

## Protein Power: Solar cell produces electricity from spinach and bacterial proteins

Alexandra Goho

Inspired by the efficiency with which plants convert sunlight into sugar, researchers have fabricated a solar cell that uses photosynthetic proteins to convert light into electricity. Although the prototype device can't yet rival commercial solar cells made of silicon, it demonstrates a new strategy for making longer-lasting photovoltaic cells.

To make the solar cell, a team of biologists and engineers led by Marc Baldo of the Massachusetts Institute of Technology (MIT) harvested photosynthetic proteins from spinach and the bacterium *Rhodobacter sphaeroides* and deposited the proteins onto a glass support. Because the proteins naturally reside in an aqueous environment inside a cell membrane, it took some creative chemistry to keep the approximately 2 billion isolated proteins functional on a solid surface.

Consider the new material that MIT molecular biologist Shuguang Zhang developed to stabilize the proteins. It consists of synthetic peptides that self-assemble into structures resembling cell membranes. When embedded in the synthetic membranes, the photosynthetic proteins retain their function.

The MIT group placed a thin layer of this membrane complex on a glass surface coated with indium tin oxide, which served as a transparent electrode. The researchers then added a soft layer of an organic semiconductor and topped it all with a silver electrode.

When the researchers shone light of certain wavelengths onto the device, the photosynthetic proteins absorbed the photons and shunted excited electrons through the semiconductor layer and into the silver electrode, creating a current. Baldo and his colleagues describe the working device in the June issue of *Nano Letters*.

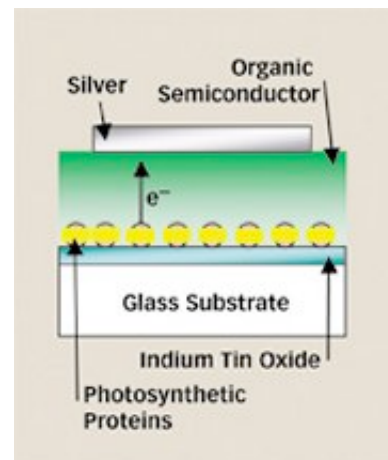
"This is very exciting work," says Peter Peumans of Stanford University, noting that the new strategy opens many possibilities for making not just solar cells but also other protein-based electronic devices. However, he says, to make a useful solar cell, the MIT team will have to dramatically increase the device's efficiency.

To boost the solar cell's power output, Baldo and his colleagues are exploring ways of packing more photosynthetic proteins into their 1-millimeter-by-1-millimeter device. One potential way of achieving that goal is to roughen the glass to increase the amount of surface area that can hold the proteins.

Even if Baldo and his colleagues can't boost their new solar cell's efficiency to match that of commercial photovoltaic devices, there could be other advantages to a protein-based design.

For example, many solar cell materials degrade over time, but a protein-based solar cell could be self-repairing, says Baldo. Just as living plants replenish their photosynthetic proteins by swapping out the old copies for new ones, it might become possible to flush a solution of fresh proteins through a solar cell to replace the photosynthetic molecules as they degrade, Baldo explains.

Stephen Forrest of Princeton University says that experiments such as Baldo's could also give researchers a greater understanding of the mechanisms underlying photosynthesis. "Nature has taken a very long time to optimize solar energy collection and conversion," he says, "and it has many strategies for doing that."



**GREEN MACHINE.** In this prototype solar cell, photosynthetic proteins (spheres embedded in yellow peptides) absorb light and pump electrons ( $e^-$ ) into a silver electrode.  
Courtesy of Baldo

### Letters:

When cyanobacteria and plants transfer electrons photosynthetically, light is absorbed not by their

photosynthetic proteins but by chlorophylls. Some of these proteins indeed participate in electron flow, but they are not plant photoreceptors. How then, do they "retain their function" and "absorb photons" in the fabricated solar cell described?

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*The materials that the scientists were referring to as proteins are actually protein complexes containing chlorophyll. When the researchers isolate the complexes, they get the associated chlorophylls.—A. Goho*

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#### **References:**

Das, R. . . S. Zhang, and M. Baldo. 2004. Integration of photosynthetic protein molecular complexes in solid-state electronic devices. *Nano Letters* 4(June):1079-1083.

#### **Further Readings:**

Vauthey, S. . . and S. Zhang. 2002. Molecular self-assembly of surfactant-like peptides to form nanotubes and nanovesicles. *Proceedings of the National Academy of Sciences* 99(April 16):5355-5360. Available at <http://www.pnas.org/cgi/content/full/99/8/5355>.

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