



Sustainable Production and Characterization of Biodiesel from Cashew Nut (*Anacardium occidentale*) Seed Oil

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ABSTRACT

This study investigates the sustainable production of biodiesel from cashew nut seed oil using a heterogeneous catalyst. Transesterification was carried out using methanol in the presence of KI/Al₂O₃ catalyst under controlled conditions. The produced biodiesel was separated and characterized using Fourier Transform Infrared (FT-IR) spectroscopy to identify functional groups. The FT-IR results confirmed the formation of fatty acid methyl esters, indicating successful biodiesel production. Physicochemical properties such as kinematic viscosity, pour point, cloud point, and flash point were evaluated and compared with ASTM standards. The results showed that all parameters were within acceptable ASTM limits. This study demonstrates that cashew nut seed oil is a viable and sustainable feedstock for biodiesel production and can contribute to renewable energy development.

Keywords: Biodiesel production, Cashew nut seed oil, *Anacardium occidentale*, Transesterification, Heterogeneous catalyst, Fourier Transform Infrared (FT-IR) spectroscopy, Fatty acid methyl esters

INTRODUCTION

Biodiesel has recently received widespread attention as an essential source of renewable and environmentally friendly energy due to its ease of production and clean burning. Cashew nutshell is a biomass waste readily available in India. The world's population is increasing, and the developing world's economies are expanding. Demand for fuel is always on the rise (Guo 2013). The major problem of fossil fuels is higher carbon emission and depletion of oil reserves (Ishola et al. 2020). The primary drivers of alternative fuels are sustainable development and environmental preservation. Because of its superior performance and benefits of renewable, clean, degradable, pollution-free, non-toxic, biodiesel is often regarded as the most viable alternative energy source to petroleum diesel (Gohain et al. 2017; Zhang et al. 2020). Fatty acid methyl ester is another name of biodiesel. It can be made by transesterifying renewable sources such as vegetable oil, animal fats with short-chain alcohol in the presence of a catalyst. (Gaur et al.,2020).

Energy sector of any country is mainly dominated by fossil fuels due to its huge consumption in industrial, transportation and agricultural sector. Depletion of fossil fuels with an alarming rate is a maximum contribution of approx. 41%. The energy requirement of a country is majorly fulfilled by non-renewable conventional energy resources. Due to their limited availability, rapid industrialization and their increasing demand, these conventional fossil fuels are depleting at a very fast rate. So, to find out the best alternative of these conventional fuels is the need of the hour today. Biofuels is the best replacement of these fossil fuels, which are renewable, releases less amount of harmful gasses and have low cost as compared to conventional fossil fuels. Many countries are now emphasizing to use these alternative fuels.

RESEARCH METHODS

Methyl Ester Synthesis Using

The cashew nut seed oil (400g) was transesterified with methanol using KI/Al₂O₃ as catalyst. The weight ratio of oil to methanol was 3:1 (48g of methanol and 400g of oil) the amount of catalyst was 0.5% w/w of the oil (2g of the catalyst). The reaction was conducted at a temperature of 60°C for one hour to produce biodiesel and glycerol. The biodiesel was separated by gravity from glycerine using separating funnel after leaving it to settle for 20hrs (Mohammed et al, 2019).

FT-IR Characterization of the biodiesel

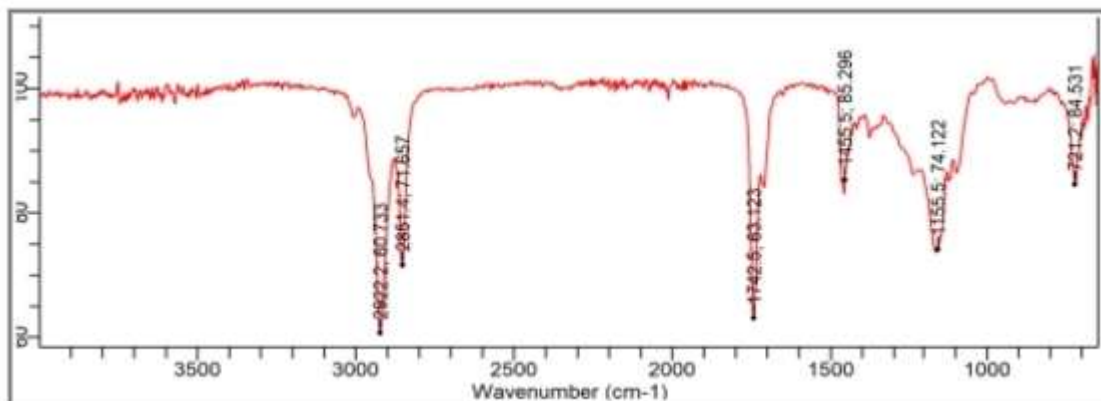
The FT-IR analysis of the product was carried out at the central advanced science laboratory Usman Danfodio University Sokoto using 630 model spectroscopy the transmission rate was set at the range of 400-650 cm^{-1} at a resolution of 4cm^{-1} a drop of the sample was place on a thin film positioned in the standard sample compartment of the FT-IR and spectral data was obtained.

FT-IR CHARACTERIZATION OF BIODIESEL PRODUCED

The esterification of cashew nut seed oil with methanol was carried out in a 250cm^3 round-bottomed flasks heated and a hot plate equipped with magnetic stirrer using $\text{KI}/\text{Al}_2\text{O}_3$ as catalyst. The FT-IR analysis of the biodiesel obtained shows the frequency of the main absorption band at 2922cm^{-1} which illustrates the C-H bond vibration of alkanes. The stretching absorption $\text{C}=\text{O}$ seen at around 1742cm^{-1} indicates a characteristic absorption of the ester group and a sharp stretching absorbance band at 1455cm^{-1} probably indicates C-O-H bending vibration of alcohol. Absorption was also observed at 1155cm^{-1} which is characteristics absorption of CH_2 alkane and sharp absorption at 721cm^{-1} was also observed indicating CH aromatic bending vibration. Similar absorption to the ones observed here where also reported by Zayyanu et al, (2023). From the spectrum obtained in the analysis of the biodiesel produced, it shows the presence of major peaks corresponding to C-H for alkyl $\text{C}=\text{O}$ absorption for carbonyls and a C-O absorption band for esters. Thus it is safe to say that the spectrum obtained was for an aromatic ester group. Again the absorption band and possible functional groups observed were presented in table;

Table 4.1.1 Absorption bands and functional group

Absorption band (cm^{-1})	Band type
2922	C-H
1742	C=O
1456	CH_2
1155	C-O
721	C-H



PHYSICOCHEMICAL PARAMETERS OF BIODIESEL PRODUCE

The physicochemical properties are important parameters that give significant information as well as the application of the oil these properties comprises of kinematic viscosity. Flash point, pour point, cloud point, among others the physicochemical properties of biodiesel produced in comparison with ASTM specification are presented.

Properties of Biodiesel in Comparison With ASTM Standards.

Properties	Unit	Biodiesel produce	ASTM limits
Kinematic viscosity	Cst	4.54	1.9-6.0

Pour point	°C	-9.8	-10-0.001
Cloud point	°C	5.0	4.8-5.3
Flash point	°C	153	100-174

Kinematic viscosity

Kinematic viscosity is the most important property of oil because it affects the fluidity, lubricity and atomization of fuel (Rangasamy et al, (2014). Fuel with low viscosity may not provide sufficient diesel resulting in wear and high viscosity causes poor combustion and also increases exhaust. The kinematic viscosity of biodiesel produced as presented in table above. is 4.54 similar result, (4.64) was obtained by Mohammed and Bhargavi.B, (2015). When they study the production of biodiesel from Cashew nut seed oil catalyzed by KI/Al₂O₃ the viscosity of the biodiesel synthesized from Cashew nut seed oil is in conformity with the standard values ASTM specifications as presented in table above.

Pour Point

Pour point of liquid is the temperature below which the liquid loses its flow characteristic. It is defined as the minimum temperature at which the oil has the ability to pour down from a container. The pour point was carried out in this work to determine the freezing point of the sample. The ASTM allowed limit of pour point is <-10°C. The pour point obtained from the synthesized biodiesel was found to be -9.8°C which is similar result with the result of -9.5°C obtained by Babatope and Racheal, (2020). The result obtained from the table above. falls within the range of ASTM specification for pour point for diesel.

Cloud Point

The cloud point is the temperature at which dissolved solids are no longer completely soluble precipitating as a second phase giving the fluid a cloudy appearance, Rangasamu et al, (2014). The ASTM specification for maximum allowed values of cloud point as presented in table above are within the range of 4.8-5.3°C. The cloud point of synthesized biodiesel was found to be 5.0°C which is similar to the result (5.0°C) obtained by (Gaur, et al.,2016). From the result, it is clear that the values obtained fall within the ASTM specification for the diesel.

Flash Point

The flash point is the maximum temperature at which fuel gives momentary flash on ignition under specified test condition it is an importance parameter for storage, handling and safety of fuel. The flash point of the synthesized biodiesel was found to be 153°C. Similar, result (162) was also obtained by Mohammed and Bhargavi B, (2015). when they study the production of biodiesel from Cashew nut based oil. The result obtained in this work was also in conformity with the ASTM specification as shown in table above.

CONCLUSIONS

This study revealed that biodiesel could be produced successfully from Cashew nut seed oil using heterogeneous catalyzed transesterification. The effect of different parameters such as kinematic viscosity, pour point, flash point and cloud point.

The physicochemical analysis of biodiesel produced showed that all the parameters analyzed are in conformity with the ASTM specifications.

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