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Production and Characterization of Biodiesel from Ricinus Communis Seeds

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Abstract

Biodiesel production from Ricinus communis seeds is one of the options being considered for partially substituting diesel fuel. Diesel chemically is monoalkyl esters of long chain fatty acids from renewable feedstock like vegetable oil, animal fats etc. the oil from the seed was extracted n-hexane as solvent and then transesterified with methanol as choice alcohol and potassium hydroxide (KOH) as the catalyst option. 123.2ml of biodiesel was realized from 913g of Ricinus communis seeds to 78.6ml of glycerol after separation. Properties like pH, free fatty acid (FFA), cloud point, flash point, pour point, specific gravity, viscosity, refractive index, colour, acid value, iodine value, saponification value, peroxide value were checked during the characterization of the produced biodiesel. The flash point and other physico-chemical properties of the produced biodiesel are within the range of American Society for Testing of Materials. Biodiesel standard specification indicated that it can be used in any diesel engine. Based on the characteristics, the produced biodiesel is biodegradable and environmentally friendly than fossil diesel. It is recommended that biodiesel be used as an alternative to fossil diesel.

Keywords: Transesterification, methylester, *Ricinus communis,* Biodegradable, environmentally friendly.

Introduction

Energy has a great impact on every aspect of our socio-economic lives as it plays an important role in survival and welfare development of any nation. In many developing countries like Nigeria, there is a serious shortage of fuel and therefore energy crisis is a reality for most families. The solution of this problem can be found in exploitation and use of renewable energy source such as biodiesel.

The consumption and demand for petroleum products are increasing every year due to increase in population, standard of living and urbanization[1]. The use of diesel vehicles and generators has been banned in many cities of the world like in New Delhi, India for serious problems of air pollution due to higher emissions of poisonous gasses. The acid rain, global warming and health hazards are the results of ill-effects of increased polluted gasses like SO_2, CO and particulate matter in the atmosphere[1].

Biodiesel is processed from a variety of feedstock including soybean oil, rapeseed and sunflower, *Jatropha curcas* oil and castor oil[2]. The feedstock for biodiesel undergoes esterification process which removes glycerine and allows oil to perform like traditional diesel[3].

Ricinus communis is identified as potential biodiesel source and comparing with potential sources, it has added advantages as rapid growth, higher speed production suitable for tropical and subtropical regions of the world[4]. It also has a higher resistance to drought, higher production of quality oil, can be used to combat desertification and poverty. The seed contains 30 – 35% oil that can be processed to produce a high quality biodiesel fuel usable in standard diesel engine. The remaining press cake of castor seeds after oil extraction could also be used as an organic fertilizer.

Nigeria is in a position to be a leading biodiesel producer by the use of *Ricinus communis* because the climate and soil are very suitable. The production of biodiesel will also boost the rural economy, which will bring more enthusiasm in more than one billion lives in the African continent as a whole. This will lead to increase in demand for agricultural products with new markets. This will also help to create job for the teeming jobless youths.

This study aims at processing and characterizing biodiesel from castor seeds.

Material and Methods

Procurement of materials and pre-production process: The castor seeds were brought from an open market (Ose market), Onitsha, Anambra State. The seeds were sundried to reduce the moisture content, and also blended to reduce the particle size in preparation for oil extraction. The weight of the *Ricinus communis* seeds were taken before and after de-shelling the seeds. The de-shelled seeds which were white in colour were oven dried at $90^{O}C$ for 45 minutes. Then the dried seeds were grounded using blender and measurements were taken.

Oil Extraction Process: The castor oil extraction was carried out by solvent extraction method using Soxlet apparatus. The solvent used was n-hexane. The grounded castor seeds were soaked with n-hexane in a flask. The mixture was shaken vigorously and then covered with aluminum foil. It was allowed at room temperature to stay for 72 hours.

Filtration: After two days, the mixture of the ground castor seeds and n-hexane was filtered into a round bottom flask using filter paper and funnel. The cake gotten from the mixture was kept to be an organic fertilizer.

N – Hexane Removal: The filtrate gotten after filtration was connected to distillation unit. This is to distill off the n-hexane, hence leaving only the castor into the flask. The n-hexane was collected from one end using a beaker, while the oil remained in the round bottom flask. The oil was then set on an electric hot plate to heat off moisture before transesterification. The total oil gotten was measured using a measuring cylinder.

Mixing of alcohol and catalyst: Methanol was used as alcohol and KOH as lye catalyst. 0.9g of KOH was dissolved in 50ml of methanol in a measuring cylinder. The mixture which is known as potassium methoxide was vigorously shaken until KOH dissolved completely in methanol.

Transesterification: The castor seed oil was then poured into a conical flask and placed on a magnetic stirrer hotplate. Then the methoxide (potassium hydroxide + methanol) as poured into the vegetable oil simultaneously and then set at 60°C for 60 minutes.

Separation of biodiesel from glycerol: Water was poured into 100ml of conical flask and heated in a water bath for 20 minutes and allowed to cool at temperature of 40°C. 100ml of hot water were measured out into 500ml beaker. The water was poured into the separating funnel containing the biodiesel. One characteristic of biodiesel is that it does not mix with water (insoluble in water). Water was separated from biodiesel after 5 minutes.

The methods employed throughout this experiment were from Fuduka *et al.*[5] and Meyer *et. al*[6].

Characteristics of the biodiesel produced: Test for pH: pH paper with readings on it was gotten. Then the biodiesel was dropped on it. The paper absorbed the biodiesel till it reached a particular reading and stopped. The reading was taken at that point. This method was adopted from Dubey[7].

Determination of specific gravity: An empty specific gravity bottle was weighted and recorded. The bottle was dried and filled with distilled water and its weight was taken. The S.G bottle was dried and filled with the oil. Then the weight was taken again[5].

$$\text{Specific gravity} = \frac{\text{Weight of oil}}{\text{Weight of water}}$$

Tests for Cloud point and Pour points: 3ml of biodiesel was measured in a beaker and put in a freezer. The biodiesel was taken out of the freezer every 1 minute and the temperature measured and visible changes were looked out for (ASTM[8]).

Observation for Cloud Point: At a particular temperature, crystals began to form in the biodiesel. Then reading was taken.

Observation for Pour Point: At a certain temperature, gel and crystals were dissolved from the biodiesel, then the temperature reading was taken (ASTM[8]).

Test for Flash Point: 2mls of the biodiesel as measured in a beaker, heated to a certain temperature that it ignited; at that point there was a flash of light on the biodiesel. That temperature at which the light flashed is the flash point. Temperature was recorded[5].

Results and Discussion

Table 1 showed measurement of processing stages in biodiesel production. The amount of oil extracted was 260ml. 123.2ml of biodiesel was produced against 78.6ml of glycerol.

The physical properties of the extracted castor oil were presented in table-2. The oil has a pH of 7.8, flash point of 135°C, viscosity at 40°C was 6.48 etc. Pour and cloud points were 1.5°C and 1°C respectively. These are not too far from readings of refined biodiesel. Table-3 contains the chemical properties of the extracted castor oil. It has a low free fatty acid value and acid value Mg NaOH/g of sample. Iodine and peroxide values were 75.82 and 150 respectively etc.

Table-1
Processing stages in biodiesel production

Parameter	Castor Value
Mass of sample used (g)	913
Percentage yield of oil	28.48%
Percentage yield of biodiesel	54.76%
Mass of KOH used (g)	2.05
Volume of methanol used (ml)	50
Biodiesel product volume (ml)	123.2
Volume of oil extracted (ml)	260
Volume of glycerol (ml)	78.6
Mole ratio	1:3

Table-2
Physical properties of the castor oil

Properties	Castor oil	Refined biodiesel
Specific gravity	0.9595	0.8658
Viscosity at 40°C (mm^2/g)	6.48	6.48
Refractive index	1.47	1.46
pH	7.8	9.2
Colour	Amber	Light yellow
Flash point	135°C	140°C
Pour point	1.5°C	2.0°C
Cloud point	1.0°C	1.2°C

Table-3
Chemical Properties of the castor oil

Properties	**Castor oil**
Acid value (Mg NaOH/g of sample)	15.71 x 10^{-3}
Iodine value (g/2/100g of oil)	75.82
FFA	7.855 x 10^{-3}
Peroxide value	150
Cetane value	53.04

Discussions: The result from this study shows that a reasonable amount of biodiesel can be obtained from *Ricinus communis* oil, which has been shown to have a very low free fatty acid value. If the free fatty acid value is too high, it may cause problem with soap formation (saponification). This finding corroborates with the findings of Mettlebatch[9], Akintayo[4] and Remesh[1] who in their various studies had low free fatty acids. The viscosity, pour point, cloud point, acid value, flash points, specific gravity, refractive index, colour, iodine value, peroxide value, pH of the biodiesel produced from the experiment are in range with American Society for Testing of Materials (ASTM) set standards. This shows that it can be used in any diesel engine.

Viscosity of the biofuel at 40°C was 6.48. Preston and Reece[10], Remesh[1] and Woulandakoye et al.[11] in their various studies on the production of biodiesel using various vegetable oil had the viscosity between the 5.00 – 6.00. The viscosity of fuel is important because it affects the atomization of the fuel been injected into the engine combustion chamber. A high viscosity fuel such as a raw vegetable oil will produce a larger drop of fuel in an engine combustion comber which may not burn as clean as fuel that produces a smaller drop. Unburned, oxidized fuel builds up in the engine around the valves, pistons sidewalls, injector tips and rings. This normally leads to stock rings and in few cases, broken rings. Biodiesel produces a much smaller drop which burns cleaner.

The cetane value was 53.04. This is a measure of self ignition quality of the fuel. Cetane index is also a measure of the knock characteristic of a fuel and also its combustibility. The ignition quality affects engine performance. A high cetane fuel may also lead to incomplete combustion if the fuel ignites too soon by not allowing the fuel to mix air for complete combustion. This value falls within the range given by the ASTM D67S7 and EN1424: 2003 standards.

The flash point of the biodiesel from the study is 140°C. Flash point of clean biodiesel should be greater than 93°C. The Department of Transport, USA, considers a material with a high flash point of 93°C and above to be non-hazardous. The result gotten was above 93°C making *Ricinus communis* biodiesel non-hazardous and safe to handle as it is not explosive.

Conclusion

The combustion of biodiesel produces fewer emissions of carbon monoxide. It also contains 100% less sulphur and lead. It is biodegradable and as a result environmentally friendly. This means if biodiesel is adopted as an alternative to fossil fuel, environmental problems like global warming and greenhouse effects can be drastically reduced. Governments of various countries like Nigeria should give subsidy to industries already on ground producing biodiesel similar to that for other alternative fuels. Also, most of the oil crops used for biodiesel should be cultivated on large scale. Improvement in processing along with the use of waste cooking oil as a raw material may help reduce cost.

The use of biodiesel by vehicles, machines etc especially in developing countries will definitely boost the rural economy thereby creating job for the teaming population.

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