Journal of Petroleum & Environmental Biotechnology

Zhang, J Pet Environ Biotechnol 2013, 4:6
DOI: 10.4172/2157-7463.1000e120

Editorial Open Access

New Golden Age of the Algal Technology

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Several days ago, a letter from a high school student who previously participated in the algae research in my laboratory got my attention. He is working on the senior project, which is based on his algae knowledge. To finish the essay, he asked a whole bunch of questions. Answering his questions will clarify why we like the algal technology during this new golden age of renewable energy.

When reviewing the history of algae research, we have to mention Aquatic Species Program, which is a U.S. Department of Energy (DOE) funded program to develop renewable transportation fuels from algae between 1978-1996. This program provided large amount of information about algae. Recently, due to concerns like the depletion of fossil fuels and greenhouse gas emissions, many companies/ventures invested huge chunks of money into algae projects. Then algae studies come back to the U.S. DOE's agenda.

Algae are present in all existing habitats where light is available. Algae can potentially produce 1,000-4,000 gallons of oil/acre/yr, which is significantly higher than soybeans (48 gallons of oil/acre/yr) and other oil crops. Algae are not traditional foods or feeds. They can be cultivated in large open ponds or in closed photobioreactors located on non-arable land, and can grow under a wide variety of climate and water conditions.

There are four major types of cultivation conditions for algae: photoautotrophic, heterotrophic, mixotrophic and photoheterotrophic cultivation. Photoautotrophic cultivation occurs when algae use light as the energy source, and inorganic carbon (e.g. carbon dioxide) as the carbon source to form chemical energy through photosynthesis. This is the most commonly used cultivation condition for algae growth. When algae use organic carbon as both the energy and carbon sources, it is called heterotrophic cultivation. Mixotrophic cultivation is that algae use both organic compounds and inorganic carbon as carbon sources for growth. This means that the algae are able to live under either phototrophic or heterotrophic conditions, or both. Photoheterotrophic cultivation is that algae require light when using organic compounds as the carbon source. The main difference between mixotrophic and photoheterotrophic cultivations is that the latter requires light as the energy source, while mixotrophic cultivation can use organic compounds to serve this purpose.

Photoautotrophic algal growth is mainly dependent on nutrients such as carbon, nitrogen, phosphorus and micronutrients. Water containing these nutrients could be used to culture algae. For example, algae used for food supplements (like DHA) or cosmetics are often cultivated in the synthetic medium. Wastewaters such as domestic, animal, and industrial wastewater could also be used as the medium.

Biodiesel, one type of biofuels, is the current target product from algae. Biofuels based on biomass will benefit our environment, because biomass growth consumes CO_2, and fuel production/burning processes often produce less greenhouse gases than petroleum. Biodiesel is typically made by chemically reacting lipids with an alcohol producing fatty acid esters. Neutral lipids and chlorophyll A produced by algae are good lipid sources for biodiesel. In order to extract the algal oil or lipids, the traditional process involves drying the algal biomass, and then followed by organic solvent extractions. New technologies which will directly process wet algae are still under development.

Algae are versatile, but not omnipotent. Mass-scale production of algal oil faces a number of technical barriers that result in the current development of algae-based fuels economically unfit. In addition, it is also necessary, but very difficult, to develop cost-effective technologies that allow efficient algae harvesting and lipid extraction. So the algal technology needs our help.

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Received November 15, 2013; **Accepted** November 18, 2013; **Published** November 25, 2013

Citation: Zhang B (2013) New Golden Age of the Algal Technology. J Pet Environ Biotechnol 4: e120. doi:10.4172/2157-7463.1000e120