

Purdue creates new method to drive fuel cells for portable electronics

Engineers at Purdue University have developed a new way of producing hydrogen for fuel cells to automatically recharge batteries in portable electronics, such as notebook computers, and eliminate the need to use a wall outlet.

The findings will be presented Sunday (Aug. 28) during the annual meeting of the American Chemical Society in Washington, D.C., and also will be detailed in a peer-reviewed paper to appear in an upcoming issue of the journal *Combustion and Flame*. The paper was written by research scientist Evgeny Shafirovich, postdoctoral research associate Victor Diakov and Arvind Varma, the R. Games Slayter Distinguished Professor of Chemical Engineering and head of Purdue's School of Chemical Engineering.

The researchers developed the new method earlier this year and envision a future system in which pellets of hydrogen-releasing material would be contained in disposable credit-card-size cartridges. Once the pellets were used up, a new cartridge would be inserted into devices such as cell phones, personal digital assistants, notebook computers, digital cameras, handheld medical diagnostic devices and defibrillators.

The method also might have military applications in portable electronics for soldiers and for equipment in spacecraft and submarines, Varma said.

The new technique combines two previously known methods for producing hydrogen. The previous methods have limitations making them impractical when used alone, but those drawbacks are overcome when the methods are combined, Varma said.

One of the methods was invented by Herbert C. Brown, a chemist and Nobel laureate from Purdue who discovered a compound called sodium borohydride during World War II. The compound contains sodium, boron and hydrogen. He later developed a technique for producing hydrogen by combining sodium borohydride with water and a catalyst. The method, however, has a major drawback because it requires expensive catalysts such as ruthenium.

The other method involves a chemical reaction in which tiny particles of aluminum are combined with water in such a way that the aluminum ignites, releasing hydrogen during the combustion process. This method does not require an expensive catalyst, but it yields insufficient quantities of hydrogen to be practical for fuel cell applications.

"Our solution is to combine both methods by using what we call a triple borohydride-metal-water mixture, which does not require a catalyst and has a high enough hydrogen yield to make the method promising for fuel cell applications," Varma said. "So far we have shown in experiments that we can convert 6.7 percent of the mixture to hydrogen, which means that for every 100 grams of mixture we can produce nearly 7 grams of hydrogen, and that yield is already better than alternative methods on the market."

The researchers have filed a provisional patent application for the technique and hope to increase the yield to about 10 percent through additional experiments, Shafirovich said.

Hydrogen produced by the method could be used to drive a fuel cell, which then would produce electricity to charge a battery. A computer chip would automatically detect when the battery needed to be recharged, activating a new pellet until all of the pellets on the cartridge were consumed. Byproducts from the reaction are environmentally benign and can either be safely discarded or recycled, Diakov said.

In addition to its potential use in portable electronics, the technology offers promise as an energy source to power hardware in spacecraft.

"The Apollo 13 accident was caused by an explosion involving liquid oxygen, which is needed along with liquid hydrogen to feed a fuel cell in spacecraft," Shafirovich said. "Use of chemical mixtures, such as ours, for generation of hydrogen and oxygen would eliminate the possibility of such an explosion."

A key step in the hydrogen-producing reaction is the use of tiny particles of aluminum only about as wide as 100 nanometers, or 100 billionths of a meter.

"You don't want to use large lumps of aluminum because then you only get reactions on the outer surfaces of those lumps, so you don't produce enough hydrogen," Varma said. "What you would rather use is tiny particles that have a high surface area, which enables them to completely react, leaving no waste and producing more hydrogen."

Another crucial component is a special gel created by combining water with a material called polyacrylamide.

"If you want to ignite a mixture of aluminum with water, the problem is that water boils at 100 degrees Centigrade and aluminum ignites at a much higher temperature," Shafirovich said. "So, if you try to ignite the mixture you just vaporize water and the aluminum doesn't ignite."

"When we use this gel, water boils at a much higher temperature, and the nanoscale powder also decreases the ignition temperature of aluminum. So you are both increasing the boiling point of water and decreasing the ignition temperature of aluminum, making the reaction possible."

The researchers believe they will be able to safely dissipate the heat produced by the reaction, making the technology practical for portable electronics.

This research is supported by the Purdue Hydrogen Economy initiative of the College of Engineering and is being conducted as a part of Purdue's new Energy Center, created this year at the university's Discovery Park.

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