Biorefinery makes use of every bit of a soybean

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The corn industry produces almost 4,000 products from every bushel. Oil refineries produce fuels and ingredients for an estimated 6,000 products with a thoroughness that actually squeezes 44 gallons of products from every 42-gallon barrel of crude.

Scientists today unveiled new technology intended to move soybeans, second only to corn as the top food crop in the U.S., along that same use-to-all path as a raw material for a wider portfolio of products. They described it — a new integrated soybean biorefinery — at the 244th National Meeting & Exposition of the American Chemical Society.

"Mention soybeans to most people, and they immediately think of the oil ," said Ramani Narayan, MSU University Distinguished Professor, who reported on the new biorefinery technology. "Soybean oil is the world's most widely used edible oil. It's in some margarines, shortenings, mayonnaise, salad dressings, frozen foods, baked goods and many other items. But soybeans are about more than oil. Soybeans are nuggets of green gold that can be a treasure trove of ingredients for other products, and our new biorefinery provides a glimpse of that potential."

The biorefinery is a relatively new concept, based on the approach used at oil refineries, which produce not just fuels from crude oil, but chemicals that become ingredients for thousands of other everyday products. Biorefineries use not oil as their raw material, but biomass — plant material — like corn and convert it into ethanol fuel, for instance, and a range of other products.

Narayan explained that soybeans pack much of corn's potential as a raw material, or "feedstock," for biorefineries. But soybean processing facilities traditionally have focused mainly on producing oil (which also has non-food uses in paints and inks, for instance) and soybean meal for livestock feed.

He described how the biorefinery can use well-established chemical processes to transform other components in soybeans into an array of valuable materials. Proteins in soybean meal, for instance, can be processed into ingredients used to make a variety of polyurethanes, including rigid foam insulation, flexible foams for packaging, as well as coatings, adhesives and elastomers. The soybean meal can further be processed to yield critical components used in polyester plastics for fabrics, ropes, car tires, plastic bottles and LCD screens; Nylon and Kevlar for bulletproof vests; and fire-resistant Nomex.

Likewise, triglycerides in soybean oil can be processed into ingredients used to make formaldehyde-free building insulation. The triglycerides can further be processed to manufacture adhesives, sealants, paints, plastic for toys and clothing using a process that does not require isocyanates. Both formaldehyde and isocyanates are potentially toxic materials, and better alternatives are preferred for these consumer goods. Soybean oil also can yield ingredients for coatings, used on electronic circuit boards, power lines and transformers. The soybean hulls can be chemically modified to make electro-rheological fluids which can be used for high-performance brakes and clutches.

"The biorefinery can utilize essentially every component of the soybean in the production of bio-based ingredients for high-value products," Narayan said. "It makes sense from a sustainability standpoint, in which we strive to reduce our dependence on petroleum as a feedstock. It also benefits the soybean farmers and raises the value of the local economy."

More information:

Abstract

Until recently crude oil was the most important source of basic chemicals and value-added polymeric materials. Using different processes and chemical reactions a barrel of oil is converted to a wide range of chemicals in addition to fuel. More recently renewable materials have become increasingly important raw materials for the chemical industry and the need arises to develop a similar wide range of processes that can utilize every component of these renewable resources. In our work with soybeans, we have used all parts of the bean (meal, oil and hulls) as sources of materials that can be converted economically to value-added products. Examples of this biorefinery concept include the proteins in the meals that were hydrolyzed and then converted to hydroxyl terminated urethanes. These urethanes were then further processed into foams, adhesives, etc. or reacted to yield useful polyesters, polyamides and polyureas. The triglycerides in the oil were subjected to catalyzed ozonation reactions that produced aldehyde, polyols and diesters functional groups. These intermediates were then used to prepare polyesters, formaldehyde-free resins and isocyanate-free polyurethanes. Alternatively, the oil was silylated to yield RTV coatings and other reactive intermediates. The cellulosic hulls were also utilized and were used in electro-rheological fluids and as reinforcing fillers in rubbers.

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