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Biodiesel: A Renewable Source of Fuel

Akshay B Randive[1], Sneha Kiran Gaikwad[2], Suhas B Khadake[3], Mallad H. M.[4]
Lecturer, SVERI's College of Engineering (Poly), Pandharpur, India[1]
Lecturer, Swami Vivekanand Institute of Technology (Poly), Solapur, India[2]
Assistant Professor, SVERI's College of Engineering, Pandharpur, India[3]
Assistant Professor, Fabtech Technical Campus, Sangola, India[4]

Abstract: *Biofuels are renewable alternatives to petroleum-based motor fuels, such as gasoline and diesel.These are derived from plants, animal waste, or algae material. The major biofuel variants available in the market include bio-gasoline from sugar-based bioethanol and biodiesel from vegetable oils or fatty acid methyl esters (FAME). These fuels offer several advantages over conventional fossil fuels, such as better lubricating properties, cost-effectiveness, ease of source, and reduced greenhouse gases emissions. Since biofuels are created from organic matter*
(Biomass), they can be quickly replenished. At the same time, the low emissions associated with their combustion means they are an attractive prospect for usage in various industries. Biodiesel production is the process of producing biofuel, biodiesel, through the chemical reactions of Trans esterification and esterification. This involves vegetable or animal fats and oils being reacted with short-chain alcohols (typically methanol or ethanol). The alcohols used should be of low molecular weight. Biodiesel has become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources. The cost of biodiesel, however, is the bottleneck to its commercialization. To make Bio-diesel, hydrocarbons (i.e., oil or fats) are filtered and get mixed with alcohol, which are usually methanol and a catalyst. Ester and glycerol bio-diesel fuel, are the major products of this reaction.

Keywords: Biomass, Biofuels, Biodiesel, Bioethanol

I. INTRODUCTION

History of Biodiesel:

Rudolph Diesel himself developed biodiesel in 1890, wherein pure vegetable oils were used in diesel engines for agriculture, where petroleum diesel was not available [1-2]. Modern biodiesel fuel is an outcome of research conducted in 1930s in Belgium, which is made by converting vegetable oils into compounds called fatty acid methyl esters [3-20]. Process of trans esterification was used to convert vegetable oils into fatty acid alkyl esters and use as diesel fuel replacement with lower viscosity of vegetable oil. Biodiesel is the trade name of fatty acid methyl esters. Concerns over environment, energy security and use of agro products brought the use of vegetable oils to the forefront [21-45].

Biodiesel blend is a mixer of methyl or ethyl esters derived from a broad variety of renewable sources such as vegetable oil, animal fat and recycled cooking oil [46-89]. These esters are oxygenated organic compounds that can be used in compression ignition engines owing to their key properties.

it is eco-friendly, renewable and sustainable fuel which offer carbon neutral cycle. "Soy Methyl Ester" diesel ("SME" or "SOME"), derived from soybean oil, is the most common biodiesel available in the United States [90-125]. "Rapeseed Methyl Ester" diesel ("RME"), derived from rapeseed oil, is the most common biodiesel blend stock available in Europe. On the other hand, Palm Methyl Ester ("PME"), derived from palm oil, is the most common biodiesel blend stock available in Asia as of today. Collectively, these fuels are sometimes referred to as "Fatty Acid Methyl Esters" ("FAME") or "Fatty Acid Ethyl Esters" ("FAEE").

Indian approach towards the development of biodiesel program is different than the other parts of world. It depends exclusively on non-edible feedstock's such as Jatropha, Karanja, Neem, Mahua, algae etc. It is targeted to raise these feed stocks on degraded/marginal or wastelands which are not suited for agriculture or diverted from stocks which are banned for human consumption such as waste cooking oil [126-150].

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II. BIODIESEL PRODUCTION

Biodiesel is produced by a process called trans esterification, in which various oils (triglycerides) are converted into methyl esters through a chemical reaction with methanol (FAME) or ethanol (FAEE) in the presence of a catalyst, such as sodium or potassium hydroxide (Fig.1). By-product of the trans esterification process includes glycerol which needs to be removed from the finished product along with traces of the methanol or ethanol, un-reacted triglycerides, and the catalyst.

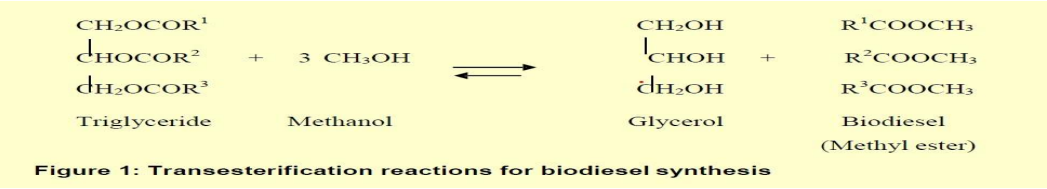

Figure 1: Transesterification reactions for biodiesel synthesis

2.1 Production process

1. Storage: Before or after treatment, raw material will be collected and stored in a storage tank for further processing. In this initial stage filtration of raw material can also be done. The storage tank is connected with the esterification tank. The raw material will be sent to the esterification tank [151-177].
2. Esterification: Esterification increases the yield of biodiesel. When oil contains an excess of free fatty acids they have to go through the process of esterification. The key to effectively preparing for the esterification process is to make sure the raw material has been sufficiently filtered by removing all contaminants and water. Upon filtration, the raw materials are fed to the acid or resin esterification process. The catalyst, sulfuric acid, is dissolved in methanol and then mixed with the pretreated oil. Once the mixture is heated and stirred, the free fatty acids are converted to biodiesel. The final step of esterification is to dewater and feed the product to the trans esterification process.
3. Trans esterification: The trans esterification reactions are the most common method of converting triglycerides (TAG) from oils into methyl esters (biodiesel). The conversion of vegetable oil into biodiesel through the trans esterification process reduces the molecular weight to one-third, reduces the viscosity by about one-seventh, reduces the flashpoint slightly, increases the volatility marginally, and reduces the pour point considerably. Then, the fuel produced has approximately the same property as petro dieseland can be used in conventional diesel engines without any change in this last. After Trans esterification, the ester can be separated from glycerol by simple gravitational sedimentation and the ester has to be washed to remove traces of alkali.
4. Decantation: Due to its low solubility in esters, separation is usually performed by either decantation or centrifugation. In the separation by decantation, the biodiesel and glycerol mixture are rested in tanks. The separation cost is low, but it is a slow process.
5. Purification: Biodiesel is conventionally purified using water and dry washing technologies. Water could eliminate the remaining sodium salts and soaps formation; this is due to their water solubility.
6. Storage and filling: Storage conditions are important for biodiesel storage. Biodiesel should not be stored or transported in copper, bronze, brass, lead, tin, or zinc metal tanks because these metals will hasten degradation. Instead, containers made fromaluminum, steel, fluorinated polyethylene, fluorinated polypropylene, or fiberglass tanks can be used. Tanks that are designed to store and transport petro-diesel can also be used to store biodiesel. Heat, sunlight, and oxygen will also cause biodiesel to degrade more rapidly, so storage should minimize exposure to these conditions. If biodiesel will be stored for longer than about four to five months, a stability additive should be used. Biodiesel will be filled by using an oil filling machine. The biodiesel shall be

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packed in suitable airtight sealed containers as agreed between the purchaser and the supplier. The use of airtight sealed containers, such as drums or totes, can enhance the storage life of biodiesel.

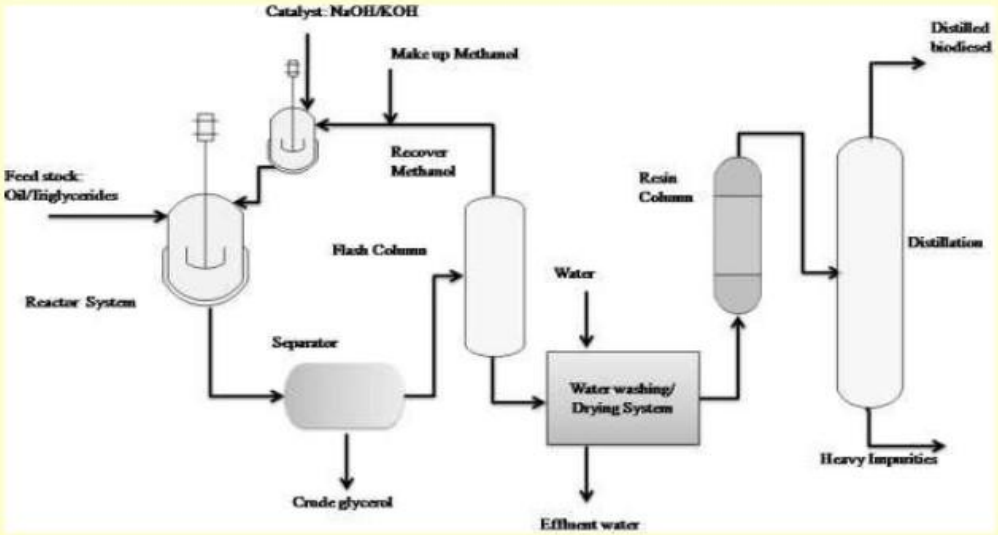

Figure 2: Simplified process flow diagram for conventional homogeneous catalytic biodiesel process

7. Shipping: When biodiesel is transported, ensure the transportation container has been cleaned (except if it recently carried petro-diesel or biodiesel) and that there is no water in the tank. The tank might require insulation or heating if the biodiesel is beingtransported in cold weather. On the other hand, the biodiesel can be allowed to freeze inthe tank and afterward be heated at the destination. Pure biodiesel is not considered flammable, has a flash point greater than 200°F, and can be transported without any warning signs. Biodiesel blends require cautioning signs if the flashpoint of the blended fuel is lower than 200°F.

R1, R 2 & R3 Fatty acid chain of triglyceride.

The simplified process schematic of the biodiesel production process is depicted in Figure 2above.

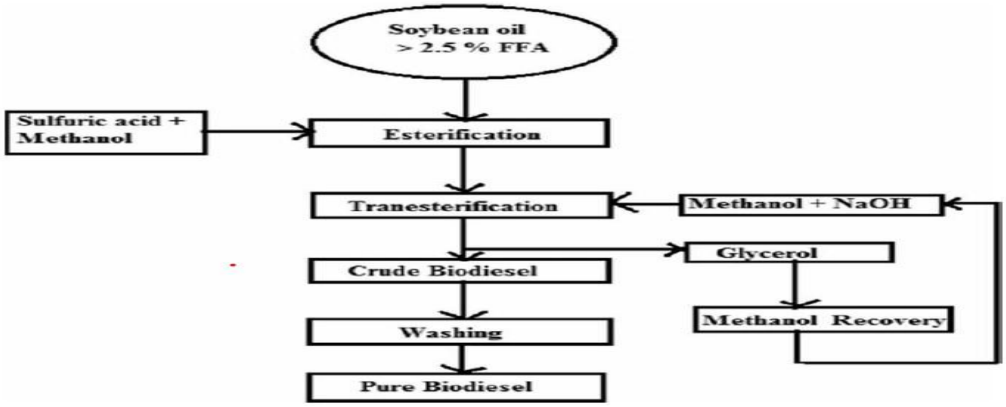

Fig. 3 Detailed Flowchart of Production Process of Bio-Diesel

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2.2 Specifications:

Biodiesel is produced in a pure form (referred to as "B100"or "neat biodiesel") and is typically blended with petroleum-based diesel fuel. Such biodiesel blends are designated as BXX, where XX represents the percentage by volume of pure biodiesel contained in the blend (e.g., "B5," "B20").

Several international organizations have adopted and continue to revise biodiesel specifications and guidelines. Specifically, ASTM International recently approved revisions to its specification for B100 biodiesel blend stock referenced as D6751. Europe's Committee for Standardization ("CEN") has adopted a technical standard for biofuels referred to as EN 14214.

In India, Bureau of Indian Standard (BIS) also adopted a technical standard i.e. IS 15607:2005 for Biodiesel as blending stock. The B5 biodiesel blend specification is similar to existing diesel specification i.e. IS 1460:2005. However, specification of biodiesel for standalone application and B6-B 20 blends are under consideration and development stage by BIS. IS 15607:2005 specification of biodiesel (B100) as blending stock. Following fig 2 shows it.

Characteristics	IS 1567 2005 :
Density, Kg / m3	860 – 900
sEster Content, % min.	96.5
Flash point (closed cup), °C	120
Water and sediment, mg / Kg, max.	500
Kinematic viscosity at 40°C, mm2/s	2.5-6.0
Oxidation Stability at 110°C, hours min.	6
Rams bottom carbon residue, % mass, max.	0.05
Sulfated ash% mass, max.	0.02
Sulfur, mg / Kg max	50
Copper strip corrosion 3 hrs. 50°C	Class 1
Cetane Number, min.	51
Acid number, mg KOH/g, max.	0.50
Methanol or Ethanol, % m/m, max	0.2
Free glycerin, % mass	0.020
Total glycerine (free glycerine and unconverted glycerides combined), % by mass, max.	0.25
Group I Metal (Na+K), mg/Kg, max	5
Group II Metal (Ca+Mg), mg/Kg, max	5
Phosphorus content, mg/Kg, max	10

Fig.4 Characteristics Specification of Biodiesel

III. RAW MATERIAL REQUIRED FOR BIODIESEL

The raw materials for biodiesel production are vegetable oils, animal fats, and short-chain alcohols. Since cost is the primary concern in biodiesel production and trading(fundamentally due to oil prices), the utilization of non-edible vegetable oils is recommended. Other than its lower cost, one more evident benefit of non-edible oils for biodiesel production lies in the fact that no foodstuffs are spent to produce fuel. Animal fats are also an interesting option, especially in countries with plenty of livestock resources, although it is necessary to carry out preliminary treatment since they are solid; furthermore, highly acidic grease from cattle, pork, poultry, and fish can be used. Methanol is the most frequently used alcohol although ethanol can also be used. Other: Catalyst, Packing materials, etc. Strong alkali catalysts such as NaOH, KOH, CH3ONa, and CH3OK (potassium meth oxide) are used for biodiesel production.

IV. STORAGE & HANDLING OF BIODIESEL

Untreated biodiesel blend stocks generally exhibit poor oxidation stability, which can result in long-term storage problems. Thus, anti-oxidation additives are added to improve its storage stability. Biodiesel blend stock and higher

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biodiesel blends act as solvents, removing historical deposits accumulated from the use of petroleum diesel fuel. The materials removed accumulate in fuel filters, resulting in more frequent than typical service intervals until the deposits have stabilized. Therefore, when converting from petroleum diesel fuel to a biodiesel blend, fuel storage and vehicle/equipment tanks should be cleaned and rid of any residual water.

Biodiesel is generally more susceptible than petroleum diesel to microbial degradation. In the case of spills in the environment, this is a positive attribute because it biodegrades more rapidly. However, microbial contamination of fuel storage tanks can plug dispensers and vehicle fuel filters and cause vehicles to stall. The best way to deal with this issue is good housekeeping & monitoring quality, especially minimizing water in contact with the fuel. Water bottoms must be removed from tanks and product tanks should be sampled and tested for microbial contamination.

B100 is not compatible with some metals and plastics. Biodiesel will degrade and form high sediment levels if contacted for long periods by copper or copper containing metals (brass, bronze) or with lead, tin, or zinc (galvanized surfaces). These high sediment levels may clog filters. B100 may also permeate some common plastics (polyethylene, polypropylene) over time, so these should not be used for storing B100.

The D6751 specification also includes the following statement:

i) "The biodiesel fuel shall be visually free of undissolved water, sediment, and suspended matter".

ii) B100 should be clear, although it may come in a variety of colors. The biodiesel's color does not indicate fuel quality.

iii) ASTM recently passed specifications for biodiesel blends. These include the allowance of up to 5% biodiesel.

V. HEALTH & SAFETY ASPECTS

Biodiesel and their blend stocks are biodegradable, which may render them useful in applications where biodegradability is desired (e.g., marine or farm application Emissions from engines using biodiesel blends have undergone successful health effects testing in accordance with EPA Tier 2 requirements for fuel and fuel additive registration. Biodiesel blends with diesel are reported to reduce particulate, HC and CO emissions.

Biodiesel has a higher flash point than petroleum-based diesel fuel, which allows for transportation and storage without the restrictions associated with flammable materials.

Biodiesel contains no hazardous materials and is generally regarded as safe. A number of studies have found that biodiesel biodegrades much more rapidly than conventional diesel. Users in environmentally sensitive areas such as wetlands, marine environments, and national parks have taken advantage of this property by replacing toxic petroleum diesel with biodiesel. The flash point of biodiesel is higher than 100C°, so it is considerably less dangerous as compared to Kerosene (flash point-38 C° to 72°C) and diesel flash point-52 C° to 96°C). However, biodiesel blends will have flash points intermediate to the two liquids.

Launching of Bio-Diesel:

In Northern Region Biodiesel has been launched on 10th August 2015, the World Biodiesel Day with HSD blended with 5 % biodiesel (B5) at one select RO (COCO) fed from Bijwasan installation. Bhatinda, Salawas, Rewari, Jobner, Mathura & Kanpur are earmarked for launching in near future.

Transportation of biodiesel:

- Biodiesel must be transported in a way that does not lead to contamination. Following precautions are recommended
- Ensure that trucks are fabricated of aluminum, carbon steel, or stainless steel.
- Ensure proper inspection or washout (washout certificate) before loading.
- Check for previous load carried and residual. Generally only diesel fuel or biodiesel is acceptable as a residual.
- Ensure that there is no residual water in the tank.
- Check that hoses and seals are clean and made from materials that are compatible.
- Biodiesel is challenging to transport in cold weather. Ensure that while transporting the fuel does not freeze.

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VI. SOME IMPORTANT ISSUE RELATED TO BIODIESEL

A. Signs, Labels, and Stickers:

No placards or warning signs are required for the transport of pure biodiesel. However, biodiesel blends with diesel are required to be transported in conventional TLs with UN code.

B. Fire Safety Considerations:

Pure biodiesel can be extinguished with dry chemical, foam, halon, CO2, or water spray, although the water stream may splash the burning liquid and spread fire.

C. First Aid Measures:

EYES: Wash eyes with a heavy stream of water for at least 15 to 20 minutes. SKIN: Wash exposed areas of the body with soap and water.

INHALATION: Remove from area of exposure, seek medical attention if symptoms persist.

INGESTION: Give one or two glasses of water to drink. If gastrointestinal symptoms develop, consult medical personnel.

Accidental Release Measures Spill Clean-Up Procedures: Remove sources of ignition, contain spill to smallest area possible. Stop leak if possible. Small spills can be controlled with “absorbent materials”, sand, or dirt. Recover large spills for salvage or disposal. Wash hard surfaces with safety solvent or detergent to remove remaining oil film. Greasy nature will result in a slippery surface.

D. *Way forward:*

Introduction of biodiesel as a fuel in India is envisaged to offer benefits w.r.t. reduction in crude oil import. It is nontoxic, biodegradable and can be used as an excellent feedstock for production of biodegradable lubricants. Keeping in view of these benefits, MoPNG has introduced B5 blend in few select cities mainly due to non-availability of feedstocks in India. The non-availability is primarily ascribed availability of non-edible oils. Therefore, to derive maximum benefits from environment and reduce dependency on crude oil import, it is utmost important to develop genetically modified non-edible oil plant such as Jatropha, Karanja for improved oil yields. Furthermore, alternate feedstock’s for biodiesel production need to be explored for long term economic viability and sustainability.

VII. BIODIESEL APPLICATIONS

i) On-road Vehicles: Practically every diesel engine powered vehicle on the roads. (Millions of miles were logged on biodiesel in EU nations) .

ii) Off-road Vehicles: Natural fuel can be used for off road construction, mining, and farm machinery.

iii) Marine Vessels: Naturol fuel can be used in marine engines safely. Marine use is especially attractive due to the elimination of any possibility for contamination of waterways.

iv) Stationary Power Generation: With new power generation capacity coming online, Naturol biodiesel makes an attractive choice to meet the regulations. Many stationary application arepermitted sources requiring exhaust emission control system, which will work well with biodiesel but will not work with diesel fuel.

v) Boiler Fuel: With natural gas prices rising high, biodiesel can be substituted easily for natural gas with minor changes necessary to the burner train.

vi) Hybrid Vehicles: With many states now mandating hybrid electric vehicles (including the fuel cell hybrid), biodiesel will make excellent reforming fuel.

vii) Agriculture Adjuvants: Biodiesel is used as a carrier for pesticides and fertilizer in agriculture sprays due to it being non-toxic and biodegradable.

viii) Solvents: Biodiesel can be used as industrial solvents and as a replacement of high VOC containing petroleum solvents. With regulations driving the VOC contents lowers for solvents used in industries, biodiesel offers an attractive solution.. Other solvent applications are household cleaning agents.

ix) Lubricity Agent/Additive: Naturol biodiesel can also be used as a lubricity agent/enhancer in many applications. It is especially useful in marine applications where water contamination with petroleum lubricity agents can create problems. With the low-sulfur fuel regulation of future, biodiesel can be used as a lubricity additive. A 1-2% biodiesel added to diesel fuel can increase diesel lubricity by 65%.

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x) Fuel Additive: Biodiesel can also be used as a diesel fuel additive for the purpose of keeping the injectors, pumps and other combustion components clean. A 1-2% blend should be sufficient for this purpose.

VII. CONCLUSION

Biodiesel provides energy security as it protects the environment, and also boosts the economy. Today, biodieselturning as the growing alternative fuel not only in America, but other parts of the world as well. One of the main reasons behind transition to biodiesel fuel is energy security. Is that the nation's dependence on foreign oil get reduced, use of locally available sources is enhanced. Thus a country finds energy security in biodiesel fuel without a decrease in greenhouse gas emissions. Although the total energy balance is still a debatable issue, but clearly the energy security due to biodiesel fuel is enhanced. It has been observed that properly managed biodiesel fuels have the prospective for strengthening the security of supply and can also help in generating different energies .

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