A Comprehensive Review of Biodiesel Production Method and Characterization from Microalgae

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Abstract. In India, the road transportation sector mostly depends only on petro-diesel. Progressively increasing prices at the same time fast diminishing rate plays a vital role in pursuit of alternative to petroleum diesel. Lots of research been carried out to explore economical as well as technical viable alternative source to petro-diesel. The sources broadly divided in to edible and non-edible category among which conversion of edible oil into biodiesel was not at all feasible in India. So most of the research been focused on nonedible oil sources for example Jatropha, Jojoba, Polanga, Karanja, Cottonseed, Neem, and Kusum. The oil per acre yield, growth rate and oil content percentage for these sources was not pretty good. In this scenario biodiesel from microalgae may be the better alternative source for petro-diesel for the developing country like India. This article is an attempt, to explain the biodiesel production method from algae along with its characterization. In addition, the comparative analysis of an important characteristic in tabular form between algae and other sources given for better understanding.

1. Introduction

Petro-diesel derived from complex mixture of chemical compound crude oil and processed further in oil refineries. Depending on crude oil form and processing (distillation), they produces mainly naphtha, kerosene, Middle distillate and fuel oils. The percentage are varying. India rank twentieth in the crude oil production and According to the March 2018 reports, India had projected capitals of 594.49 million tonnes (MT) and 1339.57 billion cubic meters (BCM) of crude oil and natural gas respectively [1]. India ranked third in the import of crude oil and its product in the world. In percentage, India imports 82% of crude oil of its total demand. Authorities was target it to bring down up to 67% by 2022 using renewable energy, local probes and ethanol fluid.

To fulfill this target biodiesel may be the better option. Biodiesel is chemically converted eco-friendly fuel extracted from either edible or non-edible oil source. Transesterification is the most commonly used chemical process for converting these raw oil in to ethyl or methyl esters (biodiesel), glycerine and some soaps. There are many oil feedstocks from which we can get the biodiesel. They mainly categorised as-

- Edible oils and
- No - Edible oils

As per as India is concern, it was quite impossible to convert edible oils into biodiesel due to availability. Also the oil percentage and its petrochemical properties should match the required standard. To match these scenario microalgae would be the better alternative.

2. Indian Scenario

In India, majority good transport (more than 60%) and passenger (more than 80%) carried by road. The energy consumption share of diesel and petrol is about 98% of in the transport sector [5]. The edible oil demand is also considerably greater as compare to its local level production. Due to this, the
edible oil cannot be considered for the biodiesel production. This fact can be validated from the statistics report of import and production data of edible oil.

To cut the enslavement on imported oil, production and use of biodiesel probably be the answer for an emerging country like India. In our country, the main non-edible oils focused were Jatropha, Karanja, Neem, Jojoba, Cottonseed, Polanga and Kusum. Above sources, can fulfill the oil demand for biofuel production as well as convert the wastelands in drought prone areas to green. It also did not sacrifice the food and feedstuff security. At the same time, advances the living standard of the rural poor peoples. It also give another cash crop option to farmers. Now, it is favorable for India to streamline its R and D program with the aim of dealing with the different linked issues such as biodiesel utilization and its impression on all parts of society, enlightening the throughput of plant cultivation and oil extraction modus operandi.

3. Biodiesel Feed Stock
Biodiesel feedstocks are the sources from which an oil can be extracted. This extracted oil then converted in to biodiesel through chemical process. The biodiesel feedstock was mainly classified in four types.

- Edible oils (oil from Rice bran, Coconut, Sunflower, Soybean, Rapeseed etc.)
- Non-Edible oils (oil from Neem, Jojoba, Jatropha, Karanja or Pongamia, Cottonseed, Kusum and Algae etc.)
- Waste or Recycled oils (Waste Cooking Oil from Hotels and Urban)
- Animal fats (oils from Yellow grease, Chicken fat, Tallow and by-products from fish oil)

4. Algae as a Promising Source
Consider the following main facts:

- Accelerated petroleum demand, particularly because of fresh Asian markets demand.
- If prices for petroleum remain low, the expected oil imports will surpass 60% of aggregate consumption in forthcoming ten years.
- With the proviso that prices for petroleum remain low, the domestic supplies will correspondingly remain low.
- CO$_2$ is recognized as the main atmospheric pollutants, which add more to the "greenhouse effect," whose main source is petro-diesel.

Considering above key points and land availability algae (Microalgae) will be better option as feedstock alternative for petroleum. Following points were also support this claim-

1. Micro-algae were single celled microscopic organisms; it converts the sun’s radiation energy into chemical energy by means of photosynthesis.
2. To achieve maximum growth and oil extraction, micro-algae can be cultivated in big bioreactors, which meets the current need.
3. In comparison with other plants, micro-algae were more efficiently convert of solar energy. Since they propagate on faces (Surfaces) where they have unconstrained access to water and CO$_2$.
4. Dried Micro-algae have aggregate oil content be up to 70% of their weight.
5. In comparison with other oil seed crops, Micro-algae turn out more than 30 times the amount of oil
6. Few of algae species can grow in seawater.
7. Micro-algae were the fastest growing photosynthesizing organisms.
8. The oil production from algae is up to 120 tons of oil per hectare per year.
9. Since algae consumes CO$_2$, increasing its concentration in the water increases the algae production.

The above points would be driving potential to use algae oil biodiesel as an alternative to Petro-diesel.
5. Algae to Biodiesel Conversion

Raw algae powdered with motor and pestle to the fullest. The powdered algae were dried in incubator to make it entirely dry. Hexane and ether solution mixed with this dried powdered algae for oil extraction. For complete settling, this mixture kept for a day. This extracted oil then vaporized using evaporator to discharge hexane and ether solutions. Then Sodium Hydroxide (NaOH) as a catalyst mixed with methanol. This mixture stirred properly. This mixture of catalyst and methanol dispensed into the algal oil in a flask. To get the biodiesel, following popular reaction and steps followed. [2]

Transesterification is the chemical reaction used to get biodiesel

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\text{Triglycerides} + 3\text{CH}_3\text{OH} \xrightarrow{\text{NaOH (Catalyst)}} \text{Esters} + \text{Glycerin}
\]
The solution kept for little more time so that sediment and biodiesel layers get clearly settle. After that, the biodiesel separated from sedimentation by using flask separator carefully. This biodiesel then washed until it was become purely clean and then dried and lastly kept for about half day (12-15 Hours). Next, the biodiesel blends were prepared by mixing it with petro- diesel on weight basis according to need.

6. Physio Chemical Properties of Biodiesel
Before using biodiesel blend or pure biodiesel as a fuel for engine, it was very much essential to found its physical as well as Chemical Properties. The physical as well as chemical properties of both edible and non-edible oils were fall quite close to petro-diesel. To be used as fuel in in diesel engine, biodiesel and their blends should fit in to the ASTM (American Society for Testing and Materials) specification [4]. The main properties which to be tested and found within ASTM standard were, density, Viscosity (Kinematic), Calorific value or Heating Value, Cetane Number, Flash Point, and fire point.
Following table will give the comparative of these properties with petro-diesel and the ASTM Standard.

| Table 01: Test Methods and Comparative Properties Values |
|---------------------------------------------------------|
| **Property** | **Unit** | **Testing Method** | **ASTM D (Petro-diesel)** | **ASTM D6751 (Biodiesel - B100)** | **Petro-diesel** | **Algae Biodiesel** |
|-------------|---------|-------------------|--------------------------|---------------------------------|-----------------|-------------------|
| Kinematic viscosity @ 40 °C | mm²/s | D 445 | 1.3 – 4.1 | 1.9 – 6.0 | 2.70 | 3.16 |
| Cetane Number | - | D 613 | 40 minimum | 47 minimum | 49 | 48 |
| Density at 15°C | Kg/m³ | D 941 | 870 | 880 | 830 | 881 |
| Flash point | °C | D93 | 52 minimum | 147 – 177 | 64 | 150 |
| Fire point | °C | D93 | 70 minimum | - | 71 | 83 |
| Heating Value: | MJ/kg | D 240 | 43 | 39 – 41 | 42 | 41.5 |

| Table 02: Comparative Physiochemical properties of vegetable oils [7, 8, 9, 10] |
|---------------------------------------------------------------|
| **Property** | **Petro-diesel** | **Algae Biodiesel** | **Corn** | **Sunflower** | **Palm** | **Cotton Seed** |
|----------------|------------------|-------------------|---------|------------|--------|----------------|
| Kinematic viscosity @ 40 °C | 2.70 | 3.16 | 34.9 | 39.6 | 39.6 | 33.5 |
| Cetane Number | 49 | 48 | 37.7 | 37.1 | 42 | 41.8 |
| Density at 15: C | 830 | 881 | 909 | 918 | 916 | 914 |
| Flash point | 64 | 150 | 277 | 274 | 267 | 234 |
| Fire point | 71 | 83 | - | - | - | - |
| Heating Value: | 42 | 41.5 | - | - | - | - |

7. Conclusion
Biodiesel has become more eye-catching in recent times owing to their environmental benefits and the truth, that they are produce from renewable resources. Most commonly used chemical process for conversion of raw algae oil in to biodiesel was transesterification, which changes the molecular structure of the oil molecules and decreases the viscosity level considerably. The physio chemical properties of biodiesel found compatible with petro- diesel.

In comparison with other alternatives, microalgae were found to be most suitable alternative, as the oil yield per acre was quite high than other. In addition, it consumes more CO₂, which help to reduce Green House gas emission.

This comprehensive review revels that microalgae oil were a potential candidate for the application in CI engines.

8. References

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