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PRODUCTION AND CHARACTERISATION OF BIODIESEL FROM CASTOR OIL

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ABSTRACT

This study produced and characterized biodiesel from Castor seed oil by acid-catalyzed transesterification reaction. Castor oil was extracted from Castor seed purchased from the Eke Ekwulobia market by solvent extraction method using n-hexane as extracting solvent. The extracted oil was characterized to determine acid value 0.6mg/g, iodine value 76.2mg/g, saponification value 179.52mg/g, specific gravity 0.92, free fatty acid 1.68%, and percentage oil yield 33.30%. It was found that castor seed oil could be used directly in biodiesel production because of its low free fatty acid content. Furthermore, the characterized Castor seed oil was transesterified to biodiesel and subsequently analyzed for fuel properties. From the tests, moisture content was found to be 5.00mm/s, cloud point 10°C, and flash point 120°C. These values were in close agreement with the ASTM criteria for biodiesel. Castor seed oil is recommended as a good feedstock for biodiesel production.

Keywords: Biodiesel, Castor seed oil, Feedstock, Free fatty Acid, Transesterification,

INTRODUCTION

Biofuels are fuels derived from renewable resources such as plant or animal materials. Gasoline and diesel are known as fossil fuels because they are made from decomposed plants and animals buried in the ground for millions of years.

Biodiesel is a vegetable-based fuel that can run in an unmodified diesel engine. It is primarily made from vegetable oil such as coconut oil, soya bean oil, rapeseed oil, castor seed oil, etc. Biodiesel can be blended with regular diesel, or run 100% on its own. Biodiesel is most commonly produced from oils through a process known as transesterification, which involves taking naturally occurring carbon chain molecules known in such feedstock as oils and animal

fats and converting them into methyl esters, which is the chemical term for biodiesel. This is achieved by reacting fatty acids with alcohol, such as methanol or ethanol, in the presence of a catalyst. One mole of triglyceride reacts with three moles of alcohol to produce three moles of alkyl ester and one mole of glycerol. To improve the rate of reaction and biodiesel yield, a catalyst is usually added with excess alcohol, which shifts the equilibrium to the product side since the reaction is reversible. Traditionally, the transesterification process utilizes solvents, including methanol or ethanol, and homogenous catalysts such as KOH, NaOH, or H_2SO_4. However, this method has shortcomings such as extensive separation process, water generation, and equipment corrosion. According to Ejikeme *et al., (2010) and Leong et al., (2013), NaOH is well-accepted* for biodiesel production because of its low price.

Biodiesel performs just as well as the petro diesel (Mccornick, 2006). Biodiesel has many applications, such as:

1. In most injection pump diesel engines, biodiesel can be used in pure form or blended with petroleum diesel in any proportion.
2. Biodiesel helps to reduce the amount of carbon monoxide produced by the vehicle through complete combustion, thus improving our health.
3. Biodiesel has been known to break down deposits of residue in the fuel lines where petrodiesel has been used.

Romano & Sorichetti, in "Biodiesel production and characterization" (2011) outlined the following advantages of Biodiesel use:

1. Biodiesel is a renewable fuel with low toxicity compared to petrol diesel.
2. It degrades more rapidly than petro-diesel, thus optimizing the environmental consequences of petro-diesel spills.
3. The health risks are lower due to reduced emissions of carcinogenic substances.

World energy is dependent on fossil fuels, which have hazardous effects on climate change and the ozone layer. Many researchers, faced with the depreciating level of fossil fuels, have proposed diversifying energy sources and using alternative energy (renewable) as one way of reducing the problems of fossil fuels.

The use of castor seed oil for biodiesel is one of the ways of reducing the problems. Castor seed oil is a vegetable oil obtained from castor beans. It is colourless with mild or no odour or taste. The boiling point of Castor seed oil is 313°C (595°F). Its density is 961kg/m^3.It is a triglyceride in which approximately ninety percent of fatty acids chains are ricinolic (Aldrich, 2003)

Castor seeds have been found in Egyptian tombs since 4000 BC (NNFCC, 2009). Castor plant is grown throughout the tropical regions. According to Raw Materials Research and Development Council (RMRDC, 2009), the yield of Castor bean ranged from 600-700kg per hectare on research plots in Nigeria compared favourably with figures from India. In 2004, when about 6000 hectares were cultivated, the production estimate was between 3000-4000 metric tons (RMRDC, 2009). Castor seed oil has produced bio-degradable hydraulic fluid and lubricant (Landa, 2000). Castor oil and its derivatives have applications in manufacturing soaps, lubricants, hydraulic and brake fluids, paints, dyes, cold-resistant plastics, waxes, polishes, nylons, pharmaceuticals, perfumes, and biodiesel. (Landa, 2000)

Extraction of Castor seed oil from Castor bean can be done by Cold Expression, Solvent extraction or Steam distillation. The parameters used to analyze Castor seed oil include the following:

1. Acid value is the proportion of the free fatty acid in the oil or fat.
2. Saponification value: The saponification value indicates the average molecular weight of the fatty acids present in the oil.
3. Iodine value: Iodine value shows the degree of unsaturated fatty acid in the oil or fat. Oils are classified as drying (greater than 130), semi-drying (100-130), and non-drying(less than 100) based on iodine number.
4. Specific gravity: The specific gravity of a substance is the ratio of its weight to the weight of an equal volume of another substance taken as standard.

MATERIALS AND METHODS

Castor seed oil was extracted from the Castor bean purchased from Eke Ekwulobia market in Aguata Local Government Area in Anambra State. Oil was extracted using the solvent extraction method, n-hexane. Oil was recovered, weighed, and recorded. The oil was then characterized using appropriate methods.

PRODUCTION OF BIODIESEL FROM CASTOR OIL

The oil was first agitated for 15 minutes using a stirrer, then 0.5g of NaOH was dissolved in 13 ml of methanol and poured into the 66 ml of the already agitated oil, and it was stirred for an hour. It was then poured into a separating funnel and allowed to stand for $2^1/_2$ hours, during which two phases were formed. The upper layer was biodiesel, while the lower layer was glycerol. The glycerol was removed, and the oil was washed with warm water to remove impurities. The oil was put in a separating funnel and stood for about$1^1/_2$hours. The oil was heated until it stopped foaming.

Characterization of Biodiesel

Moisture Content

An empty petri dish was weighed and recorded as W_1. 1g of the produced biodiesel was weighed and poured into the petri dish. It was then reweighed and recorded as W_2. The petri dish and the sample were put in an oven for another 1 hour, and the weight was noted. The drying procedure was continued until a constant weight was obtained and recorded. It was repeated with the same temperature until a constant reading was obtained and recorded as W_3. (Adeyemi, 2021)

Table 1: Result of castor seed Oil Extraction.

Viscosity

The falling method was used to determine the viscosity of the biodiesel. The measuring cylinder was filled with water, and the biodiesel was dropped into the water. The time of the biodiesel's falling was taken in seconds, and the weight of the measuring cylinder was measured. (Adeyemi,2021)

Cloud Point/Pour Point

The temperature of the biodiesel was determined when the biodiesel became cloudy and lost ability to flow. (Adeyemi,2021)

Flash Point

The biodiesel was placed in a metallic beaker, and the heat source was switched on. The temperature was observed, and at about 120°C, the biodiesel caught fire, indicating the flash point. The reading was recorded. (Adeyemi,2021)

RESULTS AND DISCUSSION

Results

The oil extraction and characterization results are presented in the tables below.

Wt. of Castor seed	Wt. of dried Castor seed	Wt. after drying	Weight of oil
700	600	400	60.72

The percentage oil content is 33.3% and is an indicator that it has reasonable oil yield.

Table 2: Analytical Characteristics of the castor seed oil .

	Parameter	Value
1	Acid value	0.6mg/g
2	Iodine value	76.20mg/g
3	Saponification value	179.52mg/g
4	Specific gravity	0.92
5	Free fatty acid	1.68%

Table 3: Characteristics of the Produced Biodiesel.

	Parameter	Value
1	Moisture content	0.0072g
2	Viscosity	5.00mm^2/s
3	Cloud point	10°C
4	Flash point	120°C

Table 4: American Society for Testing and Materials (ASTM) detailed Requirements for Biodiesel

	Property	Test Method	Limit	Units
1	Flash point	Δ93	100 minimum	°C
2	Moisture Content	Δ2709	0.05 maximum	%mass
3	Viscosity	Δ445	1.9-6.0	mm^2/s
4	Ash content	Δ874	0.02 maximum	%mass
5	Sulphur content	Δ2622	0.05 maximum	%mass

6	Cetane number	Δ613	40 minimum	%mass
7	Cloud point	Δ2500	NA	°C
8	Carbon residue	Δ4530	0.5 maximum	%
9	Specific gravity	Δ1298	0.8-0.90	g/km^3

Source: Engine Manufacturers Association (2003)

DISCUSSION

The oil content of the Castor seed was relatively high, about 33.3%, reasonable enough for biodiesel production. The acid value measures the free fatty acid present in the oil. The value obtained was 0.6mg/g. This value indicates that the oil contains considerable free fatty acid. The iodine value (76.2 mg/g) indicates that the Castor seed oil is classified as semi-drying. The saponification value of the Castor seed oil was found to be 180mg/g, indicating that it is in the same range as some other oils like groundnut oil (187-196mg/g), cottonseed oil (189-198mg/g) and coffee (170-199mg/g). The saponification value is a measure of oxidation during storage and indicates the oils' deterioration. An increase in the saponification value in oil increases the volatility of the oil (Aremu *et al.*, 2015). The moisture content of the biodiesel was found to be 0.007%. This was in agreement with the ASTM biodiesel requirement. The moisture content determines the biodiesel oil response to degradation (Kolobeng *et al.*, 2022). The viscosity of the biodiesel was found to be 5mm^2/s. This value is slightly higher than that of petroleum-based diesel but is in close agreement with the ASTM biodiesel standard.

The cloud point and the flash point are important properties of biodiesel. Cloud point is the temperature at which the biodiesel shows visible cloudiness. This cloudiness indicates that the biodiesel has started to solidify (Ramkumar & Kirubakaran, 2016). The cloud point of the biodiesel obtained was 10°C. This amount is slightly higher than 9°C, as Yunus *et al.*, (2013) obtained. The flash point is the lowest temperature at which the vapor produced above the liquid will ignite at the introduction of a test flame (Durkee, 2008). The flash point of the biodiesel was found to be 120°C, and the value satisfied the ASTM biodiesel standard as shown in Table 4.

CONCLUSION

The results have shown that Castor seed oil should be significantly utilized in synthesizing methyl esters. The aim of the transesterification reaction in this work was to lower the oil's viscosity. In the absence of any other parameter, the properties tested suggested that Castor seed oil will perform well as biodiesel in diesel engines.

RECOMMENDATIONS

With the inevitable depletion of fossil fuels' nonrenewable resources, it is recommended that farmers farm Caster seed crops with the aim of converting the oils extracted to biodiesel. Castor seed oil has proven to be a good alternative for biodiesel production. Biodiesel promises a cleaner and safer environment; therefore, commercialization of biodiesel should be encouraged by reducing the cost of production. Finally, it is recommended that biodiesel be blended with petroleum diesel to synergize their qualities.

REFERENCES

Adeyemi, D. I., Saleh, A., Akande F.B, Onyia, O.O., and Ola F.A. (2021). Determination of fuel properties of Biodiesel from Sand apple seed oil with automotive gas blend *https://www.ajol.info/index.php/jasem*. *https://www.bioline.org.br/ja*.

Aldrich (2003). Handbook of Fine Chemicals and Laboratory Equipment. Sigma Aldrich *https://www.fr.com/cins/5/0/e780d216.5fds. 11c.bofe-00007797d2ac.html. retrieved 2008*

Aremu, M.D., Ibrahim, H. and Bamidele, O. (2015). Physico-chemical characteristics of the oils extracted from some Nigerian plants foods-A Review. *Chemical and process Engineering Research, 32*

Durkee, J.B. (2008). Developments in surface contamination and cleaning. 2nd Edition.

Ejikeme, P.M; Anyaogu, I.D; Ejikeme, C.I; Egbunonu, C.A.S; Ukogu, K. and Ibemesi, J.A (2010). Catalysis in Biodiesel Production by Transesterification Process. *An insight E-J Chem* 7,1120-1132.

Kolobeng, R., Ketlogetsu, C., Mbako, J. and Moutle, D. (2022). Content on Biodiesel (B100) properties during storage: A Comparative analysis between biodiesel produced from used cooking oil and beef tallow *https://doi.org/10.1016/j.seto.2022.102844*

Landa, M (2000) *Biodegradable Hydraulic Fluid Nears Market. USDA-https://www.ars.usda.gov/is/pr/2000/000411 9.html.Retrieved*

Leong, B.S; Rus, M.; Zafia A. and Hassan, S. (2013). Continuous Biodiesel Production using Ultra Sonic Clam on Tubular Reactor. *A proceedings of the International Conference of Mechanical Engineering Research (ICMER, 2013). Kuatan, Rahang, Malaysia 1-3 July 2013 pp 1-10 (Google Scholar)*

Mccornick, R.L (2006) Biodiesel Handling and use Guide. Third Edition(PDF) *http://www.nrel-gov/vehiclesandfuelsnpbf/pdts/40555.pdf*

NNFCC (2009) *Castor. The National Non-food Crops Centre. Retrieved 2009.*

Ramkumar, V. and Kirubakaran V. (2016). Biodiesel from vegetable oil as alternate fuel for C.I Engine and Feasibility Study of Thermal cracking: A critical review. *In Energy Conversion and* management.

RMRDC (2009) Raw Materials and Research Development Centre

Romano, S.D; and Sorichetti, P.A.(2011). Dielectric Spectroscopy in Biodiesel Production and characterization in Green Energy and Technology. Springer- Verlag, London, Uk, pp 7-27

Yunus, M. M.; Zuru, A.A., Faruq, U.Z.; and Aliero, A. A. (2013). Assesment of Physico-Chemical Properties of Biodiesel from African Grapes (Lannea microcarpa Engl. & K. Krause)