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Transesterification of palm kernel oil using calcium oxide as catalyst

[1]Mercy Badu, [1]Ransford Appianin Boateng, [2]Mary Magdalene Padevoah, [1]Blessed Agbemade
[3]Timothy Quainoo, [1]Micheal Baah Mensah, [1]Nathaniel Owusu Boadi

[1]Department of Chemistry, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, [2]Faculty of Applied Chemistry and Biochemistry, University for Development Studies, Navrongo, Ghana and [3]Department of Chemistry, Wayne State University, Detroit, Michigan 48202, USA

Abstract

The study focused on using locally produced palm kernel oil, palm ethanol and CaO catalyst from guinea fowl eggshells for biodiesel production. The physicochemical properties such as density (0.8936±0.00008165 g/ml), viscosity (83.32±0.193cP/P), refractive index (1.4540±0.00036), pH (5.89±0.084 mol/L H^+), acid value (13.9±0.3 mgKOH/g), saponification value (283.305±23.24 mgKOH/g) and iodine value (20.7±5.77 mgI_2/g) of the crude oil was determined. The transesterification process was carried out by optimizing reaction conditions using the One-Factor (OFAC) at a time method. The biodiesel produced from optimum conditions had density (0.877±0.001g/ml), iodine value (13.97±1.037 mgI_2/g) and cetane index (76.215±0.531). The results also gave a kinematic viscosity (7.87±0.531 mm²/s), pour point (8.667±0.943°C), acid value (0.92±0.145 mgKOH/g) and saponification value (161.75±11.017 mgKOH/g).

Keywords: Biodiesel, calcium oxide, palm kernel oil, palm ethanol, eggshell

Full length article *Corresponding Author, e-mail: noboadi@gmail.com

1. Introduction

According to the sustainable development goal (SDG) 7, the global target is to achieve affordable and clean energy by the year 2030. This implies there is a need to explore new resources as well as upgrading the already existing technologies and infrastructure to provide clean and efficient energy [1, 2]. Fossil fuels provide about 80% of the world's primary energy use, 10% biofuels, 5% nuclear energy and 5% spread among hydro, solar, wind and geothermal energy sources [2]. Reports in the literature point to the fact that the search for alternative fuel is widespread as a result of constant demand on the limited fossil fuel as an energy source as well as it's negative environmental impact [3].

Materials such as vegetable oils have been found as one of the important materials used directly in powering diesel engines [4]. Hence, vegetable oils exhibit several challenges which are usually associated with the high viscosity, acid composition and the free fatty acid content of the particular vegetable oil. Hence, vegetable oils require modifications to ensure effective powering of diesel engines. The common method of modification used to improve the quality and efficiency of vegetable oil is referred to as transesterification. A successful transesterification reaction has been shown to reduce the viscosity of the oils leading to the production of biodiesel [5]. Biodiesel is a biodegradable and bio-renewable chemical mixture of fatty acid alkyl esters. To convert the triglyceride content of vegetable oils to alkyl esters through transesterification reaction, alcohol and a catalyst are required. Several reports have shown the efficiency in converting triglycerides into biodiesel using transesterification processes [6]. Again, it has been established that biodiesel produced from transesterification meet standard specification provided by ASTM and is used to power diesel engines efficiently [7, 8]. The annual production of palm kernel oil in Ghana has been estimated at 232 million tons, with an estimated oil content of about 47–50% weight of oil in the palm nut [9]. Though palm kernel oil is used for soap and to some extent as cooking oil, currently, it does not have any major applications and hence its production is highly underutilized.

Majority of commercial biodiesels are produced through transesterification reaction of vegetable oils and methanol to yield fatty acid methyl esters. However, the utilization of methanol renders the end product biodiesel, not entirely renewable since the methanol is derived from fossil sources such as petroleum and natural gas. Furthermore, the depleting of fossil sources has caused

uncertainty to the supply and cost of petroleum products such as methanol. To overcome this challenge, other alcohol sources are derived from biomass through a fermentation process. This makes utilization of ethanol in biodiesel production 100% renewable and relatively cheap [10]. Eggshells are a good source of calcium oxide (CaO), calcium carbonate ($CaCO_3$), calcium phosphate, or hydroxylapatite, comparing with other sources such as carbonaceous rock, precipitated soil, teeth and bone. The by-product from hen and duck represent approximately 11 and 12.6% w/w of the total weight. The advantages of eggshell waste utilization are to replace the natural calcium, to reduce the waste problem in the household, to conserve natural resources from rock and soil and to reduce the global climate warming. CaO produced from eggshells through calcination process depends on temperature and time. CaO obtained has a good dispersion, good electrical properties and high porosity [11]. The aim of this study is to increase knowledge on utilization of locally sourced palm kernel, palm ethanol and CaO catalyst derived from eggshells for biodiesel production. The present work focuses on assessing the effects of factors such as temperature, time, catalyst concentration and the molar ratio of oil to ethanol as well as evaluate the kinetics of the reaction.

2. Materials and methods

2.1. Materials

Palm kernel oil was purchased from the local producers at the Ayigya market area a suburb in Kumasi (6.6898°N, 1.5727°W), in the Ashanti Region of Ghana. The oil was brought to the Department of Chemistry and kept in a freezer (free from light) to avoid any oxidation. Chemical reagents used in the study include sulfuric acid, iodine solution, isopropyl alcohol, methanol, chloroform (all were purchased from SURECHEM PRODUCTS LTD NEEDHAM MARKET SUFFOLK ENGLAND) and potassium hydroxide (KEM LIGHT, Mumbai, India).

2.2. Physicochemical characterization

The crude Palm Kernel oil and the biodiesel produced were characterized for the presence of saturated and unsaturated fatty acid compounds using the IR and HNMR spectroscopies. The pH, refractive indices were obtained using the pH meter and refractometer. The viscosity and density of the sample were determined according to ASTM D1298 (ISO 3675) and ASTM D445 respectively. The chemical properties such as acid value, iodine value, saponification value of the crude vegetable oil and the diesel produced were also evaluated by methods described in ASTM D664, EN 14111 and ASTM D5558 respectively.

2.3. Sample preparation for transesterification reaction

The crude palm kernel oil was pretreated using oil/alcohol molar ratio of 1:12 and varying the amount of CaO used in the range of 0.5% to 2%. The pretreatment was intended to reduce the acid value below 1% limit for satisfactory transesterification reaction [12].

2.4. Catalyst preparation

Eggshells obtained from guinea fowl were crushed into fine particles and calcined at a temperature of 900°C converting the calcium carbonate ($CaCO_3$) present to calcium oxide (CaO) as discussed by Pedavoah *et al* [1]. It was then dried at a temperature of 130°C to get rid of any water droplets. After the calcination and drying, the CaO was placed in a desiccator before the production of biodiesel.

2.5. Preparation of palm ethanol

The palm ethanol was produced from palm wine tapped from the palm sap. Fermentation of the palm wine within at least 2 weeks produced the palm ethanol with approximately 46% alcohol percentage. The palm ethanol underwent distillation process which increased the alcohol percentage to approximately 96%. Alcoholmeter and pycnometer were used to measure the alcohol percentage and the density respectively.

$$\text{The percent recovery (yield) of the distillation process} = \frac{\text{volume (weight) of distilled liquid recovered from the vapour}}{\text{original volume (weight) of the liquid mixture}} \times 100\% \quad \ldots\ldots\ldots (1)$$

2.6. GC-MS analysis of the palm kernel oil

GC-MS analysis of the samples was performed using a PerkinElmer GC Clarus 580 Gas Chromatograph interfaced to a Mass Spectrometer PerkinElmer (Clarus SQ 8 S) equipped with ZB-5HTMS (5% diphenyl/95% dimethyl polysiloxane) fused a capillary column (30×0.25 µm ID×0.25 µm DF). The oven temperature was programmed from 80°C (isothermal for 2 mins), with an increase of 15°C/min to 150°C, then 3°C/min to 250°C and holding for 4 mins at 250°C. For GC-MS detection, an electron ionization system was operated in electron impact mode with ionization energy of 70eV. Helium gas (99.999%) was used as a carrier gas at a constant flow rate of 1.6ml/min, and an injection volume of 1µl was employed. The injector temperature was maintained at 250°C, the ion-source temperature was 220°C. Mass spectra were taken at 70eV; a scan-interval of 0.5 s and fragments from 45 to 4500Da. The solvent delay was 0 to 3 mins, and the total GC/MS running time was 34.5 mins, respectively. The mass-detector used in this analysis was Turbo-Mass, and the software adopted to handle mass spectra and chromatograms was a Turbo-Mass ver-6.1.0. Interpretation on mass spectrum GC-MS was conducted using the database of National Institute of Standard and Technology (NIST) having more than 62,000 patterns.

2.7 Transesterification reaction

The transesterification reaction was carried out in a 250 ml three-neck round bottom flask with a magnetic stirrer, a condenser and a thermometer to monitor and control the reaction temperature. A known weight of catalyst (0.28 g) was weighed and transferred into 4.5 ml alcohol (the volume depends on the molar ratio) and thoroughly mixed until it dissolves at 40°C forming calcium ethoxide ($Ca(OCH_2CH_3)_2$). Typically, the oil was heated at 60°C and mixed with the calcium ethoxide in the flask. The reaction was conducted in a water bath for the source of heat. The reaction was allowed to proceed by refluxing. The experiment was conducted by varying the reaction conditions such as molar ratio, temperature, time and % catalyst. One-factor at a time (OFAC) method was employed for the experiment. The molar ratio was varied from 1:3, 1:6, 1:9 to 1:12. The temperature was varied from 60, 70, 80 to 100°C. The time was varied from 90, 150, 210 to 240 mins and the % catalyst was varied from 1, 2, 3 to 4% with other parameters held constant with respect to each variation. At the end of each reaction, the mixture was centrifuged for 30 mins at 4000 rpm. The biodiesel portion separated and washed thoroughly. The yield was calculated and the product was checked for its quality as a fuel.

2.8. Yield and product characterization

The biodiesel yield was expressed in percentage weight by weight (%w/w) and percentage volume by volume (%v/v) using equations 2 and 3:

Percentage yield weight by weight (%w/w)=(weight of biodiesel/weight of oil)×100% … … … (2)

Percentage yield volume by volume (%v/v)=(volume of biodiesel/volume of oil)×100% … … … (3)

2.9. Product characterization

The biodiesel produced was characterized using the fuel properties. The pour point, total acid number and kinematic viscosity were determined according to ASTM D97-05, D974-02 and ASTM D445 respectively. The cetane index (CI) was calculated using the formula:

$$CI=46.3+5458/SN-0.225\times IV \quad \ldots\ldots\ldots (4)$$

Where SN and IV denote saponification and iodine value respectively.

3. Results and discussion

3.1. The yield of palm ethanol

Locally distilled ethanol with an alcohol content of 46% of 0.904 g/ml density was further distilled in the laboratory. About 56% ethanol yield containing 97% alcohol content was obtained at the end of the laboratory distillation. The density of the resultant ethanol measured at 27ºC gave 0.794 g/ml which confirmed the 97% purity of the ethanol. From the results obtained, it is clear that the higher the alcohol content the less dense the ethanol. This trend is in agreement with the literature value of pure ethanol at 27ºC [13].

3.2. Characterization of crude palm kernel oil

The current study considered the potential use of palm kernel oil as a feedstock for the production of biodiesel. To establish this potential, the physical and chemical properties of the palm kernel oil were determined. Infra-red (Figure 1), Proton NMR (Figure 2) and Gas Chromatography-Mass Spectrometry-GC-MS (Figure 3) spectroscopic analysis were used to identify the functional groups as well as confirm the level of unsaturation present in the Palm kernel oil.

From the IR spectrum, the palm kernel oil was found to consist of the sp^3 C-H stretches which were seen around 2800 to 2900 cm^{-1} with the asymmetric stretch around 2900 cm^{-1} and the symmetric stretch around 2800 cm^{-1} wavelength. There was no observable peak around 1680 cm^{-1} corresponding to C=C and around 3100 cm^{-1} representing C=C-H stretching. This may be due to the low level of unsaturation of the fatty acid chains present in the palm kernel oil.

Additionally, the ^{1}H-NMR analysis was employed both qualitatively and quantitatively to further characterize the crude palm kernel oil. From figure 2, the spectrum showed the appearance of $-(CH_2)n-CH_3$ (terminal methyl protons), $-(CH_2)n$ (methylene protons), $-OCO-CH_2-CH_2-$ (acyl protons), $-CH_2-CH=CH-$ (allylic protons), $-OCO-CH_2-$ (acyl protons), $-CH_2OCOR$ (glyceryl protons) and -CH=CH- (olefinic protons) designated by *a, b, c, d, e, f and g, h and i* respectively. From the integration values calculated, the percentage of each proton group was calculated to be 11.5%, 64.4%, 7.9%, 1.4%, 7.8%, 5.0% and 1.9% respectively. With the help of the GC-MS, the palm kernel oil contained 81.86% saturated fatty acids and 18.12% unsaturated fatty acids. Comparing the data obtained from the IR, H^1NMR and GC-MS analysis to the literature, it was estimated that palm kernel oil contained 82% saturated and 17.6% unsaturated fatty acids [12]. This agrees with the results obtained in this study. Alamu *et al* reported high levels of lauric acid and myristic acid which are all short-chain saturated fatty acids and low levels of oleic and linolenic acids which are unsaturated fatty acids (Table 1).

Physicochemical properties of the palm kernel oil were studied and the results obtained shown in table 2.

The density of palm kernel oil in the study was found to be 0.8936 g/ml. Density is a critical physical property when the oils are used as a starting material in the chemical industry especially in biodiesel production. In this study, the palm kernel oil used was found to have a density of 0.8936 g/ml. The large molecular size of triglycerides contained in the oil results in high densities which contribute to poor fuel atomization hence increases engine deposits [7]. For a better selection of oil for biodiesel production, the density of the

material (oil) should be very low (0.86–0.90 g/ml) to avoid engine failure.

Again, the large molecular size of triglycerides has a significant effect on both the viscosity and refractive index. Therefore, for efficient production and application of vegetable oils as biodiesels, there is the need to evaluate the viscosity and refractive index. In this study, the viscosity at room and elevated temperature, as well as the refractive indices of the palm kernel oil, were determined. The results show that palm kernel oil has a viscosity value of 83.32±0.193 cP/P at room temperature and 62.52±1.433 at 40°C. It was observed that an increase in temperature decreases viscosity. For straight vegetable oils (SVO), high viscosity and refractive index causes jets to become solid steam instead of a spray composed of small droplets resulting in poor combustion producing black smoke and provoking the development of deposits in the combustion chamber [14].

The Palm kernel oil recorded an iodine value of 20.7±5.77 mgI_2/g. The measure of iodine value gives an indication of the degree of unsaturation in the triglyceride composition of the oils A high iodine value is high, indicates a high number of double bonds in the fatty acid structure hence a high level of unsaturation. This study recorded lower iodine values (20.7) which indicates low levels of unsaturation and this confirms the results obtained from the IR and HNMR analysis. Low iodine value may be attributed to the breaking of double bonds in their triglycerides through oxidation, scission and/or polymerization process [15]. Additionally, the low iodine value may also be attributed to high saturated fatty acids as reported by [16].

The production of biodiesel using heterogeneous catalyst has a similar mechanism as that of saponification, the two reactions always compete [17]. Determination of the saponification value of crude vegetable oil before the oil is used to produce biodiesel gives a conceptual means to estimate the extent to which saponification reaction (soap production) will compete with the final biodiesel product. In this study, the saponification value of the palm kernel oil was determined to be 283.305±23.24 mgKOH/g. The kind of fatty acids, high temperature and water present in the oil greatly affects the saponification value.

The acid value was determined to be 13.9±0.3, corresponding to a free fatty acid (FFA) level of 6.95% which is above the 1% required for an efficient alkali catalysed transesterification. The high acid value of biodiesel leads to the corrosion and wear off engine parts. The measure of high acid value is as a result of the high levels of free fatty acids and any substance which contribute to the acidity of the oil. For an oil to be suitable for biodiesel production, the limit for satisfactory transesterification using an alkaline catalyst is 1% [18]. A high acid value in vegetable oil as a feedstock for biodiesel production requires pretreatment before use [19].

In this study, the pretreatment process was carried out to reduce the acid value by converting the FFA to bound acids (esters) by esterification reaction with methanol using sulfuric acid as catalyst. With all parameters constant (molar ratio of 1:12, 60℃ for 1hour duration), the catalyst was varied from 0.5 to 2% resulting in a change in the acid value. At 0.8% catalyst, the acid value reduced from 13.9 to 1.89 mgKOH/g which is satisfactory for biodiesel production.

3.3. Effects of reaction conditions on yield of product

The one-factor-at-a-time method was used to estimate the optimum yields of the product at the different reaction conditions and the results obtained shown in figure 6.

In transesterification reaction, the oil to alcohol molar ratio is an important parameter that affects the yield of biodiesel production [20]. Stoichiometrically, for 1 mole of triglyceride, 3 moles of alcohol are required to yield 3 moles of ester and 1 mole of glycerol. However, several studies have shown that the reaction of 1 mole triglyceride (oil) to 3 moles alcohol usually results in incomplete transesterification reaction [21]. Because of this, the current study looked at using different molar ratios (range 1:3-1:12) of oil: alcohol. The results obtained are shown in figure 6.

The percentage yield of the product at a molar ration of 1:3 oil to alcohol ratio increased to a maximum at 1:6 after which there was a decline in yield. At the start of the reaction at 1:3 molar ratio, the alcohol present in the reaction was not enough to ensure a complete transformation of the triglycerides into biodiesel. As the alcohol content increased, the number of alcohol molecules available to interact with the triglyceride molecules also increased hence effective collision resulting in increased forward reaction. As molar ratios increased from 1:9 to 1:12, there was a reduction in product yield and this could be due to the fact that a large number of the alcohol molecules occupied the greater portion of the catalytic surface and competes with the adsorption of the triglycerides molecules onto the surface hence a decrease in efficiency of conversion.

The amount of catalyst used in the transesterification reaction has a significant effect on the conversion efficiency of the reaction. In the current study, the catalyst content was varied from 1 to 4% and the results are shown in figure 6a. It can be seen from the results that the most effective conversion of the oil occurred at 1% catalyst content after which any further increase in the catalyst content led to a decrease in the product yield. At high catalyst percentage, the reacting materials may lead to the formation of emulsions, increasing its viscosity and hence a reduction in the yield. This trend was because as the concentration of the catalyst increased, the saponification process is favoured and the biodiesel yield was suppressed [22].

The duration of the transesterification reaction is an important factor to ensure contact between the reagent solution and the triglycerides to ensure effective conversion. In the current study, the optimum yield was obtained between 150 and 210 mins (figure 6c) after which there was a sharp decline. The decline in the yield can be attributed to the formation of saponification products at prolonged contact time. The saponification process suppresses the biodiesel yield.

To ensure molecules obtain sufficient energy for effective collision, it is critical to estimate the effect of temperature change on the transesterification reaction. In the current study, the effect of temperature on the reaction product was evaluated using a temperature range of 60°C to 100°C. The results showed that the reaction product reduced as the temperature increased (figure 6d). These results are in agreement with other reports in the literature [23]. At elevated temperatures, saponification of triglycerides is favoured in the presence of an alkaline catalyst such as the calcium oxide. This was confirmed as lather was observed during the reaction and scales found at the bottom of the round-bottom flask. Additionally, elevated temperatures result in the vaporization of the alcohol content in the reaction thereby reducing the amount of alcohol needed to convert the triglycerides into alkyl ester products. This eventually leads to a reduction in the reaction products.

3.4. Fuel properties of biodiesel

The product obtained at the end of the transesterification reaction was characterized to ascertain their fuel properties as compared with ASTM standard values. Results obtained are shown in Table 3.

Results obtained from the analysis of the physicochemical properties of the reaction products (Table 3) showed that the density and the iodine value met the ASTM standard values. The remaining properties including; acid value, saponification value, kinematic viscosity, pour point and cetane number were slightly below the ASTM standard values. However, comparing the physicochemical properties of the reaction product and that of the crude palm kernel oil (Table 1) starting material, it was observed that the product showed reduce values for all the parameters. A reduction in the physicochemical parameters for example viscosity indicates a successful conversion of the triglycerides to alkyl esters.

Using the IR, ^{1}H-NMR and GC-MS spectroscopy to characterize the reaction product, results from the IR (Figure 4) gave a characteristic peak of O-CH_2CH_3 stretch which occurred around 1050cm^{-1} indicating the presence of the transesterified product. The H^1NMR (Figure 6) also gave peak showing the presence of the methoxy protons of the methyl esters around 3.5-3.6 ppm designated as *f* and *g*. The proton groups have similar percentages as the crude palm kernel oil. From the equation described by Knothe and Kenar and the integration values, the percentage fatty acid methyl esters conversion was calculated to be 20.5%. The GC-MS displayed similar results to that of the palm kernel oil [12].

In this study, the rate constant and the order of the reaction was determined experimentally. The activation energy was determined by employing the Arrhenius equation. The order of the reaction was determined by plotting graphs for zeroth order, pseudo-first-order and second order. The regression coefficients, r^2 obtained was used to deduce the order of the reaction. The rate constant was then determined from the particular order.

From table 4, the highest r^2 value (0.6132) falls under the pseudo-first-order and hence the transesterification process is a pseudo-first-order reaction. The rate constant is determined from the graphs of the pseudo-first-order. The slopes from the graphs gave the rate constants at their respective temperatures.

From table 5, the rate constant is not a true constant because it varies when other parameters vary. It becomes constant when the reaction conditions are kept constant.

From the graph (Figure 7), the value of the slope corresponds to Ea/R and the intercept corresponds to lnA (Pre-exponential factor). This gives activation energy (Ea) of 27.41 KJ/mol and pre-exponential factor value of 6.47×10^{8} /s. This implies that the activation barrier for the reaction is 27.04 KJ/mol and energy equal to or greater than 27.04 KJ/mol is required to produce the biodiesel. The frequency of collision of the reactant molecules was determined to be 6.47×10^{8} /s.

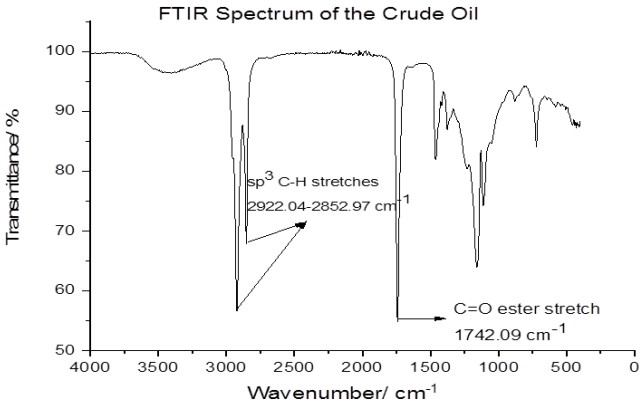

Fig. 1 shows IR of the palm kernel oil

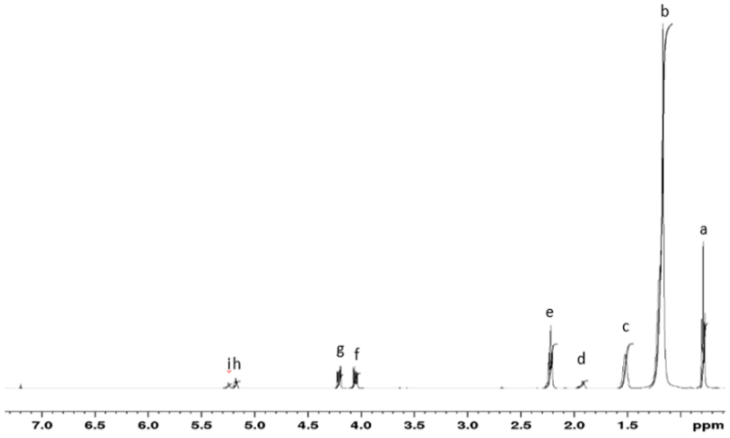

Fig. 2 ^{1}HNMR spectrum of the palm kernel oil

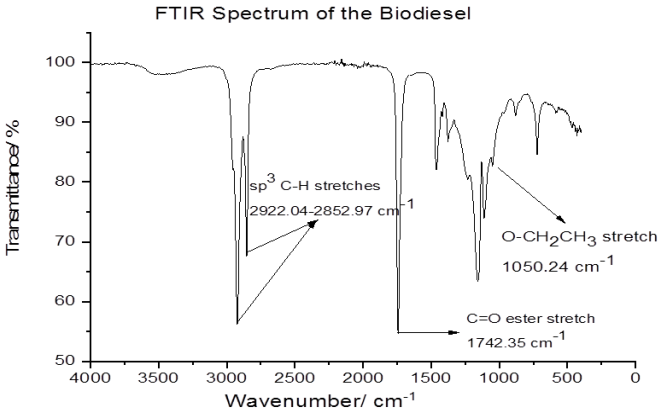

Fig. 3. FT-IR spectrum of the palm kernel ethyl ester (biodiesel)

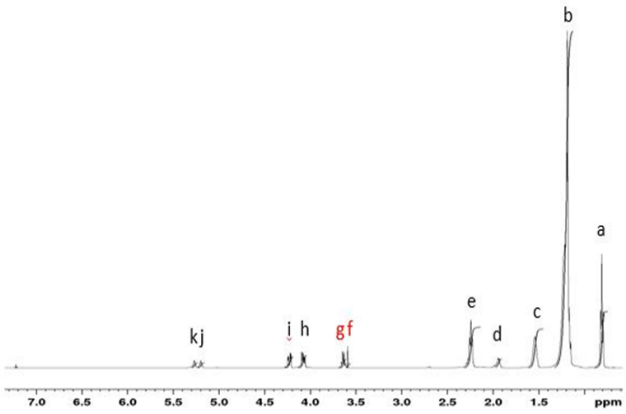

Fig. 4. ^{1}HNMR of the palm kernel ethyl ester (biodiesel)

Table 1: Major fatty acid composition of palm kernel oil

Type of fatty acid	Percentage (%)
Lauric (C12:0)	38.13
Myristic (C14:0)	24.60
Palmitic (C16:0)	11.04
Capric (C10:0)	2.82
Caprylic (C8:0)	1.98
Stearic (C18:0)	3.29
Oleic (18:1)	17.63
Linolenic (C18:3)	0.41
Others	0.10

Table 2: Values for the physicochemical properties of palm kernel oil and their corresponding S.I. unit

PARAMETER	VALUE	S.I. UNIT
Density	0.8936 ± 0.00008165	g/ml
Viscosity at RT	83.32 ± 0.193	cP/P
Viscosity- at 40°C	62.52 ± 1.433	cP/P
Refractive index	1.4540 ± 0.00036	-
pH	5.89 ± 0.084	mol/L H^{+}
Saponification value	283.305±23.240	mgKOH/g
Iodine value	20.7 ± 5.770	mgI_2/g
Acid value	13.9 ± 0.300	mgKOH/g

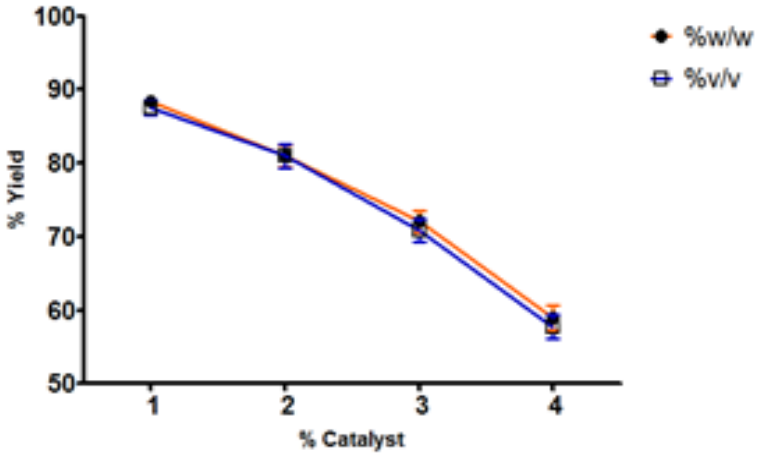

Fig.6a Effect of % catalyst on biodiesel yield

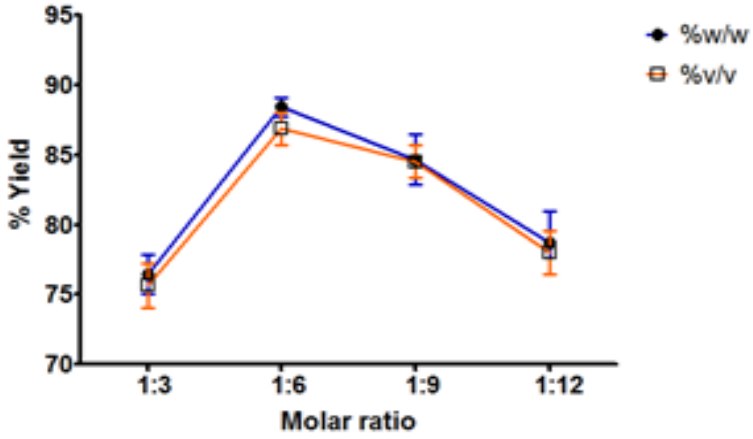

Fig. 6b Effect of molar ratio on biodiesel yield

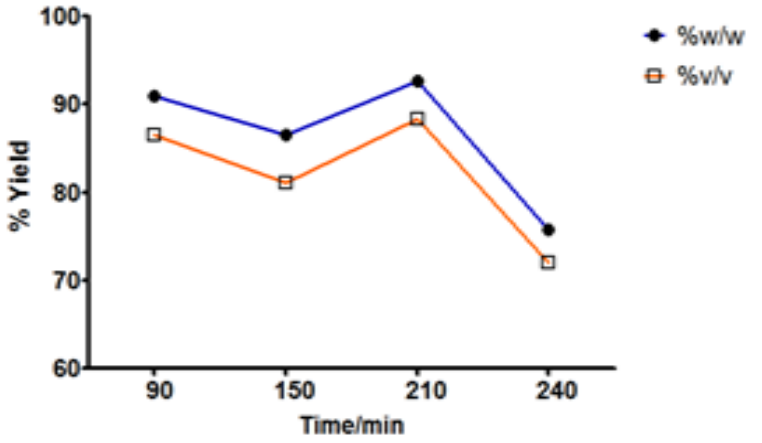

Fig. 6c Effect of time on biodiesel yield

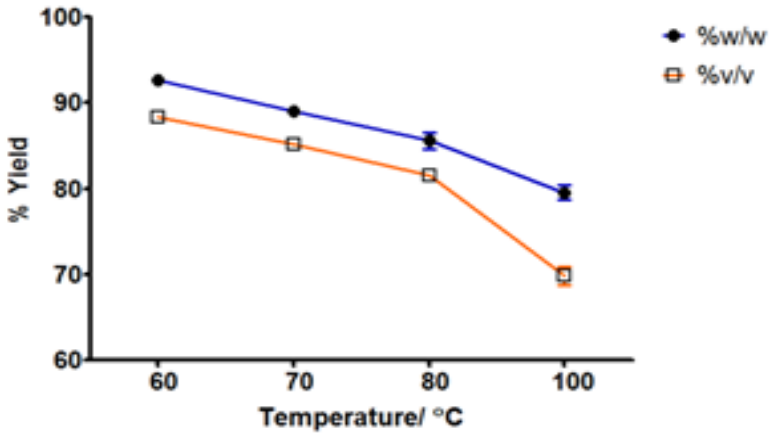

Fig. 6d Effect of temperature on biodiesel yield

Table 3: Fuel properties of the biodiesel compared to their standards

Parameter	Value	ASTM standard (D6571)	S.I unit
Density	0.877 ± 0.00129	0.86 – 0.90	g/ml
Acid value	0.92 ± 0.145	0.50 max	mgKOH/g
Saponification value	161.75±11.017	120max	mgKOH/g
Iodine value	13.97 ± 1.037	14.0	mgI_2/g
Kinematic viscosity at 40°C	7.87 ± 0.531	1.9 - 6	mm^2/s
Pour point	8.667 ± 0.943	2.5 (ASTM D97)	°C
Cetane index	76.215 ± 0.531	47min (ASTM D613)	-

Table 4 shows the verification of the order of the reaction for the transesterification of palm kernel oil based on their regression coefficient values (r^2)

Temperature/°C	Zeroth order (Conc. vs time)	Pseudo first order (ln conc. vs time)	Second-order (1/conc. vs time)
60	0.5421	0.6132	0.5261
70	0.2110	0.5181	0.2060
80	0.3205	0.4265	0.3027
100	0.2529	0.5961	0.2187

Table 5 shows the rate constants at the respective temperatures from the pseudo-first-order reaction

TEMPERATURE/°C	RATE CONSTANT / s^{-1}
60	3×10^{-5}
70	2×10^{-5}
80	2×10^{-5}
100	1×10^{-5}

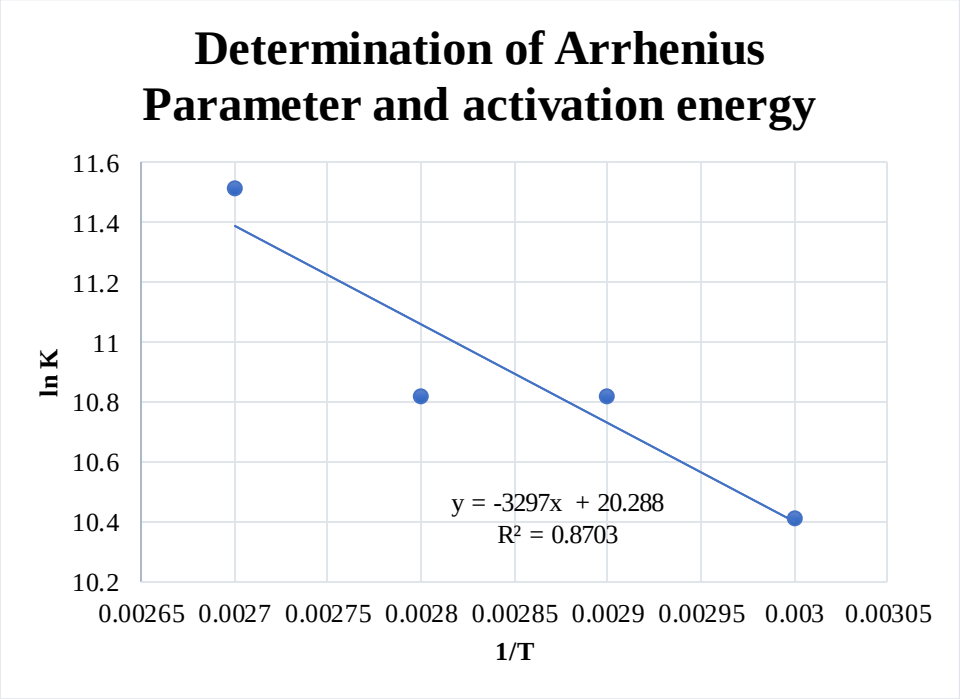

Fig. 7: Arrhenius plot for the determination of Arrhenius parameter and activation energy

4. Conclusions

In general, the results of the study revealed the suitability of palm kernel oil to be used in the production of biodiesel through a transesterification reaction. The palm kernel oil as feedstock is renewable and available and the product is environmentally friendly. Physicochemical properties of the oil provided good suitability of the oil as a precursor in biodiesel production. The optimum conditions for the transesterification of palm kernel oil were achieved at 1% CaO catalyst, 1:6 oil to ethanol ratio, reaction temperature of 60°C and time of 210 minutes. The yield at these conditions was 94.84%w/w corresponding to 92.26 %v/v. Chemical kinetics showed that the transesterification process is a pseudo-first-order, which implies that the palm kernel oil is the only limiting reagent in the reaction. The activation energy was determined to be 27.04 KJ/mol. This is the energy required to produce the biodiesel during the transesterification of palm kernel oil.

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