THE VISCOMETRIC ANALYSIS OF BIODIESEL FROM MUSTARD AND COCONUT OILS

Olamide A. Oshodi,[a] Chikaodili E. Chukwuneke[a] and Okoro Linus[a]

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In this research, we report biodiesel production and viscometric analysis from mustard oil and coconut oil, by subjecting the oil to a temperature of 65 ^{o}C through base catalyzed transesterification with the use of KOH as a catalyst. The biodiesel synthesized from mustard oil was blended with petroleum diesel in the following percentage by volume 20 %, 40 %, 50 %, 70 % and 80 % corresponding to B20, B40, B50, B70 and B80, respectively. The fatty acid methyl ester of mustard oil was mixed with that of coconut oil in the ratio of 80:20, 60:40 and 50:50 respectively. Viscometric analysis was carried out and the results obtained.

* Corresponding Authors
E-Mail: linus.okoro@aun.edu.ng
[a] American University of Nigeria, Department of Petroleum Chemistry and Engineering, School of Arts and Sciences, P.M.B 2250 Yola, Adamawa State, Nigeria.

Introduction

Biodiesel is a common biofuel that is widely used in Europe and Asia. It is produced from crops such as grape, sunflower and soya and can be blended with fossil diesel in any proportion which is compatible with most diesel engines. In 2004, biodiesel production accounted for 1.2 % of total diesel fuel consumption in Europe.[1] Biodiesel has numerous benefits ranging from their low carbon emission to little or no sulfur content. This advantage eliminates the possibility of acid-rain produced as a result of sulphur oxides in the atmosphere[2]. It is a renewable, locally-produced fuel which also reduces emissions of unburned hydrocarbons, carbon monoxides, particulate matter, sulfur compounds as well as carbon dioxide.[1] Another benefit of biodiesel is its compatibility with diesel engines as opposed to other energy sources such as natural gas, having radically dissimilar ignition properties.[2] Production of biodiesel is less energy intensive than ethanol (another commonly used biofuel from corn) due to the absence of fermentation and distillation processes used in the latter. In addition, biodiesel enhances greasiness of diesel fuel, and has good lubricity properties.[3] According to Knothe, the removal of sulfur in the refining process of conventional diesel, reduces its lubricity but biodiesel is blended with it, the lubricity property is restored.[2]

Petroleum diesel and biodiesel share some similar physico-chemical properties as well as some distinct differences. Petroleum diesel has a flash point that is well below half the value for biodiesel as well as a kinematic viscosity that is less than half of the value of biodiesel. However, both forms of diesel have similar cetane number, heating values and relative densities. The energy content of biodiesel has been found to be slightly lower than petroleum diesel. However, it does not affect performance or mileage in any way when used in the same engines.[3] Generally, studies have shown that biodiesel burns more completely than conventional diesel and leaves less residue in the engine than untreated oil.[2] Biodiesel alone cannot substitute regular diesel oil; as the world's supply of vegetable oil can only replace a small proportion of the normal energy market.[2]

Biodiesel blends of B5 (signifies the ratio rating, where 5 imply that the composition is 5 % biodiesel[4]) are generally recommended in diesel engines. Studies are yet to prove the absence of performance issues with blends above B5 and on storage of biodiesel as it degrades faster than normal diesel and yields to possible biological growth.[3] Furthermore, biodiesel also has been found to emit more nitrogen oxide than petroleum diesel when burned in an engine.[2]

The transesterification process is majorly used to synthesize biodiesel. This process has been used since the mid-19th century to separate glycerin from oil and to reduce the viscosity of vegetable oil used in diesel engines.[4] In the transesterification process, a triglyceride ester is reacted with an alcohol to produce another ester and alcohol. When the triglycerides are reacted with methanol, the resulting product is a methyl ester.[5]

The mustard oil can be extracted from the yellow mustard plant, *Sinapis Alba*.[6,7] The fatty acid components in triacylglycerols of mustard oil are: 4 *wt.* % Palmitic acid (16:0), 22 *wt.*% of oleic acid (18:1), 24 *wt.* % linoleic acid (18:2), 14 *wt.%* linolenic acid (18:3), 12 *wt.* % gadoleic acid (20:1) and 20 *wt.%* erucic acid.[3]

The viscosity of a substance is referred to as the opposition to the flow of a liquid due to the frictional force that exists between layers of liquid moving over each other.[8] The higher the viscosity of a fuel, the greater is the likelihood of it causing problems in the engine. Generally, the viscosity of a particular biodiesel is far less than the oil from which it was obtained.[9] The fatty acid content of a particular biodiesel usually determines its viscosity and it is the process of transesterification that reduces this viscosity. High viscosity is the main reason why oils are not used directly in the engines as alternative fuel. It is usually due to the number of carbon atoms and usually increases with high degree of saturation.[8]

Biodiesel can be blended in any ratio or proportion with petroleum diesel. The commonly used standard for denoting biodiesel ratio is the "B" factor, where 100 % biodiesel is referred to as B100 and 2 % biodiesel is referred to as B2. Research shows that CO_2 emissions are drastically reduced by 78 % in olive and cashew nut blends compared to regular diesel.[10] The emission rate is proportional to the level of blending where B5 blends will lower emissions proportionally not as low as a B100 blend. Generally, the increase in the B-ratio indicated the level of eco-friendliness of the fuel.[10]

Materials and Methods

Potassium hydroxide (analytical grade manufactured by Acros chemicals), Methanol (analytical grade manufactured by Fluka chemicals), Petro diesel (ConOil Plc), Bomb Calorimeter (Cal2k-3), Viscometer (Rheotek TCB-7), 100 % Pure Mustard Oil , 100% Pure Coconut Oil manufactured by KTC Edibles Ltd, Wednesbury**,** West Midlands **,** United Kingdom.

Synthesis of biodiesel from mustard and coconut oil

50 ml (43.74 g) of oil was measured and poured into an Erlenmeyer flask and preheated to 65 ºC with a magnetic stirrer. Potassium hydroxide (0.788 g) was measured and mixed thoroughly with 12.5 ml of methanol in another Erlenmeyer flask until all the Potassium hydroxide dissolved to form a homogenous mixture. The homogenous mixture provides the basis for a potassium methoxide solution which is now poured into the preheated mustard oil. The stirring was maintained at 300 rpm at 65 ºC for 120 min. After refluxing, the mixture was left overnight to separate in a separating funnel to remove excess glycerol. The transesterification process was monitored by IR spectroscopy.[13] The yields from mustard oil or coconut oil were found to be 96.56 and 94.66 %, respectively.

Measurement of viscosity

15 ml of each of the biodiesel oil samples blended was measured in to a viscometer. The viscosity was measured over specified temperature range of between 30 °C and 50 °C. The viscosity test determines the kinematic viscosity of the sample by measuring the time taken for the liquid to move under the influence of gravity through a calibrated glass viscometer. Kinematic viscosity was determined using a PSL (Poulten selfe & Lee Ltd., Essex. England) glass capillary viscometer placed in a Rheotek TCB-7 Viscometer bath observed from 30-50 °C. Using a calibration constant of 3.0, the time taken was multiplied by the constant to a unit of $mm^2 s^{-1}$.

Results and discussion

The high biodiesel yields found for both type of feedstock oil (~95-96%) could be attributed to the highly pure feedstock oils and long reaction time used in the reaction. The standard time used in comparable reactions is usually 90 min but in this work, the reflux time was 120 min. Table 1 summarizes the kinematic viscosity values of mustard biodiesel, coconut biodiesel, petro-diesel and their mixtures. From the results obtained, it can be readily inferred that viscosity decreases as temperature increases.

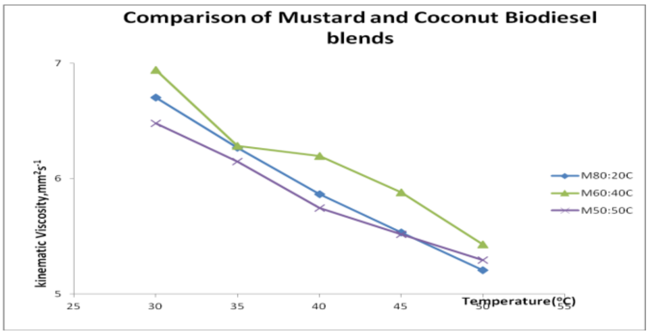

Figure 1. Viscosity of blends of mustard and coconut oil biodiesel

This is illustrated in Figure 1. The variation in viscosity between pure vegetable oil and the blends of the transesterified oil is depicted in Figure 1 and it shows that the transesterification process was effective in removing the glycerol, which is a problem in engines because of its high viscosity. In addition, blending the biodiesel of the mustard and coconut did not show any significant difference in their viscosity values (Figure 1). This implies that the biodiesel produced from the two different feedstocks have virtually the same viscosity and irrespective of the ratio of blending for both biodiesel, the viscostiy values with temperature showed no variation as depicted in figure 2. As a result of higher viscosity of biodiesel as compared to petrodiesel as shown in Figure 3, it is blended with petrodiesel in order to reduce its viscosity.

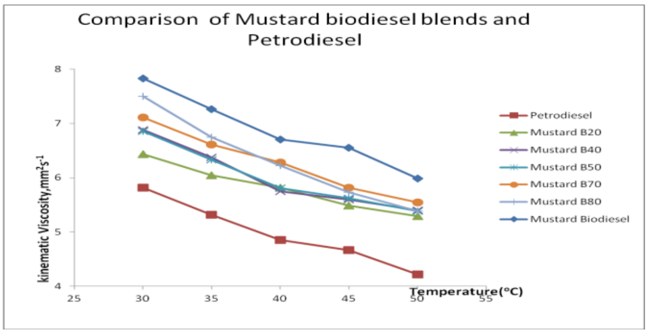

Figure 2. Viscosity of pure mustard and coconut oil compard with their biodiesel blends

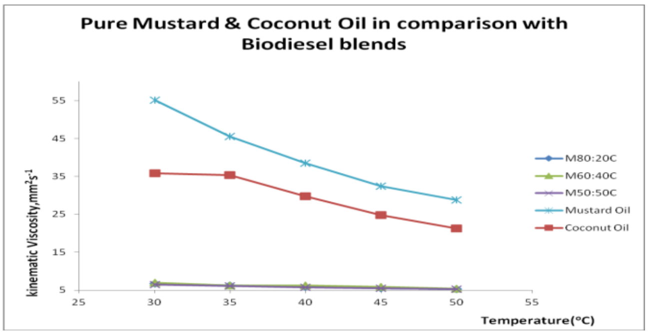

Figure 3. This shows the comparison between the viscosities of mustard biodiesel its blends and petro diesel at different temperature.

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Table 1. Kinematic viscosity values in $mm^2 s^{-1}$ between 30 and 50 °C

Temp., °C	**Mustard oil**	**Coconut oil**	**Mustard biodiesel**	**Coconut biodiesel**	**Petro-diesel**	**Mustard:coconut biodiesel**		
						80:20	**60:40**	**50:50**
30	55.170	35.820	7.830	5.565	5.82	6.705	6.945	6.480
35	45.510	35.340	7.260	5.565	5.32	6.270	6.285	6.150
40	38.490	29.715	6.705	5.565	4.85	5.865	6.195	5.745
45	32.475	24.795	6.555	5.295	4.67	5.535	5.880	5.520
50	28.770	21.330	5.985	4.125	4.22	5.205	5.430	5.295

The blend ratio from B20 to B80 as shown in Figure 3, reveals that the higher the biodiesel in the blends, the higher the viscosity. By blending biodiesel and petroleum diesel in different proportions, one can monitor and regulate biodiesel production for use in a wide range of machinery. By blending as well mustard oil with lower viscous biodiesels, it is possible to achieve suitable fuel for many purposes (see Figure 3).

Conclusion

Biodiesel was synthesized from mustard and coconut oil by the process of transesterification which reduces the viscosity of oil from which the biodiesel was obtained. Petroleum diesel was blended the produced biodiesel to reduce the viscosity of pure biodiesel to acceptable standards, suitable for use in diesel engines.

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