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Production of Biodiesel from Different Edible Oils

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***Abstract*—**Different vegetable oil based biodiesel (FAMES) were prepared by alkaline transesterification using refined oils as well as waste frying oil (WFO). Methanol and sodium hydroxide are used as catalyst under similar reaction conditions. To ensure the quality of biodiesel produced, a series of different ASTM Standard tests were carried out. In this context, various testwere done including viscosity, carbon residue, specific gravity, corrosion test, flash point, cloud point and pour point. Results revealed that characteristics of biodiesel depend on the feedstock and it is far better than petroleum diesel.

***Keywords*—**Biodiesel, Edible oils, Separation.

I. Introduction

FUELS are particularly important in human life. Their application can be found in various fields including commercial, residential and industrial. About 80% of world's energy needs are fulfilled by fossil fuels. Liquid biofuels have a positive edge over petroleum fuels. Biofuels are not harmful for environment, abundantly available, sustainable, and more reliable. Biodiesel is a first-generation biofuel which can be made using a simple chemical process from fresh vegetable oil or waste vegetable oils. Biodiesel is amixture of mono alkyl esters with long chain free fatty acids having high performance with environmental benefits. The "Biodiesel" name was first conceived in the USA in 1992 from the National Biodiesel Board. Vegetable oil or animal fat based biodiesel has been suggested as a substitute of diesel in existing diesel engines without any modification mainly due to number of reasons such as availability, renewability, non-toxicity, biodegradability and having low emission [1].

Biodiesel usage as an alternative fuel accomplishes many advantages compared to petro-diesel fuels. Clean burning is a significant property that greatly reduces the pollutant concentration that is threat to the environment. Other properties include less harmful gas emissions, low particulate matter and unburned hydrocarbons and fuel having 10–11% of oxygen thus owing high combustion characteristics. Pure biodiesel, B100, has physical and chemical properties similar to petro-diesel fuels. Various types of feedstock can be a source of producing biodiesel [2]. These include:

- Virgin oil feedstock
  i. Edible: Soya bean, cottonseed, rapeseed, palm, peanut, sunflower, mustard safflower, coconut oil.
  ii. Non edible: Jatropha, pongamia, neem, rubber seed, mahua, silk cotton tree, camelina, jojoba, and castor oil.
- Animal fats e.g. tallow, yellow grease, lard, chicken fat.
- Waste oil e.g. used frying oil.
- Algae that can be produced from waste materials like sewage and the land used for production of various food items.

The commonly used procedure for making biodiesel is the trans-etherifying the vegetable oil or animal fats with alcohol and an alkali catalyst. Use of biofuels is not new; it was started in mid 1800's. In those days research was conducted to separate glycerin from oil using transesterification process. A successful attempt of producing an attempt to produce biodiesel from vegetable oils was made by Duffy and Patrick in 1853. In 1893, Rudolf Diesel attempted to use vegetable oils in a CI engine. He used peanut oil as a fuel. The engine worked on peanut oil without any modifications [3].

Later on, diesel engine manufacturers made certain modifications in the engines that only petro-diesel could be suitable and not the vegetable oil. The reason of unsuitability of vegetable oil was due to its higher viscosity. Having less cost, abundance and government subsidies made the fossil based diesel preferred over the vegetable oils. Despite these facts and the large worldwide usage of petro-diesel, production of biodiesel from vegetable oils using trans-esterification made progress with time. Due to certain problems faced in the direct application, the scientists of various countries continued to work on testing the vegetable oils for the purpose of being used as fuels [4].

G. Chavannein 1937 was successful in patenting his research by developing a suitable method for using the vegetable oils as fuels. In this patent, a process of alcoholysis (also called trans-esterification) of vegetable oils using ethanol was suggested to separate the fatty acids from the glycerol. This initiated the production of biodiesel. Expedito Parentein 1977 was successful to patent a process having industrial application for the production of biodiesel using trans-esterification. Further research was taken up by South African Agricultural Engineers to use sunflower oil after the trans-esterification and refining as diesel fuel. Based on this research, Gaskoks (an Austrian company) in 1989 installed the first industrial scale biodiesel plant having a capacity of 30,000 tons of rapeseed oil per year [5], [6]. Later on, a number of biodiesel plants were installed in Europe and other regions of the world. Now, Europe and America have a significant number of fuel stations with biodiesel blends. In recent years, many local governments have initiated different programs to use biodiesel blends. Considerable efforts have been done for the development of vegetable oil derivatives having properties and performance similar to diesel fuels

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based on hydrocarbons. Primary routes for preparing biodiesel from fats and oils are:

- Blending with petro-diesel
- Micro emulsification (co solvent blending)
- Thermal cracking (pyrolysis)
- Transesterification (alcoholysis)

Transesterification reaction involves the transformation of form of ester into another form. When methanol is used for the production of biodiesel, the resulting products are known as fatty acid methyl esters (FAME). The method could be called as methanolysis [7], [8].

II. Materials and Methods

5 edible oil samples were collected from different stores in packed and refined form. 6th waste frying oil (WFO) sample was obtained by frying the chicken at home. Methanol, sodium hydroxide and distilled water were obtained from laboratory. The solvents used were of a grade.

A. Pre-Treatment of Samples

All oil samples were filtered twice using cotton bandage obtained from local medical store to remove solid suspended or un-dissolved particles and inorganic residues especially in case of WFO. The determination of free fatty acid contents in oils was done using titrimetry method. Heating was conducted to remove any water content. Oil may contain probably water, which can slow down the reaction and enhance saponification (soap formation) reaction. For a successful reaction the oil samples were gradually heated above 100^{o}C for the removal of water and other impurities.

B. Transesterification Procedure

250 ml of oil was taken in a flask with rounded bottom having a reflux condenser, magnetic stirrer along with thermometer. NaOH was mixed with into methanol to obtain a homogenous mixture. This mixture was added into preheated oil sample (at about 65^{o}C) and the transesterification reaction began. The mixture was blended about 90 minutes, keeping the temperature about 65^{o}C (below methanol boiling point) using hot plate.

C. Biodiesel and Glycerol Separation and Purification

After the expiry of reaction time, the solution was shifted to a separating funnel to allow the solution for phase separation and cool over-night by gravity, then carefully decanted the glycerin to perform satisfactory separation. Washing of biodiesel was done with the water at 50^{o}C. The clean biodiesel was obtained by draining the water containing soap at the bottom of separating funnel. The washed methyl esters phase (biodiesel) was reheated slowly to about 70^{o}C to remove water after washing.

D. Analyses and Product Characterization

All the experiments were carried out under the same reaction conditions so as to compare the results with the different feed stocks. For the determination of the characteristics of biodiesel produced according to the standard of ASTM D6751, a series of tests were performed on all samples of biodiesel.

III. Results and Discussions

No results obtained for sample 4 because the final product was semi-solid gel. Coconut oil contains the highest saturated fatty acids in comparison to other sample oils so it needs more quantity of methanol and high reaction temperature. Additional 30 minutes were given with higher rpm but no significant change has been observed.

A. Yield (%)

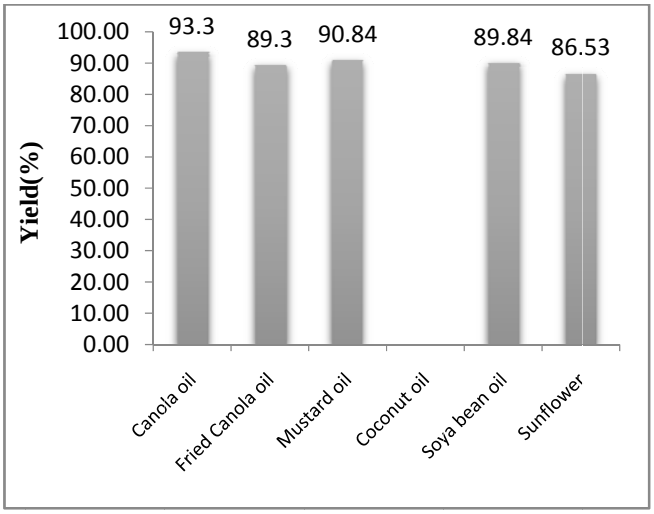

Fig. 1 % yield of different biodiesel sample

Percentage yield varied within a range of 86–94% for all 6 biodiesel types (Fig. 1). Sunflower and fried Canola oil-derived FAMES have the lowest % yield among the 6 samples. Results also showed that yield from WFO is almost similar to refined oils derived FAMES.

B. Specific Gravity

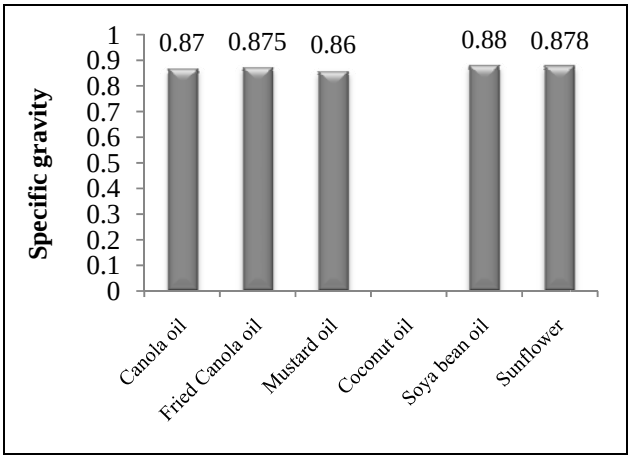

Fig. 2 Specific gravity of different biodiesel samples

The variation in specific gravity has been observed lying in a range of 0.860–0.880 for all sixtypes of biodiesel (Fig. 2).

FAME obtained from Mustard oil shows the lowest value of specific gravity of 0.86. The density specification according to EN 14214 standard is 860–900 kg/m^3.Therefore, the use of density and specific gravity is done interchangeably in this paper. It has been observed that biodiesel produced from all six types of the feedstocks meet this specification.

C. Flash Point

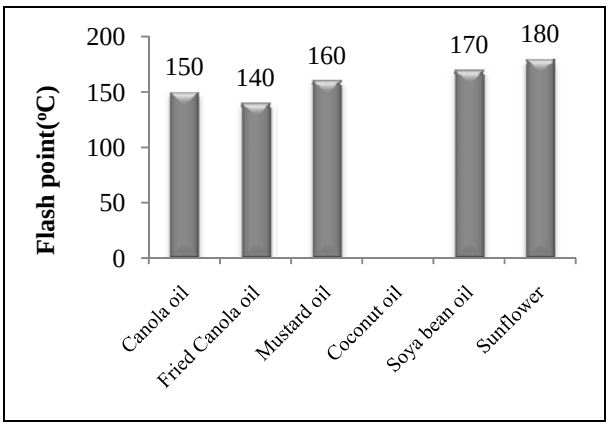

Fig. 3 Flash point of different biodiesel samples

The flash point values for all sixtypes of biodiesel lie well above the minimum specifications defined in ASTM D 6751 (Fig. 3).

Flash point is the indication of the fact that FAME has been significantly cleaned by removing excess of methanol. Small traces of residual methanol in FAME could be a reason of depressed flash point.

D. Cloud Point

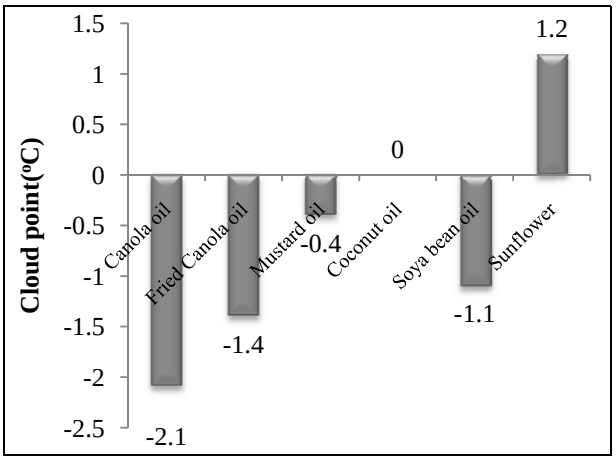

Fig. 4 Cloud point of different biodiesel samples

The cloud point values for all sixtypes of biodiesel lie within the specifications defined in ASTM D6751 (Fig. 4). Sunflower-derived FAME has poor cloud point value among the all.

Cloud point is a cold flow property of biodiesel because it affects the low temperature performance. It shows the lowest temperature for fuel to be used. Low temperature behavior is attributed to plugging of filter and engine starving because of wax formation and decreased flow of fuel. Therefore, the fuel provider has to mention cloud point to show its cold flow behavior.

E. Pour Point

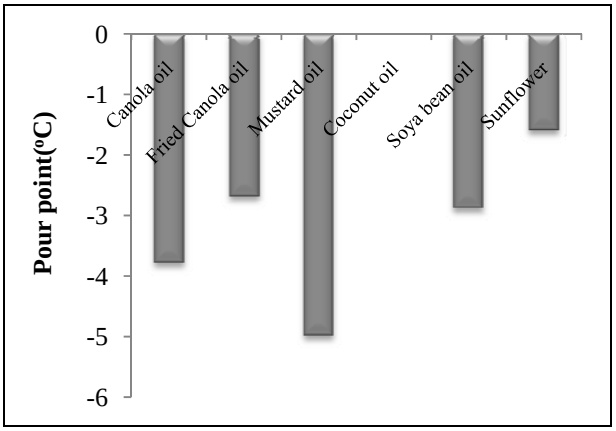

Fig. 5 Pour point of different biodiesel samples

The pour point values for all sixtypes of biodiesel lie within the specifications defined in ASTM D6751 (Fig. 5). It indicates the lowest temperature where the fuel ceases to flow. Sunflower-derived FAME has poor pour point value among the all.

Generally, the longer carbon chain FAMES have poorer low temperature performance. Saturated methyl esters are longer chain than C12 and therefore, the main cause of increasing the values of cloud and pour point, even after blending with conventional diesel.

F. Corrosion

Corrosion test of the samples was conducted by ASTM D130. No color change of copper strip indicated that all FAME samples were non-corrosive.

G. Carbon Residue

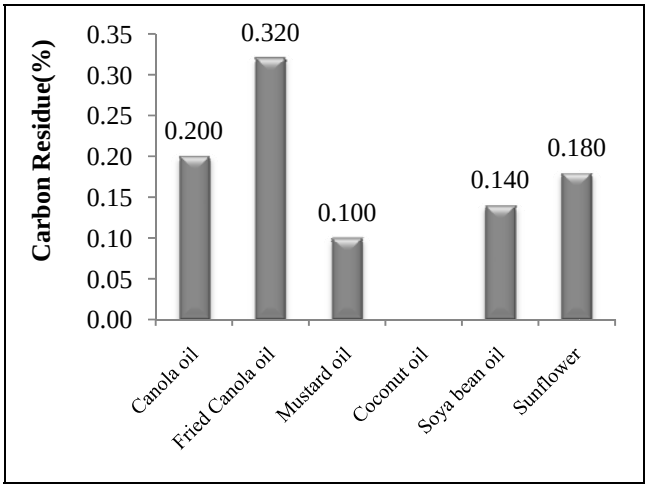

Fig. 6 Carbon residue of different biodiesel samples

Carbon depositing tendencies of a fuel oil is measured by the carbon residue (Fig. 6). The most common cause of carbon residue, when using biodiesel is a high level of glycerin.

H. Kinematic Viscosity

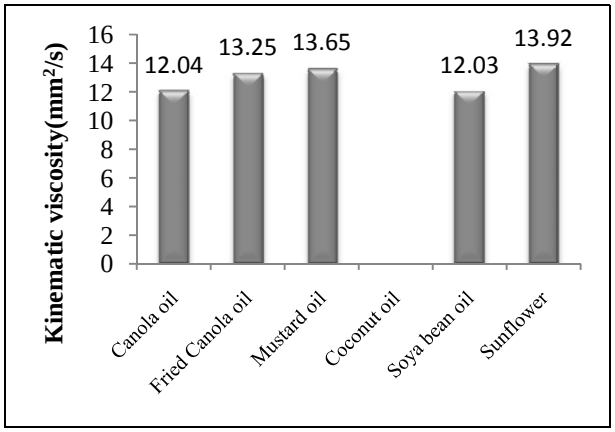

Fig. 7 Kinematic viscosity of different biodiesel samples at room temperature (32^0C)

The kinematic viscosity data show that all sixtypes of biodiesel lie within a range of 12-14 centistokes (Fig. 7). Viscosity of many biodiesel fuels is found to be greater than the petro-diesel.

IV. Conclusion

Fossil fuel has become a promising area for many researchers to explore the alternative fuels and biodiesel is one of them. It can be a potential source of fuel for existing diesel engines with no or little modification. Different methods are available for biodiesel production. The process of alkaline catalyzed trans-esterification is found to be the most effective for the conversion of triglycerides into esters having low free fatty acid level. Experimental results showed that properties of fuel produced are dependent on feedstock used. Fuel characteristics of biodiesel obtained using cooking oil are found to be in matching the biodiesel standards. The positive performance of biodiesel is because of high values of cetane number, fuel lubricity and oxygen concentration. However, the biodiesel is not yet to be found economical and therefore further research and technological development is required.

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