

## THE PRODUCTION OF BIODIESEL FROM WASTE GROUNDNUT (*ARACHIS HYPOGAEA*) OIL

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### **Abstract**

*Most of the used cooking oils are poured into the sewage system of the cities. This contributes to the pollution of rivers, lakes, seas and underground water, leading to negative effects on the environment and human health. The utilization of waste oils for producing biodiesel is one of the efficient and economical approaches to reduce these negative effects. In this research, biodiesel was produced from waste groundnut seed oil through the alkali transesterification process. The chemo physical properties of the biodiesels were determined and compared with ASTM D6751 and other international standard properties of diesel. The results were: densities 0.876g/cm<sup>3</sup> and 0.878g/cm<sup>3</sup>, API gravities 29.66 and 29.48, cloud points 10 °C and 11 °C, pour points -6.7 °C and -5.8 °C, flash points 176 °C and 179 °C, viscosities 4.5mm<sup>2</sup>/s and 5.6mm<sup>2</sup>/s and cetane numbers 53.39 and 48.65 all lie within the ASTM standards. The results show that waste vegetable (groundnut) oils can be converted into biodiesel and used in diesel engines comfortably without engine modification.*

**Keywords.** Biodiesel, Catalyst, Characterization, Transesterification, Waste groundnut oil.

### **1.0 Introduction**

Increased industrialization and motorization of the world has led to a steep rise in demand for petroleum products which are obtained from limited reserves. The continual depletion of fossil fuels has resulted in an ever increasing need to seek alternative fuels which can be produced from materials available within the environment [1]. [2] reported that not less than ten major oil fields from the twenty largest world oil producers were already experiencing decline in oil reserve. Their report revealed that a total of twenty nine major world oil producing countries were already experiencing declining oil reserves from year 2005 to 2007. It is known that the remaining global oil resources appear to be sufficient to meet demand up to 2030 as projected in the 2006- 2007 world energy outlook by the International Energy Agency (IEA) (No, 2011).

According to United Nation Development Programme (UNDP) 2007/2008 human development report, the world temperature has increased by around 0.7°C since the advent of industrialization and the rate is skyrocketing yearly. The chief cause includes burning of fossil fuels such as coal, oil and natural gas by automobiles which continually release carbon dioxide into the atmosphere [3]. The use of fossil fuels in diesel engines produces significant amounts of particulate matter and oxides of nitrogen (NO<sub>x</sub>) in the exhausts which are precursor pollutants which can combine to form photochemical smog [4].

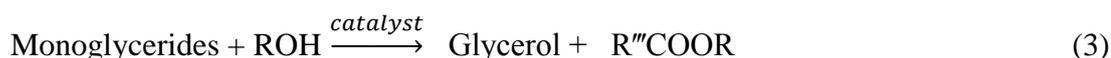
There is therefore the need to find alternative fuel resources within the locality or geographical area that can be regenerated to solve the scarcity or unavailability, environmental and sustainability problems. Biofuels like ethanol and biodiesel are gaining

worldwide acceptance. Biofuels are considered as being part of the solution for problems of environmental degradation, energy security, retracting imports, rural employment and agricultural economy for improving standards of living. Biofuels could include bio, ethanol (bio gasoline) and biodiesel as well as other fuels made from biomass and use for automotive, thermal and power generation according to specification stipulated by Standard Organization of Nigeria (SON), Department of Petroleum Resources (DPR) and any other government agency [5].

The main types of biofuel are ethanol and biodiesel. Ethanol is produced from wide range of biomass (plant) material using a relatively complex chemical process. Bioethanol is a distilled liquid produced by fermenting sugars from sugar plants and cereal crops (sugarcane, corn, beet, cassava, wheat, sorghum). Generally ethanol is mixed with gasoline, in varying concentrations, although cars are now produced in some countries that can run on pure ethanol.

Biodiesel(Greek, bio, life + diesel from Rudolf Diesel) is defined as a mixture of mono alkyl esters of long chain fatty acids (FA) derived from renewable lipids such as vegetable oils and animal fats when reacted with an alcohol (methanol or ethanol) in presence or absence of catalyst [6, 7, 8].\_Researchers and scientists have developed various methods of biodiesel production using different biofuels, with the main objective being to reduce oil viscosity. Dilution, micro emulsification, pyrolysis and transesterification are the four techniques applied to solve problems encountered with high viscosity. Among all the above mentioned methods used to convert oils to biodiesel, transesterification of the triglycerides seems to be the best choice, as the physical characteristics of the biodiesel obtained are very close to those of diesel fuel [9, 10]. Furthermore, methyl or ethyl esters of the fatty acids can be burned directly in unmodified diesel engines with very low deposit formation and a by-product (glycerol) that has commercial value [11]. The transesterification process is defined by [12], as the chemically reacting triglycerides such as one of vegetable oils with an alcohol in presence of an alkaline or acidic catalyst to produce glycerol and fatty acid ester. When the original ester is reacted with an alcohol, the transesterification process is called alcoholysis.

The transesterification reaction consist of transforming triglycerides into fatty acid alkyl esters in the presence of an alcohol, such as methanol or ethanol or a catalyst such as an alkali or acid with glycerol as a by-product [13]. Transesterification consist of a number of consecutive reversible reactions. The triglycerides are converted stepwise to triglycerides, monoglycerides and finally glycerol. A mole of ester is liberated at each step as given in equations 1- 3.



*(Vasuderan and Briggs, 2008).*

Though biodiesel is technically feasible and environmentally acceptable, it should be noted that it is not economically competitive. The high cost of virgin vegetable oil is the most important issue in the economic evaluation of the biodiesel process. Reducing the cost of the feedstock is necessary for biodiesel's long-term commercial viability.

Waste vegetable oils used to be sold commercially as animal feed. However since 2002, the European Union (EU) has enforced a ban on feeding these mixtures to animals to prevent the return of harmful compounds back into the food chain through the animal meat.

In fact, most of the used cooking oil is poured into the sewer system of the cities. This will contribute to the pollution of rivers, lakes, seas and underground water, leading to the negative effect on the environment and human health. Therefore, the disposal of waste oils in a safe way is required since it may contaminate the environment. The utilisation of waste oils for producing biodiesel is one of the efficient and economical approaches to solve this. In order to achieve production cost reduction and make biodiesel more competitive with petroleum diesel, low cost feedstock, such as non-edible oils and waste vegetable oils could be used as raw material. With the mushrooming of fast food centers and restaurants in Nigeria, it is expected that considerable amounts of used frying oil will be discarded which can be diverted for biodiesel production, and thus may help reduce the cost of water treatment in the sewerage system and assisting in the recycling of resources.

This study focuses on the utilisation of waste groundnut oil which is the form of vegetable oil extracted from groundnut seeds for the production of biodiesel.

## **2.0 Materials and Methods**

### **2.1 Biodiesel Production**

Two samples of waste groundnut oils, four litres each were collected (A sample from Chambian Heritage Hotel, Yola and another from Modibbo Adama University of Technology, Yola Commercial Guest House).

The samples were left to stand for three days so that impurities in the form of food residue settled down and then filtered by decantation to remove the impurities. The filtered waste groundnut oils were subjected to drying by heating to 100°C on a hot plate for 15 minutes while stirring continuously to boil off any water present.

200 ml of methanol was measured and poured into a conical flask equipped with a stirrer. 1.0 wt% Potassium hydroxide (KOH) was added to the flask as catalyst. The mixture was stirred until the potassium hydroxide dissolved in the methanol forming potassium methoxide.

1 litre of waste groundnut oil was heated to 55°C and poured into a blender and the prepared methoxide was introduced into the heated oil. This was mixed with the blender tightly sealed for one hour. The mixture was poured into a bottle and allowed to settle for a day. Decantation was done to separate the top layer paler liquid (biodiesel) from the bottom darker coloured layer (glycerine).

3ml acetic acid was added to the product to neutralize any soap that might have been formed. The biodiesel was washed with 0.5 litre of water to remove impurities. The mixture was stirred and allowed to settle for 8 hours and the water was drained out. This was repeated till the biodiesel was clear. The biodiesel was heated gradually on the hot plate to remove any water present.

## **2.2 Testing of the Biodiesel**

### **2.2.1 Density**

Density of fuel at different temperatures was measured by a standard 25 ml marked flask. Weight of a fixed volume of fuel (25 ml) was measured at different temperatures by an electronic balance which measures up to 0.0001 gm. The average of density values were reported in kg/m<sup>3</sup>.

### 2.2.2 Viscosity: Method: ASTM D 44

Viscosity of fuels was measured using Saybolt viscometer and accessories. The time of falling of 60 ml sample under gravity through the capillary of a calibrated viscometer under a reproducible driving head and at a closely controlled and known temperature (40 °C). The kinematic viscosity is then equal to the product of this time and a calibration constant for the tube.

### 2.2.3 Flash Point

Method: ASTM D93- Flash point, closed cup.

Flash points of test fuels were measured as per ASTM standard D93-85 using closed cup tester. A sample of the biodiesel was taken into Pensky-Martens closed-cup tester and heated slowly with continuous stirring. A flame was inserted into the oil cup at every 2°C temperature rise of the oil. The lowest temperature at which application of the test flame caused the fuel vapour to give flash of fire and then disappeared was noted and recorded as the flash point.

### 2.2.4 Cloud Point

Method ASTM D 5773

The biodiesel sample was cooled in a Peltier device at a constant rate, the sample was continuously monitored by optical detectors and the temperature that corresponded to the first formation of a cloud in the fuel recorded.

### 2.2.5 Pour Point

Method ASTM D 97

The sample was cooled at a specified rate and examined at 3°C intervals for flow. The lowest temperature at which sample movement was observed was then recorded.

### 2.2.6 Relative Density

The relative densities were calculated using the formula as obtained in the standard methods for fuel properties

$$\text{Relative density} = \frac{\text{mass of a given volume of liquid}}{\text{mass of a given volume of distilled water}} \quad (4)$$

### 2.2.7 API Gravity

The API gravities were evaluated as follows:

$$\text{API Gravity} = \frac{141.5}{\text{Relative density}@15^\circ\text{C}} \quad (5)$$

## 3.0 Results and Discussion

Table 1 shows the determined properties of the waste ground oil biodiesel while Table 2 is the comparison of some main properties of biodiesel with some international biodiesel standards.

Letter A represents sample collected from the Chembian Heritage Hotel, Yola while letter B represents sample collected from Modibbo Adama University of Technology, Yola commercial Guest house.

Table 1: Fuel properties of samples of raw waste groundnut oil biodiesel.

Sample	A	B
Density at 30 °C (g/cm <sup>3</sup> )	0.876	0.878
Relative Density	0.945	0.943
Cloud point (°C)	10	11
Pour point (°C)	-6.7	-5.8
Flash point (°C)	176	179
Viscosity(mm <sup>2</sup> /s)	4.5	5.6
API gravity	29.16	29.48

Table 2: Comparison of main properties of biodiesel prepared from waste groundnut oil some International biodiesel standards

PROPERTY	Sample A	Sample B	EN14314:2003	ASTM 6751-076	SON
Density at 30 °C g/cm <sup>3</sup>	0.876	0.878	0.86 – 0.980	0.87 – 0.90	
API gravity	18.24	18.55	3.5 – 5.0	1.9 – 6.0	
Flash point °C	176	179	120 min	>130° (150°C average)	66
Cetane number	53.39	48.65	51 minimum	47 minimum	
Cloud point °C	10	11		6	4.4
Relative density	0.945	0.943		45 – 65	
Pour point °C	-6.7	-5.8	NS	-7	
Viscosity at 40 °C (mm <sup>2</sup> /s)	4.5	5.6	3.5- 5.0	1.9- 6.0	1.6 - 5.5
Specific gravity			NS	0.839	0.820-0.870

NS= Not Specified

The biodiesel samples flash points are 176 °C and 179 °C. This result is good because it is above average (150 °C) specification by ASTM standards as in Table 2. It also exceeds specification for diesel fuel (66 °C minimum) provided by Standard Organization of Nigeria. This means that using these fuels will ensure greater safety as in risk of a fire incidence or even during storage. The cetane number for samples A and B are 53.39 and 48.65 respectively. These values are above the minimum for diesel fuel as shown on table 2 and

also above specifications for biodiesel provided by ASTM standards which implies that the fuels are expected to burn smoothly when used.

The cloud point obtained for the biodiesel samples were 10°C for sample A, and 11°C for sample B, The cloud point is an important property for biodiesel since biodiesel fuels typically have higher cloud points, i.e., crystals begin to form at higher temperature, than standard diesel fuel. This feature has implications on the use of biodiesel in cold weather applications. The cloud point is a critical factor in cold weather performance for all diesel fuels. This means that the fuel can be used satisfactorily in Nigeria without fear of gelling.

The pour point obtained were – 6.7°C for sample A and – 5.8°C for sample B. This is the temperatures below which the fuel will not be able to flow freely when used as fuel. From the results, it is clear that waste groundnut biodiesel can be handled and used even in temperate countries where temperatures can be less than 3°C.

The viscosity for samples A and B obtained at 40°C were 4.5 and 5.6 respectively. Both are within the range 3.5 – 5.0 provided by EN14214: 2003 – specification by European standard and the range 1.9 – 6.0 provided on ASTM D 6751 standards. This means the flow of the biodiesel will be good enough to replace diesel fuel and can be used in diesel engines without engine modification.

#### **4.0 Conclusion**

Based on the physico-chemical analysis it can be seen that waste groundnut oil presents a promising choice as raw material for the production of biodiesel in Nigeria as the properties are in conformity with global standards.

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