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New process yields high-energy-density, plant-based transportation fuel

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(PhysOrg.com) -- A team of University of Wisconsin-Madison engineers has developed a highly efficient, environmentally friendly process that selectively converts gamma-valerolactone, a biomass derivative, into the chemical equivalent of jet fuel.

The simple process preserves about 95 percent of the energy from the original biomass, requires little hydrogen input, and captures carbon dioxide under high pressure for future beneficial use.

With James Dumesic, Steenbock Professor of Chemical and Biological Engineering at UW-Madison, postdoctoral researchers Jesse Bond and David Martin Alonso, and graduate students Dong Wang and Ryan West published details of the advance in the Feb. 26 edition of the journal *Science*.

Much of the Dumesic group's previous research of using cellulosic biomass for biofuels has focused on processes that convert abundant plant-based sugars into transportation fuels. However, in previously studied conversion methods, sugar molecules frequently degrade to form levulinic acid and formic acid — two products the previous methods couldn't readily transform into high-energy liquid fuels.

The team's new method exploits sugar's tendency to degrade. "Instead of trying to fight the degradation, we started with levulinic acid and formic acid and tried to see what we could do using that as a platform," says Dumesic.

In the presence of metal catalysts, the two acids react to form gamma-valerolactone, or GVL, which now is manufactured in small quantities as an herbal food and perfume additive. Using laboratory-scale equipment and stable, inexpensive catalysts, Dumesic's group converts aqueous solutions of GVL into jet fuel. "It really is very simple," says Bond, of the two-step catalytic process. "We can pull off these two catalytic stages, as well as the requisite separation steps, in series, with basic equipment. With very minimal processing, we can produce a pure stream of jet-fuel-range alkenes and a fairly pure stream of carbon dioxide."

While biofuels such as ethanol are becoming more popular as blending agents in automobile fuels, they have limitations for use in jet fuel because of their low energy density. And, given present internal combustion engine designs, conventional biofuels cannot fully replace petroleum-derived hydrocarbons. "The hydrocarbons produced from GVL in this new process are chemically equivalent to those used in the present infrastructure," says Alonso. "The product we make is ready for the jet fuel application and can be added to existing hydrocarbon blends, as needed, to meet specs."

The biggest barrier to implementing the renewable fuel is the cost of GVL. Until now, says Dumesic, there has not been an incentive to mass-produce the compound. "The bottleneck in having the fuel ready for prime time is the availability of cost-effective GVL," he says.

Now that they have demonstrated the process for converting GVL to transportation fuel, Dumesic and his students are developing more efficient methods for making GVL from biomass sources such as wood, corn stover, switchgrass and others. "Once the GVL is made effectively, I think this is an excellent way to convert it to jet fuel," he says.

Provided by University of Wisconsin-Madison