Technology
PUBLISHED BY MIT Review

Wednesday, August 01, 2007

Making Gasoline from Bacteria

A biotech startup wants to coax fuels from engineered microbes.

By Neil Savage

The biofuel of the future could well be gasoline. That's the hope of one biotech startup that on Monday described for the first time how it is coaxing bacteria into producing hydrocarbons that could be processed into fuels like those made from petroleum.

LS9 (http://www.ls9.com/) , a company based in San Carlos, CA, and founded by geneticist George Church (http://www.hms.harvard.edu/dms/bbs/fac/church.html) , of Harvard Medical School, and plant biologist Chris Somerville (http://www-ciwdpb.stanford.edu/research/research_csomerville.php) , of Stanford University, had previously said that it was working on what it calls "renewable petroleum." But at a Society for Industrial Microbiology (http://www.simhq.org/) conference on Monday, the company began speaking more openly about what it has accomplished: it has genetically engineered various bacteria, including *E. coli*, to custom-produce hydrocarbon chains.

To do this, the company is employing tools from the field of synthetic biology to modify the genetic pathways that bacteria, plants, and animals use to make fatty acids, one of the main ways that organisms store energy. Fatty acids are chains of carbon and hydrogen atoms strung together in a particular arrangement, with a carboxylic acid group made of carbon, hydrogen, and oxygen attached at one end. Take away the acid, and you're left with a hydrocarbon that can be made into fuel.

"I am very impressed with what they're doing," says James Collins (http://www.bu.edu/dbin/bme/faculty/?prof=jcollins) , codirector of the Center for Advanced Biotechnology (http://www.bu.edu/cab/) at Boston University. He calls the company's use of synthetic biology and systems biology to engineer hydrocarbon-producing bacteria "cutting edge."

In some cases, LS9's researchers used standard recombinant DNA techniques to insert genes into the microbes. In other cases, they redesigned known genes with a computer and synthesized them. The resulting modified bacteria make and excrete hydrocarbon molecules that are the length and molecular structure the company desires.

Stephen del Cardayre, a biochemist and LS9's vice president for research and development, says the company can make hundreds of different hydrocarbon molecules. The process can yield crude oil without the contaminating sulfur that much petroleum out of the ground contains. The crude, in turn, would go to a standard refinery to be processed into automotive fuel, jet fuel, diesel fuel, or any other petroleum product that someone wanted to make.

Next year LS9 will build a pilot plant in California to test and perfect the process, and the company hopes to be selling improved biodiesel and providing synthetic biocrudes to refineries for further processing within three to five years. (See "Building Better Biofuels (http://www.technologyreview.com/Biztech/18827/) .")

But LS9 isn't the only company in this game. Amyris Biotechnologies (http://www.amyrisbiotech.com/) , of Emeryville, CA, is also using genes from plants and animals to make microbes produce designer fuels. Neil Renninger, senior vice president of development and one of the company's cofounders, says that Amyris has also created bacteria capable of supplying renewable hydrocarbon-based fuels. The main difference between the companies, Renninger says, is that while LS9 is working on a biocrude that would be processed in a refinery, Amyris is working on directly producing fuels that would need little or no further processing.

Amyris is also working on a pilot production plant that it expects to complete by the end of next year, and it also hopes to have commercial products available within three or four years. (See "A Better Biofuel (http://www.technologyreview.com/Biotech/18476/) .") Both companies say they want to further engineer their bacteria to be more efficient, and they're working to optimize the overall production process. "The potential for biofuels is huge, and I think theirs [LS9's] is one possible solution," Renninger says.

Indeed, many technology approaches are needed, says Craig Venter (http://www.jcvi.org/) , cofounder and CEO of Synthetic Genomics

(http://www.syntheticgenomics.com/) , of Rockland, MD, which is also applying biotechnology to fuel production. "We need a hundred, a thousand solutions, not just one," he says. "I know at least a dozen groups and labs trying to make biofuels from bacteria with sugar."

Venter's company is also working on engineering microbes to produce fuel. The company recently received a large investment from the oil giant BP to study the microbes that live on underground oil supplies; the idea is to see if the microbes can be engineered to provide cleaner fuel. Another project aims to tinker with the genome of palm trees--the most productive source of oil for biodiesel--to make them a less environmentally damaging crop.

LS9's current work uses sugar derived from corn kernels as the food source for the bacteria--the same source used by ethanol-producing yeast. To produce greater volumes of fuel, and to not have energy competing with food, both approaches will need to use cellulosic biomass, such as switchgrass, as the feedstock. Del Cardayre estimates that cellulosic biomass could produce about 2,000 gallons of renewable petroleum per acre.

Producing hydrocarbon fuels is more efficient than producing ethanol, del Cardayre adds, because the former packs about 30 percent more energy per gallon. And it takes less energy to produce, too. The ethanol produced by yeast needs to be distilled to remove the water, so ethanol production requires 65 percent more energy than hydrocarbon production does.

The U.S. Department of Energy has set a goal of replacing 30 percent of current petroleum use with fuels from renewable biological sources by 2030, and del Cardayre says he feels that's easily achievable.

Upcoming Events

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/)

Academic Enterprise Awards Europe (http://www.sciencebusiness.net/aces/)
Stockholm, Sweden
Tuesday, December 02, 2008
http://www.sciencebusiness.net/aces/ (http://www.sciencebusiness.net/aces/)

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/)