



**conference**series.com



**conference**series.com  
655<sup>th</sup> Conference

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Scientific Tracks & Abstracts (Day 1)



3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Political landscape for bioplastics and biobased materials

**Rina Singh**

Biotechnology Innovation Organization (BIO), USA

There continues to be an increased interest in synthesizing renewable chemicals from renewable resources, even with the downturn in economy, which has slowed down the time it takes to reach commercial reality, but there still continues to be partnerships and business deals in the making. As a result of the early commercialization of renewable chemicals such as 1,2-propyleneglycol, 1,3-propanediol, bioethanol, polylactic acid (PLA), polyhydroxyalkanoates (PHA), and more recently, polyethyleneterephthalic acid (PET), this has encouraged interest nationally and internationally to further build on these early successes. Investments through partnerships are occurring globally involving multitude of startup companies, and amongst mature chemical companies engaged in building their product portfolios. There is interest in complementing existing product pipelines from incumbent technologies with renewably derived products from renewable sources, providing options for consumers to select sustainable products. Now there are both federal and state policies encouraging the growth in this sector, which once, were only in discussion stages. The presentation will focus on the policies impacting the growth of the sector, and will provide the commercial status of building blocks for bioplastics and biobased materials.

### Biography

Rina Singh is director of policy in the industrial biotechnology and environmental section of the Biotechnology Industry Organization (BIO). She previously served as the business development manager at Ashland Inc. She was appointed by the president and CEO as member of an innovative 10-member team assembled to develop a new strategic direction for Ashland, identifying investment opportunities for \$1.5 billion resulting from divestiture of petroleum refining operations. She held general management positions in the technology and business development areas of Ashland, including bioproducts business development manager and platform technology manager. She started her career at The Dow Chemical Co. as a senior research chemist in the Engineering Thermoplastics Group. The holder of 24 patents and publications, Singh received a B.S., a doctorate in natural products (synthetic organic chemistry) and a post-doctoral degree in polymer science from McGill University.

rsingh@bio.org

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Biopolymer based bionanocomposites

**Chang-Sik Ha**

Pusan National University, Korea

We have prepared several biopolymer based bionanocomposites for years. Those biopolymers include chitosan (CS), poly(lactic acid), or poly(hydroxyethylmethacrylate), etc., while partner polymers or inorganic fillers for bionanocomposites include clay, graphene oxide, carbon nanotube, and silver, etc. to prepare those bionanocomposites. A series of works on the bionanocomposites will be discussed in this talk. Here, one example is the CS containing bionanocomposites. CS is a biocompatible, biodegradable, and non-toxic natural polymer and has applications in wound healing, tissue repair, antimicrobial resistance, cell adhesion, and food delivery. In this presentation, we report the facile synthesis of hierarchical mesoporous bio-polymer/silica composite materials with bimodal mesopores using a dual-template of the cationic N,N,N-trimethyl chitosan (TMCs) and the anionic sodium dodecyl sulfate (SDS) via one-step synthetic strategy. The mesoporous bio-polymer/silica composites encapsulate a large number of guest drug molecules, Ibuprofen (IBU) or 5-fluorouracil (5-FU), due to their high surface area and pore volume. In addition, the mesoporous chitosan-silica composites also had a long term biocompatibility for the target release of the drug molecules to the CEM cells and MCF cells etc. as well as a pH sensitive controlled release behavior of the drug molecules. We also present functionalized graphene oxides (GO) with chitosan (FGOCs). FGOCs were found to significantly improve the solubility of the GO in aqueous acidic media. And more topics using other biopolymers will be dealt with in this talk.

## Biography

Chang-Sik Ha has completed his PhD from Korea Advanced Institute of Science and Technology (KAIST), Seoul, Korea (1987). He has joined the Department of Polymer Science and Engineering, Pusan National University as a Professor in 1982. He is now a Director of the Pioneer Research Center for Nanogrid Materials. He has served as a Vice President of Pusan National University in 2012. He has served as an Editorial Board Member of several international journals including Associate Editor of the *Advanced Porous Materials* as well as an Associate Editor of the *Composite Interfaces*.

csha@pnu.edu

## Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Supramolecular templating of tunable peptide-melanins

**Ayala Lampel**

City University of New York, USA

Melanins are pigments shared across the living world, serving key functions including UV protection, coloration and free radical scavenging. These properties are of value in technological applications, however, despite progress, biological melanin formation, involving controlled catalytic oxidation of tyrosine residues directed by reactant compartmentalization, is poorly understood- limiting production of synthetic melanins with desired properties. We demonstrate that sequence design in tyrosine containing tri-peptides gives rise to precise control over tyrosine accessibility, reactivity and presentation, allow for the oxidation and polymerization pathway to be controlled. In this approach, the supramolecular order of tri-peptides provides a template for the formation of low cost, solution processed, biodegradable, minimalistic melanin-inspired materials with tunable electrical and optical properties.

### Biography

Dr. Ayala Lampel is a postdoctoral research associate in Prof. Rein Ulijn's research group in the Nanoscience Initiative at CUNY ASRC, and an awardee of an Israeli Council for Higher Education Postdoctoral Fellowship. Her work is focused on functional supramolecular materials design for biological systems. Prior to this, Ayala received her PhD in Biotechnology at Tel Aviv University, with Prof. Ehud Gazit, focusing on the viral capsid assembly process and antiviral design tools, and a BSc in Neuroscience (BSc Program in Neuroscience for Outstanding Students, Tel Aviv University).

lampelayala@gmail.com

**Notes:**

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Free radical polymerization of acrylic monomers from plant oils

**Andriy Voronov**

North Dakota State University, USA

Most currently available synthesis of polymers from plant oils are limited to polycondensation and oxypolymerization. Both mechanisms result in formation of exclusively cross-linked polymers, widely applicable in industrial coatings. Because of highly hydrophobic nature of triglyceride molecules, the development of waterborne polymeric materials (in particular, latexes) from plant oils has been challenging. One-step method converts fatty acid esters of vegetable oils into bio-based acrylic monomers for free radical polymerization. While the vinyl bond of these monomers is reactive in conventional addition chain polymerization and facilitates macromolecular chain growth, the double bonds of the fatty acid chains are unaffected during the free radical polymerization. Currently exemplified for soybean, linseed, sunflower and olive oil (possessing remarkably different compositions of fatty acids in triglycerides) monomers can be applied in the production of latexes that utilize acrylic monomers and polymers. The plant oil-based monomers offer unique functionality due to nature of double bonds, which allows forming linear macromolecules as well as "on-demand" cross-linking, and provides an ability to tune final material properties, including hydrophobicity. The reactivity ratios of the synthesized monomers in free radical copolymerization with petroleum-based counterparts, as well as their  $Q-e$  parameters, indicate that new monomers behave in copolymerization as conventional vinyl monomers. The resulting copolymers are capable of post-polymerization oxidative reactions to form cross-linked polymer structures, or of modification of unsaturated fatty acid chains. Specifically, degree of unsaturation in fatty acids are utilized as a criterion for comparing monomers behavior in addition chain polymerization and copolymerization to yield biobased polymer latexes.

### Biography

Andriy Voronov has completed his academic education in Ukraine, an MS in Chemical Engineering in 1990 and a PhD in Polymer Chemistry from Lviv Polytechnic National University in 1994. He received tenure and was promoted to Associate Professor at Coatings and Polymeric Materials in 2013. He was an Alexander von Humboldt Research Fellow at the University of Bayreuth, Germany, Visiting Scientist at Vienna University of Technology in Austria, Visiting Fellow at the University of Ulm, Germany and Institute Charles Sadron, CNRS, Strasbourg, France. He has published more than 90 articles, 8 book chapters and has filed 7 patents/patent applications.

andriy.voronov@ndsu.edu

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## The development of nonabsorbed potassium binding polymer microparticles (patiromer) for the treatment of hyperkalemia

**Bo Chen**  
Relypsa Inc., USA

**H**yperkalemia is a potentially life-threatening condition, and patients who have chronic kidney disease, who are diabetic, or who are taking renin-angiotensin-aldosterone system inhibitors are at increased risk. Therapeutic options for hyperkalemia tend to have limited effectiveness and can be associated with serious side effects. There are no new therapeutics for more than 50 years. Patiromer (USAN, trade name Veltassa) is a novel, spherical, nonabsorbed polymer designed to bind and remove potassium, primarily in the colon, thereby decreasing serum potassium in patients with hyperkalemia. The development process and the results of preclinical studies and early phase clinical study are reported here. Overall, patiromer is a high-capacity potassium binder and the chemical and physical characteristics of patiromer can lead to good clinical efficacy, tolerability and patient acceptance. It has been approved in 2015 by FDA used for the treatment of hyperkalemia.

### Biography

Bo Chen is a Principal Scientist in Relypsa focusing on microparticles as toxin binders for various diseases. After his PhD in 2006 from New York University School of Engineering, and Post-doctoral studies from University of California San Francisco in 2009, he started his Sanofi-Genzyme career in Biomaterials and Drug Delivery Division. He left as a Senior Scientist in 2014 and joined biotech company CPGJ (Shanghai) as an Associate Director, later in GrayBug Inc. He has broad experience in Antibody Drug Conjugate (ADC) and Drug Delivery. He has published more than 20 papers/patents. He has been serving as a Guest Editor of *Current Cancer Drug Targets* since 2014.

bchen2@relypsa.com

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Cellulose dissolution: Promising approach for the preparation of composite materials

Noureddine Abidi, Sanjit Acharya, Poorna Wansapura, Niwanthi Dissanayake, Yang Hu and Rohan Dassanayake  
Texas Tech University, USA

Cellulose is the most abundant natural polymer on earth. Cotton fiber is composed of 95% of cellulose. The dissolution of cellulose represents the first key step for most applications of cellulose and it is highly affected by its degree of polymerization (DP). Due to the high DP (9000-15000), the dissolution of cellulose is difficult to achieve under relatively mild conditions. Cellulose is a very stable polymer as it plays a crucial role in the structural soundness of plants. This stability makes it particularly difficult to deconstruct. The degree of insolubility is due to its chemical and physical structure. In order for dissolution to occur, a solvent must be able to penetrate between microfibrils and cellulose chains. The extent of the use of cellulose to develop an economically sustainable renewable bioproducts industry is limited due to its inefficient and incomplete dissolution in most common solvents. In this paper, we report on the dissolution of cellulose in three solvent systems: NaOH/urea, DMAC/LiCl and 3-butyl 1-imidazolium chloride ionic liquid (BmimCl). Microcrystalline cellulose and cotton fibers were used as source of cellulose. Cellulose was dissolved in NaOH/urea, DMAC/LiCl and ionic liquid (3-butyl 1-imidazolium chloride) followed by regeneration in water. Films and aerogel materials were formed from the cellulose gel. Electron scanning microscopy, Fourier transform infrared spectroscopy, BET, wide angle X-ray diffraction, were used to characterize the morphology, functional groups, surface porous morphology and crystallinity.

### Biography

Noureddine Abidi is Associate Professor and Associate Director of the Fiber and Biopolymer Research Institute at Texas Tech University. He holds a "Habilitation à Diriger des Recherches" from the University of Haute Alsace in France and a PhD from the University of Montpellier II in France. He has generated more than 58 refereed journal publications, 1 book, 10 book chapters, more than 123 conference papers, 1 patent, 1 provisional patent, and 6 invention disclosures. His research focuses on the characterization of biopolymers using advanced techniques to the development of bioproducts from biopolymers.

noureddine.abidi@ttu.edu

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Synthesis of biobased nano composite materials: Metal nano particles stabilized in soy bean oil polymer

**Baki Hazer**

Bülent Ecevit University, Turkey

Polyunsaturated plant oils have gained great interest as monomers to produce biodegradable polymers obtained from renewable resources due to the limited existing sources of petroleum oil and environmental issues. Among them, soybean oil is a triglyceride of saturated and poly unsaturated fatty acids which can be polymerized via autoxidation by exposure to atmospheric oxygen at room temperature. Precious metals can catalyze the autoxidation process of unsaturated oils increasing the molecular weight with peroxide linkages in order to obtain soy oil polymer. The polymeric oil was fractionated by the extraction from the solvent-non-solvent mixture  $\text{CHCl}_3$ /petroleum ether with the volume ratio of 5:15. Three polymeric oils fractions with different molecular weight (ca. 1000, 4000, and 40,000 g/mol) were obtained. Surface plasmon resonance and fluorescence emission of the nanocomposite solutions were observed. Transmission electron microscopy was used to determine size and shape of the metal nano particles. This macro peroxide initiator containing metal nanoparticles was used in free radical polymerization of some vinyl monomers in order to obtain olefin polymers containing metal nano particles. The detailed characterization of the composite materials was performed by NMR, FTIR, GPC, DSC and other physicochemical characterization methods.

### Biography

Baki Hazer received his PhD degree from the Department of Chemistry, College of Arts and Sciences, Karadeniz Technical University in 1978, and his MS and BS degrees in Chemical Engineering from the College of Chemical Engineering, University of Istanbul in 1972. He had an honorary membership by the Turkish Chemical Society in May 2005. He received Fulbright Fellowship and the NATO Collaborative Research Grant at the Department of Polymer Science and Engineering, University of Massachusetts, Amherst. He was a Visiting Scientist for the NSF joint research project at The University of Akron. He is specialized in polymers from renewable sources, block and graft copolymers, macromonomeric initiators. He has published more than 140 papers in reputed journals.

bkhazer@beun.edu.tr

### Notes:



3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Multilayer core-sheath nanofiber scaffolds used in the differential release of bioactive molecules

Dula Man, B Sansbury and R Wu  
Delaware State University, USA

The core-sheath nanofiber and hydrogel exhibit great potential in drug delivery field. It is desirable to differentially control the release rate of different drugs from the same drug delivery vehicle. Biocompatible and biodegradable materials, polycaprolactone (PCL) nanofibers and alginate hydrogels, play a significant role in both designing controlled release matrix for cell culture and tissue growth. Although prolonged release of bioactive molecules is readily achievable using these polymer materials independently as a matrix, it is not seen how to release various bioactive molecules at a different rate over a different length of time. In this study, we fabricated a multilayer PCL-PEO core-sheath nanofiber scaffold in combination with sandwiched layers of either alginate hydrogel or uniaxial electrospun PCL-gelatin nanofiber layers, and evaluated its controlled release property. Adenosine triphosphate (ATP) or glucose was encapsulated in the PEO core of the core-sheath nanofibers, and the release kinetics was studied. We demonstrated that ATP release from the exposed top layer of the scaffold has higher burst release and shorter release time compared to that from deeper layers in the scaffolds. Such a differential release property of designated layers can be employed to achieve releasing of multiple drugs at different rates over a different length of time.

### Biography

Dula Man is an Assistant Professor at Delaware State University. He has completed his PhD in Molecular Biology from the University of Texas at El Paso, and Post-doctorate at University of California Irvine. He has navigated the science fields from molecular biology, biochemistry, structural biology, DNA repair, genome editing to nanomaterial engineering. He has published numerous refereed papers.

dman@desu.edu

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Reactive extrusion and in situ compatibilization of poly lactic acid and poly glycerol succinate: A sustainable way for toughening of PLA

Manjusri Misra<sup>1,2</sup>, Oscar Valerio<sup>1,2</sup>, Jean-Mathieu Pin<sup>2</sup>, and Amar Mohanty<sup>1,2</sup><sup>1</sup>School of Engineering, University of Guelph, Canada<sup>2</sup>Bioproducts Discovery and Development Centre, University of Guelph, Canada

Glycerol is the primary co-product of biodiesel production with an estimated worldwide production of about 6 billion lbs per year by 2020. This biobased molecule is envisioned as a precursor for polymer synthesis among many other chemical syntheses which can be performed using glycerol as starting molecule. Succinic acid is a dicarboxylic acid which can now be commercially obtained from renewable resources through fermentation of biomass derived sugars. When these two monomers are combined, a biobased polymer termed poly glycerol succinate (PGS) is formed which has not yet found applications in the material science field limiting its adoption at commercial scale. In this work we have synthesized and employed PGS as a blending partner for PLA aiming to improve the tensile toughness of the blend system. The influence of the main synthesis parameters for PGS (molar ratio of reactants, monomer type and temperature of synthesis) in the mechanical behavior of PLA/PGS blends was investigated and a preferred set of synthesis conditions leading to an effective PLA toughening has been selected. Moreover, reactive extrusion has been performed utilizing free radical initiators in order to improve the compatibility of the phases in the blend. For this purpose a third monomer, maleic anhydride, was employed in the synthesis to create unsaturated poly glycerol succinate co maleate (PGSMA) polyesters which allows them to react from the unsaturation point in subsequent processing steps. It was seen that the addition of maleic anhydride as a monomer for the synthesis of PGSMA allows for the in situ compatibilization of PLA and PGSMA phases through the formation of PLA-g-PGSMA copolymers. With the in situ compatibilization effect taking place an effective toughening of PLA was achieved increasing the elongation at break of the blend from 3% for neat PLA to 150% for an 80/20 wt% PLA/PGSMA blend created in reactive extrusion mode.

### Biography

Manju Misra is a professor in the School of Engineering and holds a joint appointment in the Dept. of Plant Agriculture at the University of Guelph. Dr. Misra's current research focuses primarily on novel bio-based composites and nanocomposites from agricultural and forestry resources for the sustainable bio-economy targeting the development of bio-based and eco-friendly alternatives to the existing petroleum-based products. She has authored more than 500 publications, including 280+ peer-reviewed journal papers, 24 book chapters, and 15 granted patents. She was an editor of the CRC Press volume, "Natural Fibers, Biopolymers and Biocomposites," Taylor & Francis Group, Boca Raton, FL (2005); American Scientific Publishers volume "Packaging Nanotechnology", Valencia, California, (2009) and "Polymer Nanocomposites", Springer (2014). She was the chief editor of "Biocomposites: Design and Mechanical Performance" Woodhead Publishing (2015). She was the 2009 President of the BioEnvironmental Polymer Society (BEPS). She is one of the Associate Editors of the journal "Advanced Science Letters". In 2012, Dr. Misra received the prestigious "Jim Hammer Memorial Award" in Texas, USA from the BioEnvironmental Polymer Society.

mmisra@uoguelph.ca

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Production of an antimicrobial edible casein-based material

Elodie Chevalier<sup>1,2</sup>, Gilles Assezat<sup>1</sup>, Frédéric Prochazka<sup>1</sup> and Nadia Oulahal<sup>2</sup><sup>1</sup>Université de Lyon, France<sup>2</sup>Université Claude Bernard Lyon, France

Caseins constitute 80% of milk proteins and have great potential for producing protein-based edible films. Several problems need to be solved before casein films can be widely commercialized. For example, the high moisture sensitivity (easy adsorption and release of water molecules which act as plasticizer and affect mechanical properties) has to be controlled and the production costs due to production method have to be reduced. The goal of the present study is to obtain edible, and antimicrobial casein-based materials. The first targeted application is the development of edible labels to put on cheeses. These labels should keep a good readability during cheese ripening and commercialization, in order to guarantee the traceability of these cheeses but without sensory changes for cheeses. The current process used to produce cheese labels is a batch process implying high pressures and high temperatures during several hours, which is not compatible with thermolabile antimicrobial compounds addition. With extrusion, which is a continuous process, temperature and residence time can be adapted to preserve the activity of antimicrobial compounds added in the formulation. Casting of film forming suspensions on flat surfaces and their subsequent drying to prepare films is adequate for laboratory use and, perhaps, is sometimes also suitable for batch production. However, more efficient techniques are needed for commercial films production. Association of dairy food knowledge and polymers production processes allows a new continuous process at relatively low temperature (less than 100°C) which allows production of active films made of rennet caseins and organic acids or their salts.

### Biography

Elodie Chevalier is a 2<sup>nd</sup> year PhD student working at the University of Saint Etienne in the laboratory called IMP (Polymer Materials Engineering) with Frédéric Prochazka and also working in the laboratory called BioDyMIA (Bioengineering and Microbial Dynamics at Food Interfaces) with Nadia Oulahal. Prior to beginning of PhD program, she completed an Engineering degree in Biology as well as a Master's degree in Biotechnology at the University of Technology of Compiègne (France).

chevalier.elodie02@gmail.com

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Facelift of PLLA: Effect of orientation on physical ageing in Poly(L-Lactic Acid) films

Gagik Ghazaryan<sup>1,2</sup>, Raphael Schaller<sup>1</sup>, Kirill Feldman<sup>1</sup> and Theo A Tervoort<sup>1</sup><sup>1</sup>ETH Zurich, Switzerland<sup>2</sup>Swiss Federal Laboratories for Materials Science and Technology, Switzerland

Poly(L-lactic acid) (PLLA) is a slow-crystallising polyester which exhibits brittle behaviour due to relatively fast physical ageing of the amorphous phase. This embrittlement of PLLA narrows its application window in such fields where flexibility of a polymer is required (e.g., packaging). In this study, we investigated the effects of thermal rejuvenation and molecular orientation of the amorphous phase on physical ageing of oriented PLLA films with emphasis on mechanical properties. Uniaxial compression testing showed that physical ageing of the amorphous phase increases the yield stress and the associated strain softening response, both contributing to the observed embrittlement of PLLA in tension. Moreover, the strain-hardening response was found not to be influenced by physical ageing. Molecular orientation of the amorphous phase at constant crystallinity was applied by uniaxial and biaxial plastic deformation just above the glass-transition temperature (at 70°C) up to modest plastic strains of 200%, to avoid strain-induced crystallisation. Stress-relaxation experiments combined with tensile testing both as a function of ageing time have revealed that both uniaxial and biaxial plastic deformation in excess of 100% plastic strain, decelerates and possibly prohibits the physical ageing process. The oriented monofilaments and films have improved mechanical properties, such as stiffness, strength and strain-to-break. The latter properties were not affected by physical ageing during a testing period of 40 days. In addition, plastic deformation to higher draw ratios and/or at slightly higher temperatures (90°C), strongly enhanced crystallinity and resulted in PLLA monofilaments and films that also exhibited tough behaviour not affected by physical ageing.

### Biography

Gagik Ghazaryan is a 3<sup>rd</sup> year PhD student at the Swiss Federal Institute of Technology Zurich (ETH Zurich), working in the group of Soft Materials. He is also affiliated to the Swiss Federal Laboratories for Materials Science and Technology (Empa) in St. Gallen, Switzerland. He completed his MSc degree in Desalination and Water Treatment at the Ben-Gurion University of the Negev, Israel.

gagik.ghazaryan@mat.ethz.ch

### Notes:



**conference**series.com



**conference**series.com  
655<sup>th</sup> Conference

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Scientific Tracks & Abstracts (Day 2)



3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Biopolymers in flavor and fragrance delivery systems

**Johan Pluyter**

International Flavors and Fragrances, USA

The use of microcapsules in fragrance has become a key technology in home care (fabric softeners and detergents) and personal care (antiperspirants/deodorants) to enable efficient delivery of fragrances during the product use. The aim of this study is to obtain performance benefits such as long lasting release of the fragrance, a higher quality long lasting fragrance (lasting freshness), and fragrance release during handling of wet and dry fabrics, release of fragrance during enhanced physical activity of the wearer, and enhanced bloom during application. As such, a key aspect of the microcapsule performance is to deposit as many capsules as possible during product application. Another challenge is minimizing the fragrance diffusion out of the capsules into the consumer product as this negatively impacts shelf life and transportation in hot climates. However, it is imperative that the fragrance is released during use of the product and wear of the substrates. Biopolymers are used in many facets of encapsulation of flavors and fragrances. Biopolymers are used in encapsulation techniques based on complex coacervation (gelatin), spray drying (starch), and emptied cells (yeast, spores). Furthermore, biopolymers are used as dispersants/emulsifiers in encapsulation (i.e. beverage emulsions), as rheology modifiers in aqueous-based microcapsule dispersions. In addition, biopolymers or modified biopolymers can be used to modify capsule surface as to improve their deposition ability in rinse-off applications (detergent, shampoo, hair conditioner and body wash). This study will provide an overview of flavor/fragrance encapsulation as well as examples of where biopolymers and biobased materials are being used.

### Biography

Johan Pluyter has completed his PhD at the University of North Carolina at Chapel Hill in Physical Chemistry with an emphasis in Polymer Science. Following his PhD, he worked at Procter & Gamble. Next, he lead physical, polymer and colloid characterization at National Starch and Chemical Company (under Unilever and ICI). Since 2002, he leads research in delivery systems at International Flavors and Fragrances (IFF) where he is a Senior Research Fellow. He is inventor and co-inventor of 21 granted US patents and many pending applications.

johan.pluyter@iff.com

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Development of bio-based plywood adhesive utilizing protein recovered from hydrolyzed specified risk materials

Birendra B Adhikari, Michael Chae and David C Bressler  
University of Alberta, Canada

Currently, production of composite wood products relies almost exclusively on petrochemical-based resins, more specifically the formaldehyde-based resins, as adhesives. As petrochemicals are obtained from non-renewable resources and formaldehyde is a known carcinogen, this research was conducted with the aim to develop a formaldehyde-free plywood adhesive system utilizing waste protein as a renewable feedstock. The feedstock for this work was specified risk material (SRM), which constitutes the bovine tissues that are completely banned from any food, feed, and fertilizer applications, and are being disposed of either by incineration or landfilling with severe environmental and economic impacts. In this study, we developed a technology for utilization of SRM protein in value-added applications. In particular, the SRM was thermally hydrolyzed, protein fragments were recovered from the hydrolyzate, and the recovered protein fragments were chemically crosslinked with polyamidoamine-epichlorohydrin (PAE) resin to formulate an adhesive system for bonding of veneer sheets to make plywood specimens. The effects of crosslinking time, the ratio (wt/wt) of protein fragments and PAE resin in the formulation, and hot pressing temperature on the strength of resulting plywood specimens were investigated by lap shear strength testing method. Adhesive formulations consisting of as much as 78% (wt/wt) protein fragments met the minimum requirements of ASTM specifications for urea formaldehyde resin type of wood adhesives in dry as well as soaked conditions. Under optimal conditions of specimens preparation, some formulations yielded plywood specimens having shear strength comparable to that of commercial phenol formaldehyde resin in both dry and soaked conditions.

### Biography

Birendra B Adhikari has completed his PhD in Chemistry from Saga University, Japan, and Post-doctoral studies in Chemistry from California State University Long Beach, CA, USA. Currently, he is pursuing another Post-doctoral studies in Bioresource Engineering at University of Alberta, AB, Canada. His research experiences lie in multidisciplinary areas combining organic and analytical chemistry as well as chemical and bioresource engineering. He has published 16 papers as the first author, and has shared authorship in 15 papers in reputed peer reviewed journals.

badhikar@ualberta.ca

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Creation of keratin resin and fibroin resin using fibrous animal waste products

Shinji Hirai

Muroran Institute of Technology, Japan

Keratin resin and fibroin resin have been prepared from silk or hornet silk powder, composed of fibroin protein, and from wool or chicken feather powder, composed of keratin protein, respectively, by heating at 100–180°C under pressures of 20–40 MPa. The mechanically ground powders of wool waste or chicken feathers and pulverized waste silk, all of which are waste materials, can be used as the raw materials. In the case of wool, woven wool fabric also serves as a raw material after removal of the cuticle layers. For resinification, the powder was simply placed in a jig; in the case of woven fabric, it was stacked into the jig after punching to the size of the jig and was then heated under pressure using a hot press. The resins derived from silk or wool powder showed glass transition temperatures close to 200°C and three-point bending strengths and flexural moduli superior to those of polycarbonate resins. On the other hand, the resin derived from wool powder had a very small expansion coefficient, with a value comparable to metals such as copper or aluminum. Moreover, the three-point bending strength of the resin derived from woven wool fabric increased to 116 MPa. Furthermore, upon applying stress to the resin, reversibility to woven fabric was observed, resulting in excellent impact resistance that is superior to that of ABS resin. Compared to the resins derived from wool and silk powders, the resin derived from chicken feather powder had a lower glass transition temperature and a larger thermal expansion coefficient, whereas the three-point bending strength, the elastic modulus, and the Vickers hardness were found to be lower. However, with the sole exception of the inferior three-point bending strength, the other features of this resin were comparable with those of polycarbonate.

### Biography

Shinji Hirai obtained his PhD in Engineering from Waseda University, Japan in 1988. In 1990, he joined the Department of Materials Science and Engineering, Muroran Institute of Technology as an Associate Professor. In 1992–1993, he trained under Professor Emeritus L Brewer at the UC Berkeley. In 2003, he acquired the position of Full Professor and his research interests expanded to include high-performance biomass plastics created using animal fiber waste and effective utilization of rare earth sulfides. Since 2012, he is concurrently serving as the Director of Research Center for Environmentally Friendly Materials Engineering. Recently, as part of the ImPACT national project, he is involved in the study of resinification of artificial spider silk.

hirai@mmm.muroran-it.ac.jp

### Notes:



3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Isolation and characterization of polyvinyl alcohol (PVA) degrading fungal strains from soils

**Somayeh Mollasalehi**

University of Manchester, UK

During the last 30 years, extensive research has been conducted to develop biodegradable plastics as more environmentally benign alternatives to traditional plastic polymers (Larry et al., 1992). Polyvinyl alcohol (PVA) is a water-soluble polymer which has recently attracted interest for the manufacture of biodegradable plastic materials (Solaro et al., 2000). PVA is widely used as a paper coating, in adhesives and films, as a finishing agent in the textile industries and in forming oxygen impermeable films (Larking et al., 1999). Consequently, waste-water can contain a considerable amount of PVA and can contaminate the wider environment where the rate of biodegradation is slow (Lee & Kim, 2003). Despite its growing use, relatively little is known about its degradation and in particular the role of fungi in this process. In this study, we used culture enrichment to isolate fungal degraders from eight uncontaminated soil samples which were shown to have very different fungal populations and dominant species revealed by denaturing gradient gel electrophoresis (DGGE). While all soils contained fungal degraders, the number of recovered species was restricted with the most common being *Galactomyces geotrichum* and *Trichosporon laibachii*. One thermophilic strain, *Talaromyces emersonii* was recovered at 50°C. For *G. geotrichum*, a molecular weight range of 13-23 KDa, 30-50 KDa or 85-124 KDa had no significant effect on the growth rate (mean doubling time 6.3 to 6.9 h<sup>-1</sup>) although there was an increased lag phase for the higher molecular weight PVA.

### Biography

Somayeh Mollasalehi has completed her PhD at the University of Manchester and she is working as a Researcher at the University of Manchester, UK.

somayeh.mollasalehi@manchester.ac.uk

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Biodegradation of biopolymers under soil and compost conditions

Asma Alhosni and Geoff Robson  
University of Manchester, UK

Over the last six decades, the use of plastic materials had a major impact on our daily lives and has become essential for modern societies due to their extensive and diverse range of applications. However, the recalcitrant nature of many plastics means that they are problematic in terms of disposal and are a major industrial waste product and environmental pollutant. The use of biodegradable polymers can aid in resolving a number of waste management issues as they are degraded ultimately to CO<sub>2</sub> and water and can be directed to conventional industrial composting systems. Four different biodegradable polymers, namely polycaprolactone, polyhydroxybutyrate, polylactic acid and poly(1,4 butylene) succinate were used to study the time required for biodegradation to occur in soil and compost under laboratory conditions. Degradation of polymer discs was measured by monitoring changes in disc weight, thickness and diameter over a period of more than 10 months at three different temperatures: 25°C, 37°C and 50°C. Degradation rates varied widely between the polymers and the incubation temperatures. Polycaprolactone showed the fastest degradation rate under all conditions and found to be completely degraded when buried in compost and incubated at 50°C after 91 days. Fungi from the surface of the polymers discs following colonisation were isolated and identified by ITS rDNA sequencing.

### Biography

Asma Alhosni is a PhD student at the University of Manchester. She has completed her MSc from Nottingham University in UK. She is working as a Lecturer at the Higher College of Technology in the Sultanate of Oman.

asma.alhosni@postgrad.manchester.ac.uk

### Notes:



**conference**series.com



**conference**series.com  
655<sup>th</sup> Conference

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Scientific Tracks & Abstracts (Day 3)



3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## A chemical platform for the production of Bio-PET

**Ryan L Smith**

Micromidas Inc.,USA

Fossil based plastic, polyethylene terephthalate (PET), dominates the current plastic bottle industry. To improve the carbon footprint of their packaging, and to reduce their reliance on volatile priced oil, the plastic bottle industry desires to instead produce a biobased PET bottle. The thermoplastic polymer, PET, is a product of the polymerization of monoethyleneglycol (MEG) and purified terephthalic acid (PTA). These two monomers are almost entirely sourced from fossil sources. To date there are a few commercial efforts to produce bio-based MEG from ethanol, biobased PTA however, remains unavailable in the market. PTA is itself synthesized through the oxidation of isomerically pure para-xylene, whereas para-xylene is a product of oil refining. Micromidas Inc. is a West Sacramento, California, chemical company, which converts biomass to commodity chemicals and resins. They have recently developed the technology, piloted the process, and are planning to build a first-of-a-kind commercial demonstration plant that will convert biomass –not oil- to polymer grade p-xylene and other monomers of interest. This talk will introduce Micromidas and aspects of its core technology.

### Biography

Ryan Smith is the Chief Technology Officer and Co-founder of Micromidas, Inc., a chemical technology firm that converts biomass into both conventional petrochemicals and new chemical intermediates, monomers, and resins. Mr. Smith received his B.S. in Chemical Engineering from the University of California, Davis where he was recently named the 2016 the College of Engineering Innovator of the year.

rsmith@micromidas.com

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Certification of bioplastics – Standards and politics

**Oliver Ehlert**

DIN CERTCO GmbH, Germany

Sustainable products are more and more in the focus of the polymer, packaging and other industries. Here, the confirmation of the respective properties becomes increasingly important, especially, the so-called “end-of-life” options, like compostability or biodegradability in different environments. On the other hand, the use of biobased materials is getting more and more interesting for retailers, suppliers and end-consumers. To show the advantages of these materials, third-party certification is a powerful tool to set you apart from your competitors. In this presentation, we outline the different standards and certification systems DIN CERTCO offers and gives an insight into political developments into recently developed and released standards for end-of-life options.

### Biography

Oliver Ehlert completed his Diploma in Chemistry and his PhD at Albert-Ludwigs University Freiburg, Germany, at the Freiburg Materials Research Center (FMF). After his stay at the German Federal Institute of Materials Research and Testing (BAM), he, since 2012, works as Product Manager at DIN CERTCO, a premier certification body in the field of compostable and biobased products.

oliver.ehlert@dincertco.de

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## PEF (polyethylene 2,5-furandicarboxylate): A new emerging biobased polyester from carbohydrates

Nathanael Guigo<sup>1</sup>, Nicolas Sbirrazzuoli<sup>1</sup>, Jesper Gabriël van Berkel<sup>2</sup> and Ed de Jong<sup>2</sup><sup>1</sup>University Nice Sophia Antipolis, France<sup>2</sup>Avantium Chemicals B V, Netherlands

Poly(ethylene 2,5-furandicarboxylate) (PEF) is nowadays considered as a promising sustainable successor of poly(ethylene terephthalate) (PET) for several reasons. First, the PEF is fully biobased since it comes from the polycondensation of bio-based ethylene glycol and 2,5-furandicarboxylic acid (FDCA) which is the chemical analogue of the terephthalic acid. FDCA is currently a.o. produced at pilot plant scale by a C<sub>6</sub> sugars conversion process of vegetable biomass by Avantium. PEF possesses superior barrier properties and more attractive thermal properties (e.g., higher glass transition temperature and lower melting point) than PET. The much lower CO<sub>2</sub>, O<sub>2</sub> and H<sub>2</sub>O permeability of PEF is a tremendous advantage for packaging applications. In order to fill the requirements of industrial applications, a deep knowledge of polymer structure-property relations is needed and will be the subject of this presentation. An important aspect for both the production and application of aromatic polyesters such as PEF is their crystallization behavior. Drying and solid state polymerization processes, that are common for polyesters, occur above T<sub>g</sub> and require the material to be semi-crystalline to avoid massive agglomeration or sticking. This is initially achieved by quiescent crystallization of the polyester. PEF crystals either formed from the glass or from the melt show similar structures but the dynamic of crystal growth differs between the two crystallization pathways. Moreover, annealing at temperatures close to the PEF melting point allowed obtaining information on PEF self-nucleation behavior.

### Biography

Nathanael Guigo received his PhD in 2008 from the University of Nice Sophia Antipolis, France in the field of Furanic Based Polymers. He joined the Centre de Recherche sur les Macromolécules Végétales, Grenoble, France as a Post-doctoral Fellow to work on cellulosic fibers in high performance composites. In 2010, he became Associate Professor and in 2013, he obtained a secondment to Avantium (Amsterdam) to work on the poly(ethylene 2,5-furandicarboxylate). His scientific work has been published in more than 25 papers and he has been actively involved in three EU projects relative to the valorization of biomass into new materials.

guigo@unice.fr

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Biodegradable polymers from brewery wastewater

M C Veiga, M Romasanta and C Kennes

University of A Coruña, Spain

Brewery mills generate large volumes of wastewater that is characterized by high content of easily degradable organic matter, mainly volatile fatty acids, ethanol and sugars that can be used as substrate to produce polyhydroxyalkanoates (PHA). The PHA production process was developed in a three-step process: Acidogenic fermentation of wastewater, selection of a culture with high storage capacity fed with acidogenic effluent and finally a storage step. The acidogenic fermentation of brewery wastewater was carried out in a sequencing batch reactor (SBR) at pH 6, obtaining an acidification of 70%. Fed-batch assays were performed using the enriched biomass, obtaining a maximum of 70% PHA on a cell dry weight basis and a storage yield of 0.75 Cmmol PHA/Cmmol VFA. Moreover, some polymer properties like temperature melting and crystallization or thermal stability were determined. A study of the mixed microbial cultures was also performed in order to identify the dominant strains of PHA accumulating microorganisms. To further assess the industrial relevance of the waste-based PHA process, the second step was studied in a semi-pilot scale reactor.

### Biography

M C Veiga obtained her PhD in the field of Environmental Bioengineering from the University of Santiago de Compostela. Afterwards she held a Postdoctoral position at Michigan State University. At present, she coordinates the Environmental Engineering Group at University of A Coruña. Her primary research interests are on the development of sustainable processes for the removal of pollutants from wastewater and production of biopolymers from renewable sources.

veiga@udc.es

### Notes:

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Biopolymers-based active edible coatings to improve quality and safety of food products

**Elena Poverenov**

Agricultural Research Organization, Israel

Biodegradable and edible biopolymers can be utilized as active coatings to control safety and enhance quality of food products. Edible coatings based on natural components respond to customer demands for safe and healthy approaches for food quality management and satisfy environmental concerns. Edible coatings may protect food products from physical, mechanical, and microbial damages and also allows delivery of beneficial components. In our laboratory, we utilize advanced materials science approaches to develop highly effective, safe and applicable edible coatings based on biopolymers. Layer-by-Layer (LbL) approach enables to control properties and functionality of materials. Natural polysaccharides-based coatings were implemented for various fresh fruits (melon, orange, mandarin, grapefruit, and sweet pepper) by utilizing LbL method. The LbL coatings were combined with good adhesion of the inner poly-anion layer and beneficial activity of the outer poly-cation layer. The LbL arranged biopolymers resulted in significant elongation of product shelf life, since they slowed down tissue degradation, prevented development of hypoxic stress and off-flavors, and effectively inhibited microbial spoilage. Nanoemulsions were utilized to incorporate active component into the edible coatings. Food-source citral, a natural antimicrobial and aroma agent was introduced in matrices of various biopolymers. The nano-emulsified active coatings were compared to those of the coarse-emulsified.

### Biography

Elena Poverenov has completed her PhD in Organic Chemistry from Weizmann Institute of Science and Post-doctoral studies in Polymers and Material Chemistry from Weizmann Institute of Science. Since 2011, she is Research Scientist in the Institute of Postharvest and Food Sciences at Agricultural Research Organization, The Volcani Center. Her research group is implementing new advanced approaches from chemical science to improve quality and safety of food and agricultural products. She has published 30 papers in international journals including top journals, such as *Nature* and *JACS* and has been serving as an Editorial Board Member.

elenap@volcani.agri.gov.il

### Notes:



**conference**series.com

**conference**series.com  
655<sup>th</sup> Conference

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Workshop (Day 1)



3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA



## Richard A Gross

Rensselaer Polytechnic Institute, USA

### Biocatalytic routes to monomers and polymers

This workshop will discuss the rapid evolution of biotechnological methods that are enabling commercially important new routes to biobased monomers and polymers. Topics will include fundamental concepts involved in both cell free and whole cell biocatalysis, successful new product development as well as challenges that must be overcome. Furthermore, relative merits will be given for biocatalysis, chemical catalysis and how these methods can be successfully integrated.

### Biography

Richard A Gross is currently a Full Professor and a Constellation Chaired Professor at Rensselaer Polytechnic Institute (RPI). His research is focused on developing biocatalytic routes to biobased materials including monomers, macromers, prepolymers, polymers, surfactants and other biochemicals. He has over 500 publications in peer reviewed journals, been cited about 18,000 times (h-index 71), edited 7 books and has 26 patents (granted or filed). He was the recipient of the 2003 Presidential Green Chemistry Award in the academic category. In 2010, he was selected as the Turner Alfrey Visiting Professor, and in 2015 he became a Fellow of the ACS Polymer Division. He founded SyntheZyme LLC in 2009 and serves as CTO.

[grossr@rpi.edu](mailto:grossr@rpi.edu)



**conference**series.com



**conference**series.com  
655<sup>th</sup> Conference

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Workshop (Day 2)



3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA



## Dean C Webster

North Dakota State University, USA

### High performance, high bio-content thermosets for composites and coatings

While vegetable oils and other bio-based raw materials have been used in coatings resins for decades, new concepts are needed to transform bio-based raw materials into coatings resins that meet today's demanding performance needs. Highly crosslinked petrochem.-based thermosets are used in broad applications due to their high performance properties. Designing bio-based resins having a high no. of appropriately distributed functional groups per mol. can lead to thermosets having exceptional performance properties. Sucrose ester resins from vegetable oils, such as soybean oil, having a high degree of substitution can be epoxidized to yield biobased epoxy resins (e.g. Epoxidized sucrose soyate, ESS) having a high degree of functionality. These epoxy resins can then be crosslinked using several different mechanisms such as via anhydride-epoxy reactions, catalytic polymerization, and so on to yield coatings having high crosslink d., good hardness, excellent solvent resistance and adhesion. In addition, polyols can be derived from the epoxidized sucrose soyate resins via reaction with alcohols such as methanol to yield methoxy sucrose soyate polyol (MSSP). These highly functional polyols can be crosslinked using melamine-formaldehyde resins or polyisocyanates to yield thermoset coatings having performance properties comparable to their petrochemical counterparts and exceeding the performance of traditional vegetable oil based polyols.

### Biography

Dean C Webster is Professor and Chair in the Department of Coatings and Polymeric Materials at North Dakota State University (NDSU). He received a BS in Chemistry and a PhD in Materials Engineering Science both from Virginia Tech. Prior to joining NDSU in 2001 he worked for Sherwin-Williams and at Eastman Chemical Company. He is the recipient of the 2011 Roy W Tess Award in Coatings Science given by the American Chemical Society, the 2013 Joesph Mattiello Lecture award given by the American Coatings Association, and the Waldron Research Award given by the NDSU Alumni Association. His research is in the area of new high performance polymer systems for coatings and composites, nanocomposites, polymers for marine antifouling coatings, and use of renewable resources in polymers and coatings systems.

[dean.webster@ndsu.edu](mailto:dean.webster@ndsu.edu)



**conference**series.com



**conference**series.com  
655<sup>th</sup> Conference

3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

## Workshop (Day 3)



3<sup>rd</sup> International Conference and Exhibition on

# Biopolymers & Bioplastics

September 12-14, 2016 San Antonio, USA

**Ramani Narayan**

Michigan State University, USA

## Bio-based and biodegradable compostable plastics: Logic, definitions and testing methods

Replacing petro/fossil carbon with bio-based carbon by using plant biomass feedstock in place of fossil feedstock for the manufacture of plastic materials offers a strong 'value proposition' for a zero material carbon footprint. It may also reduce the process carbon and environmental footprint. A methodology for quantification of 'bio-based carbon content' has been developed and codified into the ASTM Standard D6866. Using bio-based carbon content calculations, one can calculate the intrinsic CO<sub>2</sub> reductions achieved by incorporating bio-based carbon content into a plastic product - the material carbon footprint. It is important to report on the process carbon footprint (process footprint arising from the conversion of feedstock to product) using lifecycle assessment methodology to ensure that the intrinsic material carbon footprint value proposition is not negated during the conversion, use, and disposal lifecycle phases of the product. Biodegradability is an end-of-life option for single-use disposable plastics and needs to be tied to a disposal environment such as composting (compostable plastic) or soil or anaerobic digestion. More importantly, if a biodegradable plastic is not completely and rapidly removed (within not more than 1-2 years) from the target disposal environment, the degraded fragments become toxin carriers, resulting in serious environmental and health risks. ASTM, European, and ISO standards define and specify the requirements for complete biodegradability in composting, soil, and marine environments and must be strictly adhered to so that serious environmental and health consequences can be avoided.

### Biography

Ramani Narayan is University Distinguished Professor, the highest honor that can be bestowed on a faculty member at Michigan State University. He is Fellow of the US National Academy of Inventors; Fellow of ASTM & received ASTM award of merit, the highest award given by the society to an individual member. He is Scientific Chair of the Biodegradable Products Institute (BPI) USA; and Convener/Technical Expert on several ISO Standards committees. He has 200 refereed publications, 30 issued patents and supervised 20 PhD and 25 Master's students. He is a successful Entrepreneur, having commercialized several bioplastics technologies.

[narayan@msu.edu](mailto:narayan@msu.edu)