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# Production of Biodiesel from Baobab Seed Oil

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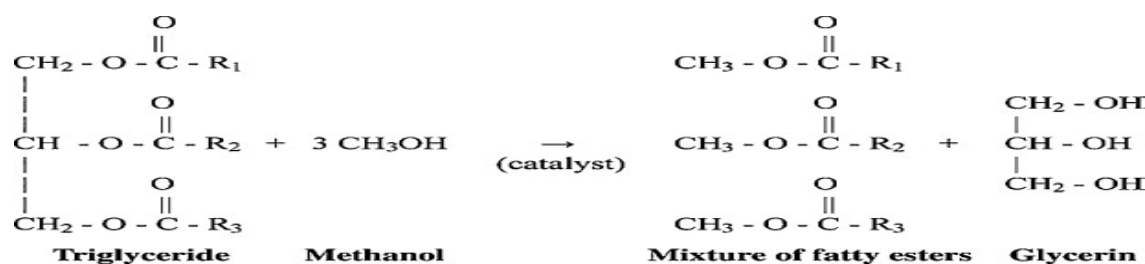
| ARTICLE INFO                                                                                                                                                                                                                                                                                          | ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
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| <p><b>Article No.:</b> 1219131042<br/><b>DOI:</b> 10.15580/GJAS.2014.2.1219131042</p> <hr/> <p><b>Submitted:</b> 19/12/2013<br/><b>Accepted:</b> 26/02/2014<br/><b>Published:</b> 13/03/2014</p> <hr/> <p><b>*Corresponding Author</b><br/>Buhari M.<br/><b>E-mail:</b> magaji.buhari@yahoo.co.uk</p> | <p>Biodiesel is a renewable, biodegradable and environmentally friendly fuel for use in diesel engines. It can overcome the problem associated with fossil fuels such as its non-renewability, polluting nature and its global politics which is a matter of concern to many nations. In this research, biodiesel was produced from the seed oil of baobab (<i>Adansonia digitata</i>) with methanol in the ratio of 5:1 (v/v) of the oil to alcohol. After the crude oil extract was transesterified, the viscosity of the biodiesel was 0.859cm<sup>2</sup>, the cloud, the pour, and the flash points obtained were 10°C, 20°C and 17°C respectively. From the results it was clear that the produced biodiesel fuel was within the recommended standards of the biodiesel fuel and so can be used as fossil fuel substitute.</p> |
| <p><b>Keywords:</b><br/>Baobab seeds, Biodiesel, Free fatty acid, viscosity</p>                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

## INTRODUCTION

Vegetable oil esters are receiving increasing attention as a non-toxic biodegradable and renewable alternative diesel fuel. These esters have become known as biodiesel. Research on vegetable oils as fuel was started at least 100 years ago, but interest lagged because of cheap and plentiful supplies of fossil fuels. Many studies have shown that the properties of biodiesel are very close to fossil diesel (Cheng et al., 2004; Freedman and Pryde, 1986). Therefore, biodiesel can be used in diesel engines with few or no modifications.

Biodiesel is comprised of monoalkylesters of long chain fatty acid derived from vegetable oils or

animals fats. In simple terms, biodiesel is the product obtained when a vegetable oil or animal fat is chemically reacted with an alcohol to produce fatty acid alkyl esters. A catalyst such as sodium or potassium hydroxide is required. Glycerol is produced as a co-product and the process of transforming the vegetable oil esters into the biodiesel esters is known as transesterification. This is done by adding methanol to the triglyceride, this removes the glycerol backbone and replaces it with a smaller methyl group, and thus, splitting part of the large molecules, methyl esters and glycerol are left as separate products as shown in the equation below where  $R_1$ ,  $R_2$  and  $R_3$  are long hydrocarbon chains.



According to Wikipedia (2008), some operational problems were reported with biodiesel due to the high viscosity of vegetable oils compared to petroleum diesel fuel, which results in poor atomization of the fuel in the fuel spray and often leads to deposits and coking of the injectors, combustion chamber and valves. Attempts to overcome these problems include heating of the vegetable oil, blending it with petroleum derived diesel fuel or ethanol, the blend is designated as "BXX" where XX is the percentage of biodiesel in the blend. For example, B20 is a blend of 20% biodiesel and 80% petroleum diesel fuel, and the other methods are pyrolysis and cracking of the oils. Despite the widespread use of fossil petroleum derived from diesel fuels, interest in vegetable oils as fuels for internal combustion engines was reported in several countries during the 1920s and 1930s and later during World War II.

The fossil fuel global politics and its high cost have mandated/necessitated the investigation and production of an environmental friendly, cost effective and renewable fuel known as biodiesel which is obtained from animal fats and vegetable oils. The oil has so many attractive features over petro diesel among which are:

- (i) Biodiesel is biodegradable
- (ii) Biodiesel improves engine performance.
- (iii) Biodiesel is essentially non-toxic and is not a skin irritant.
- (iv) It has higher cetane number than ordinary diesel and therefore does not

need improper additives as in premium petro diesel.

- (v) It has a higher flash point than ordinary diesel and so is not flammable.
- (vi) It reduces net CO<sub>2</sub> emission by 70% compared with ordinary diesel cutting green house gases that lead to global warming.
- (vii) It is much more lubricating than ordinary diesel reducing engine wear and ensuring longer fuel pump life.
- (viii) It is produced from local feedstock, reducing the need for foreign imports, while boosting the local economy and supporting the agricultural community.
- (ix) Biodiesel replaces the exhaust odour of ordinary diesel with a more pleasant smell of popcorn or French fries.
- (x) Biodiesel blends of 20% with 80% ordinary diesel can be used in unmodified diesel engines. Biodiesel can be used in its pure form but many require certain engine modifications to avoid maintenance and performance problems.
- (xi) Biodiesel requires virtually no additives.

The Baobab tree must be one of the most intriguing trees growing on the African continent and is often referred to as 'monkey bread' tree, 'Senegal Calash (fruit) bottle tree' or 'upside – down' tree which can have a lifespan of up to 6,000 years. Botanically, is

known as *Adansonia digitata* (*Bombacaceae* family), named after the French botanist Michel – Adanson who studied these trees. The tree is found throughout Africa, generally at low attitudes and in the hotter, drier areas.

The non-renewable nature of ordinary diesel and the global politics associated with its use has resulted in the high cost of this fuel, the gaseous emissions also cause environmental pollution with adverse effect on animals and plants. This paper explored the utility of *Adansonia digitata* methyl esters (ADMES) as a potential source of biodiesel fuel.

### Plants Material

Ripe seeds of *Adansonia digitata* were bought from Gombe main market, Gombe State, Nigeria.

### Preparation of material

The seeds were re-washed and sun-dried. The re-dried seeds were crushed manually to smaller sizes and pulverized using a grinding machine for easy extraction of the oil.

### Extraction method:

Extraction was carried out using, Kyari, (2008) method of extraction as follows:

250ml of n-hexane was poured into a round bottom flask. 100g of the sample was inserted in the centre of

the extractor. The soxhlet was heated at 60 - 70°C. When the solvent was boiling the vapour rose through the vertical tube into the condenser at the top. The liquid condensate dripped into the filter paper thimble in the centre which contained the solid sample to be extracted. The extract seeped through the pores of the thimble and filled the siphon tube, where it flowed back down into the round bottom flask. This was allowed to continue for 4 hours. At the end of the extraction the condenser was removed. The flask containing the resulting mixture was connected to Liebig condenser and heated up to 65 - 70°C during which the n-hexane evaporated off and was recovered in a conical flask; the oil extracted weight was taken. This procedure was repeated throughout the work.

### Characterization of the extracted oil

#### i. Determination of specific gravity:

A density bottle was used in determining the density of the oil. A clean and dry bottle of 25ml capacity was weighed and assigned as  $W_0$ , and then filled with the oil, a stopper was inserted and reweighed to give a weight

recorded as  $W_1$ . The oil was substituted with the water after washing and drying the bottle and weighed and was recorded as  $W_2$ . The expression for specific gravity (Sp.gr) is as given (ASTMD4052);

$$S = \frac{\text{mass of the substance}}{\text{mass of an equal volume of water}} = \frac{(W_1 - W_0)}{(W_2 - W_0)} \quad (1)$$

#### ii. Determination of Acid value

25ml of diethyl ether and 25ml of ethanol were mixed in a 250ml beaker. The resulting mixture was added to 20g of oil in a 250 ml conical flask and few drops of

phenolphthalein indicator were added. The mixture was titrated with 0.1M NaOH solution from the burette to the end point with consistent shaking until a dark pink colour was observed and the volume of 0.1M NaOH ( $V_o$ ) was noted (Kyari, 2008).

$$\text{Free fatty acid (FFA) value was calculated as } \frac{V_o}{W_o} = 82 - 100 \quad (2)$$

Where 1000 ml % 0.1M NaOH = 2.83g of oleic acid,

$W_o$  = sample weight; then the acid value = FFA – 2 (Cooks et al, 1997).

#### iii. Determination of iodine value (Wiji's Method)

0.3g of oil was weighed and placed into a 25ml conical flask. 10 cm<sup>3</sup> of carbon tetrachloride was added to this and similar flask containing no oil was set-up to serve as the blank. To both flask 25 cm<sup>3</sup> of Wiji's reagent were added from a burette. The solutions were mixed well and left in dark for an hour. After that, 15cm<sup>3</sup> of

10% KI solution and 100cm<sup>3</sup> of distilled water were added to both flasks and titrated with standard 0.1M Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> solution using starch as the indicator. The end-point was taken when the solution turned just colourless. While titrating the solution, the carbon tetrachloride layer was transferred to the aqueous layer. The weight of iodine absorbed by 100g of fat is

Weight of iodine absorbed by 100g of fat ( $W$ ) is given by

$$W = \frac{100 \times \text{Difference in titre value} \times \text{thiosulphate factor}}{\text{Weight of fat used}} \quad (3)$$

1cm<sup>3</sup> of 0.1M Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> = 0.072g of iodine (Diamond and Denman, 1973).

#### iv. Determination of saponification value

2g of oil was weighed in a 25ml conical flask, to which 5cm<sup>3</sup> of alcohol and 20cm<sup>3</sup> of 0.5M alcoholic KOH solution were added. Also 5cm<sup>3</sup> of alcohol and 20cm<sup>3</sup> of 0.5M alcoholic KOH solution were added for the blank and both were refluxed for an hour. After cooling,

$$sv = \frac{56.1N(V_o - V_1)}{M} \quad (4)$$

Where

$V_o$  = volume of acid solution used for the blank,

$V_1$  = volume of acid solution used for the sample,

$N$  = Normality of HCl and

$M$  = Mass of the sample.

#### vi. Determination of flash point

The flash point is the lowest temperature at which an applied ignition source will cause the vapours of a sample to ignite. Therefore, it is a measure of the tendency of a sample to form a flammable mixture with an ignition source. 15 ml of the sample of the fuel was heated in a 250 ml conical flask on a hot plate and a flame was passed over the surface of the liquid at the flash point temperature, the vapour that ignited the temperature was recorded as the flash point temperature, this was repeated for three times (ASTMD6450).

#### vi. Determination of the cloud point

The cloud point is the temperature at which a cloud of wax crystals first appears in a liquid upon cooling. 15ml of the fuel sample was taken in a small sampling bottle and put in a refrigerator while the fuel is cooled under carefully controlled conditions; the sample is continuously monitored by mercury-in-glass thermometer while the temperature that corresponds to the first formation of a cloud in the fuel was recorded (ASTMD7683 & ASTMD5773).

#### vii. Determination of pour point

The pour point is the lowest temperature at which a fuel sample will flow.

After the cloud point has been noted, it was then removed from the refrigerator and the sample was examined carefully at 5°C for flow, the lowest temperature at which the sample movement was observed was noted and recorded (ASTMD97).

#### viii. Determination of viscosity.

Viscosity is the ease with which a fluid will flow.

the contents of the flask were titrated against 0.5 M HCl using phenolphthalein as indicator.

The difference in titre between that of the blank and the sample solution is equivalent to the amount of fatty acid present 0.5 M KOH = 28.05g/dm<sup>3</sup>. The saponification value was calculated from the following expression (Diamond and Denman, 1973);

20ml of the oil sample poured into a capillary of a calibrated viscometer at a closely controlled and known temperature and the time for the volume of the oil to flow under gravity through a calibrated glass capillary tube was noted and recorded. The viscosity was obtained by multiplying the time of flow obtained and the factor on the glass calibrated viscometer (ASTMD445).

#### ix. Determination of Distillation temperature

The distillation test is used to determine the boiling range characteristics of a hydrocarbon sample. A simple batch distillation process was conducted on a sample of the fuel and the initial boiling point was recorded as the distillation temperature (ASTMD6751).

#### Transesterification of the crude oil extract

Preparation of methoxide

40ml of methanol was put into a stopped flask. 1.8g of KOH was weighed and added to the methanol. The flask was stirred until all the KOH dissolved in the methanol; the flask became warm as the KOH dissolves (Cheng et al., 2004).

The methoxide is not a chemical compound but a mixture because there are no bonds between the methanol and the KOH.

#### Transesterification Process

200ml of the oil sample was put into a beaker; the methoxide was added to it. The temperature was raised to 45°C on a hot plate and the mixture was stirred with magnetic stirrer for 25 minutes. The mixture was allowed to stand overnight in a flask. A thick brown liquid layer settled at the bottom, this was the glycerin and the lighter-coloured liquid above was the biodiesel. The glycerin which is the byproduct was drawn off through the bottom tap. The biodiesel was then washed with warm water to remove the lye, soaps and methanol that are in the biodiesel. The water is better at dissolving the impurities than the biodiesel. A straw-yellow and a cloudy liquid layer were formed, the cloudy liquid was drained out and pH test was conducted to confirm the neutrality of the washed water/cloudy liquid. The Biodiesel was heated to 55°C

on a hot plate to allow the remaining water to evaporate and was finally filtered using a filter paper (Mondala et al., 2009). The volume of the biodiesel obtained and that of the glycerin were recorded.

## RESULTS

Some physical and chemical properties of the oil extracted from *Adansonia digitata* seeds and the biodiesel obtained after transesterification are shown below in Table 1 and compared to fossil fuel.

**Table 1: Chosen properties of the crude oil extract and the biodiesel**

| Parameters                                                | Crude oil extract         | Biodiesel                 |
|-----------------------------------------------------------|---------------------------|---------------------------|
| Oil content (cm <sup>3</sup> /100g)                       | 40 - 45                   |                           |
| Colour and odour                                          | Yellow and pleasant odour | Yellow and pleasant odour |
| Density                                                   | 0.88                      | 0.86                      |
| Viscosity (g/cm <sup>3</sup> )                            | 3.486 ± 0.0729            | 0.859 ± 0.0349            |
| Cloud point (°C)                                          | 10                        | 10                        |
| Pour point (°C)                                           | 20                        | 20                        |
| Flash point (°C)                                          | 190                       | 170                       |
| Distillation Temp (°C)                                    | 225                       | 210                       |
| Acid value (mg NaOH/g of oil)                             | 0.047 ± 0.031             | -                         |
| Saponification value (mg KOH/g of oil)                    | 210.38 ± 0.044            | -                         |
| Iodine value (I <sub>2</sub> g 100g <sup>-1</sup> of oil) | 124.87 ± 0.449            | -                         |
| Cetane number                                             | -                         | Unable to determined      |

## DISCUSSION

The percentage oil yield of *Adansonia digitata* seeds is in the range of 40 - 45% which may be considered to be reasonable yield levels. The acid value is lower than 1% in the case of the oil investigated and therefore it suggests low level of free fatty acid in the oil. The saponification value (SV) is obtained to be 210.38. The SV conforms to those reported for common oils (Lab. 1960); for example, the SV for palm oil is 200, for groundnut is 193 and for coconut oil 257 respectively. Thus, the oil of *Adansonia digitata* may be used for soap making or other similar uses. The iodine value for the oil is 124.87g/100g, which confirms that the oil is highly saturated and therefore is non-drying oil. A good drying oil should have iodine value of 180 and above. Thus, the oil is not suitable as alkyl resin for paint formulation or use as varnishes; they may, however, find uses in conjunction with amino resins as a finisher for certain appliances, and in this case, the oil can also act as plasticizers. Furthermore, the density, the cloud and the pour point of the crude extract and the biodiesel are almost the same but the viscosities differ widely.

## CONCLUSION

Biodiesel is an important new alternative transportation fuel. It can be produced from many vegetable oils. In this research, biodiesel was produced from baobab seed oil (*Adansonia digitata*). The seed of *Adansonia digitata* examined in this work have been shown to contain oil in reasonable levels (40 - 45 cm<sup>3</sup>/100g).

From the work conducted, the produced biodiesel fuel was within the recommended standards, and therefore, it can be used for any required purpose.

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