Research Team Is Developing Biobased Carbon Fibers for Wind Turbine Blades

The Biopolymers and Biocomposites Research Team (BBRT) is investigating the production of carbon fibers from low-cost, lignin-based polymer blends for use in wind turbine blades.

Michael Kessler, associate professor of materials science and engineering, leads the project. "Our goal is to provide a low-cost, biobased carbon fiber that significantly outperforms glass fiber in composites for wind turbine blades," said Kessler.

To meet energy guidelines set by the Department of Energy, wind turbine manufacturers are designing wind turbines with longer blades. Increased blade length improves wind capture at lower wind speeds and increases energy output. However, the additional length increases blade weight and the load experienced by the rotor hub and wind tower.

Currently most turbine blades are made from glass fiber reinforced polymers. These glass fibers are dense and weaken over time under repeated stress, which limits turbine blade length and performance. New lightweight, low-cost blades need to be developed, which led Kessler to begin investigating carbon fibers that could replace the glass fibers currently used in wind turbine blade manufacturing. Instead of using expensive petroleum-based carbon fiber, his research group is exploring ways to use lignin, a renewable resource, to create low-cost carbon fibers for use in manufacturing wind turbine blades.

Lignin is derived from plants and is a byproduct of the wood pulping process. It is an inexpensive, readily available material, and carbon fiber produced from lignin/PLA blends.

To read more, please visit page 6. 
Starting June 1, the plastics industry will have a new tool to determine the economic viability of biobased plastics. The Polymers Environmental Calculator is a web application designed to calculate and compare processing costs, energy consumption and greenhouse gas emissions of products made from petroleum and biobased plastics.

David Grewell, chairperson of the Iowa State University Biopolymers and Biocomposites Research Team and associate professor of agricultural and biosystems engineering, has led the application’s development.

“The Polymers Environmental Calculator will allow resin producers, manufacturers and end-users to compare the environmental footprint and costs of their products. This comparison will give designers, manufacturers and consumers the information they need to determine which plastics minimize environmental impacts as well as costs,” said Grewell.

Grewell said the Polymers Environmental Calculator allows users to compare production of specific products made from various plastics. “It automatically generates reports and compares the costs and eco-profile of plastic parts made from different materials,” he said.

Users will be able to select from 12 common petroleum and biobased plastics including PET, PE, PS, PLA, and PHA. An option is available for users to enter additional plastics or enter specific information from suppliers. They will also be able to define processing costs, such as part size and overhead costs, and determine final end treatment for the product including recycling, incineration or landfill.

Grewell partnered with Nypro and M-Base Engineering + Software GmbH to make the application available to the plastics industry. They provided assistance with software design and information about plastic products and manufacturing. M-Base, a data management software company, prepared the code for the web-based application and provided support for material specifications. In addition, M-Base designed the graphic user interface that allows quick and easy use of the application.

Nypro provided consulting services for manufacturing specifications as well as material selection and financial support. The team’s efforts were synergetic in producing this powerful, easy to use application.

Eric Paszkowski, project engineer of Nypro, said, “The software helps guide our customers to make an educated decision on material and process selection based on environmental and costs constraints. While many customers want to be green, they must have business justification for their decision, and this software helps them with making a data-based decision.”

The Polymers Environmental Calculator was also supported by USDA Biopreferred, Department of Agricultural and Biosystems Engineering, and Center for Crops Utilization Research.

ONLINE – The Polymers Environmental Calculator will be available for free on June 1. For more information visit www.biocom.iastate.edu/pec.
Iowa State University Workshop to Promote Development of Biopolymers and Biocomposites

Iowa State University will host the Biopolymers and Biocomposites Workshop Aug. 14 to bring together researchers and industry representatives interested in developing products made from biomass.

The workshop is aimed at providing technicians, engineers, designers and companies wanting to incorporate this technology with the tools required to use biopolymers and biocomposites for product design and manufacturing. It will take place in the Memorial Union on the Iowa State campus.

The workshop will focus on formulating protein-based polymers, vegetable oil polymers, adhesives, composites and polyesters through fermentation; as well as processing technologies such as injection molding, extrusion, compression molding and casting. Speakers also will cover the assessment of mechanical, thermal and microstructural properties of biopolymers and biocomposites.

Speakers from universities and businesses are scheduled to begin at 8:30 a.m. and continue until 4 p.m. Tours of Iowa State’s Technology Transfer Pilot Plant and Polymer Characterization Laboratory, facilities that do biopolymer and biocomposite research, will conclude the workshop.

The workshop is part of a three-day series of workshops related to plastics. More information about the Plastics Manufacturing Technical Resources Workshop on Aug. 13 and the Bioplastic Container Cropping Systems Conference on Aug. 15 is available here: [www.biocom.iastate.edu/workshop](http://www.biocom.iastate.edu/workshop).

The Biopolymers and Biocomposites Research Team at Iowa State is organizing the workshop. The team was established in 1995 to promote research in the development of biorenewable polymers from Midwest crops, encourage bioplastics in industry and work towards new formulations and processing techniques. The research team operates under the Center for Crops Utilization Research umbrella.

Workshop registration is open online at: [www.biocom.iastate.edu/workshop/bioworkshop.html](http://www.biocom.iastate.edu/workshop/bioworkshop.html).

The workshop’s agenda with information on the plenary and keynote speakers is located at: [www.biocom.iastate.edu/workshop/agenda.html](http://www.biocom.iastate.edu/workshop/agenda.html).

Extruder Installed in Pilot Plant

The Center for Crops Utilization Research (CCUR) installed a pilot-scale extruder in the Dry Processing Pilot Plant. The Leistritz MIRCO 27 lab extruder is a co-rotating twin screw extruder with maximum screw speed of 500 rpm and output up to 20 kg/hr.

David Grewell, CCUR affiliate and associate professor of agricultural and biosystems engineering, and his bioplastics research group is currently using the extruder to produce corn and soy protein-based pellets. The mixture is extruded through a 4 mm diameter die to obtain an extrudate which is then cut into 4 mm pieces using a pelletizer. The pellets are used to manufacture biobased plant containers.

The extruder is available for fee-for-service projects. Contact Hui Wang, pilot plant manager, at (515) 294-3572 or huiwang@iastate.edu for more information.

Samuel Schrader, laboratory assistant in horticulture, (right) adds the soy protein-based mixture into the extruder and Kenneth McCabe, research associate in horticulture, feeds the extrudate into the pelletizer.
Biopolymers Research Team Exhibits at International Plastics Event

Biobased plant containers and a new plastics web application were the main attractions at the Biopolymers and Biocomposites Research Team’s (BBRT) exhibit at NPE2012 International Exposition in Orlando, Florida. From April 2-5, BBRT members met with show attendees and representatives from plastics companies interested in biobased products the group produces including plastics, composites, and coatings.

Their exhibit included a hands-on demonstration of the Polymers Environmental Calculator, a web application designed to calculate and compare processing costs, energy consumption and greenhouse gas emissions of products made from petroleum and biobased plastics. During the show attendees received a demonstration from BBRT members and then were able to enter their own information to generate an eco-profile of different plastics. More information about the Polymers Environmental Calculator can be found on page 2.

Biobased plant containers made from soy protein were also shown at NPE2012. They are a sustainable replacement for petroleum-based pots and degrade harmlessly when planted in a garden. Early results with plant containers made from soy protein show that containers degrade slowly, providing fertilizer for growing plants.

David Grewell, BBRT chairperson and associate professor of agricultural and biosystems engineering, noted that the plant containers are the perfect application for the protein-based plastics developed at Iowa State University.

“Displaying the plant containers at NPE was a great opportunity for industry and users to see these pots firsthand and to see the different types of sustainable materials produced at Iowa State,” he said.

Over 55,000 plastics professionals from 120 countries attended the NPE 2012 International Plastics Exposition.

BBRT operates under the Center for Crops Utilization Research umbrella at Iowa State University.
Researchers focused on the pretreatment steps for the enzyme-assisted aqueous extraction of soybeans process. Before the soybean material is used for oil extraction by the aqueous system with enzymes, the beans are cracked using a roller mill to loosen the hull. The hulls are separated from the soybean grits by aspiration. The dehulled soybean meat is then conditioned by adding a small amount of water and heated to make the meat pliable, before being processed into thin flakes using a flaking mill. Flaking helps rupture the oil bodies to release oil. Extrusion is used to further enhance the release of oil. The extruded full-fat soybean flour is then used for aqueous oil extraction. Juliana Nobrega de Moura, postdoctoral research associate for the Center for Crops Utilization Research, manages this project.

The vacuum drum filter was used for an industrial project. A starch slurry was fed continuously to the drum filter. Water was removed by vacuum sucking while the starch was retained on the filter belt.

Two kinds of legume materials were processed to extract bio-active components for an industrial client. In order to extract the minor component, the legume flour was mixed with water and fiber was removed by decanting centrifuge. A series of salt concentration adjustments was carried out based on the solubility differences between target components and the impurity components. The final extract was recovered by high speed tubular centrifuge.
BioCentury Research Farm Update

Testing and product development work continued in the Harvest, Storage, and Transportation Building. Affiliates Matt Darr, assistant professor of agricultural and biosystems engineering, and Stuart Birrell, associate professor of agricultural and biosystems engineering, continue to work with agricultural equipment suppliers and consumers of biomass feedstocks to improve the biomass feedstock supply chain.

In the Biomass Storage and Pretreatment Building, biomass was processed and sent to companies, research facilities, and universities including ConocoPhillips, DuPont Cellulosic Ethanol, National Renewable Energy Laboratory, Pacific Northwest National Laboratory, Virent, and Washington State University. Wood products, low ash content corn stover, sugarcane bagasse, and switchgrass were ground using the stationary hammermill and the pilot-scale hammermill.

Work continued on the completion of a new biomass drying and grinding system. The system will use equipment donated by Vermeer Corporation and components purchased by the Center for Sustainable Environmental Technologies (CSET). The Iowa Economic Development Authority funded the purchase of the remaining equipment to finish the system. It should be operational in the second quarter of 2012.

The fluidized bed and gas cleaning system located in the Thermochemical Train has nearly completed testing work for a project funded by ConocoPhillips and the Department of Energy. The cleaning system and gasifier are operated by CSET.

A project led by Mark Hargrove, professor of biochemistry, biophysics and molecular biology, continued to use the 500-liter fermenter in the Biochemical Processing Train to produce plant hemoglobins for Arch Chemicals.

CARBON FIBERS

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lignin could lead to stronger and lighter wind turbine blades.

The lignin-based carbon fibers are produced using a manufacturing process called melt spinning. First the polymer is heated to a melted state and then extruded through a spinneret, a die with numerous holes. The polymer fibers are then wound and stretched into thinner fibers for further processing. Because lignin polymers are brittle and cannot be spun and spooled into fibers without modification, Kessler’s research group had to test ways to overcome this barrier. They are chemically modifying and blending the lignin with biopolymers to enhance polymer flexibility and improve the melt spinning process.

Kessler believes there is significant potential for making the carbon fiber production greener and renewable by blending lignin with biopolymers, such as the starch-based polymer polyactic acid (PLA), rather than using petroleum-based polymers such as polyethylene terephthalate (PET).

“The expected benefits are three-fold,” said Kessler. “It uses renewable resources, it optimizes energy and materials costs for producing carbon fibers (estimated cost savings 37 percent to 49 percent), and the fibers themselves will be used for wind turbine blades to produce renewable energy.”

Although this project is focused on wind energy applications, Kessler sees other potential applications for the lignin-based carbon fibers. For example, in the automotive industry, the replacement of steel structures with stronger and lighter carbon fiber reinforced polymers would lead to vehicle weight reductions of 30 percent to 50 percent. Such weight savings would result in very significant fuel efficiency improvements.

BBRT operates under the Center for Crops Utilization Research umbrella at Iowa State University.

Michael Kessler shows how the lignin-based fiber carbons are stretched and spun.
IGQI Provides Near Infrared Spectroscopy Training to Louis Dreyfus Corporation

The Iowa Grain Quality Initiative (IGQI) hosted an informational workshop on near infrared spectroscopy (NIRS) for the Louis Dreyfus Corporation (LDC), a multinational grain processing and trading company. The half-day workshop updated LDC lab and processing personnel on the science and practice of NIRS, which is used in the agricultural sector to analyze grain quality factors including composition and physical traits. IGQI’s Grain Quality Lab operates several NIRS instruments and offers grain testing services. It is nationally recognized as a leader in NIRS calibrations. The lab’s near infrared moisture calibrations are approved for trade by the National Institute of Standards and Technology and corn traders use their corn constituents calibrations.

Charles Hurburgh, professor of agricultural and biosystems engineering and professor-in-charge of the IGQI, presented information on equipment calibrations, validation, and ongoing quality control of NIRS equipment.

The group also toured the Grain Quality Lab where they viewed different makes and models of NIRS equipment. The lab currently has 16 NIRS models from nine different manufacturers. Hurburgh highlighted the features of each machine including the user features and measurement capabilities that vary between models.

IGQI was established to create knowledge and provide information that will improve the efficiency of traditional commodity grain markets and assist with market development for user-specific grains. IGQI operates the Grain Quality Lab to provide reduced cost grain quality analysis services for genetic trials and commercial uses. The initiative is an extension and research program under the Center for Crops Utilization Research umbrella.

Grants Awarded to CCUR Affiliated Faculty and Staff


New Novel Biofuels Mycomeal, National Pork Board, $52,049, Nicholas Gabler and Hans van Leeuwen.


Graduate Student Travel Support for the 2012 Corn Utilization and Technology Conference, Iowa Corn Promotion Board, $8,000, Darren Jarboe and Lawrence Johnson.

Processing Identity Preserved Soy Protein Concentrates and Isolates from Food Grade Soybeans, Harvest Innovations, $42,030, Lawrence Johnson and George Kraus.

Processing Identity Preserved Soy Protein Concentrates and Isolates from Food Grade Soybeans, IPRT Company Assistance, $24,639, Lawrence Johnson and George Kraus.

News Briefs

Johnson Receives New Patent

Lawrence Johnson, director of the Center for Crops Utilization Research (CCUR) and BioCentury Research Farm, and Nicolas Deak, a former postdoctoral research associate for CCUR, were issued a patent on March 27 for “Vegetable Protein Fractionization Process and Compositions.”

They developed a method to fractionate soy protein into its two major components, glycinin and beta-conglycinin. Glycinin has excellent gelling properties that could be useful in processed meat products. Superior health benefits, such as cardiovascular health and anti-cancer properties, have been attributed to beta-conglycinin.

Although a Japanese product has been available at very high prices, this is the first commercially practical soy protein fractionation process. Johnson said they see great potential for this process in the meat industry and for nutritional sports beverages.

Upcoming Events

Hybrid Processing for Biorenewables Fuels & Chemicals Production Symposium
May 9-10, Howe Hall Atrium and Alliant Energy-Lee Liu Auditorium, Iowa State University
www.ucs.iastate.edu/mnet/hybrid/home.html

The Hybrid Processing Group (Zhiyou Wen, Fermentation Facility professor-in-charge, and Laura Jarboe, assistant professor of chemical and biological engineering) is hosting the Hybrid Processing for Biorenewables Fuels & Chemicals Production Symposium. Register for this two-day workshop featuring speakers from Iowa State University, U.S. Department of Energy, Argonne National Laboratory and industry plus a tour of Iowa State’s BioCentury Research Farm.

Plastics Workshops at Iowa State University
www.biocom.iastate.edu/workshop

Register to attend three days of learning, networking, and doing business in the plastics and bioplastics industry. Choose one, two or all three of the workshops below. Reduced registration is available for attending two or more workshops.

Plastics Manufacturing Technical Resources Workshop
August 13, Memorial Union

Biopolymers & Biocomposites Workshop
August 14, Memorial Union

Bioplastic Container Cropping Systems Conference
August 15, Food Sciences Building