Microorganisms found in salt flats could offer new path to green hydrogen fuel

July 17 2013

(Phys.org) —A protein found in the membranes of ancient microorganisms that live in desert salt flats could offer a new way of using sunlight to generate environmentally friendly hydrogen fuel, according to a new study by researchers at the U.S. Department of Energy's Argonne National Laboratory.

Argonne nanoscientist Elena Rozhkova and her colleagues combined a pigment called bacteriorhodopsin with semiconducting nanoparticles to create a system that uses light to spark a catalytic process that creates hydrogen fuel.

Scientists have been aware of the potential of titanium dioxide nanoparticles for light-based reactions since the early 1970s, when Japanese researchers discovered that a titanium dioxide electrode exposed to bright ultraviolet light could split water molecules in a phenomenon that came to be known as the Honda-Fujishima effect. Since then, scientists have made continuous efforts to extend the light reactivity of titanium dioxide photocatalysts into the visible part of the spectrum. The promise of these photocatalysts prompted scientists to experiment with different modifications to their basic chemistry in hope of making the reaction more efficient, Rozhkova said.

"Titanium dioxide alone reacts with ultraviolet light, but not with visible light, so we used biological photoreactive molecules as a building block to create a hybrid system that could use visible light efficiently," Rozhkova said.

Rozhkova and her colleagues turned to bacteriorhodopsin – which is responsible for the unusual purple color of a number of salt flats in California and Nevada – because it uses sunlight as an energy source that allows it to act as a "proton pump." Proton pumps are proteins that typically straddle a cellular membrane and transfer protons from inside the cell to the extracellular space.

In the Argonne system, the protons provided by the bacteriorhodopsin are combined with free electrons at small platinum sites interspersed in the titanium dioxide matrix. "The platinum nanoparticles are essential for creating a distinct spot for the production of the hydrogen molecule," said Peng Wang, an Argonne postdoctoral researcher in Rozhkova's group at Argonne's Center for Nanoscale Materials.

"It is interesting that in biology, bacteriorhodopsin does not naturally participate in these kind of reactions," Rozhkova said. "Its natural function really doesn't have much to do at all with creating hydrogen. But as part of this hybrid, it helps make hydrogen under white light and at environmentally friendly conditions."

This bio-assisted hybrid photocatalyst outperforms many other similar systems in hydrogen generation and could be a good candidate for fabrication of green energy devices that consume virtually infinite sources – salt water and sunlight.

An article based on the study was recently published in *Nanoletters*.

More information: pubs.acs.org/doi/pdf/10.1021/nl4016655

Provided by Argonne National Laboratory