Thursday, July 31, 2008
Solar-Power Breakthrough
Researchers have found a cheap and easy way to store the energy made by solar power.
By Kevin Bullis

Researchers have made a major advance in inorganic chemistry that could lead to a cheap way to store energy from the sun. In so doing, they have solved one of the key problems in making solar energy a dominant source of electricity.

Daniel Nocera, a professor of chemistry at MIT, has developed a catalyst that can generate oxygen from a glass of water by splitting water molecules. The reaction frees hydrogen ions to make hydrogen gas. The catalyst, which is easy and cheap to make, could be used to generate vast amounts of hydrogen using sunlight to power the reactions. The hydrogen can then be burned or run through a fuel cell to generate electricity whenever it's needed, including when the sun isn't shining.

Solar power is ultimately limited by the fact that the solar cells only produce their peak output for a few hours each day. The proposed solution of using sunlight to split water, storing solar energy in the form of hydrogen, hasn't been practical because the reaction required too much energy, and suitable catalysts were too expensive or used extremely rare materials. Nocera's catalyst clears the way for cheap and abundant water-splitting technologies.

Nocera's advance represents a key discovery in an effort by many chemical research groups to create artificial photosynthesis--mimicking how plants use sunlight to split water to make usable energy. "This discovery is simply groundbreaking," says Karsten Meyer, a professor of chemistry at Friedrich Alexander University, in Germany. "Nocera has probably put a lot of researchers out of business." For solar power, Meyer says, "this is probably the most important single discovery of the century."

The new catalyst marks a radical departure from earlier attempts. Researchers, including Nocera, have tried to design molecular catalysts in which the location of each atom is precisely known and the catalyst is made to last as long as possible. The new catalyst, however, is amorphous--it doesn't have a regular structure--and it's relatively unstable, breaking down as it does its work. But the catalyst is able to constantly repair itself, so it can continue working.

In his experimental system, Nocera immerses an indium tin oxide electrode in water mixed with cobalt and potassium phosphate. He applies a voltage to the electrode, and cobalt, potassium, and phosphate accumulate on the electrode, forming the catalyst. The catalyst oxidizes the water to form oxygen gas and free hydrogen ions. At another electrode, this one coated with a platinum catalyst, hydrogen ions form hydrogen gas. As it works, the cobalt-based catalyst breaks down, but cobalt and potassium phosphate in the solution soon re-form on the electrode, repairing the catalyst.

Nocera created the catalyst as part of a research program whose goal was to develop artificial photosynthesis that works more efficiently than photosynthesis and produces useful fuels, such as hydrogen. Nocera has solved one of the most challenging parts of artificial photosynthesis: generating oxygen from water. Two more steps remain. One is replacing the expensive platinum catalyst for making hydrogen from hydrogen ions with a catalyst based on a cheap and abundant metal, as Nocera has done with the oxygen catalyst.

Finding a cheaper catalyst for making hydrogen shouldn't be too difficult, says John Turner, a principal investigator at the National Renewable Energy Laboratory, in Golden, CO. Indeed, Nocera says that he has promising new materials that might work, and other researchers also have likely candidates. The second remaining step in artificial photosynthesis is developing a material that absorbs sunlight, generating the electrons needed to power the water-splitting catalysts. That will allow Nocera's catalyst to run directly on sunlight; right now, it runs on electricity taken from an outlet.

There's also still much engineering work to be done before Nocera's catalyst is incorporated into commercial devices. It will, for example, be necessary to improve the rate at which his catalyst produces oxygen. Nocera and others are confident that the engineering can be done quickly because the catalyst is easy to make, allowing a lot of researchers to start working with it without delay. "The beauty of this system is, it's so simple that many people can immediately jump on it and make it better," says Thomas Moore, a professor of chemistry and biochemistry at Arizona State University.