Midwest Biocomposites and Biopolymers Workshop brings together researchers and companies

Nearly 50 people attended the first Midwest Biocomposites and Biopolymers Workshop on April 22 at Iowa State University. The workshop brought together researchers and companies interested in creating and using biobased products. It provided a unique opportunity for both parties to discuss new products and technology and the challenges of introducing biobased products in the marketplace. Attendees were able to interact with experts in the field and gain critical knowledge about this growing industry.

“This workshop highlighted the current research at Iowa State relating to bioplastics and biocomposites. Attendances included engineers, scientist and marketing managers as far away as California and Maine,” said David Grewell, professor of agricultural and biosystems engineering and workshop organizer. “Several of the attending companies asked for proposals for future work and indicated great interest in knowing when the next conference would be.”

The keynote speaker, Ramani Narayan, University Distinguished Professor in the Department of Chemical Engineering and Materials Science at Michigan State University, spoke of the history, challenges and opportunities of biopolymers and biocomposites.

Derek Thompson from the Center for Industrial Research and Service (CIRAS) at Iowa State presented how CIRAS helps manufacturing...
Narayan discusses history and future of bioplastics industry

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The history begins with understanding why biopolymers and biocomposites, generally called bioplastics, are important. Narayan explained that by using bioplastics, which include renewable carbon, the intrinsic value reduces the “carbon footprint” depending on the amount of renewable carbon in the product and in harmony with the rates and time constraints of the natural biological carbon cycle. Opportunities abound to make these new bioplastics perform as well as or better than the synthetic counterparts by using additives and modifiers.

The challenges of bioplastics include the different ways to use them. For example, Narayan explained that biodegradability is a property that can be engineered into bioplastic products to provide for an environmentally responsible end-of-life option in appropriate disposal systems. This is a particularly important and valuable property for single-use, disposable products like packaging and consumer articles. However, not all biobased products are biodegradable and not all biodegradable plastics are biobased. It is important to recognize that biobased (using renewable carbon) focuses on reducing the carbon footprint of a product, whereas biodegradability is an end-of-life option designed for single-use disposable plastics. It is important to ensure complete biodegradability in the selected disposal system (complete consumption of the biocarbon product by the microorganisms present in the disposal system).

The opportunities for using bioplastics include the many choices available to manufacturers. The two basic routes possible for the manufacture of bioplastics include direct extraction from biomass which yields a series of natural polymer materials including cellulose, starch, fibers, and vegetable oils that form the platform on which polymer materials and products can be developed. Alternatively, the renewable resources/biomass feedstock can be hydrolyzed to biomonomers which can be transformed by fermentation or chemical or hybrid processes to plastics. For example, biomonomers can be microbially transformed to biopolymers.

Another recent announcement is to manufacture biopolyethylene from sugarcane via ethanol fermentation and chemical dehydration to ethylene. Vegetable oils provide a platform for chemical transformation to lubricants, polyesters, urethane foams, and unsaturated polyester resin composites. Polymer modifiers and additives have a major role to play in improving and imparting needed performance properties and present new opportunities.

Workshop Web Sites

Midwest Biopolymers and Biocomposites Workshop web site
www.biocom.iastate.edu/workshop

Speaker and poster presentation abstracts
www.biocom.iastate.edu/workshop/abstracts.html

Watch the speaker presentations
www.biocom.iastate.edu/workshop/video.html

Ramani Narayan was the keynote speaker at the Midwest Biocomposites and Biopolymers Workshop.
Workshop showcases Iowa State biopolymers and biocomposites research projects

Iowa State biopolymers and biocomposites research was featured at the workshop. Several researchers discussed advances they have made using plant-based materials in their formulations.

Richard Larock, distinguished professor of chemistry, explained how his research group has developed very simple procedures for the synthesis of industrially promising biopolymers. The starting materials are readily available, renewable and inexpensive.

More recent work has focused on the preparation and characterization of biocomposites of these materials using agricultural co-products, such as spent germ, distillers dried grains with solubles, corn stover, soybean hulls, and kenaf as fillers. Larock went on to describe the synthesis, characterization, properties, and potential applications of these new materials.

David Grewell, assistant professor in agricultural and biosystems engineering, reviewed an investigation of the processability and properties of commercially available corn and soy protein polymers for various products. In his research, different formulations of protein substrates were characterized for their mechanical and chemical properties.

It was seen that zein plastic sheets could be cast with tensile strengths as high as 6 MPa with a strain to failure of 6%. In addition, ultrasonic treatment of the solution prior to casting-reduced the tensile strengths; however, the treatment did enhance the strain to failure to as high as 200%.

Grewell explained that biodegradable plastics based on corn and soy protein were prepared with glycerol as a plasticizer and compounded with different additives at various temperatures after the injection molding process. The reason for this is to characterize base material strength and the effect of water absorption. The results indicated that this treatment created tensile strength and decreased water absorption significantly. Based on the optimized formulations, two applications were developed and studied: hay bale wrappers and plant pots. Hay bales were coated with zein-based plastics using spray-on formulations. Pots were compression molded and plant growth accelerated.

Douglas Stokke, senior lecturer in natural resource ecology and management, explained that soybean flour is a co-product of soy oil extraction. Use of soy flour as an adhesive ingredient can reduce formaldehyde emissions during and after wood composite production. It may also provide cost savings to wood product manufacturers.

Stokke’s work has focused on enzymatic processing of soy flour to produce soy hydrolysate for...
Representatives from several companies were invited to speak about their move towards green technologies. They discussed research, capital investments, and commercialization.

Maria Baboi, research scientist in agricultural and biosystems engineering at Iowa State, explained that Soy Works® holds exclusive commercial rights to patents for soy protein-based plastics. Soy Works customers have compelling strategic and economic reasons to replace non-degradable conventional plastic products with biodegradable and compostable plastics made from SoyPlus™ resins.

Despite its innovative nature, soy-based plastic products can be manufactured using standard equipment common in the plastics industry. This means little capital investment is required for customers to bring the technology in-house. Unlike synthetic degradable products, SoyPlus plastics come from a renewable source, are more eco-friendly than petroleum-based plastics, and eliminate problematic waste disposal.

Jay Olson, John Deere Technology Center, reviewed the development and commercialization of biopolymers for John Deere combine and tractor components. John Deere’s sheet molding compound is made from refined soybean oil that is formulated into a resin which is then used in compression molds. The molded sheet panels are used on John Deere’s combines and Series 5000 and 9000 tractors. One batch of the biobased resin saves 10 barrels of crude oil compared to using petroleum-based resins. Olson stated that using biopolymers was “the right thing” for John Deere to do.

In closing, Olson discussed what’s next for John Deere including soy urethane foam for seating and arm rests, soy-based paint coatings, and natural fiber reinforcements and fillers. He stated that John Deere is committed to using recycled or renewable materials wherever possible.

Bill Rawnsley, president of Earthfoam, LLC, discussed Earthfoam’s spray foam and pour in place products. Their line of insulation products are made from plant-based, renewable resources. He discussed new applications that include exterior spray foams and shipping containers. Rawnsley also talked about the development process for the insulation products.

He ended by discussing that many companies use the term “green” but that the use of this word should have corresponding regulations to ensure common standards. As he said, many companies use the word “green” as a marketing tool while their products are “still plastic.”
companies improve their operations by connecting them with research centers and faculty from Iowa State and off campus resources. CIRAS has a staff of 10 engineers that work with manufacturers to help them with ISO certification, plant layout, plant simulations or productivity improvement issues. In 2007, CIRAS worked with 577 companies in Iowa and as a result of CIRAS’s assistance, 1,658 jobs have been added or retained. “Our premise is to assist manufacturers so they’re profitable, more competitive; therefore, retaining jobs in Iowa, adding jobs in Iowa,” said Thompson.

Other presenters at the workshop included researchers from Iowa State and representatives from several companies that talked about the steps for developing and marketing biobased products.

As part of the workshop, attendees were able to get a close-up look at biocomposites and biopolymers research at Iowa State by touring two research areas. The Technology Transfer Pilot Plant has 3,000 square feet of space for industrial products processing. Attendees saw a number of samples made from corn and soy protein-based pellets. The pellets were made with the pilot plant’s extruding equipment.

The second stop was the Thermal and Mechanical Analysis Lab and the Vegetable Oil Plastics Lab. Attendees were able to view samples of vegetable oil-based plastics and see how the characteristics of the plastics are analyzed.

Attendees were also able to schedule private consultations with the workshop’s presenters. These sessions provided an opportunity to discuss current research or possible collaborations on future projects.

Left: Gowrishankar Srinivasan (right), graduate student in materials science and engineering, gives a tour of the Technology Transfer Pilot Plant. He shows a roll of extruded plastic made from soy protein.
Right: Srinivasan explains how he uses the extruder to make biobased products.

Thompson explains how CIRAS plays a role in helping companies grow with research and development assistance.

Thanks again to the workshop’s sponsors:

Center for Crops Utilization Research
Biopolymers and Biocomposites Research Team
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Center for Industrial Research and Service
use in combination with synthetic resins. Soy flour was mixed with the enzyme system(s) of interest at 40–60 degrees Celsius, with pH adjusted as necessary for enzyme function.

Soy hydrolysates are low in volatile organic compounds (with no objectionable odor), light in color, and have much lower viscosity than the non-treated soy flour. In addition, the degree of protein hydrolysis is controllable. The process has been successfully scaled up to 50-gallon pilot trials.

Balaji Narasimhan, associate dean for research and economic development, explained that his research is focused on engineering polyanhydrides, a type of biomaterial, that have a tailored chemistry and nanostructure to regulate drug/protein distribution and to design delivery systems with physiologically meaningful functions.

The underlying hypothesis is that polymer chemistry and nanostructure regulate drug/protein distribution and consequently determine the release mechanism. Two examples of controlled delivery systems based on this research were discussed.

Based on his results, Narasimhan has developed rational strategies for designing unique vaccines. The fundamental treatment of the mechanistic aspects of release and immune response will ultimately facilitate rational means of designing single-dose vaccines.