Minding the pools

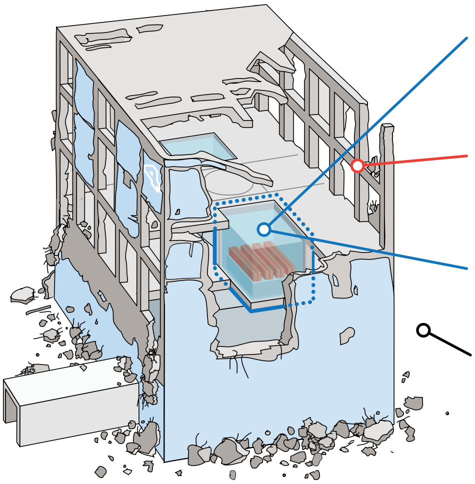
Some experts believe that governments and the nuclear power industry have done a poor job of sharing information on the risk of zirconium fires. Critics of NRC say that studies conducted for the agency likely contain relevant data but have been kept classified to keep the information away from terrorists. "To the extent that any experiments have been done at all, the public doesn't know about them," says spent-fuel expert Gordon Thompson of Clark University in Worcester, Massachusetts. The National Research Council study called on NRC to "improve the sharing of pertinent information" on pool risks.

The calamity at Fukushima Daiichi has raised particular concerns about U.S. spent nuclear fuel pools, which are thought to be packed more tightly than those in Europe or Asia. "Spent nuclear fuel may be more vulnerable than we thought," says Edwin Lyman of the Union of Concerned Scientists in Washington, D.C. The nuclear industry has added additional sprayers to pools and now mixes hot, fresh spent fuel with older fuel in the pools to redistribute the heat. But it balked at a 2008 recommendation by Jaczko—speaking in an unofficial capacity—to transfer U.S. fuel older than 5 years to dry concrete casks, where the cooled fuel is highly unlikely to catch fire. Still, the industry has begun a safety review of U.S. reactors, and NRC has launched two studies into U.S. plant safety that could lead to new rules on spent fuel.

–ELI KINTISCH

With reporting by Dennis Normile in Tokyo.

REACTOR #4: THE SECRETS OF A SPENT FUEL POOL



What caused the loss of water in the pool, and how low did the water level get?
Whether the water drained, evaporated, or boiled off would provide key clues.

What caused the hydrogen explosion?
Zirconium alloy, which makes up the tubes holding the uranium fuel pellets, reacts with steam to form hydrogen, which can ignite in the presence of oxygen.

What temperature was the water?
The zirconium reaction progresses at temperatures above 800°C.

What do recorded levels of cesium-137 outside the plant mean?
Melted and aerosolized long-lived radionuclides suggest a hot fire in the pool.

CHEMISTRY

Artificial Leaf Turns Sunlight Into a Cheap Energy Source

ANAHEIM, CALIFORNIA—Nearly all the energy we use on this planet starts out as sunlight that plants use to knit chemical bonds. Now, for the first time, researchers at the Massachusetts Institute of Technology (MIT) have created a potentially cheap, practical artificial leaf that does much the same thing.

The new device is a silicon wafer about the shape and size of a playing card. Different catalysts coat each side of the wafer. The silicon absorbs sunlight and passes that energy to the catalysts to split water into molecules of hydrogen (H_2) and oxygen (O_2). Hydrogen is a fuel that can be either burned or used in a fuel cell to create electricity, reforming water in either case. This means that, in theory, anyone with access to water can use it to create a cheap, clean, and available source of fuel.

"It's spectacular," says Robert Grubbs, a chemist at the California Institute of Technology in Pasadena, who saw the presentation here last weekend at the biannual meeting of the American Chemical Society. "There's still obviously a long way to go" to make the new device into a rugged, real-world technology, Grubbs says. But the approach is important because its potential low cost could make it widely available. It "has a chance of being scalable," Grubbs says.

Three years ago, an MIT team led by chemist Daniel Nocera devised a special cobalt and phosphorus-based catalyst that breaks water molecules apart and knits pairs of oxygen atoms into O_2 molecules (*Science*, 1 August 2008, p. 620). Researchers had previously made H_2-forming catalysts. But these were expensive. Earlier this week, Nocera reported devising a cheap catalyst that uses three different metals to form H_2.

The splits. A new silicon wafer can make hydrogen fuel from sunlight and water.

Nocera didn't reveal the makeup of the new catalyst, as the work is not yet published, and he is in the process of patenting it. But he notes that finding his new H_2-forming catalyst was made easier by the fact that his O_2 catalyst works in water, a more benign environment than existing H_2-generating compounds typically face.

To make its artificial leaf, the MIT team spread its catalysts on opposite sides of a silicon wafer. The silicon absorbs sunlight and passes energetic, negatively charged electrons and positively charged electron vacancies to the catalysts on opposite sides that use them to make H_2 and O_2. When the device is placed in a clear jar and exposed to sunlight, the setup converts 5.5% of the energy in sunlight into hydrogen fuel. "You literally walk outside, hold it up, and it works," Nocera says.

Nocera says he hopes to commercialize the new technology within 2 to 3 years. Later this year, a company he founded, Sun Catalytix, expects to produce a prototype electrolyzer using the cobalt catalyst and an external electricity source to split water to generate hydrogen. Sunlight-to-fuel water splitters using both new catalysts will likely follow after that, he says. In addition, Nocera is teaming up with Ratan Tata, chair of Tata Group, an Indian conglomerate, in hopes of producing a refrigerator-sized power plant capable of converting sunlight and water into electricity. The goal is cheap, renewable power for vast numbers of people lacking access to large amounts of energy.

–ROBERT F. SERVICE

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