A better way to make hydrogen from biofuels

August 20 2008

Researchers here have found a way to convert ethanol and other biofuels into hydrogen very efficiently. A new catalyst makes hydrogen from ethanol with 90 percent yield, at a workable temperature, and using inexpensive ingredients.

Umit Ozkan, professor of chemical and biomolecular engineering at Ohio State University, said that the new catalyst is much less expensive than others being developed around the world, because it does not contain precious metals, such as platinum or rhodium.

"Rhodium is used most often for this kind of catalyst, and it costs around $9,000 an ounce," Ozkan said. "Our catalyst costs around $9 a kilogram."

She and her co-workers presented the research Wednesday, August 20 at the American Chemical Society meeting in Philadelphia.

The Ohio State catalyst could help make the use of hydrogen-powered cars more practical in the future, she said.

"There are many practical issues that need to be resolved before we can use hydrogen as fuel -- how to make it, how to transport it, how to create the infrastructure for people to fill their cars with it," Ozkan explained.

"Our research lends itself to what's called a 'distributed production' strategy. Instead of making hydrogen from biofuel at a centralized facility and transporting it to gas stations, we could use our catalyst

inside reactors that are actually located at the gas stations. So we wouldn't have to transport or store the hydrogen -- we could store the biofuel, and make hydrogen on the spot."

The catalyst is inexpensive to make and to use compared to others under investigation worldwide. Those others are often made from precious metals, or only work at very high temperatures.

"Precious metals have high catalytic activity and -- in most cases -- high stability, but they're also very expensive. So our goal from the outset was to come up with a precious-metal-free catalyst, one that was based on metals that are readily available and inexpensive, but still highly active and stable. So that sets us apart from most of the other groups in the world."

The new dark gray powder is made from tiny granules of cerium oxide -- a common ingredient in ceramics -- and calcium, covered with even smaller particles of cobalt. It produces hydrogen with 90 percent efficiency at 660 degrees Fahrenheit (around 350 degrees Celsius) -- a low temperature by industrial standards.

"Whenever a process works at a lower temperature, that brings energy savings and cost savings," Ozkan said. "Also, if the catalyst is highly active and can achieve high hydrogen yields, we don't need as much of it. That will bring down the size of the reactor, and its cost".

The process starts with a liquid biofuel such as ethanol, which is heated and pumped into a reactor, where the catalyst spurs a series of chemical reactions that ultimately convert the liquid to a hydrogen-rich gas.

One of the biggest challenges the researchers faced was how to prevent "coking" -- the formation of carbon fragments on the surface of the catalyst. The combination of metals -- cerium oxide and calcium --

solved that problem, because it promoted the movement of oxygen ions inside the catalyst. When exposed to enough oxygen, the carbon, like the biofuel, is converted into a gas and gets oxidized; it becomes carbon dioxide.

At the end of the process, waste gases such as carbon monoxide, carbon dioxide and methane are removed, and the hydrogen is purified. To make the process more energy-efficient, heat exchangers capture waste heat and put that energy back into the reactor. Methane recovered in the process can be used to supply part of the energy.

Though this work was based on converting ethanol, Ozkan's team is now studying how to use the same catalyst with other liquid biofuels. Her coauthors on this presentation included Ohio State doctoral students Hua Song and Lingzhi Zhang.

Source: Ohio State University