ENERGY

Gasoline for Keeps?

"Milking" algae could one day make petrol cars sustainable BY VIRAT MARKANDEYA

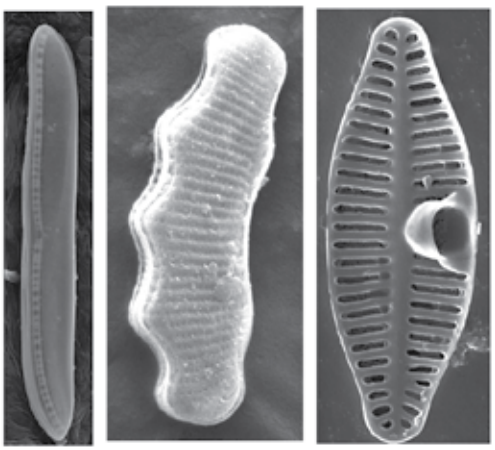
A surprising concept may provide a sustainable basis for running cars on gasoline. The idea involves "milking" single-cell algae called diatoms that flourish in oceans and freshwater ecosystems.

Geologists believe diatom graveyards could be the birthplace of much of the world's crude oil. When the algae—measuring barely a third of a strand of hair in diameter—die, they drift to the seafloor, depositing their shells and oil into the sediments.

"The DNA of a few diatom species has been fully sequenced, providing the ground work to genetically engineer a diatom that actively secretes oil. As diatoms already produce small organic molecules chemically close to those in gasoline, we envisage the possibility of direct secretion of gasoline," says Richard Gordon, Department of Radiology, University of Manitoba, Winnipeg, Canada. Gordon, along with T.V. Ramachandra, Durga Madhab Mahapatra, and Karthick Band, of the Centre for Ecological Sciences, Indian Institute of Science (IISc), Bangalore, put forward this proposal in a paper appearing in the journal *Industrial & Engineering Chemistry Research*.

There seem to be several advantages to diatoms as a source of fuel compared to agricultural oil crops, such as soybean and oil palm. For one, estimates suggest diatoms could produce 10-to-200 times as much oil per acre as oil crops. Based on the photosynthetic efficiency and the growth potential of algae, calculations predict that an annual oil production greater than 200 barrels of algal oil per hectare of land may be achievable in mass culture of oleaginous algae—100-200 times greater than that of soybeans.

For another, diatoms also grow extremely fast and can double their body weight within 5-24 hours. The body-weight-to-lipid content ratio also compares favorably. While for oil seed crops lipid content is around 5 per cent, diatoms would seem to fare, at 24.5 per cent average dry weight that they can synthesize as lipids, a little better than green algae at 17.1 per cent average. This can be enhanced by a factor of two-to-three by nitrogen deprivation, so that some can make up to 70 per cent of their non-silica weight as oil.



COURTESY T.V. RAMACHANDRA/RICHARD GORDON

GENETICALLY ENGINEERING single-cell algae known as diatoms to secrete gasoline may provide a way around the puzzle of how to make algae that both grow quickly and have very high oil content

However, the problem is that when algae such as diatoms are grown rapidly, they produce very little oil per cell. When they are starved, they produce plenty of oil per cell, but few cells. This basic dichotomy led to an impasse in the crash program for algal biofuel in the US (1980-1995).

The scientists suggest a way around this.

"Milking of algae has been done by solvent extraction methods that don't kill the cells, but in which they are otherwise passive. Here, we propose altering the cells so that they actively secrete their oil droplets," says Ramachandra .

"If we could change diatoms by genetic engineering so that they secreted their oil the way cows do, we could milk them instead of grinding them up. The only difference between extracting biofuel from algae like diatoms and this procedure is the size of the individual organisms," adds Gordon.

The current work is at a conceptual stage, where the scientists are focusing on the amount of oil that could be harvested from diatoms species-wise. This involves culturing of diatoms, isolation of mutants and extraction of lipids. But they have also gone ahead to suggest a "solar panel" approach to milking diatoms, where gasoline is secreted continuously.

"Some diatoms are tough extremophiles that live in harsh environments, so it is plausible to consider confining a diatom colony to a solar panel. Unlike ordinary solar panels that produce electricity, a diatom solar panel would produce oil for us. In designing it, we would have to solve various optical and mass transport problems," says Ramachandra.

One remarkable aspect of the system is that since diatoms like other algae, sequester carbon, it could also address the problem of global warming to some degree. Diatoms are estimated to be responsible for up to a quarter of global carbon dioxide fixation.

Of course, there is much that needs to be done. The scientists anticipate a 10-year research program before these ideas can be brought to fruition. But "any country tackling this effort might place itself in a position of exporting the technology, while reducing or eliminating its dependence on imported oil," points out Gordon.

Clearly, the fruit isn't low-hanging.