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Binary blends of petrodiesel with biodiesels derived from soyabean and groundnut oils

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ABSTRACT

This work involves a study of the effect of blending of commercially available petrodiesel with biodiesels derived from NaOH-catalyzed homogeneous transesterification of methanol with groundnut and soybean oils, respectively. Some basic properties (density, kinematic viscosity, flash point and heating value) of the purchased petrodiesel, pure groundnut and soybean biodiesels, as well as formulated blends of the biodiesels with petrodiesel were measured using standard literature procedures. The density, kinematic viscosity and flash point of petrodiesel/biodiesel blends increases with increase in the concentration of biodiesels in the blends. Blending is more important for the improvement of the quality of groundnut oil biodiesel than for soybean oil biodiesel. The heating value of petrodiesel/biodiesel blends increases with decrease in the blend levels.

Keywords: Biodiesel, Blend, Groundnut, Soybean, transesterification.

INTRODUCTION

The development of biofuels is mainly triggered by the increasing energy demand and pollution problems caused by the use of fossil fuels. Biodiesel is an environmentally benign alternative to petrodiesel that can be made from renewable biomass feedstock such as animal fats and vegetable oils. Combustion of biodiesel is more complete and produces fewer harmful emissions than petrodiesel. Replacing of petrodiesel with biodiesel will significantly reduce emissions of CO, CO_2, particulate matter, SO_x, volatile organic compounds, and unburned hydrocarbons into the environment. Furthermore, biodiesel is biodegradable and possesses better lubricity than petrodiesel. Biodiesels are usually produced via catalytic transesterification reaction of oils and/or fats with short chain alcohol such as methanol and ethanol [1-3].

Despite the many advantages of biodiesel over petrodiesel, there are several problems associated with the development and application of biodiesel [4-6]. Biodiesel is currently more expensive than petrodiesel. Also, biodiesel produces more nitrogen oxides emissions than petrodiesel. Compared to petrodiesel, biodiesel generally has higher density, viscosity, cloud point and cetane number, and lower volatility and heating value. Pure biodiesel doesn't flow well at low temperatures; hence it is generally less suitable for use under conditions of low temperatures. Furthermore, biodiesel can dissolve any deposits in the filters and in the delivery systems of diesel engines leading to clogging of fuel lines and filters. The energy content per gallon of biodiesel is about 11% lower than that of petrodiesel [4-7].

The oil yield of groundnut and soybean are 1170l biodiesel/ha and 475l for soybean oil, respectively [8]. Soybean oil is one of the major raw materials for biodiesel production. It is the major biodiesel feedstock in the United States of America [9]. The iodine index of pure soybean oil biodiesel is higher than the limit set by the European specifications for biodiesel (DIN – 14214) [10]. The oxidation stability of pure soybean oil biodiesel is poor.

Groundnut oil is another potential raw material for producing biodiesel. It has been reported that the physicochemical properties of groundnut oil biodiesel closely resemble those of petrodiesel [11].

Biodiesel is completely miscible with petrodiesel in any proportion. Blending of biodiesel with petrodiesel permits improvement in the physicochemical properties of the resultant blend [10]. The goal of the present work is to investigate the effect of the biodiesel concentration in binary blends of petrodiesel with soybean and groundnut biodiesels, respectively, on the properties of the blends (B20, B40, B60 and B80).

MATERIALS AND METHODS

Groundnut and soybean oils were purchased from a local market in Zaria town, Kaduna state, Nigeria. Petrodiesel was purchased from a fuel filling station in Zaria town, Kaduna state, Nigeria. 0.4682g of NaOH catalyst was dissolved in 120ml of methanol to form a homogenous solution of sodium methoxide. 160ml of soybean oil or groundnut oil was heated to 60^{o}C for 30 minutes. The sodium methoxide solution was then carefully poured into the heated oil. This transesterification reaction was conducted for a period of 60 minutes with constant stirring, after which the reaction mixture was cooled down to room temperature and allowed to settle. The settled biodiesel was then decanted and washed with water. All samples were analyzed for viscosity, density, flash point, and calorific value according to standard literature procedures [1]. The purchased petrodiesel was also analyzed for viscosity, density, flash point, and calorific value according to standard literature procedures [1]. The values obtained for these properties were then compared to the American (ASTM D6751) and European (EN 14214) standards of biodiesels [6, 10]. 100ml of the blends were prepared in various volume ratios of petrodiesel and biodiesels.

RESULTS AND DISCUSSION

The measured properties of the purchased petrodiesel, pure groundnut and soybean biodiesels, as well as their formulated blends with petrodiesel in various volume ratios are given in Tables 1-4. As seen in Table 1, the density of the two biodiesels is higher than that of the petrodiesel. The density of petrodiesel/biodiesel blends increases with increase in the concentration of biodiesels in the blends as reported in Table 1. The air–biodiesel ratio and energy content within the combustion chamber of diesel engines are dependent on the density of the biodiesel because fuel injection pumps meter fuel by volume, not by mass. The density of biodiesels increases with increase in the degree of unsaturation of the fatty acid methyl esters of the biodiesels as determined by their iodine values.

The differences in the densities of soybean and groundnut oil biodiesels is attributed to the difference in the iodine values of their fatty acid methyl esters (67.45 for groundnut oil and 138.7 for soybean oil) [12]. It should be noted that the American (ASTM D6751) standard of biodiesels does not include a specification of density. Whereas, the European EN 14214 standard of biodiesel density is in the range of 860-900 kg/m^3 [10].

Table 1: Density (in kg/m^3) of petrodiesel, groundnut oil and soybean oil biodiesels, and biodiesel-petrodiesel blends

Blend	Groundnut oil	Soybean oil
B20	864	871
B40	868	873
B60	875	876
B80	879	878
Pure Biodiesel (B100)	884	880
Petrodiesel (B0)	859	

According to the ASTM D6751 and EN 14214 standards of biodiesels, the kinematic viscosity of biodiesels must be in the range of 1.9–6.0 mm^2/s and 3.5–5.0 mm^2/s, respectively, at 40ºC [10], As apparent in Table 2, the kinematic viscosity of petrodiesel is lower than that of either groundnut oil and soybean oil biodiesels. The kinematic viscosity of biodiesel blends increases as the blend level increases. Viscosity of biodiesel affects both the injector and biodiesel atomization. If the viscosity of biodiesel is too high, poor combustion may result due to large droplets in injection [10]. Biodiesel may not provide enough lubrication of the fuel injection pump if the viscosity is below 1.9 mm^2/s. The kinematic viscosity of pure groundnut oil biodiesel is almost at the limit of EN 14214 specifications.

Hence, blending is more important for the improvement of the quality of groundnut oil biodiesel than for soybean oil biodiesel.

Table 2: Kinematic viscosity (at 40ºC, in mm^2/s) of petrodiesel, groundnut oil and soybean oil biodiesels, and biodiesel-petrodiesel blends

Blend	Groundnut oil	Soybean oil
B20	3.58	3.14
B40	4.10	3.55
B60	4.37	3.77
B80	4.62	3.85
Pure Biodiesel (B100)	4.96	4.08
Petrodiesel (B0)	3.14	

Flash point is the temperature at which vapors above a given fuel become flammable. The ASTM D6751 and EN 14214 specifications for minimum flash points of biodiesels are 130.0 ^{o}C and 101.0 ^{o}C, respectively [10, 12, 13]. As seen in Table 3, both groundnut and soybean biodiesels and their blends have a flash point that is considerably higher than that of petrodiesel, the ASTM D6751 and the EN 14214 limits. Therefore, the fire hazard associated with transportation, storage and utilization of biodiesel is less than that of petrodiesel.

Table 3: Flash point (in ºC) of petrodiesel, groundnut oil and soybean oil biodiesels, and biodiesel-petrodiesel blends

Blend	Groundnut oil	Soybean oil
B20	131	131
B40	143	142
B60	154	154
B80	167	165
Biodiesel (B100)	178	176
Petrodiesel (B0)	120	

The heating value of biodiesels is not specified by the American ASTM D6751 and European EN 14214 standards [10]. It is generally believed that biodiesels have about 10% heating values than petrodiesel because of the high oxygen content of biodiesels. Table 4 shows that the heating value of groundnut oil biodiesel (33.7 MJ/kg) is slightly higher than that of soybean oil biodiesel (33.5 MJ/kg). On the other hand, the heating value of petrodiesel (33.5 MJ/kg) is substantially higher than that of both groundnut oil and soybean oil biodiesels, respectively. As apparent in Table 4, the heating value of the biodiesels increases with decrease in the blend levels.

Table 4: Heating values (in MJ/kg) of petrodiesel, groundnut oil and soybean oil biodiesels, and biodiesel-petrodiesel blends

Blend	Groundnut oil	Soybean oil
B20	38.1	38.6
B40	37.0	37.4
B60	35.9	36.1
B80	34.8	34.8
Pure Biodiesel (B100)	33.7	33.5
Petrodiesel (B0)	39.5	

CONCLUSION

Synthesized groundnut and soybean oil biodiesels were blended with a commercially available petrodiesel in various volume ratios. It was found that the density, kinematic viscosity and flash point of petrodiesel/biodiesel blends increases with increase in the concentration of biodiesels in the blends. Blending is more important for the improvement of the quality of groundnut oil biodiesel than for soybean oil biodiesel. The heating value of the petrodiesel/biodiesel blends increases with decrease in the blend levels.

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