MACRO 2009

RECENT ADVANCES IN POLYMERIC MATERIALS

MARCH 9-11, 2009

Technical Programme and Abstracts of

10th National Conference of
The Society for Polymer Science, Chennai Chapter, INDIA

SPS

organized by
Department of Chemistry
Indian Institute of Technology Madras, INDIA

as a part of the golden jubilee celebrations of IIT Madras

Golden Jubilee 2008-09
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CELEBRATING
TECHNOLOGY

Foreword

It is a privilege and honor to host the 10th National Conference of the Society for Polymer Science at the Indian Institute of Technology Madras, Chennai as a part of the Golden Jubilee celebration of the Institute. The conference **"MACRO 2009: Recent Advances in Polymeric Materials"** is organized by the Department of Chemistry, Indian Institute of Technology Madras during March 9-11, 2009 in its beautiful and ever green campus. We expect close to 400 participants of practicing polymer scientists and technologists to attend MACRO 2009. The participants are from as far east as Japan, as far west as Venezuela, from central Europe and within India.

The subject of polymer science is important both from academic and technology points of view. It is highly interdisciplinary in nature, touching upon all subjects ranging from life sciences to materials for electronics applications. Over the years polymer chemists have changed focus from mere synthesis and characterization to functional aspects of the synthetic polymers. This has led to tremendous impact on the application of polymeric materials from drug delivery to membranes for fuel cells to aerospace. Future directions for polymer scientists could involve addressing the issues related food security, clean water, energy, environment and global climate changes (global warming!).

We sincerely hope that MACRO 2009 will offer ample opportunity for polymer chemists and technologists to have fruitful deliberations for three days to exchange their ideas and forge future collaborations. We wish you all a pleasant stay in IIT Madras campus during MACRO 2009.

March 09, 2009

S. Sankararaman
Convener, MACRO 2009
Professor, Department of Chemistry
IIT Madras, Chennai

B S R Reddy
Convener MACRO 2009
Director Grade Scientist
Head, Industrial Chemistry Group
CLRI, Chennai

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We express our sincere thanks to Dr. K. Mangala Sunder and Mr. Britto Jones Irudhyaraj (Webstudio, IITM), for the creation and maintenance of MACRO 2009 website.

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and many research scholars of Department of Chemistry, IIT Madras

MACRO 2009 – Recent Advances in Polymeric Materials

March 9-11, 2009

IC&SR Auditorium and CLT, IIT Madras, Chennai

All Plenary Lectures (PL) will be held in ICSR Auditorium as a single session.

Invited Lectures (IL), Oral Presentations (OP) and Posters (PO) will be held in two parallel sessions, one session in ICSR Auditorium and another session in Central Lecture Theatre (CLT). These auditoriums are located within 3-5 minutes walking distance in adjacent buildings in IIT Madras campus.

ODD NUMBERED ABSTRACT – ICSR AUDITORIUM

EVEN NUMBERED ABSTRACT – CENTRAL LECTURE THEATRE

POSTERS will be displayed on March 9 and 10, 2009. There is no poster session on March 11, 2009. The venue for poster presentation will be ICSR Exhibition Hall and HSB 132 and HSB 133 (opposite to Central Lecture Theatre (CLT)). Posters can be displayed in the morning on the prescribed date. Each day an hour (15.45-16.45 Hrs) is allotted to poster session during which lectures are not scheduled. The poster size should be 1 meter x 1.5 meter (breadth x length) only.

Please note that only the paper presenting author's name is given in the detailed program schedule. Full authorship and affiliation is available on a separate list in the book of abstracts.

Monday, March 9, 2009

Session 1: **(In ICSR Auditorium)**

8.30 – 9.00 Registration
9.00 – 9.45 Inauguration

9.45 – 10.30 **Plenary Lecture 1 (PL1)**
Polymeric Nanoobjects
S. Ramakrishnan, Department of Inorganic and Physical Chemistry,
Indian Institute of Science, Bengaluru 560012, INDIA.

10.30 – 10.45 **Tea Break**

Session 2: **(two parallel sessions, one in ICSR auditorium and another in CLT)**

10.45 – 11.30
Invited Lecture (IL1) (ICSR Auditorium)
Synthesis and self-assembling properties of end-capped poly(ethylene oxide) and grafted poly(acrylamide) hydrophobically modified with 3-pentadecylcyclohexylamine.
D. Hourdet
Physico-Chimie des Polymères et des Milieux Dispersés, UMR 7615, UPMC-ESPCI-CNRS,
10 rue Vauquelin, 75005 Paris, France.

Invited Lecture (IL2) (Central Lecture Theatre, HSB)
Investigation of Polymer Blend Miscibility Fluorescence Spectroscopy
Sabu Thomas, School of Chemical Sciences, Mahatma Gandhi University Kottayam, Kerala, India - 686 560.

11.30 – 11.50
Oral Presentation OP1 (ICSR Auditorium)
Room Temperature Living Cationic Polymerization of Styrene using α-Methylstyrene-HCl/$FeCl_3$ System in Presence of Added Salts
Sanjib Banerjee, Polymer Science Unit, Indian Association for the Cultivation of Science, Jadavpur, Kolkata 700 032, India

Oral Presentation OP2 (Central Lecture Theatre, CLT)
Chemical synthesis of conducting polymer nanofibers for H_2 storage applications
A. R. Phani, Nano-Research for Advanced Materials & Technologies, Bangalore, India

11.50 – 12.10
Oral Presentation OP3 (ICSR Auditorium)
Development of Novel Biodegradable Polymeric Nanofibers for Biomedical Applications
R. Jayakumar, Amrita Centre for Nanosciences, Amrita Institute of Medical Sciences and Research Centre, Cochin-682 026, India

Oral Presentation OP4 (Central Lecture Theatre, CLT)
Polymerizable Fluoroalkyl Surfactant for Improved PEMFC Electrodes
Mohan N. Wadekar, NanoStructured Materials, DelftChemTech, Delft University of Technology, Julianalaan 136, 2628 BL Delft, The Netherlands.

12.10 – 12.30
Oral Presentation OP5 (ICSR Auditorium)
Elucidation of Gelation Mechanism of a Two Component Supramolecular Polymer **Swarup Manna,** Polymer Science Unit, Indian Association for the Cultivation of Science, Jadavpur, Kolkata-700 032, India

Oral Presentation OP6 (Central Lecture Theatre, CLT)
Recyclable Polypropylene/Polycaprolactone Carbon Nanotubes based Bi-phasic Conducting Polymer Composite as temperature sensor.
Bijandra Kumar, Laboratory of Materials Engineering of Brittany (LIMATB)
European University of Brittany (UEB), France.

12.30 – 12.50
Oral Presentation OP7 (ICSR Auditorium)
Novel polymer shelled microbubbles for diagnostic and therapeutic purposes
Shivkumar Ghugare, Dipartimento di Scienze e Tecnologie Chimiche, Università di Roma Tor Vergata. Rome, Italy.

Oral Presentation OP8 (Central Lecture Theatre, CLT)
Growth of Bacillus species on Chemically Pretreated and Un-pretreated Polypropylene
Ambika Arkatkar, Department of Biotechnology, Indian Institute of Technology Madras, Chennai-600036

12.50 – 14.00 **Lunch Break**

Session 3: (two parallel sessions, one in ICSR auditorium and another in CLT)

14.00 – 14.45
Invited Lecture IL3 (ICSR Auditorium)
Diameter Control and Vertical Growth of SWCNTs and Its Potential Applications
Haiwon Lee
Institute of Nano Science and Technology, Hanyang University, Seoul 133-791, Korea

Invited Lecture IL4 (Central Lecture Theatre, HSB)
Biodegradable Polymers Based on Renewable Resources: Aliphatic Copolyesters Composed of L-Lactide and Isosorbide Units.
Bhaskar B. Idage
Polymer Science and Engineering Division, National Chemical Laboratory,
Dr. Homi Bhabha Road, Pune-411 008 INDIA

14.45 – 15. 30

Invited Lecture IL5 (ICSR Auditorium)

Hybrid nanomaterials from polymer gels and organogels.

J. M. Guenet

Institut Charles Sadron, CNRS UPR 22, 23 rue de Loess, BP84047,
F-67034 Strasbourg cedex 2, France.

Invited Lecture IL6 (Central Lecture Theatre, HSB)

Self-Organization in Tailor-made Urethane-Methacrylate Comb Polymers

S. K. Asha

Polymer Science & Engineering Division, National Chemical Laboratory (NCL),
Dr. Homi Bhabha Road, Pune 411008, INDIA

15.30 – 15.45 **Tea Break**

Session 4 : 15.45 – 16.45 **Poster session 1 (POSTERS 1-65)**

Session 5 : (two parallel sessions, one in ICSR auditorium and another in CLT)

16.45 – 17.05

Oral Presentation OP9 (ICSR Auditorium)

Isoconversional Analysis of Differential Scanning Calorimetric Data on Nonisothermal Crystallization of PPS/ TLCP VA 950 Composites Melt

A.K.Kalkar, Department of Physics, Institute of Chemcial Technology, Matunga,
Mumbai – 400 019, India

Oral Presentation OP10 (Central Lecture Theatre, CLT)

Synthesis and Characterization of Polyhedral Oligomeric Silsesquioxane - Cyanate ester / Epoxy Nanocomposites

Rakesh. S, Department of Chemistry, Anna University, Chennai-600 025, India

17.05 – 17.25

Oral Presentation OP11 (ICSR Auditorium)

Sorption and Difusion of Aromatic Hydrocarbons through Dynamically Crosslinked High Density Polyethylene/Ethylene Propylene Diene Terpolymer Rubber Blends

Anil Kumar.P.V, School of Technology and Applied Sciences, Mahatma Gandhi University,
Kottayam.

Oral Presentation OP12 (Central Lecture Theatre, CLT)

Novel three ring based Side Chain Liquid Crystalline Methacrylate monomers and polymers: Synthesis, Characterization and ^{13}C NMR studies

G.Sivamohan Reddy, Department of Polymer Science and Technology, S.K.University,
Anantapur 515 003,

17.25 – 17.45

Oral Presentation OP13 (ICSR Auditorium)
Use of polymeric nanomaterials in piezoelectric sensors
K. P. Singh, Membrane Biophysics and Nanobiosensor Research Laboratory, CBS&H
G. B Pant University of Agriculture and Technology, Pantnagar-263145, Uttarakhand

Oral Presentation OP14 (Central Lecture Theatre, CLT)
Synthesis, characterization and photosensitive properties of
phosphorus containing homo and copolymers
K. Kaniappan, Polymer Research Laboratory, Department of Chemistry
PSG College of Technology, Coimbatore -641 004, India

Session 6: **(In ICSR Auditorium)**

18.15 – 19.00 **SPECIAL INDUSTRY LECTURE 1**

High Throughput Research for Catalysts Development for Polymerization Reactions
Manoj Kharkar, Dow Chemical International Pvt Limited, India

19.30 – 21.30 **Dinner at Open Air Theatre (OAT)**

Tuesday, March 10, 2009

Session 7: **(In ICSR Auditorium)**

9.00 – 9.45

Plenary Lecture 2 (PL2)
Surface-Initiated Polymerization as a Tool for the Fabrication of bioactive Surfaces and thin Inorganic Films
Harm-Anton Klok,
Laboratoire des Polymères, Institut des Matériaux, Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland.

9.45 – 10.30

Plenary Lecture 3 (PL3)
Crystallization of miktoarm star copolymers in comparison to linear diblock copolymer analogs.
A.J. Müller
Grupo de Polímeros USB, Departamento de Ciencia de los Materiales, Universidad Simón Bolívar, Apartado 89000, Caracas 1080-A, Venezuela.

10.30 – 10.45 Tea Break

Session 8: **(two parallel sessions, one in ICSR auditorium and another in CLT)**

10.45 – 11.30
Invited Lecture IL7 (ICSR Auditorium)
Soft Matter for biomedicine: two case studies. A Novel Temperature Sensitive Hydrogel Microdevice based on Poly(vinyl alcohol)/Poly(methacrylate-co-N-isopropyl acrylamide)
Gaio Paradossi
Dipartimento di Scienze e Tecnologie Chimiche, Università di Roma Tor Vergata, 000133 Roma, Italy.

Invited Lecture IL8 (Central Lecture Theatre, HSB)
Conjugated Polymer Thin Film Based Biosensors
Shilpa N. Sawant
Chemistry Division, Bhabha Atomic Research Centre, Trombay, Mumbai-400085

11.30 – 11.50
Oral Presentation OP15 (ICSR Auditorium)
Titania based Self-Cleaning Finish
Bhavana Sharma
Smart and Innovative Textile Materials (SMITA) Group, Department of Textile Technology, Indian Institute of Technology, Hauz Khas, New Delhi-110016, India

Oral Presentation OP16 (Central Lecture Theatre, CLT)
Synthesis and Processing of Polyurethane for developing porous viscoelastic sheets as cushioning materials in therapeutic footwear
G Saraswathy, Central Leather Research Institute, Chennai-600020, India.

11.50 – 12.10
Oral Presentation OP17 (ICSR Auditorium)
Protein Separation and Flux Recovery Using PVDF/PS blend Ultrafiltration Membranes
D.Mohan, Membrane Laboratory, Dept. of Chemical Engg., A.C.College of Technology Anna University, Chennai – 600 025

Oral Presentation OP18 (Central Lecture Theatre, CLT)
Viscoelastic and Thermal property modified Epoxy-Clay Nanocomposites: Preparation, Characterization and Property Evaluations.
M. Suguna Lakshmi, Industrial Chemistry Laboratory, Central Leather Research Institute, Adyar, Chennai 600 020, India.

12.10 – 12.30
Oral Presentation OP19 (ICSR Auditorium)
Inherently Colored Antimicrobial Fibers Employing Silver Nanoparticles
Priyanka Katiyar, DMSRDE, Defence Research and Development Organization (DRDO), G T Road, Kanpur, UP 208 013, India

Oral Presentation OP20 (Central Lecture Theatre, CLT)
Natural and Artificial Weathering of Polypropylene Films – a solution for littered packaging films
K. Rajakumar, Department of Polymer Technology, Kamaraj College of Engineering and Technology, S. P. G. C. Nagar, K. Vellakulam Post – 625 701, India

12.30 – 12.50
Oral Presentation OP21 (ICSR Auditorium)
Chemical Modification of Cellulose Fibers by Combination of Ring Opening Polymerization and Atom Transfer Radical Polymerization.
Arvind Gautam, North East Institute of Science and Technology, Jorhat 785 006, Assam

Oral Presentation OP22 (Central Lecture Theatre, CLT)
Synthesis Of N-Isopropylacrylamide Coatedgold Nanoparticle Hybrid Nanomaterial Via Surface Confined Atom Transfer Radical Polymerization
E. Murugan, Department of Physical Chemistry, School of Chemical Science,
University of Madras, Guindy Campus, Chennai – 600 025, Tamilnadu.

12.50 – 14.00 **Lunch Break**

Session 9: (two parallel sessions, one in ICSR auditorium and another in CLT)

14.00 – 14.45
Invited Lecture IL9 (ICSR Auditorium)
Preparation and properties of Polyimides, Bismaleimides and Bisnadimides containing pyridine and anthracene rings
M.Sarojadevi
Department of Chemistry, Anna University, Chennai-600

Invited Lecture IL10 (Central Lecture Theatre, HSB)
Tailoring Functional Nanoporous Materials from Ordered Block Copolymers
Daniel Grande
Institut de Chimie et des Matériaux Paris-Est, UMR 7182 CNRS – Université Paris XII, 2,
rue Henri Dunant, 94320 Thiais, France

14.45 – 15. 30
Invited Lecture IL11(ICSR Auditorium)
Conductive Polymer Nano-BioComposite (CPC) for vapour sensing: chemo-electrical properties of chitosan-carbon nanofiller (Chit-CNF) in methanol, water and toluene vapours atmosphere.
Jean-François FELLER
Materials Engineering Laboratory of Brittany (LIMATB), European University of Brittany (UEB), UBS-Lorient (France).

Invited Lecture IL12 (Central Lecture Theatre, HSB)
Size Exclusion Chromatography – a Blessing and a Curse
Dušan Berek,
Polymer Institute, Slovak Academy of Sciences, 842 36 Bratislava, Slovakia

15.30 – 15.45 **Tea Break**

Session 10: 15.45 – 16.45 **Poster session 2 (POSTERS 65 – 130)**

Session 11 : (two parallel sessions, one in ICSR auditorium and another in CLT)

16.45 – 17. 05
Oral Presentation OP23 (ICSR Auditorium)
Optical Properties of a Novel Fluorene-Based Thermally Stable Conjugated Polymer Containing Pyridine and Unsymmetric Carbazole Groups
Sidharam Pundlik Pujari, Department of Chemical Engineering, National Taiwan University of Science and Technology, Taipei 10607, Taiwan.

Oral Presentation OP24 (Central Lecture Theatre, CLT)
Low density ceramic–polymer hybrid foams– Influence of nanofiller on mechanical, thermo-physical and high temperature performance
R Sujith, National Institute of Technology, Calicut-673601, India

17.05 – 17. 25
Oral Presentation OP25 (ICSR Auditorium)
Synthesis of Peptide-Polymer Hybrid Conjugates by Atom Transfer Radical Polymerization and Their Self-Assembly
Tapas K. Paira, Polymer Science Unit, Indian Association for the Cultivation of Science, Jadavpur, Kolkata 700 032, India

Oral Presentation OP26 (Central Lecture Theatre, CLT)
Dynamic Mechanical Analysis of Polymer Hybrid Nanocomposites
V.Selvakumar, Department of Mechanical & Production Engineering, Sathyabama University, Chennai.

17.25 – 17.45
Oral Presentation OP27 (ICSR Auditorium)
Synthesis of Polypyrrole + PS / PMMA Composites: Application as ammonia gas sensor
V. A. Bambole, Department of Physics, Institute of Chemical Technology, Mumbai.

Oral Presentation OP28 (Central Lecture Theatre, CLT)
Self Assembled Polyurethanes
Pralay Maiti
School of Materials Science and Technology, Institute of Technology,
Banaras Hindu University, Varanasi 221005, India

Session 12: **(ICSR Auditorium)**

18.15 – 19.00 **SPECIAL INDUSTRY LECTURE 2**
Sustainability in Engineering Thermoplastics
Gautam Chatterjee, Polymer Science and Technology, GE Global Research, SABIC Innovative Plastics Program, GE India Technology Center, Bangalore 560066.

19.30 – 21.30 **Dinner at Open Air Theatre (OAT)**

Wednesday, March 11, 2009

Session 13: (In ICSR Auditorium)

9.00 – 9.45
Plenary Lecture 2 (PL4)
Continuum of Structure in Chitosan-based Materials for Tissue Engineering
A. Domard
Laboratoire des Matériaux Polymères et des Biomatériaux, Université C. Bernard Lyon 1,
15, Boulevard A. Latarjet, 69622 Villeurbanne cedex, France.

9.45 – 10.30
Plenary Lecture 3 (PL5)
Multifunctional Poly(vinylidiene fluride) Graft Copolymer
Arun. K. Nandi,
Polymer Science Unit, Indian Association for the cultivation of Science, Jadavpur,
Kolkata - 700 032, India.

10.30 – 10.45 **Tea Break**

Session 14: (two parallel sessions, one in ICSR auditorium and another in CLT)

10.45 – 11.30
Invited Lecture IL13 (ICSR Auditorium)
Rheological properties of viscoelastic fluids and fracture under stress
G. Ducouret
Laboratoire de Physico-Chimie des Polymères et des Milieux Dispersés, UMR 7615, ESPCI,
10 rue Vauquelin, 75231 Paris Cedex, France

Invited Lecture IL14 (Central Lecture Theatre, HSB)
Nanomedicine: A Miracle Technology for Health Care in the 21st Century: Opportunities and Challenges
P.L.Nayak, Institute of Nanobiotechnology, Cuttack-753006, India

11.30 – 11.50
Oral Presentation OP29 (ICSR Auditorium)
Use of Biodegradable Polymers to improve new Antifouling coatings: Erosion of marine paints
Isabelle Linossier, Laboratoire de Biotechnologie et Chimie Marines, EA 3884, Université de Bretagne-Sud, BP92116, 56321 Lorient cedex, France.

Oral Presentation OP30 (Central Lecture Theatre, CLT)
A Novel Cure Shrinkage Mechanism based on the Polymerisation-induced Viscoelastic Phase Separation in Thermoplastic Modified Epoxy Resins
Jesmy Jose, School of Chemical Sciences, Mahatma Gandhi University, Kottayam, Kerala, India.

11.50 – 12.10
Oral Presentation OP31 (ICSR Auditorium)
Effect of Morphology Changes in Anthracene Substituted Lower Generation PAMAM and PPI Dendrimers on the Fluorescence Properties.
E. Prasad, Department of Chemistry, Indian Institute of Technology Madras, Chennai 600 036, India.

Oral Presentation OP32 (Central Lecture Theatre, CLT)
The influence of treated fumed silica on the hygroscopic characteristics of solid rocket motor case insulation
K.S. Abhilash, Vikram Sarabhai Space Center, Thiruvananthapuram-695 022

12.10 – 12.30
Oral Presentation OP33 (ICSR Auditorium)
Macro porous Styrene Divinyl Benzene Copolymers: Formation of stable porous structures and preparation of supported Platinum Catalyst by in situ reduction
Baijayantimala Garnaik, Polymer Science and Engineering Division, National Chemical Laboratory, Pune-411008, India.

Oral Presentation OP34 (Central Lecture Theatre, CLT)
Redox Polymerisation of Acrylamide Initiated by Cerium(IV) – Amino Acid Ligands
S. Padmavathy, Bishop Heber College, Trichy – 17, India

12.30 – 12.50
Oral Presentation OP35 (ICSR Auditorium)
Photo-Cation Curing Epoxy for Rigidization of Inflatable Structures
S.Suraj, Propellants and Special Chemicals Group, Vikram Sarabhai Space Centre, Thiruvanamthapuram – 695 022, India

Oral Presentation OP36 (Central Lecture Theatre, CLT)
Design and synthesis of a stepwise folding polymer
S. G. Ramkumar, Department of Inorganic and Physical Chemistry, Indian Institute of Science, Bengaluru 560012, India.

12.50 – 14.00 **Lunch Break**

Session 15: (two parallel sessions, one in ICSR auditorium and another in CLT)

14.00 – 14.45
Invited Lecture IL15(ICSR Auditorium)
Permeability, Diffusivity, and Solubility of Various Gases in Poly(lactic acid) Blend Membranes
Kazukiyo Nagai
Department of Applied Chemistry, Meiji University,1-1-1 Higashi-mita, Tama-ku, Kawasaki 214-8571, Japan

Invited Lecture IL16 (Central Lecture Theatre, HSB)
Effect of modifiers on thermal properties of novel thermoplastic polyurethane-peptized Laponite nanocomposite
Golok B Nando
Rubber Technology Center, Indian Institute of Technology Kharagpur
Kharagpur – 721 302, India

14.45 – 15. 30
Invited Lecture IL17(ICSR Auditorium)
Self-assembled Molecular Template for Conducting Polymer Nano-materials
M. Jayakannan
Department of Chemistry, Indian Institute of Science Education& Research (IISER),
900 NCL Innovation Park, Dr, Homi Bhabha Road, Pune 411008, INDIA

Invited Lecture IL18 (Central Lecture Theatre, HSB)
Effect of Adamantyl Derivative on Atom Transfer Radical Polymerization (ATRP) of Poly(meth)acrylates
Nikhil K. Singha
Rubber Technology Centre, Indian Institute of Technology, Kharagpur 721302, India

15.30 – 15.45 **Tea Break**

Session 16: (two parallel sessions, one in ICSR auditorium and another in CLT)

15.45 – 16.30
Invited Lecture IL19 (ICSR Auditorium)
Synthesis and Characterization of Polystyrene Nanoparticles and Their Effect on Rheological and Thermal Properties of LLDPE Matrix
Satyendra Mishra
Department of Chemical Technology, North Maharashtra University, Jalgaon-425001, India

15.45 – 16.00
Oral Presentation OP37 (Central Lecture Theatre, HSB)
Synthesis And Characterization Of Poly(dimethylsiloxane-urethane) Nanocomposites: Effect Of (In)Completely Condensed Silsesquioxanes On Thermal, Morphological And Mechanical Properties
K. Madhavan , Industrial Chemistry Laboratory, Central Leather Research Institute, Chennai-600 020, India.

16.00 – 16.15
Oral Presentation OP38 (Central Lecture Theatre, HSB)
Synthesis and characterization of bismaleimide modified caprolactam blocked hexamethylene diisocyanate toughened epoxy inter-crosslinked matrices
S. Premkumar, Department of ChemicalEngineering, Anna University, Chennai-600 025, India.

16.15 – 16.30
Oral Presentation OP39 (Central Lecture Theatre, HSB)
Micro/nano hybrid fillers for polypropylene modifications
Sinto Jacob, Department of Polymer Science & Rubber Technology, CUSAT, Kochi.

Session 17:

16.45 – 17.15 **Valedictory Function**

ABSTRACTS
OF
LECTURES

PLENARY LECTURES

PL 1 – PL 7

Polymeric Nanoobjects

S. Ramakrishnan
Department of Inorganic and Physical Chemistry
Indian Institute of Science, Bengaluru 560012, INDIA

Polymeric objects that are of nanometer dimensions and possess the capacity to sequester small molecules within their core, either because of specific interactions or due to solvophobic compulsions, are of great interest because of their potential for a range of interesting applications, such as for drug delivery, dye-encapsulation, water remediation, catalytic support, etc. Suppose one is interested to prepare such polymeric nanoobjects, the relevant question one should ask is – What are all the various feasible options to achieve the broad objective of creating such dispersible nanoscopic containers? In addressing this question we soon realize that there are several parallel approaches that are being concurrently pursued in the literature, each of which has their merits and demerits. Examples of such approaches are – dendritic core-shell systems, block-copolymer based nanoaggregates, self-crosslinked nanogels, layer-by-layer deposited nanocapsules, nanoemulsions, etc. In this talk, I shall briefly examine the various approaches to create polymeric nano-objects, specifically those that have discrete core-shell domains possessing different solubility properties, and discuss some of their interesting applications. I shall then turn to some of our own efforts in this area and discuss our recent findings on simple core-shell type hyperbranched polymers (HBP), functionalizable core-shell type HBPs, design and development of polymerizable non-ionic surfactants and their potential use to create sterically stabilized emulsions.

Surface-Initiated Polymerization as a Tool for the Fabrication of bioactive Surfaces and thin Inorganic Films

Harm-Anton Klok*
Laboratoire des Polymères, Institut des Matériaux,
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This contribution will discuss the use of polymer brushes prepared via surface-initiated atom transfer radical polymerization (SI-ATRP) as platforms for the fabrication of protein function microarrays, bioactive surface coatings and microstructured inorganic thin films.

Polymer brushes prepared via SI-ATRP of poly(ethylene glycol)methacylate (PEGMA) provide a thin polymer layer, which is not only resistant towards the non-specific adsorption of proteins, but which also contains hydroxyl groups that can be used to covalently immobilize proteins or small peptide ligands.[1] Functionalization of these brushes with benzylguanine allows the covalent, chemoselective immobilization of O^6-alkylguanine-DNA-alkyltransferase (AGT) fusion proteins, which were successfully used to detect protein-protein interactions.[2] Amongst others, the AGT-mediated immobilization offers the following advantages: (i) immobilization occurs exclusively via the AGT fusion and leaves the protein of interest accessible for interactions with other molecules, (ii) functionalization is chemoselective and can be carried out directly from crude cell lysates without the need for purification steps.

In the second example, it will be shown that modification of polyPEGMA brushes with short RGD-based cell adhesion peptides provides surface coatings, which are able to induce integrin-specific adhesion of human umbilical vein endothelial cells (HUVECs) and which may be of interest as coatings to promote endothelialization of blood contacting biomaterials.[3]

In the last part of the presentation, a novel approach for the fabrication of microstructured calcite thin films will be presented.[4,5] The process uses photolithographically patterned poly(methacrylic acid) (PMAA) brushes grown via SI-ATRP as ionotropic matrices to produce crystalline calcite films that are an exact 3D replica of the PMAA brush. The proposed strategy combines three key elements: (i) the use of photolithographic techniques to prepare microstructured PMAA brushes; (ii) the ability of the PMAA brushes to stabilize amorphous calcium carbonate (ACC) and (iii) the possibility to convert the metastable ACC phase into a polycrystalline calcite film via a thermal treatment. While the lateral dimensions of the microstructured calcite film are defined by the lithographic techniques that are used to prepare the micropatterned PMAA brush, the thickness of the films can be adjusted via the thickness of the PMAA brush, which can be controlled due to the "living" nature of the SI-ATRP procedure.

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PL - 3

Crystallization of miktoarm star copolymers in comparison to linear diblock copolymer analogs

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Linear AB block copolymers and terpolymers (ABA and/or ABC) have have been extensively studied in view of the remarkable correlation between the molecular characteristics of the components (lengths of the blocks and the segregation strength) and the ordered morphologies that these materials can exhibit.[1,2] On the contrary, a modest knowledge has been gathered about star block copolymers,[3-5] where the number and localization of the arms can be now controlled (by high vacuum anionic polymerization techniques).

AB diblock copolymers and A_2B_2 miktoarm star copolymers of poly(ε-caprolactone) (PCL) and polystyrene (PS), and AB diblock and AnBm miktoarm star copolymers (with n and m ranging from 1 to 3) of polyethylene (PE) and PS were synthesized employing anionic polymerization techniques.[4-6] The morphology and thermal properties were studied by transmission electron microscopy (TEM), Small-Angle X-ray scattering (SAXS) and differential scanning calorimetry (DSC). It was found that the relationship between the volume fractions of the various arm types and the micro (and nano) domain morphology was different from the results found in linear block copolymers. Such unexpected and novel behavior[7] was explained in terms of the higher resistance of the arms to be stretched in miktoarm star copolymers as compared to analog linear diblock copolymers.[7,8] The morphology, crystallization kinetics and thermal fractionation of the crystallizable blocks within the materials were extensively studied as a function of composition and molecular architecture. The effects of confinement on the crystallizable phases lead to well established first order crystallization kinetics in the limits of isolated cylinders and spheres.[9]

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Continuum of structure in chitosan-based materials for tissue engineering

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Chitosan is a complex chemical structure and the control of the distribution of the residues and the dimension of the polymer chains plays a key role. It is responsible of the molecular organization in all the physical forms of chitosan. Since it is a co-polymer of ionisable and neutral residues, we first worked with chitosans constituted of a random distribution of the residues with a control of both their molar fraction, represented by the degree of acetylation DA, and their dimension, with a low polydispersity index I_p. This was performed from a deacetylated chitosan reacetylated in mild conditions[1-3]. The control of the molecular dimensions and their distribution was achieved by the use of ultrasounds producing lower dimensions with exactly the same DA and distribution of the residues up to the smallest oligomers[4]. Oligomers are essential to understand the polymer behaviors or for their specific biological properties. Several ways allow their production[5,6]. The challenge is to prepare co-oligomers controlling both the dimensions and architectures. This is solved by the full synthesis which is fastidious with for a given DP, 2^{DP} different structures to produce[7]. Chemical ways with an appropriate method of separation allow a simplified processing[8].

It is then possible to study the molecular organizations from both a given molecular weight and chemical architecture. Aqueous solutions control almost all other physical forms. As a polycationic polyelectrolyte of amphiphilic character, the balance between hydrophilic and hydrophobic interactions is at the core of the molecular organizations in solution. It depends on structural and environmental parameters and the polymer concentration. We first approached the conformations in solution by means of small angle X-ray scattering showing that according to the electrostatic potential, modern theories of polyelectrolytes were verified. For a given DA, a critical concentration C_b was identified, corresponding to a transition between the string- and the bead-controlled regimes in the necklace model. Quasi-elastic light scattering allowed us to identify the formation of hydrophobic nano-aggregates.

The knowledge of the solutions was useful to understand the formation of physical hydrogels and their morphology at different levels of observation. Small- and wide-angle X-ray scattering, and small-angle laser-light scattering revealed a continuum of structure between a solution and a gel confirmed by electron-beam microscopy. It was also possible to understand the mechanisms of formation of multi-membrane systems using typical conditions of neutralization of either a gel or a solution[9,10]. All these forms find applications in tissue engineering[11,12]. Multi-membrane systems constitute bioreactors with multiple applications. One example is the case of their use for the co-culture of cartilage cells (chondrocytes)[9].

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Multifunctional Poly(vinylidiene fluride) Graft Copolymer

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The work describes a new method to graft hydrophilic side chains to the hydrophobic poly(vinylidene fluoride)(PVDF) polymer backbone to obtain high grafting density. ATRP in solution phase has been used to produce the polymer. Gravimetric analysis, NMR and GPC studies indicate ATRP mechanism is operating in the polymerization process. The synthesis results in water soluble PVDF with super tough and super gluing properties. The polymer mechanical properties (tensile strength, elongation, toughness.) are well characterized and possible reasons of dramatic enhancement of properties from supramolecular interactions are presented. DSC study indicates only 20% crystallinity in the graft co-polymers and there is a substantial decrease in crystallization and melting temperatures of the graft co-polymers than that of pure PVDF even in the low percentage of grafting. WAXS and SAXS study indicate the unusual fringed micelle crystallization of PVDF graft co-polymers than the usual chain folding crystallization observed in pure PVDF. The polymers are used to stabilize the gold nanoparticles in aqueous medium and they are modified to impart conductivity in the polymer. The polymer produces thermoreversible gels in organic medium and functional multiporous materials are produced from them. Thus a multifunctional PVDF is synthesised, characterised and possible technological use has been explored.

High Throughput Research for Catalysts Development for Polymerization Reactions

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Catalyst development is an extremely complex, knowledge based, time consuming process, involving large number of experiments, characterization, analysis, etc. This is traditionally done in laboratory catalyst synthesis units and reactor systems which are labor intensive and time consuming. With the advances in technology, it can be replaced by sophisticated high throughput (HT) experimentation techniques along with other supporting techniques such as catalyst library design, data informatics, and extraction for fast discovery. Over the years, Dow has developed capabilities and skills to effectively utilize HT research for achieving these objectives. In the present talk, the use and application of high throughput approach for catalyst development will be presented.

Sustainability in Engineering Thermoplastics

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Plastics are an integral part of modern life. From disposable garbage bags to high-technology space applications, plastics are rapidly replacing other materials. Plastics waste disposal has become a critical topic of discussion across the globe. Research and development of biodegradable and environmentally friendly polymers have become important for the sustainable coexistence of polymeric materials and the environment. Significant efforts are directed towards recycling technologies. Additionally, there is a growing urgency to develop novel bio-based products and other innovative technologies to reduce the widespread dependencies on fossil fuels. Bio-based products based on renewable resources can compete and capture markets currently dominated by products exclusively on petroleum feed stocks. Most of this research has focused on the high volume commodity plastic market. However, over the last several years, there has been significant development in the sustainability for the higher end engineering plastics.

Thermoplastics have steadily been replacing metals and glass in automotive applications, resulting in significant fuel savings (due to weight reduction), hence indirectly contributing to a safe environment. Polyetherimide based Ultem* resins are used extensively in “under the hood” applications of metal replacement. Several polymer composites are successfully replacing metals to provide fuel-efficient and Eco-friendly options. Polycarbonate, one of the most widely used engineering thermoplastics, is traditionally prepared from petroleum-based phenol. SABIC Innovative Plastics has proprietary technologies to produce polycarbonate blends, from building blocks that are derived from corn. This bio-sourced Cycoloy* has been used in housing of cell phones and has application potentials in other electrical or electronics equipments.

India has traditionally been one of the pioneers in recycling used materials, especially Plastics. Using a novel recycling technology, SABIC Innovative Plastics has developed PBT based Valox* iQ resin from waste PET bottles, a process, which is currently being commercialized in India. Polymer blends based on this material (Xenoy* iQ) are used for automotive parts such as energy absorbers and body panels. Looking to the future, one of the largest opportunities for India to participate in the “Green Plastics” Revolution, is our access to a wide variety of natural fibers, which can be used as fillers to provide various properties, including toughness, to various plastics used in automotive applications.

- Trademark of SABIC Innovative Plastics IP BV

INVITED LECTURES

IL 1 – IL 19

IL - 1

Synthesis and self-assembling properties of end-capped poly(ethylene oxide) and grafted poly(acrylamide) hydrophobically modified with 3-pentadecylcyclohexylamine.

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Water-soluble hydrophobically modified polymers continue to receive major attention since they form an important class of macromolecular additives involved in aqueous-based formulations. They actually find an increasing number of applications in technological areas such as enhanced oil recovery, cosmetic lotions, paints and coatings, food additives and pharmaceuticals. These systems are generally designed with a water-soluble backbone bearing a small number of hydrophobic stickers either dispersed along the polymer chain or present as terminal groups. While the architecture of the macromolecule highly influences the structure of the physical network, the chemical nature of hydrophobic groups strongly impact its dynamics.

In the present study we used 3-pentadecylcyclohexylamine (PDC), a hydrophobic compound synthesized starting from cashew nut shell liquid (a renewable resource material), for the preparation of two series of associating polymers: telechelic end-capped poly(ethylene oxide) (PEO-PDC) {1} and randomly grafted poly(acrylamide) (PAM-g-PDC). Starting with a single type of sticker, this work offers the opportunity to compare the associating properties of telechelic PEO, prepared from different molecular weights (10K and 20K), with those of PAM grafted with various mount of PDC; from 0.5 to 0.9% (see example in **Figure 1**).

After an introduction to the synthesis and characterization of these new associating polymers, we will investigate their self-assembling behaviour in aqueous solution using different points of view: the structure, the thermodynamic stability and the dynamic properties.

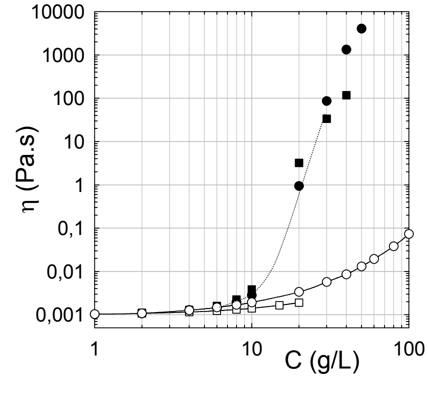

Figure 1

Concentration dependence of the viscosity for aqueous solutions of associating polymers and hydrophilic precursors:

□ PEO20K
○ PAM
■ PEO20K-PDC
● PAM-g-0.7%PDC

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Investigation of Polymer Blend Miscibility Fluorescence Spectroscopy

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Miscibility and phase behavior are of crucial importance for the final properties of polymer blends. Many experimental techniques have been developed for the characterization of polymer blend miscibility. However, the most fundamental question that still remains in the characterization of polymer blend miscibility is the scale over which the components are molecularly mixed. It is well accepted that the measured miscibility is strongly dependent upon the techniques used. Therefore, it is important to develop more sensitive technique for the study of miscibility. In recent years, excimer fluorescence spectroscopy has been proven to be a highly promising technique. The important advantages of this technique that distinguish it from other techniques are the high sensitivity of detecting phase separation and the ability to analyze phase behavior of blends which contain very small concentration (even less that 1%) of one of the components. The recent studies on excimer fluorescence spectroscopy to investigate miscibility of polymer blends will be briefly reviewed. Comparison will be made between fluorescence, light scattering, microscopy and differential scanning calorimetry. The use of this technique to study the effects of casting solvents, molecular weight etc. on miscibility will be discussed. More attention will be given to the miscibility, phase separation and kinetics of phase separation of SAN/PMMA and PS/PMMA systems

IL - 3

Diameter Control and Vertical Growth of SWCNTs and Its Potential Applications

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Single-walled carbon nanotubes (SWCNTs) have been extensively investigated as novel building blocks in broad areas ranging from composites to nanoelectronics. Many promising applications, however, have been limited by the polydispersed nature of as-produced SWCNTs. Our research is focused on the synthesis of uniform SWCNTs. An Ultraviolet irradiated ozone treatment (UV-ozone treatment) of Fe-Mo/MgO catalyst powders prepared by an impregnation method was developed to afford large-scale synthesis of SWCNTs having small and uniform diameters by catalytic decomposition of C_2H_2 at 800 °C. It was found that the UV-ozone treatment of the Fe-Mo/MgO catalyst strongly suppressed the migration of iron oxide nanoparticles on the MgO supported material at high temperature (800 °C).

The vertical alignments of SWCNTs are important to fabricate the SWCNT-based electronic devices. The SWCNT thin films were formed on a gold electrode by DC electrophoretic deposition. Applying ultrasonic energy resulted in dramatic changes of the film morphology; the deposited SWNT bundles reassembled and oriented normal to the electrode. The mechanism of SWNT orientation will be discussed by analyzing the variation in the film morphology with ultrasonication time. Vertically aligned SWCNTs were also fabricated on substrate by thermal decomposition of C_2H_2. Several methods including dipping, spin coating, and spray were used to form Fe-Mo catalyst nanoparticles on Si, MgO/Si, and Al_2O_3 substrates.

We also focused on the 3-D networking of SWCNTs that can offer the nano-sized electrodes with large surface area to the SWCNTs-based potential applications. By forming catalyst nanoparticles on the the 3-D structures of Si substrates, the SWCNTs were uniformly synthesized with desired density on those 3-D structures of Si substrates. We expect that the 3-D networks of SWCNTs will be useful as highly efficient electrodes for the potential applications in the fields of future electronics and energy alternatives.

Biodegradable Polymers Based on Renewable Resources: Aliphatic Copolyesters Composed of L-Lactide and Isosorbide Units

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Dianhydrohexitols are the important byproducts of biomass obtained in the sugar industry by the double dehydration of starch. These chiral compounds exist as three stereoisomers according to the relative configuration of their two hydroxyl functions namely, isosorbide, isomannide, isoiodide. These three isomers have been used as monomers for the manufacture of new biodegradable polymers, including polyesters, polyurethanes and polycarbonates based on natural and renewable raw materials. These polymers presented promising high glass transitions, excellent thermal stabilities and interesting physical properties.

Among this class of compounds, isosorbide is the less studied isomer as the less accessible one within four steps from D-mannose. However, it is certainly the most interesting for polymer synthesis due to the improved accessibility of the two hydroxyl groups lying in exo (pseudoequatorial) positions. Furthermore, on the basis of thermal measurements (DSC), it has been shown that the exo sustituent increases the ring thermal stability.

The Copolyesters prepared from aliphatic diols such as isosorbide are of great interest to the chemical industry because such aliphatic diols can be produced from renewable resource materials, namely sugars, rather than from petroleum feed stocks as for most presently used diol monomers. Therefore, it would be desirable to have an efficient method to produce high quality, random polyesters or copolyesters from isosorbide.

In the present work, we have synthesized a series of new copolyesters derived L-lactide and isosorbide by co-ordination/insertion ring opening polymerization using less toxic metal complex catalysts. Furthermore, the effect of incorporation of isosorbide was studied on the properties of copolyesters derived from L-lactide and isosorbide. The copolyesters derived from L-lactide and isosorbide were characterized by FTIR and ^{1}H NMR spectroscopy, solution viscosity, differential scanning calorimetry, thermogravimetric analysis and X-ray diffraction.

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IL - 5

Hybrid Nanomaterials From Polymer Gels And Organogels

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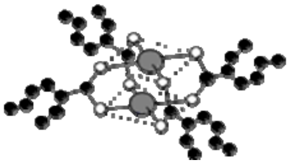
In this talk two types of hybrid materials made up from covalent polymers and self-assembling systems will be presented. The first system consists of filaments of a bicopper complex (see figure 1-left). encapsulated in isotactic polystyrene fibrils, the second system deals with intermingled gels of stereoregular polystyrenes and an organogel produced from oligo(*p*-phenylenevinylene) molecules (see figure 1-right).



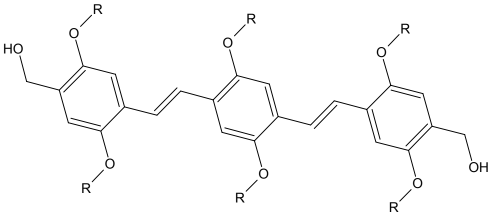


Figure 1: *right*: the bicopper complex molecules (grey= copper; white= oxygen; black= carbon). *left*: chemical structure of OPV16, the oligo(*p*-phenylenevinylene) used in this study where R= $C_{16}H_{33}$.

Results on the formation thermodynamics as observed by DSC, the morphology as determined by AFM and the molecular structure as obtained by SANS and SAXS will be presented and discussed. It will particularly be shown that a high degree of compatibility exists between all the components thus allowing one to prepare materials where one component is finely dispersed within the other. A typical AFM can illustrate this point (see figure 2).

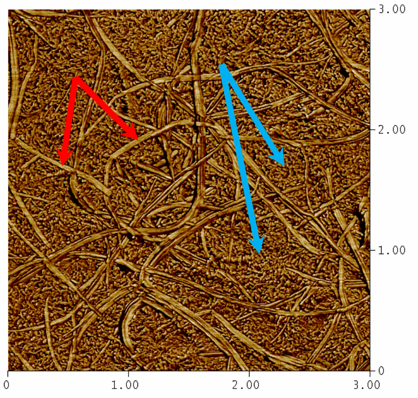


Figure 2: AFM picture of OPV16 organogels (large fibrils, red arrows) and isotactic polystyrene gel (small fibrils, blue arrows) showing the high degree of intermingling. Both gels display their own morphology, in particular the fibrils cross-sections are the same as in the binary systems. Hybrid gel prepared from *trans*-decalin. Scale in µm.

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IL - 6

Self-Organization in Tailor-made Urethane-Methacrylate Comb Polymers

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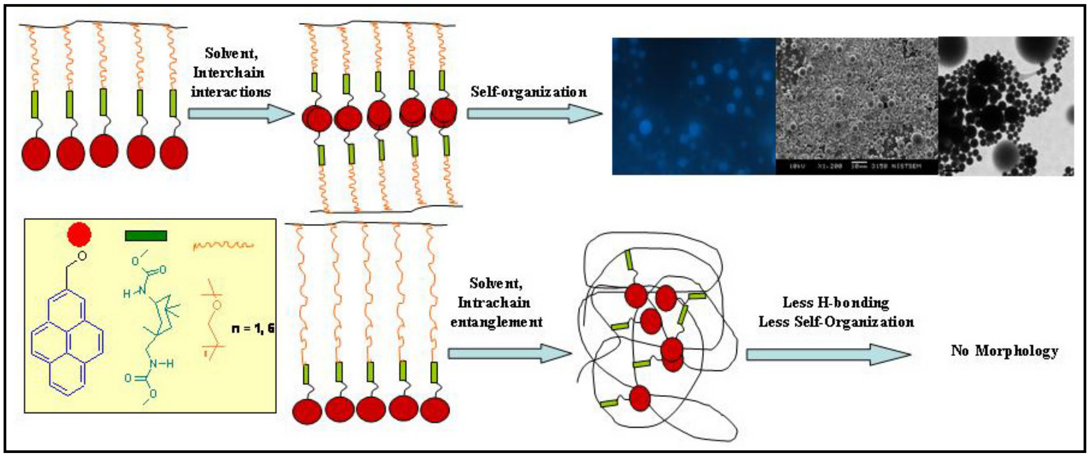
Control of chemistry, architecture and size of macromolecules allow designing self-assembled materials with desired physical and chemical properties and phase structure with the feature size ranging from nanometers to microns. A unique monomer was designed which connected a polymerizable methacrylic double bond to various hydrophobic anchoring units such as long alkoxy chains or bulky cycloaliphatic rings like tricyclodecane (TCD) and adamantane or aromatic units like cardanol, which is obtained from the renewable resource cashew nut shell liquid, via a hydrogen bonded cycloaliphatic urethane linkage. The hydrophilic-hydrophobic balance in the homopolymer design was varied by varying the length of ethyleneoxy units in the spacer segment. These homopolymers formed morphologies like 3D honeycomb patterns, vesicles, tubes, microspheres etc from various solovents like THF, $CHCl_3$ as well as from solvent combination like THF/water mixture upon simple drop casting, as observed from the SEM and TEM measurements. The self-organization at the molecular level was followed by introducing a fluorescent pendent unit- pyrene into this polymer design and studying the photophysical properties like concentration dependent UV-Vis absorption and emission in solution. The morphology of random as well as block copolymers synthesized using atom transfer radical polymerization (ATRP) methodology was also studied. The presentation will be focused on the summary of our research contribution in this area.



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IL - 7

Soft Matter for biomedicine: two case studies.
A Novel Temperature Sensitive Hydrogel Microdevice based on Poly(vinyl alcohol)/Poly(methacrylate-co-N-isopropyl acrylamide)

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In controlled drug delivery, thermoresponsive hydrogel microspheres play an important role to maintain the drug release at a predetermined therapeutic dose, with minimal adverse effect because of its five unique properties into one single entity: thermo responsive intelligence, swelling capability, favourable surface/volume ratio due to the micro-dimensions of the device, microsphere shape and size for easy delivery via injection rather than implantation and enhanced versatility of chemical modification of the surface. A lower critical solubility temperature (LCST) around 32 °C makes PNiPAAm as suitable candidate for the fabrication of polymeric thermoresponsive devices for drug delivery.

In this study, we describe a new class of temperature sensitive hydrogels PVA/Poly($MA_m NiPAAm_n$) shaped as microspheres obtained with a water-in-water emulsion photocrosslinking reaction. Poly(vinyl alcohol) chains bearing methacryloyl sidechains in the presence of NiPAAm, as intermediate comonomer of the crosslinked chains, is reacted in the presence of dextran T40 under high shear stirring.

Microparticles of PVA/Poly($MA_m NiPAAm_n$) with m:n theoretical molar ratios equal to 1:0; 1:4, 1:8 have been studied in terms of average size and responsiveness to temperature characterized by confocal laser scanning microscopy (CLSM), dynamic light scattering (DLS) and differential scanning microcalorimetry (DSC).

In view of parenteral administration of such devices, *in vitro* biocompatibility and ability to release the anti tumour drug doxorubicin have been addressed and results will be presented on these topics.

A physical network based on hyaluronic acid with a small extent (degee of substitution:1 %) of hydrophobic moiety grafted on the backbone, HYADD4, has been characterized in order to account for the influence of thermal treatment on the stability of the hydrogel. Dynamic light scattering (DLS) and small angle neutron scattering have been used for dynamic-structural characterization of HYADD4 hydrogels. Diffusion of macromolecular probes has been studied by fluorescence recovery after photobleaching (FRAP) to study the mesoscopic texture of the hydrogel and molecular dynamic (MD) simulations were used to approach the time evolution of the physical junction points and of chains clusters.

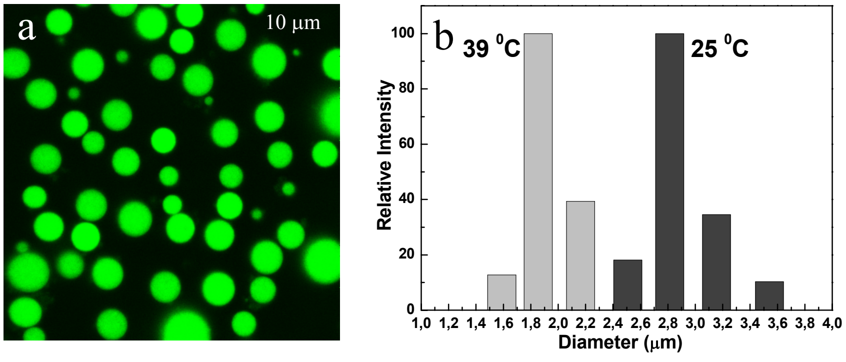

Figure 1: (a) CLSM image and (b) Particle size distribution by DLS at 25 °C and 39 °C of PVA/$PMA_m NiPAAm_n$ hydrogel microspheres.

Conjugated Polymer Thin Film Based Biosensors

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Polydiacetylene thin films are known to exhibit mechanochromism and biochromism, *i.e.*, its colour changes from blue to red on application of mechanical or biomolecular stress [1]. Hence these polymers can be used for sensing biomolecular interactions like antigen-antibody or protein-substrate binding. The most significant application of polydiacetylenes as sensors for pathogen detections was reported by Charych *et al.* for detection of influenza virus [1] and cholera toxin [2]. By using derivatized polydiacetylene films for covalent immobilization of glucose oxidase, we were able to develop an optical sensor for glucose. With an aim to develop a sensor for the detection of a substrate of an enzyme, we have used the protein enolase as a macromolecular receptor and immobilized it on a PDA film to monitor its interaction with Mg (II) ions and 2-phosphoglycerate in solution [3]. Thus polydiacetylene thin films provide a good platform for development of optical biosensors.

Another class of polymers of our research interest are the conducting polymers. Conducting polymers are paving the way for 'all-organic' electronic devices and chips. Though these materials have a large potential for application, they lack important properties required for practical application such as high conductivity, stability, processability etc. We have made several attempts for improving the physical properties of conjugated polymers. For *e.g.* Judicious selection of the dopant anion can help in improving the environmental stability of polyaniline [4]. By preparing an organic-inorganic hybrid it is possible to add extra functionality (*e.g.* magnetism) to polyaniline. Polymerisation of a monomer in its Langmuir-Blodgett film results in an ordered film of the polymer with higher conductivity [5]. From the point of view of biosensing application, we have used polyaniline to develop electrochemical sensors for detection of analytes such as glucose and lindane (a pesticide).

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Preparation and properties of Polyimides, Bismaleimides and Bisnadimides containing pyridine and anthracene rings

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Organic polymers containing imide groups in the main chain, are important members in the family of hetero atomic polymers. Aromatic polyimides can be used at temperatures higher than 350°C without damage of their polymer backbones and retain a relatively high percentage of mechanical strength and modulus at elevated temperatures. On the other hand, their applications have been limited in some fields because most polyimides are normally insoluble in common organic solvents and have extremely high T_g (or) T_m, precluding melt processing. Consequently, to improve their processability numerous research efforts have been focused on the synthesis of easily processable polyimides that retain their thermal stability and other excellent properties.

Hence, three different pyridine containing diamines with anthracene ring in the para position of the pyridine ring were prepared by the modified chichibabain reaction. Polyimides were synthesized by one step method and two step method (both thermal and chemical imidization) by solution polycondensation technique using the synthesized diamine with different dianhydrides such as PMDA, BTDA and ODPA. Bismaleimides/bisnadimides were synthesized from the prepared diamines with maleic anhydride (in the presence of sodium acetate as catalyst and acetic anhydride as dehydrating agent)/nadic anhydride. The synthesized bismaleimides were polymerized with various diamines such as m-phenylenediamine and 4,4'-diaminodiphenyl - methane in m-cresol containing a catalytic amount of glacial acetic acid to promote the polymerization to form polyaspartimides. The synthesized monomers, prepolymers and polymers were characterized by elemental analysis, FT-IR and ^{1}H-NMR spectroscopy. The number average molecular weight, weight average molecular weight and polydispersity index of the polyimides and polyaspartimides were determined in DMF using Gel permeation chromatography. The optical properties of the polyimides were studied using UV-visible spectrophotometer. The thermal stability of the polyimides, polyaspartimides, cured bismaleimide and bisnadimide resins were ascertained by thermo gravimetric analysis. The cure temperatures and the T_g were measured by DSC.

Tailoring Functional Nanoporous Materials from Ordered Block Copolymers

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Over the last decade, the generation of organic porous materials with controlled pore sizes and narrow pore size distributions as well as desired functionalities has been the subject of increasing attention in materials science. Such well-defined porous frameworks are of great interest, mainly due to the large variety of applications in which they are involved, *e. g.* monoliths, filters, supports for catalysis, sensors, etc. Much progress has recently been achieved toward engineering porous polymers with controlled morphology. Miscellaneous approaches are now applied by selectively removing single domains acting as porogen templates from macromolecular architectures, *e.g.* removal of self-assembled molecules from supramolecular architectures, selective thermal or photochemical destruction of a thermoplastic polymer homogeneously blended within a thermostable matrix, as well as selective removal of one partner from (semi-) Interpenetrating Polymer Networks (IPNs). Furthermore, block copolymers develop well-defined equilibrium domain morphologies (*i.e.* lamellar, hexagonally packed cylindrical, bicontinuous gyroid, and spherical, in linear diblock copolymers), and thus constitute arguably ideal nanostructured precursors for the formation of ordered mesoporous polymers. In this context, the selective removal of the sacrificial minority block from self-organized block copolymers constituted of at least two components of contrasted degradability has proven to be a very prolific route to a wide array of nanoporous materials with a defined porosity.

In this lecture, we will describe an original strategy for generating mesoporous polystyrene membranes with a simultaneous control over the porosity and functionality through the synthesis of polystyrene-*block*-poly(D,L-lactide) (PS-*b*-PLA) diblock copolymers with functional groups at the junction between both blocks, followed by their macroscopic orientation, and the subsequent selective hydrolysis of the PLA block. We used a combination of "living"/controlled anionic or Atomic Transfer Radical Polymerization (ATRP) and Ring Opening Polymerization (ROP) techniques to prepare well-defined diblock copolymers with carboxylic or amino functionalities at the junction between the PS and PLA blocks. By the proper design of the copolymer composition and a good control over the polymerization conditions, polymers with preferentially cylindrical morphology (PLA cylinders in PS matrix) could be obtained. After macroscopic alignment of the nanodomains, the PLA phase was quantitatively removed by basic hydrolysis, leaving behind the porous PS membrane with functional groups located along the pore walls. The PS-*b*-PLA precursors as well as the resultant porous materials were analyzed by a wide array of physico-chemical techniques, including Size Exclusion Chromatography, ^{1}H NMR, Differential Scanning Calorimetry (DSC), Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM) and Small-Angle X-ray Scattering (2-D SAXS). The porosity of the functional nanoporous materials was also quantified by nitrogen sorption porosimetry.

Obtained functional nanoporous membranes are of potential interest for heterogeneous catalysis, advanced filtration techniques and selective transport applications.

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Conductive Polymer Nano-BioComposite (CPC) for vapour sensing: chemo-electrical properties of chitosan-carbon nanofiller (Chit-CNF) in methanol, water and toluene vapours atmosphere.

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Conductive Polymer nanoComposites (CPC) transducers prepared from the dispersion of carbon nanofillers into an insulating polymer matrix have been successfully used to develop solvent vapour sensors under various shapes for many applications, evidencing the versatility of such systems[147]. Structuring hierarchically the conducting network in three dimensions using a spray layer by layer process was found to be an effective way to both control the composite architecture and enhance the sensor response by increasing the specific surface accessible to analyte molecules [89]. Considering that due to hydrophobic nature of most synthetic polymers, the resulting CPC sensors have naturally a larger ability to detect non polar solvent vapours, chitosan biomatrix-carbon nanofiller CPC (Chit-CNF) was found to be a good candidate to sense polar vapours like water and methanol whereas being also sensitive to toluene.

Chit-CNF transducers give a quantitative response when exposed to water vapours that can be considered as a sorption isotherm and very well fitted with a Langmuir-Henry-Clustering (LHC) diffusion model. This model gives a new insight into understanding of chemo electrical behaviour of CPC and appears to be helpful to optimise sensor design by tailoring transducer initial characteristics to suitable solvent vapour fraction measurement range. Moreover, Chit-CNP sensors selectivity allowed to rank vapours by relative response amplitude (A_r) in the following order: water>methanol>toluene. The origin of this selectivity was discussed in terms of χ_{12} the Flory-Huggins polymer/solvent interaction parameter, $\square_p$, $\square_r$ and d, respectively the polar component of solubility parameter, the dielectric permitivity and the molecules size of solvents.

Finally results show that chitosan nature and treatment have few influence on chemo-electrical behaviour as compared to CNF shape factor, i.e., carbon nanoparticles or carbon nanotubes.

Keywords: Conductive Polymer nanoComposites (CPC), chitosan, carbon nanoparticles (CNP), carbon nanotube, solvent vapour sensing, sorption isotherm model, chemo-electrical behaviour

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Size Exclusion Chromatography – a Blessing and a Curse

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Size exclusion chromatography (SEC) is at present the most popular and the most important tool for molecular characterization of synthetic polymers. Based on the (universal) calibration or in combination with the flow-through light scattering or viscometric detectors, SEC can provide important information on the molar mass averages and distributions, on the long chain branching, on intrinsic viscosities, on gyration radii of dissolved polymer species, as well as on preferential solvation of macromolecules in mixed solvents. Valuable products of SEC include also data on association, aggregation and micellization of macromolecules. SEC is simple, fast, repeatable, and relatively inexpensive. Within about thirty minutes, SEC produces data of **high** to **very high precision** (high intra-laboratory repeatability). Modern automated and often robotized fast SEC instruments have reduced time of analysis down to few minutes.

Recent round robin tests organized under auspices of IUPAC on five series of the commercially importants linear high polymers, however demonstrated surprisingly **low accuracy** (low inter-laboratory reproducibility) of the SEC data obtained without strict protocol. It is evident that a worldwide standardization is necessary of practical measurements, and data acquisition/calculation (for example in terms of both base line and peak limit setting). The above round robin tests results clearly show that expertise is needed for accurate SEC measurements. The approach "switch-on, inject, switch-out; computer will produce SOME data", may lead to the results differing several hundred percent from the median values. It is anticipated that the high-speed, high sample throughput procedures are especially susceptible to large errors.

The intrinsic but often ignored shortages of SEC include: **a)** Low selectivity of SEC separation; **b)** Imperfect column "linearity". The software used for SEC data processing, however often assumes linear calibration dependence; **c)** Presence of unwanted enthalpic interactions between separated macromolecules and column packing, which cause the shifts of sample retention volumes. Moreover the sample fraction, which stays fully retained within the column packing changes its pore sizes and retentive characteristics; **d)** Lacking calibration standards for many polymers. This problem is partially but often not fully solved by using light scattering or viscometric detectors. Alternatively, calibration with polystyrene standards is directly applied. Molar masses obtained in the latter way, however, represent only relative data and should be denoted "polystyrene-equivalent values"; **e)** Low sample capacity of the SEC columns. As result the minor macromolecular admixtures (1% and less) in polymer samples cannot be assessed by SEC – even if their molar masses well differ from the molar mass of the major component; **f)** Problems with sample detection; **g)** Low solubility of some polymers; **h)** Extensive broadening of the chromatographic zones; **i)** Dependence of retention volumes on injected both sample volume and concentration. The "concentration effects" vary with the polymer molar mass, with the column porosity, and also with the thermodynamic quality of eluent toward polymer; **j)** Possible changes of sizes of macromolecules during the SEC measurements. The latter are caused by the (de)association, (de)aggregation or degradation of polymer species within the column; **k)** Limited applicability to complex polymers, which exhibit more than one distribution in their molecular characteristics.

The above shortages of SEC will be discussed in detail to show that the development of SEC by far not a concluded story. Further improvements are needed, and this represents a challenge for researchers.

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Rheological properties of viscoelastic fluids and fracture under stress

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The viscoelastic fluids studied are solutions of living polymers which are chains of small molecules forming reversible non covalent bonds. The interest of these systems is motivated by their numerous potential applications in fields such as lubrication, cosmetics or food processing. We have focused on disubstituted bis-ureas which self-assemble in apolar solvents through hydrogen bonding to form molecular wires. The macroscopic properties of these supramolecular polymers have been studied by rheology and the structure of the molecular wires has been derived from scattering experiments. We report the rheological properties of solutions of disubstituted bis-ureas in the linear and non linear regimes, including a fluidization observed under stress that exhibits features similar to the fracture of solid materials. Delayed fracture is known since many decades in the domain of solid materials. It is known that the time for a fracture to occur strongly depends on the imposed stress indicating that thermal activated processes are involved.

Shear-banding appears at a given strain value in step shear rate experiment. In addition, in creep experiment, a delay is observed before the shear-banding occurs. This delay depends very sensitively on the applied stress. Finally, all the experiments are gathered in a strain vs. fluidization time diagram and we show that the data collapses onto a master curve that exhibits two branches.

Ref : Ducouret, G.; Chassenieux, C.; Martins, S.; Lequeux, F.; Bouteiller, L. *J. Coll. Interface Sci.* **2007**, *310*, 624-629

Nanomedicine : A Miracle Technology For Health Care In The 21^{st} Century : Opportunities & Challenges

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Nanomedicine is a science that uses nanotechnology to maintain and improve human health at the molecular scale. It has been defined as the monitoring, repair, construction and control of human biological systems at the molecular level, using engineering nanodevices and nanostructure nanometer is one-billionth of a meter. It is at this size scale-about 100 nm or less – that biological molecules and structures inside living cells operate: the diameter of DNA is in the 2-5 nm range, while red blood cells are approximately 7000nm.Our body is constructed from nanoscale building blocks. A drug target the body's nanostructure, like the DNA or proteins in the body, has already been developed by pharmaceutical industry long before the emergence of nanotechnology. This category of drugs includes aspirin, cisplatin, and other anti-cancer agents, as well as much more complex molecules like beta-blockers and anti-inflammatory agents. The difference between nanomedicine and conventional drugs is that nanomedicine is entirely based on small molecule chemistry. It not only covers the therapeutic agents themselves , but promise to combine the abilities to deliver those agents to specific regions or tissues in the body, to specific cells, perhaps to a specific location within a cell, and also to make release of the therapeutic responsive to a physiological condition and perform specific task. It is these enormous potential and promises to refine medicine and enable it to work more efficiently that encourages most drug companies in the world to engage in nanotechnology research. Further the applications of nanotechnology in drug delivery, orthopedics, dental care, gene therapy, cardiac therapy molecular diagnostics and imaging will be discussed in detail.

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Permeability, Diffusivity, and Solubility of Various Gases in Poly(lactic acid) Blend Membranes

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Poly(lactic acid) (PLA) is an environmentally friendly and biodegradable polymer substance. Due to the advantages that it offers, including better biological degradation behavior for the bio-recyclable material, PLA is expected to become a replacement material for petroleum-based plastics, such as polyethylene, polyvinylchloride, and poly (ethyleneterephthalate). At present, PLA is popularly used in the manufacture of packaging materials (e.g., films, membranes) and foaming materials (e.g., containers). Toward further improvements, it is important to emphasize that the mechanical, thermal, and barrier properties are important in designing these materials. The barrier properties are related to solubility, diffusivity, and permeability in a polymer. There have been some studies carried out regarding the gas transport properties of oxygen, nitrogen, and carbon dioxide in PLA homopolymers. For this study, however, we focused on PLA blends and systematically investigated its gas transport properties (i.e., permeability, diffusivity, and solubility).

The PLA blend films used in this study had a glass transition temperature of 60°C, a crystallization temperature of 116°C, and a melting temperature of 149°C. Film density increased with increasing crystallinity. In contrast, the fractional free volume that was determined using a group contribution method designed by van Krevelen decreased with increasing crystallinity. The ranking of the gas permeability at 35°C in all PLA blend films used in this study was hydrogen > carbon dioxide > oxygen > nitrogen. Moreover, gas permselectivity in all PLA blends was larger than 110 for hydrogen/nitrogen, about 6 for oxygen/nitrogen, and about 24 for carbon dioxide/nitrogen. As a general rule, as the crystallinity in a polymer increases, the gas permeability decreases. Interestingly, however, the permeability coefficients of some gases in the PLA blends with higher crystallinity were larger than those with lower crystallinity. This result suggests that the size and distribution of free volume in the crystalline PLA blends are different from those in the other crystalline polymers.

Furthermore, as measurement temperature increases, the gas permeability of polymers likewise increases. This temperature dependency on permeability is normally based on Arrhenius rule, in which there appears a linear relationship between the logarithm of permeability and the reciprocal of absolute temperature for polymers. Several polymers also show a transition in this relation across a polymer's glass transition temperature. Our PLA blends followed Arrhenius rule for all gases tested in this study. However, a distinct transition across the glass transition temperature of the PLA blend was not observed for gas permeation. The PLA blends belong to a family of polymers whose gas permeation is not significantly affected by a change in chain mobility at the glass transition.

Effect of modifiers on thermal properties of novel thermoplastic polyurethane-peptized Laponite nanocomposite

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Thermoplastic polyurethanes (TPU) find plenty of applications in various fields including biomedical and space applications. However, certain key features like thermal stability and barrier property limits its application. It is observed that incorporation of nanofillers mainly nanoclay in TPU matrix enhance the property dramatically including the thermal and barrier property. Literatures are scanty on the use of Laponite in TPU matrix for making TPU-clay nanocomposite inspite of its advantages like chemical purity and transparency. Another advantage of using laponite is that its size scale matches well with the size range of the hard segment of TPU. As compared to laponite RD, Laponite RDS is having the advantage of providing additional sites for ion exchange, hence, increasing the compatibility with the TPU. Along with retaining transparency, it also improves the storage modulus and thermal stability of TPU significantly. In this work, thermoplastic polyurethane (TPU) - modified Laponite RDS nanocomposites prepared by solution mixing technique is reported in details with reference to their thermal properties. Laponite RDS was modified with cetyl trimethyl ammonium bromide (cLS) and dodecylamine hydrochloride (dLS), respectively. Nearly **two fold increase in storage modulus** is observed in both glassy and rubbery state with merely 1% cLS addition, but gradually it decreased with the increase in clay loading. However, in case of dLS filled nanocomposite, gradual increase in storage modulus is observed with the increase in clay loading. TGA studies indicate that the onset temperature of degradation of TPU is increased by **19.1** and **12.5 ^{0}C** even with 1% loadings of cLS and dLS, respectively. The detailed about the effect of the modifier with the rate constant of TPU based nanocomposite will be discussed in details.

Self-assembled Molecular Template for Conducting Polymer Nano-materials

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One and three dimensional conducting polymer nano-materials have attained wide interest due to their potential applications in electronic and optical devices. We have recently developed a unique molecular template approach for precisely controlling shape and size of the polyaniline and polypyrrole conducting nano-materials. For this purpose we have designed a new amphiphilic azobenzenesulfonic acid molecule as a surfactant-cum-dopaant based on cardanol. Wide range of morphologies such as nano-fibers, nano-rods, nano-spheres and nano-tubes were developed using self-assembled molecular templates. This approach is very unique in the sense that all the starting materials are same in the reaction medium, but various nano- materials obtained in a controlled way depending on how these constituents are self-organized and polymerized in water under normal conditions. The mechanistic aspects of the polyaniline nano-material formation were investigated by dynamic light scattering and high resolution transmission electron microscopy to trace the factors which control the morphology of the materials. DLS studies of the templates in solution revealed the formation of micro-meter range aggregates. TEM analysis confirmed the existence of cylindrical, cylindrical + spherical and spherical geometry of reactant aggregates, which template for variety of nanostructures. The solid state properties of the nano-materials were found highly dependent on the size and shape of polymerization templates employed for the synthesis. The strategy is very attractive for new research activities in conducting polymer nano-materials more specifically for conducting polyaniline and polypyrrole. The presentation will be focused on the summary of our research contribution in this area.

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Effect of Adamantyl Derivative on Atom Transfer Radical Polymerization (ATRP) of Poly(meth)acrylates

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Adamantane containing polymers have generated a great deal of interest recently due to the fact that pendant adamantyl groups have tremendous influences on the chemical and physical properties. This investigation reports preparation of tailor-made poly(meth)acrylates bearing adamantyl group using atom transfer radical polymerization via initiator approach. The ATRP of PMMA was investigated using different initiators having adamantyl group (like AdMBr or AdBr) as well as conventional EBiB initiator and CuBr as catalyst in combination with PMDETA as ligand. The incorporation of adamantyl group into the polymer enhanced the rate of polymerization, tremendously improved thermal stability and raised the glass transition temperature of the polymers. The polymerization proceeded through first order kinetics and molecular weights increased linearly with conversion, close to the targeted molecular weights. ATRP of PMMA was also investigated using adamantyl amine (Am-AdBr) (Amantadine) as initiator. The living nature of the end group was confirmed by MALDI-TOF-mass spectrometry and chain extension experiment. Interestingly, the resultant poly(meth)acrylates bearing the adamantyl group had excellent thermal stability compare to the similar polymers without adamantyl group as evidenced from thermogravimetry analysis (TGA) and isothermal TGA studies. All the polymers were characterized by NMR, GPC, MALDI-TOF-MS, DSC and TGA analysis.

Keywords: Adamantyl, Thermal stability, ATRP, poly(meth)acrylates

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Synthesis and Characterization of Polystyrene Nanoparticles and Their Effect on Rheological and Thermal Properties of LLDPE Matrix

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Polystyrene nanoparticles (nPS) in the range of 10-100 nm with different morphology; viz spherical, dumbbell shape, nanothreads were successfully synthesized by o/w microemulsion process. In this process ammonium peroxydisulphate (APS) as an initiator, sodium dodecyl sulphate as a surfactant and three types of cosurfactants i.e. n-hexanol, n-pentanol and n-butanol were used. The effect of cosurfactant on particle size and morphology of nPS have been reported in this work. The morphology of the final nPS was characterized by TEM. Purity and thermal properties of PS nanoparticles were investigated by FTIR Spectroscopy and DSC respectively. NMR and XRD studies of nPS have also been done. Isolated surfactant free nano polystyrene particles (nPS) were incorporated in LLDPE matrix by hot melt process. Rheological and thermal properties of LLDPE/nPS composites were also explored in this work. On Brabender mixing, nPS reduced the torque and melt viscosity of LLDPE on comparing the virgin LLDPE. During DSC studies, a sharp increment in DSC peak was observed up to the 0.25 wt. % addition of nPS. Like wise in TGA study, thermal stability was also recorded to increase with the addition of nPS in LLDPE. The improvement in thermal and rheological properties is due to the close packing of LLDPE chains as recorded by improvement in crystallinity of LLDPE with addition of nPS up to 0.25 wt%.

Keywords: Microemulsion; Cosurfactant; Polymer nanoparticle; Morphology; Rheology; Thermal Properties

ORAL PRESENTATIONS

OP 1 – OP39

Room Temperature Living Cationic Polymerization of Styrene using α-Methylstyrene-HCl/$FeCl_3$ System in Presence of Added Salts

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Living cationic polymerization of styrene was achieved with α-methylstyrene-HCl adduct/$FeCl_3$ initiating system in presence of added alkyl ammonium halides [$nBu_4N^+Y^-$ (Y^-: Cl^-, Br^- I^-)] in a polar solvent (dichloromethane) as well as in a non-polar solvent (toluene) at room temperature (25ºC). Instantaneous polymerization was occurred in dichloromethane (e.g., 100% conversion was reached within 1 min of reaction). But the rate of polymerization in toluene is much slower than the previous solvent (dichloromethane) (e.g., 72% conversion was obtained in 48 h). Polystyrenes with broad molecular weight distribution [polydispersities (PDIs) = $\overline{M_w}$ / $\overline{M_n}$ = 1.32 –1.35 in toluene] were obtained in absence of added salt, whereas that obtained in presence of added salt was of very narrow polydispersities (PDIs = 1.10 - 1.15 in toluene). The number average molecular weight ($\overline{M_n}$) of the obtained polystyrenes increased linearly with conversion, which agreed well with the calculated molecular weight. After the monomer addition, $\overline{M_n}$ of the obtained polymer clearly shifted toward a higher molecular weight region compared to that of starting polymer indicating that this polymerization system is living in nature. The mechanism of this polymerization was proposed on the basis of results of ^{1}H NMR spectroscopic analysis of a model reaction involving α-methylstyrene-HCl adduct and $FeCl_3$. By analogy with this model reaction, it may be concluded that the living end of the propagating species undergoes rapid halogen exchange with $FeCl_3$ activator to generate a chloride type species that may act as a propagating center for further polymerization.

OP - 2

Chemical synthesis of conducting polymer nanofibers for H_2 storage applications

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Conducting polymer nanostructures combine the advantages of organic conductors and low dimensional systems and therefore should yield many interesting physicochemical properties and useful applications. The nanofibrillar morphology significantly improves the performance of polyaniline in many conventional applications involving polymer interactions with its environment. This leads to much faster and more responsive chemical sensors, new organic / polyaniline nanocomposites and ultra-fast non volatile memory devices. Nanofibers with diameters of tens of nanometers appear to be an intrinsic morphological unit that was found to “naturally” form in the early stage of chemical oxidative polymerization of aniline. In conventional polymerization, nanofibers are subject to secondary growth of irregularly shaped particles, which leads to the final granular agglomerates. The key to producing pure nanofibers is to suppress secondary growth. Based on this, two methods – interfacial polymerization and rapidly mixed reactions have been developed that can readily produce pure nanofibers by slightly modifying the conventional chemical synthesis of polyaniline without the need for any template or structural directing material. With this nanofiber morphology, dispersibility and processbility of polyaniline are now much improved. In the present investigation, highly rough and large surface area polyaniline nanofibers have been grown by using a template process using camphorosulfonic acid. Morphological, structural, optical properties have been investigated. Effect of surfactants on the formation of polyaniline nanofibers morphology, structure has been systematically investigated. We have also carried out the investigation to reversibly store H_2 in these polyaniline nanofibers. The rate of hydrogen sorption during the initial run is found to be very rapid and an extended plateau pressure of about 30 bars is obtained from the pressure-composition isotherm profiles of these polyaniline nanofibers. The reversible cycling capacity of ~3-4 wt.% is demonstrated at room temperature and have been attributed due their unique microstructural and surface properties.

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OP - 3

Development of Novel Biodegradable Polymeric Nanofibers for Biomedical Applications

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A novel multiscale electrospun scaffold has been fabricated by a single step electrospinning technique. The diameter of the microfibers was approximately ~ 7 μm whereas that of the nanofibers was approximately 250 nm. Both fiber types were also studied with and without reinforced nanoparticles of hydroxyapatite (nHAp) within the fibers. The human osteoblastic cells behavior such as cell attachment, proliferation on the multiscale scaffold was characterized and compared to nanofibered as well as micro fibered scaffolds. Electron microscopy studies reveal that the cells in the nano fibered scaffold had spread and flat morphology; whereas the cells in micro fibered scaffold had less spreading and globular morphology. The cell proliferation studies show that the nano fibered scaffold enhanced proliferation compared to the micro fibered scaffold. Such a novel multiscale structure with the associated guided cell interactions can potentially provide new opportunities for tissue engineering applications, especially bone.

In addition, we also successfully prepared carboxymethyl chitin (CMC) nanofibers. In order to enhance the spinnability of CMC, poly(vinyl alcohol) (PVA) was used as a binder. Nano fibers of this blended polymer systems were obtained by optimizing the polymer composition as well as the electrospinning conditions. The CMC/PVA nanofibers were characterized by scanning electron microscopy (SEM) and FTIR. In addition, human mesenchymal stem cell (hMSC) attachement and proliferation studies were carried out. The cell proliferation studies show that the hMSC had enhanced proliferation in the nanofibrous scaffold. So, these novel biodegradable polymeric nanofibers can be used for biomedical applications.

Acknowledgments

The Department of Science and Technology, Government of India supported this work, under the Nanoscience and Nanotechnology Initiative program monitored by Dr. C. N. R. Rao.

OP - 4

Polymerizable Fluoroalkyl Surfactant for Improved PEMFC Electrodes

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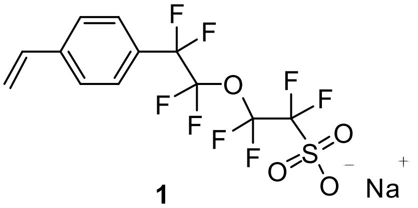
The electrodes of a PEMFC play an important role in the overall performance of the fuel cell. To improve their output, we propose to engineer their microstructure by first synthesizing polymerizable fluorosurfactants, preparing a bicontinuous microemulsion in the presence of Pt nanoparticles and carbon particles and subsequently polymerizing the structure to “freeze in” the self-assembled state.

Here we describe the synthesis of P_r-R_F-SO_3M from I-R_F-SO_2F. The polymerizable surfactant **1** has been synthesized where P_r = styryl moiety, R_F = -$(CF_2)_2O(CF_2)_2$- and M = Na^+. A non polymerizable version **2** has also been synthesized to study microemulsions where the styryl group is replaced by 4-ethylbenzene.



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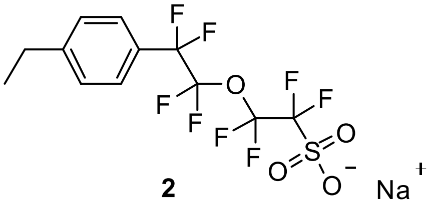

2

OP - 5

Elucidation of Gelation Mechanism of a Two Component Supramolecular Polymer

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The search for new small molecular hydrogelators continues to grow in remarkable ways with increasing impact for the potential use of hydrogels in biomedical applications. In that process a new two component thermoreversible gel in aqueous medium has been explored by supramolecular organization of riboflavin (R) and melamine (M). To elucidate the gelation mechanism morphological investigations using optical, electron, and atomic force microscopy together with time-dependent circular dichroism (CD) and photoluminescence (PL) spectroscopy has been performed. Kinetic study of gel formation using circular dichroism (CD) and photoluminescence (PL) spectra indicates that there are three steps: (1) RM complex formation, (2) conformational ordering, and (3) π-π stacking of ordered conformers. The first step of RM complex formation is established from Fourier transform infrared (FTIR) spectroscopy[1] and the second step is detected from the CD spectra. Due to the conformational ordering of the ribityl chain followed by helical fibril formation ellipticity value of the n-π* transition increases by 600 times during gel formation. The third step is concluded from fluorescence spectroscopy, which also shows a 30 times increase in intensity caused by hydrophobic core formation during π-stacking of the complex. Both the ellipticity and PL intensity show a sigmoidal increase with time (Fig.1), and analysis of data using the Avrami quation shows *n* values close to 1.5 for the former and close to 2 for the latter. The rate constant data from the CD spectra show a small positive temperature coefficient, but the rate constant values from the PL data show a negative temperature coefficient except the data at 30 and 35 °C. Arrhenius treatment of the rate constant values of the CD data indicates activation energy of ~13 kcal/mol.

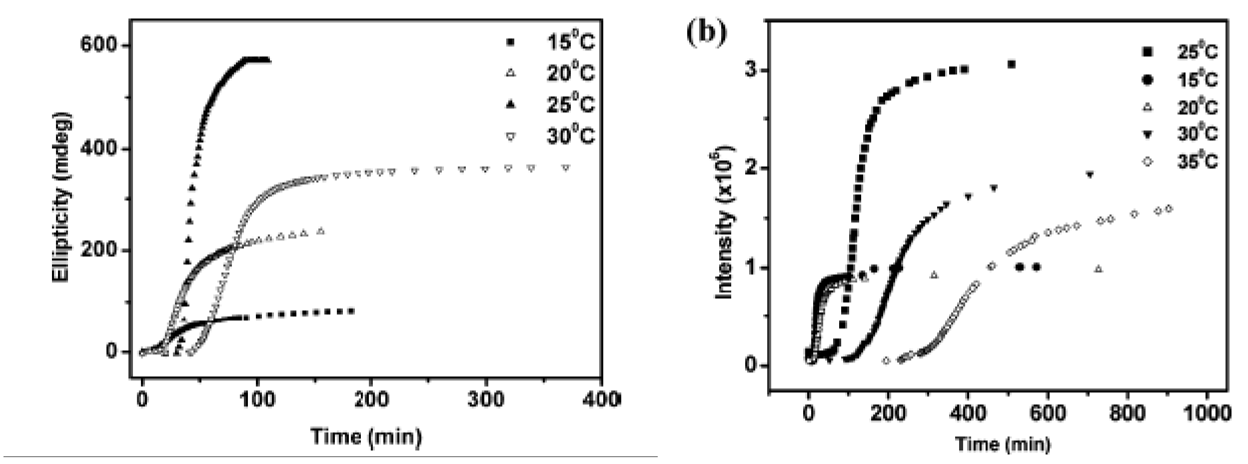

Fig. 1: Plot of (a) the ellipticity (ε), in mdeg, of the n-π* transition peak with time at different isothermal temperatures, (b) PL peak intensity with time at indicated isothermal temperatures for RM31 0.055% (w/v) hydrogels

Reference:

(1) Manna, S.; Saha, A.; Nandi, A. K. *Chem. Commun.* **2006**, 4285.

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Recyclable Polypropylene/Polycaprolactone Carbon Nanotubes based Bi-phasic Conducting Polymer Composite as temperature sensor.

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Carbon nanotube is the promising candidate as nanofiller, to generate conducting polymer nanocomposites (CPC) owing to their high surface area and electrical conductivity [1]. CPC can be used to develop smart materials able to change of electrical properties with environmental stresses such as heat or vapour [2-5]. In present study bi-phasic CPC were prepared by melt mixing 50% of polypropylene (PP) with 50% of polycaprolactone-carbon nanotubes (PP/PCL-CNT) as smart material for temperature sensing application. A co-continuous structure was obtained in which the conductive network was constituted of interconnected multi walled carbon nanotubes (CNT) dispersed in PCL phase. In a concern to fit with sustainable development we have investigated not only the thermo-electrical behaviour of CPC samples but also their end of live, i.e., their recyclability. Much attention has been paid to elucidate the impact of CPC on environment and influence of recyclability towards this impact, through its life. Even more, the effect of recycling on electrical and physical properties was investigated, showing that temperature sensing capabilities of CPC depend on recycling steps. Dynamic mechanical analysis (DMA) and differential scanning calorimetry experiments (DSC) suggest that PP phase is degrading upon recycling.

Keywords: conducting polymer composite, multi wall carbon nanotubes, temperature sensing, co-continuity, PCL, PP.

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OP - 7

Novel polymer shelled microbubbles for diagnostic and therapeutic purposes

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Microbubbles are well known ultrasound contrast agent already available on the market. The relevancy of such devices is directly linked to the widespread use of echography as diagnostic tool. However, the use of available microbubbles as injectable ultrasound scattering agents is limited by drawbacks as a broad size distribution, difficulties in the modification of the surface, short life cycle. On this basis we have designed a new concept of multifunctional microbubble entailing features as: long term chemical and physical stability, narrow size distribution, easy modification of the surface.

The structural characterization of the microbubbles, targeting and loading capability of this device with different cargo drugs and therapeutic gasses will be described. Interactions of the device with cells will be also highlighted as well as response to insonification.

These results are the fall-outs of the on-going activity of the European project SIGHT (web site: www.sight4health.eu), a consortium of 10 partners including research institutions and companies, started in September 2006.

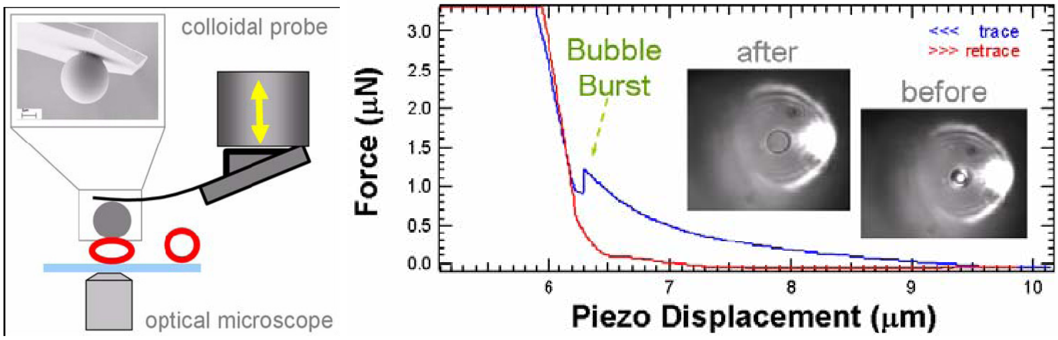

Figure 1 – AFM setup schematic (left) and typical force spectroscopy profile of PVA MBs (right)

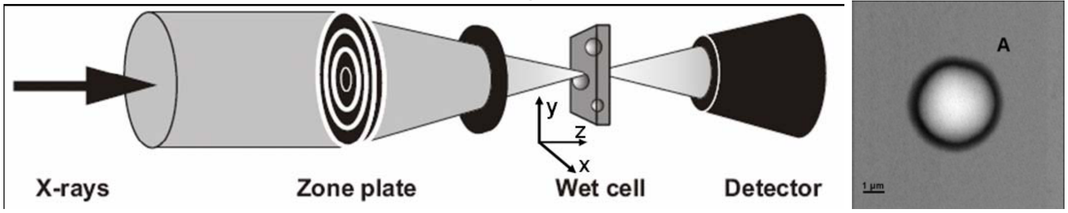

Figure 2 – STXM setup schematic (left) and typical image of PVA MBs (right)

Growth of Bacillus species on Chemically Pretreated and Un-pretreated Polypropylene

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Polymers are universal environmental threat because of their non degradable nature. The production, consumption and further dumping of polymers such as polypropylene is increasing at a high rate, whereas the rate of natural degradation of these polymers is comparably very slow. In the current study three different Bacillus species isolated from a plastic dumping site and one Bacillus species isolated from ocean were cultured in the presence of polypropylene. The growth of these four species was monitored in terms of colony forming units for twelve months. Two different type of chemically pretreated (Fenton's and Aquaregia treatment) polypropylene were used for the study, and all results were compared to that of the un-pretreated samples. FTIR spectrum revealed the oxidation of un-pretreated polypropylene with an increase in aldehyde index by 1.5 to 2 times and reduction in the carbonyl groups in chemically pretreated polymer samples in the presence of soil organism. The bacillus species isolated from marine origin showed poor growth whereas the soil organisms were able to sustain in the presence of chemically pretreated samples for twelve months using the polymer as the sole carbon source. The presence of live organisms on the films was identified by Adenosine Triphosphate (ATP) analysis. Aquaregia pretreatment appears to be better than Fenton's pretreatment in enhancing the attachment of the organisms on the polymer films.

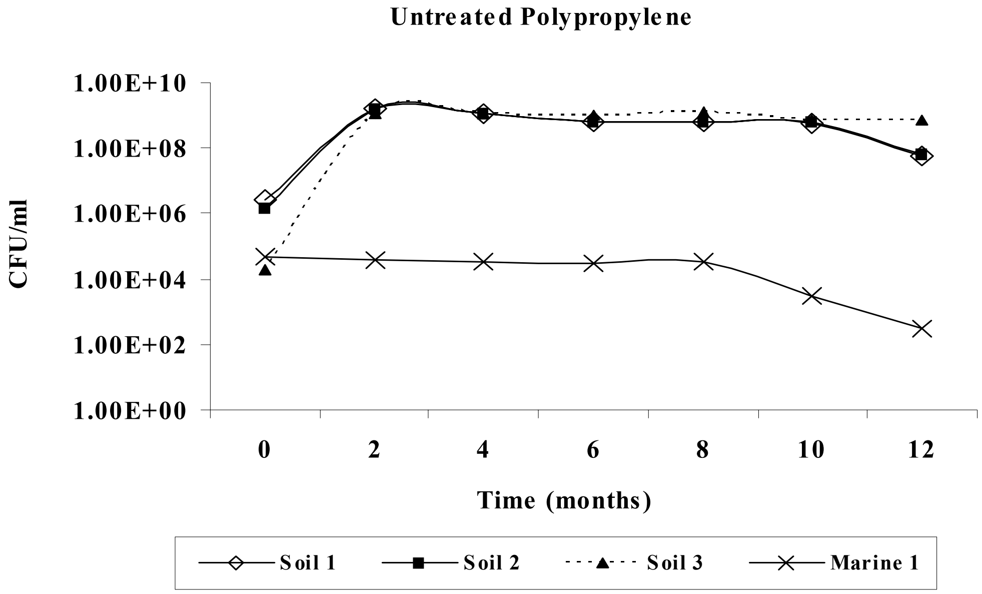

Figure: - Growth of four Bacillus species in the presence of Un- pretreated polypropylene.

Isoconversional Analysis of Differential Scanning Calorimetric Data on Nonisothermal Crystallization of PPS/ TLCP VA 950 Composites Melt

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The nonisothermal crystallization kinetics of poly (phenylene sulphide) (PPS) with a thermotropic liquid crystalline copolyester, Vectra A950, (TLCP) were investigated by Differential Scanning Calorimetry (DSC) technique. PPS/TLCP composites peak endothermic crystallization temperature was found to shift to lower temperatures as the cooling rate was increased. The widely used Takhora method and Kissinger's method with positive thermoscan rates,α, appears to be inapplicable for evaluating the activation energy at a particular conversion of crystallinity X. Such evaluation can be accomplished by using the advanced isoconversional technique of Friedman was employed to produce experimental values of the temperature dependence of the temperature coefficient (i.e., the effective activation energy, ΔE) of the growth rate as a function of average temperature. The application of this method to differential scanning calorimetric data on nonisothermal crystallization data of PPS yields an activation energy that increases with the extent of crystallization from -71 kcal mol-1 to -21 kcal.mol-1. However, significant composites composition dependent change in effective ΔE of PPS in PPS/TLCP VA 950 composites was observed. The value of ΔE increases with increasing TLCP VA 950 loading, from 10,20 and 40 wt % in composites However for the composite with 30 wt % of TLCP VA 950 , the value of ΔE are comparatively lower than the other composites but still larger than those of neat PPS. It is interesting to note that the relatively lowest values of *E*Δ were obtained for a composite with 50 wt % TLCP VA 950 loading, even lower than neat PPS. The results clearly indicate that TLCP VA 950 in PPS/TLCP VA 950 composites not only acts as nucleating agent to facilitate crystallization but also as a physical hindrance to rearrangement of PPS chain segments retards the crystallization.

Reference: Sergey Vyazovkin, Nicolas Sbirrazzuoli J. Phys. Chem. B*,* 2003*,* 107 *(*3), 882–888.

Synthesis and Characterization of Polyhedral Oligomeric Silsesquioxane - Cyanate ester / Epoxy Nanocomposites

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Epoxy polyhedral oligomeric silsesquioxane (POSS)-based hybrid nanocomposites were prepared by *in-situ* polymerization of a homogeneous blend of the diglycidylether of bisphenol-A and 4,4'- diaminodiphenylmethane (DDM) in the presence of octa[(4-cyanatophenyl)phenyldiazenyl]silsesquioxane. The synthesized POSS functionalized- bisphenols and corresponding cyanate esters were characterized by Fourier transform infrared spectroscopy (FT-IR) and Proton nuclear magnetic resonance (NMR) techniques. The cross-linked networks were confirmed by Fourier transform infrared analysis and the formation of nanocomposites were confirmed by wide-angle X-ray diffraction and scanning electron microscopy (SEM) analysis. Dynamic mechanical analysis (DMA) was used to study the crosslinking of the nanocomposite networks formed between the POSS-cyanate ester and epoxy. Thermal properties of the polymer matrix were studied by Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). The enhancement of thermal stability was observed when increasing the POSS content in the hybrid epoxy matrices. The Limiting Oxygen Index (LOI) values show that these blends have good flame retardant properties determined by Van Krevelen's equation.

Keywords: cyanate ester, epoxy resin, polyhedral oligomeric silsesquioxane (POSS), thermal properties.

Sorption and Difusion of Aromatic Hydrocarbons through Dynamically Crosslinked High Density Polyethylene/Ethylene Propylene Diene Terpolymer Rubber Blends

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The transport behaviour of aromatic hydrocarbon liquids through crosslinked High Density Polyethylene/Ethylene Propylene Diene Terpolymer Rubber Blends has been studied in the temperature range 28-60^{0}C. High Density Polyethylene/Ethylene Propylene Diene Terpolymer Rubber Blends were dynamically crosslinked using different vulcanizing systems, ie, sulphur, peroxide and a mixed system consisting of peroxide and sulphur. The sorption behaviour of the above systems was analysed in four different solvents viz. benzene, toluene, xylene and mesitylene. The effect of various vulcanisng systems, temperature, blend composition and solvents on different sorption parameters were studied. The diffusion data has been analysed and it has been observed that most of the systems follow a Fickian mode of transport. The sorption data have been used to estimate the activation energy, the enthalpy and entropy of sorption, diffusion coefficient and polymer-solvent interaction parameter. Arrhenius activation parameters for diffusion, permeation and sorption have been estimated. The experimental results were compared with theoretical predictions.

Novel three ring based Side Chain Liquid Crystalline Methacrylate monomers and polymers: Synthesis, Characterization and ^{13}C NMR studies

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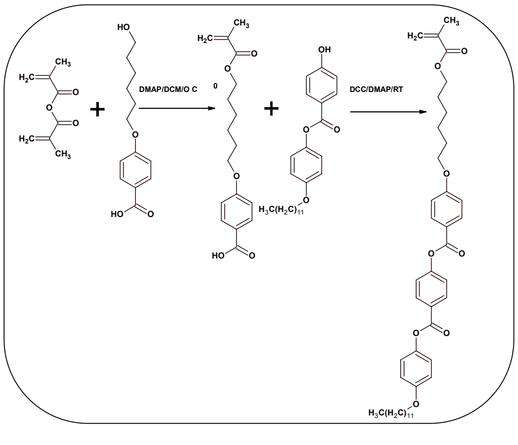
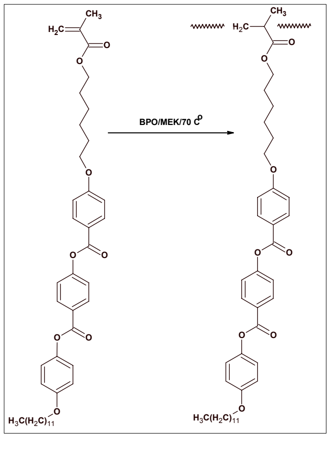
Thermotropic liquid crystalline materials are continuing to draw the attention of researchers in view of their both academic and industrial importance. The understanding of structure-property correlations of these materials is an active area through which designing of mesogens for future advanced applications can be envisaged. The calamitic mesogens, by far the most thoroughly investigated are natural choice for incorporating in polymers. Among them, side chain (mesogens) liquid crystalline polymers are the most popular. The renewed contemporary interest on these polymers is attributed due to novel applications such as artificial muscles, light scattering electro-optical switches and display materials. In the present work, we report the synthesis of novel side-chain liquid crystalline polymers by multi-step route as shown in the scheme. The basic approach is to incorporate the core mesogens along with terminal chain in the polymer as side groups. This was achieved by designing a suitable core consisting of three phenyl rings linked by an ester connecting unit. The one end of the terminal is alkoxy chain while the other end is hydroxyhexyloxy unit. The terminal hydroxyl containing chain was modified with methacrylic anhydride to get the mesogenic monomers. The earlier literature reports pertaining to side-chain liquid crystalline polymers emphasized on two ring containing core where as we have preferred three ring core. This enabled us to copolymerize the liquid crystalline monomer with non-mesogenic (conventional) vinyl monomers to investigate the influence of later on the liquid crystalline property. In order to understand the influence of terminal chains on mesophase properties of liquid crystalline monomer, model compounds were synthesized with similar core unit. The melting, clearing temperatures, nature of the phase of model compounds of liquid crystalline monomers and (co)polymers were investigated using hot-stage polarizing microscope and DSC. The molecular weight and thermal stabilities of polymers and copolymers were determined by GPC and TGA techniques. Finally, the solid-state high-resolution ^{13}C NMR (1D & 2D) of the monomer and polymer was investigated to find the molecular axis and orientation order.



Synthetic Scheme



Use of polymeric nanomaterials in piezoelectric sensors

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Polymeric nanoparticle can be defined as submicronic colloidal carriers and are also known as nanostructured polymers. Compared to other colloidal carriers, polymeric nanoparticles present a higher stability when in contact with biological fluids, and their polymeric nature allows obtaining the desired controlled and sustained drug release. They can prepared either from preformed polymers, such as polyesters (i.e. polylactic acid), or from a monomer during its polymerization, as in the case of alkylcyanoacrylates. Polymer nanoparticles have been produced for decades for use in a variety of high performance materials such as high impact resistant polymers and specialty coatings long before it was fashionable to use the "nano" label .Nowadays more and more preference is given to the preparation of polymeric nanoparticles in spite of metallic nanoparticles due to their more economic, easy to prepare, less nanotoxic and multipurpose usefulness.

The investigation undertaken represented the preparation and characterization of polystyrene nanoparticles. Chemical induced emulsion polymerization of styrene was used to synthesize the polystyrene nanoparticles. The emulsion was initiated by the water soluble initiator, potassium per sulfate (KPS). The negatively charged emulsifier, sodium dodecyl sulfate (SDS) was used to stabilize the polystyrene nanoparticles. The diameter, shape and the distribution of the prepared polystyrene nanoparticles were measured using Transmission Electron Microscopy (TEM).

The monomer conversion was studied gravimetrically and the structure of prepared nanoparticles was analyzed by Fourier Transform Infrared (FTIR) Spectrometer with full explanation of the bending and stretching of bonds. It was found that the resultant nanoparticles were spherical in shape, uniformly distributed and had an average diameter of 75 nm. These nanostructured polystyrene particles were used in piezoelectric nanobiosensor for increasing its efficacy, sensitivity by immobilizing them on transducer elements.

Key words: latex nanoparticles, nanostructured polymers, polystyrene

Synthesis, characterization and photosensitive properties of phosphorus containing homo and copolymers

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A new class of homo and copolymers was synthesized by interfacial polycondensation reactions of 1,3-bis(4-hydroxyphenyl)propenone with phenylphosphonic dichloride and terephthaloyl chloride, and 3-(4-hydroxy-3-methoxyphenyl)-1-(4-hydroxyphenyl)propenone with phenylphosphonic dichloride and terephthaloyl chloride using a phase transfer catalyst at ambient temperature. The diol monomers were prepared by condensing 4-hydroxy benzaldehyde and 3-methoxy-4-hydroxybenzaldehyde with 4-hydroxy acetophenone. The structure of the synthesized monomers and polymers was confirmed by UV, IR and ^{1}H, ^{13}C and ^{31}P-NMR spectroscopic techniques. Molecular weight of the polymers was determined by gel permeation chromatography. The thermal properties of the polymers were studied by thermogravimetric analysis and differential scanning calorimetry under nitrogen atmosphere. The photosensitive property of the polymers in film and solution states was investigated by ultraviolet spectroscopy. The photocrosslinking proceeds via $2\pi + 2\pi$ cycloaddition reaction of α,β-unsaturated carbonyl group. The comparison study on the rate of photocrosslinking of homo and copolymers was also carried out. The chemical and physical properties of methoxy substituted polymers are compared to those of the unsubstituted polymers. The structure-property relationships, flame retardant characteristics and antimicrobial activity of the synthesized polymers were also studied and the results are discussed herein.

KeyWords: Phosphorus containing; Photocrosslinkable; Polyphosphonates; Chalcone containing

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Titania based Self-Cleaning Finish

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Nanostructure titanium–di oxide (TiO_2) is the most interesting and promising material due to their fundamental size-depend properties and important technological applications. It is commercially available and easy to prepare in laboratory by the sol-gel process at low energy cost, low material consumption rate, simplicity as well as eco-friendly. A novel method was tried to form a stable TiO_2 sol by using alkoxide precursor in aqueous medium which can be applied on cotton substrate at low temperatures. The long time stability of titania sol was achieved by through study of parameters such as inhibition ratio and hydrolysis ratio and hence to increase dispersion and the sol stability. The stability of titania sol was measured by Zeta potential and aging test. TEM, Particle size analysis and X-ray confirmed the formation of sufficiently nanosized particles by stable sol. The sol was shown to give highly active titania anatase nanoparticles on hydrothermal treatment. A standard method was also developed to study the self-cleaning activity of the developed finish on cotton fabric. The standard stains applied by using dyes with different light fastness that are Solophenyl Orange ARLE (Good light fastness, CI No. Or 106), Solophenyl Green BLE (medium light fastness, CI No. Gr 26) and Solophenyl Red 4GE (poor light fastness, CI No. Re 277) were found to degrade effectively on exposure to Xenon Arc Fading Lamp and sun light. For good fastness dye a maximum % decrease in K/S value of 60% while medium fastness dye achieved 80% decrease in K/S in an exposure of 30 hrs. The durability of titania finish on cotton fabric was found more than 25 vigorous washes.

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Synthesis and Processing of Polyurethane for developing porous viscoelastic sheets as cushioning materials in therapeutic footwear

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Objectives:

Many foams and elastomers are used in shoes to replace the shock-absorbing and pressure distributing functions of natural fat pad beneath the foot that was lost due to some conditions such as diabetes, arthritis, age or overuse. In the present work, effort was made to develop viscoelastic porous polyurethane sheet of 3 - 6 mm thickness having the properties of both PU elastomer and foam by using phase inversion method for fabrication of sheets and studied their cushioning and morphological properties for application in therapeutic footwear.

Experimental:

Polyether based PU was prepared by chain extending the isocyanate terminated prepolymer with compounds having secondary nitrogen group such as aromatic semicarbazides or in combination with diol. Prepolymer was prepared with polytetramethyleneglycol (PTMG, 1000) and methylene bis(phenyl isocyanate). The fibrous elastic polymers obtained were blended with commercial polyester based polyurethane in 1:1 ratio in dimethyl formamide (DMF) and developed into sheets by phase inversion method using water as nonsolvent. Sheets of various density, hardness and thickness were developed by varying the composition and concentration of polymer solution. The resultant viscoelastic sheets were tested for cushioning and mechanical properties. The surface and inner morphology of sheets were studied by scanning electron microscopy (SEM).

Results & Discussion:

The PU based sheets developed by coagulation method have the cushioning and mechanical properties that are needed for an insole material. The sheets developed with only CPU had shown better mechanical properties and those developed with combination of CPU and PUSC had shown better cushion properties than that of commercial materials. Especially the % compression set (CS) had obtained less than 5 % for the developed materials whereas commercially available foams had shown high % CS. The micro and macro pores that were formed from solvent exchange on the surface and inside the polymer helps in cushion and water absorption properties of the materials. The fiber forming property of PUSC had contributed in viscoelastic nature of the sheets. Therefore all the sheets can be as insole material in therapeutic footwear for uniform distribution of pressure under the foot and to prevent ulcer formation. The required thickness of sheet for better cushion properties varies for each material and the density of the material determines its hardness. Therefore the required mechanical and cushioning properties of insole material for individual patient can be achieved by developing the sheet with required thickness and density by changing the polymer content, polymer concentration and solvent volume.

Keywords: Polyurethane, viscoelastic, phase inversion method, therapeutic foot wear

Protein Separation and Flux Recovery Using PVDF/PS blend Ultrafiltration Membranes

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Ultra filtration is a membrane separation process where the solute dimensions are significantly larger than the solvent dimensions. It has been extensively used for product recovery in the food, pharmaceutical and biotechnological industries. The pore size and the characterization of the membranes can be easily changed by using appropriate blends and the pore forming agent. Because of this unique ability to modify the selectivity of the membranes this becomes a good alternative to other process such as adsorption, ion exchange etc.

Poly(vinylidene fluoride) (PVDF) has increased popularity in membrane fabrication due to its excellent chemical resistance and thermal stability. Polystyrene (PS) on other hand is an amorphous with largest production and lowest production price. PS has an excellent resistance towards acid, alkali as well as bacterial attack.

Thus PVDF/PS blend Ultra filtration membranes were prepared using phase inversion technique. Casting solutions were prepared with different compositions of poly(vinylidene fluoride) [PVDF] and polystyrene [PS] in the presence and absence of the additive, poly(vinylpyrolidone) (PVP) using di- methylacetamide as solvent.

The prepared membranes were used for the separation of protein such as Trypsin, Pepsin, Egg Albumin and Bovine Serum Albumin(BSA) each having different molecular weight from which the molecular weight cut off (MWCO) of the membrane was determined. The membrane thus fouled by the protein were cleaned using NaOCl and the, flux recovery ratio(FRR) which describes the recycling property of the, membrane was studied.

Viscoelastic and Thermal property modified Epoxy-Clay Nanocomposites: Preparation, Characterization and Property Evaluations.

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High temperature resistant Epoxy-Clay Nanocomposites were prepared by blending with the organically modified clay. The organo modified clays were synthesized from long chain aliphatic amine salts by exchanging their ions with the Na^+MMT clay. The acetone solution of different Di and Tetra glycidyl epoxides [Bisphenol A diglycidylether (BDGE) , Bisphenol A Propoxylate diglycidylether (BPDGE), Bisphenol A Brominated Diglycidyl ether (BBDGE), and Tetraglycidyl of Diamino diphenyl methane (TGDDM)] were blended with 5%organoclay by the high shear technique and casted into sheets. The effect of organoclay structure on modified MMT-Epoxy nanocomposites was evaluated by their mechanical, thermal and morphological studies, using stress–strain analysis, Wide angle X-ray scattering, and Transmission electron microscopy and the obtained results were compared with the corresponding matrix.

The modified nanocomposites obtained from BDGE, BPDGE, BBDGE and TGDDM epoxy resins showed a significant increase in their properties when compared to the neat composites. Further, the effect on the incorporation of the organically modified clays namely Hexadecylammonium-MMT, Octadecylammonium-MMT and Triphenyl phosphonium-MMT into the Epoxy-nanocomposites were explored and the results were compared and discussed. Overall, all the clay loaded Epoxy nanocomposites prepared have exhibited better Mechanical and thermal property regardless of the organoclay used. This observation was attributed to the nanodispersibility of the clay components into the epoxy resins systems.

Keywords: Epoxides; Organoclays: Nanocomposites.

Inherently Colored Antimicrobial Fibers Employing Silver Nanoparticles

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We are reporting a novel method of producing inherently colored antimicrobial fibers employing silver nanoparticles. Without using undesirable dyes and chemical finishes, colors as well as antimicrobial properties have been imparted in textile grade acrylic fibers through silver nanoparticles, in such a way that these properties become inherent part of the fibers. The motivation behind silver nanoparticles is due to their unique optical properties as well as biomedical applications. A composite solution of polyacrylonitrile copolymer containing silver nanoparticles, synthesized *in-situ*, was converted into fibers using solution spinning technique. The fibers, so formed, have in-built silver nanoparticles in size ranging from 20-120nm. Colors ranging from red to blue could be prepared by varying the silver concentration, aggregate size and process. The antibacterial efficacy of the fiber was as high as 94.3% against *Escherichia coli*.

Natural and Artificial Weathering of Polypropylene Films – a solution for littered packaging films

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In recent years, polypropylene (PP) has achieved in dominating position based on number of factors particularly the excellent price/property relationship and the extensive possibilities to modify the mechanical properties as well as the superior fabrication possibilities. Among the various fields of applications, it is an attractive material for packaging due to its low cost, higher tensile strength, glossy and versatility. Therefore, their consumption increases and hence, there is a possibility for littering, thereby accumulation of plastic waste leads to environmental pollution due to the non-degradability of PP under environmental condition. To solve these problems, out of various degradation technologies available, photodegradation seems to be a better choice due to the freely available sunlight as energy source for degradation. The polymers that degrade by peroxidation followed by bioassimilation of the oxidation products are more environmentally acceptable than the biodegradable polymers. In the present work, transition metal salt of stearic acid was synthesized as prodegradant (MF01) and incorporated in PP to enhance the photodegrdability. The virgin polypropylene and its blend with 0.2 % MF01 were extruded into films of 60 μm thickness. The films were both naturally weathered from the period, May 2007 to July 2007 (summer season) and were artificially weathered at room temperature using 365nm UV lamps. The photodegradation behavior was studied using Fourier Transform Infrared Spectrophotometry (FTIR), Universal Testing Machine (UTM) and Scanning Electron Microscope (SEM). A steep increase in the various indices like hydroperoxide, hydroxyl, carbonyl, lactone, ester, carboxylic acid, vinylidene and crystallinity were noted for virgin PP after 1200 hours of exposure whereas these values increased after 200 hours of exposure for the prodegradant added PP during the course of natural weathering. However, in the case of artificial weathering, these changes were observed after 1200 hours of exposure for virgin PP whereas these values increased after 400 hours of exposure. The sudden decrease in the elongation at break (%) for the materials signifies chain scission. PP films having higher carbonyl index values showed surface cracks in the scanning electron micrographs, indicating the degradation of the material. The results concluded that the degradation of PP was influenced not only by the UV intensity but also the prodegradant as well as other weather parameters like temperature, light intensity, etc.

Chemical Modification Of Cellulose Fibers By Combination Of Ring Opening Polymerization And Atom Transfer Radical Polymerization

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The major disadvantages of biodegradable polymers obtained from renewable resources are their hydrophobic character and fast degradation rate. Cellulose is the most abundant natural biopolymer in the world, and it has great potential to be modified for enhanced performances. In the present paper, natural cellulose from different sources are used as a macroinitiator for the ring opening polymerization (ROP) of ε-caprolactone (CL) for the synthesis of polymer with a cellulose backbone grafted with PCL. The PCL end groups of the graft copolymer then converted into initiating sites for graft atom transfer radical polymerization (ATRP) of glycidyl methacryalte (GMA) to obtain a graft-on-graft architecture. Scandium(III) trifluoromethane sulfonate (Sc(OTf)$_3$ was used both as a catalyst for ROP of CL and as a reducing agent for ATRP of GMA. The grafted substrate were characterized by flourier transform infrared spectroscopy (FTIR), wide angle X-ray (WAXD), thermomechanical analysis (TMA), differential scanning calorimetric (DSC) and gel permeation chromatographic (GPC) analysis. The results showed a successful grafting of PCL and PGMA onto the cellulose fiber substrate.

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Synthesis of N-Isopropylacrylamide Coatedgold Nanoparticle Hybrid Nanomaterial Via Surface Confined Atom Transfer Radical Polymerization

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Nanometersized core shell particles containing a gold core and polymer shells were prepared by surface confined atom transfer living radical polymerization on gold nanoparticles (AuNps) [1]. In the present study, we attempted to synthesis stable functionalized Gold (core) nanoparticles containing surface confined thermoresponsive polymeric material via atom transfer radical polymerization (ATRP) technique through 3 step procedure. In the first step, by adopting the early procedure, we have synthesised stable functionalized Gold (core) nanoparticles through reduction of tetrachloroaurate ions with bifunctional organic thiol molecules in the presence of $NaBH_4$ and thus formed thiol functionalized gold nanoparticles (TFAuNps) [2]. In the second step, the above thiol functionalized AuNps is subsequently esterified with ethyl 2-bromoisobutryl bromide and thus yielded the macroinitiator in the form of self assembled monolayers of bromofunctionalized thiolates on to the gold nanoparticles (BTFAuNps). Then in the third step, the resultant macro initiator was isolated and used as a initiator for polymerization of N-isopropylacrylamide via ATRP using copper (I) bromide/ pentamethyl diethylenetriamine as a catalyst system. The resulting gold (core) stabilized hybrid polymeric material containing thermo responsive functionality has been characterized elaborately using different analytical techniques including FT-IR,^{1}H NMR, UV-VIS, and TEM.

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Optical Properties of a Novel Fluorene-Based Thermally Stable Conjugated Polymer Containing Pyridine and Unsymmetric Carbazole Groups

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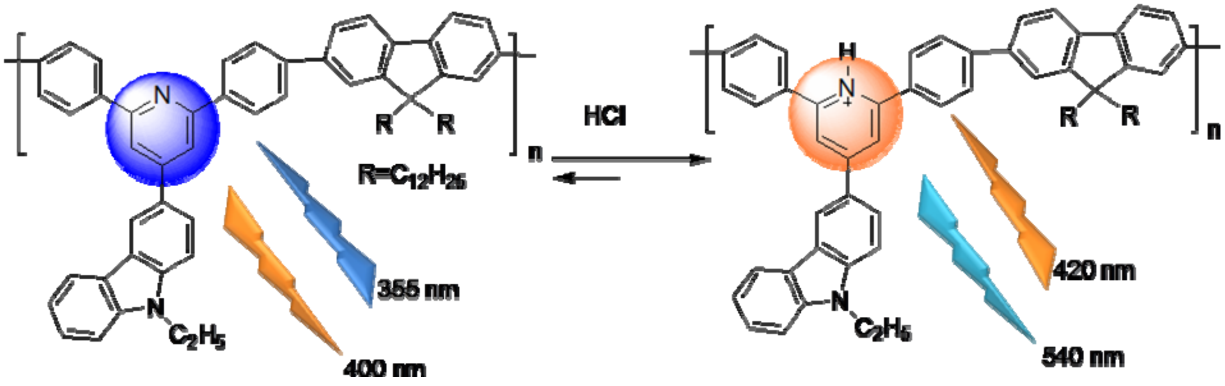

A new diiodo monomer containing heterocyclic pyridine and carbazole groups was synthesized *via* Chichibabin reaction and used in the preparation of a conjugated polymer *via* Suzuki coupling approach. The conjugated polymer was highly soluble in common organic solvents, such as NMP, THF, dichloromethane, chloroform, toluene, xylene and benzene at room temperature. The polymer had high glass transition temperature at 191℃ and Td_{10} at 434℃ in nitrogen atmosphere. The pristine polymer exhibited the UV-vis maximum absorption at 355 nm and shifted to 420 nm after protonation. The emission of the polymer in THF solution changed from the blue region with maximum peak at 400 nm to the yellow region with maximum peak at 540 nm after protonated by HCl, and the intensity of emission depended on the concentration of acid. The polymer also showed electrochromic behavior under applied voltage. The emission color of the polymer film changed from blue (435 nm) to yellow (570 nm) when 2.5 V bias voltage applied. The polymer also exhibited write-once and read-many-times (WORM) polymer memory effect with tristable states.

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Low density ceramic–polymer hybrid foams– Influence of nanofiller on mechanical, thermo-physical and high temperature performance

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Novel hybrid ceramic-polymer composites based on porous silica foam and poly (methyl methacrylate) (PMMA) resin were developed and investigated as a potential thermal protection system for re-entry vehicles under moderate heat flux conditions. The hybrid composites were prepared by impregnating silica tiles (porosity greater than 90%) with neat PMMA and also PMMA resin modified by nanoclay in different ratios. Mechanical and thermo-mechanical properties of the composites were studied as a function of the clay concentration and the optimized composition was selected for further studies. Compressive strength of the modified systems increased by 8-10 times in comparison to the neat silica foam. High temperature performance evaluation (up to 1100^{o}C) on the silica foam with PMMA resin – based systems exhibited significant improvement in performance (in terms of the back wall temperature and the rate of heating of the specimen), indicating the advantage of polymer impregnation into the ceramic substrate as a viable means for enhancing the mechanical properties while providing improved thermal protection. Difference in profile of variation in back wall temperature with respect to that of silica tile is correlated to the decomposition and evaporation of the resin. Level of dispersion of the nanoclay and microstructures of the hybrid system before and after thermal evaluation were investigated by X ray diffraction (XRD) analysis.

Synthesis of Peptide-Polymer Hybrid Conjugates by Atom Transfer Radical Polymerization and Their Self-Assembly

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A series of newly designed peptide-initiators were synthesized by conventional solution phase method. These initiators were then used for the synthesis of different peptide-polymer hybrid conjugates, such as peptide-poly(methyl methacrylate), peptide-poly(ethyl methacrylate), peptide-poly(benzyl methacrylate), peptide-poly(n-butyl methacrylate) by atom transfer radical polymerization (ATRP) using CuCl/*N*,*N*,*N*′,*N*″,*N*″-pentamethyldiethylenetriamine as the catalyst in DMSO at an elevated temperature (90ºC). The peptide-initiators and peptide-polymer hybrids were characterized via NMR spectroscopy. Molecular weights and polydispersities of the hybrids were determined by GPC. The unimodal nature of the GPC traces indicated that the polymerizations were well controlled, producing peptide-polymer hybrids with predictable controlled molecular weights and low polydispersities (PDI<1.5). The aggregation behavior of these peptide-polymer hybrids in different organic solvents such as acetonitrile, dimethyl formamide, and dimethyl sulfoxide was then investigated using different microscopic and light scattering techniques. The SEM and TEM results clearly revealed that the peptide-polymers were self-assembled into hybrid micro/nanospheres in the above-mentioned solvents and their diameters depended upon the polarity of the solvent used for assembly.

Dynamic Mechanical Analysis of Polymer Hybrid Nanocomposites

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This article addresses the effect of nanoclays montmorillonite (MMT) and organo-montmorillonite (OMMT) on morphology and dynamic mechanical properties of polypropylene (PP). The preparation of polymer hybrid nanocomposites by melt compounding PP with MMT and OMMT using polypropylene grafted maleic anhydride (PP-g-mA) as compotibilizer is described. First stage compositions with MMT content 1%, 3%, 5% and 7%by weight ratio PP/MMT nanocomposites were prepared and tested. Second stage compositions with OMMT content 1%, 3%, 5% and 7% by weight ratio PP/OMMT nanocomposites were prepared and tested. Third stage both combined MMT and OMMT equally mixed content 1%, 3%, 5% and 7% by weight ratio PP/MMT/OMMT hybrid nanocomposites were prepared and tested. The influence of nanoclays on the impact fracture morphology of the nanocomposites was studied by scanning electron microscopy (SEM). Dynamic mechanical Analysis (DMA) indicated significant improvement in the storage modulus and loss modulus compared with neat PP. The tanδ peak signifying the glass transition temperature of nanocomposites shifted to higher temperature.

Keywords: Polypropylene; Montmorillonite; Organo-Montmorillonite; Morphology; Dynamic Mechanical Analysis.

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Synthesis of Polypyrrole + PS / PMMA Composites: Application as ammonia gas sensor

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Conducting polymers are materials which exhibit electrical properties of metals. The few disadvantages of these materials like poor mechanical properties, lack of processibility and instability can be easily overcome by formation of composites with other host polymers. These unique properties have accelerated the use of conducting polymeric materials and their composites in many speciality applications like sensing, energy storage and microelectronic devices. In this work Polystyrene (PS) + Poly (methyl methacrylate) (PMMA) and polypyrrole composite films were synthesized using chemical and electrochemical techniques of polymerization. PS/PMMA was used as a host matrix to grow conducting polymer network of polypyrrole. PS / PMMA were dissolved in tetrahydrofuran and films were cast on stainless steel surfaces. Of the different proportions that were tried 77% + 23% (PS / PMMA) respectively was found to give most homogenous composite films. Polypyrrole was then grown into the preformed PS / PMMA matrix electrochemically using Potentiostat/ Galvanostat in Galvanostatic mode. Mechanically strong and free standing films of average thickness 65 μm were obtained. Characterization was carried out using FTIR spectroscopy, Electron microscopy and X-Ray Diffraction. Electrical properties were investigated using the standard two probe method. These composite films when exposed to ammonia gas exhibit change in resistance. The sensor exhibits room temperature sensitivity at ppm level.

Self Assembled Polyurethanes

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We designed self-assembled polyurethane by using suitable diisocyanate, polyol and chain extender for controlling microstructure, and thereby, the properties. By altering the linear aliphatic to branched aromatic diisocyanate together with straight chain di-ol to complex aromatic di-ol as chain extender, polyurethanes were prepared with different architects and diverse structures. Thermoplastic polyurethanes (*PU*) are special class of elastomers, which form multiphase structures owing to the thermodynamic incompatibility between hard segment and soft segments. Usually, the hard segment acts as both crosslink points and filler in a crystalline state having distinct melting point. The combination of hard and soft segments gives this class of materials very unique properties, which can be altered by changing the chemical structure and composition of the diisocyanate and diol. More importantly, by changing the chemical composition we tailor the multiphase structure and morphology of the polymers during processing. In this work, nanostructure, structure, mechanical properties including rheology and surface morphology of polyurethane will be focused. Morphology and *XRD* studies indicate novel self-assembled structure formation in polyurethane which has been verified from the rheological studies. Moreover a chemical model has been designed to understand the effect of hard segment content on the physical properties through electronic structure calculations which support the above results in the molecular level.

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Use of Biodegradable Polymers to improve new Antifouling coatings: Erosion of marine paints

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It is generally agreed that the prevention of marine fouling can be achieved by coatings from which a controlled release of toxic molecules prevents the growth of adhered organisms (bacteria, algae, molluscs) by killing them. Since the end of 90's, antifouling paints have been realized by the blending of polyacrylic resins with biocides. The aim of this study was to use new polymers in order to obtain biodegradable antifouling paints with control release of biocide.

Polyesters, such as poly(□-caprolactone), PCL, poly(lactide), PLA, and their copolymers have received much interest in environmental applications because of their biodegradability. Polyanhydrides have also been considered as useful carriers of active molecules. Two families of biodegradable binders were studied: poly(phtalic acid-co-ricinoleic acid-co-isophtalic acid ester anhydride and poly(□-caprolactone-co-L-lactide). Antifouling paints were formulated with these polymers and compared with commercial binders (PMMA-PBMA +rosin and PMMA-TBT). Several methods have been used to investigate polymer erosion such as X-ray microanalysis (EDX), scanning electronic microscopy (SEM) and confocal laser scanning microscopy (CLSM). We have demonstrated that the polymers undergo predominantly surface erosion for poly(ester-anhydride) and PMMA-TBT and bulk erosion for polyester and PMMA-PBMA+rosin.

New paints containing biodegradable polymers lead to a good antifouling activity.

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A Novel Cure Shrinkage Mechanism based on the Polymerisation-induced Viscoelastic Phase Separation in Thermoplastic Modified Epoxy Resins

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The volume shrinkage during polymerisation of a thermoplastic modified epoxy resin undergoing a simultaneous viscoelastic phase separation was investigated for the first time by means of pressure- volume- temperature (PVT) analysis. Varying amount (0-20%) of poly(styrene-co-acrylonitrile) (SAN) has been incorporated into a high temperature epoxy-diamine system viz., diglycidyl ether of bisphenol A (DGEBA) - 4,4'-diaminodiphenyl sulfone (DDS) mixture, and subsequently polymerised isothermally at a constant pressure of 10 MPa. Volume shrinkage is highest for the double phased network-like bi-continuous morphology in SAN-15% system. In neat epoxy-DDS system the PVT and infra red (AT-IR) analysis have shown the shrinkage to vary linearly with epoxy conversion. From a subsequent kinetic analysis together with the thermal transition studies of various epoxy-DDS/ SAN systems, it has been suggested that the behavior of the highly intermixed thermoplastic SAN rich phase is the key for in-situ shrinkage control. Various microscopic characterisations including scanning electron microscopy, atomic force microscopy and optical microscopy are combined to confirm that the shrinkage behaviour is manipulated by a volume- shrinkage of the thermoplastic SAN rich phase undergoing a viscoelastic phase separation during cure. Consequently, a new mechanism for volume shrinkage has been visualised for the in-situ polymerisation of a thermoplastic modified epoxy resin.

Effect of Morphology Changes in Anthracene Substituted Lower Generation PAMAM and PPI Dendrimers on the Fluorescence Properties

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Dendrimers are hyper-branched macromolecules with potential applications in various fields such as energy harvesting, host-guest chemistry and catalysis.[1] This novel group of polymers adopt nearly globular three dimensional structures with internal cavities and reactive surface end groups.[2] The peripheral modification of dendrimers with photo and electro active moieties leads to the formation of stimuli-responsive functional materials in nano dimension.[3] Herein we report the effect of the morphology changes in zero generation poly(amidoamine) {PAMAM} and poly(propyleneimine) {PPI} dendrimers containing anthracene units at the periphery on their fluorescence properties. Steady state and time resolved fluorescence studies of these compounds showed a wavelength tuneable excimer emission from anthracene moieties which is strongly dependent on the solvent used and the pH of the medium. Analysis of the results from fluorescence spectroscopy and scanning electron microscopy (SEM) suggests that pH and solvent driven morphology changes results in the formation of parallel, partially overlapped and T-shaped excimers by anthracene moieties (Figure 1). Details of the experiments will be presented.

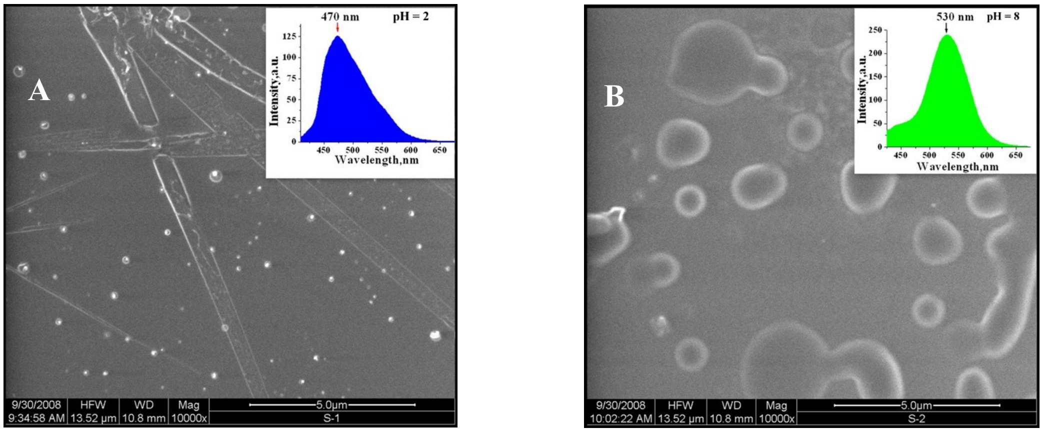

Figure 1: SEM images of amine terminated zero generation PPI (1x 10^{-3} M) at (A) pH 2 and (B) pH 8. Inset shows the corresponding emission spectrum in acetonitrile-water mixture (4:1). Excitation wavelength was 400 nm.

References

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2. Fischer. M, Vögtle.F *Angew. Chem. Int. Ed.* **38** (1999), 884–905.
3. Archut. A, Vögtle.F *Chem Soc Rev.* **27** (1998), 233–240.

OP -32

The influence of treated fumed silica on the hygroscopic characteristics of solid rocket motor case insulation

K.S. Abhilash, B. Jayakrishnan, R.S. Rajeev, R. Muraleekrishnan, and
P. Radhakrishnan Nair
Vikram Sarabhai Space Center, Thiruvananthapuram-695 022

Elastomeric insulation system protects the motor chamber from burn-through in a solid rocket motor. For the successful performance of the solid rocket motor, the interface characteristics such as insulator to metallic case bonding as well as propellant to insulator bonding are of paramount importance. The insulator to propellant bonding is enhanced by an adhesive system called liner. ISRO uses nitrile rubber based insulation system for solid rocket motor where silica is used to impart the required mechanical and thermal properties. Composite propellant is made from hydroxyl terminated polybutadiene (HTPB) based polyurethane system whereas carbon black filled polyurethane system is being used as the liner composition. The bonding between the insulator and the propellant is facilitated by the liner system. The moisture content in the insulation system, caused mainly because of the presence of silica filler, plays a detrimental role affecting the rubber to propellant bondability. In the present study, a non-hygroscopic filler, treated fumed silica, is used in the solid rocket motor case insulation composition, replacing the conventional silica filler. It is found that the composition based on treated fumed silica absorbs less moisture compared to the conventional silica filler. The effect of other compounding ingredients like plasticizers on the moisture analysis is also determined.

Macro porous Styrene Divinyl Benzene Copolymers: Formation of stable porous structures and preparation of supported Platinum Catalyst by *in situ* reduction

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Sadhana Mohan[2]
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Porous polymeric materials offer a great versatility in most of the promising fields of applications. The porous polymers have not only attracted tremendous attention in their potential applications in emerging area of science and technology such as supported catalysis, controlled drug delivery etc. but also in molecularly imprinted polymers, supramolecular assemblies, block copolymers and polymer blends based on hyperbranched polymers. We now report suspension copolymerisation of styrene and divinyl benzene (DVB) under argon atmosphere to produce styrene- DVB copolymer beads. Experimental design methods were employed to investigate the influence of crosslinker content; porogen type and porogen level on the surface area, pore volume and pore diameter of the resins. From these results, it was observed that the porogen has a greater influence than the crosslinker. Variation of porogen type and level while keeping crosslinker level constant then to the maximization of each parameter of interest, resulting in set of crosslinked polymers with a wide range of values. The purified polymer beads were characterized using TGA; BET, SEM, X-ray and pore size distribution was studied using nitrogen adsorption-desorption isotherms and mercury porosimetry etc. Chloroplatinic acid was incorporated into the polymer beads during suspension polymerization and *in situ* reduction were carried out by using various reducing agents such as sodium borohydride, formaldehyde and hydrazine. The result of polymeric beads as well as platinum supported St-DVB polymers in term of spherical beads size; pore volume, pore size distribution, surface area and thermal stability will be highlighted.

Redox Polymerisation of Acrylamide Initiated by Cerium(IV) - Amino Acid Ligands

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*padmavathymanju@yahoo.co.in **Mohamed Sathak Arts and Science College,Chennai*

The present study is a kinetic study of Redox Polymerisation of Acrylamide Initiated by Cerium(IV) – Amino Acid Ligands. Some biologically important amino acids namely dihydroxy phenyl alanine and histidine are taken as ligands. The kinetics of polymerization is studied titrimetrically following the standard iodometric procedure. The percentage conversion of monomer with respect to time and the steady states obtained for two aminoacids are given. The rate of polymerisation as a function of concentrations of monomer, Cerium (IV), and sulphuric acid are presented. The rate of polymerization with increase of temperature are also given. They are shown in various graphs. The results are explained by probable reaction schemes and the kinetic expressions derived are in consistent with the observed results. The complex formation of Cerium(IV) with amino acids is supported by the absorption spectra of complexes. The free radicals formed are supported by the EPR spectra.

Photo-Cation Curing Epoxy for Rigidization of Inflatable Structures

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Photocurable cationic epoxy resin formulations are of interest for a variety of applications that include surface coatings, adhesives, printings, laminations and photo resist for micro electronic devices. Recently considerable attention has been received for photocurable epoxy as matrix resin for inflatable and rigidizable composite structures in space. Inflatable structures constructed with fabric reinforcement and photocurable epoxy as matrix resin are foldable and remain uncured in the absence of light and become rigid when inflated or deployed in space and exposed to light. In the present work preparation of photocurable epoxy systems, evaluation of mechanical properties of the photocured epoxy resin and composites, fabrication of an inflatable and rigidizable demonstration tube using photo cure epoxy resin matrix and glass fabric reinforcement are addressed. The photocurable resin system presented in this paper is based on an alicyclic epoxy resin containing cationic photoinitiator, photosensitiser and polyol that cure on irradiation with sunlight. The cured resin exhibits mechanical properties equivalent to those of thermally cured epoxy system. The demonstration tube fabricated with the photocurable epoxy system was successfully rigidized on exposure to sunlight and displayed similar mechanical properties to thermally cured tubes of similar construction. This photo-cation curing epoxy system can be used for rigidization of inflatable structures and provide an alternative to many thermal cure epoxy systems because of the advantages such as long storage life in the absence of light, fast cure at ambient conditions on exposure to light, low cure shrinkage, better adhesion and low outgassing properties during and after cure.

OP - 36

Design and synthesis of a stepwise folding polymer

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Indian Institute of Science, Bengaluru 560012
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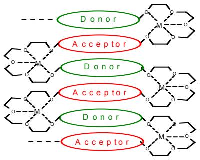
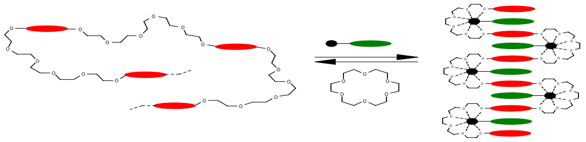
Entropy drives macromolecules to adopt a random coil conformation in solution – the motivation to overcome this and generate spatially well-organized macromolecular entities by *directed folding*, stems from the desire to emulate the elegance of nature on the one hand, while at the same time from the expectation that this will enable one to bridge the gap between the molecular scale and the macroscopic one, in terms of the evolution of structural order. A few years ago,[1-3] we demonstrated two approaches for exercising conformational control in synthetic polymers – one where the folding is induced by an 'intra-chain inter-segment' Donor-Acceptor charge transfer interaction. The second design utilized a novel two-point interaction with specifically designed *small-molecule-folding agent* to cause the folding of the polymer chain.

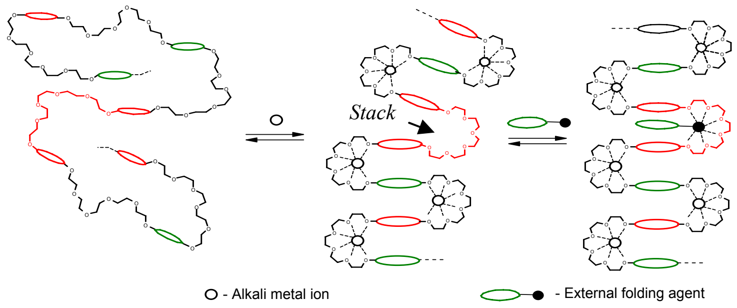


Design A



Design B

One of the key issues that precluded a complete understanding of the folding process was the *stack length*, i.e., the number of D-A pairs that are formed by the addition of appropriate folding aid. In an effort to model this, we prepared a series of copolymers using an oligo(oxyethylene) di-amine that does not contain the Donor moiety (*stack breaker*). Inclusion of this monomer in varying levels leads to an effective truncation of the stack length, which was then examined by NMR titration and UV-visible spectroscopy. An added interesting feature of this study is that the stack length can be further enhanced in a second step by using the external folding agent that leads to further stacking of the already formed stacks, as depicted in the schematic below. This study demonstrates the first of its kind where the stacking process can be carried out in a step-wise fashion.



Schematic representation of the step-wise folding process of a part of polymer backbone

Synthesis And Characterization Of Poly(dimethylsiloxane-urethane) Nanocomposites: Effect Of (In)Completely Condensed Silsesquioxanes On Thermal, Morphological And Mechanical Properties

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Recently polyhedral oligomeric silsesquioxane (POSS) blocks emerged as a new class of nanofillers for high-performance hybrids with improving thermal and mechanical properties. POSS is a class of important nanosized (1-3nm) and cagelike molecules derived from the hydrolysis and condensation of trifunctional organosiloxanes. POSS molecules possess a formula of $[RSiO_{3/2}]n$, where n is 6-12 and R can be various types of organic groups, one (or more) of which is reactive or polymerizable functional groups. The structure-properties of completely condensed and incompletely condensed silsesquioxane in the polyurethane nanocomposites containing 10-17.5wt% of silsesquioxane was investigated by FT-IR, TGA, SEM, XRD and DMA techniques. SEM analysis reveals the incompatibility of POSS molecule in the PU matrices exhibiting greater extent of phase separation and a large number of POSS aggregates on the addition of POSS molecule in the PU-POSS matrices. The TGA thermograms show the incorporation of POSS molecule leads to a decrease in the thermal properties and only the char yield values are increasing with the increase in the POSS content in the PU-POSS hybrids. The XRD pattern reveals the crystalline structure of POSS molecules are destroyed by the polymer matrices in the PU-POSS hybrid films. The decrease in the bending storage modulus E’ values with increase in the POSS-H content proving that the retardation of hydrogen bonding formation by the POSS-H molecule in the PU-POSS hybrid.

Synthesis and characterization of bismaleimide modified caprolactam blocked hexamethylene diisocyanate toughened epoxy inter-crosslinked matrices

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Department of Chemical Engineering, Anna University, Chennai-600 025, India.

Interpenetrating networks of varying percentages of caprolactam blocked hexamethylene diisocyanate (CHDI) toughened epoxy matrices were developed. The toughening of epoxy resin was carried out by using varying weight percentages (5, 10 and 15%) of CHDI. The CHDI toughened epoxy systems were further modified with different weight percentages (4, 8 and 12%) of N, N'-bismaleimido-4,4'-diphenyl methane (BMI) and cured by 4, 4'–diaminodiphenyl methane (DDM). The epoxy hybrid matrices developed, in the form of castings, were used to characterize their mechanical properties like tensile strength, tensile modulus, flexural strength, flexural modulus, impact strength and thermal properties were characterized using differential scanning calorimetry (DSC), thermal gravimetric analysis (TGA), heat deflection temperature (HDT) and dynamic mechanical analysis (DMA). Data obtained from mechanical studies and water absorption indicated that the introduction of CHDI into epoxy resin improved mechanical properties and affects the moisture resistance. The results of thermal properties of CHDI toughened epoxy systems showed lower than that of unmodified epoxy resin whereas in the case of incorporation of BMI into CMDI toughened epoxy system improved both thermomechanical properties and resistance to moisture absorption. Homogeneous surface morphology of CHDI toughened epoxy resin and bismaleimide modified CHDI toughened epoxy resin systems were ascertained using scanning electron microscope (SEM).

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MICRO/NANO HYBRID FILLERS FOR POLYPROPYLENE MODIFICATION

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[2]Dept. of chemistry, Maharaja's college, Ernakulam, Kerala, India
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ABSTRACT

Engineering polymers are attractive materials for structural applications Thermoplastic polymer composites which have good mechanical and thermal properties could be cheaper alternative matrix materials for the same. The main advantages of polymers are their easy processing and light weight. Polypropylene (PP) is a widely using thermoplastic. Traditionally, composites were reinforced with micron sized fillers. Recently nanosized fillers have been developed but the dispersion quality is one of the main difficulties regarding the use of inorganic nanoparticles in PP. Different from the conventional micro-fiber reinforced thermoplastic composites that are reinforced by the micro-fiber system or the nanocomposites which are reinforced by nanofillers, a new type of polymer composite which is reinforced by both the micro-fibers and nano-powder will be discussed in this paper.

Polypropylene (PP)-glass fiber composites with nanosilica and modified nanosilica (using silane coupling agent) were fabricated by melt compounding. The reinforcing and toughening effects of the micro and nano fillers on polypropylene were studied at different loading levels of glass fiber and nano silica/modified nanosilica. The synthesized nanosilica powder was used as reinforcing filler in PP-glass fiber composites The use of two types of fillers leads to synergistic effect on the mechanical properties of the fiber composite. 1wt.% modified nanosilica loading in PP-10wt.% glass fiber composite showed higher mechanical properties compared to PP-30 wt.% glass fiber composite

Keywords : PP, nanosilica, coupling agent, mechanical properties

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LIST OF ALL THE PROGRAMME

MACRO 2009: Recent Advances in Polymeric Materials

PLENARY LECTURES (45 minutes)

PL1: Polymeric Nanoobjects
S. Ramakrishnan, Department of Inorganic and Physical Chemistry
Indian Institute of Science, Bengaluru 560012, India.

PL2: Surface-Initiated Polymerization as a Tool for the Fabrication of bioactive Surfaces and thin Inorganic Films
Harm-Anton Klok, Laboratoire des Polymères, Institut des Matériaux, Ecole
Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland.

PL3: Crystallization of miktoarm star copolymers in comparison to linear diblock copolymer analogs
A.J. Müller[1]*, A.T. Lorenzo[1], D. Priftis[2], M. Pitsikalis[2], N. Hadjichristidis[2],
K. Inoue[3], A. Hirao[3]
[1]Grupo de Polímeros USB, Departamento de Ciencia de los Materiales,
Universidad Simón Bolívar, Apartado 89000, Caracas 1080-A, Venezuela.
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[3]Organic and Polymeric Materials Department, Graduate School of Science and
Engineering, Tokyo Institute of Technology, H-127, 2-12-1, Ohokayama, Meguro-ku,
Tokyo 152-8552, Japan.

PL4: Continuum of Structure in Chitosan-based Materials for Tissue Engineering
A. Montembault, N. Boucard, L. Notin, S. Ladet, A. Pernet Poil-Chevrier, S. Popa
Nita, R. Rivas, F. Dupasquier, C. Ladavière, S. Trombotto, L. David and
A. Domard*.
Laboratoire des Matériaux Polymères et des Biomatériaux, Université C. Bernard Lyon
1, 15, Boulevard A. Latarjet, 69622 Villeurbanne cedex, France.

PL5: Multifunctional Poly(vinylidiene fluride) Graft Copolymer
Arun. K. Nandi, Polymer Science Unit, Indian Association for the cultivation of
Science, Jadavpur, Kolkata - 700 032, India.

SPECIAL INDUSTRY LECTURES (45 minutes)

PL6: High Throughput Research for Catalysts Development for Polymerization Reactions
Manoj Kharkar, Dow Chemical International Pvt Limited, India

PL7: Sustainability in Engineering Thermoplastics
Gautam Chatterjee, Polymer Science and Technology,
GE Global Research, SABIC Innovative Plastics Program,
GE India Technology Center, Bangalore 560066.

INVITED LECTURES (45 minutes)

IL1: **Synthesis and self-assembling properties of end-capped poly(ethylene oxide) and grafted oly(acrylamide) hydrophobically modified with 3-pentadecylcyclohexylamine.**

V.S. Kadam[1,2], S. Varghese[1,2], M.V. Badiger[1], P.P. Wadgaonkar[1], G. Ducouret[2] and D. Hourdet[2]*
[1]Chemical Engineering and Polymer Chemistry Divisions, National Chemical Laboratory, Pune – India.
[2]Physico-Chimie des Polymères et des Milieux Dispersés, UMR 7615, UPMC-ESPCI-CNRS, 10 rue Vauquelin, 75005 Paris – France.

IL2: **Investigation of Polymer Blend Miscibility Fluorescence Spectroscopy**

Sabu Thomas, School of Chemical Sciences
Mahatma Gandhi University Kottayam, Kerala, India - 686 560

IL3: **Diameter Control and Vertical Growth of SWCNTs and Its Potential Applications**

Tae Jae Lee[1], Jungeun Seo[2], Sung-Kyoung Kim[3], Seung-Kyu Lee[2], Haiwon Lee[1,2],*
[1]Institute of Nano Science and Technology, Hanyang University, Seoul 133-791, Korea
[2]Department of Chemistry, Hanyang University, Seoul 133-791, Korea.
[3]Department of Chemistry & Biochemistry, University of Maryland, College Park, MD 20742-4454, USA.

IL4: **Biodegradable Polymers Based on Renewable Resources: Aliphatic Copolyesters Composed of L-Lactide and Isosorbide Units**

Bhaskar B. Idage*, Susheela B. Idage, Ajay S. Kasegaonkar, Rahul V. Jadhav
Polymer Science and Engineering Division, National Chemical Laboratory
Dr. Homi Bhabha Road, Pune-411 008 INDIA

IL5: **Hybrid Nanomaterials From Polymer Gels and Organogels**

J.M. Guenet*, D. Dasgupta, A. Ajayaghosh[§]
Institut Charles Sadron, CNRS UPR22, 23 rue du Loess, BP84047, F-67034 STRASBOURG Cedex2, France
[§]*NIIST,* TRIVANDRUM 695019, INDIA

IL6: **Self-Organization in Tailor-made Urethane-Methacrylate Comb Polymers**

S. K. Asha, Polymer Science & Engineering Division, National Chemical Laboratory (NCL), Dr. Homi Bhabha Road, Pune 411008, INDIA

IL7: **Soft Matter for biomedicine: two case studies. A Novel Temperature Sensitive Hydrogel Microdevice based on Poly(vinyl alcohol)/Poly(methacrylate-co-N-isopropyl acrylamide)**

Gaio Paradossi, Dipartimento di Scienze e Tecnologie Chimiche, Università di Roma Tor Vergata, 000133 Roma, Italy.

IL8: Conjugated Polymer Thin Film Based Biosensors
Shilpa N. Sawant
Chemistry Division, Bhabha Atomic Research Centre, Trombay, Mumbai-400085

IL9: Preparation and properties of Polyimides, Bismaleimides and Bisnadimides containing pyridine and anthracene rings
M.Sarojadevi,
Department of Chemistry, Anna University, Chennai-600025

IL10: Tailoring Functional Nanoporous Materials from Ordered Block Copolymers
Daniel Grande
Institut de Chimie et des Matériaux Paris-Est, UMR 7182 CNRS – Université Paris XII, 2, rue Henri Dunant, 94320 Thiais, France

IL11: Conductive Polymer Nano-BioComposite (CPC) for vapour sensing: chemo-electrical properties of chitosan-carbon nanofiller (Chit-CNF) in methanol, water and toluene vapours atmosphere.
Jean-François FELLER
Materials Engineering Laboratory of Brittany (LIMATB), European University of Brittany (UEB), UBS-Lorient (France).

IL12: Size Exclusion Chromatography – a Blessing and a Curse
Dušan Berek,
Polymer Institute, Slovak Academy of Sciences, 84236 Bratislava, Slovakia

IL13: Rheological properties of viscoelastic fluids and fracture under stress
G. Ducouret
Laboratoire de Physico-Chimie des Polymères et des Milieux Dispersés, UMR 7615, ESPCI, 10 rue Vauquelin, 75231 Paris Cedex, France

IL14: Nanomedicine: A Miracle Technology for Health Care in the 21st Century: Opportunities and Challenges
P.L.Nayak
Institute of Nanobiotechnology, Cuttack-753006, India

IL15: Permeability, Diffusivity, and Solubility of Various Gases in Poly(lactic acid) Blend Membranes
Kazukiyo Nagai
Department of Applied Chemistry, Meiji University,1-1-1 Higashi-mita, Tama-ku, Kawasaki 214-8571, Japan

IL16: Effect of modifiers on thermal properties of novel thermoplastic polyurethane-peptized Laponite nanocomposite
Golok B Nando, Rubber Technology Center, Indian Institute of Technology Kharagpur, Kharagpur – 721 302, India

IL17: Self-assembled Molecular Template for Conducting Polymer Nano-materials
M. Jayakannan, Department of Chemistry, Indian Institute of Science Education& Research (IISER), 900 NCL Innovation Park, Dr, Homi Bhabha Road,
Pune 411008, INDIA

IL18: Effect of Adamantyl Derivative on Atom Transfer Radical Polymerization (ATRP) of Poly(meth)acrylates
Nikhil K. Singha, Rubber Technology Centre, Indian Institute of Technology,
Kharagpur 721302, India

IL19: Synthesis and Characterization of Polystyrene Nanoparticles and Their Effect on Rheological and Thermal Properties of LLDPE Matrix
Satyendra Mishra
Department of Chemical Technology, North Maharashtra University,
Jalgaon - 425001, India

ORAL PRESENTATIONS (20 minutes)

OP1: Room Temperature Living Cationic Polymerization of Styrene using α- Methylstyrene-HCl/$FeCl_3$ System in Presence of Added Salts
Sanjib Banerjee, Tapas K. Paira and Tarun K. Mandal*
Polymer Science Unit, Indian Association for the Cultivation of Science, Jadavpur,
Kolkata 700 032, India

OP2: Chemical synthesis of conducting polymer nanofibers for H_2 storage applications
A. R. Phani[1]*, S.S. Srinivasan[2], M.U. Jurczyk[2] and E.K. Stefanakos[2],
[1] Nano-Research for Advanced Materials & Technologies, Bangalore, Karnataka State, India
[2] Clean Energy Research Center, College of Engineering, University of South Florida, Tampa, FL, USA

OP3: Development of Novel Biodegradable Polymeric Nanofibers for Biomedical Applications
K. T. Shalumon, N. S. Binulal, N. Selvamurugan, Deepthy menon, S. N. Nair and R. Jayakumar*,
Amrita Centre for Nanosciences, Amrita Institute of Medical Sciences and Research Centre, Cochin-682 026, India.

OP4: Polymerizable Fluoroalkyl Surfactant for Improved PEMFC Electrodes
Mohan N. Wadekar[1], Wolter F. Jager[1,2]*, Krishna N. K. Kowlgi[3],
Ger J. M. Koper[3], Gaby J. M. Janssen[4], Natalia P. Lebedeva[4], Stephen J. Picken[1]
[1]NanoStructured Materials, [2]NanoOrganic Chemistry, [3]Self-Assembling Systems,
DelftChemTech, Delft University of Technology, Julianalaan 136, 2628 BL Delft,
[4]Energy Centrum Netherlands, P.O. Box 1, 1755 ZG Petten, The Netherlands.

OP5: Elucidation of Gelation Mechanism of a Two Component Supramolecular Polymer
Swarup Manna, Abhijit Saha and Arun K. Nandi*
Polymer Science Unit, Indian Association for the Cultivation of Science, Jadavpur,
Kolkata-700 032, India

OP6: Recyclable Polypropylene/Polycaprolactone Carbon Nanotubes based Bi-phasic Conducting Polymer Composite as temperature sensor.
Bijandra Kumar*, Mickaël CASTRO, Jianbo LU, Jean-François FELLER
Laboratory of Materials Engineering of Brittany (LIMATB), European University
of Brittany (UEB), France.

OP7: Novel polymer shelled microbubbles for diagnostic and therapeutic purposes
Shivkumar Ghugare,[1] Pamela Mozetic,[1] Mariarosaria Tortora,[1] Andreas Fery,[2] Paulo Fernandes,[2] George Tzvetkov,[3] Rainer Fink,[4] Dmitry Grishenkov,[5] Torkel Brismar,[6] Gaio Paradossi*[1]
[1]Dipartimento di Scienze e Tecnologie Chimiche, Università di Roma Tor Vergata. Rome, Italy
[2]Department of Chemistry, University of Bayreuth, Germany
[3]Paul Scherrer Institute, Swiss Light Source, Villingen, Switzerland
[4]Friedrich-Alexander Universität Erlangen-Nürnberg, Germany
[5] Marcus Wallenberg Laboratory, Royal Institute of Technology, Stockholm, Sweden
[6]Karolinska Intitute, Stockholm, Sweden.

OP8: Growth of Bacillus species on Chemically Pretreated and Un-pretreated Polypropylene
Ambika Arkatkar[1], Sumit Bhaduri[2], Parasu Veera Uppara[2], Mukesh Doble*[1]
[1]Department of Biotechnology, Indian Institute of Technology Madras, Chennai-600036
[2]Polymer Research and Technology center, Reliance Industries Limited, V.N. Purav Marg, Mumbai-600071, India

OP9: Isoconversional Analysis of Differential Scanning Calorimetric Data on Nonisothermal Crystallization of PPS/ TLCP VA 950 Composites Melt
A.K.Kalkar*, V.D.Deshpande, M.J.Kulkarni
Department of Physics, Institute of Chemcial Technology, Matunga,
Mumbai – 400 019, Maharashtra, India

OP10: Synthesis and Characterization of Polyhedral Oligomeric Silsesquioxane - Cyanate ester / Epoxy Nanocomposites
Rakesh. S and Sarojadevi. M*
Department of Chemistry, Anna University, Chennai-600 025, India

OP11: Sorption and Difusion of Aromatic Hydrocarbons through Dynamically Crosslinked High Density Polyethylene/Ethylene Propylene Diene Terpolymer Rubber Blends

Anil Kumar.P.V[1], K.T.Varughese[2] and Sabu Thomas[3]
[1]School of Technology and Applied Sciences, Mahatma Gandhi University, Kottayam.
[2]Central Power research Institute, Bangalore
[3]School of Technology and Applied Sciences, Mahatma Gandhi University, Kottayam.

OP12: Novel three ring based Side Chain Liquid Crystalline Methacrylate monomers and polymers: Synthesis, Characterization and ^{13}C NMR studies

G.Sivamohan Reddy♦, K.Mohana Raju♦, T.Narasimhaswamy■*, N.P.Lobo⅄ and K.V.Ramanathan⅄
♦ Department of Polymer Science and Technology, S.K.University, Anantapur 515 003,
■ Polymer Lab, Central Leather Research Institute, Adyar, Chennai 600 020,
⅄ NMR Research Center, Indian Institute of Science, Bangalore 560 012.

OP13: **Use of polymeric nanomaterials in piezoelectric sensors**

K. P. Singh
Membrane Biophysics and Nanobiosensor Research Laboratory, CBS&H
G. B Pant University of Agriculture and Technology, Pantnagar-263145, Uttarakhand

OP14: Synthesis, characterization and photosensitive properties of phosphorus containing homo and copolymers

K. Kaniappan and S. C. Murugavel*
Polymer Research Laboratory, Department of Chemistry
PSG College of Technology, Coimbatore -641 004, Tamilnadu

OP15: Titania based Self-Cleaning Finish

Bhavana Sharma, Ritu Jain, Manjeet Jassal*, Ashwini K. Agrawal*
Smart and Innovative Textile Materials (SMITA) Group
Department of Textile Technology, Indian Institute of Technology, Hauz Khas
New Delhi-110016, India

OP16: Synthesis and Processing of Polyurethane for developing porous viscoelastic sheets as cushioning materials in therapeutic footwear

G Saraswathy*, Gautham Gopalakrishna, BN Das, Y Lakshmi Narayana,
Ganga Radhakrishnan, Central Leather Research Institute, Chennai-600020, India

OP17: Protein Separation and Flux Recovery Using PVDF/PS blend Ultrafiltration Membranes

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OP18: Viscoelastic and Thermal property modified Epoxy-Clay Nanocomposites: Preparation, Characterization and Property Evaluations.
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Chennai 600 020, India.

OP19: Inherently Colored Antimicrobial Fibers Employing Silver Nanoparticles
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OP20: Natural and Artificial Weathering of Polypropylene Films – a solution for littered packaging films
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C. T. Vijayakumar[a],*
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Delhi –110 054, India

OP21: Chemical Modification of Cellulose Fibers by Combination of Ring Opening Polymerization and Atom Transfer Radical Polymerization.
Arvind Gautam and Shashi D. Baruah*
North East Institute of Science and Technology, Jorhat 785 006, Assam

OP22: Synthesis Of N-Isopropylacrylamide Coatedgold Nanoparticle Hybrid Nanomaterial Via Surface Confined Atom Transfer Radical Polymerization
E. Murugan*, and D.Geethalakshmi
Department of Physical Chemistry, School of Chemical Science,
University of Madras, Guindy Campus, Chennai – 600 025, Tamilnadu, India.

OP23: Optical Properties of a Novel Fluorene-Based Thermally Stable Conjugated Polymer Containing Pyridine and Unsymmetric Carbazole Groups
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Technology, Taipei 10607, Taiwan.
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OP24: Low density ceramic–polymer hybrid foams– Influence of nanofiller on mechanical, thermo-physical and high temperature performance
R Sujith *, Dona Mathew**, R.S.Rajeev**, M.R.Ajith**, M.A.Joseph* &
C.P.Reghunadhan Nair**
*National Institute of Technology, Calicut-673601
**Vikram Sarabhai Space Center, Thriruvananthapuram-685 022

OP25: Synthesis of Peptide-Polymer Hybrid Conjugates by Atom Transfer Radical Polymerization and Their Self-Assembly
Tapas K. Paira, Sanjib Banerjee and Tarun K. Mandal*
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Kolkata 700 032, India.

OP26: Dynamic Mechanical Analysis of Polymer Hybrid Nanocomposites
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[a]Department of Mechanical & Production Engineering,
Sathyabama University, Chennai.
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OP27: Synthesis of Polypyrrole + PS / PMMA Composites:
Application as ammonia gas sensor
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[1] Department of Physics, Institute of Chemical Technology, Mumbai.
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OP28: Self Assembled Polyurethanes
Pralay Maiti,* Abhinay Mishra and Prashant Gupta
School of Materials Science and Technology, Institute of Technology,
Banaras Hindu University, Varanasi 221005, India

OP29: Use of Biodegradable Polymers to improve new Antifouling coatings:
Erosion of marine paints
Isabelle Linossier, Fabienne. Fay, Karine Vallee-Rehel
Laboratoire de Biotechnologie et Chimie Marines, EA 3884, Université de
Bretagne-Sud, BP92116, 56321 Lorient cedex, France.

OP30: A Novel Cure Shrinkage Mechanism based on the Polymerisation-induced Viscoelastic Phase Separation in Thermoplastic Modified Epoxy Resins
Jesmy Jose[a]*, Kuruvilla Joseph[a], Jürgen Pionteck, [b] and Sabu Thomas[a]
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[b] Leibniz-Institute für Polymerforschung Dresden e.V. , Hohe Straße 6, 01069
Dresden, Germany.

OP31: Effect of Morphology Changes in Anthracene Substituted Lower Generation PAMAM and PPI Dendrimers on the Fluorescence Properties
P. K. Lekha and Edamana Prasad*
Department of Chemistry, Indian Institute of Technology Madras, Chennai 600 036,
India

OP32: The influence of treated fumed silica on the hygroscopic characteristics of solid rocket motor case insulation
K.S. Abhilash, B. Jayakrishnan, R.S. Rajeev, R. Muraleekrishnan, and P. Radhakrishnan Nair, Vikram Sarabhai Space Center,
Thiruvananthapuram-695022, India

OP33: Macro porous Styrene Divinyl Benzene Copolymers: Formation of stable porous structures and preparation of supported Platinum Catalyst by in situ reduction
Smita S. Nande, [1] G V N Rathna, [1] Baijayantimala Garnaik, [1]* Rajesh Kumar, [2]
Kalyan Bhanja,[2] Sadhana Mohan[2]
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OP34: Redox Polymerisation of Acrylamide Initiated by Cerium(IV) – Amino Acid Ligands
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* Bishop Heber College, Trichy – 17,
**Mohamed Sathak Arts and Science College, Chennai

OP35: Photo-Cation Curing Epoxy for Rigidization of Inflatable Structures
S.Suraj, V.Lakshmna.Rao, P.Sasidharan Achary and V. Saseendran
Propellants and Special Chemicals Group, Vikram Sarabhai Space Centre,
Thiruvanamthapuram – 695 022, India

OP36: Design and synthesis of a stepwise folding polymer
S. G. Ramkumar and S. Ramakrishnan*
Department of Inorganic and Physical Chemistry, Indian Institute of Science,
Bengaluru 560012, India

OP37: Synthesis And Characterization Of Poly(dimethylsiloxane-urethane) Nanocomposites: Effect Of (In)Completely Condensed Silsesquioxanes On Thermal, Morphological And Mechanical Properties
K. Madhavan and B.S.R. Reddy *
Industrial Chemistry Laboratory, Central Leather Research Institute,
Chennai-600020, India.

OP38: Synthesis and characterization of bismaleimide modified caprolactam blocked hexamethylene diisocyanate toughened epoxy inter-crosslinked matrices
S. Premkumar, C. Karikal Chozhan and M. Alagar*
Department of Chemical Engineering, Anna University, Chennai-600 025, India.

OP39: Micro/nano hybrid fillers for polypropylene modifications
Sinto Jacob,[1] Suma, K. K.,[1,2] Jude Martin Mendez,[1,3] K. E. George,[1]
[1]Department of Polymer Science & Rubber Technology, CUSAT, Kochi, Kerala, India,
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POSTER PRESENTATIONS (displayed all day long)

Monday, 9 March, 2009	**Posters 1-25 (ICSR Exhibition Hall)**
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Morphology and mechanical properties of Poly Butylene Terepthalate/ Montmorillonite nanocomposites.

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Synthesis and Characterization of Metal Nanoparticles Doped Polyaniline by Interfacial Polymerization of Aniline using Metal Salt as Oxidant.

N.Janaki, J. Stella Winnarasi and K.Pandian*
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Synthesis and Characterization of Water Soluble and "Click"able Monomers and Polymers based on 3, 4-Propylenedioxythiophene

Jasmine Sinha, Rabindra Sahoo, and Anil Kumar*
Department of Chemistry, IIT Bombay, Mumbai, 76.

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Selective permeation of acids through polymeric membrane

A. R. Ahire, Y. J. Chendake, U. K. Kharul*
PSE Division, National Chemical Laboratory, Pune – 411008

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Non-fluorinated Copolymer Emulsions for Durable Hydrophobic Finishing of Textiles

Naminita Gogoi, Anandini Prusty, Manjeet Jassal*, Ashwini K. Agrawal*
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Department of Textile Technology, Indian Institute of Technology, Hauz Khas,
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Studies on Biomolecular hybrids of Conducting Polymer and RNA

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Kolkata-700032, India.

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Effect of Molecular weight on Miscibility and Orientation Function of PVC/PMMA Blend.

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Synthesis of Polyaniline thin-films on dimeraniline head group monolayer assembly on glass and ITO surfaces.

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Modification of Biodegradable Polymeric Nanofibers for Tissue Engineering Applications

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Synthesis and Characterization of novel poly(ether – amide)s

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High Performance Polymer Nanocomposites with Low Percolation

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A Comparative Study on the ATRP of n-docosyl acrylate with AIBN and BPO

Prakash J. Saikia, S. D. Baruah* N. C. Dey and P. G. Rao
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Synthesis and characterization of novelof polyphosphazene based energetic binders

Anoop. N. A., Joseph M. J. and Sreekumar. K.*
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Synthesis and characterization of Nadimide terminated resins

Madhaiyan Selladurai and Muthusamy Sarojadevi*
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Characterization and Properties of Vinyl acetate-Butyl acrylate Copolymer Latex for Coating Application

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Synthesis and characterization of novel Poly(amide-imide)s

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Edible Oil Based Bioactive Metal Containing polymers: Preparation, Physicochemical and Biological Studies.

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Novel Fluorene-Based Thermally Stable Conjugated Polymer Containing Pyridine and Chromophoric Carbazole Groups.

Sidharam Pundlik Pujari and Der -Jang Liaw *
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Process for Continuous Production of Electrospun Nano Fibers for Filtration Applications

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Biocomposites of natural rubber : Effect of various biopolymers as fillers

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HDPE/PBT blends using ionomers as compatibilizers- mechanical, electrical and morphological studies

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Thermoreversible gelation of PVDF and its copolymers in phthalates: thermodynamic and small angle neutron scattering studies.

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Electromagnetic shielding materials from polystyrene-polyaniline blend: preparation and properties

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Synthesis, Characterization and corrosion protection properties of Poly (N – Vinyl Carbazole – Co-Glycidyl methacrylate) on low nickel stainless steel.

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High refractive index of transparent acrylate polymers functionalized with alkyl sulfur groups

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pH Sensitive IPN microspheres of Poly(hydroxy ethyl methacrylate-co-Acrylic acid) for controlled release of Metformine hydrochloride

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Synthesis of SnO_2 nanofibers by electrospinning technique and their applications in gas sensors

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Eu^{3+} Doped Silver-PMMA Nanocomposite: Synthesis, Charecterization, and their Optical Properties

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Studies on Cellulose acetate and Poly(phenylsulfone) Blend Ultrafiltration Membranes and their Application Studies

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Organic/Inorganic composite membranes for fuel cells

Swaminathan Elamathi, Dharmalingam Sangeetha, Department of Chemistry, Anna University Chennai, Chennai -600025.

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Antibacterial Silver Nanoparticles Embedded in Semi Interpenetrated Hydrogel Nanocomposite: Synthesis, Characterization and Evaluation of Antibacterial Property of Nanocomposites

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Poly(ε-caprolactone)-Based Hyperbranched Polyurethanes prepared via $A_2 + B_3$ approach and its Shape-memory Behavior

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Polyaniline/carbon nanotube gel nanocomposites

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New approaches towards the synthesis of donor-acceptor type foldamers using Michael addition polymerization

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Proton conducting composite membrane from sulfonated poly styrene ethylene butytlene poly styrene and boron orthophosphate for fuel cell

Perumal Bhavani, *Dharmalingam Sangeetha.

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Phosphonic acid functionalized organic-inorganic nanostructured polyelectrolyte membrane for fuel cell application

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Synthesis and Characterization of Shape Memory Bismaleimide Resins

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Synthesis, characterization and degradation studies of acid-labile polyketals prepared via a novel melt polymerization

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Environmentally Benign Process for Bulk Ring Opening Polymerization of Lactones Using Iron and Ruthenium Chloride Catalysts

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Synthesis and characterization of novel radiopaque polyurethane for medical applications

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Green nanocomposites from maleated polycaprolactone/soy protein isolate blend with organoclay: preparation, characterization and properties.

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Isomannide based NLO active main chain chiral polyurethanes with amido diol chromophores

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Micro Encapsulation of coconut oil For Thermo Regulation

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Synthesis, characterization and bactericidal activity of certain co polyesters

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Novel sulphonated poly(ether ether ketone)/ poly (vinylidene fluoride) electrolyte membranes for fuel cells

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Cholesterol -End Capped Fluorescent Amphiphilic Block Copolymer: Synthesis, Characterization and its Interaction with Biomolecules.

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Department of Chemistry, Indian Institute of Technology, Madras.

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Synthesis and Characterization of Metal Nanoparticles Doped Polyaniline by Interfacial Polymerization of Aniline using Metal Salt as Oxidant.

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Synthesize and characterization of liquid crystalline polyesters containing α, β-unsaturated ketone in the main chain

K.Balaji and Dr. S. C. Murugavel*
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Studies on Synthesis and Characterization of Bismaleimido phenylphosphine oxide benzoxazine and its polybenzoxazine-bismaleimide polymer alloys

Karikal Chozhan C, Alagar M* and Gnanasundaram P
Department of Chemical Engineering, Anna University, Chennai – 600 025, India.

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Functionalization of Polymeric Substrates Using Atmospheric Pressure Cold Plasma

Kartick Kumar Samanta, Manjeet Jassal* and Ashwini K. Agrawal*
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Synthesis and characterization of polybenzimidazoles based on diaminobenzidine (DAB) and aliphatic dicarboxylic acids

Mrunali S. Kale, Shubhangi G. Patil, Rupesh S. Bhavsar, Ulhas K. Kharul*
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Development of Structure Modified Sulfonated Polyether Ether Ketone for Solid Polymer Electrolyte Application

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Some novel polyaniline-multiwalled carbon nanocomposites in preparation and characterization.

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Effect of Various Salts such as Sodium Chloride, Magnesium Sulfate, Sodium Citrate, Di-sodium tartrate 2-hydrate on the Thermo Reversible Sol-gel Transition Temperature of Methylcellulose-Polyethylene Glycol (PEG) Binary System.

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The luminescence study of Lead sulfide nanocrystal-Polyhydrazide/ 1,3,4 polyoxadiazole composite

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Vegetable Oil Based Polyester/Clay Nanocomposites

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Preparation and characterization of starch- clay bionanocomposites for food packaging applications.

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Metal ion adsorption by polystyrene supported schiffs base derived from salicylaldyde and oxy dianiline

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Studies on Flame Retardant Polymer Blends based on Urethane-Epoxy Systems.

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Synthesis and Characterization of Photocrosslinkable Epoxy Resin containing Dibenzylidene Cyclohexanone

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Ultrafiltration membranes prepared from blends of Cellulose Acetate and Sulfonated Styrene Acrylonitrile copolymer

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Poly lactide/ montmorillonite nanoparticles for controlled delivery of anticancer drug paclitaxel.

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Synthesis and Characterization of Copolymers of N-Phenyl Methacrylamide with Glycidyl Methacrylate

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Study on the effect of carboxylated nitrile rubber on the properties of high performance epoxy adhesive

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Nanocomposites from soy protein isolate crosslinked with furfural for controlled release of cefadroxil

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Recyclable Efficient Heterogeneous Catalyst from Gel Nanocomposite

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Controlled delivery of gentamicin sulfate from polycaprolactone–chitosan cast matrices

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Forsterite based polymer-ceramic composites for microelectronic packaging applications

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Melt Processable Copolyesters Derived From Isosorbide, Siloxane and Terephthalic Acid

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Phthalonitrile Terminated Oligoimides for High Temperature Applications: Synthesis and Characterization

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Thermal and morphological properties of siloxane modified tetra glycidyl epoxy – clay nanocomposites

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Development of non-halogenated flame retardant for electrical applications

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Polyaniline based sensor for detection of lindane

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Polydiacetylene thin film based optical sensor for detection of glucose

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Synthesis and characterisation of tetra glycidyl flame retardant epoxy resins

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Sulfonated polyurethanes as corrosion inhibitor for mild steel in acidic medium

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Modeling of drug release from various collagen scaffolds for treatment of infected dermal wound

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Silicone Impregnated Ceramic Foams: Microstructure, Mechanical properties and arc jet evaluation

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Synthesis and thermotropic liquid crystalline behavior of cholesterol linked gum acacia

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Ecofriendly Polyurethane Nanocomposites for Prosthetic Applications

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Thermal and Spectral Characterization of a novel copolymer Melamine- Silicic Acid-Thiourea.

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Development of Poly(acrylamide)/Poly(ethyleneglycol) semi-IPN hydrogel silver nanocomposites for antibacterial applications

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Phase Transfer Catalysis: Kinetics of polymerization of ethyl methacrylate using water soluble potassium peroxy disulfate in the presence of monosited phase transfer catalyst

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Synthesis and Characterization of Soluble and Low Dielectric Constant Silsesquioxane Polyimides

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Synthesis and characterization of poly (4-Benzyloxyphenylmethacrylate) and its copolymers

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Electronic Properties of Conducting Polymer- Ag Nanocomposite Thin Films: Influence of Nanoparticle Size and Density

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POSS reinforced cyanate ester - epoxy nanocomposites: Characterization of Thermal, Dielectric and Morphological properties

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Synthesis and Characterization of Resorcinol based cyanate ester- Epoxy –Organomodified Montmorillonite clay hybrid nanocomposites.

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Nano-silver based durable antibacterial finish for textile

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Anionic Polymeric Membrane as an Effective tool for alkaline fuel cell applications

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Mechanical properties and Transport Behaviour of Chitin Whiskers (CW) Reinforced Carboxylated Styrene Butadiene Rubber Latex (XSBR) Nanocomposites.

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Studies on the size distribution of particles in the combustion plume of MIP de orbit motor propellant.

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Morphology and Thermal Characterization of Poly (L-lactic acid) nanocomposite blown film

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Processing and Nanoscale Dispersion: An Approach for Structural Characterization of Polymer–Clay Nanocomposites

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The influence of filler type and concentration on the properties of solid rocket motor case insulation

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Polymer-Grafted Multiwalled Carbon Nanotubes through Dehydropolycondensation

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Mechanical preparation of cellulose microfibrils and its Characterization

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Renewable Resource Approach for Conducting Polymer Nanomaterials

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Comparative study of thermo mechanical behaviour of SPEEK and SPEEK/PES blends for fuel cell membrane applications

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Nanostructured electro-magnetic functional materials from inorganic organic hybrid guest- host system.

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Effect of compositional variations of propellant on the size distribution of particles in the combustion plume.

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Studies on formulations of Polymer Bonded High Energy Materials and their applications to Launch Vehicles

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Hydroxyl Functionalized Polyaniline Nanospheres for Sensing Bio-analytes

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Carbon Nanotube Embedded HTPB-Based Polyurethane Networks: Mechanical, Thermal and Microscopic Studies

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A study on crystallization behavior of PP/LDH nanocomposites

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Effect of electric field on the wetting characteristics of PEDOT:PSS films doped with sorbitol

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Effect of nanoclay on the mechanical and dynamic mechanical properties of cyanate ester syntactic foams

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Nanoclay reinforced thermoplastic toughened epoxy hybrid syntactic foam: Fracture toughness and Mechanical properties

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Nitrile rubber –clay/ultrasil hybrid nanocomposites

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Morphological studies of amphiphilic hyperbranched polymer films

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Natural rubber nanocomposites using nano zno

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Regulating molecular weight and polydispersity of hyperbranched polymers

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Aliphatic-Aromatic Copolyesters Derived from Isosorbide with different Ratios of Isophthalic and Terephthalic Acid

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Micro/nano hybrid fillers for polypropylene modification

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Nanostructured electro-magnetic functional materials from inorganic organic hybrid guest- host system.

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Nano-clay Incorporated Polyurethane with Shape Memory Properties

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Preparations And Studies On The Intercalation Characteristics Of Carvedilol drug Into Inorganic Clay For Drug Delivery Applications.

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Synthesis and Characterization of New Aromatic Polyesters Containing Pendant Pentadecyl Chains

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Cyanate Ester Resins Containing (Substituted) Cyclohexyl Moiety

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Novel Cationic Photoacid Generator Monomer and PAG Incorporated Photoresists for AFM Lithography and E-Beam Lithography

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Comparing and contrasting the properties of blends of urethane dispersion and acrylic emulsion with those of individual polymers

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Nanocomposites of calcium carbonate and polyethylene: Preparation and Characterization.

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