Method to capture carbon monoxide's energy for new generation of inexpensive fuel cells

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Carbon monoxide, or CO, has long been a major technical barrier to the efficient operation of fuel cells. But now, chemical and biological engineers at UW-Madison have not only cleared that barrier - they also have discovered a method to capture carbon monoxide's energy. To be useful in a power-generating fuel cell, hydrocarbons such as gasoline, natural gas or ethanol must be reformed into a hydrogen-rich gas. A large, costly and critical step to this process requires generating steam and reacting it with carbon monoxide (CO). This process, called water-gas shift, produces hydrogen and carbon dioxide (CO2). Additional steps then are taken to reduce the CO levels further before the hydrogen enters a fuel cell.

James Dumesic, professor of chemical and biological engineering , postdoctoral researcher Won Bae Kim, and graduate students Tobias Voitl and Gabriel Rodriguez-Rivera eliminated the water-gas shift reaction from the process, removing the need to transport and vaporize liquid water in the production of energy for portable applications.

The team, as reported in the Aug. 27 issue of Science, uses an environmentally benign polyoxometalate (POM) compound to oxidize CO in liquid water at room temperature. The compound not only removes CO from gas streams for fuel cells, but also converts the energy content of CO into a liquid that subsequently can be used to power a fuel cell.

"CO has essentially as much energy as hydrogen," Dumesic says. "It has a lot of energy in it. If you take a hydrocarbon and partially oxidize it at high temperature, it primarily makes CO and hydrogen. Conventional systems follow that with a series of these 'water-gas shift' steps. Our discovery has the potential of eliminating those steps. Instead, you can send the CO through our process, which works efficiently at room temperature, and takes the CO out of the gas to make energy."

The research team says the process is especially promising for producing electrical energy from renewable biomass-derived oxygenated hydrocarbons - such as ethylene glycol derived from corn - because these fuels generate H2 and CO in nearly equal amounts during catalytic decomposition. The hydrogen could be used directly in a proton-exchange-membrane fuel cell operating at 50 percent efficiency, and the remaining CO could be converted to electricity via the researchers' new process.

The overall efficiency of such a system is equal to 40 percent and, unlike traditional ethylene glycol reforming, does not require water. The overall efficiency is equivalent to 60 percent of the energy content of octane.

Dumesic's team believes the advance will make possible a new generation of inexpensive fuel cells operating with solutions of reduced POM compounds. While higher current densities can be achieved in fuel cells using electrodes containing precious metals, the researchers found that good current densities can be generated using a simple carbon anode.

Source: University of Wisconsin-Madison

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