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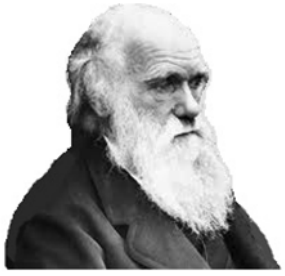

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Production and characterization of biodiesel from coconut extract (*Cocos nucifera*)

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ABSTRACT

In this study, oil was extracted from coconut. The extracted oil was used to produce biodiesel and the oil and the biodiesel produced were characterised. Biodiesel fuels are alternative diesel fuels usually obtained from renewable sources, mainly, vegetable and animal oils. Oil was extracted from coconuts bought from a local market in Wukari Taraba State, Nigeria, by means of the solvent method. The extracted coconut oil was then characterized. This showed that the coconut oil has a density of 0.91 g, viscosity of 23 mm^2/s, saponification value of 191 mg KOH/g, iodine value of 10 mgl_2/g, acid value 1of 4.0 mg KOH/g and flash point of 266 °C. The biodiesel of the oil was produced using a transesterification process. The biodiesel was also characterized. Results obtained showed that the biodiesel has a density of 0.89 g, viscosity of 2.83 mm^2/s, acid value of 0.18 mg KOH/g, saponification value of 91 mg KOH/g, iodine value of 8 mgl^2/g, acid value of 0.18 mg KOH/g and flash point of 110 °C. The physicochemical properties of the biodiesel produce from coconut oil is comparable with that of standard biodiesel in the range of ASTM specifications

***Keywords*:** Biodiesel, fuels, renewable energy, coconut, oil

1. INTRODUCTION

Fuel and energy crisis and the concern of the society for the depleting world's non-renewable energy resources led to a renewed interest in the quest for alternative fuels. The first use of vegetable oil in a compression ignition engine was first demonstrated through

Rudolph Diesel who used peanut oil in his diesel engine. The use of oils from soy bean, sunflower, safflower, peanut, linseed, rape seed and palm oil amongst others have been attempted. As the world population continue to increase annually, the demand for petroleum is also increasing with each day. Due to the limited resources of petroleum crude, it becomes a necessity to search for an alternative fuel which is renewable. The world requires fuel that can be easily transported with low toxic emission, low greenhouse gases, greater efficiency of energy use, less dependence on foreign oil imports and affordable.

Through transesterification, the oil is converted to the alkyl esters of the fatty acids present in the coconut oil. These esters are commonly referred to as biodiesel. Biodiesel is an alternative fuel that is renewable in the sense that its primary feedstock has a sustainable source. Some other feedstock's that can be converted to biodiesel are waste restaurant grease and animal fat.

In view of the current instability in oil prices, biodiesel stands as an attractive source of alternative energy. By adopting and increasing the use of biodiesel, Nigeria will also be free from her over-dependence on crude oil reserves. Besides, conventional fossil fuel has been reported as being finite. While it is worthy to note that biodiesel will not completely displace petroleum diesel, biodiesel has its place as an alternative fuel and can be a source of lubricant as an additive to diesel fuel. The emissions produced from biodiesel are cleaner compared to petroleum-based diesel fuel. Particulate emissions, soot, and carbon monoxide are lower since biodiesel is an oxygenated fuel. Seed are fertilized ovules with embryo and can geminate into new plant with the exception of a few plants. Seed contain the greatest concentration of the proteins, fat and oil present in plant. Fat and oil are carboxylic esters (trimesters) derived from glycerol ($HOCH_2OCHOHCH_2OH$) and are known as glycerides or triglycerides. Fat and oil could be in the form of simple triglycerides which the fatty acids are identical or mixed triglycerides in which the fatty acids are not the same. Examples are ester of stearic acids and ester of oleic acids.

Coconut oil

Coconut oil or copra oil is edible oil extracted from the kernel or meat of mature coconut harvest from the coconut palm. It has various applications as food, cosmetics and in the production of bio fuel. Because of it high saturated fat content, it is slow to oxidize and thus resistant to rancidification lasting up to six month at 24 °C (75 F) without spoiling. The production of coconut oil can be obtained in two ways i.e. dry process or wet process. The significance of this research work is to produce alternative source of energy which is less expensive, deliver lower toxic emission, lower greenhouse gases, greater efficiency and a friendly habitat for human. This alternative energy source shied away the fossil fuel dependence in the world. The world is depending on fossil fuel as the source of energy in which these sources of energy is not renewable and also deliver high toxic emission, high greenhouse gases leading to global warming.

In fact, because of the increase in world population annually, the concentration of fossil fuel deposit is forecasted to finish in few decades from now. These problem post effects to our environment and at the same time create an unfriendly habitat for both man and plants.

The aim of this project is to synthesise an alternative source of energy which would fuel our vehicle, power our generators, without any major modification in the vehicle. It is meant at producing a power source that is less expensive, renewable, clean burning, and thereby reducing global warming.

2. MATERIALS AND METHODS

Equipment and apparatus

Oven, Weighing balance, Rotary evaporator, Clinical flask, Shaker bath (temperature controlled), Reflux set up, Separating funnel, Burettes, Hot plate, Thermometer, Viscometer, Density bottle, Flash point tester, Beaker, Volumetric flask, Retort stand, Clamps.

Sample collection

The sample, coconut was purchase at Wukari modern market, Taraba state, Nigeria.

Drying

The drying of coconut for the production of biodiesel can be achieved by any of this means; oven drying, sun drying or shade drying.

For this research work, oven drying was adopted.

Extraction

Two methods can be used in the extraction of oil from coconut; mechanical method or solvent extraction. Solvent extraction method was used in this case.

Chemicals /Reagent

All the reagents used for this work were of analytical grade otherwise stated.

They includes potassium hydroxide (KOH), methanol (CH_3OH), coconut oil, hydrochloric acid (HCl), phenolphthalein, starch, potassium iodide, cyclohexane, wijjis solution, sodium thiosulfate ($Na_2S_2O_3$), sulphuric acid, diethyl ether, phenolphthalein.

0.5 M alcoholic potassium hydroxide, 0.2 M hydrochloric acid, 0.1 M potassium hydroxide, 1% Glucose, 10% potassium iodide, 1% phenolphthalein, 0.1 M sodium thiosulfate

Transesterification of coconut oil

Potassium methoxide was prepared by dissolving 0.5 g of KOH in 100 cm^3 of methanol. 20 ml of coconut oil was mixed with 100 cm^3 of potassium methoxide and stirred at 600 rpm and a reaction temperature of 50 °C for 2 hours in a volumetric flask. The mixture was poured into a separating funnel and allowed to stay overnight for the reaction to be completed and for the mixture to separate into two layers of biodiesel and denser glycerol at the bottom. The glycerol was drained off and the biodiesel was washed with distilled water stir gently to remove impurities such as diglycerine and monoglycerine, catalyst, soap and excess methanol, which can affect combustion and exhaust emission (Canakci and Van Gerpen, 1999). It was allowed to settle for 2 hours to separate into two layers of pure biodiesel and hydrated methanol, which was separated using separating funnel.

Heating of the oil

In order to speed up the reaction, the oil was heated. The ideal temperature range is 120-140 F. The reaction can take days at room temperatures and will be inhibited above 140 F.

Heating with electric elements was the easiest way to bring up the oil up to temperature required.

Mixing of methanol and catalyst.

The purpose of mixing methanol and the catalyst (KOH) is to react the two substances to form methoxide. Methanol and KOH are dangerous chemicals. Therefore care was taken not to touch skin when handling. KOH does not readily dissolve into methanol and KOH was slowly added to it. The methoxide was ready to be used when the particles of KOH cannot be seen. The mixing process was achieved between 20-30 minute.

Draining of glycerol

After the transesterification reaction, theglycerol was allowed to settle at the bottom of the separating funnel. This happen because glycerol is heavier than biodiesel. The settling begins immediately but the mixture was left a minimum of eight (8) hours preferably 12 hours to make sure all of the glycerol has settled out. The glycerol volume was approximately 20% of the original oil volume.

Washing of biodiesel product

The product of the transesterication reaction contains some impuritieslike un-reacted methanol; potassium methoxide and possibly potassium alkylate (soap). Therefore, it needs some form of purification before it can be used in diesel engine. Since all the impurities are polar group, water is a suitable solvent for dissolving. The following procedure was used in washing the biodiesel.

20 cm^3 of water measured using a measuring cylinder and poured gently on the product sample. The mixture was gently stirred to avoid foam formation. Shaking rigorously is not advised. The mixture of water and biodiesel was left for 16 hours to settle into two phase via; water-impurities phase and biodiesel phase. The two phase mixture was then separated using a separating funnel. The biodiesel layer was then heated to about 100 °C for 1 hour to evaporate the remaining water molecules in it. (Yusuf and Sirajo, 2009)

Determination of density

This was achieved by used of weighing balance, density bottles and circulating bath.

Procedures: The density bottles were washed, dried and marked. Some amounts of the test samples were put into the density bottle and after which the weight is taken.

Weight of empty density bottle = A

Weight of bottle + water = B

Weight of bottle + oil = C

The respective densities were then calculated from the results gotten.

Density = mass/weight of oil/ volume of oil

Specific gravity = weight of xml of oil/ weight of xml of water
= C-A/B-A

Determination of viscosity

This was done by preparing 1% glucose solution in 100 ml volumetric flask used as the standard. The flow rate of 1% glucose solution was determined using a 10 ml syringe. The flow rate of the test samples was determined using the same syringe. The viscosity of the test samples was calculated using the equation

$$V_s/V_o = F_s/F_o$$

where: V_s = Viscosity of sucrose, V_o = Viscosity of oil, F_s = flow rate of sucrose, F_o = flow rate of the oil.

Determination of the acid value (AOAC, 1990)

The acid value is the number of milligram of KOH necessary to neutralize the acid (free organic acid) in one gram of the sample. It is a measure of the free fatty acid present in an oil samples.

Procedures: 2 g of the test samples were weighed into a conical flask, 50 cm^3 petroleum ether added and mixed gently, 50 cm^3 ethanol was added into the mixture and titrated with 0.1 M KOH to pink colour.

Calculation:

Acid value (mg KOH/g) = titre value × normality × 56.1/weight of sample

% free fatty acid = titre value × 28.2 × normality/weight of sample

1 cm^3 of 1 M KOH = 56.1 mg of KOH

Determination of saponification value

This is the number of milligram of KOH required to react completely to saponify 1 g of oil. It is inversely proportional to the molecular weight of a sample; therefore, could be used to access the molecular weight of the sample oil under determination.

Procedure: The saponification value was determined by weighing 2 g of the test samples into a round bottom flask and 25 cm^3 alcoholic KOH added.

The flask was then fitted onto a condenser and the solution refluxed for 10 min, 1 cm^3 of phenolphthalein was added to the refluxed mixture and titrated with 0.2 M HCl and the titre value was recorded.

This was repeated with 25 cm^3 KOH as blank and the test titre value taken. The difference between the blank and the tested titre gives the amount of KOH absorbed by the oil.

Calculation:

Saponification value = (S-B) × M × 56.1 / weight of sample used (g)

where: B = Blank titre value, S = sample titre value, M = Molarity of the HCl, 56.1 = Molar mass of KOH.

1 cm^3 of 0.2 M HCl = 28 mg of KOH.

Determination of flash point

The flash point was determined by the used of the automatic pensky marten flash point tester. The samples was poured into the cup of the tester and covered. A flame or electric spark of specified size was directed to the cup at interval until the vapour above the sample ignited. The thermometer reading was recorded and the flash point corrected.

Determination of iodine value (AOAC, 1990)

About 0.26 g of the test samples was weighed into glass stopper flask and dissolved in 10ml cyclohexane. 20 ml of Wijjis solution was added and the flask was stoppered and allowed to stand for 30 minute in the dark at 25 °C after which 20 ml of 10% KI solution was added. The mixture was titrated witty 0.1 M $Na_2S_2O_3$ using starch indicator. A blank was carried out and the iodine value was calculated using the following equation

$$\text{Iodine value} = 12.69 \times C(V_1\text{-}V_{2)} / \text{weight (g) of sample}$$

where: C = concentration of $Na_2S_2O_3$ solution, V_1 = volume of $Na_2S_2O_3$ used in blank, V_2 = volume of $Na_2S_2O_3$ used in the determination.

3. RESULTS AND DISCUSSION

Results

The value shown in Table1 is the result of the characterization of the coconut oil, its methyl ester (coconut oil biodiesel) and ASTM standard for biodiesel. It summaries the result of the characterization, physic-chemical and fuel properties of coconut oil after transesterification

Table 1. Physicochemical and fuel properties of coconut oil after transesterification

Parameters	Coconut oil	Methyl-ester (Cocnut oil Bio diesel)	ASTM standard D6751
Density (g)	0.91	0.89	0.575 - 0.9
Viscosity 40 °C (mm^2/s)	23	2.83	1.9 - 6.0
Flash point (°C)	266	110	93 min
Acid value (mg KOH/g)	14	0.18	0.8 max
Iodine value (mg/l)	10	8	14 max
Saponification value (mg KOH/g)	191	91	120 max

4. DISCUSSION

Density: It is very evident that, the density of the coconut oil reduced from 0.91 to 0.89 after transesterification process to produce its biodiesel. Therefore, the density of the coconut oil biodiesel is within the range of ASTM standard.

Viscosity: Viscosity of the coconut oil prior to transesterification as seen in the table above Is reduced drastically after transesterification to 2.83 mm^2/s. However, the viscosity of the biodiesel is 2.83 mm^2/s which is low compared to the range of ASTM standard. Viscosity is one of the important criteria in evaluating diesel quality. High viscosity leads to operational problems including engine deposits.

Acid Value: This is the quantity of base required to titrate a sample to a specified end point. It is a measure of free fatty acid in the biodiesel. High acid value of the fuel can be corrosive and may be a symptom of water in the fuel, poor production or oxidative degradation. Excessive free fatty acid in the fuel can lead to soap formation which tends to inhibit the transesterificationprocess. The acid values for the oil and biodiesel are 14.025 mg/KOH and 0.18 mg/KOH respectively. Comparing with the ASTM standard, the acid value for the coconut oil biodiesel is very low. Therefore, coconut biodiesel is not corrosive

Saponification value: The saponification value is one of the highest for vegetable oils making it suitable feedstock for the manufacture of soaps, detergents and shampoo products. The oil has a value of 191 mg KOH/ which reduces to 91 mg KOH/ for the biodiesel. Coconut oil biodiesel has high saponification value compared to the ASTM standard.

Iodine value: Iodine value is the number of mg of KOH required to convert 1g of fat into glycerine/soap. It is a measure of the degree of un-saturation of vegetable oils, low iodine value means low content of unsaturated fat acids, hence reduced vacant bonds which translates to less reactivity of the fuel, tendency to polymerize, and better storage stability. The iodine values are 10 mg/l and 8 mg/l for the oil and biodiesel respectively. The iodine value of the coconutoil biodiesel is high compared to the ASTM standard.

Flash Points: flash point, which is the temperature at which the fuel can ignite when exposed to a heat source**,** is important from the point of view of safe handling, storage and transportation. The flash points of 266 °C and 110 °C for coconut oil and biodiesel respectively compared to 50 °C for diesel fuel. Coconut oil biodiesel compared to the ASTM standard can be classified as a non-hazardous fuel because of its high flash point.

5. CONCLUSIONS

At the end of the research work, the methyl ester (coconut oil biodiesel) was discover to have certain properties attributable to it. The Coconut oil biodiesel can be classified as a non-hazardous fuel because of its high flash point. The saponification value is one of the highest for vegetable oils making it suitable feedstock for the manufacture of soaps, detergents and shampoo products. The density and viscosity of the coconut oil and it methyl ester was found to be low. The iodine value is high meaning, high content of unsaturated fat acids. Hence, the low acid value of the fuel tells us that the fuel can't be corrosive because High acid value of the fuel can be corrosive and may be a symptom of water in the fuel or poor production.

Finally, coconut oil can be classify as one of the best vegetable oil for the production of biodiesel. Coconut oil was extracted and biodiesel was produced from it and also characterized in this study. From the results obtained and discussed, it is very evident that coconut oil is a good feedstock for biodiesel production and the biodiesel can be used in convectional diesel engine without modification because of close fuel properties

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