International Journal of Applied Science-Research and Review www.ijas.org.uk

Original Article

Coconut and Neem Biodiesel as an Alternative to Fossil Diesel for Blending

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ARTICLE INFO

Received 25 June 2014
Received in revised form 05 July 2014
Accepted 20 July 2014

***Keywords*:**
Coconut,
Neem,
Biodiesel,
Transesterification,
Blending,
Fuel properties.

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ABSTRACT

This work studied the feasibility of blending two biodiesels made from coconut (*Cocos nucifera*) and neem seed (*Azadirachta indica juss*) oils without the need for diesel for blending. A comparative study on the physicochemical properties of the blend was done. Oils were transesterified before blending. For neem biodiesel, the values for these parameters were density, 900.3 kg/mm³, viscosity, 15.631 mm²/s, acid value, 2.198 and % free fatty acid (FFA), 1.099 and 876 kg/mm³, 3.0 mm²/s, 0.374 and 0.187 respectively for coconut biodiesel. Upon blending the fuel properties were significantly modified and conformed to standard specifications. Fossil diesel was used as a control. The density, flash point, sulphur content, viscosity and cetane number for blend were 897.3 kg/mm³, 171°C, 0.1168°C, 10.56mm²/s and 39.6respectively. Blending of coconut-neem biodiesels without using diesel produced desirable fuel properties.

INTRODUCTION

Neem oil is non-edible, generally light to dark brown in colour. It has a rather strong odour that combines the odours of peanut and garlic. It contains large amounts of triterpenoid compounds, responsible for its bitter taste. Coconut oil, on the other hand, is colourless or yellowish in colour and has a pleasant taste and smell. The fatty acids content of these oils are described elsewhere[1].

Biodiesel is alkyl esters of fatty acids produced by the transesterification of vegetable oils[2]. It is an environmentally friendly liquid fuel similar to diesel in terms of combustion properties[3].

Increasing environmental concern, diminishing petroleum reserves and the agro-based economy of Ghana, are the driving forces which promote biodiesel as an alternate fuel[4]. With agricultural commodity prices approaching records lower than petroleum prices, biodiesels produced from domestic surpluses of vegetable oils and non-edible vegetable oils have become a lucrative fuel source[5]. Increased utilization of renewable biofuels can result in immeasurable microeconomic benefits for both the industrial and agricultural sectors. Also, biodiesels obtained from vegetable sources have low sulphur content, aromatic hydrocarbons and metals. They are oxygenated fuels which emit lesser amounts of soot and carbon monoxide, cause less air pollution[6].

The aim of the study was to prepare a biodiesel from neem seed and coconut oils by transesterification, blend and compare their fuel properties with those of fossil diesel (control).

MATERIALS AND METHODS

Materials

Neem seeds were obtained from Oyarifa and Kwaema-Danfa in the Eastern Region of Ghana. Coconut fruits (copra) were purchased from the Madina Market in Accra, Ghana. Oils from the neem seeds and copra were extracted using a mechanical expeller (Botanical gardens, KNUST). Samples were authenticated and kept in KNUST herbarium.

The titration process

One g of neem oil was added to 10 ml of methanol and titrated against 0.025M KOH, using phenolphthalein as indicator. The same was done for coconut oil. The average titre value was used to calculate the acid value using the formula; Acid value = 56.1×N×V/M, where V is the volume of KOH (ml), N is the normality of KOH and M is the mass (in g) of sample. Generally, FFA value is half of the acid value[5].

The transesterification process

The two-step transesterification process was adopted[7]. Thirty ml of H_3PO_4 was added to 650 ml neem oil, heated for 30 minutes whiles stirring continuously with a magnetic stirrer; the acid pretreatment process. KOH6.32 g was dissolved in 200 ml of CH_3OH to prepare the $KOCH_3$ which was added to the oil mixture, heated for two hrs and stirred continuously - the base catalyzed step. Due to the very low % FFA value of coconut oil, a direct base catalyzed transesterification process was used. NaOH 4.32 g was dissolved in 200 ml of methanol to prepare the Sodium methoxide which was added to 550 ml of coconut oil, heated for 2 hrs and stirred. The solution was left to stand for 8 hrs after which it separated into biodiesel on top and glycerin at the bottom (plate 1). The biodiesel portion was decanted, washed with distilled water using a separating funnel. The biodiesel was then heated at 100°C for any excess water to evaporate. The yield of methyl ester (Biodiesel) produced was calculated using the formula:

Yield= (Weight of methyl ester produced, W1) / (Weight of oil used in reaction, W_2) × 100%[7].

Physicochemical properties

A Pensky-Martens closed tester was used to determine the flash point whiles the density was determined with a hydrometer. Flash Point, Viscosity and Cetane Number were determined by standard methods. HORIBA sulfur-in-oil analyzer SLFA-2100 was used to measure sulfur contents.

RESULTS AND DISCUSSION

From the graph (Fig. 1), it was observed that crude neem oil had a viscosity of 40 mm²/s at 40°C lower than 37.42 mm²/s obtained[8] which reduced to 15.631 mm²/s after transesterification. That of coconut oil also decreased from 10.7 to 3.0 mm²/s (Fig. 1). The viscosity of coconut oil before transesterification (10.7 mm²/s) was higher than that of diesel 6.5 mm²/s (Fig. 1). This is consistent with works carried out on vegetable oils[9,10] The viscosity after transesterification for coconut biodiesel 3.0 mm²/s was close to 2.83 mm²/s[11]. Viscosity (3.0 mm²/s) was within the acceptable range (1.6 – 6.5mm²/s) but that of neem biodiesel (15.631 mm²/s) was extremely high and outside this range. This may be due to incomplete transesterification of neem oil because of its high % FFA[12]. Therefore using this neem biodiesel alone in diesel engines could cause poor atomization of the fuel upon injection into the cylinder, deposit formation, clogging of fuel pumps and carbon build up[13].

For any biodiesel production to have a good yield, the acid value and the % FFA must be considered. A very high acid value leads to poor yield and an increase in cost of production[8]. Crude neem oil had an exceptionally high acid value of 31.836 and % FFA of 15.918 (Fig. 2). These values were much lower than 52 and 26 respectively[8]. Acid value of coconut oil was 0.607 and % FFA was 0.304 (Fig. 2). This resulted in coconut oil having a higher yield (90.91%) than neem oil (84.615%). Factors that may have affected the yield include fluctuations in temperature, reaction time, impurities in the catalyst used, some un-reacted alcohol, residual catalyst and emulsion removed during the washing stage of the production process[14].

After blending of coconut and neem biodiesels in the proportion 50:50, the characteristics of the blend improved compared to those of neem biodiesel alone. The density for this blend was 897.3 kg/mm³ (Fig. 4) and viscosity at 37.7°C was 10.56 mm²/s. Though these values were outside the standard range, they were better than the values of neem biodiesel before the blend. Thus, it can be inferred that the density and viscosity values were influenced favourably after the blend.

The flash point of the coconut-neem biodiesel blend (171°C) was higher than that for diesel (55°C) (Fig. 4). The flash point is usually used in testing the overall flammability hazard of the fuel. It is given as the lowest temperature at which application of a test flame can cause a sample to burn. It might therefore be inferred that the coconut-neem biodiesel is not hazardous in terms of flammability as it could only burn at a high temperature of 171°C[5].

The cetane number for the coconut-neem biodiesel blend (39.6) was lower than that of diesel (42) (Fig. 4). Cetane number for coconut biodiesel is 51[11] and that of neem biodiesel is 48[5]. However, blending coconut and neem biodiesel resulted in a decrease. Factors that may have affected this include the quality of the biodiesel and the methanol used for the transesterification process[15]. The cetane number measures the fuel's ignition delay and hence a low cetane number would result in an increase in the delay of the fuel's ignition[9].

The sulphur content for the diesel fuel was 0.5 and that for the coconut- neem blend was 0.1168 ± 0.00079 (Fig. 5). These results were in agreement with reports[6,16,2,3]. The lower the sulphur content, the lower the fuel emissions in the environment.

P-value for cetane number, density and sulphur were 0.707, 0.135 and 0.175 respectively. These values showed that the variation between the biodiesel and diesel is insignificant. This means that using the biodiesel may run in diesel engines without problems. In terms of viscosity p-value was 0.010 meaning there is significance difference between the biodiesel and diesel. This may be corrected by blending in different proportions in order to achieve desirable results or blending with solvents like alcohol or kerosene[17].

CONCLUSION

Coconut-neem biodiesel blend was found to have better fuel properties than neem biodiesel. The fuel properties of the biodiesel include density (897.3 kg/mm³), viscosity (10.56 mm²/s), flash point (171°C), Sulphur content (0.1168), and cetane number (39.6). Even though fuel properties of neem biodiesel were not very good, addition of coconut biodiesel changed the properties significantly. This project has shown that it is possible to blend two biodiesels to get desirable fuel properties instead of the usual practice of blending fossil diesel with a biodiesel.

ACKNOWLEDGEMENT

We are forever grateful to the staff of Tema Oil Refinery, Ghana for their assistance and allowing us to do this work in their Labs.

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Plate 1. Separation of glycerin from coconut biodiesel

Legend: Coconut biodiesel layer on top with glycerin at the bottom.

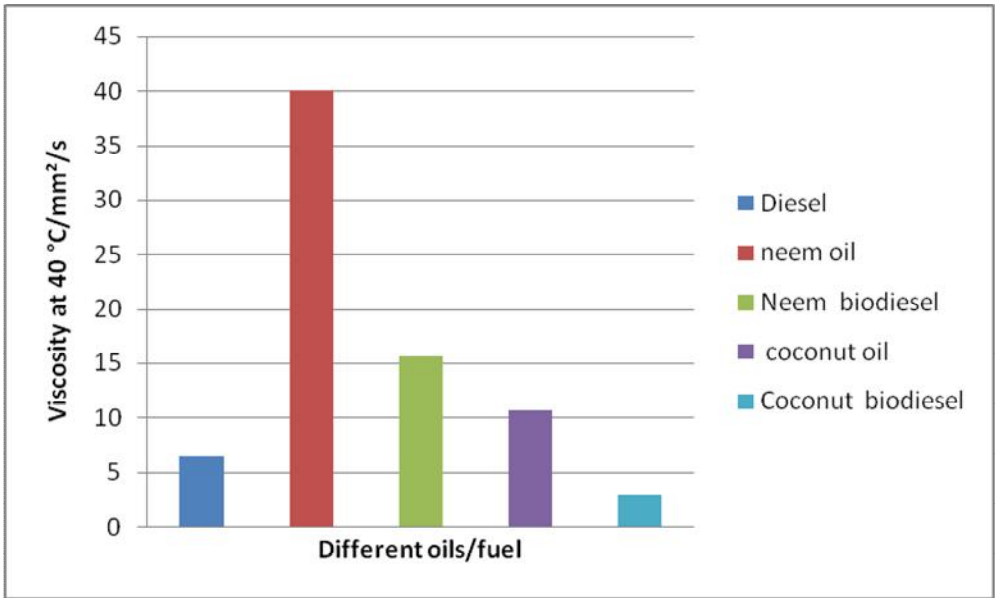

Figure 1. Viscosity of neem and coconut oils and their biodiesels compared with that of diesel at 40 °C/mm²/s

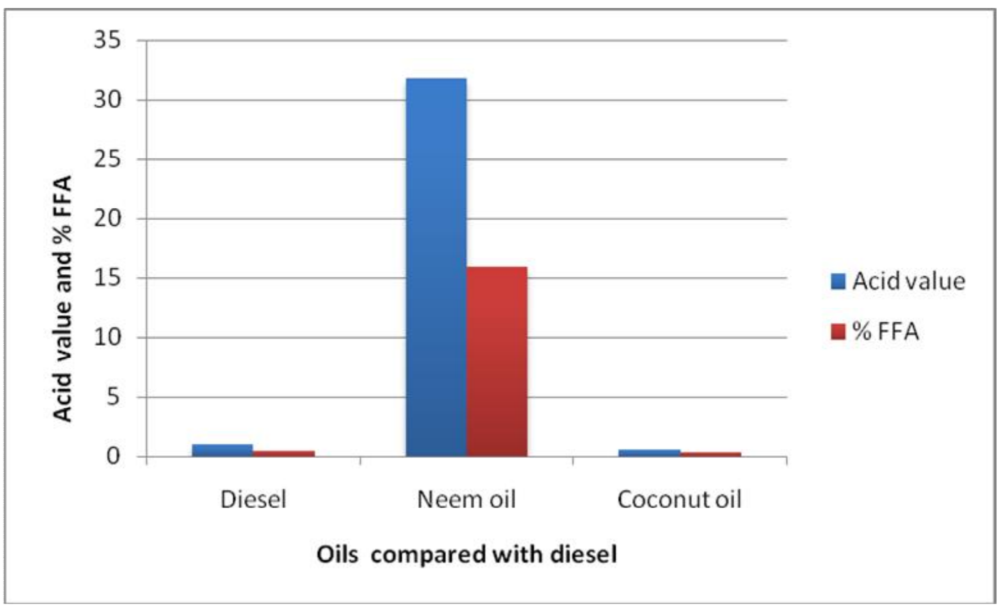

Figure 2. Acid value and % FFA of neem and coconut oils compared with those of diesel

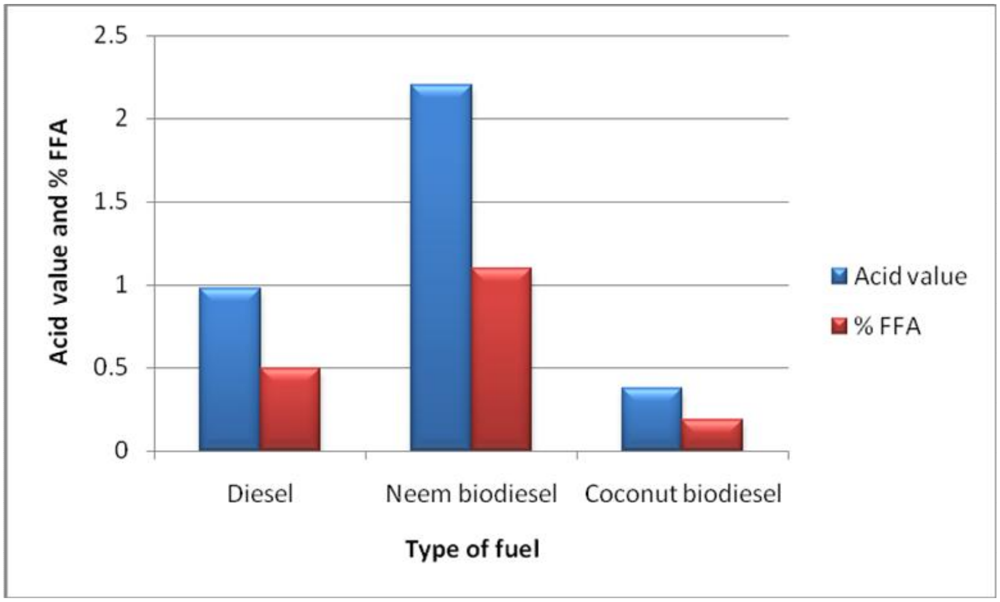

Figure 3. Acid value and % FFA of neem and coconut biodiesels compared with those of diesel

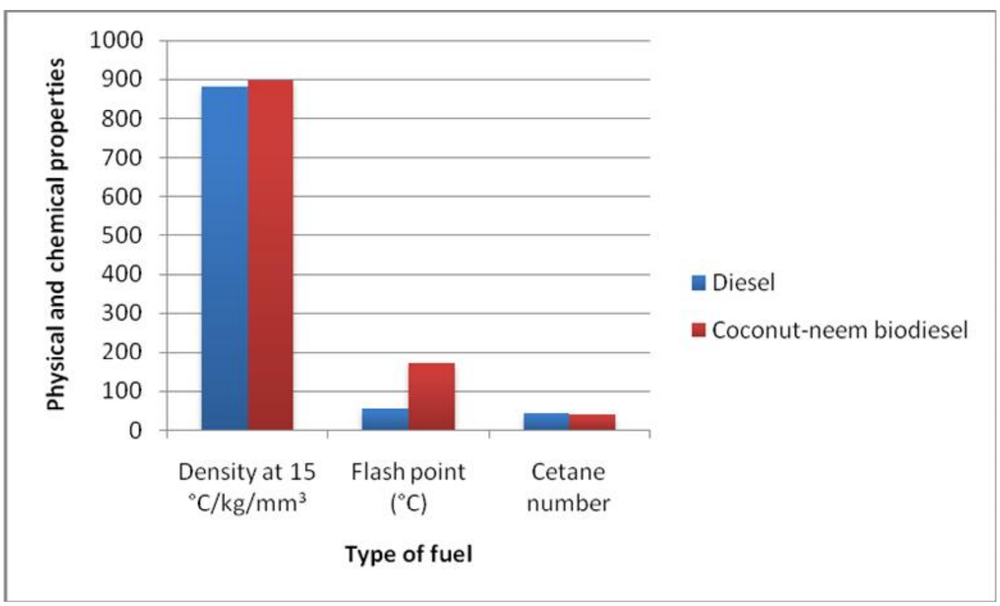

Figure 4. Density, flash point and cetane number of coconut-neem biodiesel compared with those of diesel

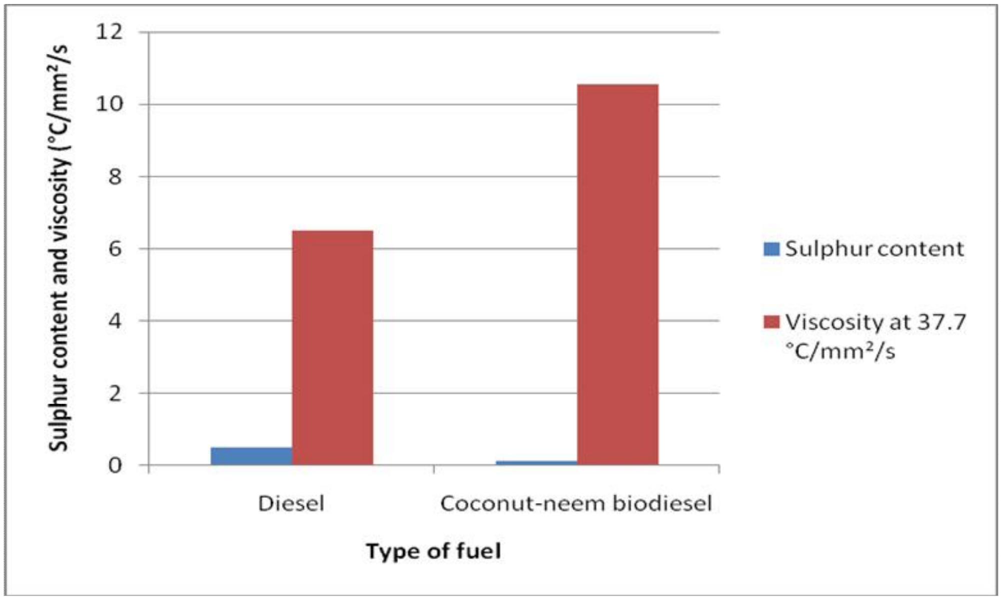

Figure 5. Sulphur content and viscosity of coconut-neem biodiesel compared with those of diesel