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Scientists Create a New Biofuel From E. Coli

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By Jennifer Bogo

First there was ethanol. Then there was butanol. Now there's an alcohol biofuel poised to put both to shame. Using new tricks of the trade, scientists at UCLA have synthesized an alcohol molecule that has as many carbon atoms as a molecule of gasoline. It releases as much energy per gallon and can be dropped right into the tank.

As bacterium goes, *E. coli* is a public health scourge, but a lab favorite. It's one of the most thoroughly studied microbes out there, and so one of the most easily manipulated for genetic engineering. Scientists can tweak its metabolic pathways to produce insulin, antibiotics and anticancer drugs; they can increase its ability to make ethanol or even engineer it to manufacture hydrocarbons. But until now, they couldn't push it to create something that didn't exist naturally: long-chain alcohols.

By manipulating *E. coli* to produce alcohols with up to eight carbon atoms, James Liao and his colleagues at the University of California-Los Angeles recently introduced a new twist to the field of biofuels research. Long-chain alcohols overcome some of the traditional limitations of ethanol, which has only two carbon atoms. They have both high-energy density—on par with gasoline—and low water solubility, so they are compatible with existing infrastructure.

"Long-chain alcohols can be directly used in automobiles or aircraft," Liao says. "Unlike E85, which requires retrofitted vehicles, [they] can be used without vehicle modification."

The current research, published in the *Proceedings of the National Academy of Sciences* on Dec. 8, builds on work Liao published in the journal *Nature* last January. The *Nature* study demonstrated that *E. coli* can metabolize glucose into branched chain alcohols with four or five carbon atoms—and do so in higher yields (for isobutanol, 86 percent of the theoretical maximum) that will be necessary for large-scale biofuels production.

Alcohols with six to eight carbon atoms in each molecule could only be generated by pioneering a whole new metabolic pathway—a nonnatural one, created by chemically synthesizing amino acids that allow the microbe to manufacture alcohols longer than what would be naturally possible.

Companies such as LS9 and PM Breakthrough Award winner Amyris have already engineered organisms to turn simple sugars into long hydrocarbon chains; Amyris opened its first pilot plant to produce renewable diesel in November 2008. Though Liao's long-chain alcohols could be chemically converted to even longer chain hydrocarbons (diesel has 12 to 16 carbons per molecule), Liao speculates that, because they are partially oxygenated, the alcohols may burn more cleanly and efficiently.

Because these biological tools are opening up new frontiers for biofuels, the country is eventually going to have to address the question of how many pumps it wants at the station, says Brian Davidson, the chief scientist for Systems Biology and Biotechnology at Oak Ridge National Laboratory. It will be years before Liao's (S)-3-methyl-1-pentanol is produced at scale, but when it is, will we need that, isobutanol, E85 and biohydrocarbons?

For now, Davidson says, we should continue to pursue all options. "We're really in an exciting era," he says. "We have multiple generations of technology, all behind each other, trying to come out in the market in a rapid deployment cycle. For an industrial process, it's very surprising—this is more like what you would expect to see in the electronics industry." The confluence of alternative fuels fits well with our national imperative, Davidson says. "This can't be research as usual to actually make an impact."

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