Synthesis of Heterogeneous Catalyst from Waste Snail Shells for Biodiesel Production using *Afzelia africana* Seed Oil

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ABSTRACT

Biodiesel has gained more recognition as a fuel to replace fossil fuel which has cause a lot of damage to the environment and high cost of the product. The best way to reduce the cost of the production of biodiesel is to use feed stocks which are cheap which accounts for the larger percentage of biodiesel production cost. The use of less expensive feed stock and optimization of process variables that affect the yield presents the opportunity of significantly reduction of the cost. An investigation was carried out with Afzelia africana oil seed and waste snail shells as raw materials. One step transesterification was conducted to produce the biodiesel. Snailshells was used as a source of Calcium oxide (CaO) heterogeneous catalysts by calcination process at 600^0C for 6h. Four processe variables were optimized; methanol to oil ratio (6:1), reaction temperature (55 0^C), catalyst concentration (1.5 wt%) and reaction time (65 min). The fuel properties of the produced biodiesel from A. africana seed oil were compared with ASTM standard and all the properties determined from the oil were all within the standard.

Keywords: Snail shell, A. africana seed, optimization, Biodiesel, transesterification, fuel properties.

INTRODUCTION

The depletion of world petroleum reserves and increased environmental concerns have stimulated the search for alternative renewable fuels that are capable of fulfilling an increasing energy demand[1]. In recent decades, research concerning and knowledge about the external benefit of renewable raw materials have intensified the efforts for sustainable energy sources. Biodiesel plays a major role in this field because of the world-wide research, development and deployment activities of this sustainable energy source[2].

Biodiesel is produced from different sources (vegetable oil, animal fat, and from micro algae)[3]. The most suitable and acquired method of biodiesel production is transesterification of triglycerides of oils using alcohol, by using an acid or a basic catalyst. Transesterification reaction concerts tryglycerides in preserve of methanol into biodiesel. The transesterification reaction involves reaction of triglycerides in order to form diglycerides, monoglycerides and glycerol, by three sequential, reversible

reactions of triglycerides[4]. The efficiency of the transesterification process using a heterogeneous catalysts depends on some process parameters such as temperature, catalyst, methanol to oil ratio, reaction time and agitation. Several types of alcohol can used for transesterification namely methanol, ethanol and propanol[5].

In this study, methanol is most widely used, as it has an appropriate viscosity, boiling point and average cetane number. The transesterification process produce triglycerides and glycerols. In order to enhance this reaction several researchers have used different catalysts to speed up the reaction process and attain a high quality product[6]. Biodiesel production process involves two basic types of catalysts (homogeneous and heterogeneous). The heterogeneous catalyst has a lot of advantages of reusability property, it does not release large amount of waste water, also it does not undergo saponification hence undergoes lesser number of stages for processing eventually, has a low cost[7]. The homogeneous catalyst has a lot of disadvantages such as large amount of water required for washing process, non-reusability of catalysts, soap production heading in high viscosity and formation of gels hence the overall cost of the production is comparatively high considering the separation and purification[8].

In order to overcome these problem a heterogeneous catalyst produce from a waste snail shells is used as an alternative to the conventional heterogeneous catalyst (NaOH) and (KOH). Most heterogeneous catalysts are solids that provide the surface as the base for diverse mechanisms of reactions to takes place, depending upon the characteristics of adsorption that occur. The benefit of solid heterogeneous catalyst is the low cost involved in the production. The major problem facing the production of biodiesel is the feed stock. In this study an under-utilized seeds (*Afzelia africana*) prevalent in North Central Nigeria is used as potential feedstock to replace edible seeds such as groundnut, melon and sesame. The oil of these seed *Afzelia africana* contains high fatty acid which need to be neutralized before it can be used as feedstock for biodiesel production[9].

The aim of this study is to developed a heterogeneous catalysts from waste snail shells for biodiesel production and optimize the process parameters.

MATERIALS AND METHODS

Collection of samples

A non-conventional feed stock *A. africana* was selected for this study, as this plant is native to Ayingba in Kogi state, North Central Nigeria and there is a need to exploit the benefit of this plant as substitute feed stock for biodiesel production. The seed of *A. africana* were

36

collected from the farm. The botanical description of this plant is given as:

Table 1: Botanical Description of *A. africana*

Common name	Local name		Botanical name	Family
African Oak	English: African Oak		Afzelia Africana	Fabacea
	Yoruba: Bilinga			
	Hausa:	Kawu		
	Igbo:	Akparata		

Pretreatment of A. africana Seeds

Seeds were first unshelled and made clean of any other impurity and then dried at room temperature for five days. The dried seeds were then pulverized into uniform powdered, sieved, weighed, bottle, labeled and stored in plastic container (air-tight) to ensure that no moisture can interact with the sample seeds.

Extraction of A. africana oil

30 g of ground seeds were taken in a soxhlet apparatus on a water bath. Extraction was done in n-hexane for 2 h and repeated three times to obtain enough quantity of oil sample. Extracted oil was made free of the solvent under vacuum in rotary evaporator (Heidolph HB digital, Laboratory 4001 efficient). The percentage oil yield was calculated using the formula:

$$\text{Oil content} = \frac{\text{weight of oil extracted}}{\text{weight of seed}} \times \frac{100}{1}$$

Refining of Extracted A. africana Oil

Degumming

Degumming was done to remove phospholipids from the oil. This was done by the addition of 50 cm^3 boiled water to 150 cm^3 of the extracted oil. The mixture was stirred for 5 min and allow to stand in the separating funnel.

Thereafter, the aqueous layer was then removed. The procedure was repeated three times to ensure complete removal of most gums[10].

Neutralization

This was done to remove the free fatty acid. 100 cm^3 of the degummed oil was poured into a beaker and heated to 150 ^{0}C, after which 150 cm^3 oil of 0.1 M NaOH was added and stirred to obtain a uniform solution. 10 g of sodium chloride was added to salt out the soap formation. This was further transferred into a

37

separating funnel and allowed to stand for 1 h. The soap formed was separated from the oil. 50 cm^3 of hot water was added and used to wash the oil solution several times until the soap remaining in the solution is removed. The neutralized oil was then drawn off into a beaker and heated in a heating mantle at 150 ^{0}C for 50 min to remove the water completely from oil[10]. The neutralized oil was characterized for its physicochemical properties.

Physicochemical Properties of A. africana Oil

All the test done for physicochemical chemical properties of *A. africana* were according[10]. The tests performed were iodine value, pH, free fatty acid, saponification value, peroxide value, acid value, odour, specific gravity, ash content, moisture content and colour. The test was tabulated in Table 2.0.

Table 2: Physicochemical Properties of *A. africana* Oil

Properties	Values
Yield (%)	30.14±0.20
Specific gravity	0.806±0.01
Moisture content (%)	1.24±0.15
Refractive index (40°C)	1.47±0.02
pH	4.37±0.21
Colour	Yellow
Viscosity (mm^2/s) at 25°C	30.37±0.15
Ash content	3.33±0.10
Iodine value (g/100g)	121.2±0.31
Peroxide value (meq/kg)	6.82±0.02
Acid value (mgKOH/g)	4.4±0.01
Saponification (mgKOH/1g)	100.16±0.15
FFA	2.2

Values are mean±SD of duplicate determinations

Preparation and Characterization of Catalyst

The waste snail shells were collected from different restaurants in Bida. The collected shells were washed and dried in a hot air oven at 120 ^{0}C for 24 h. The dried shells was pulverized in a mortar until they become powered.

38

The powdered snail shells was clalcined in an electric furnace at different temperature 100, 200, 300, 400 500 and 600 ^{0}C for 6 h. The weight change after calcinations process was noted. The percentage weight loss was calculated according to the equation;

$$\% \text{ Weight Loss} = \frac{W_1 - W_f}{W_1} \times 100\%$$

Where W_1 = initial weight

W_f = final weight

% yield = 100 - %weight loss

The powdered calcined snail shells was then sieved with a mesh size of 105 – 110 μm and kept in a desiccator to prevent moisture. The powdered calcined shell containing calcium oxide (CaO) was characterized for thermogravimetric analysis (TGA) to determine the calcinations temperature and time. The elemental composition of the calcined powdered shells was determine using x-ray fluorescence (XRF), the functional group was analyzed using Infrared Ray (IR). The morphology was analyzed using scanning electron microscopy (SEM), while the crystallinity is determined using Brunauer Emnet Teller (BET) analysis.

Transesterification by Heterogeneous Catalysts from Snail Shells

The oil extracted from *A. africana* seed was transesterified by one step alkaline transesterification process because the oil has low fatty acid content less than 3%. 100 g of the *A. africana* oil seeds was heated to 60 ^{0}C and 100 cm^3 of methanol followed by addition of 3 w% of CaO prepared from snail shells. The reaction was carried out under reflux at a stirring speed of 200 – 350 rpm. The mixture was stirred at all time throughout the transesterification process.

An electronic temperature controller was used to vary the reaction temperature in the range of 50 – 70 ^{0}C, reaction time 40 – 65 min. After the reaction time was over, the catalyst is filtered out and the product was poured into a separation funnel and was left overnight for separation of methyl ester and triglyceride to occur.

After separation the lower layer which is triglyceride (glycerol) is drawn out of separating funnel and the methyl ester was the product obtained which is biodiesel. The biodiesel yield is calculated as;

$$\text{Yield (\%)} = \frac{\text{Raw } D. oliveri \text{ oil seed (g)}}{\text{Biodiesel (ester) weight (g)}} \times \frac{100}{1}$$

RESULT AND DISCUSSION

The percentage oil yield and the physicochemical properties of the extracted oil were determined. After the extraction it was found that the seed contains 30.5% of oil, which was slightly higher than 28.5% reported

39

by[11]. The variation in the oil yield could be attributed to the extracting solvent, difference in variety of plant, cultivation climate. In this study petroleum ether was used using soxhlet extractor. The results of the physicochemical properties of *A. africana* oil seed is presented in table 2.0.

The resources of the physic-chemical properties of *A. africana* oil shows that the seed contain appreciable quantity of oil that is enough for the commercial production of biodiesel. The free fatty acid (2.2 mgKOH/g). The oil has low fatty acid which is less than 3%. This low value is as a result of refining process of the oil[12]. The oil with high fatty acid above 3% need to be esterified with acid between transesterification. In this study one step alkaline transesterifcation is used because of the low fatty acid[13].

The peroxide value obtained in the analysis is below those reported by Akpan *et al.*[14] which are 28.8 mg/kg and 126.4 mg/kg for avocado and native pears respectively. Peroxide value correlates with the extent to which oxidative rancidity has taken place in oil, and thus a measure of the shelf life of the vegetable oil. With the low peroxide value obtained it shows that the oil is not highly oxidized and therefore will be generally acceptable for the absence of odor and flavor in its content[15]. Pearson reported that oil become rancid when peroxide value range from 20.0 to 40.0 mg/g. Therefore it has a los susceptibility to oxidative rancidity

and deterioration as confirmed by the peroxide value which also serves as indicators of the presence or high levels of anti-oxidants in the oils.

The acid value is a measure of total acidity of system, which may involve contributions from all the constituent fatty acids that make up the glyceride molecule. It is a measure of the extent to which the triglycerides in the oil have been decomposed by lipase action into free fatty acids; Acid value depends on the degree of rancidity which is used as an index of freshness[16]. The acid value of oil may be used as a measure of quality.

The acid value of 4.4 mg/g was obtained for the *A. africana* seed oil which is low compare to that of breadfruit seed oil that is 7.38 mgKOH/g but higher than that of butter oil which is 1.79 mgKOH/g[17] but are lesser than those of cashew nut. 10.7 mgKOH/g[18]. avocado seed oil 16.8 mgKOH/g. The low acid value suggest that the oil may be good for paint making[14]. The lower the acid value of oil, the few fatty acid it contains which makes it less exposed to the phenomenon rancidity[19].

However, the acid value of the oil must be too high, as this denotes an excessively high content of free fatty acids, which causes the oil to turn sour. It is a common knowledge that these parameters are a measure of the level of spoilage of oil, so that fact that they are of low

40

magnitude is a reflection of the freshness and edibility of the crude oil[6].

The iodine value of 121.2 $\pm$ 0.31 mg/g was obtained for *A. africana* seed oil. Hence, the *A. africana* seed oil contains high percentage of unsaturated fatty acids. However, the iodine value of the oil is in agreement with the standard, thus, the oil could be classified as drying oil, since their iodine value are greater than 100[20].

The saponification value obtained for *A. africana* seed oil is (100 mgKOH/g) mg. The high saponification value indicates that the oil contains a high degree of triglycerides and higher molecular weight fatty acids, which indicates that the oil may be good for soap making. According to Ezeagu *et al.*[21] a saponification value of 200 mgKOH/g indicates high proportion of fatty acids of low molecular weight. This shows that the oil may have a potential for use in soap making and cosmetics industry.

The moisture content obtained for *A. africana* oil is (1.24 $\pm$ 0.15). This value is significantly higher than that of seasane oil (1.2) but lower than those reported for neem oil (4%)[12], castor oil (8%), neem seed oil (7.6%) and shea butter oil (10%) and also comparable to 9.4% low pea and 7.8% green pea[22]. High moisture content in a seed reduces it quality and the oil yields.

The refractive index of *A. africana* oil is (1.47 $\pm$ 0.02) from this result the value are in consistent with that of cotton seed oil is 2.45$\pm$ 0.05 reported by Oderinde *et al.*[23] for the production of biodiesel. The refractive index of oil increases with increases in unsaturation of its component fatty acids.

The pH value of the oil as presented in Table 2.0 is (4.37 $\pm$ 0.01). This value is within the range according to Codex[24] for biodiesel production. The pH for this oil is less than seven is due to the presence of fatty acid content.

The colour of the extracted *A. africana* oil is yellow. This colour is acceptable for biodiesel production according to Codex[24]. Singh and Singh[25] reported brown colour for Jatropha oil for the product of biodiesel, Sanjay[26] reported brown yellow colour for neem oil for the production of biodiesel which are all accepted by Codex Standard for biodiesel production.

The ash content in *A. africana* oil is presented in Table 2, which shows that oil has low ash content of 3.33 $\pm$ 0.10. The low value is in an indication that the mineral contents are low[27].

Specific gravity, the density of oil is usually express as specific gravity and measured at specific temperature 20^0C[28]. It is an important property in diesel engine performance, since fuel injection operates on a volume metering by stem. From this study the specific gravity of *A. africana* oil is reported as (0.806 $\pm$ 0.1).

41

This values is in agreement with values of $(0.83 g/cm^3)$ cotton reported by Yahaya *et al.*[29].

Characterization of the Snail Shells

The weight loss during the calcination of the snail shells is presented in Table 3.0. The shells is calcined at different temperature of $(100^0C – 600 \, ^0C$ for 6 h). The carbon and oxygen content in the shells were lost after calcination under high temperature and time. More calcined sample is activated with a mineral acid. More than 40% weight loss were recorded after these temperature and time.

Table 3: Snail Shell Weight Loss after Calcinations

Time(hr)	Temp. (ºC)	Wt loss (%)	Yield (%)
1	100	48	52.00
2	200	45	55.00
3	300	43	57.00
4	400	42	58.00
5	500	41	59.00
6	600	40	60.00

The crystalline structure of the shell was changed after calcination. The change is as a result of decomposition of the calcium carbonate $(CaCO_3)$ present in the shell to give carbon IV oxide (CO_2) and calcium oxide (CaO) (Viriya *et al.*, 2010). As the temperature increases over the time, the yield also increase. The determination of chemical composition of the catalyst from the snail shells was performed using X-ray fluorescence (XRF) at temperature different of ranging from (100 – 600 ^0C) and results are shown in Table 5. CaO was derived from calcined snail shell. The CaO was derived from the calcined snail shell on a dry basis by XRF. The result shows that ash from snail shell mainly CaO (96.72%), considered a favorable base catalyst in biodiesel production with high basic strength, minor toxicity and easy reactions with water[30]. The remaining (3.28%) was composed of different metal oxides (MgO, SiO, P_2O_5, Na_2O, Al_2O_3, K_2O, FeO, Cr_2O_3, ZnO and SrO) in trace amounts. The acidic components

42

(P_2O_5, SiO_2 and SO_3) potential to mediate esterification of the oil free fatty acid content.

Table 4: Chemical Composition of Snail Shells with XRF

Compounds	CaO	MgO	SiO	P_2O_5	Na_2O	Al_2O_3	Cr_2O_3	TiO_2	SrO
%n concentration	94.00	1.30	1.20	0.8	0.3	1.5	0.9	0.1	0.2

The IR study of *A. africana* shows that the sample contains different functional groups. The functional groups ranging from hydrocarbon, carboxylic acid, amino and aromatic compound. The presence of (COOH) groups shows that the oils contain fatty acids. The wavelength of each of the functional group is presented in Table (5).

Table 5: IR Studies of *A. africana* Oils

Unrefined Wavelenght (cm^{-1})	Refined (Wavelength (cm^{-1})	Assignment
2285	2275	C – H stretch
1724	1720	NH_2 bending
1516	1516	C – O stretch
1901	1903	C = C bending
2918	2715	COOH rocking

The scanning electron microscopic (SEM) image of a CaO catalyst is shown in Figure 1.0. The morphology of CaO with irregular pores, shapes and size, varying from one surface to

43

another (3 – 6 μm of width). The shape of the calcined shell was formed by tiny crystals embedded on the large particles, probably due to the heterogeneous distribution in the mechanical properties of the snail shell used which can be regarded as an attribute of high catalytic activity[32]. This characterization heterogeneous morphology of CaO from calcined egg shell has been noted previously under similar conditions[33].
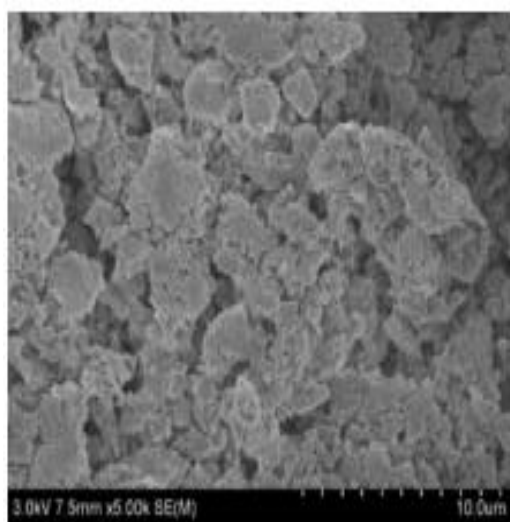
The prepared catalyst was characterized for (BET) analysis; the result is presented in Table 6. The pore size for the calcined shell is (81.52 A) with high surface area of (12.61 m^2/g) which allow reactants to diffuse easily into the interior of the catalyst. Birla[34] reported that a high pore size is desirable for better diffusion of reactant and product molecules. The observation is in agreement with that of Lee *et al.*[35] with a slightly higher value of (99.18 A) pore size of CaO catalyst.
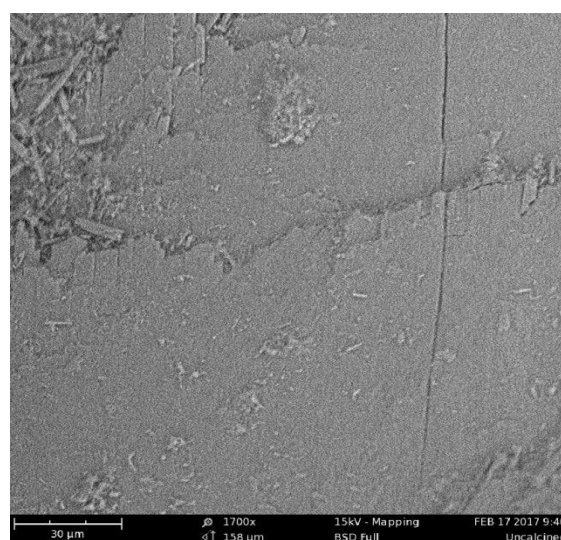

Figure 1: SEM Studies of Calcined Snail Shell

Table 6: Brunauer Emmett and Teller Analysis of Calcined SSC

Properties	Calcined
Pore size (A)	81.52
Pore volume (cm^3/g)	12.61
Specific surface area (m^2/g)	20.20

44

Optimization of process parameter for transesterification reaction

In this study, four process parameters affecting transesterification reaction namely methanol to oil ratio, temperature, catalyst and reaction time were determine for optional biodiesel production.

Effect of methanol to oil molar ratio Figure 2 Presented the effect of methanol to oil molar ratio. Optimum biodiesel was observed at
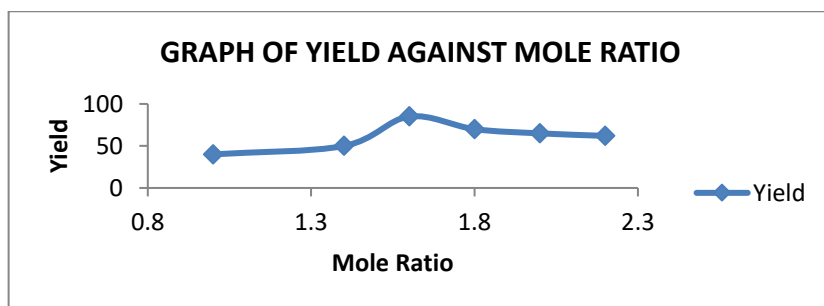
methanol to oil ratio of 6:1 and yield of 85%. An increase in mole ratio beyond the optimum mole ratio of 6:1 and yield of 85%. An increase in mole ratio of 7:1 had a negative effect on the yield. The yield decreased above this optimum point. Alamu *et al*[36] showed that the most suitable molar ratio was found to be within the range of 6:1 to 10:1, in the production of biodiesel using egg shell ash (CaO) as heterogeneous catalyst.

GRAPH OF YIELD AGAINST MOLE RATIO

Figure 2: Effect of methanol to oil mole ratio on the biodiesel yield. Reaction condition: catalyst concentration 1.50 wt%, reaction time 65 min, reaction temperature 55^0C.

Effect of Temperature

Temperature plays an important role during biodiesel production; this is because the rate of reaction strongly influenced by the reaction temperature. Figure 3 shows the result of temperature variation from $(20 - 75\ ^0C)$ at a catalyst concentration of 1.5 wt%. As the temperature increases from $(20 - 75\ ^0C)$ the conversion yields of biodiesel also increases considerably. Further increase in temperature result in decrease in the yield of biodiesel. In this study, optimum temperature for the production of biodiesel took place at $60\ ^0$C.

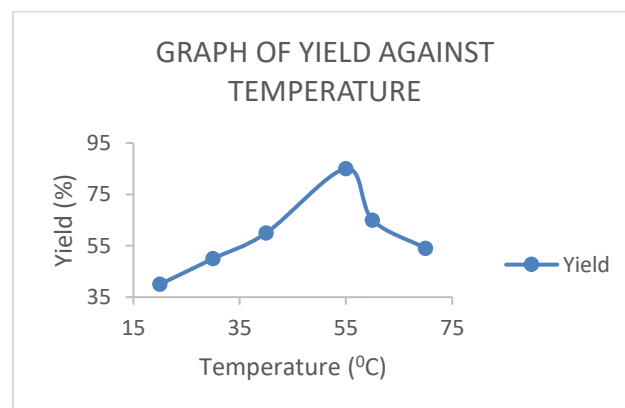**GRAPH OF YIELD AGAINST TEMPERATURE**

Figure 3: Effect of reaction temperature on the biodiesel yield. Reaction condition: catalyst concentration 1.50 wt%, reaction time 65 min, mole ration (6:1).

45

Effect of catalyst concentration.

From the result obtained from figure (4), the catalyst concentration increases from 0.5 – 1.5 wt%, a progressive increase in percentage conversion in the reaction was achieved and thereafter experienced a decrease in yield above this concentration (1.5 wt% of CaO). It was obvious that increased in catalyst concentration beyond 1.5 wt% of CaO result to decrease in biodiesel yield[34].
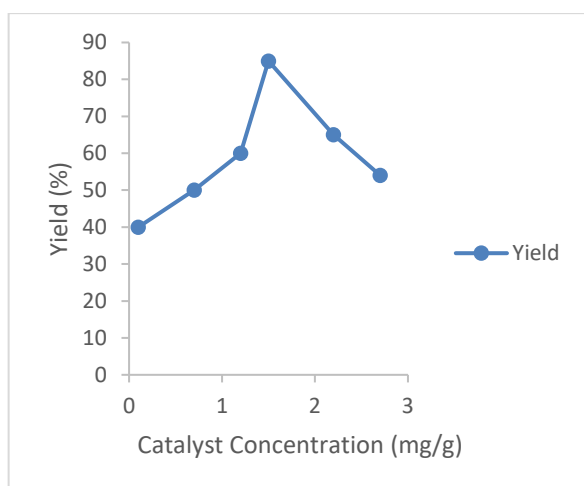

Figure 4: Effect of catalyst concentration on the biodiesel yield. Reaction condition: temperature 55^{0}C, reaction time 65 min, mole ration (6:1).

Effect of Reaction Time

Figure 5 reflects optimum transesterification time for *A. africana* seed oil. The maximum biodiesel yield was obtained at 65 min. the yield was found to be 85%. At first few minutes the reaction time was slow due to dispersion of interaction between molecules is still in progress[34]. As the reaction time increases, the yield also increased due to high effective collision occurring beyond the reaction time of 65 min. There is decreased in the yield of the feedstock.
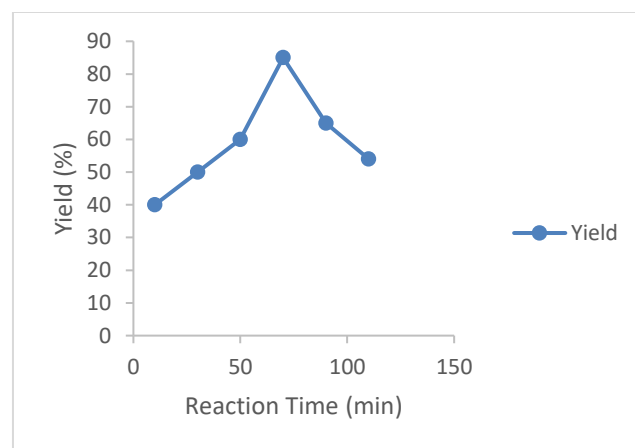

Figure 5: Effect of reaction time on the biodiesel yield. Reaction condition: temperature 55^{0}C, catalyst concentration 1.5 wt%, mole ration (6:1).

Fuel properties of the produced biodiesel

Some of the important fuel properties of the biodiesel produced from *A. africana* oil seed are compared with the biodiesel standard (ASTM 6751) and are presented in Table 7.

Kinematic viscosity is a measure of resistance of fluid flow under the influence of gravity[38]. The result from this work shows a kinematic viscosity of 4.49 $\pm$ 0.04 which is quite in agreement with the ASTM norms and the reported work. The result is however slightly higher than the European Norms (EN

46

standard) and ASTM standard for the kinematic viscosity of the fossil diesel. Viscosity of a fuel is related to the fuel lubricity. Low viscosity fuels are unlikely to provide satisfactory lubrication in fuel injection pumps; these often lead to seepage and increase in wear[38]. High viscosity in fuel are responsible for automization of fuel, incomplete combustion and increased exhaust emissions, choking of the injections thereby forming larger droplets on injector, ring carbonization and accumulation of the fuel in the engine[29]. The result from this study shows that biodiesel from *A. africana* seed oil can be used for biodiesel production

Specific gravity of the fuel is very important in diesel engine because fuel injection system operates on a volume metering basis. The values of specific gravity obtained for *A. africana* seed oil methyl ester was 0.86 ± 0.02 with a corresponding density value of 860 kg/m^3. This value lies within the notable standards and also in close proximity to the findings of other studies[39].

Flash point is the minimum temperature at which a fuel must be heated for it to ignite air-vapour mixture. The U.S. Department of Transportation specified 90 ^{0}C as the flash point for non hazardous fuel[39]. The flash point for this work is 165 ^{0}C. This result shows appreciable consistency with both ASTM, EN

standard for biodiesel and works of other researchers. The high value obtained in this study clearly signifies that the biodiesel produced in basically free from methanol; this is because even small quantity of methanol can reduce the flash point reasonably and also negatively affects diesel engine parts such as fuel pumps, seals and elastomers.

Cetane number is a measure of ignition quality of diesel fuel. The higher the cetane number, the easier the fuel will ignite when it is injected into the engine the better the fuel. Beside the reduction of viscosity resulting from transesterification of vegetable oil, one of the most evident changes that result from process is the significant increases in the cetane number of the fuel produced. This work indicates that the cetane number was 51.20. The value obtained is in agreement with both ASTM and EN standard. This implies the *A. africana* biodiesel produced to have high ignition quality[40].

The cloud and pour point are criterion used for low temperature performance of a fuel. This work report a values -11.10 $\pm$ 0.10 ^{0}C and -7.8 $\pm$ 0.07 ^{0}C for cloud and pour point respectively and the reported literatures. This properties help to show the behavior of the biodiesel under a specified climate setting. This shows the biodiesel produced from *A. africana* can be used in cold climate region[41].

Table 7: Comparism of biodiesel properties with ASTM standard

Property	Biodiesel (AaO)	ASTM 6751	Diesel
Ash content (wt %)	0.03 ± 0.01	0.05	-
Flash point (^{0}C)	165.17 ± 1.34	100 - 170	70 – 100
Acid value (mgKOH/g)	0.03 ± 0.01	0.05	0.02 – 0.05
Pour point (^{0}C)	-7.8 ± 0.07	-10	-
Viscosity (mm^2/s)	4.49 ± 0.04	1.9 – 6.0	5.0
Water content (%)	0.02 ± 0.01	0.05	
Cetane number	51.20 ± 0.01	48 – 65	

Values are mean $\pm$ SD of triplicate determinations.

CONCLUSION

Afzelia africana seed oil is suitable for the production of biodiesel which has similar properties to petrol diesel. The oil yield of the seed is about 30.5% which is high compared to other oil seeds. The optimum perimeters for the biodiesel production was recorded at methanol to oil ratio (6:1), temperature (55 ^{0}C), catalysts concentration (1.5 wt) and reaction time (65 min) to give the highest yield of 85%. The result of the physiochemical properties shows that the oil is suitable for the production of biodiesel. The result of the fuel properties shows that the fuel fulfills most of the ASTM standard, so can be used as a possible alternative for petroleum fuel. The waste snail shell contains high percentage of $CaCO_3$ which can be used as an alternative catalysts to the conventional (NaOH and KOH). The heterogeneous catalyst synthesis from the snail shell is cost effective compare to (NaOH and KOH).

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48

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