Production of Biodiesel (Biofuel) from Algae

Niranjan Dev Bharadwaj¹, Govind Vajpayee², Rajesh Jain³, Arvind Kumar Sharma⁴

¹. *Environmental Chemist , Analitika Ecolab Pvt. Ltd., Gwalior, India
². Chemist, Analitika Ecolab Pvt. Ltd., Gwalior, India
³. Technical Manager, Analitika Ecolab Pvt. Ltd., Gwalior, India
⁴. Quality Manager and Head of Microbiological Section, Analitika Ecolab Pvt. Ltd., Gwalior, India

Abstract — The global dependence on the non-renewable energy sources (i.e. fossil fuels) is leading us towards the worldwide energy insecurity. It is really no surprise why there is global effort to cut down the dependence on fossil fuels and develop an economically viable and scalable alternative fuel source that will significantly reduce massive emissions of CO2 in the atmosphere which in turn will lead to reduction environmental pollution. Among mostly talked about alternative sources are biofuels. Biofuels are quite adequate to provide an alternative to fossil fuels and can also reduce total CO2 emissions. Algae have many reasons why they could be consider as one of the most perfect choices for biodiesel production. In this research, we used common species of Algae: Spirogyra and Oedogonium along with catalyst like NaOH and KOH in trans-esterification process to compare the amount of biodiesel produced by the use of solvents Hexane and Ethane. The results indicated that biodiesel can be produced from both species and also in the produced biodiesel of both species, there is no significant difference in pH.

Keywords — Biofuel, Algae, Trans-esterification, Alternative fuels.

I. INTRODUCTION

Bioenergy is derived from biofuel. A biofuel is a fuel that is produced through contemporary biological processes, such as agriculture and anaerobic digestion (i.e. process in which microorganisms break down biodegradable material in the absence of oxygen to produce fuel or gas) rather than a fuel produced by geological processes such as Fossil fuels which contain high percentages of carbon and include petroleum, coal, and natural gas from biological matter of age of millions of years. Biofuels are fuels produced directly or indirectly from organic material – biomass – including plant materials and wastes like: animal, domestic, municipal and/or industrial wastes.

Renewable biofuels mostly involve contemporary carbon fixation, such as those that occur in plants or microalgae through the process of photosynthesis. The biomass can be converted to convenient energy-containing substances in three different ways: thermal conversion, chemical conversion, and biochemical conversion. This biomass conversion can result in fuel in all three forms: solid, liquid, or gas form. This new biomass can also be used directly for biofuels. There are various social, economic, environmental and technical issues with biofuel production and use, which have been discussed in the popular media and scientific journals. These include: the effect of moderating oil prices, the “food vs fuel” debate, food prices, poverty reduction potential, energy ratio, energy requirements, carbon emissions levels, sustainable biofuel production, deforestation and soil erosion, loss of biodiversity, impact on water resources, the possible modifications necessary to run the engine on biofuel, as well as energy balance and efficiency.

Algae fuel or algal biofuel is an alternative to liquid fossil fuels that uses algae as its source of energy-rich oils. Also, algae fuels are an alternative to common known biofuel sources, such as corn and sugarcane. Several companies and government agencies are funding efforts to reduce capital and operating costs and make algae fuel production commercially viable. Like fossil fuel, algae fuel releases CO2 when burnt, but unlike fossil fuel, algae fuel and other biofuels only release CO2 recently removed from the atmosphere via photosynthesis as the algae or plant grew. The energy crisis and the world food crisis have ignited interest in algaculture (farming algae) for making biodiesel and other biofuels using land unsuitable for agriculture. Among algal fuels’ attractive characteristics are that they can be grown with minimal impact on fresh water resources, can be produced using saline and wastewater, have a high flash point, and are biodegradable and relatively harmless to the environment if spilled. Algae cost more per unit mass than other second-generation biofuel crops due to high capital and operating costs, but are claimed to yield between 10 and 100 times more fuel per unit area. Bio diesel is a biodegradable fuel obtained from renewable sources which can be used as a alternative fuel.

It can also decrease the worldwide dependency on petroleum based fuels. Biodiesel refers to a vegetable oil - or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, ethyl, or
propyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, soya bean oil, animal fat) with an alcohol producing fatty acid esters. Biodiesel is meant to be used in standard diesel engines and is thus distinct from the vegetable and waste oils used to fuel converted diesel engines. Biodiesel can be used alone, or blended with petro-diesel in any proportions. Algae are reported to be one of the best yielding feedstock for biodiesel. Studies have shown that some species of algae can produce 60% or more of their dry weight in the form of oil. Because the cells grow in aqueous suspension, where they have more efficient access to water, CO₂ and dissolved nutrients, microalgae are capable of producing large amounts of biomass and usable oil in either high rate algal ponds or photobioreactors. This oil can then be turned into biodiesel which could be sold for use in automobiles. Regional production of microalgae and processing into biofuels will provide economic benefits to rural communities.

II. MATERIALS AND METHODS

Site: The experiment was carried out in the Analitika Ecolab, Gwalior, Madhya Pradesh, India.

Sample collection: Two sets of eight Petri dishes Algae (4 of Spirogyra sp. (D1, D2, D3 and D4), and 4 of Oedogonium (L1, L2, L3 and L4) 25 g) were made, which were collected from the Tigra Water Dam in Gwalior, India.

Oil extraction: Algae were ground with motor and pestle as much as possible. The ground algae were dried for 30 min at 80°C in an incubator for releasing water. Solvent like : Hexane and ether solution (25 and 25 mL) were mixed with the two-two sets of dried ground algae of both the species to extract oil. Then the mixture was kept for 24 h for settling.
Biomass collection: The biomass was collected after filtration and weighted.

Evaporation: The extracted oil was evaporated in vacuum to release hexane and ether solutions using rotary evaporator.

Mixing of catalyst and methanol: 0.25 g NaOH and 0.25 g KOH were mixed with 24 mL methanol in 2-2 different sets of Oedogonium and Spirogyra sp.to analyze their respective yields of biodiesel and were stirred properly for 20-25 min.

Biodiesel production: The mixture of catalyst and methanol was poured into the algal oil in a conical flask. The following reaction and steps were followed.

Trans-esterification: The reaction process is called trans-esterification. The conical flask containing solution was shaken for 3 h by electric shaker at 300rpm.

Setting: After shaking the solution was kept for 16 h to settle the biodiesel and sediment layers clearly.
III. RESULTS AND DISCUSSIONS

The experiments of biodiesel production were performed on 4-4 samples of Spirogyra sp. (D1, D2, D3 and D4), and Oedogonium (L1, L2, L3 and L4) each weighing 25 gm.

We analyzed the results of each algae sample by mixing it with different solutions of Hexane and Ether and thereafter, by using NaOH and KOH as catalyst in Trans-esterification reaction to find out which is the best possible methodology of biodiesel production.

The following table illustrates the results:

<table>
<thead>
<tr>
<th>Name</th>
<th>Fresh Weight (gm)</th>
<th>Dry weight (gm)</th>
<th>Extracted Oil (gm)</th>
<th>Biomass (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 (Hexane +NaOH)</td>
<td>25</td>
<td>14.80</td>
<td>3.7</td>
<td>6.20</td>
</tr>
<tr>
<td>D2 (Ether +KOH)</td>
<td>25</td>
<td>14.80</td>
<td>N.R.</td>
<td>N.R.</td>
</tr>
<tr>
<td>D3 (Hexane+ KOH)</td>
<td>25</td>
<td>14.80</td>
<td>N.R.</td>
<td>N.R.</td>
</tr>
<tr>
<td>D4(Ether + NaOH)</td>
<td>25</td>
<td>14.80</td>
<td>2.9</td>
<td>4.90</td>
</tr>
</tbody>
</table>

Table 1: Showing the results of Spirogyra sp. With different combination of Solvent and Catalyst. (N.R. =No Results)

Table 2: Showing the results of Oedogonium with different combination of Solvent and Catalyst. (N.R. =No Results)

Percent Dry weight of algae (before oil extraction) was higher in Spirogyra sp than in Oedogonium. The oil was extracted in Spirogyra sp. Using NaOH as the catalyst for trans-esterification reaction. However, KOH as a catalyst yielded results when used with Oedogonium than in Spirogyra (Table 1 and 2). Biomass production was found maximum in Spirogyra. Another important finding is that NaOH when used as a catalyst for trans-esterification process yields best results for Spirogyra and KOH for Oedogonium in biodiesel production.

Further the obtained samples of Biodiesel were tested on following parameters for re-confirmation.

- Clarity: Ideally, there will be two distinct layers: an amber (ranging from very light to very dark depending on the oil used) biodiesel layer on top and a darker glycerol layer on the bottom (usually contaminated with catalyst, alcohol, or food particulates). These layers are soap from too much catalyst or water and often appear milky or yellowish. In the samples D1, D4, L2 and L4 we can easily see two distinct layers (Fig 6 and 7).

- pH: When an acid is poured into water, it gives up hydrogen (H) to the water. When a base is poured into water, it gives up hydroxide (OH) to the water. We can measure pH using litmus paper or a digital pH meter. Unwashed biodiesel will have a pH around 9[22] and in the research conducted the biodiesel is unwashed. The pH of D1, D4, L2 and L4 were tested and found out to be 8.4, 8.15, 9.20 and 9.04 respectively.
D4roduction, less land, etc. There is also the
Lies”.

Graph 1 : Determination of pH from algal biodiesel.

IV. CONCLUSION

Algae have long been recognized as potentially good sources for biofuel production because of their relatively high oil content and rapid biomass production. Algae generally grow very quickly compared to terrestrial crops; the practice of algal mass culture can be performed on non-arable lands using non-potable saline water and waste water. Algae are an ideal biodiesel feedstock, which eventually could replace petroleum-based fuel due to several advantages, such as high oil content, high rates of production, less land, etc. There is also the ever-present climate change and global warming problems and the tendency to reduce greenhouse gas emissions on global level as well as national and regional levels, so it is the right time for a fresh look at algae as a potential energy source.

Thus, use of algae for production of an alternative biodiesel biofuel is proving to be an economical choice because of its low cost and easy availability. Although, the present research is essentially a primary work and needs to be further investigated to arrive at specified conclusion with respect to other implications.

ACKNOWLEDGMENT

We are very grateful to Dr. Dinesh Kumar Uchchariya Head of Water Section , Analitika Ecolab Pvt. Ltd., Gwalior, India for his valuable guidance. We also acknowledge Mr. Puneet Mishra and staff of Analitika Ecolab Pvt .Ltd., Gwalior, India for their cooperation.

References

6. Yang, Jia; Ming Xu; Xuezhi Zhang; Qiang Hu; Milton Sommerfeld; YongShen Chen (2010). “Life-cycle analysis on biodiesel production from microalgae: Water footprint and nutrients balance” (PDF). Bioresources Technology. 10: 1016.