Research yields pricey chemicals from biodiesel waste

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In a move that promises to change the economics of biodiesel refining, chemical engineers at Rice University have unveiled a set of techniques for cleanly converting problematic biofuels waste into chemicals that fetch a profit.

The latest research is available online in the journal *Metabolic Engineering*. The new paper and others published earlier this year describe a new fermentation process that allows *E. coli* and other enteric bacteria to convert glycerin -- the major waste byproduct of biodiesel production -- into formate, succinate and other valuable organic acids.

"Biodiesel producers used to sell their leftover glycerin, but the rapid increase in biodiesel production has left them paying to get rid of it," said lead researcher Ramon Gonzalez, Rice's William W. Akers Assistant Professor in Chemical and Biomolecular Engineering. "The new metabolic pathways we have uncovered paved the way for the development of new technologies for converting this waste product into high-value chemicals."

About one pound of glycerin, also known as glycerol, is created for every 10 pounds of biodiesel produced. According to the National Biodiesel Board, U.S. companies produced about 450 million gallons of biodiesel in 2007, and about 60 new plants with a production capacity of 1.2 billion gallons are slated to open by 2010.

Gonzalez's team last year announced a new method of glycerol fermentation that used *E. coli* to produce ethanol, another biofuel. Even though the process was very efficient, with operational costs estimated to be about 40 percent less that those of producing ethanol from corn, Gonzalez said new fermentation technologies that produce high-value chemicals like succinate and formate hold even more promise for biodiesel refiners because those chemicals are more profitable than ethanol.

"With fundamental research, we have identified the pathways and mechanisms that mediate glycerol fermentation in *E. coli*," Gonzalez said. "This knowledge base is enabling our efforts to develop new technologies for converting glycerol into high-value chemicals."

Gonzalez said scientists previously believed that the only organisms that could ferment glycerol were those capable of producing a chemical called 1,3-propanediol, also known as 1,3-PDO. Unfortunately, neither the bacterium *E. coli* nor the yeast Saccharomyces -- the two workhorse organisms of biotechnology -- were able to produce 1,3-PDO.

Gonzalez's research revealed a previously unknown metabolic pathway for glycerol fermentation, a pathway that uses 1,2-PDO, a chemical similar to 1,3-PDO, that *E. coli* can produce.

"The reason this probably hadn't been discovered before is that *E. coli* requires a particular set of fermentation conditions for this pathway to be activated," Gonzalez said. "It wasn't easy to zero in on these conditions, so it wasn't the sort of process that someone would stumble upon by accident."

Once the new metabolic pathways were identified, Gonzalez's team began using metabolic engineering to design new versions of *E. coli* that could produce a range of high-value products. For example, while run-of-the-mill *E. coli* ferments glycerol to produce very little succinate, Gonzalez's team has created a new version of the bacterium that produces up to 100 times more. Succinate is a high-demand chemical feedstock that's used to make everything from noncorrosive airport deicers and nontoxic solvents to plastics, drugs and food additives. Most succinate today comes from nonrenewable fossil fuels.

Gonzalez said he's had similar success with organisms designed to produce other high-value chemicals, including formate and lactate.

"Our goal goes beyond using this for a single process," he said. "We want to use the technology as a platform for the 'green' production of a whole range of high-value products."

Technologies based on Gonzalez's work have been licensed to Glycos Biotechnologies Inc., a Houston-based startup company that plans to open its first demonstration facility within the next 12 months.

Source: Rice University

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