TRANSESTERIFICATION OF *HURA CREPITANS* OIL FOR BIODIESEL PRODUCTION

O.O. Oniya*, F.B. Akande, A.A. Adedeji and O.L. Olukayode
Department of Agricultural Engineering,
Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.
E-mail: toyinprayer@yahoo.com

ABSTRACT: *This work focused on the transesterification of Hura crepitans oil and the determination of the suitability of the oil and its ethyl ester to power a diesel engine. Hura crepitans oil was transesterified in a two step transesterification process using ethanol and potassium hydroxide to produce ethyl ester (biodiesel). The fuel properties of Hura crepitans oil and its ethyl ester were determined and compared with that of Automotive Gas Oil (AGO). The results showed that the biodiesel yield was 80.5% after transesterification. The flash point, cloud point, pour point, specific gravity at 15 °C, viscosity at 40 °C, heating value, acid value, ash content, sulphur content, free fatty acid, peroxide value, iodine value and pH of the oil was obtained as 72.60 °C, 7.40 °C, 3.12 °C, 0.864, 2.870 mm²/s, 48.90 MJ/I, 19.074 MgKOH/g, 0.104%, 30.75%, 0.9588, 0.061 Meq/KOH, 0.940 wijis and 3.50 respectively. The fuel properties of Hura crepitans biodiesel were obtained as follows; specific gravity at 15 °C was 0.884, viscosity at 40 °C was 3.420 mm²/s, acid value was 6.732 mgKOH/g, peroxide value was 0.021 Meq/KOH, Sulphur content was 8.74%, cloud point was 75.10 °C, flash point was 94.60 °C, free fatty acid was 0.3304, pH was 3.30, heating value was 38.74 MJ/I. The result showed that Hura crepitans biodiesel can be used to power a compression ignition engine.*

Keywords: *Hura crepitans*, Transesterification, Biodiesel, Ethyl Ester, Fuel Properties, Diesel Engine.
Received for Publication on 22 July 2014 and Accepted in Final Form 28 July 2014

INTRODUCTION

Due to rising demand of biofuel and crude oil, the importers express their concern on the cost and sustainability of users (Umar, 2006). This has really encouraged the scientist to go for research on renewable fuel such as biodiesel.

Biodiesel is an alternative fuel for diesel engine and it has been known worldwide, because they both have similar physical and chemical features (that is also based on petroleum). It can also be used either pure or in blends with diesel. It is used in diesel engine without major modification and it reduces some exhaust pollutants (Gerpen *et al.*, 2004).

Biodiesel can be produced from straight vegetable oil, animal oil, fats tallow and waste cooking oil which will all chemically reacted with an alcohol in a transesterification process to produce fatty acid alkyl ester. The process used to convert these oils to biodiesel is called transesterification and a catalyst such as sodium hydroxide or potassium hydroxide is required for this process.

The use of vegetable oil as fuel was experimented over a century ago, but no serious thought was given to this alternative until recently (Umar, 2006), using oil from the agricultural industry represents the greatest potential source but it is not being produced commercially simply because the raw oil is too expensive. After the cost of converting the vegetable oil to the biodiesel has been added, it's simply too expensive to compete with fossil diesel.

Biodiesel can also be made from other feedstock as explained by Umar, (2006) such as restaurant waste oil (frying oil), animal fat (beef tallow or lard), and other vegetable such as corn seed, cotton seed oil, palm oil and also *Hura crepitans* oil.

Hura crepitans the sand box tree, also known as possum wood and jabillo, i.e. an evergreen tree of the spurge family (Euphorbiaceae), it is usually found in tropical regions of North and South America in Amazon Rainforest. It is recognized by the mark dark, pointed spines and smooth brown bark. These spines caused it to be called monkey no climb.

Sand box trees can grow up to 30m (100ft), and the large ovate leaves grow up to two feet (2ft) wide. They are monoecious. The red flowers have no petals. Male flowers grow on long spikes while female flowers are solitary in axils. The fruit is a large capsule with explosive dehiscence when ripe, pods catapult the seeds as far as 100metres (300H). It has also been as the Dynamite tree, so named for explosive sound of the ripe fruit as it splits into segments (Feldkamp 2006).

Most of the current challenges facing the use of biodiesel are the present availability of non-renewable crude petroleum diesel has hindered the development of production performance of biodiesel produced from local crops in Nigeria. Other vegetable oils which have been successfully used in producing biodiesel are soybean oil, palm oil, palm kernel oil, sunflower oil, rape seed oil, Jatropha oil, *etc.* (Rao *et al.,*2008; Rahman *et al.*, 2010).

The main objective of this work was to produce *Hura crepitans* biodiesel and the determination of the suitability of

Hura crepitans oil and its ethyl ester in a diesel engine.

MATERIALS AND METHODS

Hura crepitans oil was transesterified in a base-catalyzed transesterification process to produce biodiesel according to the method described by Oniya and Bamgboye 2012. Ethanol was used as alcohol for transesterification, the input amount of ethanol was calculated from the following formulae:

$$\mathrm{EtHO} = 0.2738 \times \mathrm{RO} \qquad (1)$$

Where;

EtOH = Amount of ethanol required in litres

RO = The desired amount of *Hura crepitans* oil to be processed in litres.

Also,

$$\mathrm{KOH} = 0.013 \times \mathrm{RO} \qquad (2)$$

Where;

KOH = Amount of potassium hydroxide required in kg.

RO is as defined above.

Therefore, ethanol was added at a 65% stoichiometric excess, or a molar ratio of 5.0: 1 EtOH to oil. The KOH was added at 1.43% of the weight of input oil.

Transesterification of *Hura crepitans* Oil

This involved the reaction of *Hura crepitans* oil with ethanol in the presence of potassium hydroxide as a catalyst. A measured volume of *Hura crepitans* oil was poured into a beaker and heated to the required temperature of 60 ^{o}C. The required amount of potassium hydroxide was prepared according to the formula given in equation 1 and 2. The potassium hydroxide was poured into the *Hura crepitans* oil and was mixed with reactor for an hour.

Once the reaction vessel was completed, the mixture was poured inside the closed glass also known as separating funnel. The mixture was kept for 48hrs. Two major products exist inside the separating funnel, the glycerol and ethyl ester, where the biodiesel was at the top and the glycerol was at the bottom inside separating funnel. The separating funnel has a tap bottom which was used to separate the mixture inside the separating funnel by opening or closing of the tap. Washing was done by adding distilled water which was 15% of the volume of ethyl ester separated from the separating funnel, and the mixture was then stirred vigorously for 10mins. After then, the mixture was allowed to settle for 48hrs.

Determination of Specific Gravity

Specific gravity was determined according to ASTM D1298 (ASTM, 1995) using a thermometer, the temperature of the sample was cooled and measured as 20 °C after being cooled.

An empty density bottle was weighed (W_1) using electric balance. A measured volume of the samples was poured into density bottle and weighed (W_2). Also an equal volume of distilled water was also weighed (Ww).

Specific gravity of the sample is given by:

$$S.G = \frac{W_2 - W}{W_W - W_1} \qquad (3)$$

Where;

W_1 = Weight of empty density bottle

W_2 = Weight of density filled with sample

Ww = Weight of density bottle filled with water.

Determination of Pour Point, Cloud Point and Flash Point

According to ASTM D97 procedure (ASTM, 1995), the pour point was measured at the temperature at which melting became visible when the fuel sample was cooled after freezing. Cloud point which is important for low temperature operation of fuel was determined at the temperature at which the fuel began to solidify using ASTM D2500 procedure (ASTM, 1995). The flash point was determined at the temperature when vapour ignited as flame pass over the surface of the sample. ASTMD 93 procedures were employed (ASTM, 1995).

Determination of Viscosity and Heating Value

Viscosity was obtained as viscometer tube and stop watch was used according to method prescribed in ASTM D445 (ASTM, 1995). The apparatus was used include 1m cotton, bomb calorimeter, thermocouple and sample galvanometer, as prescribed by ASTMD240 method (ASTM, 1995).

Determination of pH Value and Other Physico-chemical Properties

The iodine value, pH value, ash content, sulphur content, acid value and peroxide value of the oil samples were determined according to the method prescribed in the AOCS official and tentative methods.

RESULTS AND DISCUSSION

The results of fuel properties of raw *Hura crepitans* oil, its ethyl esters and AGO used as reference were determined according to the method prescribed in ASTM standards (ASTM, 1995) and are presented in Table 1 and 2.

The viscosities obtained for *Hura crepitans* oil and *Hura crepitans* ethyl ester were 2.870 mm^2/s and 3.420 mm^2/s respectively. The highest kinematic viscosity for biodiesel as specified in D 6751 was 6.0 mm^2/s. The biodiesel standard for European market specifies a viscosity limit for biodiesel of 3.5-5.0 mm^2/s. Since the biodiesel produced from *Hura crepitans* oil has met this specification, there is no need for correcting the viscosity by blending it with a fuel that has a lower or higher viscosity. Specific gravity values of *Hura crepitans* oil and the biodiesel at 15 ^oC were 0.864 and 0.884 respectively while that of AGO was 0.86.

Lower heating value was obtained for *Hura crepitans* ethyl ester compared to 44.68 MJ/I and 48.90 MJ/I obtained for raw AGO and *Hura crepitans* oil respectively. The specific gravity values obtained from *Hura crepitans* oil and its ethyl ester fell within the limit specified by various international standards. The low value of the specific gravity of *Hura crepitans* oil and *Hura crepitans* ethyl ester indicated good ignition property which means the biodiesel produced with *Hura crepitans* have a good combustion characteristics (ASTM, 1995).

The result of iodine value (wijis) was 0.052. Iodine is a measure of the unsaturation of fats and oil (Clark, 1988). Therefore, the value of iodine obtained in the biodiesel enhances a good stability of the biodiesel during storage (Knothe, 2005).

The flash point (72.60 ^oC and 94.60 ^oC), pour point (3.12 ^oC and 2.04 ^oC) and cloud point (7.40 ^oC and 7.10 ^oC) obtained from raw *Hura crepitans* oil and its ethyl ester respectively were higher compared to -12 ^oC, 74 ^oC, -16 ^oC from AGO (Table 1 and 2). However, the higher cloud and pour points of the biodiesel than the reference diesel fuel may involve some complications for their use in diesel engine during cold season (Mittelbach and Tritthart 1998). The high flash point of biodiesel allows it to fall under the non hazardous category of the National fire protection association code.

The value of the ash content *Hura crepitans* oil and the biodiesel produced were 0.104% and 0.012% respectively were lower compared to AGO obtained as 0.12. Therefore, this result indicated that the use of *Hura crepitans* biodiesel would reduce injector tip plugging, combustion deposits and injector system wear compared to AGO which had higher ash content.

The pH value of raw *Hura crepitans* oil and its ethyl ester were 3.50 and 3.30 respectively, which implied that *Hura crepitans* oil was not as acidic compared to its ethyl ester. The acidity was due to the presence of free fatty acid. However, the pH of *Hura crepitans* oil and its ethyl ester were higher than that of AGO. The lower values of peroxide from *Hura crepitans* oil and biodiesel indicated that they were more stable in storage than that from AGO (0.14 Meq/KOH).

The sulphur contents of *Hura crepitans* oil and its ethyl ester (30.75%, 8.74%) were lower compared to AGO obtained as 61.8% was indicative of considerably reduced hazardous sulphur dioxide emissions when *Hura crepitans* oil and its ethyl ester are used in diesel engine.

The result showed by the fuel properties of *Hura crepitans* oil and *Hura crepitans* ethyl ester indicated that both have the potentials to be used as a fuel for compression ignition engine. However, the fuel properties of *Hura crepitans* biodiesel were better than that of *Hura crepitans* oil based on its viscosity, cloud point, pH, iodine value and flash point.

Also, the percentage biodiesel yield from 50 ml of *Hura crepitans* oil was averagely 81.34% (Table 3) which indicated that *Hura crepitans* oil had great yield of biodiesel.

CONCLUSION

Hura crepitans oil and its ethyl ester have fuel properties which are close to that of reference AGOs oil and are suitable for use in diesel engines. Transesterification enhanced fluidity of *Hura crepitans* ethyl ester in diesel engine and reduced the heating value and therefore the energy content of the vegetable oil. The high flash point of *Hura crepitans* biodiesel ensures safe storage and safe transportation free from fire hazards. The higher cloud and pour points of *Hura crepitans* biodiesel than the reference AGO may involve some complications for its use in diesel engine during cold weather. The use of the biodiesel fuel would not constitute a corrosion problem in the injection system and pressure chamber of a diesel engine.

REFERENCES

Umar B. (2006). "*Potential Problems and Prospect of Biodiesel Production in Nigeria*" Proceeding of Nigeria Institution of Agric. Engr. Vol. 27. P. 73-79.

Gerpen, J; Vam D. Clement, Knothe G. (2004). "Biodiesel Analytical

Method." National Renewable Energy Laboratory Pp. 1-45.

Feldkamp, Susan (2006). Modern United State. Holt, Rine Hart and Winston p. 618.

Rao YVH, Voleti RS, Hariharan VS, Raju AVS (2008). Jatropha Oil Methyl Ester and Its Blends Used as an Alternative Fuel in Diesel Engine. *Int. J. Agric. Biol. Eng.* 1(2).

Rahman, K.M., Mashud, M., Roknuzzaman, M. and Al Galib, A. (2010). Biodiesel from Jatropha Oil as an Alternative Fuel for Diesel Engine. *International Journal of Mechanical & Mechatronics. IJMME-IJENS* Vol. 10, No. 3, Pp. 1.

Oniya O.O. and Bamgboye A.I. (2012). Loofah (*Luffa cylindrica,* L.) Biodiesel as Fuel for Diesel Engine. *Journal of Engineering and Applied Science.* Vol. 4 pp 8-19.

American Society for Testing and Material (ASTM), (1995). *ASTM Book of Standard Test Methods.* American Society for Testing Materials, Philadelphia, PA, USA, Pp. 1-8, 268-271.

Clark G.H. (1988). Laboratory Test on Fuels and Their Significance in Industrial and Marine Fuels. London: Butterwoth Reference Book; p. 3-21.

Knothe, G. (2005). Dependence of Biodiesel Fuel Properties on the Structure of Fatty Acid Alkyl Esters. *Fuel Processing Technology.* Vol. 86, Pp. 1059-1070.

Mittelbach, M and Tritthart, P. (1998). Diesel Fuel Derived from Vegetable Oils. Emission Tests Using Methyl Esters of Used Frying Oil. *J. Amer Oil Chem. Soc.* Vol.65, Pp. 1185-1187.

Table 1: *Hura crepitans* Oil Properties

Fuel Properties	*Hura crepitans* Oil
Specific gravity @ 15 °C	0.864
Viscosity @ 40 °C (mm^2/s)	2.870
Acid Value (mg KOH/kg	19.074
Peroxide Value (Meq/KOH)	0.061

Iodine Value (Wijis)	0.940
Ash content (%)	0.104
Sulphur content (%)	30.75
Cloud point (°C)	7.40
Flash point (°C)	72.60
Pour point (°C)	3.12
Free Fatty Acid (g/100 g)	0.9588
pH	3.50
Heating Value MJ/I	48.90

Table 2: *Hura crepitans* Biodiesel and AGO Properties

Fuel Properties	Biodiesel	AGO
Specific gravity @ 15°C	0.884	0.86
Viscosity @ 40°C (mm^2/s)	3.420	2.95
Acid Value (g/100g)	6.732	8.00
Peroxide Value (Meq/KOH)	0.021	0.14
Iodine Value (Wijis)	0.052	0.21
Ash content	0.012	0.12
Sulphur content (%)	8.74	61.8
Cloud point	7.10	-12
Flash point	94.60	74
Pour point	2.04	-16
Free Fatty Acid g/100g	0.334	8
pH	3.30	2.8
Heating Value MJ/I	38.74	44.68

Table 3: Biodiesel Production Yield

Experiment No.	Volume of Oil (ml)	Yield (ml)	Percentage Yield (%)
1	50	40	80
2	50	42	84
3	50	40	80
Average	50	40.67	81.34

Reference to this paper should be made as follows: O.O. Oniya *et al.* (2014), Transesterification of *Hura crepitans* Oil for Biodiesel Production. *J. of Engineering and Applied Scientific Research,* Vol. 6, No. 1, Pp. 91 – 97.