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PHYSIOCHEMICAL ANALYSES OF CASHEW SHELL OIL, FOR BIODIESEL PRODUCTION WITH SULPHATED ZIRCONIA SUPPORTED ALUMINA CATALYST.

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ABSTRACT
In these times of global market uncertainties and harsh economic realities, the world needs energy in increasing quantity for both domestic and industrial purposes. With the world's population rapidly increasing, energy will go a long way in enhancing economic and social progress. In this study, Cashew nut samples were collected from

INTRODUCTION
The demand for new fuel from non-conventional sources has been the major attention of the twenty-first century. Nonconventional sources of energy have been able to provide partial energy supplements to provide to increasing requirements for fossil fuels and it has paved way for fastest-growing economies in the world. It is very critical to sustain this economy through sustainable and non-sustainable developments. The gradual decrease in fossil fuels and increasing environmental degradation raise serious issues with non-conventional sources (fossil fuels) of energy (Koyama, 2017). This ever-increasing hunger for energy has to be supplemented with new and alternate sources of energy. The search for new alternate energy sources has given rise to a new sustainable and environment-friendly fuel called "biodiesel". Countries need to have energy security for socio-economic developments. Biodiesel is a cleaner-burning fuel similar to fossil

diesel in terms of qualities and featur es (Ogunkunle and Ahmed, 2019). However, because of biodiesel uniqueness, it seems to be higher in quality than conventional fossil diesel (Yusuff *et al.*, 2017).

After few years of its discovery, biodiesel through its properties has proven to be suitable for powering diesel engines (Noor *et al.*, 2018). It is obtained from renewable resources, sustainable and also lowers the life cycle of greenhouse gases by a significant amount compared to fossil diesel (Xu, *et al.*, 2020). Biodiesel is a mono-alkyl ester of long-chain fatty acid which are derived from edible oil, nonedible oil or animal fats and it has been an area of ameliorated research and has been produced from a broad variety of sources (Arumugam and Sankaranarayanan, 2020). Other sources of biodiesel include microalgae and waste oils (Chen *et al.*, 2018).

The biodiesel produced can be used directly in a diesel engine because the biodiesel produced has similar molecular properties like paraffinic petroleum compounds and no modification of the engine is needed (Damanik *et al.*, 2018). Furthermore, biodiesel can be blended with diesel derived from petroleum in different proportions. Currently, biodiesel is considered a real alternative to diesel fuel due to the following advantages: It can reduce the dependence on crude oil imports and enhance energy security, reduces greenhouse emissions and lower harmful emissions. It is biodegradable, non-toxic and renewable and helps improve rural economics since the

Kure Market, Minna, Niger State, Nigeria. The samples were then pretreated and analyzed to determine the chemical and physical properties as well as their suitability for use in producing biodiesel. From the results, the saponification value was 144.28 mgKOH/g; the free fatty acid was 7.35 mgKOH/g; the refractive index was 1.464; the pour point was 3.00 °C; the kinematic viscosity was 62.20 mm²/s. Consequently, the cashew nuts obtained and analyzed will give a good yield in biodiesel production.

Keywords: *Biodiesel, Cashew nuts, Saponification, Kinematic viscosity, Energy.*

agricultural surplus is used as raw materials (Hasan and Rahman, 2017). Furthermore, Biodiesel has many advantages which include: higher cetane number with no aromatics, almost no sulphur and 10-12 % oxygen by weight, biodiesel fueled engines produce less carbon monoxide; CO, hydrocarbon and particulate emissions, biodiesel improved the lubricity which results in longer engine component life (Aldhaidhawi *et al.,* 2017). Moreover, in most of the developed countries, regulations have restrained sulphur content in diesel fuel within the acceptable limit of 50 ppm (Ni *et al.,* 2020). Many developed countries use edible oilseed crops such as groundnut, soybean, rapeseed, sunflower, among others for the production of biodiesel (Madadi and Aqleem Abbas, 2017). Hence, researchers and scientific community worldwide have focused on the development of biodiesel and the optimization of the processes to meet the standards and specifications needed for the fuel to be used commercially without compromising on the durability of engine parts (Zahan and Kano, 2018). Cashew nut liquid generated from cashew nut processing factories has proven to be among the most versatile bio-based renewable materials, particularly in the search for functional materials and chemicals from renewable resources (Mgaya *et al.,* 2019). This nut has significant potential for use as a raw material for the production of fuels and value-added chemicals due to the abundant volumes generated globally.

Different technological strategies which include chemical and biological biorefinery approaches have been established to process and maximize the value of resources derived from this cashew nut (Mgaya *et al.,* 2019). This derivation has environmental and economic merits leading to the creation of jobs and improved economic growth. Cashew nut chemical products have been proven to replace fossil-based petroleum resources for the production of chemicals, materials, polymers, energy and fuels (Kumar and Rosen, 2018). Synthesis of biodiesel using heterogeneous solid catalysts could promisingly lead to the economical production of biodiesel because of reusability of the catalyst, easy separation from the reaction mixture and the circumstances for carrying out both transesterification and esterification processes simultaneously (Arumugam and Sankaranarayanan, 2020). Adding to the benefits is its lesser consumption of catalyst, the more surface areas, and pores on the catalyst molecule can help triglyceride molecules anchor themselves and react better and also reduces the need for effective washing (Vakros, 2018).

The discovery and application of eco-friendly benign products and product mixtures in this manner, in pursuit of replacing hazardous chemicals, are recognized as important areas of green chemistry (Mgaya *et al.,* 2019). In the 1970s, Africa was the largest producer of raw cashew nuts accounting for 67.5 % of world production. This subsequently declined to 35.6 % by 2000, with Nigeria, Tanzania and Mozambique being the largest producers (Hammed *et al.,* 2008). In recent years, the potential and prospect of biodiesel production from first and second-generation feedstocks have been extensively reported. However, there is a need to quest for biodiesel production that will bring enormous benefits to human beings and the environment.

OBJECTIVES

With the understanding that nonconventional sources of energy have been able to provide partial energy supplements to augment the increasing demand for fossil fuels and have also paved a way for fast-growing economies in the world, this study is aimed at exploring the oil potential of cashew nut. The objectives are to extract and characterize oil from cashew shell, and also to produce biodiesel from the extracted cashew shell oil.

METHODOLOGY

Materials

The regents that were used in this study are of analytical grade with percentage purity and manufacturers as shown in Table 3.1.

Table 3.1: List of Reagents/Chemicals

S/N	Item	Formula	% Purity	Manufacturer
1.	Zirconium sulphate	$ZrSO_4$	98	BDH Chemicals England
2.	Sodium hydroxide	NaOH	97	Merck,
3	Potassium hydroxide	KOH	98	BDH Chemicals England

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4	Ethanol	C_2H_5OH	96	BDH Chemicals England
5.	Hydrogen chloride	HCl	98	BDH Chemicals England
6.	Sodium thiosulphate	Na_2S2O_3	67-70	BDH Chemicals England
7	Sodium trioxocrbonate (V)	Na_2CO_3	99.5	BDH Chemicals England

Sample Collection and Pre-treatment

The cashew nut samples were obtained from Kure market, Minna, Niger State, Middle Belt, Nigeria.

Sample pretreatment

In this study, the amount of cashew nut seed used were 2500 g and the amount of solvent to be used was 3000 cm^3. The nuts were sundried to remove the moisture until a constant weight is achieved. The dried samples were grounded to reduce the size.

Oil Extraction

The Soxhlet apparatus and n-hexane as a solvent were used for the extraction of the oil. About 20 g of the ground sample was weighed and inserted into a thimble covered with a cotton wool. The extractor was placed in 250 cm^3 round bottom flask containing 120 cm^3 of n-hexane. The condenser was connected to reflux for 6 h to ensure complete extraction of the oil in the sample. The flask was dried in the oven to completely remove the solvent.

$$\text{Oil cntent } (\%) = \frac{\text{Weight of oil}}{\text{Weeight of sample}} \times 100 \qquad (3.1)$$

Characterization of the Extracted Oil

Saponification value

About 2.0 g of the extracted oil will be weighed into a 250 Erlenmeyer flask. 25 cm3 of alcoholic KOH will be added and the flask will be covered with a cork which act as a condenser. The solution will be heated in a water bath for 30 min. The flask will be removed from the heat source, shaken vigorously and titrated against standard weak acid, using 2 to three drops of phenolthalein as an indicator. A blank will be studied by the same method but without the extracted oil sample.

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$$\text{Saponification value} = \frac{(S - B)\ 56.1M}{W} \qquad (3.2)$$

where S = Value of used HCl for blank
B = Value of used HCl for sample
W = Weight of sample

Peroxide value

About 1.0 g of the oil sample was measured into a clean boiling tube. 1.0 g of potassium iodide and 20 cm^3 of solvent mixture (2:1 of glacial acetic and chloroform) were added. The boiling tube was transferred to the boiling water and allowed to boil for 30 min. 25 cm^3 of water was added and swirled thoroughly. The solution was titrated against 0.002 M sodium thiosulphate solution until the yellow colour disappeared. 0.5 cm^3 of starch solution was added, shaken vigorously and titrated until the blue colour disappeared. A blank will be carried out using the same method but without the oil sample.

Free Fatty acid determination

About 2.5 g of the oil sample was weighed into 250 cm^3 conical flask, 2.5 cm^3 of neutralized alcohol added and then boiled on a water bath. The solution was shaken thoroughly for proper dissolution of fatty acid. The alcohol was added to provide a medium for dissolving the fatty acid. 1.0 cm^3 of phenolphthalein indicator solution was added to the mixture while hot and titrated against 0.1 M sodium hydroxide. The end point was observed when the pink colour persists for 30 seconds

Kinematic viscosity

The kinematic viscosity will be carried out using a capillary tube viscometer test technique. The extracted oil sample will be placed into a glass capillary U-tube and suction until it reaches the start position shown on the tube's side. The suction will be released, allowing the sample to flow back through the tube under gravity. The kinematic viscosity will be investigated from the time it takes to flow from the starting point to the stopping point. . Calculation;

$$\text{Kinematic viscosity} = \frac{gD^4\rho}{128VL} \qquad (3.3)$$

where; g = acceleration due to gravity
D = diameter of capillary
L = average distance between upper layer menisci
V = timed volume of liquid passing through the capillary
ρ = flow rate

Flash point

The oil sample will be placed in the cup of the tester with the lid closed. It will be heated at a slow constant rate and ignition source (lighted match stick) will be directed into the cuo at interval. The flash point will be taken at the lowest temperature on application of light source for it to ignite.

Cloud point

The oil sample will be poured into a jar to a half level. A cork carrying the test thermometer will be used to close the jar and then subjected to a constant temperature cooling bath to avoid excessive cooling. The sample will be taken out every 1 oC to inspect the formation of cloud/wax. The temperature at which the first appearance of wax crystal will be observed in the sample will be recorded as the cloud point.

Pour point

The oil sample will be kept in a test jar and allow to cool in a water bath for the formation of paraffin wax crystal. The test jar will be removed at every 3 oC to check for surface movement. The sample in the jar will not flow when it is tilted and horizontally held for 5 sec. The temperature at which it flows on being tilted will be recorded as the pour point temperature.

MAJOR FINDINGS

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, DEPARTMENT OF WATER RESOURCES, AQUACULTURE AND FISHERIES TECHNOLOGY, LABORATORY ANALYSIS RESULT SHEET

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(PROXIMATE ANALYSIS OF CASHEWNUT)

SERIAL NO	PARAMETER	VALUES OBTAINED
1	% MOISTURE CONTENT	10.36
2	% CRUDE PROTEIN	4.18
3	% CRUDE FIBRE	44.75
4	% TOTAL FATS	24.92
5	% CARBOHYDRATE	13.2

(CHEMICAL AND PHYSICAL ANALYSIS OF CASHEWNUT OIL)

SERIAL NO	PARAMETER	VALUES OBTAINED
1	SPECIFIC GRAVITY	0.967
2	SAPONIFICATION VALUE mgKOH/g	144.28
3	FREE FATTY ACID mgKOH/g	7.35
4	ACID VALUE mgKOH/g	14.69
5	PEROXIDE VALUE meq/kg	1.32
6	IODINE VALUE g/100g	46.26
7	UNSAPONIFIABLE MATTER	1.78
8	REFRACTIVE INDEX	1.464
9	FLASH POINT °C	288
10	FIRE PoINT °C	325
11	POUR POINT °C	3.00
12	CLOUD POINT °C	5.30
13	KINEMATIC VISCOSITY mm^2/s	62.20

CONCLUSION

In this study, the physiochemical properties of cashew nuts from Kure market were analyzed. On the basis of the samples' oil potential for biodiesel production, a better understanding has been obtained. From the results obtained for parameters like saponification value, pour point, kinematic viscosity, flash point, the sample under consideration will generate good biodiesel.

REFERENCES

Abbah, E. C., Nwandikom, G. I., Egwuonwu, C. C., & Nwakuba, N. R. (2016). Effect of reaction temperature on the yield of biodiesel from neem seed oil. *American Journal of Energy Science*, 3(3), 16-20.

Abdelmalik, M.S. and Abdulaziz. H.M. (2020). Homogenous Acidic and Basic Catalysts in Biodiesel Synthesis: A Review. Acta Chemica *Malaysia (ACMY),* 4(2), 76-85.

Abdullah, S. H. Y. S., Hanapi, N. H. M., Azid, A., Umar, R., Juahir, H., Khatoon, H., & Endut, A. (2017). A review of biomass-derived heterogeneous catalyst for a sustainable biodiesel production. *Renewable and Sustainable Energy Reviews*, *70*, 1040-1051.

Abdullah, S. H. Y. S., Hanapi, N. H. M., Azid, A., Umar, R., Juahir, H., Khatoon, H., & Endut, A. (2017). A review of biomass-derived heterogeneous catalyst for a sustainable biodiesel production. *Renewable and Sustainable Energy Reviews*, *70*, 1040-1051.

Abomohra, A. E. F., Elsayed, M., Esakkimuthu, S., El-Sheekh, M., & Hanelt, D. (2020). Potential of fat, oil and grease (FOG) for biodiesel production: A critical review on the recent progress and future perspectives. *Progress in Energy and Combustion Science*, *81*, 100868.

Abomohra, A. E. F., Elsayed, M., Esakkimuthu, S., El-Sheekh, M., & Hanelt, D. (2020). Potential of fat, oil and grease (FOG) for biodiesel production: A critical review on the recent progress and future perspectives. *Progress in Energy and Combustion Science*, *81*, 100868.

Ajanovic, A. (2011). *Biofuels versus food production: Does biofuels production increase food prices? Energy, 36(4), 2070–2076.* Adak, A., Singh, S., Lavanya, A. K., Sharma, A., & Nain, L. (2018). Sustainable production of biofuels from weedy biomass and other unconventional lignocellulose wastes. In *Sustainable Biotechnology-Enzymatic Resources of Renewable Energy* (pp. 83-116). Springer, Cham.

Aldhaidhawi, M., Chiriac, R., & Badescu, V. (2017). Ignition delay, combustion and emission characteristics of Diesel engine fueled with rapeseed biodiesel–A literature review. *Renewable and Sustainable Energy Reviews*, *73*, 178-186.

Arumugam, A., & Sankaranarayanan, P. (2020). Biodiesel production and parameter optimization: An approach to utilize residual ash from sugarcane leaf, a novel heterogeneous catalyst, from Calophyllum inophyllum oil. *Renewable Energy*.

Balan, V. (2014). Current challenges in commercially producing biofuels from lignocellulosic biomass. *International Scholarly Research Notices*, *2014*.

Balasubramanian, N., & Steward, K. F. (2019). Biodiesel: History of Plant Based Oil Usage and Modern Innovations. *Substantia*, *3*(2), 57-71.

Chen, J., Li, J., Dong, W., Zhang, X., Tyagi, R. D., Drogui, P., & Surampalli, R. Y. (2018). The potential of microalgae in biodiesel production. *Renewable and Sustainable Energy Reviews*, *90*, 336-346.

Chuah, L. F., Klemeš, J. J., Yusup, S., Bokhari, A., & Akbar, M. M. (2017). A review of cleaner intensification technologies in biodiesel production. *Journal of cleaner production*, *146*, 181-193.

Dahdah, E., Estephane, J., Haydar, R., Youssef, Y., El Khoury, B., Gennequin, C., Aboukaïs, A., Abi-Aad, E. and Aouad, S., 2020. Biodiesel production from refined sunflower oil over Ca–Mg–Al catalysts: Effect of the composition and the thermal treatment. *Renewable Energy*, *146*, 1242-1248.

Damanik, N., Ong, H. C., Tong, C. W., Mahlia, T. M. I., & Silitonga, A. S. (2018). A review on the engine performance and exhaust emission characteristics of diesel engines fueled with biodiesel blends. Environmental Science and Pollution Research, 25(16), 15307-15325.

Das, P., & Ganesh, A. (2003). Bio-oil from pyrolysis of cashew nut shell—a near fuel. *Biomass and bioenergy*, *25*(1), 113-117.

Dash, S. K., & Lingfa, P. (2017, July). A review on production of biodiesel using catalyzed transesterification. In *AIP conference proceedings* (Vol. 1859, No. 1, p. 020100). AIP Publishing LLC.

De, A., & Boxi, S. S. (2020). Application of Cu impregnated TiO2 as a heterogeneous nanocatalyst for the production of biodiesel from palm oil. *Fuel*, *265*, 117019.

Demirbas, A. (2005). Biodiesel production from vegetable oils via catalytic and non-catalytic supercritical methanol transesterification methods. *Progress in energy and combustion science*, *31*(5-6), 466-487.

Esonye, C., Onukwuli, O. D., & Ofoefule, A. U. (2019). Chemical kinetics of a two-step transesterification of dyacrodes edulis seed oil using acid-alkali catalyst. *Chemical Engineering Research and Design*, *145*, 245-257.

Faruque, M. O., Razzak, S. A., & Hossain, M. M. (2020). Application of Heterogeneous Catalysts for Biodiesel Production from Microalgal Oil—A Review. *Catalysts*, *10*(9), 1025.

Ferreira, R. S. B., dos Passos, R. M., Sampaio, K. A., & Batista, E. A. (2019). Heterogeneous Catalysts for Biodiesel Production: A Review. *Food Public Health*, *9*, 125-137.

Ferreira, R. S. B., dos Passos, R. M., Sampaio, K. A., & Batista, E. A. (2019). Heterogeneous Catalysts for Biodiesel Production: A Review. *Food Public Health*, *9*, 125-137.

Galadima, A., & Muraza, O. (2020). Waste materials for production of biodiesel catalysts: Technological status and prospects. *Journal of Cleaner Production*, 121358.

Ganesan, R., Manigandan, S., Samuel, M.S., Shanmuganathan, R., Brindhadevi, K., Chi, N.T.L., Duc, P.A. and Pugazhendhi, A., 2020. A review on prospective production of biofuel from microalgae. *Biotechnology Reports*, p.e00509.

Gerhard, Knothe. "The history of vegetable oil-based diesel fuels." *The Biodiesel Handbook,* (2005): 12-24.

Giakoumis, E. G., & Sarakatsanis, C. K. (2019). A comparative assessment of biodiesel cetane number predictive correlations based on fatty acid composition. *Energies*, 12(3), 422-451.

Gopinath, A., Puhan, S., & Nagarajan, G. (2009). Relating the cetane number of biodiesel fuels to their fatty acid composition: a critical study. *Proceedings of the*

Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, *223*(4), 565-583.

Hammed, L. A., Anikwe, J. C., & Adededji, A. R. (2008). Cashew nuts and production development in Nigeria. *Am. Eurasian J. Sci. Res*, *3*(1), 54-61.

Hammed, L. A., Anikwe, J. C., & Adededji, A. R. (2008). Cashew nuts and production development in Nigeria. *Am. Eurasian J. Sci. Res*, *3*(1), 54-61.

Hanaki, K., & Portugal-Pereira, J. (2018). The effect of biofuel production on greenhouse gas emission reductions. In *Biofuels and Sustainability* (pp. 53-71). Springer, Tokyo.

Hanif, M. A., Nisar, S., Akhtar, M. N., Nisar, N., & Rashid, N. (2018). Optimized production and advanced assessment of biodiesel: a review. *International Journal of Energy Research*, *42*(6), 2070-2083.

Hasan, M. M., & Rahman, M. M. (2017). Performance and emission characteristics of biodiesel–diesel blend and environmental and economic impacts of biodiesel production: A review. *Renewable and Sustainable Energy Reviews*, *74*, 938-948.

Ibrahim, M. M., Mahmoud, H. R., & El-Molla, S. A. (2019). Influence of support on physicochemical properties of ZrO2 based solid acid heterogeneous catalysts for biodiesel production. *Catalysis Communications*, *122*, 10-15.

Ibrahim, M. M., Mahmoud, H. R., & El-Molla, S. A. (2019). Influence of support on physicochemical properties of ZrO2 based solid acid heterogeneous catalysts for biodiesel production. *Catalysis Communications*, *122*, 10-15.

Ibrahim, M. M., Mahmoud, H. R., & El-Molla, S. A. (2019). Influence of support on physicochemical properties of ZrO2 based solid acid heterogeneous catalysts for biodiesel production. *Catalysis Communications*, *122*, 10-15.

İhsan, E. K. İ. N. (2019). Quality and composition of lipids used in biodiesel production and methods of transesterification: A review. *International Journal of Chemistry and Technology*, *3*(2), 77-91.

Introduction to biodiesel and glossary of terms. (2020). *Bioenergy, 45-49*

Jain, S. (2019). The production of biodiesel using Karanja (Pongamia pinnata) and Jatropha (Jatropha curcas) Oil. In *Biomass, Biopolymer-Based Materials, and Bioenergy* (pp. 397-408). Woodhead Publishing.

Junior, E. G. S., Perez, V. H., Reyero, I., Serrano-Lotina, A., & Justo, O. R. (2019). Biodiesel production from heterogeneous catalysts based K2CO3 supported on extruded γ-Al2O3. *Fuel*, *241*, 311-318.

Kamani, M.H., Eş, I., Lorenzo, J.M., Remize, F., Roselló-Soto, E., Barba, F.J., Clark, J. and Khaneghah, A.M., 2019. Advances in plant materials, food by-products, and algae conversion into biofuels: use of environmentally friendly technologies. *Green chemistry*, *21*(12), pp.3213-3231.

Kannan, G. R., & Anand, R. (2012). Biodiesel as an alternative fuel for direct injection diesel engines: A review. *Journal of Renewable and Sustainable Energy, 4*(1), 012703. Monteiro, M. R., Kugelmeier, C. L., Pinheiro, R. S., Batalha, M. O., & da Silva César,

A. (2018). Glycerol from biodiesel production: Technological paths for sustainability. *Renewable and Sustainable Energy Reviews*, *88*, 109-122.

Karmakar, B., Samanta, S., & Halder, G. (2020). Delonix regia heterogeneous catalyzed two-step biodiesel production from Pongamia pinnata oil using methanol and 2-propanol. *Journal of Cleaner Production*, *255*, 120313.

Ko, J. K., Lee, J. H., Jung, J. H., & Lee, S. M. (2020). Recent advances and future directions in plant and yeast engineering to improve lignocellulosic biofuel production. *Renewable and Sustainable Energy Reviews*, *134*, 110390.

Kothandaraman, J., Kar, S., Goeppert, A., Sen, R., & Prakash, G. S. (2018). Advances in homogeneous catalysis for low temperature methanol reforming in the context of the methanol economy. *Topics in Catalysis*, *61*(7-8), 542-559.

Koyama, K. (2017). The Role and Future of Fossil Fuel. *IEEJ Energy Journal, Special Issue*, 80-83.

Krishnaprabu, S. (2019). A Review on Biodiesel Production as Alternative Fuel. *International Journal of Pure and Applied Bioscience,* **7(2),** 258-266

Kumar, S., & Rosen, M. A. (2018). Cashew Nut Shell Liquid as a Fuel for Compression Ignition Engines: A Comprehensive Review. *Energy & Fuels*, *32*(7), 7237-7244.