Sweet Biofuels and Biopolymers

Editor's Note: In the November issue of SJ, we looked at a new process using glucose and fructose to make 5-hydroxymethylfurfural, better known as HMF. HMF, traditionally made from petrochemicals, is used in large quantities to create plastics and other chemicals. In this month's article, we look at another approach to using sugars to produce biofuels.

Scientists at the University of Wisconsin (Madison), describe a new process which is a hybrid of traditional thermo chemical and biological approaches to biofuel production. Starches are first broken down by biological enzymes to produce fructose, which is then converted in an acid-catalyzed reaction to an intermediate compound, 5-hydroxymethylfurfural (HMF). The team developed a carbon-supported copper–ruthenium catalyst to convert the HMF into DMF as a final product. The process is much faster than ethanol fermentation and avoids the energy-intensive steps in biodiesel production that break biomass down into carbon monoxide and hydrogen (together called syngas) and then recombine these components into larger fuel molecules.

DMF's energy content is 40% higher than that of ethanol, and DMF avoids ethanol's problem of absorbing water from the atmosphere.

Glucose, which is more widely available from biomass, can be converted efficiently to fructose for the process, the authors add, and the sugars and starches in nonfood biomass, such as paper-mill waste, could also be converted to DMF.

The Importance of Biopolymer Research and Development.

Biofuels aren't the only way that American industry is using grain as a replacement for petroleum. Corn has been the source for polymers for a few years, and the uses are exploding into the clear packaging used for fresh-cut fruits and vegetables, coating for paper coffee cups, blankets and clothing, and medical devices etc. According to NatureWorks, one major manufacturers of polylactic acid (also known as polylactide, or PLA), production of conventional plastics is dependent upon petroleum, using more than 180 million barrels of oil per year.

According to USDA, biopolymers use about 0.1% of the corn produced in the U.S., while alcohol for fuel uses about 18%. World oil demand is growing at its fastest pace in 16 years. US imports are 20% higher than one year ago. For every $5/barrel increase in the cost of oil, PLA gains a competitive price advantage of $0.01/lb.

NatureWorks has grown by leaps and bounds since 1999 when the firm, then a co-venture between Cargill and Dow, built its pilot plant in Blair, NE. The manufacturing facility now has a rated capacity of 300 million lb (140,000 metric tons) of polymer. The plant came on line in 2002; NatureWorks LLC purchased Renewable Energy Certificates (wind power) to offset all nonrenewable energy used for its entire 2006 production, making NatureWorks polymer the world's first greenhouse gas-neutral polymer. The polymers were joined by Ingeo fibers, made from polylactic acid and used in fabrics, carpets, blankets, and similar products. NatureWorks LLC is now a wholly owned subsidiary of Cargill.

Corn-based polylactic acid is made by fermenting dextrose (glucose) into lactic acid and then polymerizing the lactic acid to form films, sheets, and fibers. Another manufacturer of biobased plastics is Novamont, in Italy. The company makes a starch-based biopolymer (potato starch, primarily), used for clear packaging products.

Other types of biobased plastics are coming on line: PHA (polyhydroxy-alkanoate) is a biopolyester produced by bacterial fermentation with properties much like polyolefins. It is made in a pilot plant by Metabolix, which recently formed a joint venture with Archer Daniel Midland (ADM). ADM plans to have a 110-million lb/yr PHA plant running by 2008. Metabolix also is researching and developing a means of extracting PHA directly from genetically modified switchgrass.

Production, Use Outlook.

BCC Research estimated global biopolymer demand at about 206 million lb/year in 2005, including 95 million lb for compost bags, 55 million lb for loose-fill "peanuts", 28 million lb for packaging film and sheet, and 28 million lb for miscellaneous uses. The stated capacities of the two biggest companies are about 377 million lb per year. As more plastic films are replaced, these biobased products will begin to replace part of the estimated 16 billion lb demand by 2011.

There are currently some problems with using PLA and similar based biofuels. Composting requires special treatment systems, not just burying in a landfill. Stability can be a problem at high temperatures. Companies that use biobased plastics may find that the difficulty of getting rid of the package may taint the pure green image. Whole Foods is arranging composting facilities near some of their stores, while Wal-Mart has indicated that disposal isn't their core competency.

More than 15,000 grocery stores are selling products in packaging made from the corn- based polymer. Biodegradable polymers have been in development for a number of years as a medical device, such as for controlled drug release in which drugs, cells from specific organs, or stem cells are inserted into a human body where they release drugs via ultrasound or magnetic pressure or form a scaffold for cells to regrow organs or repair damaged ones.

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