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Extraction of Biofuel from Oscillotoria

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Abstract: ***With hiking energy prices, biofuel as an alternative fuel is coming to attention. Currently, biofuel is made from a variety of feed stocks such as vegetable and animal fat; however, the limited supply of feedstock impedes the further expansion of biofuel production. Microalgae have long been recognized as potentially good sources for biofuel production because of their high oil content and rapid biomass production. Biofuel from microalgae seems to be most promising renewable biofuel that can have the potential to completely displace petroleum derived transport fuel without adversely affecting supply of food and other crop products. In the present study I used oscillotoria, a type of blue green algae from wastewater, as a feedstock for biofuel production. Algal biofuel was produced by the collection of algae from different sources, screening and isolation by lab culture. Open pond cultivations in artificial pond were done followed by harvesting and oil extraction using soxhlet apparatus. Yield was low since natural conditions are only provided. Further studies needed to carry out by providing artificial condition to make a clear idea of the potentiality of commercialization.***

Keywords: Microalgae, feedstock, biofuel, soxhlet apparatus, oscillotoria

1. Introduction

In context of climatic changes and soaring prices per barrel of petroleum, renewable carbon neutral, transport fuels are needed to displace petroleum derived transport fuel (Pokoo-Aikins et al.,2010), which contribute to global warming and are of limited availability. Biodiesel derived from oil crop is a potential renewable and carbon neutral alternative to petroleum fuel (Perlack et al., 2005). Unfortunately, biodiesel from oil crop, waste cooking oil and animal fat cannot realistically satisfy even a small fraction of the existing demand for transport fuel. Biodiesel from microalgae seem to be the most promising renewable biofuel that has the potential to completely displace petroleum-derived transport fuel without adversely affecting supply of food and other crops products. Like plants, microalgae use sunlight to produce oil but they do so more efficiently than crop plants (Li et al., 2008). Oil productivity of many microalgae greatly exceeds the oil productivity of the best producing oil crops.

Microalgae comprise a vast group of photosynthetic, auto/heterotrophic organism which has an extraordinary potential for cultivation as energy crops (Olivier et al., 2005). These microscopic algae use photosynthetic process similar to that of higher-developed plants. They are veritable miniature biochemical factories, capable of regulating carbon dioxide (CO2), just like terrestrial plants (Chisti 2007). In addition, these micro-organisms are useful in bioremediation applications and as nitrogen fixing bio fertilizers. This report discusses the potential of microalgae for sustainably providing biodiesel for the displacement of petroleum derived transport fuels in India. The need of energy is increasing continuously, because of increase in industrialization as well as human population. The basic sources of this energy are petroleum, natural gas, coal, hydro and nuclear.

The major disadvantage of using petroleum based fuel is atmospheric pollution. Petroleum diesel combustion is a major source of greenhouse gases (GHG). Apart from these emissions, petroleum diesel combustion is also major source of other air contaminants including NOx, SOx, CO, particulate matter and volatile organic compounds, which are adversely affecting the environment and causing air pollution (Klass., 1998). These environmental problems can be eliminated by replacing the petroleum diesel fuel with an efficient renewable and sustainable biofuel. Algal biomass is one of the emerging sources of sustainable energy. The large-scale introduction of biomass could contribute to sustainable development on several fronts, environmentally, socially and economically.

The biodiesel generated from biomass is a mixture of mono-alkyl ester, which currently obtained from transesterification of triglycerides and monohydric alcohols produced from various plant and animal oils (Fukuda et al., 2001). But this trend is changing as several companies are attempting to generate large scale algal biomass for commercial production of algal biodiesel. Biodiesel is non-toxic and biodegradable alternative fuel that is obtained from non-renewable sources. In many countries, biodiesel is produced mainly from soybeans. Other sources of commercial biodiesel include canola oil, animal fat, palm oil, corn oil, waste cooking oil. But the recent research has proved that oil production from microalgae is clearly superior to that of terrestrial plants such as palm, rapeseed, soybeans or jatropha (Chisti 2007, Xu et al., 2006).

Important advantage of microalgae is that, unlike other oil crops, they can double their biomass within 24 hr. In fact the biomass doubling time for microalgae during exponential growth can be as short as 3 to 4 hr, which is significantly quicker than the doubling time for oil crops (Pokoo-Aikins et al., 2010). It is for this reason microalgae are capable of synthesizing more oil per acre than the terrestrial plants which are currently used for the fabrication of biofuels and using microalgae to produce biodiesel will not compromise production of food, fodder and other products derived from crops. In the production of energy from micro algal biomass, two basic approaches are employed depending on the particular organism and the hydro carbon which they produce. The first is simply the biological conversion of nutrients into lipids or hydrocarbons (Metzger et al., 2005, Guschina et al., 2006). Depending on species, microalgae produce many different kinds of lipids, hydrocarbons and other complex oils.

The second procedure entails the thermo-chemical liquefaction of algal biomass into lipid or hydrocarbons (Becker et al., 1994, Laura et al., 2009). Lipids and hydrocarbons can normally be found throughout the micro algal biomass. They occur as membrane components, storage products, metabolites and sources of energy for microalgae. Algal strains diatoms, and cyanobacteria (categorized collectively as microalgae) have been found to contain proportionally high level of lipid (over 30%). These microalgal strains with high lipid content are of great interest in search for sustainable feedstock for production of biodiesel. The enormous amount of burning of fossil fuel has increased the CO level in the atmosphere (Wang et al., 2008), causing global warming.

Biomass is focused as an alternative energy source, as it's a renewable resource and it can fix atmospheric CO through photosynthesis. Among biomass, algae (macro and microalgae) usually have a higher photosynthetic efficiency than other biomass producing plants. Biodiesel from microalgae appears to be a feasible solution to India, for replacing petro-diesel. The estimated annual consumption of petroleum product in India is nearly about 120 million tonnes per year, and no other feedstock except microalgae has the capacity to replace this large volume of oil (Banerjee, et al., 2008). To elaborate, it has been calculated that, in order for a crop such as soybean or palm to yield enough oil capable of replacing petro-diesel completely, a very large percentage of current land available need to be utilized only for biodiesel crop production, which is quite infeasible.

For small countries, in fact it implies that all land available in the country be dedicated to biodiesel crop production. However, if the feedstock were to be algae, owing to its very high yield of oil per acre of cultivation, it has been estimated that less than 2-3 percent of total Indian cropping land is sufficient to produce enough biodiesel to replace all petrodiesel currently used in country. Clearly microalgae are superior alternative as a feedstock for large scale biodiesel production. Microalgal strains with high oil content are of great interest in search for sustainable feedstock for the production of biodiesel (Spolaore et al. 2006). Algae can have anywhere between 20-80% of oil by weight of dry mass (Metting 1996; Spolaore et al. 2006).

2. Materials and Methods

1. Collection, screening and isolation of algae:

Algae were randomly collected from different water source and identification of algae were done using microscope. Oscillotoria was identified from collected algae, are isolated from other algae by screening, and then stored in collection tube.

2. Lab Scale Cultivation Of Algae:

Cultivation of oscillotoria was done using Pringsheim's soil-water media. About 50g of garden soil was added in 200ml of pond water in four 250ml conical flasks and then add 1g of $CaCO_3$ to each flask. Boil the medium for 1hour for two days. Inoculate the screened algae into the prepared medium and incubate at 30°C under sunlight.

3. Large Scale Cultivation of Algae:

Like plants, algae use the sunlight for the process of photosynthesis. Algae capture light energy through photosynthesis and convert inorganic substances into simple sugars using the captured energy. I create an artificial pond of length 1m, breadth 1m and height 1m. About 1kg of soil with 2 litres of water and 5g of $CaCO_3$ were added to the artificial tank. Then I inoculate 250g of screened and isolated wet algae to it.The biggest advantage of these open ponds is their simplicity, resulting in low production costs and low operating costs.

4. Harvesting of Oscillotoria

Harvesting of microalgae can be a single step process or two step process which involves harvesting and dewatering. Techniques for harvesting microalgae include settling or flotation, Centrifugation and filtration. I used floatation and filtration to collect algae. Then they were dried under sunlight and finally powdered to fine powder using mixer (Figure 1). This was the feedstock used for soxhlet extraction.

Figure 1: The pictures shows the harvesting stages of algae – wet, dried and powder form of oscillotoria respectively

5. Extraction of Algal oil

Soxhlet method was used. Oil/ fat from algae are extracted by repeated washing with n-hexane or petroleum ether, under reflux in soxhlet extractor (Figure2). It is cost effective and more economical if used at large scale.

Figure 2: Soxhlet extraction of biofuel from oscillotoria

3. Result

Algal biofuel was obtained, but the quantity obtained was less. Algae to biodiesel have been widely discussed among experts in the petroleum industry and conservationist who are looking for a more reliable and safer source of energy that is both renewable and easy to attain. Flame test was done, and it was positive. Further characterization was not done because of low yield. Further studies needed to be carried out for characterization and estimation of biofuel.

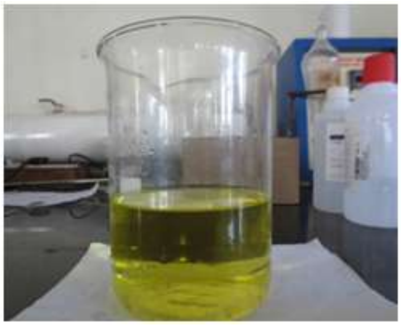

Figure 3: Biofuel produced from oscillotoria

4. Discussion

We know today the price of fuel is increasing day by day. Even though Government is undertaking many measures to control the situation, the situation remains the same. One of the key reasons why algae are considered as feedstock for oil is their yields. DOE (Department of Energy, Gov of USA) has reported that algae yield 30 times more energy per acre than land crops such as soybeans, and some estimate even higher yields up to 15000 gallons per acre (Wen Z, 2009).

The production cost of algal oil depends on many factors, such as yield of biomass from the culture system, oil content, scale of production systems, and cost of recovering oil from algal biomass. Currently, algal-oil production is still far more expensive than petroleum -diesel fuels. Assuming the oil content of the algae to be approximately 30 percent, Chisti., 2007 determined a production cost of $2.80 per liter ($10.50 per gallon) of algal oil (Wen Z, 2009). This estimation did not include costs of converting algal oil to biodiesel, distribution and marketing costs for biodiesel, and taxes. At the same time, the petroleum-diesel price in Virginia was $3.80 to $4.50 per gallon. Whether algal oil can be an economic source for biofuel in the future is still highly dependent on the petroleum oil price. (Chisti, 2007).

Aside from keeping the earth clean and free form pollution, these algal biodiesel fuels help to utilize a resource that is available in abundance just waiting to be harnessed and exploited. Algal biofuel is an ideal biofuel candidate (Ho et al., 2010) which eventually could replace petroleum-based fuel due to several advantages (Banarjee et al., 2002), such as high oil content, high production, less land, etc. Currently, algal-biofuel production is still too expensive to be commercialized (Canakci and Van Gerpen 1999, 2001). Due to the static cost associated with oil extraction and biodiesel. A study conducted by the United States Department of Energy estimates that if algae fuel replaced all the petroleum fuel in the United States, it would require 15,000 square miles (39,000 km^2) which is only 0.42% of the U.S. map (Chisti., 2007). This is less than $\frac{1}{7}$ the area of corn harvested in the United States in 2000 (Wen Z, 2009). So let us take a step ahead and be back to nature.

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