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New Route to Hydrocarbon Biofuels

A simple catalytic process converts plant sugars into gasoline, diesel, and jet fuel.

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Researchers at the University of Wisconsin-Madison have developed a simple, two-step chemical process to convert plant sugars into hydrocarbon fuels. The compounds created during the process could also be used to make other industrial chemicals and plastics.

Several companies are making hydrocarbon biofuels--which can be cheaper to produce than ethanol and have higher energy density--using microbes. Startups such as LS9 and Amyris are trying to genetically engineer the metabolic systems of microbes so that they ferment sugars into useful hydrocarbons.

The Wisconsin researchers, led by chemical- and biological-engineering professor James Dumesic (http://www.engr.wisc.edu/che/faculty/dumesic_james.html) , employ chemical reactions instead of microbial fermentation. They use catalysts at high temperatures to convert glucose into hydrocarbon biofuels. The process works thousands of times faster than microbes do because of the higher temperatures, so it requires smaller, cheaper reactors, Dumesic says. The catalysts and reformer systems that they use are similar to those used in oil refineries, which would also make the process simpler.

The catalytic process, presented online in *Science*, requires two main steps, which can be integrated and run sequentially with the output from one reactor going to the other. Both the catalyst mechanism and the continuous process design make the new approach promising, says John Regalbuto, director of the catalysis and biocatalysis program at the National Science Foundation, which funds Dumesic's work. Moreover, the catalysts can be recycled, whereas the microbes die and have to be replenished, he says. Compared to using enzymes or microbes, he says, "my sense is that at this stage of the game, catalysts have more potential."

In the first reactor, a sugar-water solution is passed over a platinum-rhenium catalyst at about 500 K. This strips five out of six oxygen atoms from the sugar, creating a mixture of various hydrocarbon compounds, such as alcohols and organic acids. The compounds form an oil-like layer that floats on top of the solution.

The oil is transferred to the second reactor, where it is passed over various solid catalysts, resulting in a range of hydrocarbon molecules that make up gasoline, diesel, and jet fuel. For instance, a copper and magnesium-based catalyst produces the hydrocarbons found in diesel and jet fuel. Gasoline contains hydrocarbons in which carbon atoms are connected in branched and ring-shaped structures, while carbon atoms in diesel and jet fuel form long, linear chains. The alcohols and organic acids in the oil from the first step could also be used to make plastics and industrial chemicals, Dumesic says.

The researchers' final goal is to use sugars derived from cellulosic biomass such as agricultural waste and switchgrass instead of using food sources such as corn and sugarcane. That would be the key to making environmentally beneficial hydrocarbon fuels from plants that are economically competitive with petroleum fuels. However, enzymes used to extract glucose and other sugars from cellulose are currently too expensive to make the process competitive for creating cellulosic biofuels.

Whether or not biogasoline competes with its petroleum counterpart, it might still make more sense than making ethanol, Regalbuto says. One of the most expensive parts of producing ethanol is the energy-intensive distillation step, in which ethanol has to be separated from water. Hydrocarbons such as gasoline and diesel, meanwhile, float to the top, so they are easier and less expensive to separate. Plus, he says, "you're getting a fuel that's 30 percent more energy dense [than ethanol]. So it's cheaper to make, and it gives you 30 percent more gas mileage."

Upcoming Events

AVS 55th International Symposium and Exhibition (http://www2.avs.org/symposium)
Boston, MA
Sunday, October 19, 2008 - Friday, October 24, 2008
http://www2.avs.org/symposium (http://www2.avs.org/symposium)

2008 Medical Innovation Summit (http://www.clevelandclinic.org/innovations/summit)
Cleveland, Ohio
Monday, November 10, 2008 - Wednesday, November 12, 2008
http://www.clevelandclinic.org/innovations/summit (http://www.clevelandclinic.org/innovations/summit)

MITX Awards (http://www.mitxawards.org/)
Boston, Massachusetts
Wednesday, November 19, 2008
http://www.mitxawards.org/ (http://www.mitxawards.org/)

WHIT 4.0 (http://www.whitcongress.com)
Washington, DC
Monday, December 08, 2008 - Wednesday, December 10, 2008
http://www.whitcongress.com (http://www.whitcongress.com)

EmTech08 (http://www.technologyreview.com/emtech/08/)
MIT Campus, Cambridge, MA
Tuesday, September 23, 2008 - Thursday, September 25, 2008
http://www.technologyreview.com/emtech/08/ (http://www.technologyreview.com/emtech/08/)