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Photonic Nanocrystals Convert Sunlight to Solar Steam

HOUSTON, Nov. 20, 2012 — Light-absorbing nanoparticles efficient at turning sunlight into heat can produce solar steam from nearly frozen water. The new technology is more efficient than solar panels in generating electricity, but its inventors expect its first applications to be for sanitation and water purification in developing countries.

Discovered by Rice University scientists, the method uses nanoparticles that can be activated by visible sunlight and by shorter wavelengths that humans cannot see to convert solar energy directly into steam. The overall energy efficiency is 24 percent; photovoltaic solar panels, by comparison, typically are about 15 percent efficient.

New solar steam technology developed at Rice University uses nanoparticles so effective at turning sunlight into heat that it can produce steam from icy-cold water. Images courtesy of Jeff Fitlow/Rice University.

About 90 percent of the world's electricity is produced from steam. Most industrial steam is produced in large boilers, but because of its very small footprint and high efficiency, the Rice method is a more economical alternative. Steam also is used to sterilize medical waste and surgical instruments, to prepare food and to purify water.

When submerged in water and exposed to sunlight, the particles heat up so quickly, they instantly vaporize water and create steam. Overall energy efficiency could be increased as the technology is refined, said Naomi Halas, director of the university's Laboratory for Nanophotonics.

"We're going from heating water on the macro scale to heating it at the nanoscale," she said. "Our particles are very small – even smaller than a wavelength of light — which means they have an extremely small surface area to dissipate heat. This intense heating allows us to generate steam locally, right at the surface of the particle, and the idea of generating steam locally is really counterintuitive."

To show just how counterintuitive, the scientists videotaped demonstration in which a test tube of water containing light-activated nanoparticles was submerged in a bath of ice water and a lens concentrated sunlight onto the near-freezing mixture. The result: steam from nearly frozen water.

"This is about a lot more than electricity," Halas said. "With this technology, we are beginning to think about solar thermal power in a completely different way."

Rice University graduate student Oara Neumann and scientist Naomi Halas are co-authors of new research on a highly efficient method of turning sunlight into heat. They expect their technology to have an initial impact as an ultrasmall-scale system to treat human waste in regions without sewer systems or electricity.

Developing countries will be among the first to see the benefits of solar steam. Rice engineering undergraduates have already created a solar steam-powered autoclave capable of sterilizing medical and dental instruments in clinics that lack electricity.

“Solar steam is remarkable because of its efficiency,” said Rice graduate student Oara Neumann. “It does not require acres of mirrors or solar panels.”

The technology also could be used to power hybrid air-conditioning and heating systems that run off sunlight during the day and off electricity at night. The team conducted distillation experiments and discovered that solar steam is about 2½ times more efficient than existing distillation columns.

Halas recently won a Grand Challenges grant from the Bill and Melinda Gates Foundation to create an ultrasmall-scale system for treating human waste in areas without sewer systems or electricity.

“We’re not changing any of the laws of thermodynamics,” Halas said. “We’re just boiling water in a radically different way.”

Details of the method were reported in *ACS Nano* (doi: 10.1021/nn304948h).

For more information, visit: www.rice.edu

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