



CHARACTERIZATION OF BIODIESEL PRODUCED FROM COTTON SEED OIL USING HETEROGENEOUS CATALYST

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Abstract - The main objective of the study is to characterize the biodiesel produced from cotton seed oil using heterogeneous catalysts. In a muffle furnace, clay was thermally activated to create the catalyst. The oil came from Zaria's Ahmadu Bello University. The characterization of the oil was determined by employing conventional techniques and certain instrumentation analysis, following the American Society for Testing Materials (ASTM) D4067 (1986). There is a presence of saponification value which shows that the oil is a source of biodiesel production. BET characterization was carried out to determine the catalytic properties of the thermally activated clay catalyst, the result shows there is an increase in the properties after it was treated. The oil was subjected to a catalyst transesterification process to make biodiesel. Main properties include flash point (170°C), cloud point (-8°C), density (875kg/m³), acid value (0.20), pour point (170°C), kinematics viscosity (4.05Cst), aniline point (188°C), comply with ASTM standards. The major functional groups of the biodiesel are C-H Stretch (alkanes and alkyls), and C=O Stretch (unsaturated nitrogen compound). The GC-MS result shows that the fatty acid of the oil was converted to methyl esters. This implied that linoleic acids and oleic acids were converted to linoleate and oleate. The effects of the process parameters carried out in the biodiesel produced showed that the catalyst concentration ranged from 0.4 to 1.2 weight percent, the reaction temperature ranged from 40 to 70 degrees Celsius, and the reaction time ranged from 50 to 90 minutes at a constant agitation speed of 300 rpm. From the study, it can be deduced that the characterization of the biodiesel produced complies with ASTM standards.

Keywords: Cotton seed oil, Biodiesel, Transesterification, Catalyst, Clay

1 Introduction

It is improbable that the world's existing supply of natural gas and petroleum from conventional resources would be sufficient to meet the rising demand for energy. The issue of energy crises is the big challenge in the modern technological world. The improper waste management also adds to many issues regarding the environment and economy. The establishment of systems for production of renewable energy sources can greatly help in overcoming the energy crises as well as environment protection (Amin, 2009; Balan, Chiaramonti, & Kumar, 2013; Cao et al., 2014; Chandel et al., 2007). There is an enormous demand for fossil fuels due to the ongoing expansion of industry and different kinds of cars. Because of the expansion of the

automotive industry, the average annual growth in energy consumption in the transportation sector alone is 1.1% worldwide. According to reports, the transportation sector alone would account for 63% of the increase in the world's overall use of liquid petroleum between 2010 and 2040 (Mahamudul et al., 2017).

Biodiesels appear to be the best intriguing and effective alternative energy source that academics have investigated for several reasons. One of the sustainable, safe, and environmentally beneficial alternative biofuels that can be utilized in a diesel engine is biodiesel. It is a byproduct of the combination of animal fats with vegetable oil. It is very biodegradable, contains little toxicity, emits no

sulfur, no aromatic compounds, less carbon monoxide, less particulate matter, less smoke, and more oxygen, all of which frequently result in full combustion. The ability to produce biodiesel offers a further outlet for vegetable and animal fats as well as the fuel required to keep farm equipment operating smoothly. This will inevitably reduce farmers' reliance on imported fuel (Abdullah et al 2011).

The primary obstacle to the commercialization of biodiesels are their high costs, which is attributed to the costs of the new material. Biodiesel is typically made from vegetable oils that are of food grade using an alkali-catalyzed transesterification process; it is composed of mono alkyl esters of long chain fatty acids and is produced using acids or by base catalyzed transesterification with ethanol or methanol. Transesterification of oils from *Jatropha curcas*, soybean, sunflower, cotton seed, rapeseed, and palm oils has produced notable results (Abdullah et al 2011).

The production of biodiesel from different non-edible oilseed crops has been extensively investigated over the last few years (Heroroo and Bharadwaj, 2013; Thangaraj et al., 2014; Sinha et al., 2016). From the review of the previous studies, there is need to produce biodiesel using cotton seed oil as substrate and clay as heterogeneous catalyst.

2. Materials and Method

2.1 Materials, Reagents and Equipment Used

All the chemical reagents used were of analytical grades. The material and chemical used in this experiment were purchased at Ogbete market, Enugu. They include methanol, distilled water and imidazole. The cotton seeds oil was procured from Ahmadu Bello University, Zaria, Kaduna State. Equipment/devices used include; electronic weighing balance, stop watch, measuring cylinders, beakers, Electric heater with magnetic stirrer, reflux condenser, conical flasks, GC-MS (Model: 5977C GC/MSD) and Fourier transform infrared (FTIR) spectrophotometer (Model No.:HV- 5500).

2.2 Method

2.2.1 Characterization of the oil

• Determination of density

A 100ml empty bottle's weight was ascertained by means of an electronic weighing scale. The oil was then poured into the bottle to the brim, and the combined weight of the oil and bottle was measured. The formula below was used to calculate the density when this process was repeated.

$$\text{Density } (p) = \frac{W_2 - W_1}{V} \quad (1)$$

Where w_1 = weight of the bottle without the oil, w_2 = weight of the bottle with the oil, v = volume of the oil

• Saponification value (S.V)

Following the addition of 30 ml of oil sample, 25 ml of a 0.5 M ethanol potassium hydroxide solution was added to a 250 ml conical flask. Before simmering, the contents of the flask were refluxed for 30 minutes over a water bath while being constantly swirled. There is now a reflux condenser. The surplus potassium hydroxides were titrated with 0.45 hydrochloric acids using a heated phenolphthalein indicators. Under the same conditions, distilled water was used for a blank determination, and the saponifications values was evaluated using the following equation:

$$\text{Saponification value (S.V)} = \frac{(B-R) \times 28.05}{\text{Weight of oil}} \quad (2)$$

Where B = Titre values of blanks (Distilled water), R = Titre values of real samples (oil)

• Determination of Free Fatty Acid (FFA) reagent

25 ml of a 0.5 M ethanol potassium hydroxide solution was added to a 250 ml conical flask that had 30 ml of oil sample in it. Before simmering, the contents of the flask were refluxed over a water bath for 30 minutes while continuously swirling. They installed a reflux condenser. A heated phenolphthalein indicator was used to titrate the excesses potassium hydroxides with 0.5 hydrochloric acids. The same conditions were followed for a blank determination using distil water, and the saponification values was evaluated using the followings equations:

$$\% \text{ FFA (as oleic)} = \frac{\text{Titre} \times N \times 28.2}{\text{Weight of sample}} \quad (3)$$

where, N = molarity of base

• Determinations of peroxide values

2.0g of oil was added to a 22 cm³ solution containing 12 cm³ of chloroforms and 10 cm³ of acetic acids. Saturated KI (0.5 cm³) was added to the flask. The flask was corked and then allowed to stand for a minute, shaking it continuously. The mixture was titrated against 0.1M of Na₂SO₃ after 30cm³ of distilled water was added until the yellow tint was almost eliminated. The starch indicator was added in increments of 0.5 cm³, and the titration process was continued until the blue hue barely disappeared. At the same conditions, a blank titration was also conducted.

$$\text{Peroxide value} = \frac{((S-B)*N*1000)}{W} \quad (4)$$

- **Determinations of acids values (A.V.)**

Before adding the 40 ml of oil sample, a 250 ml conical flask was warmed. One drop of 0.14M sodium hydroxide solution, two drops of phenolphthalein indicator, and vigorous shaking were added when a permanent light pink color that lasted for one minute was observed. The FFA value was computed using this point as the end point, as indicated below:

$$\text{Acid value} = \%FFA \text{ (as oleic)} \times 1.99 \quad (5)$$

- **Determination of iodine value**

A 250 ml conical flask stopper was filled with 15 ml of the sample, which was then incubated for precisely 30 minutes. After adding 10 milliliters of 14% W/V potassium iodine solution to the flask, any remaining iodine on the stopper was washed away. This was titrated up to a pale-yellow color using 0.14M Na₂SO₃. After adding the starch indicator (1%, 2 ml), the titration was carried out until the blue color vanished. Under the same circumstances, a blank determination using distilled water was performed. As seen below, the titre's values were noted and utilized to get the iodine values.

$$\text{Iodine value} = \frac{(B-R) \times \text{molarities of Na}_2\text{SO}_3 \times 12.69}{\text{Weight of sample}} \quad (6)$$

B= Titre's values of blanks (distilled water),

R= Titre's values for real determinations.

2.2.2 Characterizations of the Clay Sample

For the raw and active clay sample, the surface area, average pore diameter, and grand pore volume were measured using Brunauere-Emmette-Tellers (BET) characterization. The surface areas, pores volumes, and average pores width were estimated from the

adsorption's isotherm, using a micrometric ASXBP 2030 surfaces analyzers. The sample was degas using two-stage temperature ramps at vacuums of less than 10 mm Hg to eliminate moistures and other adsorbed gas from the catalysts surfaces before sample analyses at 78 K using nitrogenous gases.

2.2.3 Biodiesel Production Process

The process of transesterification was employed to produce biodiesel. A heated magnetic stirrer was used to move 100 grams of the oil sample into a flask with a flat bottom. The oil was then combined with 0.7 g of the clay and the required amount of methanol (6:1). Throughout the reaction, the reaction flask was maintained at a constant temperature of 60 °C and 250 rpm of agitation speed on a hot magnetic stirrer. The sample was removed at the predetermined 60-minute mark, allowed to cool, and then allowed to settle overnight at room temperature to separate the biodiesel (the methyl ester in the upper layer) from the by-product (the glycerol in the bottom layer). By comparing the weight of the layer, it was possible to calculate the percentage of biodiesel yield.

$$\text{Biodiesel Yield} = \frac{\text{weight of biodiesel}}{\text{weight of oil used}} \times 100 \quad (7)$$

2.2.4 Characterization of the biodiesel

2.2.4.1 Proximate analysis of the biodiesel

- **Determination of pour point**

Wax crystals were allowed to develop by chilling the heated specimen in a cooling bath. The test jar is taken out and labeled to look for surface movement at a temperature that is marginally over the predicted pour point and for each further X°C deducted. The jar is maintained horizontally for five seconds if the specimen does not flow when it is titled. The temperature at which it pours is the outcome if it does not flow.

- **Determination of cloud point**

The sample is then added to a test jar (50 ml) until it is around halfway full. A test thermometer is fastened to a cork, which seals the jar. The thermometer bulb should be positioned such that it lies at the bottom of the jar. In order to prevent overcooling, the entire test subject is then placed on top of a gasket in a cooling solution that is kept at a constant

temperature. At intervals of 10C, the sample is quickly reinstalled after being taken out and examined for clouds. Depending on the cloud point, cooling baths with successively lower temperatures may be employed.

- **Determination of flash point**

The flash point was identified using the Cleveland Open Cup (COC). The sample was placed in an open, heated cup, and the surface was periodically exposed to a flame. When the flame was high enough above the oil's surface, the measured flash point temperature was documented. The measured flash point changed with flame height.

- **Determination of kinematic viscosity**

The kinematic viscosity was determined according to ASTM D7042-04 standard. It was analyzed by injecting a sample into the digital automatic viscometer analyzer analyzed at 40°C.

- **Determination of calorific value**

The calorific values of biodiesels were obtained in bomb calorimeters according to ASTM D2016 standards methods. An oxygen bomb was pressurized to 4 Mpa with oxygen containers. The bombs were heated automatically after the jackets and the buckets temperatures equilibrate within acceptable accuracies of each other.

- **Determinations of moisture contents**

A known quantity of the samples was weighed in aluminum weighing dishes, and it was then dried to a constant weight for roughly 48 hours in a closed oven at 40–45°C. After 45 hours, the sample was weighed, put back in the oven, and weighed once more after 48 hours. The sample is deemed dry when the weight difference is less than 2%. The moisture content in the sample was then determined by weighing the dried sample. Moisture content is thus calculated as:

Initial weight of the sample (wet) = Xgm,
After drying the sample.

Final weight of the sample (dry) = Ygm,
 $Moisture\ content\ (Z\ \%) = \left(1 - \left(\frac{Y}{X}\right)\right) \times 100$ (8)

- **Determination of cetane number**

The fuel's chemical and physical characteristics have a significant impact on the ignition delay time. One such crucial factor that accounts for

the delay time is the fuel's cetane number. An indicator of a fuel's ability to ignite is its cetane number. A fuel with high cetanes numbers reduces delay times and facilitates smooth engines running. Because biodiesels contain more oxygen than petrodiesel, it has a higher cetane number. Using the sample's aniline point (AP) and degree API at specific gravity at 60°F (15.56°C), the cetane number was calculated. In a beaker, 10 millilitres of aniline solution were mixed with 10 millilitres of biodiesel to find the biodiesel's aniline point. The mixture was warmed by a heater and agitated until the two blended into a uniform solution. The beakers and their contents were allowed to cool before the heating was turned off and a thermometer was placed inside. The aniline point is the temperature at which the two phases split and was measured. The following formula was used to calculate the sample's degree API and Diesel index.

$$\text{Degree API} = \frac{141.5}{\text{Specific gravity at } 60^\circ\text{C}} - 131.5 \quad (9)$$

$$\text{Diesel Index (DI)} = \frac{\text{Degree API} \times \text{Aniline point}}{100} \quad (10)$$

Lastly, the cetane numbers of the samples were evaluated using the equation 10):

$$\text{Cetane Number} = 0.71\text{DI} + 11 \quad (11)$$

2.2.4.2 Fourier's transforms infra-reds spectrometers (FTIRs) analyses of the biodiesel

The oil sample from cotton seed was analyzed using FTIRs to determining which function groups were present. The infrareds spectrum was obtained in an evacuation chamber of a Shimadzu FTIRs-8410S spectrophotometers in the mid-infrared band (500-5000cm⁻¹) using potassium bromide discs as matrices. The spectral was gathered throughout the scans with a 2 cm⁻¹ spectral resolution. The materials were subjected to FTIR spectroscopy. To make the disk, 100 mg of KBr and only 2 mg of each sample were combined, then the mixture was pressed under 6 tones for 2 minutes. To make the KBr pellets, the sample was first ground and crushed. Using the Shimadzu 8400S over the 500–5000 cm⁻¹ operating window, OPUS 2000 software was used to fit the peaks and smooth them.

2.2.4.3 Gases chromatographs massive spectrometers GCsMS of the biodiesel

Following Onukwuli and Ude's (2019) technique, the free fatty acids content of the oil sample was ascertained by GCMS. An SGEBPX5MS fuses silicon capillaries columns (films thicknesses 0.30micronsmeter) for GCsMS detections and a Thermos Finnigian Traces GC/Trace DXQ/B1200 equipped with an electron ionization system with an ionization energy of 700eV were used to analyze the oil. The carrier gas, helium, was employed at a flow rate of 10 mL/min. The injector and MS transfer line temperatures were set to 220°C and 290°C, respectively. The oven was set to rise from 50°C to 150°C at a rate of 3°C per minute, with a planned decrease of 10°C per minute to 250°C. The oven was maintained at an isothermal temperature for 100 minutes. injecting a diluted sample of 1.00 µL (1/200, vol./vol, in methylenes chlorides) of 1.10 microliter was injects manually in the slit less modes. The identifications of individual's component were based on the comparisons of their relatives' retentions time with those of authentic sample on SGEAPY5 capillary columns, and by matches their masses spectra of peak with those obtain from authentic sample and/ or the Wileys 7N and TXLIBS library spectrum and publish data.

2.2.5 Effects of process variables on biodiesel yield

On the biodiesel yield, the effects of process factors (methanol/oil ratio, catalyst concentration, temperature and time) on the biodiesel yield were determined. The aim of this is to find out the variables that will interact actively to produce give the biodiesel glycerin yield.

3.0 Results and Discussion

3.1 Physiochemical property of the oil

Table 1 shows the physiochemical properties of the unrefined cotton seed oil. The oil has a modest acid number, with free fatty acid levels of 4.68 mgKOH/g, or 2.34%. These results suggest that the raw oil should undergo a homogeneous catalyst pretreatment step before the transesterification phase; nevertheless, the process may not proceed if heterogeneous catalysts are used. When compared to other non-edible oils, such as gmelina seed oil (Ude

and Onukwuli, 2018), *Jatropha curcas*, and African pear seed oil (Onukwuli and Ude, 2019), the raw oil's physicochemical properties are advantageous. The oil is difficult to atomize during internal combustion due to their high densities and viscosities. CSO has an iodine value of 21.92 (g/100 g). The iodine values are low, and it indicates non-drying oil and unsaturation (Ude and Onukwuli, 2018). High saponification values show that oil will be useful for household products like liquid soap and shampoo, hence they can be used for both domestic and industrial purposes. The measure of rancidity is the peroxide value, hence 0.28 meq/kg of CSO, shows they can withstand peroxidation during storage.

Table 1: Physicochemical Characteristics of the Oil

Property	Cotton seeds oil
Density (g/cm ³)	0.8995
Kinematic viscosity at 40°C (mm ² /s)	21.3
Saponifications Values (mg/g)	158.21
Acids Values (mg/g)	4.68
Free Fatty Acids (%)	2.34
Iodine Value (g/100g)	21.92
Peroxide value (meq/kg)	0.28

3.2 BET analysis

The catalytic properties of the raw clays catalysts and thermally activated clays catalysts were determined with BETs surfaces areas analysers and depicted in Table 2. From the table, it was noticed that the property of the clay catalyst enhanced after activations. The pore size of the row clay increases after thermal activations, and this could be due to openings of pore by the activations.

Table 2: Catalytic properties of the thermally activated clay catalyst

Parameters	Raw clay	Thermally activated clay
Surface area (m ² /g)	274.5	463.8
Pore size (nm)	2.13	3.24
Total pore volume (cm ³ /g)	10.71	21.3

3.3 Proximate Analysis result of the biodiesel

Table 2 provides an overview of all the biodiesel properties that were investigated along with a comparison of those attributes to the ASTM D 6751 (2002) requirements. Table

3 shows that the CSOB densities evaluated at 30°C were within the ASTM limitations for biodiesel. It was observed that the oil's viscosities dropped after the transesterification reaction. It is also mentioned that the viscosities of the biodiesel fall between 1.6 and 6.0 Cst ASTM. The flash point of pure methyl ester is usually greater than 200°C, indicating that it is "non-flammable." However, not all the methanol may be removed throughout the production and purification of the biodiesel, making it dangerous to handle and store if the fuel's flash point falls below 130°C. The CSOB was safe for storage because their flash points were higher than 130°C, which is the ASTM requirement.

High fuel acidity has been linked to corrosion and deposits in engines. CSOB has an acid value of less than 0.5 mg KOH/g. Since the ASTM value for TANs is 0.5 mg KOH/g, the acid values of the biodiesel are considered acceptable. The cetane number is a measure of the quality of ignition. Higher emissions are the

result of incomplete combustion of fuels with low cetane levels. The cetane index has a lower bound of 47 criteria set by the ASTM. The CSOB's cetane number was >47, which is more than the permissible limit. Therefore, the outcomes are satisfactory.

3.3 FTIR Analysis of the Biodiesel

The Fourier Transform Infrared Spectrometer used to convert the triglyceride of CSO into methyl ester by means of thermally activated clay is depicted in Figures 4. According to the results, the biodiesel's hydroxyl (OH) groups are stretching, which is responsible for the IR peak at 3278–3887.6cm⁻¹. The IR peaks located at 1375.4–1457.1 cm⁻¹ correspond to the O=C=O group's bending vibration peaks. The C-H stretching of the alkyl group and the C=O stretching of the esters group, respectively, are responsible for the two bands in the range of 2855.1–2922.2cm⁻¹ and the peak in 1744.4cm⁻¹ on the infrared spectra of the catalyst. These bands developed because of the unconsumed triglycerides in the oil.

Table 3: CSOB properties compared with ASTM limits

PROPERTY	UNITS	ASTM METHODS	CSOB	ASTM LIMITS
Density	kg/m ³	ASTM D-1298	875.9	830-880
Kinematics Viscosity	Cst	ASTM D-445	4.05	1.6-6.0
Flash Point	°C	ASTM D-93	170	≥130
Pour Point	°C	ASTM D-97	-13	+15 max
Cloud Point	°C	ASTM D-2500	-8	-15 to 5
Acid Value	mgKOH/g	ASTM D-974	0.20	≤ 0.80
Low Heating Value	MJ/kg		38	≥ 35
Aniline Point	(°C)	ASTM D-4737	188	
Cetane number		ASTM D-130	50	47 min
Biodiesel yield	%		97.1	

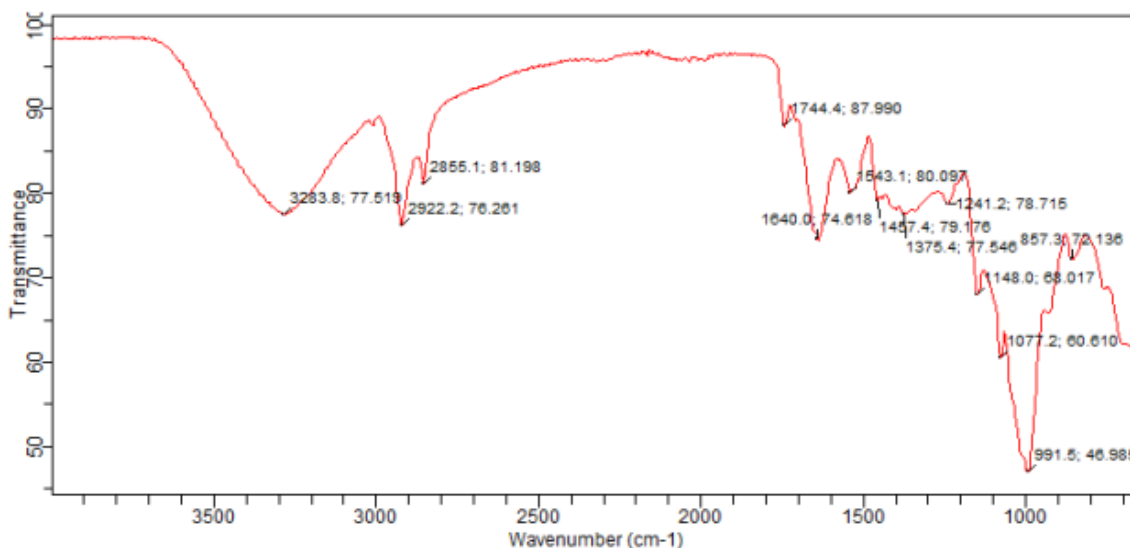


Figure 1: FTIRs spectrum of biodiesel produced from cotton seed oil.

3.4 GC-MS Analysis of the Biodiesel

The biodiesel produced was analyzed using GC-MS to confirm the conversion of fatty acid of the oil to biodiesel. The chromatogram of biodiesel is presented in Table 4. It shows that the fatty acid of the oil were converted to biodiesel. This implied that linoleic acids and oleic acids were converted to linoleate and oleate.

Table 4: Fatty acid compositions of biodiesel

S/N	FFAs Profiles		Biodiesel
	Fatty Acids	Components	Compositions (%)
1	Laureate	C ₁₂	4.01
2	Myristeate	C ₁₄	4.300
3	Palmitate	C _{16:0}	6.35
4	Palmitoleate	C _{16:2}	14.53
5	Stearate	C _{18:0}	11.72
6	Oleate	C _{18:1}	15.46
7	Linoleate	C _{18:2}	40.41
8	Arachideate	C ₂₀	3.12
	Total		100

3.5 Effects of Process Variables on the Biodiesel Yield

3.5.1 Effect of methanol/oil molar ration on yield

Figure 2 displays the production of biodiesel to the various molar ratios of methanol/oil of cotton seed oil, catalyzed by thermal activation clay. The findings showed that methanol oil ratio have significant impacts on biodiesel yields. For a methanol/oil molar ratio of 6:1 produced the highest ester output. The biodiesel yield increased as a result of the

greater molar ratio. When the molar ratio went above 6:1, the yield decreased. This could be because methanol contains polar hydroxyl groups that function as emulsifiers, generating emulsification that made it difficult to separate the esters layers from the water layers at higher methanol volumes, resulting in a reduction in ester yield (Ude and Onukwuli, 2020). The outcomes are consistent with the findings of Ude and Onukwuli's prior research (2020).

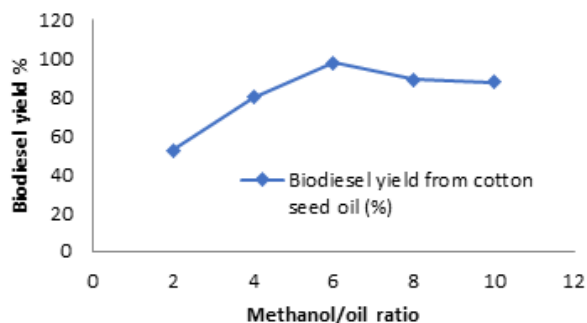


Figure 2: Effect of Methanol/Oil Ratio on the Biodiesel Yield

3.5.2 Effect of catalyst concentration on biodiesel yield

Figure 3 shows the impact of catalyst concentrations on the production yield reported as a weight percentage of the cotton seed oil. As the catalyst weight climbed up to 0.8 weight percent, the yield of biodiesel increased as well, as seen in the figure, before starting to decline. At first, the catalyst's quantity aided in quickening the reaction by raising its rate.

Because there is more catalyst in the reaction medium, the ester yield increases as catalyst weight increases. The biodiesel yield decreased when the catalyst weight was increased above the threshold of 0.8 weight percent. This could be because too much catalyst is producing issues with dispersion and mixing, which is impeding the formation of end product (Ude and Onukwuli, 2020).

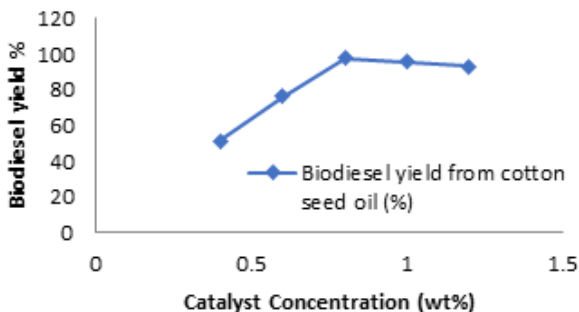
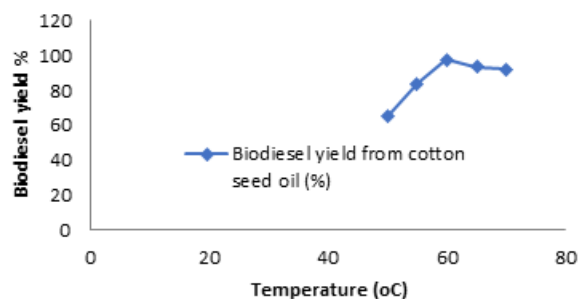


Figure 3: Effect of Catalyst Concentration on the Biodiesel Yield

3.5.3 Effects of temperatures on biodiesel yield

The impact of temperature on the yield of biodiesel from the oil of cotton seeds is shown in Figure 4. The reaction temperature was adjusted to 50, 55, 60, 65, and 70 degrees Celsius while the other parameters remained constant in order to investigate the impact of temperatures on the yields of the transesterification's reaction of cotton seeds oil with thermally activated clay. The reaction rate was slow at lower temperature, as Figure 4 illustrates, but when the reaction temperature rose over 60 °C, the yield of biodiesel first increased and subsequently dropped. High temperatures often allowed for faster reaction rate, but they also caused methanol to vaporize and generate a lot of bubbles, which slowed down the two phases' reactions. Similar finding was reported by Ude and Onukwuli, (2020).



b

Figure 4: Effect of Temperature on the Biodiesel Yield

3.5.4 Effect of time on biodiesels yields

As reaction time increase, so did the percentage yield of biodiesel. This study used thermally activated clay catalyst to examine the impact of reaction times ranging from 50 to 90 minutes on the reaction yield, as illustrated in Figure 5. It was discovered that the yield of the cotton seed oil biodiesel dropped after a response time of 70 minutes (Figure 5). The reversible transesterification reaction that results in the loss of biodiesel may have contributed to the yield decline after the 70-minute time frame mentioned above. The reaction was extremely sluggish because methanol and triglyceride diffused slowly into the catalysts' active sites.

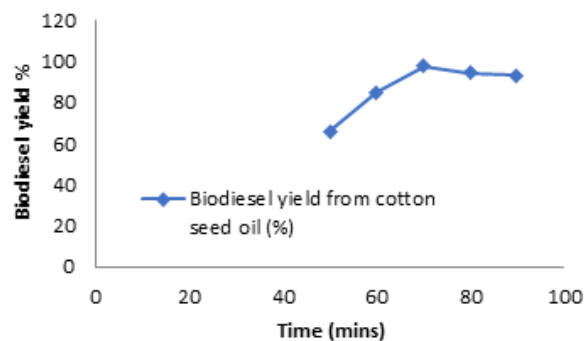


Figure 5: Effect of Time on the Biodiesel Yield

4.0 Conclusion

The physico-chemical properties, the saponification value of 158.21 of the cotton seed oil is normal, this shows that it is a potential raw material for biodiesel production. The catalytic properties of the clay (surface area, pore size and total pore volume) increased when it was thermally activated using BET method, making the clay more active. The biodiesel was produced by transesterification

process using clay as catalyst. Main properties include flash point (170°C), cloud point (-8°C), density (875kg/m³), cetane number (50) acid value (0.20), pour point (170°C), kinematics viscosity (4.05Cst), aniline point (188°C). The major functional groups of the biodiesel are C-H Stretch (alkanes and alkyls), C=O Stretch (unsaturated nitrogen compound). The GC-MS result shows that the fatty acid of their cotton seed oil was converted to biodiesel. This implied that linoleic acids and oleic acids were converted to linoleate and oleate. The effects of process parameters show that the biodiesel yield increased as a result of the greater molar ratio. When the molar ratio went above 6:1, the yield decreased. This is the same with temperature, catalyst concentration and time. From the study, it can be deduced that the characterization of the biodiesel produced comply with ASTM standards.

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