

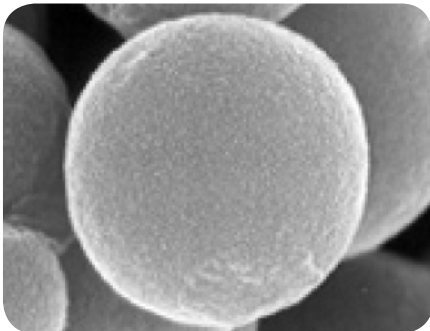


THE Ames Laboratory
Creating Materials & Energy Solutions

Biodiesel from Algae

An Ames Laboratory process uses nanosphere-based catalysis to harvest algae oil multiple times from the same organisms, paving the way for competitively priced renewable fuels

Scientists have long viewed algae as the holy grail of biofuel precursors. The lipids naturally created by algae can be converted into biodiesel – a commercialized alternative fuel that's already available. Moreover, carbon sequestered via algae farming roughly equals the amount of carbon produced when the fuel is burned, making algae-derived biodiesel carbon neutral. Algae organisms grown on a single acre of



These spheres can be chemically prepped to perform a variety of functions, including the extraction of lipids from algae cells for use in making biodiesel.

land could yield as much as 10,000 gallons of fuel annually. By comparison, an acre of soybeans will produce only about 70 gallons of biodiesel per year by some estimates, while an acre of corn will produce an estimated 230 gallons of ethanol.

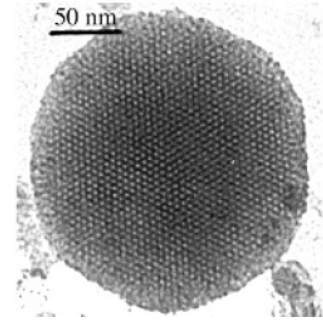
Moreover, unlike soybeans or corn, algae, one of the most primitive

organisms on the planet, are able to thrive in many different climate zones. Ponds used to raise algae need not be located on prime agricultural land, meaning renewable fuel production need not compete for land with food crops. Algae can even be grown in deserts or in the ocean. Other growing methods range from low-tech, open-air ponds to state-of-the-art transparent cylinders that expose the organisms to optimal sunlight while also feeding in required nutrients.

An economically viable method of harvesting and extracting oil from algae for use in making fuel has eluded researchers. The difficulty lies in extracting the oil. Algal oil is stored between the organism's relatively thick cell walls and its membrane. Existing extraction methods include drying, along with ultrasound as well as the use of enzymes and chemicals, which are intended to rupture or erode the cell walls. Each of these methods destroys the algae cells. This requires that a new batch of algae be introduced each time oil is harvested. The breakthrough from the U.S. Department of Energy's Ames Lab team is a process that allows fuel-relevant chemicals to be extracted from the lipids of algae without killing them.

Secrets of the spheres

The key to the Ames Lab process



Viewed through an electron microscope, these Ames Lab nanospheres have a seemingly rough-hewn texture that's designed to increase the available surface area used for dispensing or extracting substances into or out of the living cells the spheres come in contact with.

lies with millions of sponge-like nanospheres that were specially engineered by Ames Lab Program Director for Chemical & Biological Sciences, Victor Lin and his colleagues.

The Ames Lab spheres do their work thanks to a proprietary collection of chemicals, which are embedded on each sphere's surface and within its nanoscale tunnels.

CONTACT INFORMATION:

Steve Karsjen

Public Affairs

karsjen@ameslab.gov

515-294-9557

111 TASF, Ames, IA 50011-3020



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The process begins when the spheres comingle with the algae inside a pond or tank, where they are chemically drawn to come in contact with individual algal cells. The Ames Lab team was able to design the spheres so they only cause minimal damage to the organism while gaining access to the algal lipids. Chemicals embedded inside the sphere's tunnels begin to draw oil from the cell. Minute quantities of the oil are then stored inside the tunnels of each sphere.

In other conventional oil-extraction processes, the algal extract typically contains a mixture of chemicals. But only a few chemicals in the algal extract are suitable to be converted to fuels. Current methods for separating the fuel-relevant chemicals from

algae. At the same time, these nanospheres can be refurbished so they – like the algae – may be used again. This unique selectivity enables the use of nanospheres for selective sequestration of algal chemicals for fuel production. Lin and his co-workers are collaborating with Catilin Inc., a company Lin helped establish, in producing biodiesel from algae.

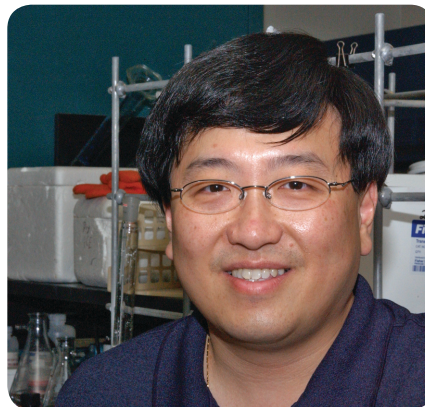
Two views on algae farming

Lin and his colleagues envision that once scaled up to a commercial operation, algae farming would take place as a continuous process with spheres extracting oil from algae. Questions remain, however, over exactly what form such a facility might take. Some envision a simple pond that would use

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the other compounds are tedious and expensive. In contrast to these extraction methods, the nanospheres are capable of selectively adsorbing the fuel-relevant compounds from

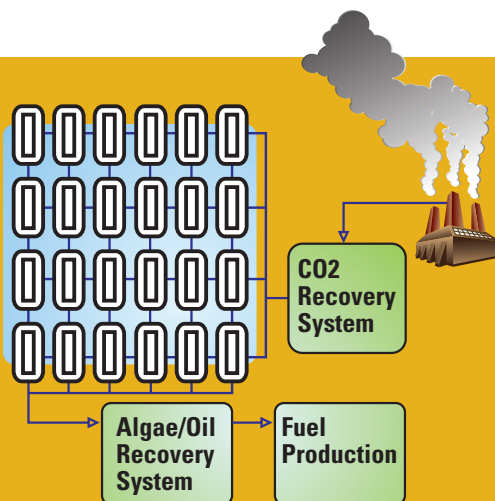
existing varieties of algae. However, this approach would limit where the farming could take place. Algae require sunlight and warmth in order to thrive.



Ames Lab Program Director Victor Lin's discovery of a way to harvest lipids from algae could help to make large-scale production of biodiesel fuel economical.

Others have argued for bioengineering the algae to boost the organisms' ability to produce lipids and then raising the resulting bioengineered organisms in giant transparent canisters. This approach has potential drawbacks as well. Algae plants may mutate rapidly, meaning fresh batches of algae genetically optimized for oil production would need to be continually introduced.

The Ames Lab team's ongoing research is looking into both approaches so it can respond if either or both ultimately prove viable.



While some alternative fuel advocates believe algae farms can be simply a low-tech collection of open-air vats, others argue that a mechanized approach would allow an algae farm to perform more than one function.

The diagram shows a large-scale farm that could recover carbon emissions from an adjacent power plant, while also generating lipids for biodiesel production.