BIOMASS TO HIGH-VALUE PRODUCTS

Researchers have been working for decades to make energy production from non-food biomass economical. Advanced technologies now exist to produce ethanol from lignocellulosic biomass (grasses, agricultural waste, woody material). New technological advances have allowed the use of mixed and wet feed stocks for processing cellulosic biofuels. But a fundamental impediment remains — lignin.

The cementing agent that binds the matrix of cellulose fibers of tough plant cell walls, lignin currently takes more energy to break down than it is worth. Commercialization is at a near standstill. Two of three pioneering cellulosic ethanol plants touted in the U.S. Department of Energy's "2016 Billion-Ton Report" are now bankrupt.

ISTC is continuing the long search for economical methods to break down lignin macromolecules. In one research project, the Center has developed a novel catalyst which has shown promise for separating lignin into shorter polymers and monomers. The catalyst works at a much lower temperature than existing techniques, potentially making the process significantly cheaper.

In another project, biomass feedstocks containing higher lignin amounts and lignin by itself were depolymerized to produce high-value antioxidant additives and these antioxidants were found to be as effective as commercial petroleum-derived additives in improving oxidation stability of biodiesel and biolubricants.

The optimum pretreatment strategy does not yet exist which can efficiently release sugars from the crystalline structure of cellulose and the more complex matrices of hemicellulose and lignin. That is because energy used to achieve the release of sugar dehydrates lignin, making it harder still to break down.

Several types of lignin have market value on their own of between $50-500/tonne. But if biofuel producers could produce higher-value materials from lignin (>$1,000/tonne) the economics of biorefineries would greatly improve.

Higher-value chemicals which can be derived from lignin could replace petrochemicals used in the manufacture of polyurethanes, polyesters, resins, and activated carbon. Carbon fibers used today in cars, jets, and sporting goods might be more cheaply produced using lignin-derived materials. The material could replace more metals in consumer products, with lasting environmental benefits.

The Center also characterizes novel biochemicals to evaluate their potential for product commercialization. For instance, biobased-lignin modifiers added to binders in asphalt production are being investigated to displace petroleum products and deliver better pavement durability during summer months.

ISTC also has an active research focus on waste-to-energy approaches and thermo-chemical processing of various waste streams including food waste and agricultural residue. Of particular interest is the recovery of high-value petroleum fractions (catalysts) and rare earth elements.

Cellulosic ethanol represents a rare convergence of environmental, social, economic and national security goals. A healthy bio-economy would permit more sustainable agriculture, better land use, and fertilizer reduction. Homegrown fuels would reduce greenhouse gases, and create new markets for farm crops, wastes, and residues.

The Energy Policy Act (2005) established a Renewable Fuel Standard program to promote the use of renewable fuels in cars and trucks. The Energy Independence and Security Act (2007) increased requirements for biofuels production.

Ten years later, only 1.7 percent of that production target for cellulosic ethanol has been achieved.

FOCUS AREAS

Energy

Pollutants

Waste Utilization

Water Use & Reuse

ISTC/PRI Advantages

- 30+ year record in waste management and sustainability leadership in Illinois
- 30+ year record as technical advisor to Illinois industry and state and federal agencies
- Experience with energy and waste R&D projects
- Record of large-scale facility partnerships
- Experience with large regional networks
- Respected laboratory known for its precision work on analysis and chemical processes

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