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Oil Rig of the Future: A Solar Panel That Produces Oil

Researchers propose a novel approach to producing biofuel using diatoms

By Saswato R. Das

BANGALORE, India—In the ongoing hunt for alternative fuel sources that are also cost-effective, researchers are looking into making biofuel from genetically engineered diatoms, a type of single-celled algae with shells made of glasslike silica.

These microscopic plants, commonly observed as a brown skin coating submerged stones in rivers and lakes and as phytoplankton in seas and oceans, typically contain oil droplets inside their cells. The oil is a food source for the plants in lean times. Scientific analysis of diatom oil has shown that it is very suitable for use as biofuel, says T. V. Ramachandra, a professor of ecological sciences at the Indian Institute of Science (IISc) here who is working on this project with IISc researchers Durga Mahapatra and Karthick Balasubramanian, along with Richard Gordon, a radiology professor at the University of Manitoba in Winnepeg.

Sitting in his book-lined office in a leafy corner of the IISc campus in Bangalore, Ramachandra proposes it might just be possible "to milk diatoms for oil just as we milk cows." He and his colleagues have been talking about a solar panel that could extract this oil instead of producing electricity.

The oil can be as much as a quarter of the total mass of a diatom cell, and if a way could be found to efficiently wrest it from diatoms, he adds, a hectare of "diatom cultivation could produce 10 to up to 200 times the oil that is produced by soybean cultivation," Ramachandra says. (This estimate has been borne out by other, independent research groups, as well.)

The researchers propose creating a biological solar panel, which will contain diatoms instead of photovoltaic cells. Diatoms would float about in a nutrient-rich water solution and produce oil when exposed to sunlight. Diatoms already secrete silica by exocytosis—a biological process by which cells direct secreted material outside the cell walls. If diatoms could be made to similarly secrete the oil they produce, then it could be easily harvested. (Because the oil is used as a reserve nutrient—like fat—diatoms have evolved no mechanism to secrete it.)

New diatom species

Diatoms may have other advantages when it comes to oil production. They multiply rapidly—some species double their biomass in as little as five hours. Diatoms are also quite numerous, with the estimated number of species exceeding one million. "There are 2,500 species of diatoms in India alone," says Balasubramanian, who is writing his doctoral thesis on these algae. He discovered three new species in India while hunting for those with the most oil content.

Ramachandra and his colleagues propose to genetically modify diatoms by manipulating the genes that produce oil so that they enhance its production. "It may be possible to genetically engineer diatoms so that they exocytose [release] their oil

droplets," the researchers wrote in a paper outlining their thoughts, published in a recent issue of the American Chemical Society's journal *Industrial & Engineering Chemistry Research*: "This could lead to continuous harvesting with clean separation of the oil from the diatoms, provided by the diatoms themselves."

For instance, the water-based nutrient solution in the solar panel will cause the oil to separate out. Ramachandra envisages a process similar to cream rising to the top in milk.

As he and his collaborators put it, "with at least a boundary layer of water on the diatoms, secreted oil droplets would separate under gravity, rising to the top of a tilted panel forming an unstable emulsion, which should progressively separate. The oil could then be skimmed, very similar to the cream that rises to the top of mammalian milk that has not been homogenized."

Production cost

Many experts are intrigued by this study but point out that it is still too early to know how it will play out. Mark Hildebrand, a researcher at the Scripps Institution of Oceanography at the University of California, San Diego, says, "A major consideration" in development of such technology "is the economic costs of production."

To date, models have shown that "the only economically viable way to produce the large amount of biomass required to supplant a large portion of our fossil-fuel needs requires an open-pond system," Hildebrand says. Although he does not discount the value of systems such as proposed by Ramachandra, which could be especially useful for research, he says it's still too early to know.

"The basic concept is similar to proposing to grow agriculture crops in greenhouses instead of in open fields," he says. "On a large scale, it just costs too much."

Sustainable farming

But Ramachandra insists an advantage of the diatom solar panel is that it can be created and maintained with equipment and methods that are inexpensive. This is different from photovoltaic solar panels, which require sophisticated fabrication facilities, Ramachandra says. In tropical countries like India with an abundance of sunlight, biofuel-producing solar panels containing local diatoms could be placed in every village. Investigation has shown that diatom oil can be used as biofuel without further processing, says Ramachandra—another advantage. A further advantage is that diatoms consume carbon dioxide, so the diatom solar panels would be very sustainable.

So far, the team has cultured and studied different diatoms and explored approaches to genetically engineering them, but has yet to build a solar panel. Nevertheless, corporations such as Hindustan Unilever, Ltd., (the Indian subsidiary of the multinational Unilever) have shown interest by talking to the researchers a number of times.

The next step, Ramachandra says, is to figure out how to implement the diatom solar panel at the lowest possible cost.

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