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Cheap Hydrogen

A new process uses sunlight and a nanostructured catalyst to inexpensively and efficiently generate hydrogen for fuel.

By Kevin Bullis

Nanoptek (http://www.nanoptek.com/) , a startup based in Maynard, MA, has developed a new way to make hydrogen from water using solar energy. The company says that its process is cheap enough to compete with the cheapest approaches used now, which strip hydrogen from natural gas, and it has the further advantage of releasing no carbon dioxide.

Nanoptek, which has been developing the new technology in part with grants from NASA and the Department of Energy (DOE), recently completed its first venture-capital round, raising $4.7 million that it will use to install its first pilot plant. The technology uses titania, a cheap and abundant material, to capture energy from sunlight. The absorbed energy releases electrons, which split water to make hydrogen. Other researchers have used titania to split water in the past, but Nanoptek researchers found a way to modify titania to absorb more sunlight, which makes the process much cheaper and more efficient, says John Guerra, the company's founder and CEO.

Researchers have known since the 1970s that titania can catalyze reactions that split water. But while titania is a good material because it's cheap and doesn't degrade in water, it only absorbs ultraviolet light, which represents a small fraction of the energy in sunlight. Other researchers have tried to increase the amount of sunlight absorbed by pairing titania with dyes or dopants, but dyes aren't nearly as durable as titania, and dopants haven't produced efficient systems, says John Turner, who develops hydrogen generation technologies at the National Renewable Energy Laboratory (http://www.nrel.gov/) (NREL), in Golden, CO.

Nanoptek's approach uses insights from the semiconductor industry to make titania absorb more sunlight. Guerra says that chip makers have long known that straining a material so that its atoms are slightly pressed together or pulled apart alters the material's electronic properties. He found that depositing a coating of titania on dome-like nanostructures caused the atoms to be pulled apart. "When you pull the atoms apart, less energy is required to knock the electrons out of orbit," he says. "That means you can use light with lower energy--which means visible light" rather than just ultraviolet light.

The strain on the atoms also affects the way that electrons move through the material. Too much strain, and the electrons tend to be reabsorbed by the material before they split water. Guerra says that the company has had to find a balance between absorbing more sunlight and allowing the electrons to move freely out of the material. Nanoptek has also developed cheaper ways to manufacture the nanostructured materials. Initially, the company used DVD manufacturing processes, but it has since moved on to a still-cheaper proprietary process.

NREL's John Turner says that Nanoptek's process is "very, very promising." And Harriet Kung, the acting director of the DOE's office of basic energy sciences, which has funded Nanoptek's work, says that the strained-titania approach is "one of the major exciting advances" since titania was first discovered to be a photocatalyst in the 1970s.

If it works as expected, the technology could help address one of the fundamental problems with using hydrogen as fuel. Hydrogen is attractive because it is light, and burning it only produces water. But today most hydrogen is made from natural gas, a process that releases considerable amounts of carbon dioxide. The other main option is electrolysis. But even if it's powered by clean energy, such as electricity from photovoltaics, electrolysis is inefficient and expensive. Guerra says using strained titania, and Nanoptek's inexpensive manufacturing process,

makes the process cheap and efficient enough to compete with processes that create hydrogen from natural gas. What's more, Guerra says, the Nanoptek technology can be located closer to customers than large-scale natural-gas processes, which could significantly reduce transportation costs, thereby helping make the technology attractive. And if in the future carbon emissions are taxed or regulated, Nanoptek's carbon-free approach is another advantage.

Turner says that in addition to making hydrogen for fuel-cell vehicles, Nanoptek's process--if it is indeed efficient and inexpensive, as the company claims--could also be important for large-scale solar electricity. If solar is ever to be a dominant source of power, finding ways of storing the energy for night use will be essential. And hydrogen, he says, could be a good way to store it.
