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The Study of Different Biodiesel Production from Various Resources and Its Properties - An Overview

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ABSTRACT

Biodiesel is a renewable resource of energy, which helps to reduce the dependence on the limited economy resources available in the world. The present research work is an approach towards attaining price competency of biodiesel to petroleum diesel. Biodiesel either directly or blended with diesel fuel is widely investigated to reduce the depletion of fossil fuels and environmental degradation. There has been growing interest in alternative fuels like biodiesel, a best substitute fuel for internal combustion engines. This paper reviews the biodiesel from various resources, different methodologies used for biodiesel production and the properties of different biodiesel. Biodiesel is an eco-friendly, alternative diesel fuel produced from vegetable oils and animal fats. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a blended fuel (Diesel and Biodiesel) to reduce levels of particulates, carbon monoxide and hydrocarbons from diesel-powered vehicles. The main objective of this study is the development of biodiesel by various methods and fuel-related properties.

Keywords: Alternate fuel, Bio-fuel, Biodiesel, Transesterification, Fuel Properties.

I. INTRODUCTION

Biodiesel is an alternative fuel from vegetable oil and animal fats, which could be edible or non-edible. Before the first diesel engine became functional, scientists E.Duffy and J.Patrick conducted the transesterification of a vegetable oil in1853. Rudolf Diesel invented the diesel engine in 1893, which first ran on peanut oil. Biodiesel has a high potentialas new and renewable energy resource in future. Without any modification in diesel engines, biodiesel can be used as a substitution fuel for petroleum diesel. Biodiesel is produced from edible and non- edible oils, but there may be a cause of negative effect on the world by using edible oils, such as depletion of food supply leading to economic imbalance. The biodiesel from non-edible oils such as

Pongamia, Calophyllum inophyllum, Jatropha, Cebia petandra, karanja, waste cooking oil are the future sources of energy. Bio-fuels were discovered even before fossil fuels like gas, coal and oil. The U.S. has accepted Biodiesel as clean alternative fuel and at present, its production is about 100 million gallons. Biodiesel has better fuel properties and it can be used as fuel for diesel engines (as either B5-a blend of 5% biodiesel in diesel fuel or B20 or B100). However, blends up to 20% should not give any problems. Biodiesel can be used as an additive to diesel fuel in order to reduce the overall sulphur content to blend and to compensate for the lubricity loss due to sulphur removal from diesel fuel.

The cost components of biodiesel are

- ✓ Price of seed
- ✓ Seed collection
- ✓ Oil extraction
- ✓ Transesterification of oil
- ✓ Transport of seed and oil

The benefits of using biodiesel as a fuel in diesel engines are:

- ✓ Biodiesel is environment- friendly than other fuels like petrol or diesel.
- ✓ Biodiesel is a clean fuel and more economic.
- ✓ Biodiesel is a renewable source of energy unlike other natural resources like coal and petroleum.

- ✓ Biodiesel has lower flash point and thus it prevents firing damage.
- ✓ There are limited or no change in engine modification for using biodiesel as fuel.
- ✓ Biodiesel allows longer engine life and equal engine performance and there is no need to change the transportation and storage systems to handle.

II. METHODS AND MATERIAL

1. Biodiesel Feedstock Selection

A variety of oils can be used to produce biodiesel.

- ✓ Edible oil feedstock such as rapeseed oil, soybean oil, mustard oil, sunflower oil, palm oil, etc.
- ✓ Non-edible oil feed stock's such as Jatropha, Pongamia, Castor,etc.
- ✓ Waste vegetable oil (WVO)from restaurants.
- ✓ Animal fats including tallow, lard, yellow grease, chicken fat and Omega-3 fattyacids from fish oil.
- ✓ Algae that can be grown using waste materials such as sewage and without displacing land currently used for food production.

2. Biodiesel Production Methods

The different used for biodiesel production are:

(i) Direct use/blending,
(ii) Micro-emulsion,
(iii) Pyrolysis,and
(iv) Transesterification.

2.1 Direct Use/Blending

Vegetable oil can be directly used as a fuel in engine without any modification in engine. High viscosity is the primary concern with vegetable oil as fuel i.e. atomization of vegetable oil is difficult which leads to problem for longer run of engine.

2.2 Micro-emulsion

One of the best definitions of micro-emulsions is from Danielsson and Lindman "a micro-emulsion is a system of water, oil and an amphiphile which is a singleoptically isotropic and thermodynamically stable liquid solution".

Micro-emulsions are clear, thermodynamically stable, isotropic mixtures f oil, water and surfactant, frequently in combination with a cosurfactant. The aqueous phase may contain salt(s) and/or other ingredients, and the "oil" may actually be a complex mixture of different hydrocarbons and olefins. In contrast to ordinary emulsions, micro-emulsions form upon simple mixing of the components and do not require the high shear conditions generally used in the formation of ordinary emulsions.

The three basic types of micro emulsions are:

- ✓ Direct (oil dispersed in water, o/w)
- ✓ Reversed(water dispersed in oil, w/o) and
- ✓ Bicontinuous.

In ternary systems such as micro-emulsions, where two immiscible phases (water and 'oil') a represent with a surfactant, the surfactant molecules may form a mono layer at the interface between the oil and water, with the hydrophobic tails of the surfactant molecules dissolved in the oil phase and the hydrophilic head groups in the aqueous phase.

2.3 Pyrolysis(Thermal cracking)

Pyrolysis is a thermo chemical decomposition of organic material at elevated temperatures in the absence of oxygen (or any halogen). It involves the simultaneous change of chemical composition and physical phase, and is irreversible. The word is coined from the Greek derived elements **pyro** means **"Fire"** and **lysis** means, **"Separating"**.

Pyrolysis is a type of thermolysis, and is most commonly observed in organic materials exposed to high temperatures. It is one of the processes involved in charring wood, starting at 200-300˚C (390-570˚F). In general, pyrolysis of organic substances produce gas and liquid products and leaves a solid residue richer in carbon content, char. Extreme pyrolysis, which leaves mostly carbon as the residue, is called carbonization.

2.4 Transesterification

Transestification, also called alcoholysis, is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis. This process has been widely used to reduce viscosity of triglycerides. The transestrification reaction is represented by the general equation:

RCOOR' + R''OH = RCOOR'' + R'OH

If methanol is used in the above reaction, it is termed as "methanolysis". The reaction of triglyceride with methanol is represented by the general equation given below.

CH_2OOR_1				CH_20H
|				|
$CHOOR_2$	+ $3CH_3OH$	→	$3CH_3OORx$ +	$CHOH$
|				|
CH_2OOR_3				CH_2OH
Triglyceride	**Methanol**		**Biodiesel**	**Glycerin**

Triglycerides are readily transesterified in the presence of alkaline catalyst at atmospheric pressure and at a temperature of approximately 60-70°C with an excess of methanol. The mixture at the end of reaction is allowed to settle. The lower glycerol layer is drawn off while the upper methyl ester layer is washed to remove entrained glycerol and is then processed further. The excess menthol is recovered by distillation and sent to a rectifying column for purification and recycling. The transesterification works well when the starting oil is of a high quality. However, quite often, low-quality oils are used as a raw material for biodiesel preparation. In cases where FFA (Free Fatty Acids)content of the oil is above 1%,difficultiesarise due to the formation of soaps which promote emulsification during the water washing stage,andatanFFAcontentabove2%, the process becomes unworkable.

Two step process of transesterification process:

1. Acid Catalysed Esterification (Pre- treatment process) – to reduce Acidic value

-H2SO4

- ✓ Acid catalyzed transesterification is very slow process compared to base-catalyzed transesterification.
- ✓ It is suitable for oil that has higher FFAs.
- ✓ This process uses strong acid to catalyze esterification of the FFAs and transesterification of triglycerides.
- ✓ The process does not produce soap with high FFAs because no metal is present.
- ✓ Esterification of FFAs is generally faster but produces water.

2. Base Catalyzed Transesterification

-KOH (or) NaOH

- ✓ This is the most widely used technique to produce biodiesel.
- ✓ Possibility of formation soap if there are high free fatty acids (FFAs) content in triglycerides.
- ✓ Excessive water can hydrolyze to form FFAs.

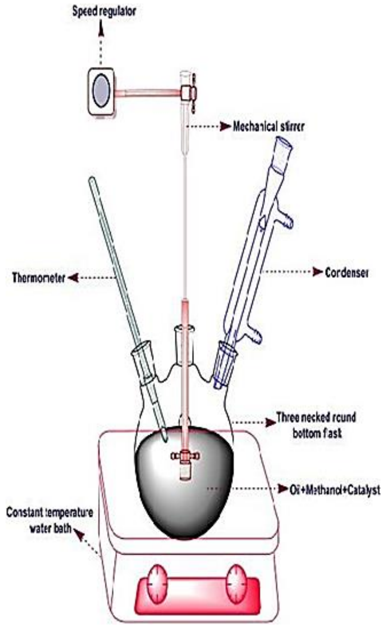

Figure1: Experimental setup

Transesterfication was carried out in a system, as shown inFigure1. The reactor system consisted of spherical flask, constant temperature water bath, stirrer, and condenser. The spherical flask consisted of three openings. Thermometer placed at one opening which continuously monitors the temperature of the reaction. Stirrer was placed inside the spherical flask at centre opening which is driven by motor and controlled by the speed regulator. Condenser was placed in the third opening to reflux the vapours back to the reactor to prevent any reactant loss. Constant temperature water path was a part of heat jacket, which maintained the temperature of oil and in turn the temperature of the reactants at a desired value. The reaction was carried out at around 65-70°C.

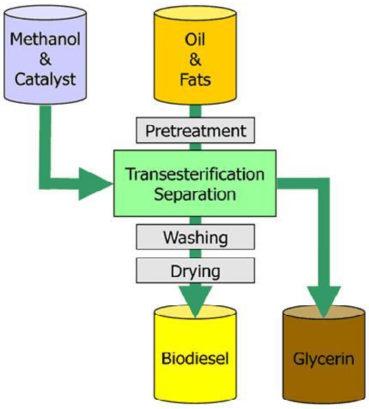

Figure2: Experimental Process

A known quantity of oil (100mL for each run) was taken inside the reactor and heated at about70°C. This temperature was maintained throughout the reaction by the constant temperature water bath. Preheating was used to remove unwanted moisture present in the oil. The transesterification was carried out in which KOH was used as catalyst. Catalyst was dissolved in alcohol. Once the oil temperature reached70°C,alcohol solution (containing dissolved catalyst) was added to the reactor and an equilibrium temperature was maintained.

During the reaction alcohol gets vaporized. To prevent any reactant loss condenser was used to condense the alcohol vapour and reflux it back into the reactor. Condenser was also helpful in maintaining atmospheric pressure inside the reactor (Figure 2).Once reaction was over the products were taken out through the outlet in the lower side of the reactor and put in the separating funnel. Two phases (having different density) are formed as a result of transesterification. Separation was done using a separating funnel (separation took around two hours). Upper layer consisted of biodiesel, alcohol, and some soap (formed as a result of side reaction saponification–free fatty acids get converted to soap). Lower layer consisted of glycerin, excess alcohol, catalyst and impurities.

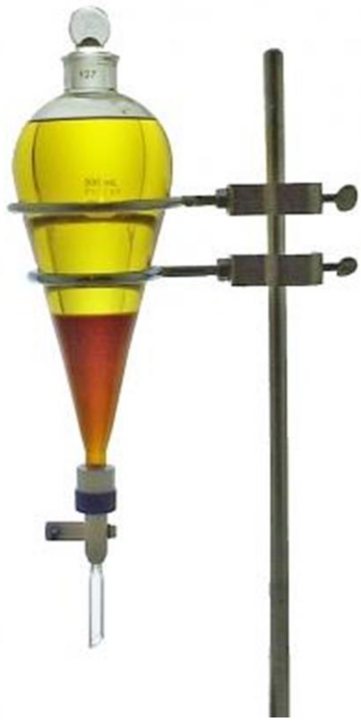

Figure 3: Separating Funnel

Purification of upper layer (to obtain biodiesel) was done in two steps:

(i) Removal of alcohol - by keeping mixture at elevated temperature~80 °C
(ii) Removal saponified products- by washing with warm water. Water is immiscible with biodiesel, hence can be easily separated from biodiesel.

III. RESULTS AND DISCUSSION

Properties of Biodiesel

A general understanding of the various properties of biodiesel is essential to study their implications in engine use, storage handling and safety. Table 1shows the typical properties of biodiesel as compared to diesel.

Some important properties of biodiesel are described below.

3.1 Density/SpecificGravity

Biodiesel is slightly heavier than conventional diesel fuel (specific gravity 0.88 compared to 0.84 for diesel fuel). This allows the use of splash blending by adding biodiesel on top of diesel fuel for making blends.

3.2 Cetane Number

Cetane number is indicative of its ignition characteristics. The higher is the Cetane number; the better is its ignition properties. The Cetane number affects a number of engine performance parameters like combustion, stability, drive ability, white smoke, noise, and emissions of CO and HC. Biodiesel has a higher Cetane number than conventional diesel fuels this results in higher combustion efficiency and smoother combustion.

3.3 Viscosity

In addition to lubrication of fuel injection system components, fuel viscosity controls the characteristics of the injection from the diesel injector (droplet size, sprayer characteristics, etc.).The viscosity of biodiesel can reach very high levels, and hence, it is important to control it within an acceptable level to avoid negative impact on the performance of the fuel injection system. Therefore, the viscosity specifications proposed are same as that of the diesel.

3.4 Distillation characteristics

The distillation characteristics of biodiesel are quite different from that of diesel fuel. Biodiesel does not contain high volatile components; the fuel evaporates only at higher temperature. This is the reason that sometimes the dilution of sump lubrication oil is observed in many tests. Boiling point of biodiesel generally ranges between 330 – 357°C.

3.5 Flash point

The flash point of a fuel is defined as the temperature at which it will ignite when exposed to a flame or spark. The flash point of biodiesel is higher than the petroleum-based diesel fuel. Thus, in storage, biodiesel and its blends are safer than conventional diesel. The flash point of biodiesel is around 160°C, but it can reduce drastically if the alcohol used in the manufacture of biodiesel is not removed properly. Residual alcohol in the biodiesel reduces its flash point drastically. A minimum flash point for biodiesel is specified more from the point of view of restricting the alcohol content rather than fire hazard. A minimum flash point of 100°C is specified to ensure that the excess methanol used for esterification is removed.

3.6 Cold Filter Plugging Point (CFPP)

At a low operating temperature, fuel may thicken and not flow properly, affecting the performance of fuel lines, fuel pumps and injectors. The CFPP of the biodiesel reflects its cold weather performance. It defines the fuel limit of filterability. CFPP has a better correlation than cloud point for biodiesel as well as diesel.

3.7 Cloud Point

Cloud point is the temperature eat which a cloud or haze of crystal appears in the fuel under test conditions, and thus, it is important for low temperature operations. Biodiesel generally has a higher cloud point than diesel.

3.8 Oxidation Stability

Poor oxidation stability can cause fuel thickening, formation of gums and sediments, which in turn, can cause filter clogging and injector fouling. The iodine number indicates the tendency of fuel to be unstable as it measures the presence of C=C bonds that are prone to oxidation. The oxidation stability of biodiesel varies greatly depending upon the feedstock used.

3.9 Iodine Number

A high content of unsaturated fatty acid in the ester (indicated by a high iodine number) increases the danger of polymerisation in the engine oil. Oil dilution decreases the oil viscosity. A sudden increase in oil viscosity is attributed to oxidation and polymerisation of unsaturated fuel parts entering in to oil through dilution. The tendency of the fuel to be unstable can be predicted by the iodine number thus the iodine number refers to the amount of amount of iodine required to convert unsaturated oil into saturated oil. It does not refer to the amount of iodine in the oil but to the presence of unsaturated fatty acid in the fuel.

3.10 Lubricity

The Lubricity of the fuel depends on the crude source. There fining process to reduce sulphur content and the type of addictive used. Lower the wears car diameter

(WSD) better is the Lubricity of the fuel. Even with 2% biodiesel mixed in diesel fuel, the WSD value comes down to around 325 microns and is sufficient to meet the Lubricity requirements of the fuel injection pump. B100 performs still better with WSD of about 314 microns.

3.11 Acid Number

The acid number reflects the presence of free fatty acid or acid used in manufacture of biodiesel. It also reflects the degradation of biodiesel due to thermal effects.

3.12 Conradson Carbon Residue (CCR)

Carbon residue of the fuel is indicative of carbon depositing tendencies of the fuel. The CCR of biodiesel is more important than that in diesel because it has a high correlation with the presence of FFAs.

3.13 Calorific value

Calorific value is the amount of heat released by a unit weight or unit volume of a substance during complete combustion.

- Higher Calorific value (or Gross Calorific Value-GCV or Higher Heating Value-HHV) - the water of combustion is entirely condensed and that the contained in the water vapour is recovered.
- Lower Calorific value (or Net Calorific value-NCV or Lower Heating Value-LHV) - the products of combustion contains the water vapour and that the heat in the water vapour is not recovered.

IV. CONCLUSION

Biodiesel is a one promising environment-friendly alternative fuel due to renewable energy nature and clean burning characteristics. In this paper, various biodiesel production from various resources and its properties were discussed. The biodiesel viscosity is one of the most important parameters required in the design of the combustion process. The viscosity must be closely correlated with design parameters of fuel flow systems. Hence, the neat biodiesel or biodiesel blends should meet the preferred viscosity in order to avoid damage of fuel injectors and fuel pump. Overall diesel, with small proportions of biodiesel blends, is technically feasible as an alternative fuel in compression ignition engines without modification to engine. As the stock of fossil fuel is being depleted, emphasis should be given to renewable sources of fuel such as sustainable bio-fuel crops and tree-borne oil seeds. The small partial replacement of diesel with biodiesel will alleviate the pressure on existing diesel oil resources and decrease import case of diesel fuel. Moreover, it is expected that the price of biodiesel will be lower than the price of conventional diesel fuel in the near future due to linear increase in the price of conventional diesel fuel with the increase in its demand and limited supply.

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