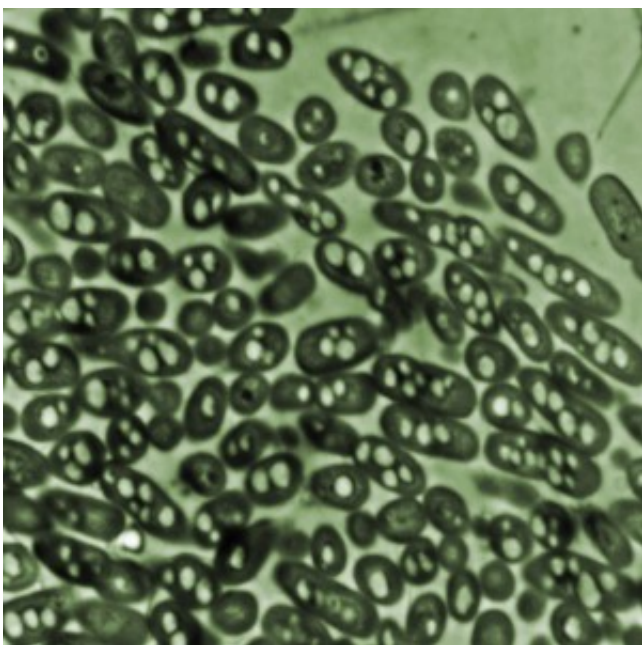


Clean, green high performance biofuels from carbon dioxide

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Micrograph shows *Ralstonia eutropha* bacteria in culture. Credit: Christopher Brigham, MIT

Could there come a time in which the carbon dioxide emitted from natural gas or coal-burning power plants that warms the atmosphere and exacerbates global climate change is harvested and used to produce clean, green and renewable liquid transportation fuels? A pathway to that possibility has been opened by a team of researchers with the U.S. Department of Energy (DOE)'s Joint BioEnergy Institute (JBEI) who have engineered a microbe now being used to produce biodegradable

plastic into a strain that can produce a high-performance advanced biofuel.

"We've shown that the bacterium *Ralstonia eutropha* growing with carbon dioxide and [hydrogen gas](#) is able to generate significant quantities of diesel-range methyl ketones," says Harry Beller, a JBEI [microbiologist](#) who led this research, which was funded through DOE's Advanced Research Projects Agency-Energy (ARPA-E) program. "This holds the promise of making carbon-neutral biofuels using non-photosynthetic, carbon-dioxide fixing bacteria as a less resource-intensive alternative to making these biofuels from cellulosic biomass."

Beller, who directs the Biofuels Pathways department for JBEI's Fuels Synthesis Division, and also is a Senior Scientist with Berkeley Lab's Earth Sciences Division, led a previous study in which genetic engineering was used to develop a strain of the bacterium *Escherichia coli* (*E. coli*) that made methyl ketone compounds from the glucose in cellulosic biomass. Methyl ketones are naturally occurring aliphatic compounds now used in fragrances and [flavorings](#). Beller and his JBEI colleagues have demonstrated that methyl ketones also have high diesel fuel ratings (cetane numbers), making them strong candidates as advanced biofuels.

"We've shown that, with the same set of genetic modifications, *R. eutropha* and *E. coli* can make comparable amounts of methyl ketones, but *R. eutropha* is making the ketones from carbon dioxide while *E. coli* is making them from glucose," Beller says. "This shows that the methyl ketone pathway that we've designed is versatile and able to function well in bacterial hosts with substantially different metabolic lifestyles."

Current strategies for producing advanced biofuels that could replace gasoline, diesel or jet fuels in today's engines and infrastructures are based on extracting fermentable sugars stored in the cellulosic biomass

of green plants. Those sugars represent chemical energy that was converted from solar energy via photosynthesis and provide the carbon atoms needed to make fuels. *R. eutropha* is a common soil bacterium that can naturally use hydrogen rather than sunlight as an energy source for converting carbon dioxide into various organic compounds. However, native strains of *R. eutropha* do not produce detectable levels of methyl ketones and generate very low levels of the fatty acids that are precursors to methyl ketones.

"Since our engineered strains of *R. eutropha* can use fixed carbon dioxide to make methyl ketones, its biofuels don't require many of the steps needed to convert cellulosic biomass into fuels, such as growing and harvesting the biofuel crop, digesting the lignocellulosic biomass, and enzymatically saccharifying the digested biomass to produce fermentable sugars," Beller says. "The resources needed for these steps could therefore be eliminated if *R. eutropha* were used to make biofuels directly from [carbon dioxide](#)."

Beller is the corresponding author of a paper in the journal AEM that describes this research titled "Engineering of *Ralstonia eutropha* H16 for Autotrophic and Heterotrophic Production of Methyl Ketones." Co-authors are Jana Müller, Daniel MacEachran, Helcio Burd, Noppadon Sathitsuksanoh, Changhao Bi, Yi-Chun Yeh, Taek Soon Lee, Nathan Hillson, Swapnil Chhabra and Steven Singer.

Provided by Lawrence Berkeley National Laboratory

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