International Symposium on

Sustainable Polymers

&

National Symposium on

Chemistry Education for Sustainable Engineering

August 23-25, 2019

Abstract Book

Jointly Organized by

Indian Institute of Technology Guwahati
The Society for Polymer Science, India
& Assam Engineering College

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Sustainable Polymers

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Assam Engineering College

भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

Prof. T. G. Sitharam
Ph.D Waterloo (Canada)
FICE (UK), FIGS, FISET

Director, IIT Guwahati
Phone: +913612690401
Email: tgs@iitg.ac.in /
director@iitg.ac.in

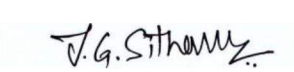
August 19, 2019

Director's Message

It gives me great pleasure to know that the Department of Chemical Engineering, Indian Institute of Technology (IIT) Guwahati and The Society for Polymer Science, India (SPSI) are jointly organizing the '**International Symposium on Sustainable Polymers'** during August 23–25, 2019 as part of the **Silver Jubilee Celebration of IIT Guwahati**. It is noteworthy to mention that the event will also feature the **Launch of SPSI-North East Chapter** and **SPSI-MACRO-2020 Conference** to be held at IIT Guwahati during Dec 13–17, 2020. I am delighted to know that the organizing team at IIT Guwahati has also involved Assam Science and Technology University to spread knowledge and awareness about sustainable polymers, chemistry and engineering practices among the participants from various institutes of the northeastern part of India. This endeavor will strengthen IIT Guwahati's vision and commitment to act as a *Network of Excellence.*

I welcome all the distinguished speakers and delegates who will be visiting IIT Guwahati to participate in this event. The event will help disseminate knowledge on the state-of-the-art emerging advances in sustainable polymers, in line with the current global emphasis on products and technologies for eco-friendly society. I believe that this symposium will provide an opportunity for eminent academicians, researchers, scientists, and other professionals to deliberate and discuss the issues associated with the development and widespread adoption of sustainable polymers, and related advancement of products and technologies. This event will further act as a driving force towards creating greater awareness about sustainable polymers amongst research scholars, young professionals, and students.

I take this opportunity to congratulate the Organizing Team of the event and the Department of Chemical Engineering, IIT Guwahati, and wish the event a grand success.



(**T. G. Sitharam**)

প্ৰঃ ধীৰাজ বৰা
উপাচার্য
প্রো. धीराज बोरा
कुलपति
PROF.DHIRAJ BORA
VICE CHANCELLOR

অসম বিজ্ঞান আৰু প্ৰযুক্তিবিদ্যা বিশ্ববিদ্যালয়
असम विज्ञान और प्रौद्योगिकी विश्वविद्यालय
ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY
(A State University of Government of Assam)
Tetelia Road, Near Assam Engineering College,
Jalukbari,Guwahati-781013,Assam, India. Website:
www.astu.ac.in

Phone no : +91 9435519245
Email id :dhirajboraipr@gmail.com

MESSAGE

It gives me immense pleasure to welcome all the participants to National Symposium On "CHEMISTRY EDUCATION FOR SUSTAINABLE ENGINEERING" August 23-25, 2019. To my knowledge, this is the first ever joint activity organised by the Assam Science and Technology University; Dept of Chemistry, Assam Engineering College and Indian Institute of Technology, Guwahati (Suspol-Centre). First of all, I extend my heartiest congratulations to all the organizers of this event, for taking up such an initiative to promote knowledge sharing and networking among the researchers. Through this event a platform is being created where persons from both Technical and Non-Technical institutes including universities also are coming under the same roof making the events truly multidisciplinary in nature. I wish such an multi institutional efforts will be continued in future also.

I wish this event a great success.

Date: 14/08/2019

(Dhiraj Bora)

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www.spsi.co.in

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Registered Office:
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Registered Charity Number: Maharashtra/929/2001/Pune
Tel : +91 20 2590 2614
Fax : +91 20 25902615

Dr. S. Sivaram, FNA
Honorary Professor and INSA Honorary Scientist
Indian Institute of Science Education and Research, Pune 411007

Message

I am indeed very pleased to note that a Chapter of the Society of Polymer Science, India is being inaugurated at IIT, Guwahati on August 23, 2019. This has been a long pending desire of our fellow scientists in the north-eastern part of India, to create a community of practicing scientists and technologists interested in the discipline of polymer science. I hope this Chapter becomes one of the most vibrant chapters of the Society in India with a diverse range of activities, which will benefit the professionals in this region together for greater benefits to every-one. I hope the young students who are involved in research in many institutions in this region will find this forum a useful one to periodically meet and exchange ideas.

The northeastern part of India is rich in natural resources and can be a source of many ideas for the development of new materials, which will bring immense economic and social benefit to this region. Whereas, our mother earth provides a surfeit of resources, we as scientists, have a great responsibility to devise means of harvesting and exploiting these resources with utmost care and sensitivity so that all innovation is deeply rooted in the goals of Sustainability and Circularity. As individuals well versed in the nuances of science and technology, we owe this to our fellow citizens and generations yet unborn.

I hope the Chapter grows from strength to strength and opens new windows and vistas for polymer science and technology in the northeastern part of India. I also wish to compliment all the scientists who took a keen interest in organizing the Chapter. My special thanks to Professor Vimal Katiyar of IIT, Guwahati for his inspired leadership towards this effort.

S. Sivaram

August 23, 2019

THE SOCIETY FOR POLYMER SCIENCE (INDIA)

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Dr. S. Sivaram (Pune)

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Registered Office:
A 202, Polymers and Advanced Materials Laboratory, National Chemical Laboratory, Dr. Homi Bhabha Road, Pune 411008 INDIA
Registered Charity Number: Maharashtra/929/2001/Pune
Tel : +91 20 2590 2614
Fax : +91 20 25902615

Dr. S. Ramakrishnan
Professor
Indian Institute of Science, Bangalore

Message

It gives me immense pleasure to welcome yet another regional chapter of the Society of Polymer Science – India. Polymer Science is a discipline that seamlessly brings together expertise from science and engineering; during the course of its development it has witnessed numerous fundamentally important contributions from chemistry, physics, chemical engineering, mechanical engineering that has enriched our understanding of this remarkable cross-disciplinary field. Therefore, it is only fitting that the North-east chapter of the SPSI is being inaugurated with a symposium in one of the fine institutions in our country – IIT, Guwahati, that exemplifies and celebrates the richness of science and engineering. I am confident that the North-east chapter will become one of the most vibrant chapters in the country as it is home to some of the fine educational and research institutions, which nurtures outstanding young students and researchers.

The theme of the conference touches upon one of the corner stones of human development today, namely Sustainability; in the context of polymers this implies use of starting materials that can be readily recycled or bio-degraded with zero detrimental effects to the environment. This indeed is a very big challenge to polymer scientists across the world and needs the best minds to bring about *no less than a revolution* in the way we think. This conference, on the occasion of the inauguration of the North-east chapter, I am confident will be an excellent beginning to a concerted effort of researchers from across our country to address this critical issue. I wish the symposium a great success and the infant SPSI chapter long years of vibrant deliberations.

Organizing Committee

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International Symposium on Sustainable Polymers & National Symposium on Chemistry Education for Sustainable Engineering

August 23-25, 2019, IIT Guwahati, India

Programme Schedule

Day 1 - August 23, 2019			
Registration (08:30 - 09:00)			**Venue: Conference Hall; IIT Guwahati**
Inauguration of National Symposium on Chemistry Education for Sustainable Engineering (09:00 - 10:00)			**Venue: Conference Hall; IIT Guwahati**
Talk	**Time (Hrs)**	**Title**	**Speaker**
IL-01	10:00-11:00	**Popular Science Talk** Bionics and Bionic Engineering: Learning Science from Nature	Dr. Pradeep Kr. Srivastava, Former Deputy Director, Central Drug Research Institute, Lucknow
11:00 – 11:20		***High Tea***	
IL-02	11:20-11:50	Sustainable Science at the Nanoscale for Potential Technology	Prof. Arun Chattopadhyay, Indian Institute of Technology Guwahati
IL-03	11.50-12.20	Ligand Anchored 3-D $\{SiO_2\}n$ Networking for Sample Clean-up of Some Heavy and Toxic Elements Through Their Selective Separation and Preconcentration	Prof. Bhabatosh Mandal, Visva-Bharati University, West Bengal
IL-04	12:20-12:50	Chemistry Education for Sustainable Engineering	Prof. Okhil K. Medhi, Former Vice-Chancellor, Gauhati University & Royal Global University, Guwahati
IL-05	12:50-01.20	Designing biodegradable polymeric particles of various architecture and their applications in active delivery	Dr. Sampa Saha, Indian Institute of Technology Delhi
01:20-02:20		***Lunch***	
IL-06	02:20-02:50	Sequence Controlled Alternating Copolymers Via RAFT Polymerization	Prof. Priyadarsi De, IISER Kolkata

IL-07	02:50-03:20	Optically active polymers for Sustainable applications in Membrane Sciences	Dr. (Ms) Swapnali Hazarika, NEIST Jorhat
OL-01	03:20-03:30	The eco-friendly synthesis of Spirooxindoles using Deep Eutectic Solvent	Prof. Okram Mukherjee Singh, Manipur University, Imphal
OL-02	03:30-03:40	Green Synthesis of Ag nanoparticle using Activated carbon as support and study of its activity for organic transformations	Dr. Parasa Hazarika, Jorhat Institute of Science and Technology, Jorhat
OL-03	03:40-03:50	Synthesis of Bromo Organics with Special Reference to Green Chemistry	Dr. Jayashree Nath, J. B. College, Jorhat
03:50-04:10		***High Tea***	
Inauguration of International Symposium on Sustainable Polymers **Launch of SPSI North East Chapter and SPSI-MACRO-2020 (04:10-05:00)**			**Venue: Conference Hall; IIT Guwahati**
IL-08	05:00-05:45	Janus Folded Chains	Prof. S. Ramakrishnan (President, SPSI) Indian Institute of Science, Bangalore
IL-09	05:45-06:30	Sustainability of Polymers: Future Directions	Prof. S. Sivaram, (Past President, SPSI) IISER Pune
IL-10	06:30-07:15	Supercoiled Supramolecular Polymers of Linear π-Conjugated Molecules	Dr. Ayyappanpillai Ajayaghosh, Director, CSIR-NIIST, Thiruvananthapuram, Kerala

Day 2 - August 24, 2019

Talk	Time (Hrs)	Title	Speaker
IL-11	09:00-09:30	Microcellular Foam Processing of Polymers- A Sustainable Approach	Prof. A.K. Ghosh, Indian Institute of Technology Delhi
IL-12	09:30-10:00	Sustainable Development for Controlled Drug Delivery and Implants	Prof. Pralay Maiti, Indian Institute of Technology (BHU), Varanasi
IL-13	10:00-10:30	High Specific Strength Polymer Composites: Development, Characterization and Model Formulation	Dr. Gaurav Manik, Indian Institute of Technology Roorkee
IL-14	10:30-11:00	Sustainable hyperbranched polyurethane elastomeric nanocomposites with multifaceted attributes	Prof. Niranjan Karak, Tezpur University

11:00-11:15		***Tea Break***	
IL-15	11:15-11:45	A New Class of Elastomers based on Renewable Bioresources	Prof. Nikhil K. Singha, Indian Institute of Technology Kharagpur
IL-16	11:45-12:15	Stimuli-Responsive Poly(2-oxazoline) Copolymers and Their Self-Assembly	Prof. Tarun Kumar Mandal, Indian Association for the Cultivation of Science, Kolkata
IL-17	12:15-12:45	Polymers from vegetable oil through carbon dioxide insertion and catalytic property of carbon based nano materials	Prof. Swapan Kumar Dolui, Tezpur University
IL-18	12:45-01:15	An insight into sustainable cellulose derivatives based clay nanocomposites as biodegradable material for multifaceted applications: From packaging to biomedical	Prof. Dipankar Chattophdhyay, University of Calcutta
01:15-02:15		***Lunch***	
02:15-03:00		**POSTER SESSION**	
IL-19	03:00-03:20	Secondary Manufacturing of Sustainable Polymer-based Fiber-Reinforced Composites	Dr. Kishor Debnath, NIT Meghalaya
IL-20	03:20-03:40	Biopolymer Based Hydrogels as Template for Entrapment of either the 'Blue' or 'Red' form of Methylene Blue (MB) dye – Possibility of Using MB dye as Amine Sensors	Prof. Homendra Naorem, Manipur University
IL-21	03:40-04:00	Development of biochemically reduced graphene-oxide filled pi-conjugated polymer nanocomposites as sensors for volatile organic compounds	Dr. Surajit Konwer, Dibrugarh University
IL-22	04:00-04:20	Fruit and vegetable coating from waste bio-mass: A sustainable approach	Dr. Tridib Kumar Bhowmick, NIT Agartala
04:20-04:30		***Tea Break***	
OL-04	04:30-04:40	Biobased Polymeric Vapor Sensor: Using Custom Made Gas Casing	Gourhari Chakraborty, Indian Institute of Technology Guwahati
OL-05	04:40-04:50	Principles of Green Chemistry & Engineering for Sustainable Development	Dr. Bhaskar Jyoti Sarmah, Jorhat Institute of Science and Technology, Jorhat
OL-06	04:50-05:00	Enhanced Nucleation and Trans-crystallization in Poly(lactic acid) biocomposites induced by covalent modification of Gum Arabic	Dr. Purabi Bhagabati, Indian Institute of Technology Guwahati
OL-07	05:00-05:10	Chitosan/Magnetic Cellulose Nanofiber Based Edible Nano-Coating Facilitated By Bioactive Compounds for Kiwi fruit products	Tabli Ghosh, Indian Institute of Technology Guwahati
OL-08	05:10-05:20	Novel Fluorescent Probe for Detection of Iron	Moitreyee Bhattacharjee, Handique Girls College, Guwahati
OL-09	05:20-05:30	Enzymatic degradation behaviour of distinct PLLA/PDLA blends through thermostable enzymes	Naba Kr. Kalita, Indian Institute of Technology Guwahati

05:30-07:30	**Science outreach workshop by Prof. Anil Kumar, Indian Institute of Technology Bombay**

Day 3 - August 25, 2019			
Talk	**Time (Hrs)**	**Title**	**Speaker**
IL-23	09:00-09:20	Green Composites: An Insight into Development, Mechanical Properties and Characterization	Dr. Sumit Bhowmik, NIT Silchar
IL-24	09:20-09:40	Nano Bio-polymer composites and its applications	Dr. Devasish Chowdhury, IASST, Guwahati
IL-25	09:40-10:00	Structural and Degradation Behavior of Compostable Composites Comprising Poly(butylene adipate-co-terephthalate) and Natural Fibers	Ms. Jyoti Giri, Tribhuvan University, Nepal
IL-26	10:00-10:20	Poly(meth) acrylate grafted Starch: Synthesis and Characterization	Dr. Dhruba J. Haloi, Bodoland University
OL-10	10:20-10:30	Polylactic acid/nano-Hydroxyapatite composite: Sustainable materials for orthopedic fracture fixations	Arbind Prasad, Katihar Engineering College, Bihar
OL-11	10:30-10:40	Biosorption of a Basic Dye Rhodamine B on Indian Sandalwood (Santalum Album) Leaf Powder: A Case Study	Dr. Nayan Jyoti Khound, Digboi College, Digboi
OL-12	10:40-10:50	Green synthesis of nitrogen heterocycles	Dr. Mohit Lal Deb, GUIST, Gauhati University
10:50-11:00		***Tea Break***	
OL-13	11:00-11:10	Molecular Dynamics Simulation Study Under the Effect of External Electric Field and High Temperature on Conformation of the Protein β-Lactoglobulin	Dr. Gargi Borgohain, Cotton University, Guwahati
OL-14	11:10-11:20	Arjuna bark powder [ArBP], a natural adsorbent used in sorption of Cr[VI] from aqueous solution	Dr. Sumi Sarma, Gauhati University, Guwahati
OL-15	11:20-11:30	A study of drinking water quality in an around Tetelia, Jalukbari, Assam	Dr.Sanghita Dutta, Assam Science and Technology University
OL-16	11:30-11:40	Fabrication of interpenetrating polymer network-based nanocomposites of bio-based polyurethane and polystyrene with inherent surface hydrophobicity and shape memory attributes	Tuhin Ghosh, Tezpur University, Tezpur

OL-17	11:40-11:50	A review on the applicability of using biodiesel blends as fuel in a CI Engine	Kamaldeep Kalita, Assam Don Bosco University, Guwahati
OL-18	11:50-12:00	Carbon Nanomaterial-Vesicles Hybrid System for Biomedical Application	Jayanta Sarmah Boruah, IASST, Guwahati
OL-19	12:00-12:10	Mobility and Bioavailability of Cd, Co, Cu and Zn in surface runoff sediments in the urban catchment area of Guwahati	Upama Devi, Assam Engineering College, Guwahati
OL-20	12:10-12:20	Acrylic Based Fluorescent Adhesive: Role of Fluorescence in Crafts and Anti-Counterfeiting Applications	Samiran Upadhyaya, IASST, Guwahati
OL-21	12:20-12:30	Development of Nano-Bio-Conjugate Film using Aloe vera to detect hazardous chemicals found in cosmetics	Ankita Deb, IASST, Guwahati
OL-22	12:30-12:40	Surface induced catalysis of Aza-Michael reaction using zeolite as the catalyst; an efficient green synthetic approach	Parineeta Das, NIT Nagaland
12:40-01:40		**Valedictory Session**	
02:45-04:00		**CoE-SusPol Lab Visit**	

Speakers Profile

Prof. S Sivaram is presently an INSA Senior Scientist and Honorary Professor at the Indian Institute of Science Education and Research, Pune, India. Prior to this he held the position of CSIR Bhatnagar Fellow (2010-15) and J.C. Bose National Fellow of the Department of Science and Technology (2007-15) at CSIR-NCL. He served as the eighth Director of National Chemical Laboratory (NCL) from 2002-2010. Prof. Sivaram is a highly decorated scientist with numerous awards to his credits. He is a recipient of the Vishwakarma Medal (INSA), Silver Medal of the Chemical Research Society of India, Millennium Medal of the Indian Science Congress Association, Distinguished Alumnus Award of IIT, Kanpur, Professor S.R. Palit Memorial Award of the Indian Association for Cultivation of Science, Kolkata, K.G. Naik Gold Medal of M.S. University, Baroda, and many others. Prof. Sivaram's research interest concerns polymer synthesis, surface chemistry of polymers, porous polymers for energy related applications, biodegradable polymers, organic-inorganic hybrids, nanocomposites and structure-property relationship in polymers.

Prof. S Ramakrishnan is a Professor in Indian Institute of Science Bangalore, Karnataka, India. His research areas include conjugated polymers, foldamers, hyperbranched polymers, polymerizable surfactants, novel polyethers, etc. He has published multiple research papers in highly reputed journals and has been awarded India's prestigious "Shanti Swarup Bhatnagar award" in the area of chemical science for the year 2005 and "DAE-SRC Outstanding Research Investigator award" in 2005. Prof. S. Ramakrishnan has been elected as Fellow of Indian Academy of Sciences (FASc). He is also endowed with several other awards and collaborations.

Prof. Ayyappanpillai Ajayaghosh is the Director of the CSIR-National Institute for Interdisciplinary Science and Technology (CSIR-NIIST), Thiruvananthapuram, India and is a Professor and the Dean of Chemical Sciences, Academy of Scientific and Innovative Research (AcSIR). His research contributions are in the interdisciplinary areas of organic photoresponsive materials, supramolecular chemistry, molecular self-assembly, organogels and molecular probes, and sensors. He has developed a new class of functional soft materials namely pi-gels having potential applications in energy harvesting, sensing and security materials. He has developed several fluorescent probes for sensing and imaging of biological specimen. His scientific contributions are recognized with the prestigious Shanti Swarup Bhatnagar Prize for Chemical Sciences (2007), the Infosys Science Prize (2012), the Silver Medal of the Chemical Research Society of India (2013), the TWAS Prize for Chemistry (2013) and the J. C. Bose National Fellowship (2015). He is the first chemist to receive the Infosys Science Prize. He has published over 160 research articles, five book chapters, filed 13 patents and supervised 25 Ph.Ds. He is a member of several academic and institutional bodies and a member of various selection committees.

Prof. Pradeep K. Srivastava is the Former Sr. Principal Scientist (Dy. Director) at Central Drug Research Institute, Lucknow. Further, as a Principal scientist in the Medicinal and Process Chemistry Division of Central Drug Research Institute, Lucknow, he is involved in developing technology for the production of various drugs and pharmaceuticals and has got R&D experience of more than 33 years in the area of synthetic and natural products chemistry. Further, in the area of technology development work, he has worked on a drug for Brain Stroke.

Prof. Anup Kumar Ghosh is currently Head of the Department of Materials Science and Engineering, IIT Delhi. With over 1300 citations, an h-index of 20, and 8 patents to his credit, he is regarded as a global leader in Polymer Processing and Rheology. Prof Anup K. Ghosh's work of over 29 years of research with significant contribution in the areas of Reactive Processing of Polymer Blends and Alloys, and Microcellular Processing. He is a fellow of National Academy of Sciences, India, He held the prestigious Reliance Chair Professor at IIT Delhi during 2006-11. He has supervised 22 Ph.D. thesis and over 90 M.Tech. thesis. For his innovative development of polymeric orthotic knee joints for locomotor disabled people, with successful field trials on 1000 patients, he was conferred the National Award (2015). He is Member, Board of Governors, NIT Delhi and Member, Research Advisory Council, GAIL (India) Ltd. and Shriram Institute for Industrial Research. He is elected as International Representative of the Polymer Processing Society (PPS), Asian Workshop in Polymer Processing (AWPP) and Fellow of Indian Plastics Institute (IPI).

Prof. Anil Kumar is currently working as Professor in Department of Chemistry, IIT Bombay. His research is mainly focused on continuous flow synthesis, reaction mechanism and kinetics, transparent conductors, chemical and biosensors and others. He has several publications in reputed peer reviewed journals and 29 patents to his credit. He did his Ph.D. at the Department of Inorganic and Physical Chemistry, Indian Institute of Science, Bangalore. He did his Postdoc at the University of Florida, Gainesville, U.S.A. where he worked in the field of conducting polymers reporting, for the first time, an exhaustive study on the effect of alkyl group and the length of the alkylenedioxy ring on the electrical and optical properties of PEDOT. His group also explored, successfully, the possibility of using textile fabrics coated with conducting materials as gas sensors. He worked in the field of dendrimers, conducting polymers for biosensor applications and supramolecular chemistry. Member of the Editorial Advisory Board of "ACS Sustainable Chemistry & Engineering" from 2016. Prof. Kumar is the recipient of several awards like CRSI Bronze Medal for 2016, Dr. P.K. Patwardhan Technology Development Award of IIT Bombay.

Prof. Nikhil K. Singha is Professor and Chair of the Rubber Technology Centre, IIT Kharagpur. His research interests include tailor-made functional polymers and elastomers *via* controlled/living radical polymerization (CRP), preparation of smart self-healing, superhydrophobic, and specialty polymeric materials *via* CRP and "Click Chemistry", preparation of block, graft copolymers, electro-active, bio-active polymers, and tailor-made polymer composites *via* controlled polymerization, polymerization in ionic liquid, and polyurethane-ionic liquid composite. He has received several honors and awards, which include Prof. M. Santappa Award (2014) by Society of Polymer Science India (SPSI), MRSI Medal by Material Research Society of India (MRSI) (2013), Fulbright Senior Fellowship (2013), Fifth Polymer Foundation Award by Prof. Sukumar Maiti Polymer Award Foundation (2012). He was a Visiting Scientist in University of Sheffield, UK with fellowship from Royal Society, London, UK (2006), in Institute for Polymer Research, Germany with INSA-DFG & DAAD fellowship (2008 & 2011) & in EPFL, Switzerland with fellowship from Swiss Federal Institute (2009). He is a Fellow of Royal Society Chemistry (FRSC), Life member of Materials Research Society of India (MRSI), Society of Polymer Science of India (SPSI) and Chemical Research Society of India (CRSI). He is a member of the editorial board of several peer-reviewed journals and has 127 journal publication, 11 patents (one US, one European, eight Indian patents), 5 book chapters and 82 conference proceedings, along with one edited book published by Smithers RAPRA, UK.

Prof. Pralay Maiti is Professor and Coordinator of the School of Materials Science and Technology, IIT (BHU) Varanasi. Dr. Maiti received Master's in Chemistry from Indian Institute of Technology Kharagpur in 1991 and a Ph.D. in Polymer in 1996 from

Indian Association for the Cultivation of Science (Jadavpur University). He was COE Researcher and Lecturer at Venture Business Laboratory, Hiroshima University, Japan (1997-1999) and was post-doctoral fellow at Toyota Technological Institute, Japan (1999-2001). He was Visiting Scientist at Cornell University, USA from 2002 to 2004. He was Quick Hire Fellow at Central Leather Research Institute, Chennai before joining the School of Materials Science and Technology in December 2004. His research interests are in the areas of nanocomposites of polymers, biomaterials, self-assembly, biodegradable polymers, polymer for renewable resources, radiation resistant polymer, fuel cell membrane and polymer electronics. He has received several honors and awards for his contribution in these areas.

Prof. Arun Chattopadhyay is currently working as Professor in the Dept. of Chemistry & Centre for Nanotechnology, Indian Institute of Technology Guwahati. His research interest spans in the various areas of nanomaterials synthesis, composites, nanobiotechnology, chemical locomotion, quantum dots, chemical reaction of nanoparticles. He has authored over 160 research papers in reputed international journals and has 4 patents to his credit. He is the recipient of several awards like the Fellow of Indian Academy of Sciences, Fellow of the Royal Society of Chemistry, Young Career Award in Nano Science and Technology (2013), DST (Nano Mission), materials Research Society of India Medal, 2008. He did his Ph.D (Chemical Physics) from Columbia University and Post. Doc. from Standford University. At IITG, besides teaching and research, Prof. Chattopadhyay has also served in various other capacities; some of which include Head, Department of Chemistry, (2009 -2014), Head, Centre for Nanotechnology (2004-2009). management Committee Member of Institute School, 2001, Warden, Hostel (1996-1998).

Prof. Niranjan Karak is a Professor of Polymer Science and Nanomaterials of Chemical Sciences Department (former HoD) and present Head, Sophisticated and Analytical Instrument Center (SAIC) of Tezpur University. Prof. Karak has published 202 research papers including review articles and authored six books, as well as written seven chapters in different edited books including two encyclopedias. He has supervised sixteen Ph.D. students and is presently supervising many more students along with two post-doctoral fellows. Dr. Karak has also filed five patents on his innovative works. His fields of research interest are mainly based on bio-based high performance hyperbranched polymeric nanocomposites as multifaceted sustainable materials including biomaterials. Prof. Karak has received eight national awards from different learned academic societies including Prof. Karak has been awarded with the prestigious Fellow of the Royal Society of Chemistry (FRSC) in recognition of his contribution to the field of Chemistry. The President of India and Ministry of Fertilizer and Chemicals, Government of India. He has also gained international recognition as one of the most highly prolific authors for ACS Sustainable Chemistry & Engineering in the world for his outstanding contribution in the field.

Prof. Dipankar Chattophdhyay is currently working as a Professor in the Department of Polymer Science & Technology, University of Calcutta, He has an expertise in Polymer Science and Technology: synthesis and characterization, polymer nanocomposites, hydrogel based biomaterial, rubber compounding and technology, conducting polymers and initiative to affect creative solutions to a broad range of research problems in the above fields. His research is focused on the development of advanced polymers and nanomaterials with special emphasis on biodegradable, biocompatible advanced polymers and nanomaterials obtained through the dictates of green chemistry and green technology to meet the challenges of today's society. He has served in various capacities as an advisor both in academic and industry. He has 3 patents and several publications in

peer reviewed journals to his credit. He also held the position of Lecturer in Shahid Bhagat Singh College of Eng. & Technology, Punjab and Lecturer in Vidyasagar University, Kolkata.

Prof. Swapan Kumar Dolui is currently working as Professor in Department of Chemical Sciences, Tezpur University, Assam. His research is mainly focused on Polymer Chemistry. With over 2000 citations Prof.Dolui has several publications in reputed peer-reviewed journals. He did his PhD from IIT Kharagpur and Masters in Physical Chemistry from Calcutta University. He is the recipient of the National Technology Innovation Award for the Excellence in R&D by Ministry of Chemicals and Fertilizers for the year 2016.

Prof. Tarun Kumar Mandal is currently working as Senior Professor of Polymer Science Unit, IACS, Kolkata. His research is mainly focused on the use of different controlled polymerization techniques as tools to synthesize various stimuli-responsive polymers/block copolymers/polypeptides, mesoporous polymers, peptide-polymer hybrids, amino acid-based polymers, metal/metal oxide-polymer hybrids for exploiting them in the diversified range from advanced self-assembled nanomaterials to catalysts. His group also aim to investigate the phase behaviors of newly designed ionic liquids, poly(ionic liquid)s and poly(zwitterions) in solid state and in solution and their materials applications. The research further includes synthesis of size- and shape-tunable metal, metal alloy, and metal oxide nanostructures for catalysis/photocatalysis. He has over 96 publications and over 3000 citations to his credit. He is also Recipient of several awards like Materials Research Society of India (MRSI) Medal, 2012Chemical Research Society of India (CRSI) Bronze Medal, 2013Fellow, West Bengal Academy of Science & Technology, 2014M. Santappa Award in Polymer Science (The Society for Polymer Science, India), 2018.

Prof. Priyadarsi De is currently working as Professor at Department of Chemical Sciences, Indian Institute of Science Education and Research Kolkata, India. He did his B.Sc. (Chemistry Honors) and M.Sc. (Physical Chemistry) from Jadavpur University, Kolkata, India and Ph.D. (Polymer Chemistry) from Indian Institute of Science, Bangalore, India. Prof. De's research interests include controlled/living radical polymerizations [atom transfer radical polymerization (ATRP) and reversible addition fragmentation chain transfer (RAFT) polymerization], water soluble "smart" responsive polymers for drug delivery applications, polymer-drug/bio-active molecule conjugate and their biological evaluations, synthesis and characterization of hybrid materials and nanomaterials, controlled/ Living carbocationic polymerization for macromolecular architecture, combination of living cationic polymerization with ATRP, RAFT, and "click" chemistry to generate novel macromolecular architectures, oxidative polymerization, polymerization of vinyl monomers under high pressure of oxygen. He is a reviewer of several journals and visiting scientist at Université Pierre et Marie Curie, Paris, France (2002). He has 10 patents, 2 book chapters and over 54 peer-reviewed publications to his credit.

Prof. Bhabatosh Mandal is currently working as a Professor of Chemistry in Visva-Bharati. University, Bolpur with a teaching experience over 25 years in graduation and post-graduation level, he has more than 15+ years of research experience in analytical chemistry. His research interest is in selective separation and preconcentration of toxic and heavy metal ions in trace/ ultra-trace level, development of in-exchange material, functionalization of silica gel. In the field of Nanomaterials, his key interest includes the development of nanomaterial having in-exchange and photo-electronic properties, HOMO-LUMO adsorption of high-low oxidation states, rationalization of chemical properties in terms of DFT and others. He is serving as

an editorial member and reviewer of several international reputed journals. Dr. Bhabatosh Mandal is the member of many international affiliations. He has authored of many research articles/books related to Analytical Chemistry; Bio-analytical Chemistry, and Photochemistry.

Prof. (Emeritus) Okhil Kumar Medhi, currently holds the position of Vice Chancellor of Guwahati University, Assam. With over 33 years of experience in Academics Prof. Medhi is a Professor of Chemistry at Gauhati University since 1991. He has taught at the North-Eastern Hill University, Shillong. He specializes is bio inorganic chemistry and has over 8000 citations and 70 publications in reputed journals to his credit. Prof. Okhil K. Medhi received his Ph.D. from the Indian Institute of Technology, Kanpur. He obtained his Post-Doctoral degree from University in UK. Previously he also served as Head of Chemistry Department and as Dean of Faculty of Science in the University.

Prof. Vijayamohanan K. Pillai is currently the Director, CSIR-CECRI, Karaikudi, Tamil Nadu. An alumnus of the Indian Institute of Science, Dr. Pillai's research work of more than 20 years is primarily focused on batteries, fuel cells, bio-electrochemistry, electrochemical sensors, chemically modified electrodes, anodization, electro-deposition, electro-organic synthesis. Dr. Pillai has more than 250 research papers and 20 patents to his credit. Under his guidance, 17 students have received Ph.D. degrees. He is a recipient of many prestigious awards including Medals of the MRSI and CRSI. He is an active member of advisory board of various Research committee and Universities. He is a Fellow of the Indian Academy of Sciences and Affiliate Member of the IUPAC. He is also in the editorial boards of several prestigious journals.

Prof. Naorem Homendra is Professor of Physical Chemistry in the Department of Chemistry, Manipur University. Prof. Naorem completed his M.Sc. in Physical Chemistry from NEHU-Shillong in the year 1984 and Ph.D. from IIT-Delhi in the year 1990. During the period (1989-1990), he worked as a Senior Research Officer at IRD, IIT Delhi. During his life, he has done 6(Six) Research Project and have published more than 30 research paper. Prof. Naorem's research interests include surfactants, biopolymer gels and their controlled release, development of microemulsions using essential oils extracted from fruit peels for targeted applications, Self aggregation of dyes in mixed aqueous organic solvent media, development and assembly of dye sensitized solar cells, etc. He published numerous articles in reputed journals and delivered talks in both national and international conferences. He also earned several accolades and awards such as "DST-MASTECH Young Scientist at PSU, IACS, Kolkata (1997)" and "BN Gosh Memorial Medal (2012) by the Indian Chemical Society"

Prof. Dilip Kr. Kakati is a Professor in the Department of Chemistry, Gauhati University, Assam, India. He has obtained his Ph.D. from DIC, London. His research areas include polymer chemistry and organic synthesis. He has in his credit several published articles and also authored books and monograph in LAMBERT Academic Publishing, Germany, 2013. Prof. Kakati has been awarded "State overseas fellowship" and "INSA fellowship." He also serves as a member in the Editorial board of Journal of Polymer Materials.

Dr. Sampa Saha is the Assistant Professor of Centre for Polymer Science and Engineering (CPSE) at IIT Delhi since June, 2015. She has several years of experience in the field of polymer chemistry. After finishing her PhD from Michigan State University, USA and postdoc from University of Michigan, Ann Arbor, USA, she has worked for companies like BASF, Singapore and Prochem, Singapore as team leader. More than 1 million dollar worth research grant was awarded during her work period in BASF, Singapore. Her research area spans from biodegradable polymeric particles (multi-layered and multi-compartmental) to polymer brushes. She has several publications in reputed international journals. She has also written 2 book chapters and filed 2 Indian patents. She emphasizes on multi-disciplinary approach to solve problems and hence believes in strong collaborative efforts.

Dr. Devasish Chowdhury is an Associate Professor in the department of physical sciences, Institute of Advanced Study in Science and Technology, Guwahati, Assam, India. He obtained his M.Sc. from Delhi University in the year 1998 and Ph.D. from the Indian Institute of Technology Guwahati in the year 2004 and post-doctoral from Weizmann institute of Science, Israel during the period 2004-2007. Dr. Chowdhury's research interests include polymer nanocomposites, surface self-assembly, surface nanochemistry, atomic force microscope mediated nanolithography. He has to his credit patents and several published research articles with high impact factor in reputed journals. He also supervised multiple projects and has been recognised with different awards and fellowships such as Indo-US Science and Technology Forum Fellowship (IUSSTF) 2009 and American Chemical Society Membership Award, 2015.

Dr. Gaurav Manik is an Associate Professo in Polymer and Process Engineering Departmentin the Indian Institute of Technology Roorkee. Dr. anik obtained his Master's in Chemical engineering in the year 2000 from Indian Institute of Technology Kanpur and Ph.D. in same from the Indian Institute of Technology Bombay in the year 2010. His rsearch interests include polymer composites, coatings, process optimization and control, molecular simulation of polymers, synthesis of novel industrially important adhesives, etc. He supervised several projects and thesis. He also has in his credit several filed patents and publications in high impact factor journals. He also serves as a Life Member in Material Research Society of India and Indian Society for Technical Education.

Ms. Jyoti Giri is an Assistant Professor in the Department of Chemistry, Tribhuvan University, Tri-Chandra Campus, Ghantaghar, Kathmandu, Nepal. She obtained her Master's in Organic Chemistry from Central department chemistry, Tribhuvan university, Laboratory Secondary Boarding High School. His research interests include Biomaterials, Polymer Composites, Biodegradable Materials, Green Chemistry. Ms. Giri published several research papers and are involved in various projects. She also served as a Life Member of Nepal Chemical Society (NCS), Executive Member (2009 – 2011) period.

Dr. Sumit Bhowmik is an Assistant Professor in the Department of Mechanical Engineering, National Institute of Technology Silchar. Dr. Bhowmik's research interests include composite material, fracture mechanics, structural analysis, tribology, pressure vessels, virtual Manufacturing. He has authored and co-authored several peer-reviewed scientific papers and presented works at many national and International conferences. Dr. Bhowmik's academic career has been decorated with multiple reputed awards and funding.

Dr. Tridib Kumar Bhowmick is an Assistant Professor in the Department of Bio engineering from National Institute of Technology Agartala, India. He obtained his Mater's from Jadavpur University and Ph.D. from Indian Institute of Technology Bombay. Dr. Bhowmick's research interests include Biomaterial Characterization, Indian Traditional Medicine, Particle mediated drug delivery, Bio-analytics, Electron Microscopy, Recombinant protein. He has in his credit several published articles and co-authored books and chapters.

Dr. Kishore Debnath is an Assistant Professor at the Department of Mechanical Engineering in the National Institute of Technology Meghalaya. Dr. Debnath received his Master's in Mechanical Engineering from National Institute Of Technology Rourkela in the year 2011 and Ph.D. in same from the Indian Institute of Technology Roorkee in the year 2015. Dr. Debnath's research areas includes green composites, biodegradable polymers, advanced machining methods, composite materials. His commendable efforts and dependable diligence shadowed with a rich blend of dynamism in the domain spanning research have also enabled him to publish a total of 63 technical manuscripts in peer reviewed journals. He has also authored several books and chapters. He has also edited one book titled, "Primary and Secondary Manufacturing of Polymer Matrix Composites" being published by CRC Press (Taylor and Francis Group). He is also an active reviewer of different peer reviewed journals published by Elsevier, Springer, Taylor & Francis, Sage, Wiley, etc.

Dr. Surajit Konwer is Assistant Professor in the Department of Chemistry in Dibrugarh University, Assam, India. He received his Master's degree from Gauhati University in the year 2004 and Ph.D. from Tezpur University in the year 2011. His research interests include material science, conducting polymer, graphene and nano-chemistry. He has published several articles in reputed journals and authored books and chapters such as in "GmbH & Co. KG Heinrich-Böcking-Str.6-8, 66121, Saarbrücken, Germany." He received awards and recognition in the field of chemistry and also served as a life member in Society for Material Chemistry India, Indian Institute of Material Engineers, India and Indian Science Congress Association.

Dr. Dhruba Jyoti Haloi is an Assistant Professor at the Department of Chemistry in the Bodoland University, Kokrajhar, India. He received Master's and Ph.D. in Rubber Technology from the Indian Institute of Technology Kharagpur in the year 2008 and 2012 respectively. Dr. Haloi's research interests are controlled radical-polymerization, modification of polymer via CRP and in-situ polymer nanocomposite via CRP. Dr. Haloi has also earned expertise in teaching colleges in Assam. He also published numerous articles in reputed journals.

Dr. Swapnali Hazarika is a Pr. Scientist and Group Leader of Chemical Engineering Group, Engineering Science & Technology Division. Dr. Hazarika obtained her M.Sc. degree in Chemistry specialization in Physical Chemistry from Dibrugarh University, Assam in the year 1996 and Ph.D. in same at CSIR NEIST at 2002. Her research interests include design and development of membranes, separation and purification, biomolecule separations, Gas separations, polymer and biochemical engineering and modelling and simulation, she has completed 9 nos. of R&D projects as Principal Investigator from DST/MOEF and 4 nos. of projects from CSIR as Nodal Scientist. She published several research papers and also authored 2 books and 3 chapters as her credit. She has been awarded with recognitions such as National VICAL Award in Chemical Engineering from IIChE, 2015 and as the Fullbright Fellow under 'Woman in Science' program in 2013-2014.

Technical Session

Invited Lectures

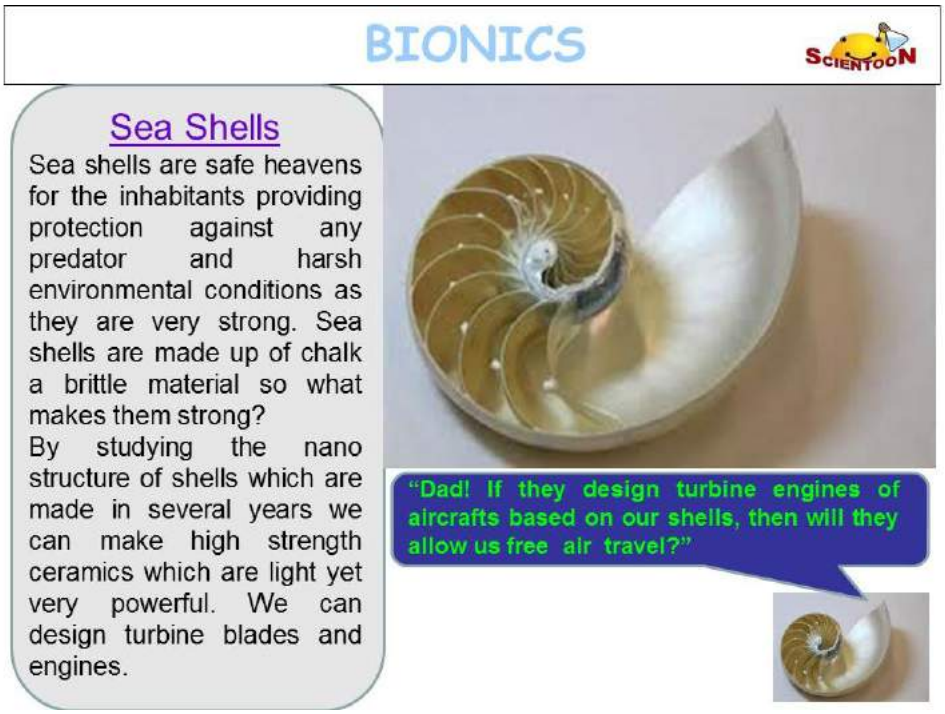
IL-01: Bionics and Bionic Engineering: Learning Science from Nature

Pradeep K. Srivastava

Senior Principal Scientist (Ex), Medicinal and Process Chemistry Division, CSIR-CENTRAL DRUG RESEARCH INSTITUTE Sector 10, Jankipuram Extension Lucknow-226031, India
** Corresponding author, e-mail: pkscdri@gmail.com*

Abstract: **BIONICS** some times called **BIOMIMETICS** or **BIOMIMICRY**, basically biologically inspired engineering is defined as a ***"New science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems".*** Prof. Janine Benyus suggests looking to Nature as a "Model, Measure, and Mentor" and sustainability as an objective of bionics. Bionics looks to nature and natural systems for inspiration. After millions of years of tinkering, Mother Nature has worked out some effective processes. In nature, there is no such thing as waste — anything left over from one animal or plant is food for another species. Human engineers and designers often look there for solutions to modern problems.

Few examples of Bionics are very interesting. The fastest train in the world at speed of up to 200 miles per hour initially, Japan's Shinkansen Bullet Train as a marvel of modern technology faced a terrible problem in the beginning that was terrible unbearable noise. Each time the train emerged from the tunnel, it caused a change in air pressure that caused thunder-like sounds that were a nuisance from a quarter of a mile away. The train's chief engineer, a bird-watcher, had an idea: taking inspiration from the shape of a **bird's beak** to make it more aerodynamic. The resulting design was based on the narrow profile of a kingfisher's beak, resulting in a quieter train that also consumes 15% less electricity and goes 10% faster than before.



Similarly, while most animals flee from fires, fire chaser beetle (*Melanophila)* head *towards* a blaze. They can only lay their eggs in freshly burnt trees. Fire is such an essential part of the beetles' life cycle that they'll travel over 60 to 130 kilometres to find it. They're not fussy about the source, either. Forest fires will obviously do, but so will industrial plants, kilns, burning oil barrels, vats of hot sugar syrup, and even cigarette-puffing sports fans. So new fire sensing device is being developed learning from this small insect. Sea shells are safe

havens for the inhabitants providing protection against any predator and harsh environmental conditions as they are very strong. Sea shells are made up of chalk a brittle material so what makes them strong? By studying the nano structure of shells which are made in several years we can make high strength ceramics which are light yet very powerful. We can design turbine blades and engines. Tropical Morpho butterfly (*Morpho sulkowskyi) found in Colombia, Peru and Ecuador and* is famous for its stunning colours but these colours are changed in response to any change in the vapours. This is caused by the nanostructure of the wings scale which is capable of reacting and detecting to the gases in the atmosphere. This will help us to build more sensitive and selective safety sensors which can be used in metros, subways, stadium, sports arena, public concerts and gatherings for catching terrorists.

What is most important today is that people are not aware of the promises **Bionics** holds for the future especially for a country like India and other developing countries. Author who has started a novel concept of science communication called **scientoon** (a new class of cartoons based on science to understand, learn and enjoy science: www.scientoon.com) and subsequently a new science called **Scientoonics**, will deliver a unique lecture using every slide as scientoon to create awareness about Bionics as what enormous future this science hold specially in the area of medical, pharmaceutical sciences, water conservation to climate change and thus helping in sustainable development.

IL-02: Sustainable Science at the Nanoscale for Potential Technology

Arun Chattopadhyay

Department of Chemistry and Centre for Nanotechnology, Indian Institute of Technology Guwahati, Guwahati - 781 039, India
** Corresponding author, e-mail: arun@iitg.ernet.in*

Abstract: A sustainable earth can only be supported by the efforts of a large number of scientists pursuing sustainable science and technology. Thus technology can be developed keeping in mind the local conditions in terms of resources. These will help manage the earth abundant resources and make the technology available to a larger populace at an affordable cost. The current demands require intense focus in research on healthcare, energy and the environment so that the available resources can support the increasing population and its requirements.

Our laboratory focuses on developing science with a potential for technological application. The hard part is to be able to translate the research in the laboratory into practical applications. This requires focus on the goal in long term. We thus are currently working on potential real life applications of the materials and develop appropriate technology. For example, a "thumb imprint" based device for diagnosis of hyperbilirubinemia (jaundice) could be made accessible to a larger populace [1,2]. This is based on the interaction of bilirubin molecule with luminescent nanomaterials. The simple process of fabrication and portable nature of the device make it convenient to probe excess bilirubin deposited on skin of the afflicted patients. Further, a device for use in gene and protein analyses on a single platform, with the Au nanoclusters as the signal generating agent, has been developed in the laboratory [3,4].

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IL-03: Ligand Anchored 3-D $\{SiO_2\}n$ Networking for Sample Clean up of Some Heavy and Toxic Elements Through Their Selective Separation and Preconcentration

Bhabatosh Mandal

Department of Chemistry, Visva-Bharati University Santiniketan, 731235, India

Abstract: The most widely accepted techniques for the enrichment and separation include solvent extraction, [1-2] powerful supercritical fluid extraction, [3-4] and solid phase extraction. [5-7] Among these, solid phase extraction, because of its operational simplicity, time-cost effectiveness, high level of enrichment and breakthrough capacity, reusability of the extractant, and procedural eco-friendliness becomes the most acceptable. [8-13]

Advancement in the field of networking ceramics, particularly in the field of mesoporous silica, [14,15] has offered a authoritative and resourceful foundation to develop high surface area heterogeneous catalysts, [16] sensors, [17] molecular recognition materials [18] and solid phase extractors' (SPE). [19-21] The exceedingly high surface area to mass ratios ($\leq 1000\pm200$ m^2 g^{-1}) afford a massive amount of surface area to accommodate a huge amount of ligating sites (1000 ± 200 μmol g^{-1}) within a very small volume is the exciting focus of the SPEs'. [8-13] The terminal –OH functionality and an effective silane coupling reagent decorates the mesoporous silica surface with suitable ligands, whose hard-soft binding chemistry can be fine-tuned to selectively sequester a specific environmentally problematic species, or a specific class of compounds. [20,21] During sorption desorption equilibration these covalently attached ligands practically remain unmoved and are only a lit bit affected even at an exceedingly high concentration acid washing (8M HNO_3) and the material could be recycled / reused over 1000±250 cycles without any loss of exchange capacity. [22]

Since 1969 aminopropyltrimethoxysilane (APS) [23,24] and its derivatives [5-7] are found to be utilized as first generation silane coupling reagent for the surface modification of mesoporous silica surface with aliphatic amine (γ-trimethoxyaminopropylsilane). Its subsequent digestion with p-nitrobenzoylchloride introduces an aromatic nitro group. The nitro group was selectively reduced and diazotized, and at the final step a selective ligand of unique metal trapping ability was introduced through conventional diazo coupling reaction. But, the methodology was too much time consuming (90-120 h), complicated (refluxing and repetitive filtration) and requires costly /and hazardous chemicals (CCl_4, $CSCl_2$, APS etc.). As an advancement, dimethyldichlorosilane (DMDCS) has recently been adopted as an effective second generation silane coupling reagent to introduce the selective ligands on networking silica gel surface through a straightforward methodology (no need of refluxing and repetitive filtration) [8-13] and the preparative time was found to be drastically reduced (need only 1 h) with single step synthesis. [22]

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IL-06: Sequence Controlled Alternating Copolymers Via RAFT Polymerization

Priyadarsi De *

Polymer Research Centre and Centre for Advanced Functional Materials, Department of Chemical Sciences, Indian Institute of Science Education and Research Kolkata, Mohanpur - 741246, Nadia, West Bengal, India.
** Corresponding author, e-mail: p_de@iiserkol.ac.in*

Abstract: Sequence controlled polymers are synthetic macromolecules, where monomer units of different chemical nature are arranged along the polymer chain in an ordered fashion. Monomer sequence is strictly maintained in many biomacromolecules such as DNA, RNA and proteins, thus monomer sequence regulation plays a key role in biology, complex self-assembly, data storage, molecular recognition, etc.[1-3] Recently, efforts have been initiated in developing complex synthetic polymers containing controlled monomer sequence throughout the polymer chain. In this regard, few novel strategies have been proposed in the literature for controlling sequences of monomers in chain-growth and step-growth polymerizations. In chain-growth polymerization, sequence regulation can be attained by using specific comonomer pairs consisting of an electron-donor monomer and an acceptor one. We have synthesized copolymers composed of tert-butyl carbamate (Boc)-protected D-alanine appended styrenic monomer (donor, 1) and N-substituted maleimide monomer bearing L-alanine in the side chain (acceptor, 0) via reversible addition-fragmentation chain transfer (RAFT) polymerization. The RAFT polymerization ensured targeted molecular weight of the polymers, narrow molecular weight distribution (dispersity (Đ)) and precise chain-end functionality. Characterization of the polymers by 13C NMR spectroscopy confirmed that the monomers are copolymerized in an alternating manner to give a 01 sequence, because in these specific combinations of monomers, cross-propagation is favoured over homopropagation (Figure 1). The present discussion will focus recent developments of sequence controlled polymers for various applications from our research group.[4-7]

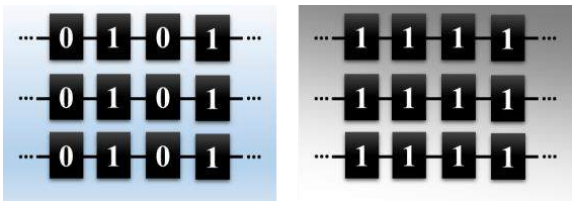

Figure 1. Precise monomer distribution in the polymer chains. Comonomer pairs (**0** and **1**) arranged in an alternating fashion (left) in the alternating copolymer. Distribution of monomers in homopolymer of styrenic monomer (**1**).

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IL-07: Optically Active Polymers for Sustainable Applications in Membrane Sciences

Swapnali Hazarika*

Chemical Engineering Group, Engineering Science & Technology Division, CSIR-North East Institute of Science and Technology, Jorhat – 785006, Assam, India
** Corresponding author, e-mail: shrrljt@yahoo.com*

Abstract: Most of the macromolecules in nature are found to be chiral and optically active. If we look at the chirality of nearly 800 drugs derived from natural sources, only 2% are racemates and only 1% are achiral. The remaining 97% of the drugs are optically active. Thus, we are living in a chiral world. The optically active polymers have been receiving much attention for their stereo chemistries and extensive studies have been done on their development from industrial point of view. Synthesis, conformations and functions of optically active polymers are needed to be studied from commercial point of view.

The simplest method of synthesizing optically active polymer involves the polymerization of optically active monomers. However, this is often less attractive from the viewpoint of the polymerization reaction. Asymmetric polymerization is much more attractive and challenging. It has made remarkable advances, particularly on helical polymers. Chiroptical techniques such as optical activity, circular dichroism (CD), and vibrational circular dichroism measurements are the main characterization techniques of optically active polymers. In recent years, asymmetric reactions and catalysis with chiral reagents have become remarkably advanced and some of these reagents have been introduced onto polymer supports to be used as immobilized reagents. Polymer-specific chiral agents or catalysts with high selectivities like enzymes have to be developed.

The synthetic chiral polymers have many applications e.g. separation of chiral compounds and polymeric catalysis in asymmetric reactions. Different methodologies to separate enantiomers in preparative scale are available. However, the use of membranes prepared from chiral polymers have been pointed out as a promising methodology for scale-up enantiomeric separation due to the low energy consumption, continuous operability, variety of materials and supports, simplicity, eco-friendly and easy to integrate into other separation processes.

Enantioselective or non-enantioselective membranes can be used to achieve chiral resolution [1]. The ideal enantioselective membrane can provide high transport rate with high selectivity and high stability in high range of pH as well as good reproducibility and robustness. Enantioselective membranes are able to achieve selectivity through the binding of the enantiomers to chiral recognition sites with different affinities including hydrogen bonding, hydrophobic interactions, van der Waals interactions, as well as steric effects [2,3]. The chiral sites of the membrane, responsible for preferentially allowing a specific enantiomer to be adsorbed or diffused into the membrane, can be either bulk structures of membrane materials or chiral selectors added to the membranes [4,5].

Keywords: *Optically active polymer, membrane, chiral separation*

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IL-08: Janus folded chains

S. Ramakrishnan

Department of Inorganic and Physical Chemistry
Indian Institute of Science, Bangalore 560012

Abstract: Periodically grafted amphiphilic copolymers (PGACs) were earlier shown to fold in a zigzag fashion to enable segregation of the two immiscible segments, namely the backbone and the pendant segments; crystallization of one or both segments led to the formation of a lamellar structure with the two segments located in alternate layers. In the present study two different pendant segments, namely PEG and fluorocarbon, were installed at periodic intervals in an alternating fashion along a polyethylene-like polyester backbone; *the mutual immiscibility between the three different segments, namely backbone alkylene (HC), PEG and fluorocarbon (FC), causes the polymer to fold as earlier, but now the zigzag folded chain would carry fluoroalkyl segments on one side and PEG on the other, thereby generating de-symmetrized Janus-type folded chains.* Using DSC, SAXS, WAXS, AFM and FT-IR measurements, we demonstrate the self-segregation and independent crystallization of all three segments, and the formation of a lamellar morphology bearing three different layers. Such layering of three different types of segments in a graft copolymer is unprecedented and could pave the way for interesting applications that require separation of two different functional entities at sub-10 nanometre length scales. I shall discuss some of the implications of our novel design and possible applications.

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IL-09: Sustainability of Polymers: Future Directions

S. Sivaram*

Indian Institute of Science Education and Research, Dr Homi Bhabha Road, Pune 411008, India
** Corresponding author, e-mail: s.sivaram@iiserpune.ac.in*

Abstract: The rapidly deteriorating environmental impact of plastics-after-use by society, created by the linear -economy model of "make-use and throw", has raised serious questions regarding sustainability of plastics. Sustainability issues in polymer materials is largely centered around the issue of persistence of waste polymers in the ecosphere on account of its durability and non-bio-degradability. This topic has attracted global attention, press coverage, public conversation and call for action by several Governments worldwide. Many strategies have been explored for shifting the building blocks of polymers to more sustainable bio-derived feed-stocks. While there has been some success, this area is largely beset with problems of high cost of feed-stocks and products, low economies of scale and inability to build the desired diversity in structure and properties in biodegradable polymers that synthetic polymers are capable of. Emerging science in this area is lacking in clarity and purpose and technology is unable to meet the material property envelopes that synthetic polymers have proven to be capable of. Polymer science community appears to be on the defensive, when questioned about this problem. We are not sure whether this is a problem of science and technology or a challenge in social engineering.

Chemistry has played a pre-eminent role in creating synthetic materials on which our civilization is so critically dependent upon. Chemistry, therefore, has to contribute to the mitigation of the problems associated with some of the plastic materials that we consume. It is in this context that we must view the emergence of the discipline of "sustainable polymer science and technology". Sustainable polymers are defined as "materials derived from renewable or non-renewable feedstocks that are safe in, both, production and consumption and which after use can be recycled or disposed of in ways that are environmentally benign" [1]. However, responsible action demands that the scientific community do not oversimplify the problem or offer poorly thought out quick-fix solutions that is not likely to stand the test of time.

In this lecture, I will elaborate on the origins of the problem and question some of the common perceptions about sustainability issues as applied to polymers. I will attempt to frame the scientific questions afresh within the emerging framework of "Circular Chemistry and Economy" [2]. I will also define some of the important problems that the polymer science community, in academia and industry, must address and redeem this science from the negative perception that it has acquired in our society [3].

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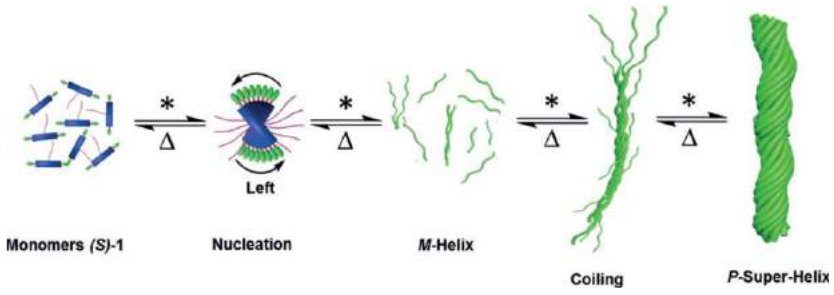
IL-10: Supercoiled Supramolecular Polymers of Linear π-Conjugated Molecules

Ayyappanpillai Ajayaghosh

CSIR-National Institute of Interdisciplinary Science and Technology (CSIR-NIIST), Trivandrum – 695 019, India
** Corresponding author, e-mail: ajayaghosh@niist.res.in*

Abstract: Supramolecular polymers are a class of nonconventional macromolecular architectures formed by the "bottom-up" self-assembly of organic molecules. While a large number of different molecular systems have been used as the building blocks, extended π-systems such as *p*-phenylenevinylenes, *p*-phenyleneethynylenes, and thienylenevinylenes are of interest due to the formation of supramolecular architectures of different size, shape and properties.[1] For example, nano to micro sized fibers, rods, tubes, toroids, vesicles, helices etc. could be designed using small molecular building blocks. The π-interaction in these systems can be strengthened by incorporating H-bonding functional groups, leading to their spontaneous self-assembly to supramolecular polymers. However, control on the size and shape of these macromolecular architectures is a challenge.[2] In recent times several approaches have been reported for the controlled synthesis of supramolecular polymers. One of the approaches involves the use of directional H-bonding motifs to achieve shape control. For example, spontaneous assembly of linear 1D assemblies can be directed to circular assemblies using radially H-bonding functional groups.[3] Another strategy is the use of logistically designed donor-acceptor type molecular building blocks.[4] We have also used C_3-symmetrical H-bonding core groups attached to donor acceptor systems for the creation of supercoiled supramolecular polymers.[5] In a recent report we have demonstrated the self-assembly of chiral phenyleneethynylenes to superhelices (see Figure).[6] Details of these studies will be presented.



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IL-11: Microcellular Foam Processing of Polymers- A Sustainable Approach

Anup K. Ghosh *, Sabapathy S

Department of Materials Science & Engineering (Formerly, Centre for Polymer Science & Engineering), Indian Institute of Technology, Delhi, India
** Corresponding author, e-mail: anupkghosh@gmail.com*

Abstract: Microcellular foam processing of polymers is one of the sustainable approach to reduce the density and weight of the products while retaining their mechanical properties. Different foam processing techniques has been emerged in the last 50 years using chemical and physical blowing agents. Generally, physical blowing agents are compressed gasses used at supercritical fluid state which dissolves in polymer matrix, plasticizes the polymer chains and foams the polymer melt to produce polymer foams. Due to high compression ratio, the efficiency of physical blowing agents is higher than the chemical blowing agents. Selection of high pressure CO_2 as a physical blowing agent increases the solubility in polymer matrix and produces foam structure with zero chemical entrapments. Therefore, supercritical assisted foaming processing of polymers is sustainable and green approach to develop zero-toxic foam structure for packaging and health care applications.

The current study uses CO_2 as a green physical blowing agent to study the foam processability of Plasticized PLA Nanocomposites (P-PLANCs) using batch foaming set-up. Polyethylene glycol (PEG) and nanoclay are used for plasticization and heterogeneous nucleation respectively. The objective of the current study is to study the combined effect of plasticization and heterogeneous nucleation on the foamability of PLA and also to establish their structural-relationship. P-PLANCs were prepared by melt-mixing PLA with an optimum content of PEG (10 wt.%) and with varying content of nanoclay (0.5 wt.%, 1wt.% and 2 wt.%). The prepared compounds were saturated with CO_2 under high pressure conditions (50 bar) and the CO_2 saturated P-PLANCs were subsequently foamed at their melt and solid states. Crystalline and foam morphologies of P-PLANCs were characterized by using scanning electron microscopy (SEM) and wide angle X-ray diffraction (WAXD) analysis respectively. Difference in nucleating efficiency of nanoclay in sonication bath and glycerine bath was examined. In addition to the nucleating effect, reinforcing effect of nanoclay on increasing toughness of microcellular P-PLANCs was studied.

Keywords: *PLA, Nanoclay, CO_2, foam processing and CO_2 induced crystallization.*

IL-12: Sustainable Development for Controlled Drug Delivery and Implants

Pralay Maiti *[1], Arpan Biswas [1], Sudipta Senapati [1], Aparna Shukla[1], Arun K. Mahanta[1], Sunil Kumar[1]

[1] School of Materials Science and Technology, Indian Institute of Technology (BHU), Varanasi 221 005
** Corresponding author, e-mail: pmaiti.mst@itbhu.ac.in*

Abstract: Biodegradable nanocomposites offer the possibility of combining biodegradability with the physical and mechanical properties of polymer typically associated with engineering plastics. The challenge remains to design biodegradable alternatives to conventional plastics that combine the mechanical strength and physical properties of the latter, yet they are susceptible to microbial and/or environmental degradation without adverse effect on the environment. In this discussion, we will focus our efforts on developing nanocomposites of biodegradable polyester with organically modified layered silicates. Further, the controlled biodegradation in presence of nanoparticles will be discussed. The application of nano-biohybrids for its biological use involving animal and clinical studies will be discussed in details with the emphasis of drug delivery and implant materials. New design of vehicle will be discussed in details which heal the melanoma and breast tumors by enhancing the bioavailability of drug and specific interaction without having any side effects as opposed to conventional chemotherapeutic treatment.

IL-13: High Specific Strength Polymer Composites: Development, Characterization and Model Formulation

Rupam Gogoi[1], Byravan Arun[2], Gaurav Manik[1*]

[1]Department of Polymer and Process Engineering, Indian Institute of Technology Roorkee, India.
[2]Technical Department, Innovation Center, 3M India Limited, Bangalore, India.
** Corresponding author, e-mail: manikfpt@iitr.ac.in, gauravmanik3m@gmail.com*

Abstract: The talk shall focus on understanding the synergistic effect of surface treated hollow glass microspheres (HGM) addition on various physical, mechanical and rheological properties of short carbon fibre (SCF) reinforced polypropylene (PP) hybrid composites. Hybrid composite samples were prepared by melt mixing PP, maleic anhydride-grafted-PP (MA-g-PP), SCF and surface-treated HGM. Effect of varying concentration of HGM (0-40 wt.%) and SCF (0, 5, 8 wt.%) on various composite properties was analyzed. While HGM showed an impressive positive impact in reducing the overall density of composites with its increasing concentration, SCF provided the much needed improvement in tensile and flexural strengths (up by ~110 and ~112% over pure PP). Most interestingly, the *specific* tensile strength with only 8 wt.% SCF was observed to be significantly high (~100 MPa/g/cm^3) and similar to commercial PP composites that used much higher (40 wt.%) fibre contents. Empirical estimates of tensile modulus evaluated using several available micromechanical models, indicated that a combination of Ishai and Cohen (upper bound) and Halpin-Tsai models which assume a perfect particle- and fibre-matrix interfacial adhesion, were found to be in excellent agreement with results of this investigation. Morphological analysis of cryo-fractured surfaces revealed good dispersion and distribution of both HGM and SCF with very negligible broken HGM fillers. Additionally, the hybrid composite formulations showed much improved thermal stability captured through degradation temperature, improved thermal conductivity and flowability. The benefits of improved processability, physical, thermal and *specific* mechanical properties make the proposed HGM-SCF based hybrid PP composites ideal candidates for light weight-high strength industrial applications.

IL-14: Sustainable Hyperbranched Polyurethane Elastomeric Nanocomposites with Multifaceted Attributes

Niranjan Karak*

Advanced Polymer and Nanomaterial Laboratory, Chemical Sciences Department, Tezpur University, Napaam-784028, India.
** Corresponding author, e-mail: karakniranjan@gmail.com*

Abstract: Sustainable materials are the order of the day in this civilized society. However, sustainable elastomeric product is difficult to obtain. In our research, therefore, numbers of attempt have been made to produce industrially important sustainable polyurethanes and their nanocomposites with different types of nanomaterials with multifaceted attributes. They are obtained from renewable raw materials like castor oil, soybean oil, sunflower oil, starch, tannic acid, citric acid, glycerol, dimer acid, etc. along with the conventional reactants. The elastomeric polyurethanes with varieties of structures and compositions have been synthesized from this laboratory. The nanocomposites of these polyurethanes with different nanomaterials such as metal and metals oxides, clay and silica, multi-walled carbon nanotubes (MWCNT), graphene oxide (GO), reduced graphene oxide (RGO), carbon dots, carbon nitride dots, etc. have been fabricated by the standard techniques. The results showed that such polyurethanes are not only biodegradable but biocompatible too. Further, properties like mechanical, thermal, chemical, etc. along with optical, electrical and biological properties upon incorporation of low amount of nanomaterial in the pristine polyurethane matrices are enhanced significantly. Most interestingly, these elastomeric nanocomposites exhibited shape memory, self-cleaning, self-healing, etc. properties, which are very interesting. Specially designed polyurethane nanocomposites have hydrophobic surface with static water contact angle up to 140°, and hence exhibiting anti-icing ability. Some of them also showed great potential as biomaterials in tissue engineering, smart suturing, antibacterial self-expandable stent, etc. A few of such nanocomposites showed capability of removing different heavy metal ions, different organic contaminants, e-pollutants, etc. An overview of this research (Figure 1) will be discussed in this great international symposium.

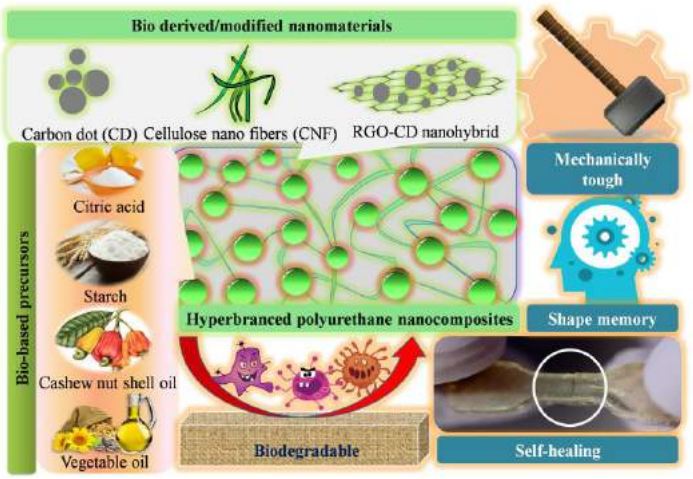

Figure 1.

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IL-15: A New Class of Elastomers Based on Renewable Bio-Resources

Nikhil K. Singha

Rubber Technology Centre, IIT Kharagpur, Kharagpur, India-721302
School of Nano Science & Technology, IIT Kharagpur, Kharagpur, India-721302

Abstract: In recent times, there has been a paradigm shift in research of synthetic polymer scientists from petro-polymers to the polymers from sustainable renewable resources. In this regard, terpenes have attracted a great deal of attention from polymer scientists. Terpenes are known to be the largest group of natural products and are constituents of essential oils of many types of plants and flowers. They have the carbon-carbon double bond backbone like in isoprene, the building unit of natural rubber and many other synthetic diene elastomers. Because of this very reason, the attempts are being made to synthesize elastomeric materials based on terpene and its derivatives. Amongst the vast family of terpenes, *β*-Myrcene (*MY*) is an important renewable monomer, a component of essential oils obtained from hops, ylang-ylang, bay, lemongrass, cannabis, wild thyme, etc. In 1960, Marvel and Hwa first reported the polymerization of *MY* via Ziegler-Natta polymerization. But other methods of polymerization and detailed study of the *MY* monomer were not carried out until very recently. In 2014, Bhowmick *et al.* synthesized an elastomer from *MY* via emulsion polymerization. The T_g of this elastomer was found to be –70 °C, which is similar to that of natural rubber. A sustainable elastomer having low-rolling resistance and improved wet grip was also synthesized by copolymerization of styrene and *MY* by the same group. Kobayashi *et al.* combined ring-opening metathesis with cationic polymerization to synthesize poly(3-methylenecyclopentene) taking *MY* as the starting material. A fully biobased ABA type and highly branched comb-like poly(*MY*)-graft-poly(L-lactide) TPEs based on L-lactide and *MY* was prepared by Zhou *et al.* in 2018 using anionic polymerization. In our investigation, we have prepared ABA triblock copolymers based on *MY* and Styrene via RAFT polymerization process. This process neither requires highly stringent conditions nor very low temperatures like the conventional ionic polymerization processes. We have been able to achieve a very high molecular weight for the polymyrcene employing emulsion polymerization technique. The triblock copolymer showed very good mechanical properties along with distinct phase separation, as shown by AFM analysis. This talk will delineate the literature review as well as the present work in our lab on the polymerization of *MY* via different techniques.

IL-16: Stimuli-Responsive Poly(2-oxazoline) Copolymers and Their Self-Assembly

Somdeb Jana, M. Anas *[1], Tarun K. Mandal *[1]

[1] School of Chemical Sciences, Indian Association for the Cultivation of Science, Jadavpur, Kolkata
** Corresponding author, e-mail: psutkm@iacs.res.in*

Abstract:Poly(2-alkyl-2-oxazoline)s (POxs) are bioinspired polymers and termed pseudopeptides due to their close the structural similarity with polypeptides. Being hydrophilic, POxs with side alkyl chain up to propyl are soluble in water and exhibits lower critical solution temperature (LCST)-type thermoresponsiveness and the cloud points are dependent on the side chain substituent, DP, and the block/graft copolymer formation by the addition of a comonomer. POxs are nonionic and biodegradable and possesses all characteristics features required for different potential applications such as in drug delivery, tissue engineering etc. Therefore, recently, research efforts are being dedicated to develop POxs-based stimuli responsive polymers/copolymers which undergo a change of solution properties as well as the morphology of self-assembled aggregates upon action of external stimuli. For last couple of years, we are involved in designing and development of poly(2-oxazoline)-based various multi-stimuli responsive copolymers for dye encapsulation/release applications. For example, poly(2-oxazoline)-based photo-responsive block copolymer (BCP) is synthesized by the combination of CROP and ATRP, which self-assemble into primary micelles in THF/H_2O as well as further secondary aggregation into compound micelles. Upon UV irradiation, BCP micelles/compound micelles rupture and consequent the encapsulated hydrophobic guest molecules release into aqueous solution. These BCP also self-assembles into reverse micelles in non-aqueous environment. The synthesis of polypeptide-poly(2-oxazoline) graft copolymers, polytyrosine-*graft*-poly(2-ethyl-2-oxazoline) (PTyr-*g*-PEtOx) and polycysteine-*graft*-poly(2-isopropyl-2- oxazoline) (PCys-*g*-P*i*pOx) graft copolymers using ROPs and CuAAC "click" techniques are described. These copolymers exhibit LCST-type phase behaviors in water. PTyr-*g*-PEtOx undergoes self-assembly into unit micelles/compound micelles both in aqueous and non-aqueous media; whereas (PCys-*g*-P*i*pOx) self-assembles into unit vesicles/composite vesicles. A random copolymer poly(oligo(2-ethyl-2-oxazoline)acrylate)-*ran*-PNBA (P(OEtOxA) -*ran*-PNBA) with dual thermo- and photo-responsiveness is achieved via CROP and RAFT techniques. The P(OEtOxA)-*ran*-PNBA exhibits LCST-type phase behavior and the effect of UV irradiation on the T_{cp} of the P(OEtOxA)-*ran*-PNBA is investigated. Finally, the thermo- and photo-triggered release of encapsulated NR from copolymer micelles is also demonstrated. Furthermore, the synthesis of photoresponsive positively charged 2-nitrobenzyl functionalized polymethionine (P[MetNB][Br]) and its block copolymer of pseudopeptidic poly(2-ethyl-2-oxazoline) (PEtOx-*b*-P[MetNB][Br]) by employing ROP, followed by post-functionalization through nucleophilic substitution reaction is also reported. The binding of DNA with these cationic polypeptide/block copolypeptide and its photo-triggered release is also studied by gel electrophoresis and fluorescence spectroscopy.

IL-17: Polymers from Vegetable Oil through Carbon Dioxide Insertion and Catalytic Property of Carbon based Nano Materials

S. K. Dolui

Tezpur University, Napaam, Assam, Pin: 784028
** Corresponding author, e-mail: dolui@tezu.ernet.in*

Abstract: The utilization of renewable resources in polymer synthesis has received worldwide attention in the age of depletion of fossil resource, global warming, and other environmental concerns for sustainable development in the future. Among the various types of renewable raw materials, vegetable oils have gained attracted much more consideration owing to their easy availability, environmental, inherent biodegradability, low price and low toxicity. The utilization of renewable resources can substitute petro-based products and avoiding emissions of major green house gas CO_2 which is mainly responsible for global warming. For that reason, academic and industrial researchers are trying to use renewable resources for the production of both chemicals and polymeric materials as raw materials. Among the different types of vegetable oils sunflower oil and jatropha oil have been used to synthesis various polymeric resins such as epoxy, polyurethane, polyester and alkyd resin etc. Among the various vegetable oils based polymer, polyurethane and alkyd resins are special group of polymeric materials that are in used in many different applications. The sunflower oil based non isocyanate polyurethane and jatropha oil based alkyd resin exhibited excellent mechanical properties which are suitable for coating applications.

Carbon based nanomaterials are one of the most widely researched topics due to their outstanding properties. In the recent years, a lot of attention has been focused on finding different ways to integrate them in devices or systems so as to improve their performance. In this respect, graphene based aerogels are an excellent candidate for application in systems that involve electrode/electrolyte interfaces, such as supercapacitors and dye sensitized solar cells (DSSCs). The most important features of an aerogel are their large surface area, high porosity and extremely light-weight. We have shown the application of functionalized reduced graphene oxide aerogel (rGOA) as electrode materials in an asymmetric supercapacitor to obtain a maximum cell voltage of 1.8 V. A low temperature organic sol-gel method was employed to prepare two different types of aerogels: rGOA functionalized with silver nanorods acted as the negative electrode while rGOA functionalized with polyaniline nanotubes acted as the positive electrode. The assembled asymmetric supercapacitor provided a high energy density of 52.85 W h kg^{-1} and power density of 31.5 kW kg^{-1}. Meanwhile, rGOA functionalized with polyaniline nanotubes also served as an excellent electro-catalyst towards the reduction of triiodide ions present in the electrolyte of a DSSC. Thus, it was applied as a counter electrode in DSSC, which gave a power conversion efficiency of 5.47% when used in a polymer gel electrolyte system.

IL-18: An Insight into Sustainable Cellulose Derivatives based Clay Nanocomposites as Biodegradable Material for Multifaceted Applications: From Packaging to Biomedical

Dipankar Chattopadhyay*

Department of Polymer Science and Technology, University of Calcutta

Abstract: The engineering of materials to attain sustainability is an inevitable need for polymer scientists. Due to the escalating concern on environment, a huge challenge exists to develop biodegradable and sustainable materials for packaging and biomedical applications. Packaging materials are generally disposed randomly into the environment. Thus, inevitable risk persists for the flora and fauna due to the release of toxic by-products and heaping up of pollutants. Moreover, mammoth efforts are undertaken to restrain the dependence on petroleum based products. Therefore, biodegradable polymers have captivated huge attention in the packaging and medical industries to trounce the biomedical, ecological and environmental challenges. However, bio-polymers have inadequate strength, barrier, and thermal properties to compete with the commercialized synthetic polymers. Thus, the advent of nanotechnology opens up a wider window to meet the different service requirements by inclusion of nanomaterials. Thus, the main quest of our research work in this realm was to explore the unique potential of nanoclay and biodegradable cellulose derivatives. Further, the applications of these uniquely developed nanocomposites were explored in the zone of packaging industry and biomedical niche.

In brief, a nanocomposite films based on cellulose acetate/PEG/modified montmorillonite was developed as nontoxic active packaging material. Organoclay was incorporated in PEG plastisized cellulose acetate by a solution intercalation process, with enhanced mechanical and thermo-mechanical properties compared to pure polymer. Further, another active packaging material with anti-microbial activity based on cellulose acetate butyrate/PEG/aryl ammonium cation modified clay was prepared. The non-toxic nature and anti-bacterial activity of the nanocomposites were further evaluated to project it as active packaging material. Furthermore, for biomedical purpose, a methylcellulose/pectin/montmorillonite nanocomposite was prepared that exhibited good mechanical and thermo-mechanical properties and improved the water resistivity and barrier properties and had assisted sustain drug release for transdermal delivery. Overall, the potentiality of biodegradable and non-toxic nanocomposites was explored with high future prospective in packaging and biological domains.

IL-19: Secondary Manufacturing of Sustainable Polymer-based Fiber-Reinforced Composites

Kishore Debnath*

Department of Mechanical Engineering, National Institute of Technology Meghalaya, Shillong, Meghalaya-793003, India

Abstract: The application of petroleum-based synthetic polymers such as polyethylene, polypropylene, nylon, polyester, polytetrafluoroethylene, etc. has serious problem associated with waste disposal and environmental pollution. Thus the environmental friendly sustainable polymers are emerging to address the environmental challenges associated with synthetic polymers. Sustainable polymers namely polylactic acid (PLA) has already replaced many synthetic polymers in different engineering applications. This polymer is widely used to develop composites reinforced with synthetic and natural fibers. PLA-based composites are mostly fabricated to near-net-shape by means of primary manufacturing processes such as compression molding, injection molding, etc. But the development of a PLA-based composite product with intricate shapes necessitates machining and then joining of individual components in an assembly. However, secondary manufacturing processes such as machining and joining of such composites is quite challenging due to their inhomogeneous nature. The cutting forces developed during machining and the stresses developed at the joint area affect the surface integrity and the overall performance of the product. Both the machining and joining parameters need to be optimized to improve the performance of the product. Thus the different strategies have been followed, analyzed, and discussed to obtain better machined surface and joint strength of the PLA-based composites.

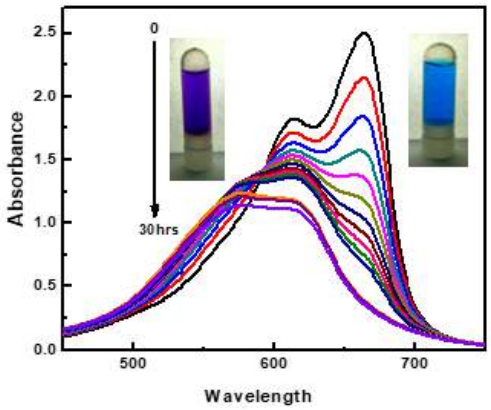
Keywords: *Sustainable polymer; composites; machining; joining.*

IL-20: Biopolymer Based Hydrogels as Template for Entrapment of either the 'Blue' or 'Red' form of Methylene Blue (MB) dye – Possibility of Using MB dye as Amine Sensors

Homendra Naorem*

Chemistry Department, Manipur University, Canchipur, Imphal, India
** Corresponding author, e-mail: naorem.homendra@gmail.com*

Abstract: Methylene Blue (MB) is a well-known thiazine dye with characteristic blue color in aqueous solution. The aggregation behavior of MB dye in aqueous and mixed aqueous organic solvent has been investigated in terms of its dimerization constant (K_D). Presence of organic solvent with more hydrophobic groups favors the self-aggregation of the dye. It was observed that in presence of organic amines, the blue color of the dye changed to red giving rise to 'Red MB' solution.



Change from 'blue' to 'red' MB dye solution in presence of amine with time

The kinetics of the change from blue to red form has been studied. The change of color from blue to red MB solution was found to continue even after the MB dye in amine solution was entrapped in gelatin or chitosan hydrogels. However, no change in the blue color of MB dye was observed when the dye in amine solution was entrapped in glutaraldehyde crossed linked chitosan hydrogel or in formaldehyde crossed linked gelatin hydrogel. Based on the findings, we made a modest attempt to develop stripes of MB entrapped chitosan or gelatin hydrogels as possible use for detecting the presence of simple organic amines by observing the change in the color of the dye. On the other hand, the blue color of MB in amine solution can be retained by entrapment of the dye in crossed linked chitosan or gelatin hydrogels. It was observed that the change in color could be detected faster in case of ethylamine as compared to those of ethanolamine. The time taken for the change in color was found to be affected by the concentration of the MB dye, the amine and also by the nature of the amine. The aggregation behavior of the MB dye in homologues of ethylamine or ethanolamine has been analyzed in terms of their observed K_D values which revealed that more aggregates are formed in presence of more hydrophobic '$-CH_2CH_3$' group as compared to less hydrophobic '$-CH_2CH_2OH$' groups in the amine. Flow behavior of the crossed linked hydrogels with or without MB and their swelling behaviors have also been studied. The results will be highlighted during the presentation.

IL-21: Development of Biochemically Reduced Graphene-oxide Filled pi-conjugated Polymer Nanocomposites as Sensors for Volatile Organic Compounds

S. Konwer*[1], S. Bordoloi[1,2], S. K. Dolui[3]

[1]*Department of Chemistry, Dibrugarh University, Dibrugarh, Assam-786004, India.*
[2]*Department of Chemistry, MDKG College, Dibrugarh, Assam-786004, India.*
[3]*Department of Chemical Sciences, Tezpur University, Tezpur, Assam-784028, India.*
** Corresponding author, e-mail:surajitkonwer@dibru.ac.in*

Abstract: The biochemically reduced graphene-oxide (rGO) encapsulated with pi-conjugated polymer viz., polyaniline (PANI) were prepared by in-situ chemical oxidative polymerisation of aniline where polymerization was carried out in presence of rGO using suitable initiator in an acid medium. The synthesized samples were characterized by scanning electron microscopy (SEM), X-ray diffraction (XRD) and electrical conductivity measurements. The electrical conductivity get increases with temperature showing semiconducting behaviour. The composite materials are exposed with various concentrations of vapours of different volatile organic compounds (VOCs) such as acetone, chloroform and carbon tetrachloride and compared with the pristine polymer. The change in resistance was measured using a two probe Keithley 2400 source meter with labtracer software at room temperature at the scan rate 0.1 V/s. Hexane was used as a diluent to obtain different concentration of the VOCs. The sensing ability of the composite was investigated by recording the electrical responses when exposed alternately to different concentration of VOCs at room temperature and withdrawing the sensor from the analyte molecule to recover the sensor. The oxidising VOCs like acetone on exposure to pristine polymer and PANI/rGO composite is found to be decrease in resistivity by hydrogen bonding with the redox cites of the polymer. It was observed that the composite found to be a highly sensitive ($\Delta R/Ro$ = 32.5-36.5) material for chloroform (100-300 ppm) than that of carbon tetrachloride ($\Delta R/Ro$ = 19-24.5) and acetone ($\Delta R/Ro$ = 18-24). The response time and reversibility of polymer/rGO composite is much efficient that of pure polymer. These observations paved the way of applicability of polymer/rGO nanocomposite as a sensor material for detecting volatile organic compounds.

Keywords: *Polyaniline; reduced graphene-oxide; In-situ polymerisation; conductivity, sensor, capacitor*

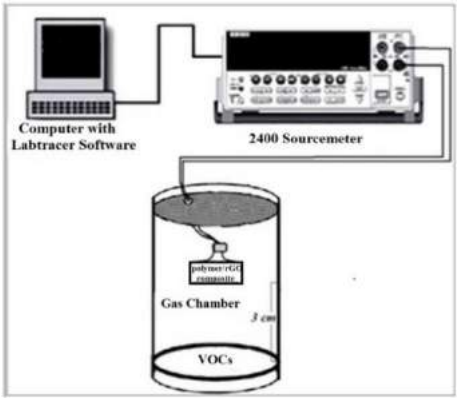


Figure 1: Gas sensor set-up

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IL-22: Fruit and Vegetable Coating from Waste Bio-mass: A Sustainable Approach

Satyajit Bhattacharjee*[1], Tridib Kumar Bhowmick[2*], Mriganka Sekhar Manna[1], Kalyan Gayen[1]

[1] Department of Chemical Engineering, NIT Agartala, West Tripura 799046, India
[2]Department of Bioengineering, NIT Agartala, West Tripura 799046, India

Abstract: The rising population in the world is expected to create increasing pressure on the existing food system. The quality of the food and nutritional value depend on the moisture, temperature and other factors which affect the growth of the microbes causing food spoilage. Therefore, there is a growing need worldwide to reduce food spoilage and improve the storage quality of food in sustainable fashion. Coating of fruits and vegetables with suitable edible material would keep them fresh for a considerable time after their harvest till it reaches to the demanding consumers. The non-edible portion (peel, crown, shell etc.) of pineapple which is otherwise discarded in the process of pine apple juice preparation are identified as an inexpensive source for the production of such edible coating material. The present work is focused on the synthesis and analysis of edible coatings synthesized from waste bio-mass. In this presentation, the scope of the large scale production of coating material and its appropriateness as edible coatings would be discussed.

IL-23: Green Composites: An Insight into Development, Mechanical Properties and Characterization

Divya Zindani[1], Krushna Gouda[2], Rahul Kumar[3], Sumit Bhowmik[*4]

[1,2,4]Department of Mechanical Engineering, National Institute of Technology Silchar, Silchar, Assam- 788010, India.
[3]Department of Mechanical Engineering, Dayananda Sagar University, Bengaluru, Karnataka - 560078, India.
** Corresponding author, e-mail: bhowmiksumit04@yahoo.co.in*

Abstract: Alternative solutions to petroleum-based products are required in the backdrop of greater concern towards depleting petroleum resources and environmental concerns. Scientists around the globe are working to explore new solutions to the traditional plastics. As such green composites have occupied the center stage for the research community. Green composites are developed from green fibers with their source emanating from surrounding plants. Production and introduction of such green composite materials represents an interesting proposition in the area of polymer science. Green composites can aid in maintenance of environmental sustainability through replacement of petroleum based products and hence minimizing the waste dumps. Although, green composites are abundant and cheap, it requires intensive research and development to develop such materials that can meet the expansive application of interest.

The process of development of green composite material incepts with selection of suitable combination of fiber, matrices, manufacturing process and arrangement of fibers as per the application requirements. A number of evaluating criteria as such environmental, biological, mechanical, quality, cost, availability, thermal etc., are required to be considered while selecting a suitable fiber for development of green composites. Selection of suitable polymer matrix type can aid in minimizing the drawbacks associated with natural fibers. Therefore, few critical factors as such thermal, environmental, mechanical, physical, toxicity and cost have been identified for selecting suitable polymer [1]. In the present study, multi-criteria decision making tools have been employed to identify suitable fiber material and therefore composites have been prepared using coir, pineapple, bamboo and wood dust particulates and epoxy resins.

Processing of raw materials is the next step to develop green composites. The extracted natural fibers are washed with distilled water and then dried in oven. The filler particles with size less than 75 μm are obtained through grinding process by means of planetary ball mill. After the filler particles have been washed multiple times, chemical treatment is carried out for adhesion improvement. Surface modification is one of the critical factors in obtaining composites with better mechanical properties [2]. Composites are then synthesized through a proper manufacturing process i.e., injection molding, resin transfer molding, compression molding, hot pressing, hand layup etc. Composite specimen are prepared in accordance with the ASTM standard for which the mechanical properties as such static tensile and flexural, fracture, fatigue and dynamical mechanical properties are required to be investigated. Characterization of treated as well as untreated fillers is achieved through Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and Thermo gravimetric analysis (TGA) that aids in elucidating the impact of chemical treatment. Assessment of filler dispersion and interfacial adhesion has been carried out using Field Emission Scanning Electron Microscopy (FE-SEM). The developed green composite will give a viable and promising alternative to the existing reinforced plastics in terms of operating range, durability and cost effectiveness.

The work has been extended to develop green hybrid composite materials. The extended work aimed to enhance the properties of developed green materials. As such, hybridization of bamboo filler with graphene nano platelet was accomplished and the hybrid composite material were developed using the same specific grade epoxy. Mechanical properties were analyzed and compared with the developed bamboo filler reinforced epoxy composites. The properties were revealed to better in comparison to the existing bamboo composites.

Keywords: *Agro-waste; Green composites; Hybrid composites; Mechanical properties; Material selection; Characterization*

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IL-24: Nano Bio-polymer Composites and Its Applications

Devasish Chowdhury

Material Nanochemistry Laboratory, Physical Science Division, Institute of Advanced Study in Science and Technology, Guwahati-781035, Assam, India
** Corresponding author, e-mail: devasish@iasst.gov.in*

Abstract: In this talk I discuss some novel fabrication of Nano Bio-polymer composites and its applications developed by my laboratory. We report a facile and green method for reduction of graphene oxide using carbon dots (CDs) derived from "Assam CTC (crush tear curl) Tea". The efficient reduction of graphene oxide by tea-CDs was monitored using UV− visible spectroscopy. The reduced graphene oxide (rGO) prepared by this method adsorbs some amount of tea-CDs on its surface and forms a very good dispersion in aqueous medium without the use of any other capping or stabilizing agents. Subsequently, the tea-CDs reduced graphene oxide (TCD-rGO) was used for fabrication of a cotton-based conducting fabric with anticipated applicability in different electronic gadgets where high flexibility of the conducting material is required. Coating of cotton with TCD-rGO improved the thermostability of the fabric. In another work we demonstrate the synthesis of highly fluorescent, natural product-derived carbon dot (CD) by microwave treatment using *aloe vera* as the carbon precursor. The synthesized carbon dot was characterized by DLS study, UV-Vis spectroscopy, Photoluminescence (PL) measurement and Transmission Electron Microscopy (TEM). Also, the *aloe vera* carbon dot (AV CD) showed to possess antimicrobial activity. Further, the prepared carbon dots were immobilized to fabricate nano-bio-conjugate film composed of alginate and *aloe vera* of definite proportion. The synthesized film showed enhanced mechanical strength and thermal stability compared to the film without the nanomaterial. Interestingly, one of the commonly used ingredients in sunscreens, p-aminobenzoic acid (PABA), regarded as a harmful chemical due to its endrocrine disruption and bioaccumulation problem, could potentially quench the fluorescence intensity of the nano-bio-conjugate film, thereby acting as PABA sensor. Therefore, this work illustrates the use of herbal formulation in synthesis of green CDs, fabrication of nano-bio-conjugate film along with its sensing study.

IL-25: Structural and Degradation Behavior of Compostable Composites Comprising Poly(butylene adipate-co-terephthalate) and Natural Fibers

Jyoti Giri Name*[1,2,3], Ralf Lach[4], Wolfgang Grellman[4], Md. Abu-Bin Hasan Susan [5], Jean-Marc Saiter[6], Seven Henning [7], Vimal Katiyar [8], Rameshwar Adhikari[1,2,9]

[1]Central Department of Chemistry, Tribhuvan University, Kathmandu, Nepal
[2]Department of Chemistry, Tri-Chandra Campus, Tribhuvan University, Kathmandu, Nepal
[3]Nepal Polymer Institute (NPI), Kathmandu, Nepal
[4]Polymer Service GmbH Merseburg (PSM), Merseburg, Germany
[5]Department of Chemistry, Dhaka University, Dhaka, Bangladesh
[6]Université de Normandie Rouen Laboratoire SMS Faculté des Sciences and Onyx Developpement, Rouen, France
[7]Fraunhofer Institute for Microstructure of Materials and Systems (IMWS), Halle, Germany
[8]Department of Chemical Engineering, Indian Institute of Technology (IIT), Guwahati, India
[9]Research Centre of Applied Science and Technology (RECAST), Tribhuvan University, Kathmandu, Nepal Name of the
** Corresponding author, e-mail: giriys@yahoo.com*

Abstract: An agricultural waste, the wheat stalk, was used for the extraction of microcrystalline cellulose (MCC) and nanocrystalline cellulose (NCC) via a series of thermochemical and mechanical treatments. The MCC and NCC were then compounded with the biodegradable polymer, poly(butylene adipate-co-terephthalate), PBAT, by melt mixing. The properties of the composites were evaluated by soil composting, contact angle and water absorption measurements, scanning electron microscopy (SEM) and gel permeation chromatography(GPC). The cellulosic filler was found, as per SEM results, to uniformly disperse in the polymer matrix forming a quite homogeneous composite which visibly degraded completely within a few months under soil composting and showed high water absorption, these properties being enhanced with the filler content. Compared to the neat PBAT, the composites showed enhanced surface hydrophilicity thereby increasing the ability of degradation. In spite of seemingly remarkable change in mechanical stability of the polymers.

Keywords: *Microcrystalline cellulose(MCC); Nanocrystalline cellulose(NCC); Soil composting; Gel permission chromatography(GPC)*

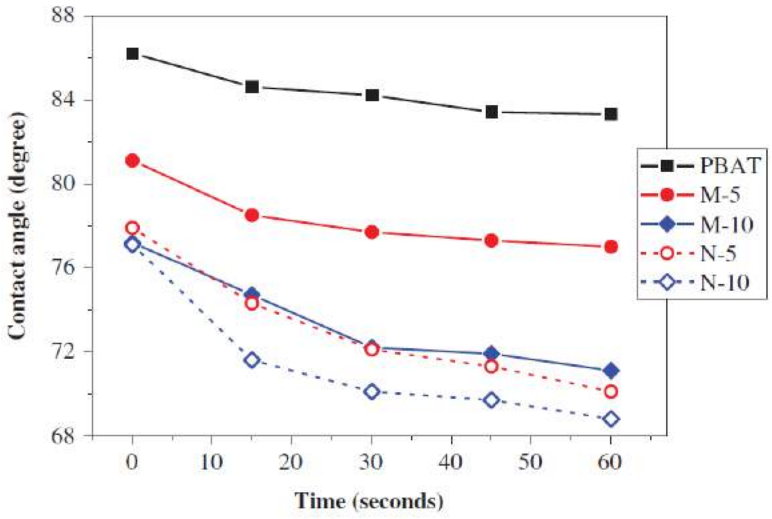

Figure 1. Contact angle variation in composites surface with time and content of MCC and NCC

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IL-26: Poly(meth) acrylate Grafted Starch: Synthesis and Characterization

Dhruba J. Haloi*

Bodoland University, Kokrajhar-783370, Assam, India
** Corresponding author, e-mail: dhruba2k3@gmail.com*

Abstract: Starch is a renewable and biodegradable polymer obtained from a variety of corns. It can be used for the production of biodegradable plastics. Graft copolymerization is a way to prepare such new material from Starch. Grafting of (meth) acrylates from Starch may lead to a thermoplastic elastomeric material with an edge of biodegradability. For this, the starch is modified first and then the modified starch is used as macroinitiator to graft polymer onto it via a suitable reaction. Activators Regenerated by Electron Transfer Atom Transfer Radical Polymerization (ARGET ATRP) is a type of controlled radical polymerization which can be used to graft poly(meth) acrylates onto the Starch. For this, the native starch is fabricated with ATRP initiator via an esterification reaction. The graft polymerization of (meth) acrylate then is carried out from the ATRP initiating sites introduced in the Starch. Conversion of the monomer and hence the progress of the grafting polymerization is monitored gravimetrically. The prepared and purified poly(methyl methacrylate) grafted Starch (Starch-g-PMMA) is analysed via the corresponding characterization techniques to extract the information about its molecular weight, structure and other physio-mechanical properties.

Keywords: *Starch, ARGET-ATRP, (meth) acrylate, grafting*

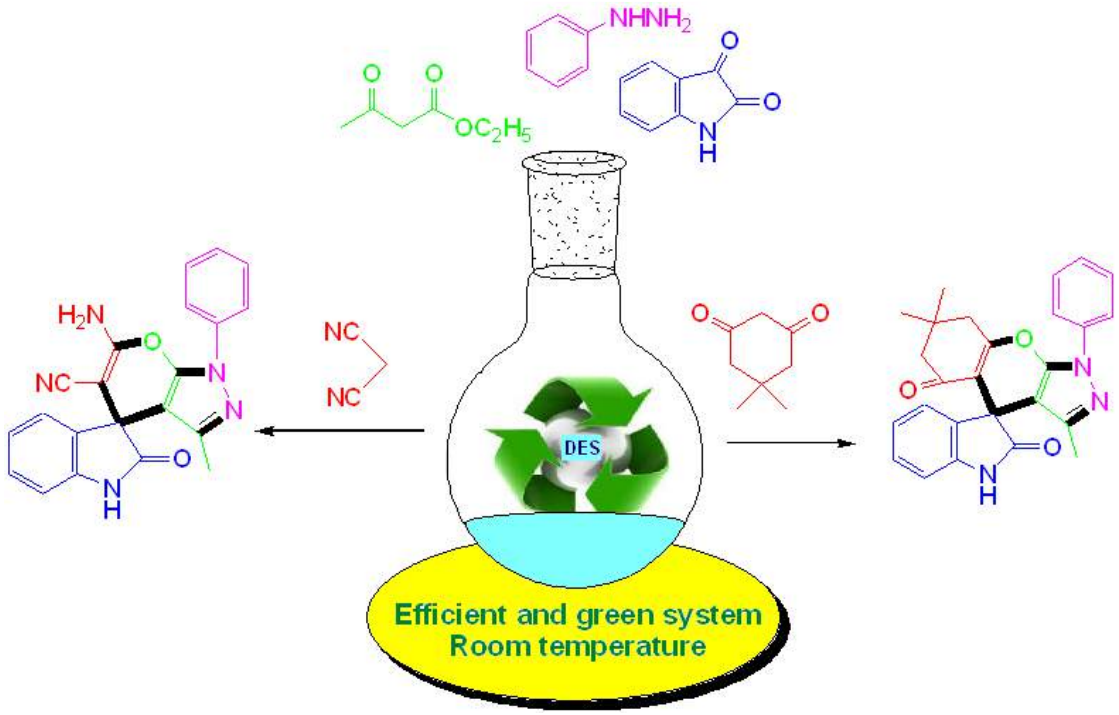
Oral Presentations

OL-01: The eco-friendly synthesis of Spirooxindoles using Deep Eutectic Solvent

Th. Prasanta Singh*[1], Th. Jeeta Devi[2], O. Mukherjee Singh[3]

[1,2,3] *Chemistry Department, Manipur University, Canchipur-795003, manipur, India.*
** Corresponding author, e-mail: ok_mukherjee@yahoo.co.in*

Abstract: The chemistry of indole is one of the most exciting and challenging field among the heterocyclic chemistry. The significant application of indole derivatives in pharmaceuticals, agrochemicals and organic electronics continues to inspire the tireless efforts of synthetic organic chemists since time immemorial.1 Among the indole derivatives, the spirooxindole derivatives also occupy a special place in organic and medicinal chemistry since they exhibit diverse biological and pharmacological activities.2 In light of their unique structural features along with the important biological activities, spirooxindole derivatives have drawn considerable attention to synthetic chemists for their preparation.3 Thus, in continuation of our work in indole chemistry, 4 we are reporting an eco-friendly one-pot synthesis of spiro[indoline-3,4'-pyrano[2,3-c]pyrazole derivatives using deep eutectic solvent (DES)-catalyzed four-component reaction of β-ketoesters, phenylhydrazines, malononitrile, and isatins, Scheme 1. The protocol avoids the use of costly and toxic catalysts and organic solvents which show a number of side effects on the environment and human beings. The simplicity and versatility of this eco-friendly method is described.



Scheme 1. Synthesis of spirooxindoles in DES.

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OL-02: Green Synthesis of Ag nanoparticle using Activated carbon as support and study of its activity for organic transofrmations

Parasa Hazarika*

Department of Chemistry, Jorhat Institute of Science & Technology, Jorhat-785010, Assam, India
** Corresponding author, e-mail: pl.hazarika@gmail.com*

Abstract: In recent years, noble metal nanoparticles have been the subject of focused research due to their unique optical, electronic, mechanical, magnetic, and chemical properties that are significantly different from those of bulk materials1. Nanoparticles as catalyst in organic reactions provide additional benefits such as catalyst recycling, scale-up of reactions using continuous flow processes, and easy purification of the reaction mixture offering green and cost-effective alternatives. Ag nanoparticles were synthesized using Activated carbon as support. The activated carbon was prepared from Eucalyptus bark, Coconut shell and Neem leaf using physicochemical activation method which consisted of pre-carbonization and NaOH treatment which were then characterized by XRD, SEM, FT-IR and TGA. Ag nanoparticles were then synthesized by using activated carbon as support in water and the naopartiles synthesized were characterized by XRD, SEM, FT-IR. The catalytic activity and efficiency of the catalyst were then studied by using this synthesized Ag nanoparticle for the reduction of p-nitro phenol.

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OL-03: Synthesis of Bromo Organics with Special Reference to Green Chemistry

Jayashree Nath*

Department of Chemistry, J. B. College (Autonomous), Jorhat, India.
** Corresponding author, e-mail: jayashree.nath@gmail.com*

Abstract: The elimination of chlorine and bromine containing organic compound (VOCs and PBBs/PCBs) has been targeted by recent legislation. While the growing numbers of halo metabolites identified in recent years questions the validity of campaigns for total eliminations of halogenated organics from our environment. It is certain that many existing halogenation processes do not advance the goal of nontoxic waste free chemistry. So, it is also relevant to mention here that research in green chemistry or sustainable technology is making dramatic achievement in the design of chemical synthesis and chemical processes that are environmentally benign and ecologically feasible. Based on this concept, as a part of our ongoing research work, we have presented some green protocols for the synthesis of bromo organics.

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OL-04: Biobased Polymeric Vapor Sensor:Using Custom Made Gas Casing

Gourhari Chakraboty*[1], S. Narendran[2], G. Pugazhenthi[3], Vimal Katiyar[4]

[1,2,3,4]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Assam, India, PIN-781039
** Corresponding author, c.gourhari@iitg.ac.in*

Abstract: Conductive bio materials are implemented in advance areas like capacitor, fuel cell application, paper battery and sensors. Bio degradable polymers like PLA, PCL are lucrative as matrix because of existing properties along with bio based nature. Conducting modifications like blending with conductive polymers and composite fabrication incorporating conductive fillers extends application domains of bio based polymers towards value added product preparation. Magnetic nanomaterial reinforcement also now a days are studied in the area of bio based polymeric composite fabrication for advanced applications like smart fluid, electrochemical sensor, bio sensor etc. Utilization of conductive biomaterials are less for solvent detection both in liquid and vapor phase. In this work carbon filler based magnetic nanomaterials were synthesized with different magnetism and morphology. Co-precipitation method was followed for the preparation of magnetic nanomaterials. Afterwards in combination with biodegradable polymer this magnetic material was tested for ethanol vapor detection in various gas flow rate. Vapor sensor set-up was made by assembling inter digital electrode in 3D- printed gas casing. The impedance change was found to be dependent on carrier gas (Nitrogen) flow rate and composition of the composite.

Keywords: *Magnetic Nanomaterial; Bio based polymer; Vapor sensor*

OL-05: Principles of Green Chemistry & Engineering for Sustainable Development

Bhaskar Jyoti Sarmah*

Department of Chemistry, Jorhat Institute of Science and Technology, Jorhat, India.
** Corresponding author, e-mail: bhaskar.rrl@gmail.com*

Abstract: Green chemistry is the design of chemical products and processes that reduce or eliminate the generation of hazardous substances. In 1998, Paul Anastas and John C. Warner published a set of principles to guide the practice of green chemistry. The twelve principles address a range of ways to reduce the environmental and health impacts of chemical production, and also indicate research priorities for the development of green chemistry technologies. Green chemistry is a multidisciplinary field drawing knowledge from chemistry, chemical engineering, toxicology, and ecology and covers areas such as synthesis, solvents, catalysis, raw materials, products and efficient processes. Important examples of green chemistry include: phasing out the use of chlorofluorocarbons (CFCs) in refrigerants, which have played a role in creating the ozone hole; developing more efficient ways of making pharmaceuticals, including the well-known painkiller ibuprofen and chemotherapy drug Taxol; and developing cheaper, more efficient solar cells. Green engineering focuses on how to achieve sustainability through science and technology. The 12 Principles of Green Engineering provide a framework for scientists and engineers when designing new materials, products, processes, and systems that are benign to human health and the environment. It is evident that sustainable chemistry education involves different methodologies in teaching fundamental chemistry concepts, whereby new terms and new philosophies are introduced. The core topic of thermodynamics needs to be discussed in terms of energy efficiency of chemical processing and manufacture in addition to energetics and spontaneity of chemical reactions. The core topic of kinetics needs to be discussed in terms of selective catalysts, which maximize product yield by decreasing by-product formation. Such discussions interlink core chemistry knowledge with green chemistry principles and form the foundation on which sustainability of the chemical enterprise is progressed. As a consequence of such inclusions in chemistry curricula, a suite of new terms emerges such as ‘feedstock’ replacing ‘reactant’ and ‘E-factor’, which is the ratio of the mass of ‘waste’ compared to that of ‘product’. The latter is a simple empirical measure of the ‘greenness’ of a chemical process, and hence, its sustainability.

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OL-06: Enhanced Nucleation and Trans-crystallization in Poly(lactic acid) Biocomposites Induced by Covalent Modification of Gum Arabic

Purabi Bhagabati, Vimal Katiyar*

Department of Chemical Engineering, Indian Institute of Technology Guwahati, North Guwahati, Assam- 781039, India.
** Corresponding author, e-mail:vkatiyar@iitg.ac.in*

Abstract: The work presents development of enhanced nucleation and trans-crystallization phenomenon in poly(lactic acid) [PLA] matrix induced by chemically grafted modified Gum Arabic (GA). The chemical modification of Gum Arabic was carried out through grafting oligomeric lactic acid (OLLA) via. microwave assisted in-situ polymerization of lactic acid. The modified Gum Arabic (mGA) of varying grafting concentration was used for the fabrication of PLA biocomposites [1]. The resultant biocomposites showed enhanced nucleation, trans-crystallization phenomenon and rate of crystallization, which were clearly observed from the polarized optical microscopic analysis during isothermal crystal growth of the samples. There was a decrease in T_g of composite with 2wt% mGA that caused little to insignificant reduction in T_g, whereas plasticization effect was found to be prominent in composites with 5wt% and 7wt% mGA concentration as appreciable reduction in T_g was observed. The mechanical strength of the PLA biocomposites were found to be reasonably high even after the addition of large size GA particles, which can be referred to good polymer-filler interfacial interaction between PLA and mGA.

Keywords: *Trans-crystallization, Poly(lactic acid), Gum Arabic*

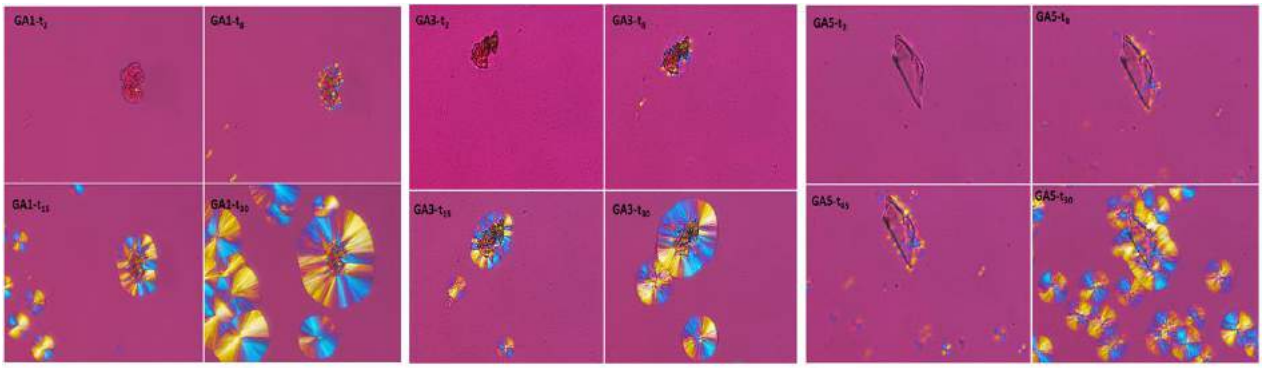

Figure 1. Polarized optical microscopic images of PLA/mGA biocomposites to present the nucleation as well as trans-crystallization effect of mGA particles upon PLA crystal morphology

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OL-07: Chitosan/Magnetic Cellulose Nanofibre Based Edible Nano-Coating Facilitated By Bioactive Compounds for Kiwi fruit products

Tabli Ghosh*[1], Yoshikuni Teramoto [2], Kohei Nakano[3], Vimal Katiyar[4]

[1,4] Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam-781031, Assam, India
[2] Faculty of Applied Biological Sciences, Gifu University, Gifu 501-1193, Japan
[3]The United Graduate School of Agricultural Science, Gifu University, Gifu 501-1193, Japan
** Corresponding author, e-mail: vkatiyar@iitg.ac.in*

Abstract: The study reports the development of magnetic cellulose nanofiber dispersed chitosan-based edible nano-coatings for perishable food products. The development of magnetic cellulose nanofibers is obtained through following single-step co-precipitation method [1], which is used as a carrier material for the delivery of bioactive compounds such as curcumin. The present work involves the utilization of magnetic cellulose nanofiber dispersed chitosan-based edible nano-coating materials with added advantages of iron fortification for packaging of kiwi fruit for tailor-made fruit properties. Further, the work details the effect of the specified coating materials for various property analysis such as weight analysis, total soluble solids, microbial load, and others during stored fruit products at 10 °C for 10 days. It is noteworthy to mention that chitosan being an antimicrobial agent can help to improve the shelf life of food products when used as edible coating materials. However, the inclusion of the specified bio-based nanomaterials with curcumin has a potential to improve the product life of kiwi fruits in comparison to chitosan coated and uncoated fruit products. Further, such primary coating will not only increase the shelf life of perishable food products but also provide nutraceuticals to the human body.

Keywords: *Magnetic cellulose nanofibers; Chitosan; Curcumin; Edible Nano-coating; Perishable food products*

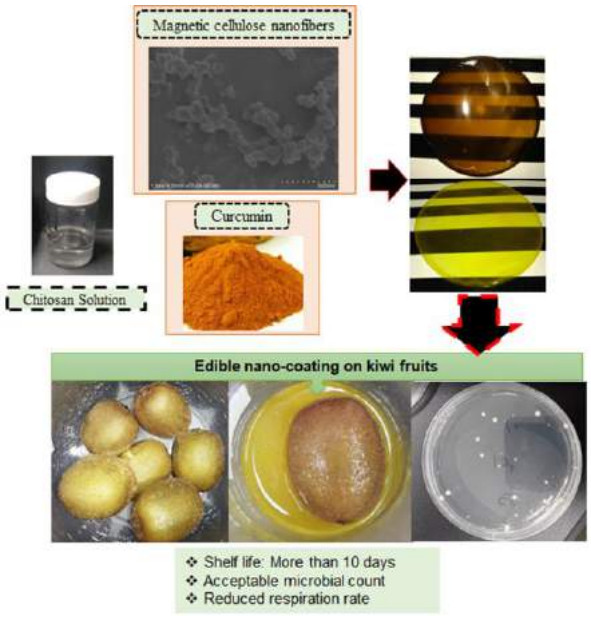

Figure 1. Chitosan/magnetic cellulose nanofiber/curcumin based edible nano-coating on kiwi fruit products

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OL-08: Novel Fluorescent Probe for Detection of Iron

Moitreyee Bhattacharjee *

Handique Girls' College, India
** Corresponding author, e-mail: moitreyee_bhattacharjee@yahoo.com*

Abstract: The condensation product of an amino acid and an aldehyde was synthesized by taking an appropriate amount of both. The solvent to be used was carefully chosen. The product so formed was synthesized using FTIR Spectroscopy, and it is found that the product had an excellent fluorescent property. The next attempt was to test its selectivity towards metal detection and it was found to be highly selective toward $Fe^{3+.}$ The proposed probe showed sensitivity of some extent towards other metal ions like Na^{+}, Ca^{2+}, Mg^{2+}, Al^{3+}. But the sensitivity towards iron is extraordinary. The detection of Fe^{3+} ions is on the basis of complete quenching of fluorescence of the probe. This is attributed to the strong binding affinity of the probe with Fe^{3+} ions. This water-soluble sensing system exhibits excellent sensitivity towards iron even in the presence of other ions viz. Na^{+}, Ca^{2+}, Mg^{2+}, Al^{3+}. The detection limit was found to be 10-12 M. The fluorescence and UV-Visible spectral data reveals a 1:1 interaction between the sensor and Fe^{3+} ions. This advantage of using this method is that the synthesis of the sensor is very easy and the sensor is obtained in good yield. It also does not require any complex methodology for the detection of metal ions. Moreover, the sensitivity of the sensor is so high that the detection requires only few seconds.

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OL-09: Enzymatic degradation behaviour of distinct PLLA/PDLA blends through thermostable enzymes

Naba Kumar Kalita [1], Kengo Kitadokoro[2], Fusako Kawai[2], Shinichi Sakurai[3] and Vimal Katiyar[1*]

[1]Department of Chemical Engineering, Indian Institute of Technology, Guwahati, Assam, India
[2] Department of Biomolecular Engineering, Graduate School of Science and Technology, Kyoto Institute of Technology, Kyoto, Japan
[3]Department of Biobased Materials Science, Kyoto Institute of Technology, Kyoto, Japan
**Corresponding author Email: vkatiyar@iitg.ac.in*

Abstract: Higher use of plastic materials increases problems related to waste disposal and management. Growing concerns related to environmental degradation has directed research towards the development of plastics that could undergo biodegradation [1]. The degradation mechanism behind the enzymatic degradation of poly (-L) lactic acid (PLLA) and poly (+D) lactic acid requires detailed understanding for designing various PLLA/PDLA blended products. In this study, we extracted cutinase enzyme in the form of cutinase Est1 from Thermobifida alba [2] and compared its degradation activity with proteinase K, maintained at pH 7.8 and temperature 50 °C. Neat (nPLLA), nPDLA, PLLA/PDLA: 60/40, PDLA/PLLA: 60/40, PLLA/PDLA: 80/20 and PDLA/PLLA: 80/20 samples were analyzed for enzymatic degradation activity. Differential scanning calorimetry (DSC) studies revealed formation of stereo-complexation (Sc) with homocrystals, in all the PLLA/PDLA blended samples. Customization of the degree of stereocomplexation of the ScPLA leads to different degradation stability under blank and enzymatic media at pH 7.8 and temperature 50 °C. PLLA/PDLA: 50/50 blend showed less degradation activity under all the media used. Our work demonstrated the enzymatic degradation of PLLA/PDLA blends using cutinase est1 and proteinase K, which revealed that customization of PLLA/PDLA blends leads to different degradation activity.

Keywords: poly (-L) lactic acid; poly (+D) lactic acid; Thermobifida alba; cutinase; proteinase K

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OL-10: Polylactic Acid/Nano-Hydroxyapatite Composite: Sustainable Materials for Orthopedic Fracture Fixations

Arbind Prasad[1], M. Ravi sankar[2], Vimal Katiyar[3]*

[1]*Assistant Professor, Department of Mechanical Engineering, Katihar Engineering College, Katihar, Bihar, India*

[2]*Assistant Professor, Department of Mechanical Engineering, IIT Tirupati, Andhra Pradesh-517506, India*

[3]**Professor, Department of Chemical Engineering, IIT Guwahati, Guwahati, Assam-781039, India*

** Corresponding author, e-mail: vkatiyar@iitg.ac.in*

Abstract: Bone fracture are increasing day by day. The current solution existing for bone fracture fixations are applications of metallic Internal fixation devices. But metallic internal fixation devices have got many limitations like stress shielding, stress palpability, leaching of ions and migrations to the nearby tissues and resurgery for extraction of the implants after healing. Polymeric based internal fixation devices are now the gold standard for these applications to overcome the limitation experienced by the metallic fixation devices. The main advantages involve no requirement of resurgery after fractured bone healing, matches of mechanical properties with the bone, no radiotherapy interferences etc. The main challenges of this bioabsorbable internal fixation devices are mechanical strength. Thus, the mechanical strength of the polymer can be enhanced by introducing the nano fillers into it to form as nano biocomposites. In this work, Polylactic acid (PLA) has been extruded cum injection molded with nano–Hydroxyapatite (nHAp) particles in twin screw extruder cum injection molding machine. The parameters for doing the process is shown in table 1. The fabricated composites (figure 1 (b)) as per the processing parameters (Table 1) were tested mechanically and characterized through XRD, FESEM, DSC, TGA and Optical Microscopic analysis. The bioactivity analysis was also conducted as per standard protocols. The result suggested that the mechanical properties matches with the properties of the bone. The flexural strength of the composites was in the ranges of 50-58 MPa, the elastic modulus values was in the range of 2.3-4 GPa obtained through universal tensile testing machine. The ultimate tensile test was about 58 MPa. The simulated body fluid was used to study the biocompatibility test; it was observed that after 3-4 weeks the apatite layer formation was observed which confirms about the biocompatibility of the composites. Thus, it was suggested for probable applications to use it as sustainable materials for bone fracture fixations.

Keywords: *PLA, nano-Hydroxyapatite, bone, fixations, bioabsorbable polymers.*

Table 1: Parameters for extrusion process of the PLA/nHAp composites

Parameters	**Values**
Processing temperature (ºC)	190
Screw speed (rpm)	110
Residence time (min)	1.5
Cylinder temperature(ºC)	200

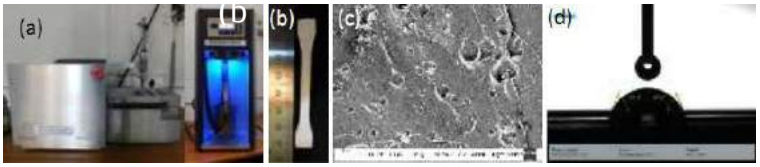

Figure 1: Extrusion cum Injection moulding machine, (b) fabricated composites (c) cross-sectional surface image from FESEM, (d) Contact angle of the PLA/nHAp

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OL-11: Biosorption of a Basic Dye Rhodamine B on Indian Sandalwood (Santalum Album) Leaf Powder: A Case Study

Nayan J Khound*

[1] *Department of Chemistry, Digboi College, Digboi, 786171, Assam, India*
** Corresponding author, e-mail: njkhound@gmail.com*

Abstract: The synthetic dyestuffs produced and utilized by industries like textiles, leather, cosmetics, paper, printing, plastics, etc., are suspected to be carcinogenic, mutagenic and toxic that might affect aquatic biota and also humans. In recent years, highest toxicity is recorded among the basic and diazo direct dyes. It is therefore essential to adopt certain techniques by the industries to decolorize the effluents before disposal into the water sources or to the land. In compared to other methods of wastewater treatment such as coagulation, floatation, chemical oxidation, solvent extraction, hyper filtration, etc., adsorption has been found to be excellent technique because of its cost-effective, simplicity of design and operation, availability, effectiveness and insensitivity to dyes. The biosorbents, collected and prepared from nature, are most widely used for this purpose. In the present work, removal of a basic dye called Rhodamine B from aqueous solution by adsorption onto a biosorbent, Indian Sandalwood (Santalum Album) leaf powder (SLP) was investigated. Green mature leafs of Sandalwood trees were collected, cleaned, dried and converted into powder for use as a biosorbent. Removal was tested in a batch process with concentration of dye solution, SLP load, pH, temperature and contact time as the working variables. The biosorbent was effective at the pH range of 5.0 –7.0 and its dye removal capacity was found to be above 80%. The kinetics of the interactions was measured with pseudo first order Lagergren equation (mean K1:0.30×10^{-1} min^{-1}), simple second order kinetics (mean K2:4.13×10^{-1}g/mg/min), and intra-particle diffusion (mean Ki: 2.30 $\times10^{-2}$ mg/g/min0.5) mechanism. The adsorption data gave good fits with Langmuir and Freundlich isotherms and yielded Langmuir monolayer capacity of 5.88 mg/g. Thermodynamically, the process was found to be exothermic accompanied with a decrease in entropy and increase in Gibbs energy as the temperature of adsorption was increased from 303 to 333 K. These results indicated that Sandalwood leaf powder might be an effective adsorbent for treatment of water contaminated with the basic dye Rhodamine B.

Keywords: *Biosorption; Rhodamine B; Santalum Album; thermodynamics; kinetics; isotherms.*

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OL-12: Green Synthesis of Nitrogen Heterocycles

Mohit L. Deb*

[1] *Dept. of Applied Sciences, GUIST, Gauhati University, Guwahati, Assam, India.*
** Corresponding author, e-mail: mohitdd.deb@gmail.com*

Abstract: Nitrogen heterocycles are the most important heteocycles due to their excellent pharmaceutical behaviors. Synthesis of some N-heterocycles will be described here by using multi-component approach, C-H functionalization, umpolung. Multi-component processes gained much attention in organic chemistry due to their advantages of inherent atom-economy, simpler procedures, and energy savings [1]. In addition, they offer reduced reaction steps, waste and cost. C-H Functionalization is a growing field and continues to draw attention of enthusiastic organic chemists for last two decades due to its non-requirement of prefunctionalization of substrates, step economical, directive, and environment-friendly features [2]. Functionalization of α-sp3 C-H bond of tertiary amine is one of the most studied areas because of its huge importance. This strategy is utilized to synthesize various complex natural and unnatural products from small molecules. A lot of progress has been made by various research groups to extend the scope and to develop new synthetic strategies for these reactions [3]. Generally, transition metals salts, molecular iodine and its salts or Bronsted acids were reported to catalyze these reactions in presence of oxidants. Indole is an electron rich compound and generally C3 position of it is more preferred site for electrophilic substitution followed by C2 position. However, indole does not exhibit nucleophilic reaction in normal condition. Therefore, many important derivatives of indole are difficult to synthesize through its conventional reactivity. Using the umpolung strategy (polarity inversion) one can overcome this limitation [4].

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OL-13: Molecular Dynamics Simulation Study Under the Effect of External Electric Field and High Temperature on Conformation of the Protein β-Lactoglobulin

Dr. Gargi Borgohain

Department of Chemistry, Cotton University, Guwahati-781001, India

Abstract: In the present study we have tried to explore the effect of static external electric field of strength 3.0 V/nm on the conformational changes adopted by the protein β-lactoglobulin. We have chosen two different temperatures viz. 300K and 400K to evaluate the effect of electric field. We have observed that combined effect of high temperature and static external electric field show significant changes on the structural conformation of the protein which in turn may affect the functional properties of the protein [1,2]. Calculations of root mean square deviation, radius of gyration, hydrogen bond, dipole moment and solvent accessible surface area (SASA) reveal that both helical and β-sheet regions of the protein are noticeably affected at high temperature. However, at high temperature β-sheet region is more affected than helical region. We have used SASA and dipole moment values to explain the changes in hydrophobicity of the protein surface due to presence of external electric field [3]. The present study reveals that electric field in combination with high temperature can be used to alter the conformation of the protein.

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OL-14: Arjuna bark powder [ArBP], a natural adsorbent used in sorption of Cr[VI] from aqueous solution

Sumi Sarma *[1], Krishna G Bhattacharyya[2]

[1] Department of Chemistry, Gauhati University, Guwahati 781014, Assam, India.
[2] Department of Chemistry, Gauhati University, Guwahati 781014, Assam, India.
** Corresponding author, e-mail: sumi.subhanga@gmail.com*

Abstract: Now a day it is considered to be very important to remove the toxic metal ions present in natural water. Natural water contaminants with toxic metal ions in various ways. Cr (VI) is one of such toxic metal present in aqueous water and its removal from water has been considered as very important. Agro-waste materials have been finding increasing use as sorbent materials for toxic metal ions from water. In this present work, a powder made from Arjuna Bark has been studied as a biosorbent for the removal of Cr (VI). The experiments were carried out with various Cr (VI) concentrations, amount of adsorbent and pH in a batch experimental process. Optimum Cr (VI) removal from the aqueous solution was found to be 98.5% at pH 2 by a biosorbent amount of 2 g L^{-1}. Several kinetic models (Lagergren, Ho and McKay, Elovich, Weber and Morris) were applied to the results to find out the most appropriate mechanism for the interactions between Cr (VI) and Arjuna Bark powder. The linear correlation coefficient and the rate coefficient were computed in each case.

Keywords: *Chromium (VI), Arjuna Bark Powder, biosorption, kinetic modelling.*

OL-15: A Study of Drinking Water Quality in An Around Tetelia, Jalukbari, Assam

Sanghita Dutta*

Assam Science and Technology University, India
** Corresponding author, e-mail: sanghitadutta1@gmail.com*

Abstract: Ground water forms the major source of water supply for drinking purposes in Greater Guwahati city. Guwahati, which is a geo-morphologically alive city, is in a state of disarray at present in the context of groundwater availability and demand (1). Pollutants are being added to the ground water system through numerous human activities and natural processes. However, the quality of ground water also depends on the geologic, climatic, environmental, biological and other anthropogenic activities. A study on ground water quality in an around Tetelia, Jalukbari was attempted with a view to examine the suitability of water with reference to some trace elements. The pH of the underground water system of different sites was found in the safe zone of 6.5-8. Among all the elements, the concentration of iron was found much higher than the tolerance limit prescribed for drinking water. The presence of iron above acceptable limit often imparts an alien taste to the water. It also promotes bacterial activities in pipes causing objectionable odour.

Keywords: *Ground water; iron; Guwahati; drinking water; trace elements*

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OL-16: Fabrication of Interpenetrating Polymer Network-based Nanocomposites of Bio-based Polyurethane and Polystyrene with Inherent Surface Hydrophobicity and Shape Memory Attributes

Tuhin Ghosh, Niranjan Karak*

Advanced Polymer and Nanomaterial Laboratory, Department of Chemical Sciences, Tezpur University, Napaam, Tezpur 784028, Assam, India.
**Corresponding Author, E-mail: karakniranjan@gmail.com*

Abstract: Designing of mechanically tough, durable, thermally stable and smart polymeric material is the most desired material of today's world because of its multi-dimensional utility [1-3]. Even though it is a mammoth task but a huge research is going on across the globe in search of such kind of smart polymeric material. This article demonstrates the fabrication of three different compositions of interpenetrating polymer network-based nanocomposites of bio-based polyurethane and polystyrene using simultaneous polymerization technique containing different amount of functionalized-reduce graphene oxide (f-RGO). Most interestingly, to obtain desired level of properties RGO was functionalized with monoglyceride of sunflower oil. The structural insights of the f-RGO and the fabricated nanocomposites were confirmed using FTIR, XRD, Raman, TGA, SEM and TEM analyses. The nanocomposites showed outstanding flexibility and good tensile strength along with good thermal stability. Fabricated nanocomposites also demonstrated good water repellent behavior (static contact angle > 125°). Moreover, the fabricated nanocomposites showed excellent multi stimuli (microwave output: 450 W, sunlight: average temperature 42±2 °C) responsive ultrafast shape memory behavior. Therefore, the studied nanocomposites have significant potential to pave a new direction in the field of smart graphene-based nanocomposites for multifaceted advanced applications.

Keywords: *Interpenetrating polymer network; functionalized-RGO; nanocomposite; hydrophobic; shape memory*.

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OL-17: A Review on the Applicability of Using Biodiesel Blends as Fuel in a CI Engine

Kamaldeep Kalita *[1], Dimbendra Kumar Mahanta[2]

[1,2] Assam Engineering College, Guwahati, Assam, India.
** Corresponding author, e-mail: kamaldeepkalita4@gmail.com*

Abstract: Diesel engines are widely used due to the application of high compression ratio resulting in better thermal efficiency [1]. The depletion of fossil fuel as well as the environmental hazard has become one of the major concerns of the present era. One of the promising alternatives that have been well reported in the available literature for substitution of mineral diesel is Straight Vegetable Oils (SVOs) [2]. SVOs are renewable energy sources, biodegradable as well as easily available. The high viscosity and the poor volatility are the major limitations of vegetable oils for their utilization as fuel in diesel engines. The high viscosity of SVOs causes long term problems in engines like nozzle choking, carbon deposition in different parts of the engine as well as dilution of lubricating oil [3]. Hence the methods mainly adopted to reduce the viscosity of SVOs are preheating and transesterfication [4]. Tranesterfication is a chemical process where the fatty vegetable oils are converted to esters with the addition of alcohol and a catalyst. The transesterfication of vegetable oils into esters is called biodiesel. Biodiesel is an oxygenated fuel which results into lower greenhouse gas emissions. The oxygen content of biodiesel is in the range of 8-12% [5]. The physical and chemical properties of biodiesel like calorific value, density, cloud point, pour point and flash point are almost at par with diesel. A lot of research work has been carried out in this area to predict the applicability of biodiesel blends as fuel in a compression ignition (CI) engine [6,7]. The present study establishes from the available literature that blending of biodiesel with diesel in proportion of 10-20% shows superior engine performance and emission characteristics as compared to diesel. The performance parameters taken from the literature are brake thermal efficiency (BTE), brake specific energy consumption (BSEC) and exhaust gas temperature (EGT). The main emission parameters that are mostly considered are unburned hydrocarbons (UBHC), carbon monoxide (CO) and nitric oxide (NOx) [8.9.10]. It has been reported from the work of Ganesan et al. that all the major performance and emission parameters are improved with biodiesel blends up to 40% as compared to diesel [11]. Hence in the long run biodiesel can be substituted as a vehicular fuel in diesel engines to overcome the concern of fossil fuel depletion and greenhouse gas emissions.

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OL-18: Carbon Nanomaterial-Vesicles Hybrid System for Biomedical Application

Jayanta Sarmah Boruah*[1], Devasish Chowdhury [2]

[1,2] Material Nanochemistry Laboratory, Physical Sciences Division, Institute of Advanced Study in Science and Technology, Paschim Boragaon, Garchuk, Guwahati-781035, India,
** Corresponding author, e-mail: devasish@iasst.gov.in*

Abstract: Fatty acid or lipid vesicles are now-a-days becoming very good agent in biomedical research for their bio-mimicking characteristics. Mainly, in case of drug delivery, these are targeted by scientific community as these are similar to cell organelles expecting that there will be good interaction of the targeted site of drug delivery in the body and the drug delivery systems. Such systems have already been used in many aspects like drug/gene delivery, nano-reactor etc. Here, we developed a hybrid system of fatty acid vesicles taking oleic acid as staring material and the carbon nanomaterial called graphene quantum dot (GQD). The so formed hybrid vesicles were successfully used to load drug (used methylene blue as model drug) and pH dependent drug release was observed. Drug loading was quite higher in hybrid vesicles (98.3%) compare to bare oleic acid vesicles (71.98%). Similarly, drug release was significantly higher for hybrid vesicles than the bare one and at pH 5, it gives more release than at pH 7.4. Hence it will work as pH sensitive drug delivery vehicle. Apart from that we also prepared a nanohybrid system from palmitic acid vesicles and (palmitic acid-cholesterol) carbon dot. Subsequently, it was used for uric acid (UA) and ascorbic acid (AA) absorption which act as prominent toxins in our body. Interestingly, the nanohybrid was found to be efficient UA absorber (~80%) compare to pure palmitic acid vesicles (~60%) confirming the role of carbon dot in absoption. In case of ascorbic acid, both systems absorb to the same extent. Till now there is no report of toxin absorption by vesicles system. So, this will lead to an effective material for toxin removal from our body. Both the bio-mimicking system based nanocomposites will contribute to the sustainability in biomedical application.

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OL-19: Mobility and Bioavailability of Cd, Co, Cu and Zn in surface runoff sediments in the urban catchment area of Guwahati

Upama Devi *[1], Krishna G Bhattacharyya[2]

[1,2] Department of Chemistry, Assam Engineering College, Jalukbari, Guwahati – 781013, Assam, India
** Corresponding author, e-mail: upama.devi28@gmail.com*

Abstract: The stormwater runoff sediment is recognised as major sink of the heavy metals for deteriorating the soil quality for their highly persistent nature with high residence time. The heavy metals are the potentially toxic contaminants of the runoff sediments. Hence, it is a major issue in the management of contaminant transport to receiving water bodies. In the present work, stormwater during several major rain events were collected from 9 principal locations of Guwahati, India. The solid phase was separated from the liquid phase and investigated for the total contents of Cd, Co, Cu and Zn as well as their distribution among the different chemical phases. Sequential extraction procedure was used for the chemical fractionation of the metals that contains five steps. The total metal concentration showed the trend, Cd < Cu < Co < Zn. The relative distribution of the metals showed 73% of Cd available mostly in exchangeable and carbonate bound forms being the most mobile and hence is at a very high risk. Hence, the Cd could be bioavailable easily. Next to it, 48% of Co available in exchangeable and carbonate bound forms with medium mobility was found to be in high risk category. On the other hand, the mobility of Cu (18% in exchangeable and carbonate bound forms) and Zn (15% in exchangeable and carbonate bound forms) was found to be relatively low being the least bioavailable and hence falls in medium risk category.

Keywords: *Cd, Co, Cu, Zn; stormwater sediment; rain events; sequential extraction.*

OL-20: Acrylic Based Fluorescent Adhesive: Role of Fluorescence in Crafts and Anti-Counterfeiting Applications

Samiran Upadhyaya*[1], Neelotpal Sen Sarma[2]

[1,2] Advanced Materials Laboratory, Institute of Advanced Study in Science and Technology, Guwahati, Assam, India.
** Corresponding author, e-mail: neelot@iasst.gov.in*

Abstract: Fluorescent adhesives are widely used in various applications, such as dental care, crafts, constructions and repairs, substrate processing materials, etc.

This work presents the synthesis of an acrylic-based adhesive, applicable for cellulose materials, such as paper and wood. The adhesive was characterized by various techniques. The adhesive strength was found to be appreciably higher when compared with a commercially available adhesive. The adhesive was found to be thermally stable up to 300 ^{o}C, making it a suitable candidate for high-temperature adhesive application. It shows appreciable fluorescent character, which makes it an important tool for museums and crafts to detect fractured joints, which are unnoticeable under normal light. Moreover, the adhesive can be useful in anti-counterfeiting applications, because of its fluorescence nature.

Figure 1. Picture depicting the bonding of a broken specimen design (left) by the adhesive and the visibility of the broken joint under normal light (middle) and long-wavelength UV light (right)

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OL-21: Development of Nano-Bio-Conjugate Film Using Aloe Vera to Detect Hazardous Chemicals Found in Cosmetics

Ankita Deb*[1], Rasna Saikia[2], Devasish Chowdhury [3]

[1,2,3]Material Nanochemistry Laboratory, Physical Science Division, Institute of Advanced Study in Science and Technology, Paschim Boragaon, Garchuk, Guwahati, Assam-781035, India.
** Corresponding author, e-mail: devasish@iasst.gov.in*

Abstract: Awareness of the presence of harmful chemicals in cosmetics and health care products affecting human health is of utmost importance. This necessitates the development of detection techniques of such hazardous chemicals. Herein, the work reports the use of the popularly known traditional medicinal herb, Aloe vera to fabricate nano-bio-conjugate film and demonstrate its applicability in sensing. In the process, a simple, cost-effective, and greener approach was undertaken to synthesize highly fluorescent carbon dots by the microwave-assisted method using Aloe vera as the carbon precursor. The synthesized carbon dot was characterized by DLS study, UV-Vis spectroscopy, Photoluminescence (PL) measurement and Transmission Electron Microscopy (TEM).

Further, Aloe vera carbon dot was immobilized in a bio-conjugate system comprising of aloe vera gel itself and sodium alginate to form a fluorescent nano-bio-conjugate film. The film could successfully serve as an optical 'turn-off' sensor in detecting some of the structurally similar carcinogenic chemicals found in cosmetics, listed as 'red-listed' chemicals.

The work, therefore, illustrates the development of a bio-conjugate system from sustainable materials like Aloe vera and alginate, thereby paving the way of utilizing greener materials to detect hazardous chemicals.

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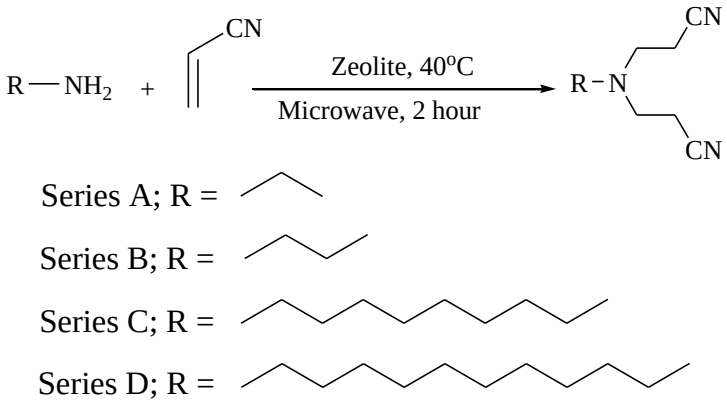
OL-22: Surface induced catalysis of Aza-Michael reaction using zeolite as the catalyst; an efficient green synthetic approach.

Parineeta Das [1], Nirmala Devi [2], Amrit Puzari [3]

[1,2,3] Department of Chemistry, National Institute of Technology Nagaland, Chumukedima, Nagaland, India
** Corresponding author, e-mail: amrit09us@yahoo.com*

Abstract: Zeolite catalysts are befitting the environmental guidelines and enhances the time for desired product under mild reaction conditions. These are easy to handle, reusable heterogeneous catalyst. Therefore, it is used as a green chemistry protocol to synthesize the respective di-nitriles using Aza-Michael reaction under microwave irradiation at a frequency of 2.45 GHz. It proves to be a convenient access to the di-nitrile synthesis allowing the reactants to get adsorb on the microporous structure of the zeolite favouring the reaction to take place. Microwave synthesis adds up to the greener approach for acrylonitrile di-adduct synthesis. By optimizing the appropriate pore diameter of the zeolite with respect to that of the reactants, selective conversions can be done. In this work, a series of reactions has been performed with primary aliphatic amines and acrylonitrile. This reaction has a wide range of application in the production of antibiotics, anticancer and bioactive molecules. The proposed reaction upgraded by adding the zeolites as catalyst under mild temperature in the microwave. The acrylonitrile di-adducts are purified using preparatory TLC and various techniques such as FT-IR, 1H-NMR and ESI-MS have been used for characterization.



Scheme-1: Synthesis of acrylonitrile di-adducts

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Poster Presentations

PP-01: Hydrophobically Modified Amphoteric Starch based Hydrogel for Dye Removal from Industrial Effluent

Dimpee Sarmah[1] and Niranjan Karak[*1]

[1]Advanced Polymer and Nanomaterial Laboratory, Chemical Sciences Department, Tezpur University, Tezpur, Assam-784028, India.
**Corresponding author email:karakniranjan@gmail.com*

Abstract: The advancement in technologies along with the enormously growing industrialization and urbanization has created lots of toxic materials, which cause terrible impact on the environment. Designing of smart materials from bio-based resources for removal of these toxic pollutants has received tremendous impetus in today's era because of their sustainability and wide usability. Among these, hydrogels are one of the most interesting polymeric materials which are widely used for treatment of industrial effluents along with biomedical applications [1]. Further the charged functional groups of hydrogels allow penetration of ionic or neutral molecule into their swollen network [2]. But the high hydrophilic nature of them limits their applications. Therefore, in the present work the authors wish to report synthesis of a hydrophobically modified amphoteric starch based hydrogel for the treatment of industrial effluent. Modification was done by epichlorohydrin, which enhanced the hydrophobicity through etherification reaction. But a little cross-linker cannot be ruled out. Furthermore, triethyl amine was incorporated for the opening up of epoxy ring with the formation of positive charge on the structure. Again *N, N*-methylene bis acrylamide was used for cross-linking of acrylic acid onto starch for creation of the second network. The creation of such structure enhances the hydrophobicity of the hydrogel, while carboxylate anions of acrylic acid moiety provide hydrophilicilty. Thus the hydrogel became amphoteric in character. The structure of the hydrogel was characterized by FT-IR and thermostabilty was determined by thermal degradation studies. The positive charge created during quaternization of epichlorohydrin with triethyl amine and the negative charge on acrylic acid used for adsorption of both negative and positive dyes from the industrial effluent. The synthesized hydrogel showed high efficiency for dye removal with noticeable recyclability. Hence the studied hydrogel could be used as a potential material for waste water treatment.

Keywords: *hydrogel; water absorption capacity; hydrophobic; amphoteric*

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PP-02: Fabrication of Hydrophobic/Oleophilic Membranes for Their Potential Application in Oil/Water Separation

Fayez U Ahmed*[1], Mihir Paul[1], Debarun Dhar Purkayastha[1]

[1] Department of physics, NIT Nagaland, chumukedima, Nagaland- 797103, India.
** Fayez U Ahmed, e-mail: fayezpcc@gmail.com*

Abstract: In this work we have fabricated hydrophobic/oleophilic polyvinylidene fluoride (PVDF), PVDF@ZnO, PVDF@CdS-ZnO composite membrane using the phase separation technique. ZnO and CdS-ZnO composite was blended as an additive into the membrane matrix for the alteration of the membrane properties. The membranes were characterized by XRD, FTIR and contact angle studies. The water contact angles for pure PVDF, PVDF@ZnO and PVDF@CdS-ZnO membrane was found to be 111.65^{o}, 105.5^{o} and 115.8^{o} respectively. The hydrophobicity of samples is attributed to the low surface energy of the samples. Oil/water separation study reveals that the oil permeability was superior for PVDF@CdS-ZnO as compared to pure PVDF and PVDF@ZnO. PVDF@CdS-ZnO with excellent oil passing capacity will have potential application separation of oily waste water.

Keywords: *Membrane; Contact angle; Surface energy; Oil/water separation*

PP-03: Fabrication of High Performing Waterborne Polyester/ Citric Acid Modified Reduced Graphene Oxide Nanocomposite

Geeti Kaberi Dutta[1] and Niranjan Karak*[1]

[1]Advanced Polymer and Nanomaterial Laboratory, Department of Chemical Sciences, Tezpur University, Napaam, Tezpur, Assam, India, 784028
** Corresponding author, e-mail: karakniranjan@gmail.com*

Abstract: The growing environmental concern has drawn substantial research interest towards the development of environmentally compatible synthetic polymers as highly advanced materials by using different renewable resources [1, 2]. Such advanced polymers with unique multifunctional activities may be achieved through unison of nanotechnology and molecular engineering. Among different synthetic polymers, polyesters are one of the significant interests due to their inborn versatile properties along with their wide variety of applications [3]. In this venture, bio-based waterborne polyester nanocomposite was fabricated in the present investigation by using vegetable oil based dimer acid, citric acid and glycerol as the reactants; and citric acid modified reduced graphene oxide as the nanomaterial at varying amounts. The fabricated polyester nanocomposite was then characterized by FTIR, XRD, Raman, TGA and TEM analyses. On addition of triethylamine as a neutralising agent, the fabricated nanocomposites becomes water-soluble, which were then cross-linked with glycerol-based epoxy and fatty-acid based poly(amido amine) to obtain their respective thermosets. The fabricated thermosets showed good mechanical, thermal and chemical performances. Moreover, they also showed good bacterial biodegradability and good antistatic properties. Therefore, these types of environmentally benign polymeric materials can overcome the shortcomings of petroleum based synthetic polyesters as well as they could be used as a promising high performing material for coating applications.

Keywords: *Sustainable polyester nanocomposite, mechanically tough, biodegradable, antistatic.*

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PP-04: Surface Modified Conducting Polyaniline based Biochemically Reduced Graphene-oxide/Zero Valent Iron Ternary Hybrid Composite as a Capacitor Electrode

Shreemoyee Bordoloi[*1,2], Biswajit Pegu[1], Surajit Konwer[1*], Geetika Borah[1]

[1]Department of Chemistry, Dibrugarh University, Dibrugarh, Assam-786004, India.
[2] Department of Chemistry, MDKG College, Dibrugarh, Assam-786004, India.
** Corresponding author, e-mail: shreemoyeebordoloi@dibru.ac.in*

Abstract: Composite materials based on the blending of reduced graphene oxide (rGO), zero valent iron (Fe^0) and polyaniline (PANI) are expected not only to improve the conductivity of PANI, but also relieve rGO and Fe^0 aggregation via a synergistic effect. We report an easy one step synthesis of a PANI/rGO/Fe^0 composite via reductive deposition of rGO and Fe^0 onto the PANI. The composites were characterized by Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), transmission electron microscopy (TEM), thermogravimetric analysis (TGA), ultraviolet-visible absorption (UV-vis), X-ray diffraction (XRD) and electrical conductivity measurements. The composites exhibited noticeable improvement in thermal stability and electrical conductivity in comparison to bare polymer. The electrochemical and capacitance behavior of the composite was also investigated. The composites comprising rGO and Fe^0 exhibited better specific capacitance than the pristine polymer thereby providing a novel way for fabrication of supercapacitor electrodes.

Keywords: *polyaniline; biochemical reduction, graphene-oxide; capacitance, ternary composite*

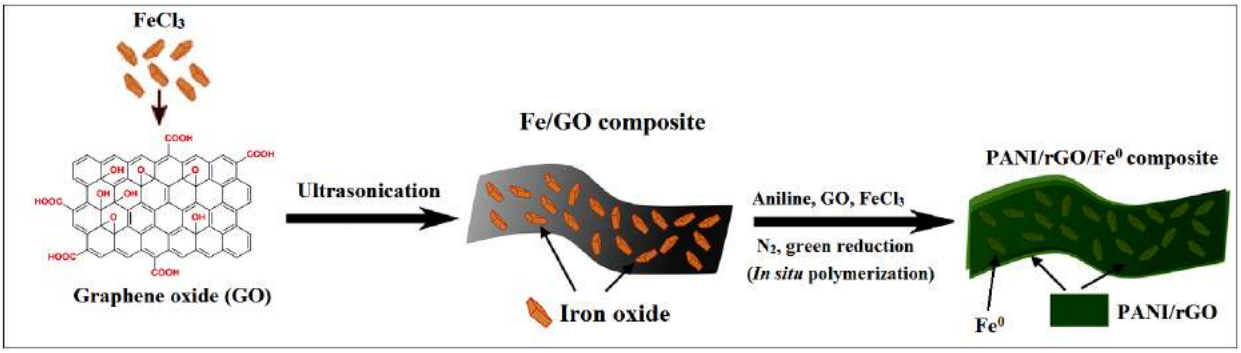

Figure 1: Schematic presentation of preparation of PANI/rGO/Fe

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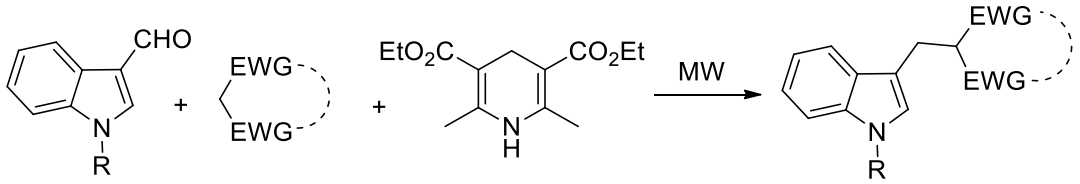
PP-05: Microwave Promoted 3-Component Synthesis of 3-Alkylatedindoles

Biswajita Baruah *

[1] Dept. of Chemistry, Pandu College, Guwahati, Assam, India
** Corresponding author, e-mail: biswajitabaruah@gmail.com*

Abstract: Indole skeleton is one of the most attractive heterocyclic structures and is often found in various alkaloids, agrochemicals and pharmaceuticals.1 Moreover, C-3 substituted indoles are highly significant, which are the key components of many promising therapeutic agents, especially in the neuroscience field. The endogenous neuro-transmitting agents of the central nervous system, such as melatonin and serotonin are important C-3 substituted indole-based compounds. Tryotophandehydrobutyrine diketo-piperazine (TDD) is an inhibitor of glutathione-S-transferase (GST) enzymes due to which many tumour cells become resistant to chemotherapeutic agents. A number of other indoles (e.g., Meridianins) having heterocycles at the 3-position have also been obtained from nature with potential biological activity. In the last few decades' multi-component process (MCP), a green technology achieved much interest in synthetic chemistry due to their advantages of atom economy, simplified mode of operation, and energy savings.2 Moreover, reduced reaction steps, waste, and cost are the additional advantages of the MCPs. Here I report a three-component reaction of indole-3-carboxaldehyde, active methylene compounds and Hantzsch 1,4-dihydropyridine under microwave irradiation and solvent-free condition.



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PP-06: A Case Study of The Industrial Plastic Waste Management and Awareness Campaign

Dipak Nahata *[1], Nisika Das [2], Nirmali Haloi [3], Jutika Goswami [4], Gitanjali Majumdar [5]

[1,2,3,4,5] Assam Engineering College, Jalukbari, Guwahati-13, Assam, India
** Corresponding author, e-mail: dipaknahata5@gmail.com*

Abstract: With the increasing growth of population, the demand for plastic is escalating and it is leading to further generation of wastes. Plastics, mostly being non-biodegradable, get accumulated on the earth's surface, thus defacing the environment. Plastic doesn't allow seepage of rainwater hereby decreasing the groundwater level. Toxic chemicals leaching out of these materials are linked to critical diseases. Chemicals discharging from the plastic wastes washed off to water bodies cause threat to aquatic and marine lives depriving them of essential nutrition. Lack of adequate waste management and insensitiveness among the general masses also serves this issue. Most of the plastics like polyethylene terephthalate (PET), high density polyethylene (HDPE), low density polyethylene (LDPE) are recyclable. Recycling methods followed by the industries include processing of PE films to granules. PE and PP films are either sold to scrappers or sent to pyrolysis industries. Plastics mixed with bitumen are also used in road construction. Eco-bricks made from plastic bottles and stuffed with plastic wastes are used to make building blocks. Unawareness among the people and improper disposal methodologies are prime reasons for plastic pollution in the environment. Therefore, making people acquainted with the issues is the foremost objective of this case study. The study team visited and surveyed plastic processing industries and collected data about the waste disposal management of the same. The team also campaigned among the school going children to make the next generation aware of the problems associated with the extensive use of plastics and its effect on the environment.

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PP-07: Catalytic destruction of phenol by measuring reduction in Chemical Oxygen Demand

Gitali Baruah *[1], Krishna G Bhattacharyya[2]

[1,2] Department of Chemistry, Pandu College, Guwahati 781012, Assam, India
** Corresponding author, e-mail: gitalibaruah75@gmail.com*

Abstract: Chemical industries particularly those involved in pesticide production release phenol and its compounds in their effluents and these compounds find their way into the water bodies. At very high concentrations of phenol conventional biological oxidation processes are inapplicable, and this causes a need for the development of efficient and inexpensive water treatment processes. The catalytic destruction of phenol in aqueous medium was monitored by measuring reduction in Chemical Oxygen Demand (COD), the reactions of phenol (1×10^{-3} M) were carried out in 250 ml double necked round bottom flask with a magnetic stirrer at 423 K. For this purpose, the performance of only two catalysts, Fe_2O_3 and TiO_2, was measured under different reaction conditions with H_2O_2 as the oxidizing agent. In the present study, it was found that for a catalyst loading of 5×10^{-6}kg m^{-3}, TiO_2 catalyst gave 86.4 % COD reduction when phenol and H_2O_2 ratio was 1:10.

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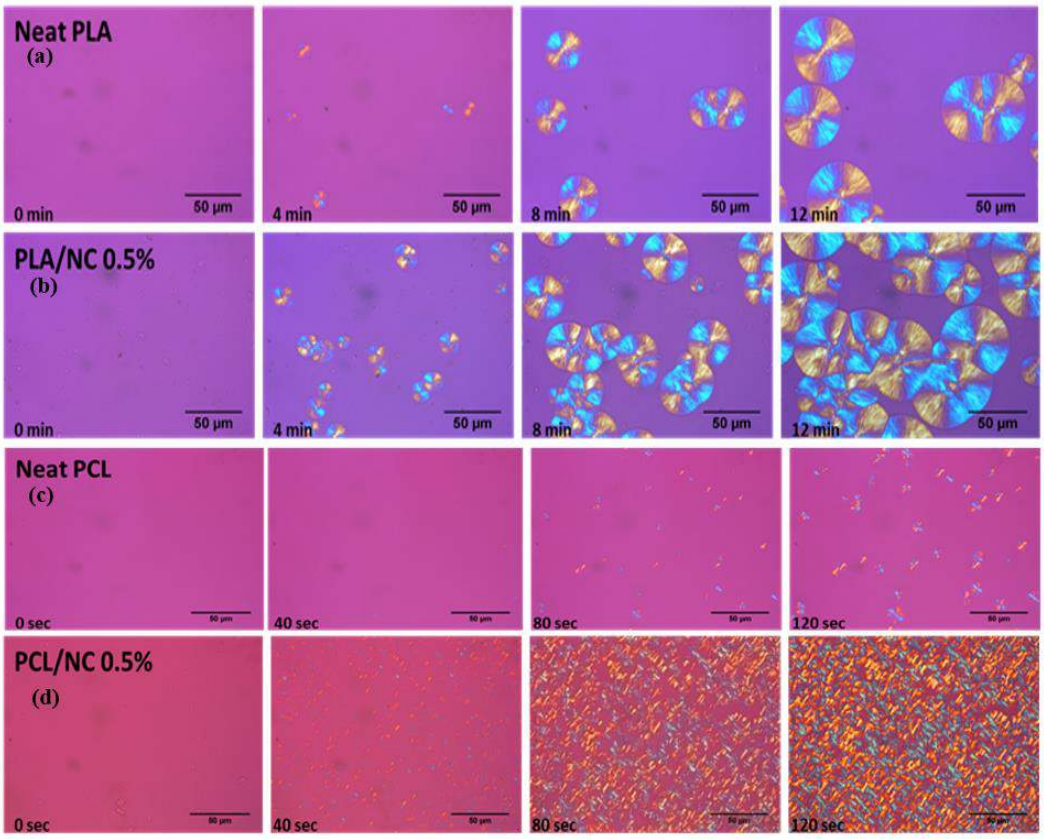
PP-08:Effect of Nano Cellulose From Green Algae Waste and Its Reinforceing effect in Biodegradable Polymer Film

Kona Mondal [*1], Shinichi Sakurai[2], Yoko Okahisa[3], V.V Gound[4] and Vimal Katiyar*[5]

[1,4,5] Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India.
[2,3] Biobased Material Science, Kyoto Institute of Technology, Kyoto, Kyoto-606-8585, Japan.
** Corresponding author,,e-mail: vkatiyar@iitg.ac.in*

Abstract: Green algae are widely available around the world and its exploitation for the production of biodiesel, bioethanol, and agar has become an important industry in recent years aiming to conserve the fossil fuels and minimizing global warming. Also, it became the alternative source for third generation biodiesel production. Furthermore, petroleum-based plastics are reason for occurring global warming, plastic waste, and many other hazards. Contrariwise, biodegradable polymers with identical properties have been found as a great research outcome for substitution of petroleum-based plastics. Thus, the green or sustainable polymer would be the best possible replacement for conventional plastics to protect our globe from the environmental hazard. However, the industrial processing of green algae generates a large quantity of solid wastes, which constitutes a source of serious environmental problems. Further, these algae wastes contain polysaccharide such as cellulose which is a natural biodegradable polymer with some unique characteristics of renewability, biodegradability, high tensile strength and stiffness, cost effectiveness and light weight [1]. However, other lignocellulosic biomass sources are available in environment for extractions of cellulose, in spite of those algae are of special interest, ideally suitable for a variety of applications, including polymer reinforcement [2]. Additionally, algae derivatives consist of several valuable components such as a polysaccharide, antioxidants, pigments, fatty acids, proteins and vitamins, and minerals. On the otherside, the demand of food packaging is increasing more with the growing population. Nano Cellulose (NC) has emerged as a biobased material that has captured considerable research and industrial interest. They feature a high aspect ratio, low density, high mechanical strength, and low coefficient of thermal expansion. In addition, they display abundant hydroxyl groups that facilitate NC functionalization and allow strong inter fibrillar hydrogen bonding. In the present work, utilization of green algae waste as a raw material to produce value added nano celluloses (NC) has been investigated, and the effect of the as-isolated NC as reinforcing material in biodegradable polymer (Poly (Lactic acid) (PLA) and Poly (Caprolactone) (PCL) has been studied. All composite films have been developed using solvent casting. It has been observed that NC acts as good nucleating agent in both the polymer matrix. Non-isothermal Differential Scanning Calorimetry (DSC) study has shown the decrease in cold crystallization temperature in PLA composite films from 135.8˚C to 123.2˚C, whereas the crystallization temperature in case of PCL composite has increased from 29.4˚C to 35˚C. Both of the result indicates improvement of crystallization in the composite films. To establish the DSC result isothermal crystallization kinetics study has been conducted to check the nucleation and crystallization effect using Avrami theory. Isothermal study also confirms the quick formation of crystals in composite films compare to neat polymer film. Further, Polarized Optical Microscopy (POM) study has shown the same effect of NC as reinforcing agent in polymer matrix which confirms the result of isothermal study. The growth rate and diameter of spherulites has increased in composite films compared to neat with increasing filler loading percentage. Moreover, these composite films could be used in food packaging purpose due to its transparency and nucleating effect which will aid to improve the barrier properties of packaging material.



Keywords: *Nano cellulose; Algae; (Poly (Lactic acid) (PLA); Poly (Caprolactone) (PCL), Biodegradable;*

Figure. Figure (a) & (b) is showing the POM image of spherulites in neat PLA and 0.5% NC loaded composite films in which more spherulites has been formed in comparison to neat within a specified time.

Figure (c) & (d) is showing the POM image of spherulites in neat PCL and 0.5% NC loaded composite films in which same patter has been observed as incase of PLA but in case of PCL the nucleation is very much faster that complete spherulite has not been seen.

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PP-09:Synthesis of Poly(ε-caprolactone)-r-Poly(lactic acid): Thermal and Mechanical Properties

Neha Mulchandani[1], Kazunari Masutani[2], Shinichi Sakurai[2], Yoshiharu Kimura[2], Vimal Katiyar[*1]

[1] Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam- 781039, India.
[2] Department of Biobased Materials Science, Kyoto Institute of Technology, Kyoto-6068585, Japan.
** Corresponding author, e-mail:vkatiyar@iitg.ac.in*

Abstract: Poly(lactic-acid) (PLA) and poly(ε-caprolactone) (PCL) are the aliphatic polyesters that have gained significant interest in several applications owing to their biocompatibility and biodegradability. PCL is flexible in nature due to its lower glass transition temperature (Tg) which is around -60˚ C and possesses high toughness whereas PLA is known for its brittle nature (Tg ~60˚ C), ease of processability and relatively good tensile strength. Therefore, while developing the copolymers, PCL and PLA can act as complementary to each other and lead to the development of polymers with tailored properties for targeted commodity, engineering and biomedical applications. In line to this, the current work aims at developing copolymers by connecting the soft PCL segments to the hard PLA segments. The random copolymerization ε-caprolactone (CL) and lactide (LA) has been carried out (Figure 1) to identify the influence of varying the molar ratio of lactyl and caproyl content on the thermal and mechanical properties of the synthesized copolymers. The molecular weight of the synthesized copolymers is determined by gel permeation chromatography. It is indicated from the differential scanning calorimetry (DSC) analysis that the Tg of the copolymer is increased from -6.3 °C to 59.7 °C upon increasing the lactyl content. Thermogravimetric analysis (TGA) reveal that the thermal degradation is improved with the increasing caproyl content possibly due to the presence of long alkyl chains. Further, the elongation at break (%) of the copolymer is improved to ~800% as the lactyl content is decreased and the toughness is found to improve to 84 MJ/m^3. The results indicate that varying the molar ratios of lactyl and caproyl content into the copolymer matrix significantly alters the overall properties of the copolymer which may be taken advantage of, for developing the materials for intended applications.

Keywords: *Poly(lactic-acid); Poly(ε-caprolactone); random; copolymer*

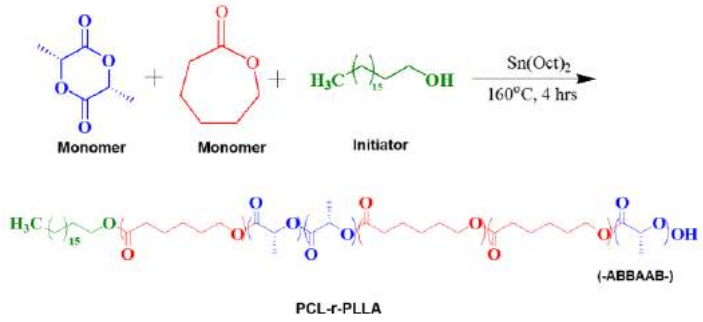

Figure 1. Synthesis route for random copolymerization of ε-caprolactone and lactide

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PP-10: Application of Cellulose Nanocrystals as Ionic Conductor for Fabrication of Solid Electrolyte Membrane for Direct Methanol Fuel Cells

Surendra Singh Gaur[1], Prodyut Dhar[2], Amit Kumar[3] and Vimal Katiyar*[4]

[1,2,3,4]*Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam, India –781039.*
** Corresponding author, e-mail:* vkatiyar@iitg.ernet.in

Abstract: The study reports the use of bio-filler: cellulose nanocrystals (CNCs) in the area of fabrication of solid electrolyte membranes for direct methanol fuel cells (DMFCs). CNCs were synthesized by hydrolysis process by using three types of acids H_2SO_4, HNO_3 and HCl. The acids used in hydrolysis had effect on the shape, size and morphology of CNCs, which affected the properties of electrolyte membranes also. Poly (vinyl alcohol) (PVA) and chitosan were used as the polymer matrix. Crosslinking of PVA and chitosan provided the stability to the membranes. CNCs are incorporated in the polymer matrix to improve the ion conductivity. The methanol permeability of prepared membranes was ~10^{-8} cm^2 s^{-1}, which is significantly lower than the base PVA membrane. Along with it, the membranes had good thermo-mechanical properties, low swelling characteristics and higher ion conductivity. Among the three types of CNCs, HNO_3 hydrolysed CNCs based membrane showed better performance in water uptake, ion conductivity and swelling, while HCl CNCs based membrane had better methanol barrier properties. As the methanol permeability of HNO_3 CNCs based membrane was almost equal to HCl CNCs based membrane and it was superior in other properties, so it can be concluded that HNO_3 CNCs based membrane can be a suitable and sustainable option for solid electrolyte used in DMFCs.

Keywords: *CNC; DMFC; Ion conductive material*

Acknowledgements: The authors are thankful to the Department of Chemicals and Petrochemicals (GoI) funded Centre of Excellence for Sustainable Polymers, IIT Guwahati and Central Instruments Facility, IIT Guwahati for utilizing their research facilities.

PP-11:Studies on non-isothermal crystallization kinetics of poly(lactic acid) PLA/ in-situ PLLA_Silk nano crystal (SNC) nanocomposite films

Doli Hazarika[1], Amit Kumar[1] and Vimal Katiyar*[1]

[1]Chemical engineering Department, Indian Institute of technology Guwahati, Guwahati, Assam-781039, India.
** Corresponding author, e-mail:vkatiyar@iitg.ac.in*

Abstract: A feasible study has been put forward using nano biofiller SNC in order to develop a homogeneous mixture of PLLA/SNC nanocomposite by in-situ ring-opening polymerization of L-lactide followed by mixing with commercial PLA to study the crystallization behaviour of the solvent casted nanocomposite films. The morphological studies for the in-situ polymerized nanocomposite for homogeneous distribution of 0.25% of SNC has been confirmed using Field Emission Scanning Electron Microscope (FESEM) and Field Emission Transmission Electron Microscope (FETEM). Moreover hydrophobic SNC benign its hydrophobic character even after its incorporation during polymerization into the PLLA so as to obtain a hyrophobic nanocomposite. A fundamental understanding considering 5-15% of highly crystalline PLLA/SNCnanocomposite into PLA was made by covering up the non isothermal crystallization kinetics on the basis of Diffential thermogram calorimetry, DSC thermogram using Avrami, Ozawa and Mo et al. models and the crystallization parameters of the samples were obtained equation at four different heating rate (5, 7.5, 10, 12.5 °C/min). In order to support the high crystallinity of SNC nanopartiles after having modified methodology i.e. insitu polymerised PLLA/SNC nanocomposite the spherulite growth behaviour has been revealed by using Polarizing optical microscope (POM) for the same. The crystallinity percentage of the nanocomposite has also been enhanced due to incorporation of high crystalline SNC which has been confirmed by Xray Diffraction,(XRD) analysis. The thermogravimetric analysis revealed the thermal degradation parameters of the in-situ polymerized PLLA/SNC nanocomposite without and with PLA which got increased after its incorporation.

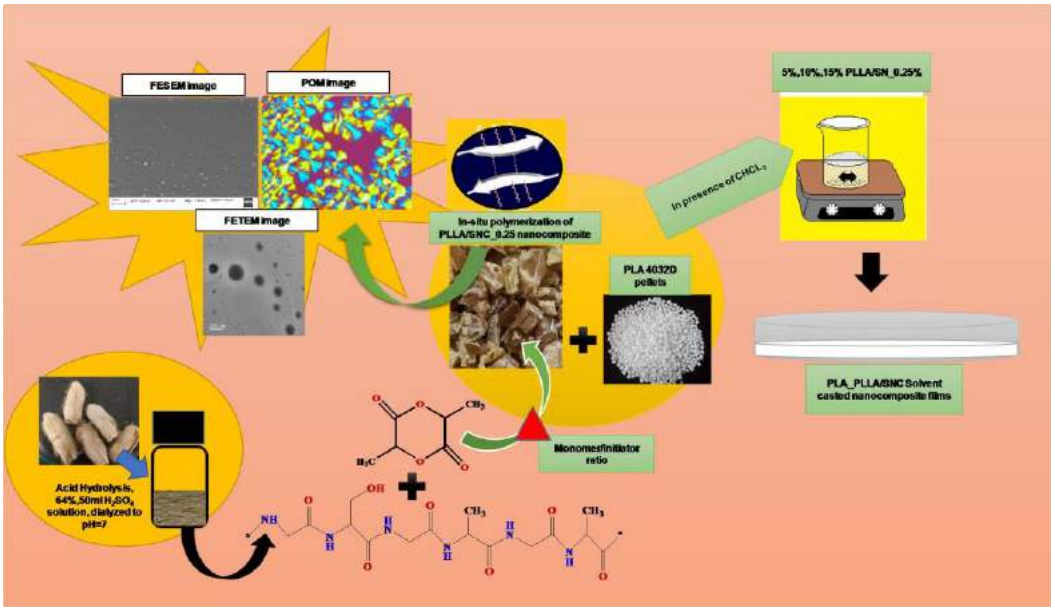

Figure 1. Schematic diagram of fabrication of PLA-PLLA/SNC nanocomposite films

Keywords: *Silk nanocrystals; Poly (L-lactic acid); In-situ polymerization; Nanocomposite; Non isothermal crystallization kinetics.*

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PP-12: Copper(II) Incorporated Chitosan Hydrogel Gel Beads for the Removal of Benzoquinone from Aqueous Solution

P. Nagaraaj*[1], C. A. Aswathy[2]

[1]Department of chemistry, Anna University, Chennai, Tamilnadu-600025, India
[2]Department of chemistry, Anna University, Chennai, Tamilnadu-600025, India
[*]Corresponding author Email: nagaiitd@gmail.com

Abstract: The development of sophisticated biomaterials capable of effectively extracting dissolved organic compounds in waste water is of excellent concern for environmental remediation due to the high cost of current techniques and the continuous rise in water consumption. In this study, copper (II) incorporated chitosan hydrogel beads (Cu-CSHB) have been synthesized and used as adsorbent for water purification. Cu-Chitosan complex, morphology has been defined by electron microscopic method, confirming the material's porous nature. Adsorption capacity of Cu-CSHBs was evaluated using batch adsorption method. Quantification of organic compound in aqueous solution was determined by UV-Visible spectrometer and adsorption kinetic studies also carried out.

Keywords: Biomaterials, Hydrogel, Adsorption, Water purification.

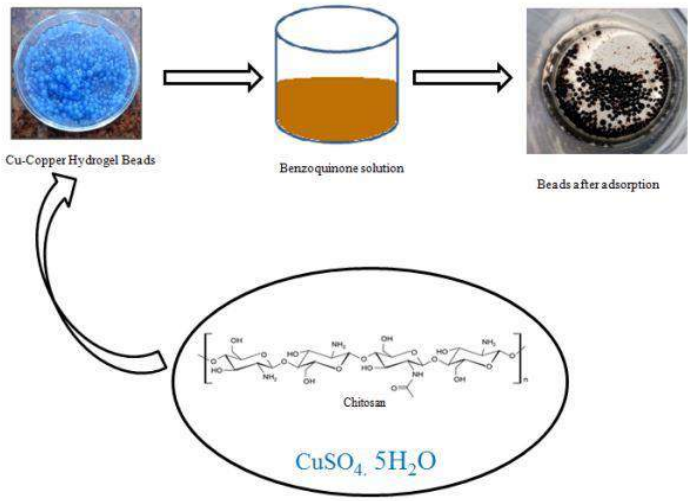

Figure 1: Schematic representation of Cu-Chitosan hydrogel bead formation and Adsorption of Benzoquinone from aqueous solution.

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PP-13:Extraction of proteins from Algal Biomass: Effect of different cell disruption methods

Khalid Mehmood*[1], Ramgopal Uppaluri [2], Vimal Katiyar[3]

[1,2,3] Chemical Engineering, IIT Guwahati, Guwahati, Assam,781039, India.
Corresponding Author , e-mail: vkatiyar@iitg.ac.in, ramgopalu@iitg.ac.in

Abstract: The algal biomass structure has been investigated to evaluate the release of proteins in alkaline media using different Protocols: Dispersed in DI water with and with out heat treament, alkaline treatment with and with out sonication and combination of homogenisation, freeze thawing and sonication. After conducting cell disruption, the protein concentration was determined for the algal biomass and the results are discussed within the context of their cell wall structure.From the study it was found that the combination of alkaline treatment with sonication yeilded maximum amount of protein than the other methods. Influence of Ultrasonication on the cell-wall of the algal biomass was reported by the SEM study.

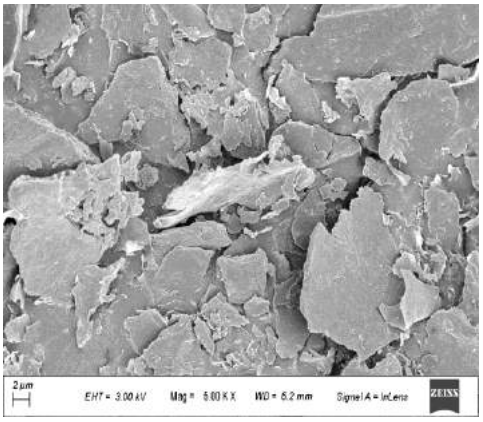

Figure 1: SEM micrographs of Algal protein powders obtained by extraction with an alkaline treatment

Keywords: *Algal Biomass, Alkaline treatment, Sonication, Protein Concentration, SEM*

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We sincerely acknowledge the Centre of Excellence for Sustainable Polymers (CoE-SusPol) at IIT Guwahati, for providing the research facilities. We also thanks to the Central Instrumental Facility, IIT Guwahati for providing characterization facilities.

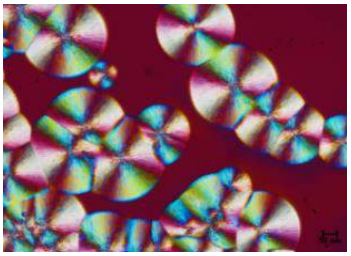
PP-14:Polylactic Acid/functionalized Gum Arabic based Reactive modified Biocomposite film: Mechanism, Mechanical and UV properties

Monika*[1], Khalid Mehmood[2], Vimal Katiyar[3]

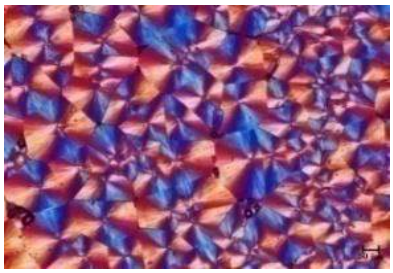
[1,2,3]Chemical Engineering, Indian Institute of Technology Guwahati, Assam-781039, India.
** Corresponding author, e-mail: vkatiyar@iitg.ac.in*

Abstract: In this work, incorporation of functionalized gum arabic (fG) into Poly (lactic acid) (PLA) is one of the effective approach because of the oligo-l lactic acid (OLLA) linked with Gum Arabic help to tune the properties in presence of dicumyl peroxide (DCP). However, melt processing is still a challenging task at elevated temperature to prevent the thermal decomposition of biocomposite. Reactive modified film of PLA/fG is fabricated with various loading of fG content in presence of free radical initiator such as DCP. Finally, fG compatiblized PLA biocomposite are characterized using morphological, mechanical and UV barrier. From the FTIR profiles, a change in chemical structure due to the formation of new C-C linkage between PLA and FG chains is noticed. The results confirmed that the compatibility and elongation at break (ε_b ~ 28%) is improved in case of DCP treated PLA-1fG. The UV-C blocking effect is remarkably improved up to ~95%, as compared to PLA which confirms its applicability in UV sensitive packaging. Polarized optical microscopy (POM) investigation shows the fG with or without addition of DCP into PLA showed nucleation effect.
Keywords: *Functionalized Gum Arabic; Dicumyl peroxide; Reactive extrusion*

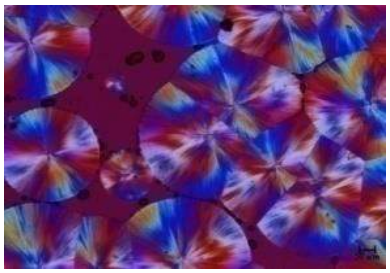
Figure 1. POM investigation of PLA, PLA-fG with or without combination of DCP after 30 min.



(PLA)



(PLA-1FG)



(DCP treated PLA-1FG)

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PP-15: Isolation and Characterization of Biological Pigment Prodigiosin from *Serratia Nematodiphila CoE-SusPol1*and Its Novel Application as Colorant for Polymers

Chethana Mudenur[1], Amit Kumar[1], Vimal Katiyar*[1]

[1] *Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India.*
** Corresponding author, vkatiyar@iitg.ac.in*

Abstract: Prodigiosin is a tripyrrole pigment molecule synthesized biologically by numerous species of bacteria. Current study focused on the isolation of bacteria capable to produce prodigiosin and to obtain the pure culture. 16S rRNA sequencing and phylogenetic analysis confirmed the isolate belong to gram negative genus *Serratia* and named as *Serratia nematodiphila* CoE-SusPol1. Further the isolate is optimized with various media components and culture conditions to achieve maximum product on solid state fermentation with 4 g/L peptone as a sole nutrient source at 30 °C, 48 h incubation. Prodigiosin is extracted using acidified ethanol to produce ~ 0.37 g/g of wet cell biomass. The extracted pigment is purified through column chromatography to obtain the purified fractions. Further the produced pigment is confirmed by UV-Vis spectroscopy (λ_{max} =535 nm), molecular weight by MALDI-TOF-MS (m/z=323.6) functional groups by FTIR and ^{1}H NMR analysis. The strain is further studied for its antibiotic resistance (MAR=0.2). The pH sensitivity is confirmed by its color change from pink to yellow. Further the prodigiosin is used as a novel antimicrobial agent for *Staphylococcus aureus* and colorant to produce transparent poly (lactic acid) (PLA) biodegradable plastic films for various plausible applications.

Keywords: *Bacterial pigment; Serratia nematodiphila CoE-SusPol1;16S rRNA sequencing, prodigiosin*

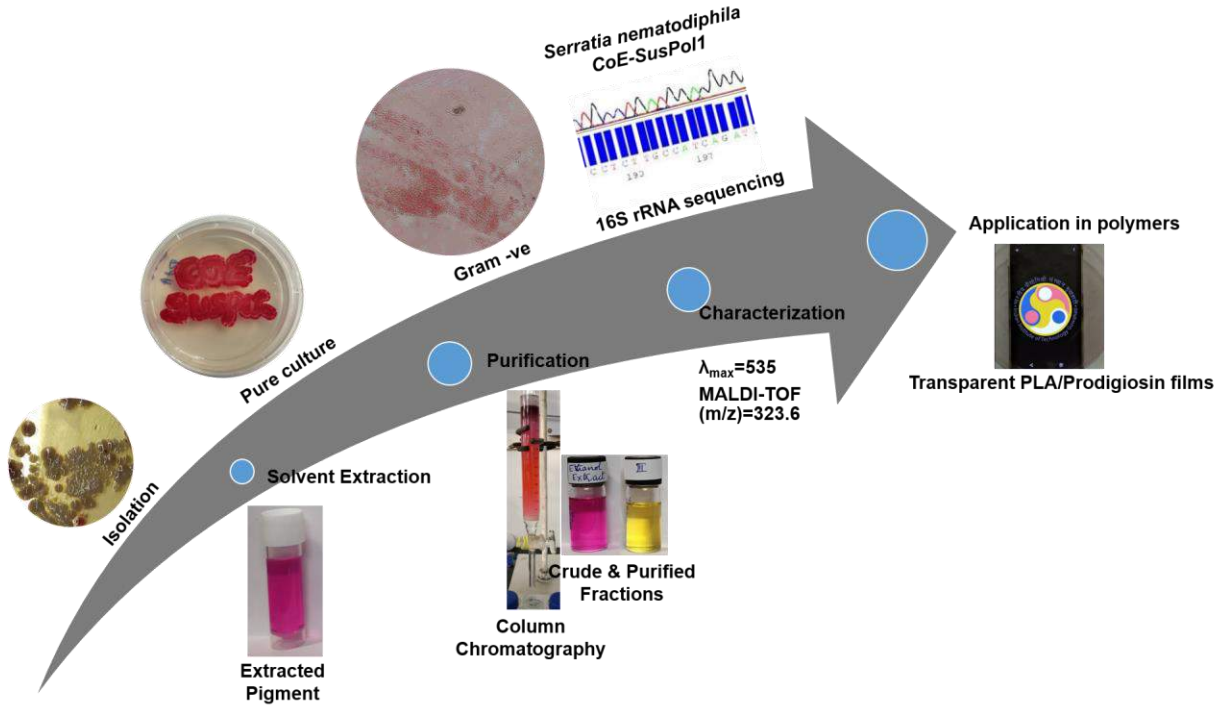

Figure 1. Isolation, extraction and characterization of the bacterial pigment prodigiosin

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PP-16:Biodegradable Polymeric Membrane for High-Power Microbial Fuel Cells.

Bhanupriya Das[1], Vimal Katiyar*[1], Chin Tsan Wang*[2]

*[*1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam- 781039, India.*
*[*2]Department of Mechanical and Electromechanical Engineering, National Ilan University, Yilan City, Yilan County-260, Taiwan.*
** Corresponding author, vkatiyar@iitg.ac.in;ctwang@niu.edu.tw*

Abstract: The main hindrance to make microbial fuel cells (MFCs) a viable technology is to obtain low cost alternative and environmentally sound materials for their components. Separator layer between anode and cathode is an essential part of the microbial fuel cell (MFC) and its property significantly influences the system performance. The performance of the dual chambered batch type MFC with newly prepared bio-based polymeric Poly vinyl alcohol (PVA) membrane and Chitosan membrane was evaluated with respect to power density and operating voltage. Higher power density was achieved in case of PVA membrane compared to commercial Nafion membrane mainly due to low internal resistance and less biofouling. A maximum power density of 180 mW/m^2 and 142.57 mW/m^2 was obtained when domestic wastewater containing mixed culture of bacteria was used in acetate medium fed MFC equipped with PVA based membrane and Chitosan membrane respectively. PVA membrane exhibited as a suitable inexpensive alternative to the costly Nafion membrane commonly used in the MFC.

Keywords: *Microbial Fuel Cell, Biodegradable membrane, Wastewater treatment, Low cost alternavtive, Wastewater management, Power Generation.*

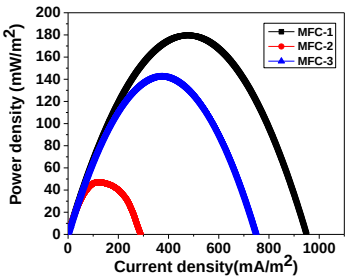

Figure 1. Power density vs current density curve of Biodegradable PVA membrane based MFC as compared to Nafion membrane

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PP-17: Melt Rheological properties of Rice Straw filled Poly(butylene succinate) Biocomposites through Melt Extrusion Process

Sayan Kumar Bhattacharjee*[1], Raghvendra Gupta[2], Vimal Katiyar[3]

[1,2,3]Department of Chemical Engineering, IIT Guwahati, Guwahati, Assam, 781039, India.
** Vimal Katiyar, e-mail: vkatiyar@iitg.ernet.in*

Abstract: In the recent decades, researchers have shown an enormous interest for the production of sustainable and renewable biodegradable polymers and their composites as the conventional petroleum derived synthetic polymers are the major sources of waste management problems [1]. Poly (butylene succinate) (PBS) is one of the most interesting and promising biodegradable aliphatic thermoplastic polyesters which is chemically synthesized by the two bio-based renewable monomers (1,4-butanediol and succinc acid) with many excellent desirable properties i.e. biodegradability, melt processability, thermal and chemical resistance. However, some properties of PBS, such as tensile strength, elastic modulus, gas barrier properties, softness, melt viscosity and its high cost hinders its extensive applications and further development [2]. Different techniques have been used for the improvement of the mechanical and processing properties of PBS, among which blending with other polymers or filling with natural fibers is an effective, easy and cost economic method. The present study involves the valorisation of rice straw (RS) for the fabrication of poly (butylene succinate) (PBS) based biocomposites through a melt extrusion method using dicumyl peroxide (DCP) as the cross-networking agent, and studies the melt rheological behaviours of the biocomposites.

Keywords: *Bio-composites; Poly(butylenes succinate); Rice Straw; Rheology*

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PP-18: Milk Quality Assessment

Akashi Baruah

Department of Chemistry, Cotton University, Guwahati, Assam, India

Abstract: Milk is considered as the wholesome or complete nutritious food with a series of physical, chemical and biological characteristics. It has some organoleptical characteristics like colour, smell, taste, texture, freezing point, pH and density. The practice of adulteration of milk reduces its quality and thereby increases the risk of consumers' ill health. Various instances of adulteration of milk have been reported locally as well as globally. FSSAI also has prescribed standards for quality milk and has declared the potential adulterants and different methods have been developed for the detection of those adulterants using different techniques like DSC, RP-HPLC, LC-GC, HPTLC, Immunoassays: CE, ELISA, FAMPST, FTIR, NIR-spectroscopy, PAGE, IEF, DNA-based methods and MALDI-MS those have been developed and employed. There is equipment for rapid tests and sophisticated instruments for complex analysis. Work and study going on for the development of distinct, easy and simple techniques for detection of the adulterants by the end users.

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PP-19: Development of Sustainable Polymer Based Bionanocomposites as a Degradable Food Packaging Material

Munmi Das [1], Nabanita Saha[2], Petr Sáha[2], Bishnupada Mandal[1],Vimal Katiyar[*1]

[1] Department of Chemical Engineering, Indian Institute of Technology Guwahati, Assam-781039, India.
[2] Centre of Polymer Systems, University Institute, Tomas Bata University in Zlin, Zlın, 760 01 Czech Republic
** Corresponding author, e-mail: vkatiyar@iitg.ac.in*

Abstract: Bacterial cellulose(BC) pellicles were produced from *Glucanobacter xylinum* culture in standard Hestrin and Schramm (H.S.) medium. A series of bacterial cellulose (BC)/poly(ε-caprolactone) (PCL) membranes have been prepared by the impregnation of PCL into dried BC mats, incubated in acetone solution for a specific time. XRD results showed an increase in crystallinity (~83%) as well as the presence of cellulose I patterns were observed in BC/PCL bionanocomposites compared with neat BC membranes. Typical BC and PCL peaks in the prepared BC/PCL bionanocomposites are confirmed by Fourier Transform-infrared(FT-IR) spectroscopy. Thermogravimetric analysis (TGA) and morphological analysis by scanning electron microscopy (SEM) showed a significant interaction between both the components, with an improvement in thermal stability of BC/PCL membranes (350 °C) as compared to neat BC (270 °C). Good sealing property of the developed novel BC/PCL bionanocomposites could be utilized for the development of biodegradable food packaging material.

Keywords: *Bacterial cellulose; Poly(ε-caprolactone); Bionanocomposites; Sustainable; Biodegradable*

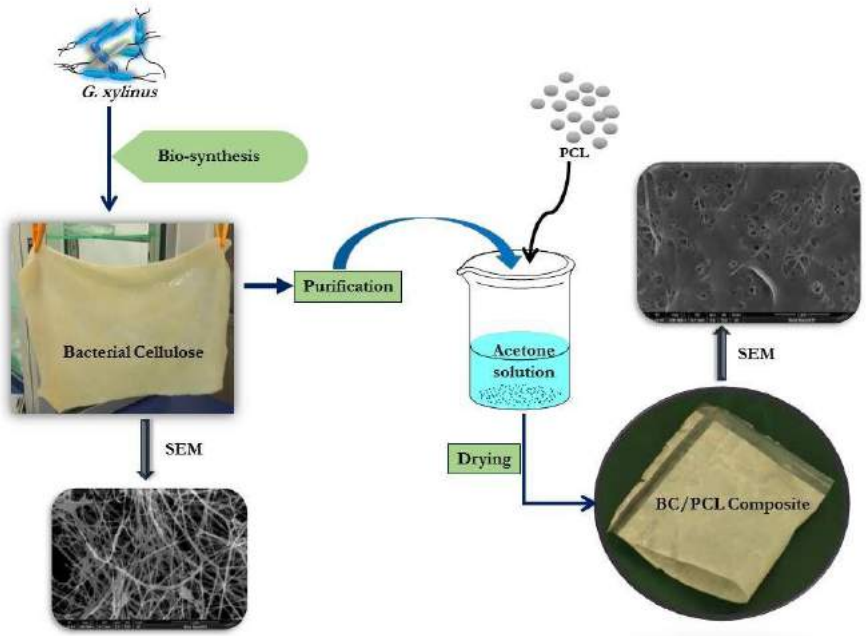

Figure 1. Biosynthesis of bacterial cellulose, followed by the preparation of bacterial cellulose based PCL bionanocomposites.

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PP-20: Development of Novel Poly(lactic acid), PLA/Algae Based Bio-Composites by Melt-Extrusion Technique

Deepshikha Das, Siddharth Bhasney, Khalid Wani, Amit Kumar, Vimal Katiyar*

Department of Chemical Engineering, Indian Institute of Technology Guwahati, Assam-781039, India
**Corresponding author, e-mail: vkatiyar@iitg.ac.in*

Abstract: Green composites with biodegradable polymer as a matrix represents a prominent area of research in the domain of polymer science. These type of bio-based composites finds its application in areas of packaging and is potential as a feedstock for the development of sustainable materials, in-particular short-term use. Melt–extrusion of polymer is mainly required for commercialization of polymeric composites. Non-uniform distribution of filler generates phase-separation and thus creating defects in extruded polymeric films. Different techniques like covalent-grafting, non-covalent wrapping, click chemistry are some of the approaches explored by different groups to address dispersion difficulties in melt-processing. In this work, we developed Poly (lactic acid) PLA/Algae based bio-composites and studied the effect of pre-treatment and master batch dilution on the properties of melt processed composites. Different characterization techniques such as fourier transform infrared spectroscopy (FTIR), gel permeation chromatography (GPC), x-ray diffraction methods (XRD) and differential scanning calorimetry (DSC) are carried out to investigate the affect of algae on the properties of PLA. The crystallinity data revealed the highest value of cold crystallinity (X_{cc} ~ 57%) of the PLA/Algae composite.

Keywords: Poly (lactic acid), Bio-composite, Packaging

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PP-21: Natural Fiber and Poly Lactic Acid based Epoxy Composites

Prasanta Baishya[1] and Vimal Katiyar[1*]

[1] Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati- 781039, Assam, India.
** Corresponding author, e-mail:vkatiyar@iitg.ernet.in*

Abstract: An effort has been made to develop solvent free natural fiber reinforced wood polymer composites using polylactic acid (PLA) and epoxy resin with great engineering aspects. The low cost bamboo powder was used as the reinforcing agent in the preparation of the PLA based composites. The epoxy resin was used for improving the interaction between the bamboo powder and PLA. Four different percentages of bamboo powder i.e., 25%, 30%, 35% and 40% have been used to optimise the fiber loading and their effects were investigated. The 40% fiber loading composites exhibited the maximum improvement in dynamic mechanical and mechanical properties. The storage modulus and hardness values were increased up to 11.46% and 7.66% respectively than the neat PLA composites. The ultimate tensile strength results revealed that the value for neat PLA has almost equal to the 40% natural fiber reinforced composites. The incorporation of 40% bamboo powder also significantly reduced the cost of the PLA based product

Keywords: *Epoxy resin; PLA; Bamboo fiber*

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PP-22: Utilization of Untreated Bacterial Cellulose for the Preparation of PLA based Bionanocomposites (PLA/OLLA-g-BC) via In-situ Polycondensation cum Solvent Casting Method

Rahul Patwa[1,2], Nabanita Saha[2*], Petr Sáha[2] and Vimal Katiyar[1*]

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam India-781039

[2] Centre of Polymer Systems, University Institute, Tomas Bata University in Zlín, Tř. T. Bati 5678, 760 01 Zlín, Czech Republic.

** Corresponding author, e-mail: vkatiyar@iitg.ac.in, nabanita@utb.cz*

Abstract: This work reports a maiden effort for the fabrication of PLA/lactic acid oligomer - grafted untreated bacterial cellulose (PLA/OLLA-*g*-BC) based bionanocomposites by in-situ polycondensation cum solvent casting technique for food packaging applications. [1,2] Untreated bacterial cellulose [3] is mixed with lactic acid and used to prepare oligomer which results in increased compatibilization between hydrophobic poly (lactic acid) and hydrophilic BC. Fourier transform infrared spectroscopy (FTIR) confirms the grafting of OLLA chains onto BC backbone through hydroxyl groups. Homogeneous dispersion of untreated BC nanospheres can be seen in bionanocomposites using TEM analysis. Fabricated bionanocomposites displayed comparable ultimate tensile strength but elongation at break (ε_b) showed ~20% improvement with 20wt% filler loading. The temperature at maximum degradation (T_{max}) for bionanocomposites was found to be comparable to PLA and above the PLA processing temperature indicating that the bionanocomposite can be used for industrially viable applications. The glass transition temperature (T_g) of bionanocomposites showed a decrease indicating towards plasticization of PLA which is highly required for flexible food packaging. The transparency studies show that the fillers in bionanocomposite films slightly reduce transparency but act as excellent UV blocking agents. The prepared bionanocomposites were hydrophobic in character with a contact angle of 102.5°. The water-vapor barrier for bionanocomposites was improved ~40% just by mere 5wt% addition, which is a significant reduction. The reduction in T_g, improvement in ε_b combined with improved hydrophobicity and water-vapor barrier make them suitable for flexible food packaging applications.

Keywords: *oligomer, bacterial cellulose, polylactic acid, in-situ polymerization, solvent casting*

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PP-23: Synthesis, Characterization and Catalytic Applications of μ3-O-Bridged Trimer that Contains Octahedrally Coordinated Mixed Valence Iron Ion Bridged by Fumarate Ligands

Anamika Talukdar*[1], Monideepa Chakrabortty[2]

[1,2] Department of Chemistry, Assam Engineering College, Guwahati-781013, INDIA
** Corresponding author, e-mail: anamikatalukdar010@gmail.com*

Abstract: A new iron complex of formula $[Fe_3O(fum)_3(H_2O)_3]_n$ where fum= $C_4H_2O_4$ has been synthesized and characterized by using various physicochemical methods such as infrared, UV-visible spectroscopy and single crystal X-ray diffraction. This polymeric complex is insoluble in common organic solvent. Crystal structure analysis reveals that it is a trinuclear oxo centered metal carboxylate complex. The adjacent iron atoms are bridged by bidentate fumarate ligands. It is a mixed valence complex in which iron atom is in 2+ and 3+ oxidation state. This type of complex shows interesting electronic and magnetic properties.

This complex has been found to display good photocatalytic activity in the egradation of some azo dyes.

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PP-24: Effect of Modified Chitosan Poly (lactic acid)/Poly (butylene succinate) Blends as Studied via Synchrotron X-Ray Scattering, DSC and XRD

Pankaj Boruah*[1], Shinichi. Sakurai[2], Raghvendra Gupta[1], Vimal Katiyar*[1]

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Assam, 781039, India
[2]Department of Biobased Materials Science, Graduate School of Science and Technology, Kyoto Institute of Technology, Matsugasaki, Sakyo-ku, Kyoto 606-8585, Japan
** Corresponding author, e-mail: vkatiyar@iitg.ac.in*

Abstract: Poly (L-lactic acid) (PLA) and poly (butylene succinate) (PBS) the polymers are gaining much attention for industrial and research applications. But these polymers are having the own merits and demerits hence blending these polymers may lead to the tunable properties. Therefore, PLA and PBS blend was prepared with varying compositions of the polymers and chitosan grafted with lactic acid oligomers (MCH) were added to it. Structure and morphology of PLA and PBS with different combinations were studied in presence of MCH by synchrotron small angle X-ray scattering (SAXS) and differential scanning calorimetry (DSC) and XRD. SAXS results reveals that the long period decreases with increases in PBS percentage and decreases with addition MCH. Information obtained about the lamellae orientation indicates the presence of dual lamellae structure which can be confirmed from the presence of two peaks on the 1-D SAXS profile. The corresponding scattering peak for qmax for PLA and PBS are 0.35 nm^{-1} and 0.61 nm^{-1} and long period of 17.5 nm and 5 nm, respectively. The decrease in long period of PLA with increases in PBS wt.% in the blends and increase in long period with the addition of MCH indicates the increase and decrease in crystallinity respectively which can also be corroborated from XRD results.

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PP-25: Valorization of Balanite Aegyptiaca (Desert Date) Seed Shell for Isolation of Crystalline Cellulose and its Characterization

Mohammed Modu Aji*[1], Gourhari Chackroborty[1], Mihir Kumar Purkait[1], Vimal Katiyar[1]

[1] Department of Chemical Engineering, Indian Institute of Technology, Guwahati, Assam 781039, India.
** Corresponding author, vkatiyar@iitg.ac.in*

Abstract: Waste utilization is one of the keys to sustainability. In this work, valorization of *Balanite aegyptiaca* (Desert Date) seed shell was done by isolation of crystalline cellulose from the agro-waste using a chemical method. Initially, an alkali treatment was used to swell the fibers, followed by a bleaching step to remove the residual lignin and finally an acid hydrolysis step to break the β-1, 4-glycosidic bonds. The result of this sequence of up-scalable chemical treatments was analysed by Fourier transform infrared (FTIR) for functional groups, thermogravimetric analysis (TGA) for thermal analysis, X-ray diffraction (XRD) for crystallinity, field emission scanning electron microscopy (FESEM) for morphological studies, scanning electron microscopy-energy dispersive X-ray (SEM-EDX) for elemental analysis. The yield of about 46% crystalline cellulose was recorded and the outcome shows a spherical morphology which differs from the common rod shape morphology. Utilization of agro-waste for crystalline cellulose has various potential application among which are membrane fabrication, food packaging, polymer nanocomposites and biomedical.

Keywords: *Balanite aegyptiaca; valorization; Desert date; Crystalline cellulose; Seed shell.*

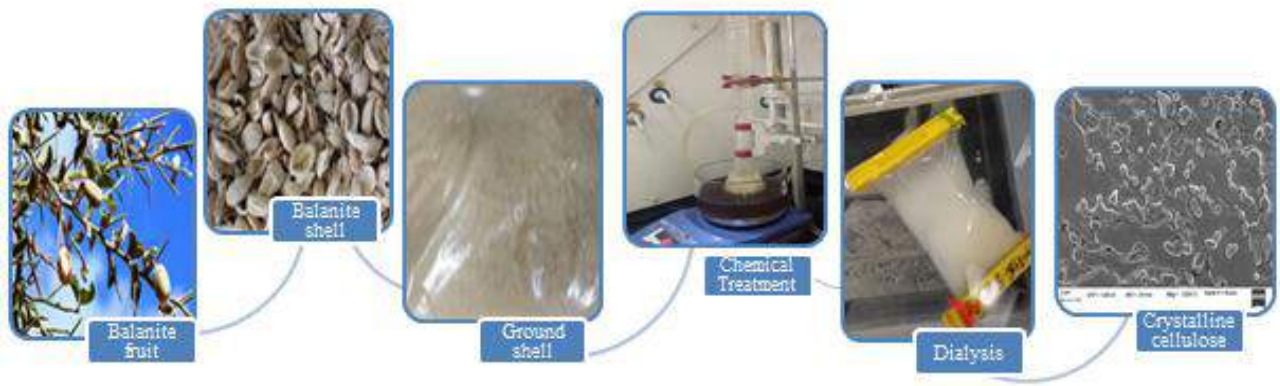

Figure 1. Graphical abstract showing the schematic representation of the process

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PP-26: Process Intensification strategies for opticalluy pure D-Lactic acid: A Sustainable Biobased Monomer Production Process

Kiran Kumar Gali[1,2], Vimal Katiyar[2*] and Senthilkumar Sivaprakasam[1,2*]

[1] BioPAT laboratory, Department of Biosciences and Bioengineering, Indian Institute of Technology Guwahati.
[2] Centre of excellence for Sustainable Polymers, Department of Chemical Engineering,
Indian Institute of Technology Guwahati, Guwahati, Assam-781039 India
** Corresponding author, e-mail: vkatiyar@iitg.ac.in, senthilkumar@ iitg.ac.in*

Abstract: Process Intensification strategies are necessary to achieve the desired economic and environmental aspects in any biobased production process. The design and operation of such strategies will enhance the productivity and sustainability of the process especially in integrated mode. Fermentative production is preferred in industries because of its stereospecificity and selectivity of bioresources. The biobased method involves three major process hydrolysis, fermentation and purification. The enzyme recovery is a major hurdle in hydrolysis, fermentation is hindered by consumption of large volumes of alkali for acid neutralization and its subsequent salt disposal. Lactic acid purification is hampered by its strong affinity towards water and its low volatility, which makes its separation by solvent extraction or distillation highly difficult. All these issues were addressed in a sustainable manner to make the process more efficient in a greener way. This process model would become an attractive alternative to the conventional method as it reduces capital savings, improves conversion of reactants, improved selectivity of desired products, reduced catalyst requirement, reduced by-product formation, and heat integration. The preliminary results are very promising and need to be validated further.

Keywords: *D-Lactic acid, Process Intensification, Fermentation.*

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Biosynthesis of heparosan, a precursor for heparin polysaccharide in recombinant *Bacillus spp.*

Ganesh Nehru[1*], Subbi Rami Reddy Tadi[1], Senthilkumar Sivaprakasam[1#]

[1]. Department of Biosciences and Bioengineering, IIT Guwahati, Assam-781039, India
 # Corresponding author, e-mail:senthilkumar@iitg.ernet.in

Abstract: Heparosan is a commercially valuable biopolymer used for various biomedical applications. Heparosan is synthesized by polymerization of two nucleotide sugars UDP-glucuronic acid and N-acetylglucosamine by the enzyme complex (*kfiC* and *kfiA*). *Escherichia coli* K5, the native heparosan producer is a known human pathogen and hence discourages its use in heparin synthesis followed by subsequent use in healthcare industry. It would be advantageous to develop alternative sources for heparosan production using a non-pathogenic strain. In this present study, we reported the production of heparosan *via* metabolic engineering of *Bacillus spp*. as a production host. The key genes, *kfiC* and *kfiA* derived from *E. coli* K5 were cloned and expressed in a polycistronic manner. The yield of heparosan was low due to the polycistronic expression system. The enhancement of heparosan yield was aimed by developing a dual promoter expression system, where *kfiC* and *kfiA* would be cloned independently under each promoter. Significant increase in the heparosan yield was achieved. Furthermore, homolog of the rate limiting enzyme *kfi*D, which encodes for UDP-glucose dehydrogenase was expressed to enhance the heparosan production. Further, *Bacillus spp*. derived heparosan was characterized by ^{1}H-NMR and ^{13}C-NMR. This study establishes an effective process for the production of heparosan as a precursor of bioengineered heparin using a generally regarded as safe organism.

Keywords: *Heparosan, polysaccharides, Bacillus, Heparin*

Preparation of Cellulosic Magnetic Particles for Controlled- Stimuli Responsive Drug Delivery

Somashree Mondal, Gourhari Chakraborty, Surendra Singh Gaur, Vimal Katiyar*

Department of Chemical Engineering, Indian Institute of Technology Guwahati
**Corresponding Author: vkatiyar@iitg.ac.in*

Abstract: Magnetic Particles are emerging as a new class of material which has wide range of applications owing to its different properties, morphology and responsive nature to magnetic field. Its applications spread to different fields like catalyst, adsorbant, drug delivery, magnetic fluid, smart fluid preparation, packaging etc. Magnetic materials are enhanced by using different templates like graphene oxide, carbon nano tube, cellulose nano crystal, micro crystalline cellulosel(MCC) etc. This enhances the morphology of the magnetic particles, and it dispersion of iron oxides over the different templates. There are various synthesis routes that has been and are being explored, namely, coprecipitation method, hydrothermal method, reduction. In this work MCC is used as a template to prepare ferro-magnetic material. Hydrothermal route has been adopted for preparation of Magnetic MCC. Morphology and magnetism of the sample were investigated in order to study the regularity in morphology and various magnetic properties of the magnetic MCC. FESEM, FETEM and VSM analysis showed successful synthesis of well dispersed and ferro-magnetic MCC. This MCC can be future utilized for contollled- stimuli responsive drug delivery.

Keywords: Micro Crystalline Cellulose, Hydrothermal Method, controlled-drug delivery.

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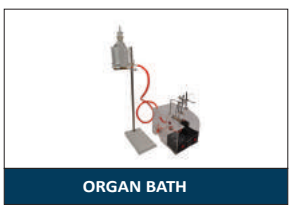
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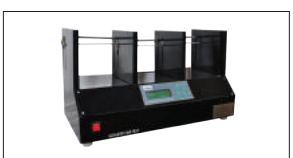
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