Micro Algae as the Dependable Source for Energy Security

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Abstract

The depletion of petroleum fuels and the concentration of petroleum reserves in some portions of world leads to searching of alternative energy resources. Many researchers found that blending of 20% methyl or ethyl ester of vegetable oils (Bio-diesels) with petro-diesel can be adopted as fuel for diesel engines, with out any modifications. 100% bio-diesel also can be used as fuel for the diesel engines with minor modifications in the engine. But the vegetable oils are the seasonally available and utilization of these oils for diesel engines also leads to increase in the price. These difficulties can be over come by using micro algae as source for production of bio diesel. Micro-algae is third generation bio-fuel, it can be grown up in the any type of land and in any atmosphere throughout the year. The yielding of bio diesel from the micro algae is 70 times more than the yielding from vegetable oils for the same area. The Micro-algae production time and grown up time is very less compared with the vegetable oil plants. Micro algae utilize the CO_2 from the atmosphere in day reactions, and leads to reduction of pollution levels in the atmosphere. In this paper different types of algae available for economical yielding bio-diesel, separation of algae from the water, different techniques to extract the lipid from the algae, extraction of bio-diesel from lipid and its characterization is presented.

1. Introduction

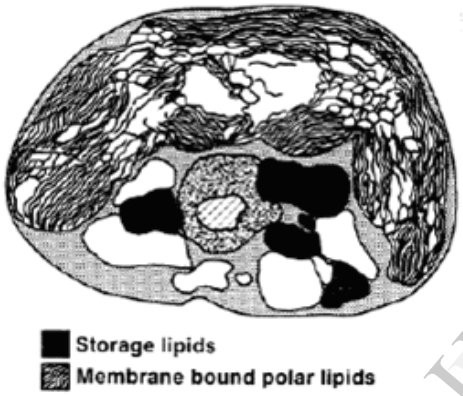
The depletion of petroleum fuels and the concentration of petroleum reserves in some portions of world leads to searching of alternative energy resources. Micro-algae are sunlight-driven cell factories that convert carbon dioxide to potential bio-fuels, foods, feeds and high-value bio-actives [1, 2]. This article focuses on micro-algae as a potential source of bio diesel. Micro-algae can provide several different types of renewable bio-fuels. These include methane produced by anaerobic digestion of the algal biomass bio diesel derived from micro-algal oil and photo biologically produced bio-hydrogen. The idea of using micro algae as a source of fuel is not new [3, 4]. But it is now being taken seriously because of the escalating price of petroleum and, more significantly, the emerging concern about global warming that is associated with burning fossil fuels. Bio diesel is produced currently from plant and animal oils, but not from micro algae. In the United States, bio diesel is produced mainly from soybeans. Other sources of commercial bio diesel include canola oil, animal fat, palm oil, corn oil, waste cooking oil. In India Jatropha, pongamia and mahua vegetable oils are preferred for preparation of bio-diesel. Transesterification is the viable process to extract bio-diesel from the vegetable oils commercially. Any future production of bio diesel from micro algae is expected to use the same process [5, 6].

2. Potential of micro-algal bio diesel:

Oil crops, waste cooking oil and animal fat cannot realistically satisfy the demand for petroleum diesel. But it can be used as supplement, So that it will reduce the rate of utilization of petro-diesel. Algae are divided into macro algae and micro algae. In Macro algae produce only small amounts of lipid, which function mainly as structural components of the cell membranes, and produce carbohydrates

which can be used as their primary energy storage compound. Where as Micro algae, specifically, possess several attractive characteristics in the context of energy and bio-fuels:

- They provide much higher yields of biomass and fuels, 10-100 times higher than comparable energy crops.
- They can be grown under conditions which are even unsuitable for conventional crop production.
- Micro algae are capable of fixing CO_2 in the atmosphere, thus facilitating the reduction of increasing atmospheric CO_2 levels, which are now considered a global problem.
- Algae bio-fuel is non-toxic, contains no sulphur, and is highly biodegradable.



Φιγ.1 Λιπιδ Χοντεντ οφ Αλγαε

Micro algae contain lipids and fatty acids as membrane components, storage products, metabolites and sources of energy. The lipid appears primarily as droplets within the cytoplasm, not within the chloroplast or other cellular organelles **(Fig.1)**. The lipid droplets often appear adjacent to a mitochondrion. Some micro algal strains have been found to contain proportionally high levels of lipids (over 30%). These micro algal strains with high oil or lipid content are of great interest in the search for a sustainable feedstock for the production of bio diesel. The land requirement to cultivate different types of vegetable oils and micro algae is shown in Table 1. Oil content present in different types of micro algae are shown in Table.2. [7, 8, 9]

Crop	Oil yield	Land area
Corn	172	1540
Soybean	446	594
Canola	1190	223
Jatropha	1892	140
Coconut	2689	99
Oil palm	5950	45
Microalgae	136	900

Ταβλε 1: Χομπαρισον οφ σομε σουρχεσ οφ βιοδι εσελ ωιτη λανδ ρεθυιρεμεντ

Microalgae	Oil content (%
Botryococcus braunii	25-75
Chlorella sp.	28-32
Crypthecodinium cohnii	20
Cylindrotheca sp.	16-37
Dunaliella primolecta	23
Isochrysis sp.	25-33
Monallanthus salina	20
Nannochloris sp.	20-35
Nannochloropsis sp.	31-68
Neochloris oleoabundans	35-54
Nitzschia sp.	45-47
Phaeodactylum tricornutum	20-30
Schizochytrium sp.	50-77
Tetraselmis sueica	15-23

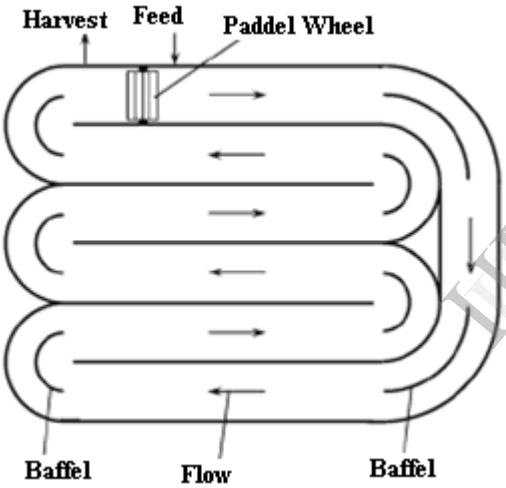
3. Micro algal biomass production:

Producing micro algal biomass is generally more expensive than growing crops. Photosynthetic growth requires light, carbon dioxide, water and inorganic salts. Temperature must remain generally within 20 to 30 °C. To minimize expense, bio diesel production must rely on freely available sunlight, despite daily and seasonal variations in light levels. Growth medium must provide the inorganic elements that constitute the algal cell. Essential elements include nitrogen (N), phosphorus (P), iron and in some cases silicon. Minimal nutritional requirements can be estimated using the approximate molecular formula of the micro algal biomass, that is $CO_{0.48}H_{1.83}N_{0.11}P_{0.01}$. This formula is based on data presented by Grobbelaar (2004) [4]. Micro algal biomass contains approximately 50% carbon by dry weight. All of this carbon is typically derived from carbon dioxide. Producing 100 t of algal biomass fixes roughly 183 t of carbon dioxide. Carbon dioxide must be fed continually during daylight hours. Feeding controlled in response to signals from pH sensors minimizes loss of carbon dioxide and pH variations. Bio diesel production can potentially use some of the carbon dioxide that is released in power plants by burning fossil fuels. This carbon dioxide is

often available at little or no cost. Large-scale production of micro algal biomass generally uses continuous culture during daylight. In this method of operation, fresh culture medium is fed at a constant rate and the same quantity of micro algal broth is withdrawn continuously. Feeding ceases during the night, but the mixing of broth must continue to prevent settling of the biomass. Micro- algae can be produced in to ways, one is raceway pond cultivation and the second one is the photo bio-reactors.

3.1 Raceway ponds

A raceway pond is made of a closed loop recirculation channel that is typically about 0.3 m deep. Mixing and circulation are produced by a paddlewheel. Flow is guided around bends by baffles placed in the flow channel. Raceway channels are built in concrete or compacted earth, and may be lined with white plastic. During daylight, the culture is fed continuously in front of the paddlewheel where the flow begins (Fig. 2).

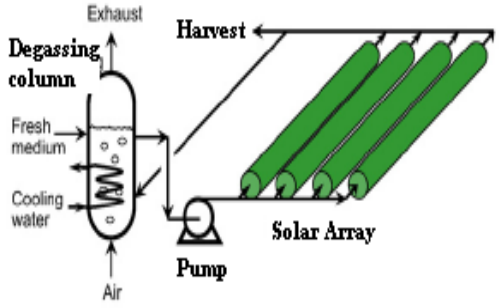


Φιγ.2: Ραχε ωαψ πονδ

Broth is harvested behind the paddlewheel, on completion of the circulation loop. The paddlewheel operates all the time to prevent sedimentation. Raceway ponds for mass culture of Microalgae have been used since the 1950s. Extensive experience exists on operation and engineering of raceways. The largest raceway-based biomass production facility occupies an area of 440,000 m^2. In raceways, any cooling is achieved only by evaporation. Temperature fluctuates within a diurnal cycle and seasonally. Evaporative water loss can be significant. Because of significant losses to atmosphere, raceways use carbon dioxide much less efficiently than photo bioreactors. Productivity is affected by contamination with unwanted algae and micro organisms that feed on algae. The biomass concentration remains low because raceways are poorly mixed and cannot sustain an optically dark zone.

3.2. Photo bioreactors

Unlike open raceways, photo bioreactors permit essentially single-species culture of micro algae for prolonged durations. Photo bioreactors have been successfully used for producing large quantities of micro algal biomass. Tubular photo bioreactor consists of an array of straight transparent tubes that are usually made of plastic or glass. This tubular array, or the solar collector, is where the sunlight is captured (Fig. 3).



Φιγ. 3 Ηοριζονταλ Πηοτο βιο–ρεαχτορ

The solar collector tubes are generally 0.1 m or less in diameter. Tube diameter is limited because light does not penetrate too deeply in the dense culture broth that is necessary for ensuring a high biomass productivity of the photo bioreactor. Micro algal broth is circulated from a reservoir (i.e. the degassing column in Fig. 3) to the solar collector and back to the reservoir. Continuous culture operation is used, as explained above. The solar collector is oriented to maximize sunlight capture. In a typical arrangement, the solar tubes are placed parallel to each other and flat above the ground. Horizontal, parallel straight tubes are sometimes arranged like a fence, in attempts to increase the number of tubes that can be accommodated in a given area. The tubes are always oriented North–South. The ground beneath the solar collector is often painted white, or covered with white sheets of plastic to increase reflectance. A high albedo (reflectance) increases the total light received by the tubes. Instead of being laid horizontally on the ground, the tubes may be made of flexible plastic and coiled around a supporting frame to form helical coil tubular photo bioreactors

4. Extraction of bio-diesel from Micro-Algae:

The lipid portion is inside the cells of micro algae as shown in Fig.1. To extract the lipids cell wall cracking is required. This can be done by using ultrasonicator or saxholet lipid separator. Then the lipid can be separated by using centrifuge. The lipids

from the Algae have to be analyzed for the percentage of different fatty acids. For the analysis of lipid the chromatographic techniques may be adopted. For the extraction of Bio-diesel from the algae lipids the transesterification procedure can be adoptable. To adopt the extracted bio-diesel on the diesel engine its characteristics should be compared with the existing petro-diesel. So that, one can predicts the combustion behaviour of the extracted bio- diesel.

5. Conclusions:

Based on the following merits of Micro Algae Based bio-diesels, it is the dependable resources for energy security.

- Micro-algae is the third generation bio-fuel and it will not cause for hike in the price of consumer oriented oil extractions and it can be grown up in the any type of land, throughout the year.
- The extraction of the bio diesel from micro-algae is cheaper than the extraction of the bio diesel from non -edible oil. Some of the findings of the researchers conclude that, the yielding of bio diesel from the Micro-algae is 70 times more than the yielding from non-edible oils for the same area.
- The Micro-algae production life cycle is very less compared with the production life cycle of the trees which produces non edible oils.
- Micro algae cultivation has got no restrictions with the type of water used and the type of soil and geo-graphical location.
- The bio-diesel production is continues because of the abundant available of micro algae through out the year.
- They produce more oxygen than all the other plants. Micro algae are capable of utilizing CO_2 in the atmosphere, thus facilitating the reduction of increasing atmospheric CO_2 levels and there by protect the environment.
- The conclusions of some of the researchers infer that micro-algae based bio-diesel will replace petro-diesel
- Apart from the Bio-Diesel, Hydrogen, Methane, Ethanol, syngas and other hydrocarbon fuels can also be extracted.

6. References:

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