Production of Biodiesel from Groundnut Crude Oil

Makasson R. Cland[1], Offong O. Aniekan[1], Muhammad A. Tahir[3], Ogbaka T. David[4*]

[1,3,3]*Department of Science Laboratory Technology, College of Science and Technology. Adamawa State Polytechnic, Yola. Adamawa State, Nigeria*

[4]*Department of Pure and Applied Physics, Adamawa State University, Mubi, Adamawa State, Nigeria*

**Corresponding Author*

Abstract: **Groundnut oil is an organic material oil derived from groundnuts and it has been noted to have the aroma and taste of its parent legume. The study therefore produced biodiesel crude groundnut oil through alkali catalyzed transesterification using methanol, in the presence of Sodium Hydroxide (NaOH). The physiochemical parameter of biodiesel was characterized and from the results obtained, the methyl ester produced can be effectively used in a diesel engine since the value is within the range of the required standard. Groundnuts oil has biodiesel optimum yield of 93.9% and the fuel properties of the biodiesel are close to that of petroleum diesel and hence can be used as alternative fuel.**

Keywords: **Biodiesel, fossil fuels, ground nut oil, transesterification, vegetable oil, greenhouse gas, global warming.**

I. INTRODUCTION

Groundnuts (*Arachis hypogaea*), is a significant subsistence and food crop in sub-Saharan Africa. Groundnuts are grown in practically every country, with the continent accounting for roughly a quarter of the world's production. Nigeria is the largest groundnut producing country in West Africa, accounting for 51% of production in the region. The country contributes 10% of total global production and 39% that of Africa [1].

Groundnut oil is an organic material oil derived from groundnuts and it has been noted to have the aroma and taste of its parent legume.

It is major component fatty acids are oleic acid (46.8% as olein), linoleic acid (33.4% as linolein), and palmitic acid (10.0% as palmitin). The oil also contains some stearic acid, arachidic acid, arachidonic acid, behenic acid, lignoceric acid and other fatty acid [2, 3]. The replacement of mineral fuel by biodiesel is one of the effective ways of solving the problem of saving and effective usage of energetic resources. Biodiesel is becoming an increasingly acceptable alternative to fossil diesel because of narrowing gap between worldwide oil production and consumption. Also, Nigeria's vegetation and rainfall regime support agrarian activities that can produce feedstock for biofuel production. Sustainable biofuel production will create more jobs and stimulate related industries thus improving the socio-economic industries of the country [4]. The surge of interest in biodiesel has highlighted a number of positive environmental effects associated with its use. These potentialities include reduction in greenhouse gas emission, deforestation, pollution and the rate of biodegradation [5]. Biodiesel is a non-petroleum based fuel made from virgin or used vegetable oil (both edible and non-edible) and animal fat. The main sources or biodiesel can be non-edible oils obtained from plants species available in different countries. Direct application of vegetable oils as fuel for diesel engine is not possible due to its higher viscosity, hence reduction of vegetable oil viscosity is an urgent need. The viscosity of vegetable oils can be reduced by using different methods, namely blending, pyrolysis, micro-emulsification and transesterification [6, 7].

However, transesterification methods have been widely used to reduce the viscosity and improved the fuel property of vegetable oil. Transesterifiction is the process of biodiesel production which involves the reaction of fat/oil with alcohol in the presence of acidic, basic or enzymatic catalyst to form esters and glycerol [8].

Biodiesel generally is an ester produced from transeseterification by reacting vegetable oil with alcohol. It is biodegradable, non-inflammable, non-toxic and free of sulfur and aromatics. It shows favorable combustion emission profile producing less carbonmonoxide, sulfur oxides and unburned hydrocarbons than petroleum based diesel. Although, the diversity of oils and fats as sources of diesel fuel had been investigated and reported, however, an important aspect again today and striving for energy independence were reflected in other historic investigations [2].

The properties of biodiesel can be influenced by several factors such as fatty acid composition of the parent vegetable oil or animals fat, the quality of the feedstock in the production process and other materials used in the process as well as post-production materials. Biodiesel is a mixture of fatty acids with each contributing to the properties of the fuel [9]. The nature of fuel component ultimately determine the fuel properties in a particular biodiesel. The properties of biodiesel fuel that are determined by the structure of its component fatty esters include the following: density, viscosity, lubricity, cold flow properties cloud and pour point [10]. Other properties that affect biodiesel fuel properties include: flash point, specific gravity, acid number, moisture content [11].

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Over the years, Nigeria has faced a crisis of oil supply and unpredictable prices due to its dependence on fossil fuels. The unpredictable rise in oil prices, increasing global demand, declining supply of oil reserves, and the threat of global warming and climate change due to combustion engine emissions highlight the energy crisis and challenges facing the world today. Use of fossil fuels lead to increase in greenhouse gases which has lead to destruction of ozone layer and contribute to climate change. These problems provide adequate reasons and incentives to focus on renewable energy alternatives to fossil fuels. Diversification of renewable energy sources such as solar energy, wind energy; geothermal energy and biofuels have not been utilized.

Groundnut seed contain high quality edible oils, protein, and carbohydrate. Globally, 50% of groundnut produced is used for oil extraction, 37% for confectionary use and 12% for seed purpose. The fat in the oil is approximately 50% monounsaturated, and 30% polyunsaturated [14] (Graboski *et al.*, 1998). In comparison, groundnut oil has been reported of having capacity to produce approximately 123 gallons of biodiesel per acre while soybeans yield only 50 gallons [11]. Biodiesels offer a significant opportunity for further reductions in dependence on fossil fuels and reduction of greenhouse gas emissions that contribute to environmental pollution, destruction of ozone layer and global warming.

II. MATERIALS AND METHOD

2.1 Equipment and Chemicals

The materials for study comprises of conical flask, Thermometer, Water bath, Beaker, fresh groundnut oil, KOH, Methanol, reactor, and Distilled water, sodium hydroxide,GC,FTIR.

2.2 Production of Biodiesel (Transesterification)

Production of biodiesel from groundnut oil was carried out in accordance to the experimental procedure reported by [15]. Methoxide will first prepare in a suitable container by dissolving sodium hydroxide catalyst in methanol. For all test runsthe variation of catalyst concentration were carried out at 0.4, 0.5, 0.8, 1.0, and 1.2w/w% while the temperature, time and stirring speed were kept constant at 60°c, 90minutes,and 300rpm.And 6:1 methanol to oil mole ratio was used. The mixture of catalyst and methanol was added to the oil in the reactor and the mixture was stirred for 90 minutes. This processes was repeated for the five test runs that was carried out after reaction time will be reached, the reaction mixture was poured into a separating funnel and allowed to settle gravitationally for about 8-20hrs. After settling, a lighter colored biodiesel on top of a layer of darker glycerin was observe. The bottom layer (glycerol) was drained off and the top layer (methyl esters) was collected in a clean beaker.

Properties of the feedstock tested for are the specific gravity (or density), flash point, kinematic viscosity, acid value, iodine value, sulphur content, moisture content, free fatty acid and acid value. Determination of these properties will be carried out using the experimental description reported by [16]. Next to the preliminary production of biodiesel from groundnut oil will be process optimization by investigating the effects of various parameters on the yield of biodiesel from groundnut oil.

2.3 Sample Analysis

The biodiesel produced was analyze to determine the specific gravity, flash point, cloud point, kinematic viscosity, pour point, centane number, acid value, bottom water and sediment, sulphur content, ash content and distillation characteristics. All experimental analysis will be conducted in triplicate and the results reported are the average values with average deviation of ±0.0015.

III. RESULTS AND DISCUSSION

In this research catalyst concentration were varied and the yield of biodiesel was investigated, the result obtained were shown in table 3.1 below and fig. 3.1 above it shows that the greater the weight of the catalyst, the higher the yield at the fixed reaction ratio with increase in number of catalyst it will increase the reaction speed so that the yield increases. Large amount of catalyst will reduce the activation energy that will lead to low biodiesel yield. Highest yield was noticed at the catalyst concentration of 0.9 %w/w which gives 93.9% yield.

Table 3.1: Effects of catalyst concentration on yield of biodiesel

S/N	KOH Catalyst (w/w%)	Mass of BD(g)	Yield(%)
1	0.3	129.40	64.70
2	0.5	146.57	73.29
3	0.7	154.20	77.10
4	0.9	184.80	93.9
5	1.2	112.13	56.07

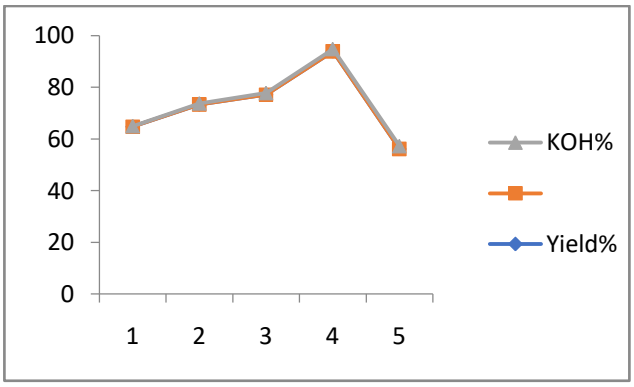


Figure 3.1: Results of the FTIR analysis of Fresh Groundnuts Oil BD Extract

From the FTIR analysis of fresh groundnuts crude oil extract, it shows that the functional group alkene (C=C) was best

depicted at the wave length of 1456.2 cm^{-1}, alkane (C-H) was sharpest at the wave length of 2857.0 cm^{-1}, esters (C=O) is sharpest at the wavelength of 1744.1 cm-1, and alcohol is sharpest at the wave length of 2921.7 cm^{-1}.

Table 3.2: Fourier Transform Infrared (FTIR) Spectral peak values and Functional groups for G BD extract

Wavelength/ Transmittance	Functional group	Characteristic absorptions	Intensity
1164.1 cm^{-1}, 11.80%T	C-O	1000-1100	Strong
1369.5 cm^{-1}, 20.85%T	-C-H	1000-1200	Variable
1456.2 cm^{-1}, 14.91%T	C=C	1000-1250	medium-weak, multiple bands
1744.1 cm^{-1}, 1744.1%T	C=O	1000-1900	Variable
2407.9 cm^{-1}, 7.34%T	C-H	2000-2250	Strong
2857.0 cm^{-1}, 5.98%T	C-H	2000-2900	strong, very broad
3458.3 cm^{-1}, 2.71%T	C-H	2000-2980	strong, very broad
2921.7 cm^{-1}, 87.83%T	O-H	3000-3250	Strong, broad

Alkene: =C-H, C=C Alkyl Halide: C-F Alkane: C-H, -C-H Ester: C=O Alcohol: O-H and C-O

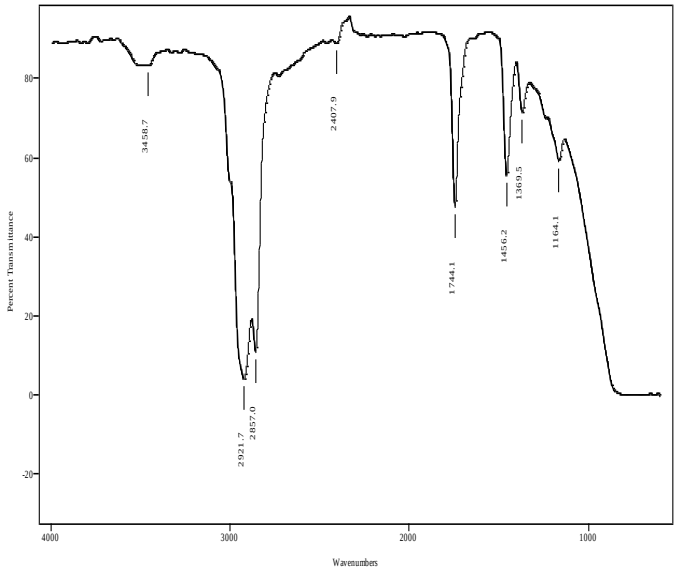
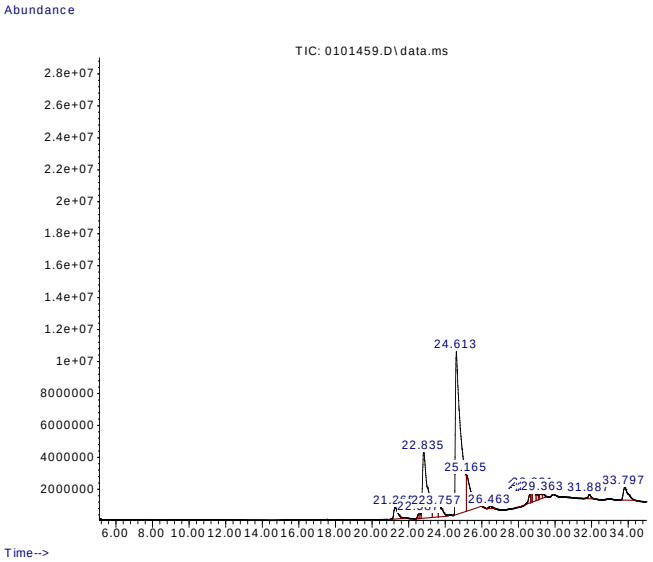


Fig. 3.2: Fourier Transforms Infrared (FTIR) Spectral Peak Value and Functional Groups for Fresh Groundnuts Oil BD Extract.

From table 3.3, fresh groundnuts crude oil extract show seven different compounds which were obtained from the GC-MS analysis with their retention time, percentage area, molecular weight, molecular formula and their compounds are: Hexadecanoic acid,(2.87) Palmitoleic acid, (0.44)ethyl 6-Octadecenoic acid (0.28), oleic acid (0.65), and Cis-13-0ctadecanoic acid with 9,12-octadecadienoic acid (Z,Z)-(18.54), which has the highest percentage area with a phenol functional group.

Table 3.3: Results of the GC-MS analysis of fresh groundnuts crude oil Extract

Retention time	Area (%)	Molecular weight	Compound name	Molecular Formula
21.264	2.87	284.477 Da	Hexadecanoic acid ethyl ester	$C_{18}H_{36}O_2$
22.834	18.54	280.445	9, 12-Octadecanoic acid (z, z)-, methyl ester	$C_{18}H_{32}O_2$
26.463	0.44	254.41	Palmitoleic acid	$C_{16}H_{30}O_2$
29.026	0.65	282.461	Oleic acid	$C_{18}H_{34}O_2$
28.722	0.71	254.494	Octadecanoic acid	$C_{18}H_{36}$
23.375	2.38	308.499	Linoleic acid ethyl ester	$C_{20}H_{36}O_2$
28.670	0.28	282.5	Cis-13-0ctadecanoic acid	$C_{18}H_{32}O_2$



Pour point on the other hand is the temperature at which the amount of wax that comes out of solution is sufficient to gel the fuel and prevent it from being poured hence not able to flow. The pour point from the groundnut oil biodiesel was 8.2^{o}C. Flash point is the measure of flammability of fuels and thus an important fuel safety criterion. The biodiesel oil had a flash point of 139.03℃ and this satisfies the standard. Viscosity is an important property of biodiesel since it affects the operation of fuel injection equipment, particularly at low temperatures when the increase in viscosity affects the fluidity of the fuel or leakage at high temperature when too thin (Bello et al., 2011). The kinematic viscosity of biodiesel produced was 4.54mm^2. Calorific value is the among of energy produce by the complete combustion of material of fuel. Calorific value of this oil was found to 38.74j, ASTMD5865.

IV. CONCLUSION

Biodiesel was successfully produced from fresh groundnuts oil through alkali catalyzed transesterification using methanol

in the presence of NaOH. The physiochemical parameter of biodiesel was characterized and from the results obtained, the methyl ester produced can be effectively used in a diesel engine since the value is within the range of the requirements standard of ASTM D 6751. Obtaining higher percentage yield of product depends upon the quality of the oil used and its treatments. Groundnuts oil has biodiesel optimum yield of 93.3% and the fuel properties of the biodiesel are close to that of petroleum diesel and hence can be used as alternative fuel.

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