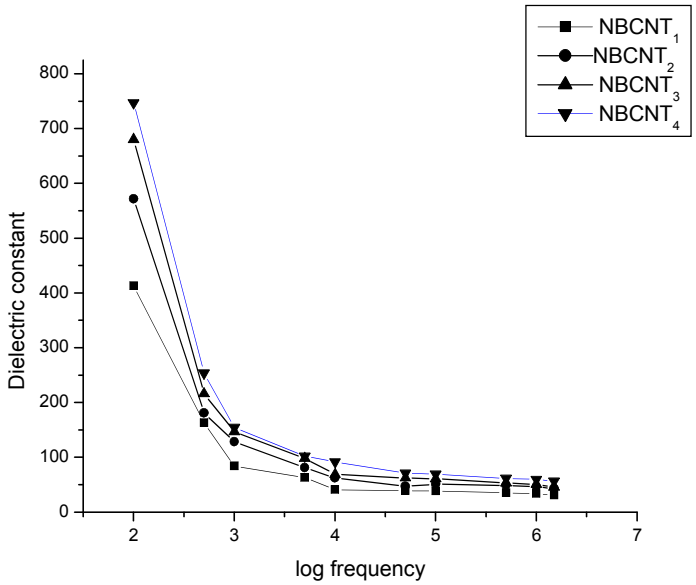


Fig.3.8. Variation of dielectric constant with log frequency

The change in dielectric loss has been evaluated as a function of frequency and is given in fig.3.9. The dielectric loss showed an increase with increase in concentration of CNT from 1 phr in $NBCNT_1$ to 7 phr in $NBCNT_4$. All the vulcanizates exhibited more loss at lower frequencies. At high frequencies, the dielectric loss factor is low because the orientation polarization due to chain motion of polymer becomes out of phase with the rapidly oscillating electric field.

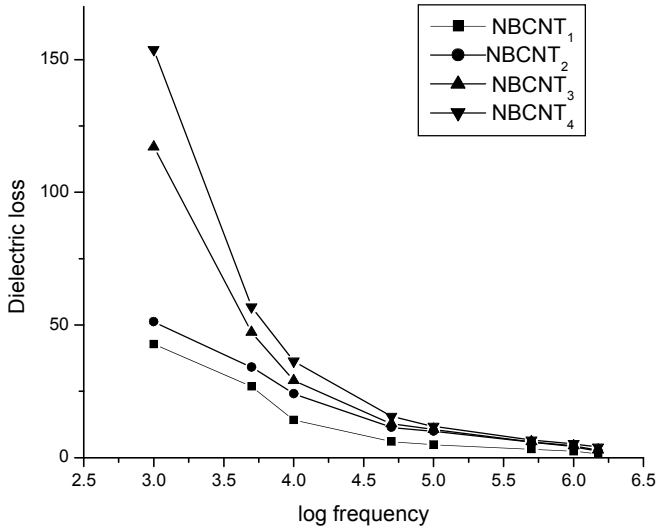


Fig.3.9. Variation of dielectric loss with log frequency

4. SUMMARY AND CONCLUSION

N-benzylimine aminothioformamide / N-cyclohexyl benzthiazole sulfenamide binary accelerator system is effective in the vulcanization of NBR / NR-CNT vulcanizates. The enhancement in the formation of percolating network of CNTs in the polymer matrix increased the conductivity of the composites. The polar groups on the CNTs have also increased the conductivity. The dielectric constants of the NBR/NR composites increased with increase in the dosage of CNT. This is due to

the increased filler-polymer interaction and the resultant maximum dispersion of filler particles in the matrix. As the concentration of CNT increased, more polar groups were incorporated. The overall polarizability of the resulting nanocomposite was increased leading to higher dielectric constant. The microscopic images and the XRD curves offer proof for the higher filler-polymer interaction in the composites.

Due to the high dielectric constants of the CNT-filled NBR / NR vulcanizates, high dielectric devices like high performance capacitors can be developed using these compounds.

5. REFERENCES

1. Moniruzzaman M., Winey K. I., Polymer nanocomposites containing carbon nanotubes, Macromolecules: 2006(**39**:16) 5194-5205.
2. Gojny F. H., Wichmann M. H. G., Fiedler B., Kinloch, I. A, Bauhofer, W., Windle, A.H. Evaluation and identification of electrical and thermal conduction mechanisms in CNT/epoxy composites, Polymer: 2006(**47:**6) 2036 – 2045.
3. Kim Y. J., Shin, T. S. , Choi, H. D. , Kwon, J. H. , Chung, Y.C. , Yoon, H. G. Electrical conductivity of chemically modified multiwalled carbon nanotube/ epoxy composites, Carbon: 2005(43:1) 23 -30.
4. Song Y. S., Youn J. R. Influence of dispersion states of carbon nanotubes on physical properties of epoxy nanocomposites , Carbon: 2005(43:7) 1378-85.
5. Ajayan, P. M., Schadler L. S., Giannaris C., Rubio A. Advanced Materials : 2000(12**)** 750-757.
6. Xu L., Wong S.Y., Tjiu W. C., Lyons B. P., Oh S. A., He C. B., Non-covalent functionalization of multi walled carbon nanotubes and their application for conductive composites**,** Carbon: 2008(46:5)829-831.
7. Sirisinha, C., Limcharoen, S., Thunyarittikom, J., Oil resistance controlled by phase morphology in natural rubber/nitrile rubber blends, Journal of Applied Polymer Science : 2003(87:1) 83-89.

8. Mathai A. E., Singh R. P., Thomas S. Transport of substituted benzenes through nitrile rubber/natural rubber blend membranes,Journal of Membrane Science: 2002(202:1-2) 35-54.
9. Dogadkin B. A., shershnev V. A., The Interaction of Tetramethylthiuram Disulfide with Rubber and with Compounds Containing a Labile Hydrogen Atom, Rubber Chemistry and Technology: 1960(33**)** 401-411.
10. Skinner D.,Watson A. A. Rubber Age: 1960(99**)** 76-84.
11. Skinner D., Watson A .A. EV Systems for NR and. The Purpose of Efficient Vulcanization and Development of Curing System, Rubber Chemistry andTechnology: 1969(42**)** 404-417.
12. Shaji.P.Thomas, Mathew E.J., Marykutty C.V., Journal of Applied Polymer Science DOI.10.1002 / app.35406, 29 Nov 2011.
13. Thomas P. C, Ph.D Thesis submitted to M.G. University (2011).
14. Chan V., Sun K., Yarin A., Megaridis C.M. Intercalation of Poly-acrylonitrile (PAN) into carbon nanotubes, Journal of Undergraduate Research: 2007(1) 52-56.
15. Das A. K. , Stockelhuber W., Jurk, R., Saphiannikova M., Fritzsche, J., Lorenz H., Kluppel M., Heinrich, G., Modified and unmodified multiwalled carbon nanotubes in high performance solution-styrene–butadiene and butadiene rubber blends, Polymer: 2008(49:24), 5276 -5283.
16. Yue D., Liu Y., Shen Z., Zhang, L., Study on preparation and properties of carbon nanotubes/ rubbercomposites, Journal of Material Science: 2006(41:8), 2541-2544

17. Tahermansouri H., Chobfrosh D., Meskinfam M., Functionalization of CarboxylatedMulti-wall Nanotubes with 1,2-phenylenediamine, International Journal of Nano Dimensions :2010(1:2), 153-158

18. Tavangar A., Tan B., Venkatakrishnan K., Synthesis of three-dimensional calcium carbonate nanofibrous structure from eggshell using femtosecond laser ablation, Journal of Nanobiotechnology :2011 (9:1)

19. Mishra S., Shimpi N. G. , Comparison of nano CaCO3 and flyash filled with styrene- butadiene rubber on mechanical and thermal properties, Journal of Scientific & Industrial Research : 2005(64**)** 744-751.

20. Gupta A., Bhatti H. S., Kumar D., Verma N. K., Tandon R. P., Nano and bulk crystals of Zno: synthesis and characterization, Digest Journalof Nanomaterials and Biostructure :2006 (1:1**)**, 1-9

21. Khairurrijal L, Abdullah M., Rosi M., Noor F. A. Indonesian Journal of Physics:2008 (19:3**)** 91-102

22. Kumari P., Radhakrishnan C. K. , Unnikrishnan G. P., Varghese S., Sujith A. Natural Rubber/Acrylonitrile Butadiene Rubber Blend Membranes: Vapor Permeation Properties, Chemical Engineering &Technology :2010(33:1), 97-102.

23. Kutty, S. K. N. , Chaki, T. K. , Nando, G. B. ,Thermal degradation of short kevlar fibrethermoplastic polyurethane composite**,** Polymer Degradation Stability:1992(38)187-192.

24. Mohammad M, Suong V. H . Electrical resistance of CNT-PEEK composites under compression at different temperatures, Nanoscale Research Letters:

2011(6:1) 419-424

25. Seema A., Kutty S. K. N. Thermal Degradation of Short Nylon-6 Fiber–Reinforced Styrene Butadiene Rubber Composite, International Journal of Polymeric Materials:2006(55:1**)**, 25-35.

26. Seema A., Kutty S. K. N. Characterization of Short Nylon-6 Fiber/Acrylonitrile Butadiene Rubber Composite by Thermogravimetry, International Journal of Polymer Analysis and Characterization: 2005(10:3-4**)** 169 -178.

NATIONAL SEMINAR
PHOTOS





National Seminar-Inauguration by **Rt. Rev. Dr. Selvister Ponnumuthan**, Bishop of Punalur Diocese



Invited Speak- **Dr. Nandakumar Kalarickal** (Joint Director, Centre for Nano Science and Nano Technology, M.G. University, Kottayam)



Invited Speak- **Dr.Vidya Ramaswami** **(**Chairperson,International Centre for Intellectual Training and Empowerment, Trivandrum, Kerala)



Invited Speak- **Dr. Sunny Kuriakose** Associate Professor, St.Thomas College, Pala.



Invited Speak- **Dr. M. R. Anantha Raman** Head, Department of Physics Cochin University of Science and Technology, Kochi.



Invited Speak- **Dr. C. K. Mahadevan**
Associate Professor, S.T. Hindu College, Nagercoil, Tamil Nadu



Invited Speak- **Dr. Deepthi Menon**
Associate Professor, Centre for Nanosciences, Amrita centre for Nanosciences, Kochi.



Participants



Participants



Paper Presentation



Valedictory Function