Nanotechnology could promote hydrogen economy

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Say "nanotechnology" and people are likely to think of micro machines or zippy computer chips. But in a new twist, Rutgers scientists are using nanotechnology in chemical reactions that could provide hydrogen for tomorrow's fuel-cell powered clean energy vehicles.
In a paper to be published April 20 in the Journal of the American Chemical Society, researchers at Rutgers, The State University of New Jersey, describe how they make a finely textured surface of the metal iridium that can be used to extract hydrogen from ammonia, then captured and fed to a fuel cell. The metal's unique surface consists of millions of pyramids with facets as tiny as five nanometers (five billionths of a meter) across, onto which ammonia molecules can nestle like matching puzzle pieces. This sets up the molecules to undergo complete and efficient decomposition.

"The nanostructured surfaces we're examining are model catalysts," said Ted Madey, State of New Jersey professor of surface science in the physics department at Rutgers. "They also have the potential to catalyze chemical reactions for the chemical and pharmaceutical industries."

A major obstacle to establishing the "hydrogen economy" is the safe and cost-effective storage and transport of hydrogen fuel. The newly discovered process could contribute to the solution of this problem. Handling hydrogen in its native form, as a light and highly flammable gas, poses daunting engineering challenges and would require building a new fuel distribution infrastructure from scratch.

By using established processes to bind hydrogen with atmospheric nitrogen into ammonia molecules (which are simply one atom of nitrogen and three atoms of hydrogen), the resulting liquid could be handled much like today's gasoline and diesel fuel. Then using nanostructured catalysts based on the one being developed at Rutgers, pure hydrogen could be extracted under the vehicle's hood on demand, as needed by the fuel cell, and the remaining nitrogen harmlessly released back into the atmosphere. The carbon-free nature of ammonia would also make the fuel cell catalyst less susceptible to deactivation.

When developing industrial catalysts, scientists and engineers have traditionally focused on how fast they could drive a chemical reaction. In such situations, however, catalysts often drive more than one reaction, yielding unwanted byproducts that have to be separated out. Also, traditional catalysts sometimes lose strength in the reaction process. Madey says that these problems could be minimized by tailoring nanostructured metal surfaces on supported industrial catalysts, making new forms of catalysts that are more robust and selective.

In the journal article, Madey and postdoctoral research fellow Wenhua Chen and physics graduate student Ivan Ermanoski describe how a flat surface of iridium heated in the presence of oxygen changes its shape to make uniform arrays of nanosized pyramids. The structures arise when atomic forces from the adjacent oxygen atoms pull metal atoms into a more tightly ordered crystalline state at temperatures above 300 degrees Celsius (or approximately 600 degrees Fahrenheit). Different annealing temperatures create different sized facets, which affect how well the iridium catalyzes ammonia decomposition. The researchers are performing additional studies to characterize the process more completely.

Source: Rutgers, the State University of New Jersey