Production of Biodiesel from Partially Refined Palm Oil

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Abstract: The Palm Oil was partially refined by adsorptive bleaching using kaolinite clay. The clay used was acid and alkaline activated and the performance of the activated and unactivated in terms of colour reduction was examined using the lovibond Tintometer. The results show that the activation with 2M H_2SO_4, 2MNaOH and the unactivated clay gave colour reduction of 75.13%, 69.90% and 64.68%respectively. Therein acid activated clay used for the adsorptive bleaching procedure was then used for the transesterification process. The physico-chemical properties of the partially refined and unrefined palm oil were determined. Palm oil biodiesel was produced through transesterification of palm oil with methanol at 60^0C using NaOH and K_2CO_3 catalyst. The biodiesel yield from NaOH and K_2CO_3 were 93.8% and 85% respectively. The fuel properties of the biodiesel were characterized using ASTM standard methods. Fuel test conducted on the methyl esters showed 86.7% and 85.9% reduction of viscosity over crude palm oil. The results obtained from the characterization of the biodiesel; %free fatty acid, acid value, flash point, cloud point, cetane number and fuel potential were compared favourably with those from other vegetable biodiesel as well as various international standards for biodiesel fuel.
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Introduction

Biodiesel is defined as a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats designated B100 (Stildham, et al., 2000). Biodiesel is an alternative fuel for diesel engines that is gaining attention globally. It is one of the renewable fuels currently available. Its primary advantages are that it is non toxic and biodegradable. It can be used directly in most diesel engines without requiring any diesel modifications.

Transesterification of fats and oils can be achieved by the reaction of fats and oils with alcohols using different types of catalyst, such as, alkaline, acid, enzymes, and heterogeneous catalyst (Assman,et al., 1996; Wimmer, 1995).

However, report has it that yield of the product, methylester, using any of these catalysts as dependent on various factors, such as the quality of oil used.

This work is aimed at partially refining palm oil through adsorptive bleaching using modified clay. The trans-esterification reaction was carried out using different homogenous catalysts such as sodium hydroxide and potassium carbonate at constant molar ratio of the partially refined oil to methanol, constant temperature and constant reaction time.

Materials and methods

Sample collection and preparation

The crude palm oil (which had stayed for seven months from the date of production stored in plastic bottle) used for this work was obtain from Amurie-Omanze oil mill company, Amurie-Omanze Isu L.G.A Imo State of Nigeria.

Clay preparation

The clay sample was dispersed in the distilled water contained in 5 liter plastic bucket. The dispersed clay was stirred and allowed to settle. The upper layer which consists of plant particles were sieved off. The lower layer was continuously stirred and sieved off until it become free from suspended particles. The dispersed clay was allowed to settle for 24 hrs to allow the sedimentation process since different clay particle sizes are present. The top layer was collected via decantation and the remainder was washed with distilled water, allowed to settle for 24 hrs (for further sedimentation) and decanted to collect the top layer. The sol (prepared clay) was dried under the sun for several days, pulverized and sieved using 100µm mesh size to obtain clay of less than 100µm particle size.

Clay activation

150g of prepared clay was mixed with 200ml of 2M H_2SO_4 solution for acid activation of clay and 200ml of 2M NaOH for base activation of clay in a 1000ml beaker. The mixture was stirred and diluted with distilled water up to 800ml mark of the beaker and was allowed to settle for 24hrs. The aqueous phase was gently decanted. The acid treated or modified clay was placed in a crucible and oven dried for 3hrs at a temperature of 180—200 ^{0}C. The dried activated clay was pulverized and sieved using 100µm mesh size.

Refining of crude palm oil
Degumming

300g of crude palm oil was weighed, mixed with 20ml of phosphoric acid in a 500ml beaker, stirred and allowed to settle in a separating funnel over-night and finally the gums was separated from the palm oil.

Neutralization of the degummed palm oil

200g of degummed palm oil was weighed into a 500ml beaker and then subjected to heat maintained at the temperature of 60^{0}C, and was subjected to stirring, 150 ml of 0.8 M NaOH solution was gradually added. Stirring was allowed for 5 minutes and the solution was allowed to settle for about 15 minutes followed by separation. After separating the soap stock from the degummed palm oil, the oil was washed with hot water until the remaining of oil was free from soap stock. After the neutralization process, the neutralized palm oil was dried and then analyzed for % FFA

Adsorptive bleaching of the neutralized palm oil

100g of neutralized palm oil was weighed into a beaker and heated to a temperature of 90-95^{0}C. Then 5g of the various clay samples in bleaching operation was added to neutralized palm oil.The mixture was continuously stirred and heated 30^{0}C for 30 minutes and then allowed to settle for 4 hrs. The bleached palm oil was collected via decantation and dried at oven temperature of 105—110 ^{0}C for 2 hrs. This was done to avoid rancidity.

Colour determination using lovibond tintometer method

The oil in each case was introduced in the cell and subjected Lovibond Tintometer. A colour match of the oil in the ratio of 1.0:0.5 yellow to red filter gave a satisfactory colour match for the various samples of palm oil.

Transesterification process
Base catalyzed

The alkoxides used in the reaction were prepared by dissolving 0.1 wt% sodium hydroxide and potassium carbonate respectively in methanol in a conical flask and left overnight. Into the alkoxides contained in the conical flask were added partially refined palm oil (200ml) gradually, under a reflux condenser and a stirring device, while heating at 60^{0}C for 15minutes. The two layer mixture formed thereof was extracted with n-heptane to obtain the methyl ester and glycerol layer runned off. The methyl ester/n-heptane mixture left was washed until neutral pH with water, after which the solvent was removed to obtain a clear, golden-yellow, less viscous methyl ester.

Characterization of samples

The physico-chemical properties of the partially refined palm oil and the methyl esters were determined using ASTM standard methods (ASTM D 1639-90, 1994, ASTM D 1541-60, 1979; ASTM D 1962-67, 1979). Biodiesel properties of the partially refined palm oil and its methyl esters were determined using ASTM standard methods (ASTM, 2003).

Results

The physic-chemical properties of the crude and partially refined palm oil are shown in table 1 below. From the result, partially refining of the oil decreases the acid value, Viscosity, % free fatty acid (%FFA). This could be explained by the fact that refining removes impurities and contaminant present in the oil, which includes soapstock, Pigment, lecithin, trace metal and many other non lipid materials (Hoffmann, C. 1986). The reaction show saponification values of 210.31 (mg/KOH/g) for the crude palm oil and 210.50 (mg/KOH/g) for partially refined palm oil. The saponification value reveals the average molecular weight of the fatty acids of triglycerides present in the Palm oil as the mean molecular. The acid value of the crude palm oil is 16.60 (mg KOH/g) and the partially refined palm oil is 0.68 (mg KOH/g). The results obtained from partially refining of palm oil indicated that it would be suitable for biodiesel production

From Table 2 below the acid activated clay shows a better performance in terms of percentage colour reduction of palm oil which was about 75.13 %. The alkaline and the unactivated clay colour reduction were 69.90% and 64.68% respectively.

TABLE 1: The Values Physico-Chemical Properties of Crude and Partially Refined Palm Oil.

PROPERTIES	CRUDE PALM OIL	Partially Refined Palm Oil
Saponification value	210.31	210.50
Viscosity (in mm^2/s) 40^0C	-	34.5
Acid value	16.6	0.68
Iodine value	44.03	45.12
Calculated Cetane No.	49.04	49.04

Table 2
Y = Yellow Filter with Value of 1.0
R = Red Filter with Value of 0.5

Clay Samples	Lovibond Reading	Colour Value	%Colour Reduction
Unactivated	14 R +17Y	24	64.68 %
Alkaline activated	10. 9 R +15Y	20.45	69.90 %
Acid activated	3.8 R +15Y	16.9	75.13 %

The fuel properties of the partially refined biodiesel are depicted in table 3 below. The results shows that the yield of the methyl esters obtained when K_2CO_3 and NaOH were used in transesterification process gave 85% and 93.8% which is an indication that the impurities and contaminant present in the oil, which include soapstock, Pigment, lecithin, trace metal and many other non lipid material partially have been removed during refining, which was the result of the low acid value.

Biodiesel has higher viscosity than conventional diesel fuel which is in agreement with reports from several researchers (Yuan, 2004; Knothe, and Steidly. 2005; Peterson, 1990; Graboski, and McCormick 1998).

The viscosity of fuel is important for its flow through pipelines, injector nozzles and for atomization of fuel in cylinder. The reduction in viscosity is the major reason why alkyl esters of vegetable oils-biodiesel are used as fuel. The viscosities of the biodiesel were $4.865mm^2/s$ when K_2CO_3 catalyst was used in the transesterification process and $4.865mm^2/s$ for NaOH catalyst and they were in accordance with the ASTM specification. Flash point of vegetable oils are very high, which are considerably higher than those of fuels oils with flash point of 100^0C,vegetable oils are consider to be relatively safer than hydrocarbon (Ali, 1995). The flash point was 170^0C. The flash point is of prime importance for storage and transportation of liquid fuels (Bajpai and Tyagi , 2006). Cetane number is a dimensionless descriptor of the ignition quality of a diesel fuel. The cetane numbers of the biodiesel palm oil were 49.30 and 50.01 from K_2CO_3 and NaOH catalyst respectively and were in accordance with the ASTM biodiesel specification. Generally, the higher the cetane number, the shorter the ignition delay time is and the higher the propensity of the fuel to ignite (Knothe, et al., 2003). The cloud point which is used to access the low temperature properties of biodiesel has no limit, rather a “report is specified. The reason is that climatic condition of the United State varies considerably and therefore the needs of biodiesel users vary accordingly (Rashid and Anwar, 2008).

Table 3: fuel properties of biodiesels

Biodiesel properties	K_2CO_3	NaOH	Biodiesel (ASTM)
Density (in g/cm^3)	0.877	0.874	0.890
Viscosity (in mm^2/s) 40^{0}C	4.865	4.588	1.9-6.0
Flash point (in ^{0}C)	170 ^{0}C	170 ^{0}C	130 ^{0}C
Cloud point (in ^{0}C)	13 ^{0}C	13 ^{0}C	Report
Colour	Golden-yellow	Golden-yellow	-
Cetane	49.30	50.01	≥47
Percentage Yield	85%	93.8%	-

Conclusion

Refining through adsorptive bleaching using acid activated clay (Kaolinite) gives a better performance in terms of percentage colour reduction compared to the alkaline and unactivated clay (Kaolinite) which were both above average.

Transesterification of partially refined palm oil using NaOH catalyst gave the highest percentage yield than K_2CO_3 catalyst. Biodiesel properties do not vary within the sample irrespective of the experimental conditions. Thus, properties of biodiesel produced by transesterification of partially refined palm oil are comparable with the international standard and therefore recommended.

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