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The Artificial Leaf

My May 2010 column began with the statement, “If we can learn how to capture and store just a fraction of the 85,000 terawatts of energy that our sun provides us yearly, we could meet all our energy needs without ever using another drop of fossil fuel.” The two key words are “capture” and “store.” The May issue column explored the capture side of the equation. This column will explore recent significant breakthroughs in energy storage that just might eventually break our dependence on fossil or nuclear energy.

For any solar energy solution to become a fully viable alternative, we need a simple, relatively inexpensive energy storage solution that can pump energy back into the system at night and on cloudy days. For over 50 years, scientists have tried to find a way to duplicate plant photosynthesis. Their goal was to replicate how plants, algae, and some bacteria efficiently use sunlight to convert water and carbon dioxide into storable energy and oxygen.

If photosynthesis could be tapped as an inexpensive way to produce hydrogen from water, the hydrogen could be used as a fuel to run electric generators and fuel cells when solar generated electricity fell below electricity demand.

A fuel cell is a nonpolluting method of generating electricity through a chemical reaction that combines hydrogen with oxygen. (For more details, see www.techtodaynews.net/Fuel_Cells_Zero_Pollution.htm.)

Daniel Nocera, a chemist at the Massachusetts Institute of Technology (MIT), was the first researcher to produce a practical system that mimics photosynthesis. The tabletop apparatus in front of Nocera in Photo 1 is producing oxygen as if it was an artificial leaf. The process performs photosynthesis without duplicating the physical structure of a leaf. To show the actual bubbles of oxygen being created, I zoomed in on the left side of the apparatus (Photo 2).

This artificial leaf works at room temperature. A solar cell provides electric current to the electrodes. The water solution in the vessel contains dissolved cobalt phosphate. The current causes the cobalt phosphate to form a catalyst on the electrode that you see in Photo 2 covered with oxygen bubbles.

The flow of electric current creates a catalytic reaction in the water, which releases oxygen and hydrogen ions. The oxygen ions flow to the surface above the catalytic electrode and are captured as a gas on that side of the apparatus. The hydrogen ions are drawn through a membrane to the opposite side, where they are captured as a gas. A great deal of research and the creation of new infrastructure is necessary before this process could be used commercially.

Photos: Daniel Nocera, MIT

Photo 1 (above)—Tabletop apparatus is performing photosynthesis as if it was an artificial plant leaf.

Photo 2 (left)—Close up shows the oxygen bubbles the “artificial leaf” created.

The quest to develop synthetic photosynthesis systems has intensified. The most recent technological breakthrough that I could find was reported in June. It describes how an MIT team of scientists from materials science, mechanical engineering, and chemical engineering genetically modified (GM) a virus to perform photosynthesis.

The scientists built an apparatus that combined a catalyst, their GM virus, and a special pigment that absorbs sunlight. Their modified virus used the solar energy absorbed by the pigment to meet its own metabolic needs. Their experiment proved that it is possible to genetically modify a virus—note that they selected one that is harmless to people—so it can perform photosynthesis. Their goal is to ramp up their experiment to create a system that can inexpensively split water into hydrogen and oxygen.

The dream is that artificial photosynthesis will one day be able to supply an inexpensive unlimited energy storage system for solar power. Perhaps in a decade or two, this technology could make it possible for us to generate all our electricity to run our cars and factories using only the hydrogen and oxygen created by a new synthetic photosynthesis infrastructure.

Recalling the Facts

1. This column describes two photosynthesis research projects. How are they the same and how do they differ?

2. Since plant photosynthesis plays such a significant role in creating our food supply, do you think that artificial photosynthesis might one day be used to end world hunger? Explain why.

Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit www.technologytoday.us for past columns and teacher resources.

