Biodiesel as an Alternative Fuel

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Abstract: Energy is a critical input for socio-economic development. Today when development is in the air and technology has reached its zenith, pollution walks side-by-side with development, most of which is due to emissions caused by combustion of fossil fuels. Biodiesel is one of the best ways to solve the problem as its combustion causes lesser CO_X and NO_X emissions. The main benefit of biodiesel is that it is carbon neutral. Also it is rapidly biodegradable and completely non-toxic. Biodiesel has a higher flash point than fossil diesel and so is safer even in the event of a crash.

As a result, it has brought us to the era where biodiesel has to replace the conventional fuel party or wholly.The aim of this paper is to study the various options available for biodiesel production. The paper lists the various methodologies used for production of biodiesel out of which it focuses on biodiesel from algae, jatropha, mahua, and from used cooking oil. The paper also focuses on the usage, advantages and disadvantages of the various methodologies of biodiesel generation. Apart from this biodiesel has various other advantages such as it helps to clean oil spills, acts as a lubricant.

1. INTRODUCTION

The problem of global warming seems to be a never ending one. This is mainly due to the emissions caused by excessive use of non-conventional fossil fuels. These fossil fuels are dwindling day by day and it is almost impossible to meet the ever-growing demands of fossil fuels. Many innovations and researches have been made to tackle this problem on a global scale viz. switching to conventional sources of energy such as solar, wind, tidal, nuclear energy etc. apart from these, there are many modern technologies and ideas which are coming up from all around the world, one of which is Biodiesel technology.

Biodiesel is defined as monoalkyl esters of vegetable oil or animal fats obtained by transesterification process. [1] "Bio" represents its biological and renewable source in opposition to traditional petroleum based diesel fuel; "Diesel" refers to its usage in diesel or compression-ignition engines. Biodiesel fuel has received considerable attention in recent years as it is obtained from non-toxic, biodegradable and renewable resources and provides many environmental benefits due to the reduced emissions of toxic gases into the atmosphere.

Biodiesel is used majorly in two ways; either in pure form i.e. (B100) or blended with petroleum diesel in any concentration (B20-consists of 20% biodiesel and 80% petroleum diesel, B80, etc.). The various methodologies of producing biodiesel are -:

1) Biodiesel from algae
2) Biodiesel from Jatropha
3) Biodiesel from oilseeds
4) Biodiesel from used coffee grounds
5) Biodiesel from used cooking oil
6) Biodiesel from corn
7) Biodiesel from sugarcane
8) Biodiesel from vegetable oil and animal fats.
9) Biodiesel from Hemp.

2. BIODIESEL FROM ALGAE

Algae are one of the most efficient biological producers of oil and they have higher photosynthesis efficiency which leads to increased carbon fixation process and higher production of diatomic oxygen. Most of the algae are found in wet and damp areas and hence can also be cultivated on non-agricultural lands leading to maximum land optimization.

Some microalgae have high oil content (table 1) [2] and can be induced to produce higher concentration of lipids.

Microalgal species	Oil content(% dw)
Ankistrodesmus TR-87	28-40
Botryococcus braunii	29-75
Chlorella sp.	29
Chlorella protothecoides	15-55
Cyclotella DI- 35	42
Dunaliella tertiolecta	36-42
Hantzschia DI-160	66
Nannochloris	31(6-63)
Nannochloropsis	46(31-68)
Nitzschia TR-114	28-50
Phaeodactylum tricornutum	31
Scenedesmus TR-84	45
Stichococcus	33(9-59)
Tetraselmis suecica	15-32
Thalassiosira pseudonana	(21-31)
Crpthecodinium cohnii	20
Neochloris oleoabundans	35-54
Schiochytrium	50-77

Methodology-

Oil extraction: Algae are ground with motor and pestle as much as possible. The ground algae is then dried for 20 min at 80°C in a incubator for releasing water. Hexane and ether solution are mixed with the dried ground algae to extract oil. Then the mixture is kept for settling for a duration of 24 h.

Biomass collection: The biomass is collected after filtration and weighted.

Evaporation: The extracted oil is evaporated in vacuum to release the hexane and ether solutions.

Mixing of catalyst and methanol: NaOH is mixed with methanol, according to the stoichiometry and then stirred for 20 min.

Biodiesel production: The mixture of catalyst and methanol is then poured into the algal oil. The following reaction and steps were followed: **Transesterification**: The reaction process is called transesterification. The conical flask containing solution is shaken for 3 hours approximately.

Shetteling: After shaking, the solution is kept for 16 h to settle the biodiesel and sediment layers clearly.

Seperation of biodiesel: The biodiesel is separated from sedimentation by flask separator.

Washing: Biodiesel is then washed by 5% water until it becomes clean.

Drying: Biodiesel is dried by using dryer and finally kept under the running fan for 12 hours. In this way the biodiesel is produced from algae.

3. BIODIESEL FROM JATROPHA

Jatropha curcas is a small oleaginous fruit bearing tree from the Euphorbiaceous family that thrives in warm weather and can grow in barren soil. The oil found in its seeds can be converted into a high quality diesel fuel. Since Jatropha is inedible, it does not compete with food crops. Furthermore, its ability to withstand periods of drought, naturally repel pests, and grow in

subprime soil makes it a great candidate for combating soil erosion and providing energy independence to a number of third world countries.

Jatropha incentives in India:

Jatropha is a major source of biodiesel in India. According to former president of India late dr. APJ Abdul kalam azad, 600000 km2 of wasteland that is available in India, over 300000 km2 area is suitable for jatropha cultivation. As India stands 4th in the energy consumption rate in the world, there is immense scope in the production of biodiesel to meet the ever increasing energy demands.

Oil Extraction-

After harvesting the fruits and removing the seeds, it is necessary to extract the oil for use as feedstock in biodiesel production. The average Jatropha seed is approximately 30-40 weight % oil. The seeds need to be dried in an oven at 105 C or dried under the sun for three weeks. Oil extraction can be accomplished mechanically or chemically. The traditional mechanical approach involves pressing the oil out of the seeds in a screw press. Seeds are fed into a hopper and subjected to intense frictional and shear forces by a rotating screw. Engine driven presses can extract anywhere from 75 - 80% on a single pass and as high as 89-91% if precooked and subjected to two passes. The chemical approach uses a solvent to chemically leech the oil from ground seed kernels. The ideal solvent will have high oil solubility and a low boiling point. Upon multiple passes of a chemical solvent in a commercial distillation tower it is possible to boil off the solvent and concentrate nearly all of the oil present in the ground kernels in the bottoms product of the tower. This method is only feasible for large scale production schemes due to the cost of maintaining and running a distillation tower.

Biodiesel Production:

Transesterification:

Transesterification Once the oil has been extracted, it's time to transform it into biodiesel. In order to convert the triglycerides in Jatropha oil into biodiesel FAMEs, they must undergo a transesterification reaction with an alcohol with an acid or base catalyst. Transesterification is the process of swapping the organic groups an ester with the organic group on an alcohol. A triglyceride consists of an ester with three fatty acid chains. Swapping the hydrocarbon chains of a triglyceride with methanol or ethanol produces the desirable FAME. The reaction may be catalyzed by a strong acid or base. In the case of an acid, a proton is donated to the carbonyl group on the ester to create a carbocation. Alcohol makes a nucleophilic attack on the carbocation producing FAME, a hydronium ion, and glycerol as a byproduct. In the case of a base, the reverse occurs with the strong base removing a hydrogen atom from the alcohol to create a strong nucleophile. The resulting alkoxide makes a similar nucleophilic attack on the carbonyl group to yield a FAME, alkoxide ion, and glycerol. It should be noted that it takes significantly less steps for the reaction to take place under basic conditions, leading to faster reaction times. This makes base catalyzed reactions the preferred method in the industry. [3]

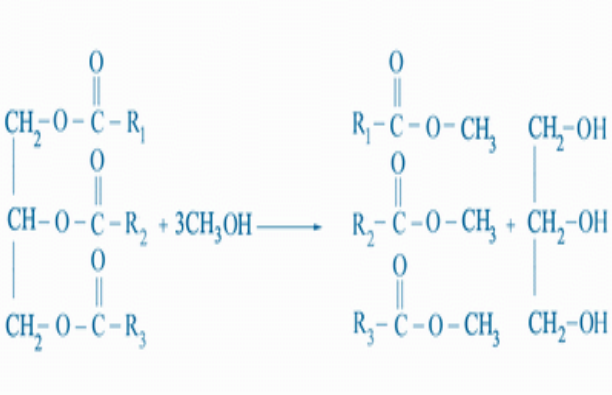


Fig.1: Transesterification

Advantages of Jatropha biodiesel:

(1) As southern Asian countries like India have suitable climatic conditions for the cultivation of jatropha, it requires less investment, irrigation, fertilizers etc.
(2) Jatropha even grows well on soil having low nutritional values too.
(3) Jatropha cultivation is possible even in drought prone areas and isn't prone to huge financial losses to farmers.
(4) Jatropha seeds have a good oil content (40-42%) [4]
(5) Hydrocarbon emissions of jatropha diesel are almost half of that emitted by fossil diesel, leading to a reduced carbon footprint.
(6) It has a long lifespan (around 50 years)

Disadvantages of Jatropha-

(1) Jatropha harvesting is labor intensive farming. Hence countries having less population density of farmers pose a problem in te cultivation of jatropha
(2) Gestation period of jatropha plants is long (3-4 years)
(3) Jatropha fruits and seeds are highly toxic.

4. BIODIESEL FROM USED COOKING OIL

All types of cooking oils, be it used or fresh, have a very high viscosity. Raw vegetable oil cannot be used directly to run diesel engines because of the above mentioned reason and need to be chemically processed before being used as diesel. It is important that the fuel produced meets the biodiesel ASTM standards, otherwise there could be engine damage.

In order to reduce the cost of biodiesel, waste or used cooking oil was thought of as an excellent solution. This also reduced the wastage of oil and solved disposal problems.

Production technique-

1) Oil collection:

Used cooking oil is first collected from various sources such as households, fastfood joints etc. This also serves helpful to the roadside vendors who have a problem disposing their waste used oil.

Several factors are taken into consideration before collecting the oil:

(1) It should look drker than regular unused cooking oil and may also contain some leftover food particles in it.

(2) It shouldn't used if the oil is milky or cloudy. This may mean that it has excess amount of water and this may have a negative impact on the biodiesel production process.

2) Preheating and filtration:
The collected oil is first preheated to about 363-368 ^{0}C. this process allows any foreign particles present in oil to club together. This oil is ten filtered mechanically and all external particles are separated from the oil

3) Reheating and settling:
The oil is then reheated to a temperature of around 413^{0}C and is then allowed to settle and get to room temperature. This is then stored in containers, ready to be processed as biodiesel.

4) Titration:
The oil is then tested for acidity or basicity witH the help of standard iye solution.

5) Transesterification(as discussed above)

5. BIODIESEL FROM MAHUA-

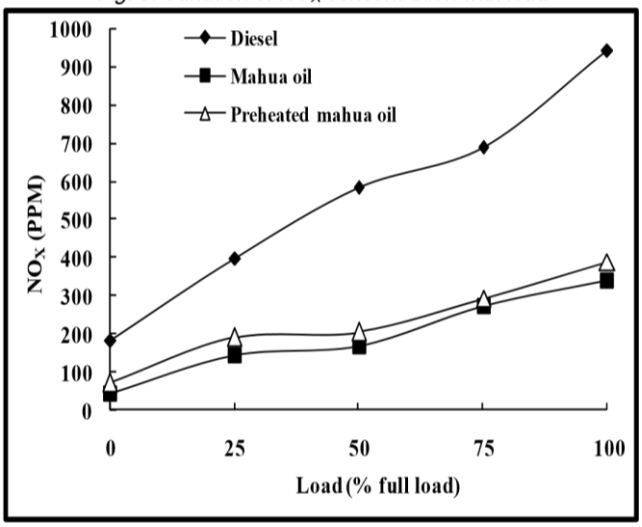
Mahua (Madhuca longifolia) is an Indian tropical tree found largely in the central and north Indian plains such as Maharashtra, Chattisgarh, Tamil Nadu, Madhya Pradesh, Telangana, Kerala, Gujarat, Orrisa and many other tropical part. Mahua tree is found in abundance in the country and the number of trees found in northern india is 8023000 whereas 1325000 mahua trees are found in southern India. Mahua tree produces around 100kg to 150kg of seeds annually. The amount of oil extracted is 34% to 40% to the weight of kernel [5].

METHODOLOGY:

The Mahua seeds are maintained with less than 6% of moisture. Expeller process is used to extract mahua oil. It has about 18% free fatty acid which is determined using titration method. A two stage esterification process is used with Acid esterification followed by base catalyzed esterification. A two-step transesterification process was employed comprising of acid catalyzed esterification and base catalyzed esterification to convert mahua oil with higher FFA content into its corresponding biodiesel. During the transesterification reaction, Sodium hydroxide and methanol are mixed to form sodium methoxide for the production of Mahua Oil Methyl Esters. The fatty acid methyl esters are subjected to Gas chromatography/Mass Spectrometry analysis and Fourier Transform Infrared technique to identify the various FAMEs present in it. The physio chemical properties of mahua oil biodiesel are also analyzed and found within ASTM standards. An optimization study is also conducted by varying parameters like Molar ratio of 1:6, reaction time, Reaction temperature and quantity of Methanol and Sodium hydroxide which is used as catalyst neutralize the fatty acids.

The viscosity of mahua oil is found to be 9 times higher than that of diesel fuel.It has been reported that with preheated fuel the peak pressure was similar to diesel fuel operation due to the changes in oil viscosity and improved droplet size. [6]

Fig. 9. Variation of NO_X concentration with load



ADVANTAGES:

1) Mahua tree can grow in drought prone area easily and it has very low manure and fertilizer requirements.
2) Its harvesting period is of more than 40 years and the crop harvest quantity is also huge.
3) The smoke density is comparatively lower if preheated mahua oil is used.
4) Cetane number of mahua oil is generally in the higher range of diesel fuel.
5) Hydrocarbon emission is low of preheated mahua oil in CI engines. [7]
6) Flash point and fire point of mahua oil is better than other nonedible oils used for biodiesel blending.

DISADVANTAGES:

1) The country doesn't have any collective farming of mahua so collecting the mahua seed is bit expensive.
2) The flash point and calorific value of mahua oil is not good as diesel oil.
3) The process of manufacturing the oil and making it more refined is still not developed.

GENERAL APPLICATIONS OF BIODIESEL-

(1) Biodiesel is known for being environmentally benign. Biodiesel has been tested as potential cleaning agent for shorelines contaminated with crude oil, and has been found to increase the recovery of crude oil from artificial sand columns (ie, the beach).
(2) It's been used in commercial biosolvents shown to be effective in coagulating crude oil and allowing it to be skimmed off the surface of water. In 1997, the product Cytosol was licensed by the California Department of Fish and Game as a shoreline cleaning agent.
(3) Bioheat has has grown in popularity over the last few years, and biodiesel can be used as a home heating oil in domestic and commercial boilers.
(4) High blends of biodiesel will also clean out fuel pipes, which can improve heating efficiency but may initially cause fuel filter clogging.
(5) Adding Lubricity to Diesel Fuel.
(6) Corrosion Preventation agent.
(7) Removing Paint and Adhesives.

6. CONCLUSION:

Manufacturing large quantities of biodiesel is currently an expensive process as compared to diesel but as technology advances,in the years to come, biodiesel can be the cheapest fuel and most efficient fuel for running compression-ignition engines. For countries who are economically backward, producing their own indigenieos biodiesel would be an excellent solution instead of importing petroleum diesel from gulf countries. Usage of biodiesel on a large scale will significnatly reduce the CO_x , NO_X emmissions and would play a huge role to reduce the earth`s global warming. Hence it can be concluded that biodiesel can be used as the best alternative to petroleum based diesel in various compression-ignition engines.

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