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The optimization of production of biodiesel from palmkernel oil

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ABSTRACT

Global concerns about the depletion of the world`s non- renewable energy sources and the associated environmental impact of fossil fuel provided the incentives to seek alternative to petroleum based fuels. Nigeria is no exception in the fears for crude oil production going extinction as recently stated by the energy commission of Nigeria. Alternative renewable foundin vegetable oils such as palm kernel oil (PKO) abound in Nigeria forest. In this work, biodiesel was produced from palm kernel oil. Potassium hydroxide was selected to catalyze the transesterification process with methanol. The temperature was varied between 50^{o}Cand 70^{o}C and catalyst weight varied between 2.5g and 3.5g. The highest amount of biodiesel (205 ml) was obtained at temperature of 70^{o}C and 3.5g catalyst weight gave highest of biodiesel (210 ml). The biodiesel was characterized and the measured properties found to be closed with that of petroleum diesel. The fuel characterization carried out show that the biodiesel produced can successfully fuel a diesel engine by the level of agreement between the results obtained and fossil fuel.

Introduction

The fuel and energy crises of the late 1970`s and early 1980`s as well as accompanying concerns to seek alternatives to conventional, petroleum-based fuels. Globally at present, the most widely used fuel are gasoline and diesel both coming from fossil fuel. Besides the fear for depletion of fossil fuel due to largely to its non-renewable status, use of gasoline is associated with environmental problems. Aside from being extremely flammable, it contributes to increase hazardous emissions. On the other hand diesel has high particulate matters, high sulphur dioxide and high poly aromatic hydrocarbons. The need to consider renewable sources of fuel, with acceptable environmentally friendliness to meet the ever increasing global energy demands can therefore not be over emphasized.

In Nigeria the energy commission (ECN,2012) reported that Nigeria`s fossil led economy is under severe pressure. In decades to come, the sun will slowly but certainly set on crude oil production. Today, large hydropower plants are increasingly threatened by a shrinking river Niger, shaking the security of electricity supplies (ECN, 2008). Nigeria currently imports about 80% of its petroleum requirements and has been hit hard by rapidly increasing cost and uncertainty. Unfortunately, in Niger region, the centre for oil extraction, severe environmental impacts have been ignored in the country`s haste to develop the oil industry. This has generated militancy from the local people in the region making successful oil prospecting a nearly impossible task for the multinational companies in Nigeria. As a result the cost of extracting the reserves will go on increasing in Nigeria. Thus there is an urgent need to find alternative renewable forms of energy before mineral oil supplies run dry. Hence, in the medium (2015) and long term (2016-2025), Nigeria envisions of energy transition from crude oil to renewable energy (ECN, 2005).

Interestingly, Nigeria is endowed with significant renewable energy resources including large and small hydroelectric power resources, solar energy, biomass, wind and potential for hydrogen utilization and development of geothermal and ocean energy. Vegetable oil as an alternative fuel has been under study in certain part of the world far back as 1979. Since then researches have considered the use of vegetable oil such as canola, rapeseed, soybean oil as diesel fuel substitute. High viscosities of these oils have however been reported to have limited their applications. (Silvia et al, 2008) were reported to have stated that high viscosities of pure vegetable oils reduce the fuel atomization and increase fuel spray penetration which would be responsible for high engine deposit and thickening of lubricating oil. The use of chemically system or transterified vegetable oil does not require modification in engine or injection system or fuel lines and is directly possible in diesel engine. Biodiesel is a name applied to fuels manufactured by the transesterification of renewable oil, fats and fatty acids. It has gained importance in the last years in more than 21 countries leading to commercial projects in Austria, the Czech Republic, France, Germany, Italy, Malaysia, Sweden and the USA. The use of biodiesel as fuel continues to attract attention because of the successful results obtained in its applications and the intent to utilize a domestic renewable resource that provides environmental benefits with lower emissions compared to the conventional petroleum based fuel. Oil palm is an oil bearing crop common in Nigeria. It has been found to be an appropriate renewable alternative source of biodiesel. The kernel of this crop is used to extract oil with about 50% palm kernel oil recovery. It contains 3.8mt oil found mostly in Malaysia, Indonesia and Africa (Jekagifa, 2006). While considerable works have appeared in print on biodiesel production from vegetable oils, limited studies were found for vegetable oil common in Nigeria. (Abigor et al, 2008) produced fatty acids esters from tho Nigeria Alaric oils, palm kernel oil and coconut oil, by transesterification of the oil with different alcohols using KOH as a catalyst. This work therefore seeks to produce test quantities of ethyl ester of palm kernel oil (EEPKO) via transesterification of the PKO with methanol using alkali catalyst, KOH. The choice of potassium hydroxide amongst other alkali catalyst was made as a result of possible generation of potash fertilizer as a

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byproduct alongside glycerine. This work further seeks to characterize the EEPKO biodiesel produced as alternative diesel fuel through test for specific gravity, viscosity, cloud point, pour point and flash point. The results are expected to contribute to baseline data needed for future replacement of conventional diesel with renewable biodiesel specifically these findings will find useful applications in energy sector of the Nigeria economy.

Methodology of Biodiesel Production

The following steps are involved in the production of biodiesel from palm kernel oil;

Preparation of solution of potassium methoxide

A solution of potassium was prepared into a 250ml beaker using 3g of potassium hydroxide pellet and 60ml of methanol and stirred it until all stakes of potassium hydroxide dissolved.

1. About 200ml of palm kernel oil was poured into a conical flask and heated to a temperature of 50^{o}C.
2. The potassium methoxide was poured into the warm palm kernel oil and stirred vigorously for 10 minutes using magnetic stirrer. The mixture produced was transferred into a separating funnel hung on a retort stand and allowed to settle for 24 hours.
3. The lower layer which is made up to glycerol and soap was with drawn out from the bottom of separating funnel while the upper layer (biodiesel) was decanted into a separate beaker.
4. The biodiesel produced was washed out thoroughly using distilled water to remove some traces of soap and other contaminants. The quantity of biodiesel and glycerol were measured and recorded. The above procedure was repeated with some variation.
5. (6) Two different set ups were made with same volume of palm kernel oil heated to 60^{o}C and 70^{o}C to produce other separate biodiesel using the above procedure.
6. (7) Similar procedure was followed to produce other separate biodiesel and using potassium methoxide with varying concentration as 2.5g, 160ml and 3.5g, 60ml at temperature of 60^{o}C.

Characterization Procedure

The pure biodiesel obtained through the above procedure was characterized to test for the following fuel physical properties.

Flash Point

The flash was determined using the Pensky –Marten equipment. The apparatus consists of a small cup into which the sample is put. The cup was gradually heated while being stirred continuously to distribute the heat uniformly in the cup. At regular intervals, the cup was opened and open flame was directed into it when the vapour in the cup was able to produce a momentary flame the temperature range that produced the flame is the flash point.

Viscosity

The common Fenske viscometer was used to determine the viscosity of the sample. Some quantity of the sample was put in the viscometer so that it just conceded with the level of the upper mark on the viscometer. The time taken for the meniscus of the sample to fall from the upper of the bulb was noted and the viscosity was calculated.

Relative density (R.D)

The relative density of the fuel sample was measured using two methods.

1. It was measured using the hydrometer.
2. It was also measured using the pignometer.

The pignometer was washed and dried and the temperature was measured the weight of equal volume of the sample and water both at 25oC were measured and the relative density based on the equation below was calculated.

$$R.D = \frac{\text{Mass of sample}}{\text{Mass of equal volume of water}}$$

Results and Discussion

For the alkali-catalyzed transeterification experiments conducted using the stated reaction parameters, the experimental results were evaluated and shown in the table below

Table A

Experimental conditions	50^{o}C	60^{o}C	70^{o}C
Reaction time (minute)	10	10	10
Settling time (Hour)	24	24	24
Palm kernel oil (PKO) quantity (ml)	200	200	200
Methanol quantity (ml)	60	60	60
KOH (catalyst) weight (g)	3	3	3
PKO biodiesel produced (ml)	190	204	205
Glycerol obtained (ml)	30	39	40
PKO biodiesel yield (%)	95	102	102.5
(by volume of 200ml PKO)			

Effect of Catalyst Weight on Biodiesel Yield

Table B

Experimental condition		CATALYST WEIGHT(g) 2.5	3.5
Reaction time (minutes)		10	10
Settling time (Hours)		24	24
Palm kernel oil (PKO) quantity (ml)		200	200
Methanol quantity (ml)		60	60
PKO biodiesel produce (ml)		180	210
Glycerol obtained (ml)		28	41
PKO biodiesel yield (%)		90	105
(by volume of 200ml PKO)			

With biodiesel yield of 205 ml and 210 ml at temperature of 70oC and catalyst weight of 3.5g, it shows that the combinations of experimental parameter used are within reasonable ranges around which the parameters could be varied to achieve optimum combination of operating conditions for PKO biodiesel production.

In characterizing the PKO biodiesel produced as alternative diesel fuel, the PKO biodiesel, the petroleum diesel used as control were analyzed for specific gravity at (60^{o}F/60^{o}F), viscosity and flash point. The results obtained are presented in the table below.

Measured fuel properties

Fuel characteristics

Characteristics of Biodiesel Produced

Table C

PKO BIODIESEL PRODUCED	PETROLEUM DIESEL		
Specific gravity (at 60^{o}F/60^{o}F)	0.872	0.820 minimum	
Viscosity (at37^{o}C) (mm^2/s)	3.43	1.60- 5.50	
Flash point (^{o}C)	70	65 minimum	

Discussion of Results

From the result obtained from the experiment, temperature is one of the important parameters for the production of biodiesel because the rate of reaction is strongly influenced by the reaction temperature. The effect of temperature on biodiesel production from palm kernel oil using potassium hydroxide as a catalyst was studied by conducting experiment at different temperature of 50^{o}C, 60^{o}C and 70^{o}C. For each temperature the yield of biodiesel was found and is shown in table A, the amount of biodiesel obtained was 190 ml, 204 ml, and 205 ml respectively. The table shows that during the course of transesterification the biodiesel yield continues to increase till 70^{o}C.

The amount of biodiesel produce at temperature 60^{o}C and 70^{o}C are 204ml and 205ml respectively which produce at temperature 60^{o}C and 70^{o}C are 204 ml and 205ml respectively which is a different of 1 ml. It means that it is not economical to heat the process to 70^{o}C. Therefore biodiesel production can suitably be produced at temperature of 60^{o}C. Also the table shows different amount of glycerol obtained at different temperature of 50^{o}C, 60^{o}C and 70^{o}C. The amount of glycerol obtained was 30ml, 39ml and 40ml respectively. Different percentages of PKO biodiesel yield (by volume of 200ml PKO) were obtained at different temperature of 50^{o}C, 60^{o}Cand 70^{o}C. The percentages are 95%, 102% and 102.5% respectively.

The effect of catalyst weight in biodiesel production is presented in table B. It is clear therefore from table B that increment in catalyst weight resulted in increment in volume of biodiesel obtainable from palm kernel oil. This is in agreement with the work of Darnoke where it was concluded that the volume of biodiesel increases with increment in catalyst weight.

The result of characterization of the produce is table C. The result revealed that the specific gravity recorded for the PKO biodiesel is higher than the values obtained for petroleum diesel. This is in agreement with earlier observations made by several authors (Peterson et al, 1990, Graboski and Mc comic, 1992, Yuan et al , 2004).

Specific gravity has been described as one of the most basic and most important properties of fuel because of fuel because some important performance indicators such as cetane number and heating are correlated with (Tat and Van gerpen , 2000, Ajav and Akingbelin, 2002).

It has also reported to be connected with fuel storage and transportation (Yuan et al, 2004)

Viscosity, the measurement of the internal flow resistance of liquid constitutes an important property of vegetable oils. It is of remarkable influence in the mechanism of atomization or fuel spray. Results obtained for viscosity measurement fall within the range of values for alternative diesel fuel. These results also agree closely with a number of earlier works on other oil crops as well as series of Alcohol Diesel blends. From the results obtained it can be seen that the transerterification of PKO (a. vegetable oil) produced a marked decrease in values of viscosity. This appreciable reduction in viscosity no doubt will enhance the fluidity of the catalyzed ethyl ester alternative fuel in diesel engine.

The flash point of a fuel is defined as the temperature at which the fuel becomes a mixture that will ignite when exposed to a spark or flame. The flash point of biodiesel has been tested and reported by various sources. Specific testing at south west Research institute concluded that biodiesel has a flash point above the flash point of petroleum based diesel fuel. The result obtained above is in agreement with the report of south west Research institute. Therefore pure biodiesel and blends of biodiesel with petroleum diesel are safer to store, handle and use than conventional diesel fuel.

Conclusion

In conclusion, from the laboratory scale production and characterization of biodiesel studied it can be concluded that the fuel characterization carried out showed that biodiesel produced can successfully fuel a diesel engine by the level of agreement between the results obtained and fossil fuel. Also it could be inferred that palm kernel oil is a viable biodiesel resource and that the commercialization of the process of biodiesel production from palm kernel oil is not a mirage and not far into the future.

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