Nano World: Stabilizing explosive elements

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Capsules only nanometers or billionths of a meter wide that stabilize extremely dangerous compounds normally prone to igniting or exploding can safely generate more than enough hydrogen gas to beat U.S. Department of Energy goals for hydrogen production for 2015 just by dropping them in water.

The capsules are finding use in simplifying pharmaceutical manufacture. They could also help clean petroleum of sulfur and destroy ozone-destroying CFCs, dangerous mustard gas and organic pollutants such as PCBs, explained Michael Lefenfeld, New York-based SiGNa Chemistry's president and chief executive officer. Users so far include Pfizer, ExxonMobil, Shell, DuPont, BASF and Motorola.

The capsules are safe and easy to handle, and after they react the only byproducts are environmentally friendly, such as sand or sodium silicate, "which is the main ingredient in toothpaste," Lefenfeld said.

Sodium, potassium and other alkali metals are potentially extraordinarily useful elements because they are highly chemically reactive. However, this also makes them dangerously volatile.

"If you drop sodium in water, you'll see it dance as a fireball on the surface. If you drop rubidium in water, it's like a hand grenade. And cesium is like a depth charge. It's why people have avoided using them," Lefenfeld said. He and his colleagues developed a method to enclose nanoparticles of alkali metals in porous capsules made of ceramics such as silica or alumina. These capsules soak up the loose electrons that make the alkali metals so violently unstable, while at the same time maintaining their reactivity. "If the alkali metals were not in nanoclusters, you could not achieve stabilization," Lefenfeld said.

"The nice thing about our technologies is that our materials can be made through currently commercially available ingredients, processes and equipment. There's no need for specially designed or really expensive types of equipment. It can all be very simple," Lefenfeld said.

At first "I thought it was too good to be true," said Boris Gorin, director of research and development at pharmaceutical industry process development firm Alphora Research in Mississauga, Canada, who has tried out these materials. "These are a really exciting set of materials. People need to discover the power of this invention just as I did."

One exciting possibility for these capsules is generating hydrogen gas for vehicles in the future. Combining hydrogen gas with oxygen results in energy and water, and none of the dirty mix of toxins and global warming gases burning gasoline spews forth. The cleanliness of hydrogen is in large part why government and industry support for hydrogen vehicles has reached into the billions of dollars.

Scientists worldwide are experimenting with cost effective and convenient sources of hydrogen. The U.S. Department of Energy requirement for hydrogen production for 2015 is a material that can generate 8 weight percent hydrogen, "so if you put in 100 grams of a material, you're supposed to get eight grams of hydrogen back," Lefenfeld said. "Our materials currently can get up to 9 weight percent hydrogen, exceeding the 2015 requirement, with the potential of achieving 13 or 14 weight percent hydrogen which is nearly double the DoE 2015 requirement."

The capsules also promise to simplify pharmaceutical synthesis. The drug industry traditionally tried controlling alkali metal reactivity by dispersing it in liquid ammonia, which requires cryogenic temperatures as well as dealing with environmental and safety hazards and regulations.

"To avoid using alkali metals, two to four steps get added to the process of drug synthesis that incur big costs, with each step costing $200 to $2,000 per kilogram," Lefenfeld said. "Now, using our stabilized alkali metals, you don't have to use liquid ammonia and replace all those steps. This could also reduce impurity levels substantially."