Original Article

Properties of Biodiesel Produced From Various Oilseeds

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Abstract

Biodiesel is an alternative and renewable diesel fuel which can be obtained from the transesterification of vegetable oils with simple alcohols. Biodiesel was prepared using a variety of vegetable oils such as rapeseed, soybean, groundnut, coconut and neem oil. Various properties of biodiesel such as viscosity, specific gravity, cloud point, pour point, flash point and heat value were investigated. Experiments to look for biodiesel from neem oil and coconut oil were not successful. Soybean methyl ester was closest to a practical biodiesel as seen from its properties. The viscosities of all the three esters were found to be quite suitable to function in an I.C engine almost like petroleum diesel. RME (Rapeseed methyl ester) is the most inferior among the three for heat values though all these have heat values less than that of petroleum diesel.

Keywords: Biodiesel, Groundnut, Oilseeds Rapeseed, Soybean, Transesterification

Introduction

Increasing population density and economic development, particularly in developing countries like India, has led to huge increase in energy demand. The depletion of world petroleum reserves, the instability of petroleum sources, recent increase in petroleum prices and uncertainties concerning petroleum availability have generated interest in vegetable oil fuels for diesel engines. Biodiesel is a promising non-toxic and biodegradable renewable fuel comprised of mono-alkyl esters of long chain fatty acids, which is produced by a catalytic transesterification reaction of vegetable oils with short-chain alcohols (Sharma and Singh, 2008). Biodiesel has become an interesting alternative to diesel, because it has similar properties to the traditional fossil diesel fuel and may thus substitute diesel fuel with none or very minor engine modification (Ma and Hanna, 1999; Oliveira et al., 2006). Biodiesel is oxygenated and essentially free of sulfur making it a cleaner burning fuel than petroleum diesel with reduced emissions of SOx, CO, unburnt hydrocarbons and particulate matter. Other studies have clearly indicated that the use of biodiesel may potentially reduce the dependence on petroleum diesel fuel and improve environmental aspects with satisfactory performance (Knoth et al., 2006; Knoth and Steidley, 2006; Altiparmak et al., 2007).

Vegetable oils are the best candidates as alternative or emergency fuel. Several vegetable oils available commercially have been tested as fuel components for diesel engines. Some of these oils are soybean, cottonseed, sunflower, rapeseed, safflower, peanut, algal oil etc. (Lang et al., 2002; Spolaore et al., 2006). The vegetable oils cannot be used as such (neat) because they may affect the engine performance adversely due to greater viscosities, less volatilities and high degree of unsaturation than diesel fuel. Their heat content range approximately 80-90% of the diesel fuel (Sharma et al., 2008). Other edible and non-edible oils, animal fats, algae and waste...
cooking oils have also been investigated by researchers for the development of biodiesel (Karmee and Chadha, 2005; Wang et al., 2007).

Chemically biodiesel is defined as the alkyl esters of long chain fatty acids derived from renewable lipid sources. It is technically produced through the reaction of a vegetable oil or animal fat with methanol or ethanol in the presence of a catalyst to yield glycerine and biodiesel (chemically called methyl or ethyl esters). Biodiesel can be used in neat form or blended with petroleum diesel for use in diesel engines. Methanol has been the most commonly used alcohol in the commercial production of biodiesel. Biodiesel has been gaining worldwide popularity as an alternative energy resource because of its benefits. It is environment friendly, non-toxic, its cost compares well when compared to other alternative fuels.

In the present communication, preparation of biodiesel from various oilseeds has been discussed as also different properties of biodiesel prepared from these vegetable oils to find their suitability as a fuel in relation to petroleum biodiesel.

**Materials and Methods**

Many crops have been proposed or being used for commercial production of biodiesel. The focus in this study has been mainly on oils like soyabean, rapeseed, sunflower, coconut oil and neem which are essentially edible in nature. Oilseeds were purchased locally from the market. In the present investigation biodiesel was prepared from various oilseeds by the following method:

Measured quantity of lye (Sodium hydroxide) and methanol were put in a conical flask containing glass beads for stirring. Sealed the flask and kept it on the magnetic stirrer for about half an hour till lye and methanol reacted well to form sodium methoxide. Meanwhile, took the measured amount of oil in the reactor and heated it to the reaction temperature. After the attainment of temperature, methoxide was mixed with the oil while stirring it. Sealed the reactor and allowed the reaction to take place for about two hours. Contents were taken out from the reactor through the drainage valve into a separating funnel and allowed it to settle overnight. Two layers were formed, one of glycerine (lower layer) and the other of methyl ester or biodiesel (upper layer). Drained the lower layer and washed the biodiesel with 10% acetic acid solution.

All samples were characterized following standard laboratory procedures. Each mixture was analyzed for specific gravity, viscosity, cloud point, pour point, flash point and heat value. These properties were measured according to ASTM methods. The values obtained for these properties were then compared to the European specifications (DIN – 14214).

Exhaust gas emissions were determined by employing an I.C engine, CO and HC meter. Fuel used consisted of B20 blend of SME with petroleum diesel. The engine was run on petroleum diesel and its CO and unburnt hydrocarbon emissions were recorded at full engine load. The same was repeated with B20 at full engine load.

**Results and discussion**

Initial run of rapeseed oil was carried out in a magnetic stirrer which was successful. The amount of rapeseed oil taken was 200 ml and the yield of biodiesel was 190 ml, which is quite high whereas yield of RME (Rapeseed Methyl Ester) on batch reactor was less than expected. The intermediate soap layer was predominating which may be due to excess of free fatty acids and traces of water in the oil. Kusdiana and Saka (2004) observed that water could pose a greater negative effect than presence of free fatty acids and hence the feedstock should be water free. Romano (1982), Canakci and Van Gerpen (1999) and Canakci (2007) observed that even a small amount of water (0.1%) in the transesterification reaction would decrease the ester conversion from vegetable oil. Demirbas (2006) too reported a decrease in yield of the alkyl ester due to presence of water and FFA as they cause soap formation, consume catalyst and hence reduce the effectiveness of the catalyst. Srivastava and Verma (2007) removed the moisture content from the vegetable oil by heating in oven. Another experiment was performed using rapeseed oil obtained from Raghuvar India Ltd., Jaipur. No biodiesel was obtained from this, may be due to highly impure oil. The same experiment was repeated with soybean oil in a batch reactor and the yield was 87% (Table 2).

Biodiesel was produced from coconut oil using transesterification process. After the contents were poured in the separating funnel, no biodiesel layer was observed. Total saponification reaction had occurred which may be due to excess free fatty acids or water content in the oil (Kusdiana and S. Saka, 2004).

Viscosity: It is a measure of a fluid’s resistance to flow. The greater the viscosity, the less readily the liquid flows. Viscosity of rapeseed oil was 24.1 cp whereas viscosity of RME was 4.56 cp. Similarly, viscosity of RME and GME were quite less than their respective oils. Albuquerque et al. (2009) also reported similar type of flow data for many oilseeds.

Specific gravity value of Soybean, Rapeseed and Groundnut oils and their respective methyl esters was 0.940, 0.983, 0.916 and 0.896, 0.910 and 0.870 respectively. The specific gravity of all the esters is comparable to that of diesel fuel (about 0.8). The specific gravity of the esters is also comparatively lesser than that of the corresponding oil as expected.

**Cloud Point** The cloud point is the temperature at which a cloud of wax crystals first appears in a fuel sample that is cooled under conditions described by ASTM D2500. Cloud points of SME, RME and GME were observed to be 0°C, 1°C and 5°C respectively. Thus the cloud points obtained for the three esters are within the specified limits (-3°C to 12°C) and comparable to that of petroleum diesel.

**Flash Point** (ASTM D93) The flash point is the lowest temperature at which a combustible mixture can be formed above the liquid fuel. It is dependent on both the lean flammability limit of the fuel as well as the vapour pressure.
Table 1: Standard values of properties of biodiesel

<table>
<thead>
<tr>
<th>Property</th>
<th>Limits</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash point</td>
<td>130 min.</td>
<td>Degree °C</td>
</tr>
<tr>
<td>Water and sediment</td>
<td>0.05 max.</td>
<td>% vol.</td>
</tr>
<tr>
<td>Kinematic viscosity</td>
<td>1.9-6.0</td>
<td>Mm²/sec</td>
</tr>
<tr>
<td>Sulfated ash</td>
<td>0.02 max.</td>
<td>% mass</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.05 max.</td>
<td>% mass</td>
</tr>
<tr>
<td>Cloud point</td>
<td>-3 to -12 °C</td>
<td>°C</td>
</tr>
<tr>
<td>Free glycerine</td>
<td>0.02 max.</td>
<td>% mass</td>
</tr>
<tr>
<td>Pour point</td>
<td>-15 to 16 °C</td>
<td>°C</td>
</tr>
</tbody>
</table>

Table 2: Yield of Biodiesel from Test oils

<table>
<thead>
<tr>
<th>Vegetable oil</th>
<th>Quantity of oil taken</th>
<th>Yield of biodiesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>soybean</td>
<td>500 gm.</td>
<td>430 ml.</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>500 gm.</td>
<td>215 ml.</td>
</tr>
<tr>
<td>Groundnut</td>
<td>500 gm.</td>
<td>425 ml.</td>
</tr>
<tr>
<td>Neem oil</td>
<td>200 ml. (magnetic stirrer)</td>
<td>Reaction products solidified</td>
</tr>
<tr>
<td>Coconut oil</td>
<td>500 gm.</td>
<td>Complete saponification occurred</td>
</tr>
</tbody>
</table>

Table 3: Properties of Biodiesel Prepared from Three different oils

<table>
<thead>
<tr>
<th>Property</th>
<th>RME</th>
<th>GME</th>
<th>SME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity</td>
<td>4.56 cp</td>
<td>3.33cp</td>
<td>3.15cp</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>0.91</td>
<td>0.870</td>
<td>0.896</td>
</tr>
<tr>
<td>Flash Point</td>
<td>-</td>
<td>222 °C</td>
<td>138 °C</td>
</tr>
<tr>
<td>Cloud point</td>
<td>1 °C</td>
<td>5 °C</td>
<td>0 °C</td>
</tr>
<tr>
<td>Pour point</td>
<td>-4 °C</td>
<td>-5 °C</td>
<td>-3 °C</td>
</tr>
<tr>
<td>Heat value</td>
<td>4.55 gm.</td>
<td>3.48 gm.</td>
<td>3.58 gm.</td>
</tr>
</tbody>
</table>

of the fuel constituents. The flash point is determined by heating a sample of the fuel in a stirred container and passing a flame over the surface of the liquid. Flash point of SME is 130 °C whereas GME has a value of 222 °C. The flash point of Petroleum diesel is 0 to 80 °C however, it is quite high in GME which may prohibit its use as an ideal biodiesel.

Pour Point is the lowest temperature at which movement of the fuel sample can be determined when the sample container is tilted. The apparatus used is the same as for the Cloud Point determination. The temperature where the sample stopped flowing for about 5 seconds was noted as its pour point. The pour points of all the three esters are within specified limits (-15 to 16 °C) and within range of petroleum diesel. Pour points of SME, RME, GME and petroleum diesel are respectively -3 °C, -4 °C, 5 °C and -35 to -15 °C.

Heat values of SME, RME, GME and petroleum diesel were found to be 4.55 gm, 3.584 gm., 3.48 gm and 2.55 gm respectively. Thus the heat values of all the three esters were more than that of petroleum diesel. Hence petroleum diesel exhibited highest calorific value among the four types of samples. B20 blend of SME and diesel was prepared and fed to an I.C. engine running at full load and the exhaust gas emissions were found to be less than petroleum diesel emissions.

To check the performance of rapeseed oil, the oil was obtained from the market (edible grade) and was used for the experiment in the batch reactor. This was successful however; the yield of biodiesel was less than expected. Some saponification might have occurred which formed the middle layer in the separating funnel. This may be because of excess of lye and free fatty acids. Similar experiments were carried out with coconut oil and groundnut oil. No biodiesel was obtained in the case of coconut oil due to the occurrence of total saponification. On the contrary, groundnut oil gave yields of GME as high as 85%. The properties exhibited by GME are quite expected and suitable to be a biodiesel. The reaction products got solidified in case of neem oil.

The amount of reactants taken for the synthesis of biodiesel was in excess (sodium hydroxide) so as to ensure complete conversion. Due to this reason, the biodiesel had to be washed so as to remove excess catalyst. Traces of water present in the oil along with excess of lye may have contributed to saponification. The experiments indicated that one can use waste cooking oil for synthesis of biodiesel. But the waste oil should be properly filtered and heated so as to remove impurities and water respectively. Removal of water is quite essential as it hinders esterification reaction and contributes to soap formation thus significantly affecting the
efficiency of the process. Even animal fats like tallow and lard can also be used for the synthesis. Lesser conversion may be because of the low agitator speed which was 150 rpm in our experiments whereas the recommended speed is as high as 500-600 rpm. On the basis of the analysis part of the biodiesel it can be concluded that among the three esters (SME, RME and GME), SME is the closest to a practical biodiesel as is evident from its properties. Though GME is quite suitable but it has a flash point of 222 °C which is much higher than the specified limits. Heat value of all the three esters was recorded to be less than petroleum diesel with the least being found in RME. As far as cloud and pour points are concerned, all the three esters can function quite well in cold weather, however, petroleum and diesel are still better in this context as compared to biodiesel. The viscosities of the all the three esters were found to be quite suitable to function in an I.C.engine and almost comparable to that of petroleum diesel.

Though petroleum diesel looks superior to biodiesel in some respects, yet biodiesel needs to be used as an alternative fuel to save fossil fuel, encourage renewable sources of energy due to lesser exhaust emissions thus environment friendly fuel. Even as per government policy 10% supplementation of biodiesel is permitted to petroleum diesel and it is going to increase.

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