PRODUCTION OF BIODIESEL FROM TGX-1778 SOYBEANS (Glycine max) BY SODIUM HYDROXIDE-CATALYZED TRANSESTERIFICATION

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ABSTRACT

This study investigated the potential of a Nigerian-grown soyabean (TGX-1778) to produce biodiesel. The Soybeans at room temperature, were dehulled, ground to a powdery form, and the oil extracted by Soxhlet extraction method using n-Hexane. 50 ml of the Soybean oil extract and 0.5 g of NaOH were charged into three different reactors labeled A, B, and C, and transesterified in turn with 50, 100, and 150 ml of methanol respectively. Results showed that transesterification with 50, 100, and 150ml of methanol produced biodiesel of densities 0.79, 0.80, and 0.77g/ml respectively, while the corresponding kinematic viscosities at 40^0C were 4.4, 4.6 and 4.1mm^2/s. Other parameters of the biodiesel were refractive index, which ranged from 1.33 to 1.34, pH from 8.5 to 9.6, cloud point (<-32^0C), pour point (-52^0C) and flash point (150^0C). Comparison with the American Society for Testing and Materials (ASTM) D6571 standard indicated that the densities were outside the specified range, while kinematic viscosities were within the acceptable limit. Furthermore, the flash point of the biodiesel produced was higher that the specified minimum level. It was also observed that increasing the methanol quantity from 50 to 150ml, resulted in an increase in biodiesel produced. On the whole, therefore, the oil from the locally grown soybean has a great potential for biodiesel production.

KEYWORDS: Biodiesel, soybean oil, transesterification.

1. INTRODUCTION

The world is in a feverish pitch to replace fossil fuel with renewable fuel because of the continuous depletion of the world’s petroleum reserves, global warming, and other environmental concerns. Biodiesel is a clean and renewable fuel, which is considered to be the best substitute for petroleum-based fuel (Singh and Singh, 2010). The use of biofuels was first championed by Rudolf Diesel in the late 1800s when he envisioned vegetable oil as a fuel source for his diesel engine, (Scott, et al., 2009). Although, biodiesel is usually used as a blend with petro-diesel at varying ratios, it can also be used to fuel compression ignition engines alone, (Koc, et al., 2011).

According to the Alternative Fuels Data Center, (2013), soybean oil is one of the major feed stocks for biodiesel production. The use of soybeans for biofuel production is not so new. However, it is now assuming greater importance because of the increasing price of petroleum and more significantly, the emerging concern about global warming that is associated with burning fossil fuels (Gavrilescu, and Chisti, 2005). Biodiesel is a technically acceptable substitute, replacement or blending stock for conventional diesel fuel because it can be used at a 100-percent level (B100) or mixed with diesel fuel in any proportion. However, the most commonly used mixtures are B2 containing 2 percent biodiesel and B20 containing 20 percent biodiesel (Alternative Fuels Data Center, 2013). According to international convention B is used to denote that the fuel is a biodiesel or contains a certain percentage of biodiesel.
Transesterification is a common method for biodiesel production from vegetable oils and animal fats (Abreu, et al., 2003). Although vegetable oils such as soybean oil has been used in the production of biodiesel (Koc, et al. 2011), the potential of the locally available variety of soybeans in Nigeria, (TGX-1778) in the production of biodiesel has not been examined.

The objective of the current study, therefore, was to investigate the potential of the TGX-1778 variety of soybeans in the production of biodiesel by NaOH-catalyzed transesterification with methanol.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The experiment was carried out in the Chemical Analysis Facility of the Department of Chemical/ Petrochemical Engineering, Rivers State University of Science and Technology, Port Harcourt, Nigeria. Port Harcourt is characterized by high humidity (≥80%), and moderately high temperature (25- 30^{0}C), (Fubara-Manuel and Jumbo, 2014). The area is also characterised by heavy rainfall, about 2,400 mm per annum, occurring mostly in the months of June through September. Port Harcourt is located within 4^0 47' 21" N and 6^0 59' 54" E.

2.2 Experimental Procedure

The TGX-1778 variety of soybean seeds were purchased from Premium Seeds Ltd., Zaria, Kaduna State, Nigeria. The soybean seeds were pretreated by cleaning, air drying, and dehulling. The dried seeds were then ground to a powdery form (Figure 1).


Figure 1: Dried and ground TGX-1778 soybean seeds prior to oil extraction.

Approximately 70 g of the ground soybeans was placed in the thimble of the Soxhlet extractor while 250 ml of n-hexane was added to the Soxhlet extractor, and then heated at a regulated temperature of between 60 and 79^{o}C to extract the oil from the soybeans as shown in Figure 2. After the extraction, the mixture of n-Hexane and oil from the Soybeans was then subjected to distillation at a regulated temperature of between 60 and 79^{o}C. This temperature range was chosen because n-Hexane has an optimum boiling point of 78^{o}C. The soybean oil was then recovered and exposed for 72 hours to allow any residual n-Hexane in the mix to evaporate. After the 72 hours, 250 ml of the extracted soybean oil was used to produce the biodiesel by transesterification.

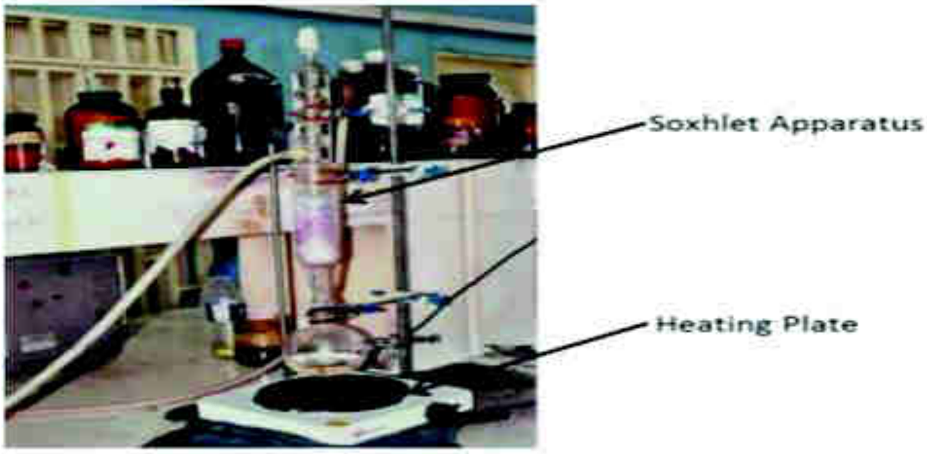

Figure 2: Extraction of oil from powdered TGX-1778 Soybean seeds using Soxhlet apparatus

The soybean oil was divided into 3 aliquots of 50 ml each and placed in reactors labelled A, B, and C. A fixed mass of NaOH and various volumes of methanol were added to each reactor as shown in Table 1.

Table 1: Volumes of methanol and mass of NaOH added to the Soybean oil in each reactor

Starting materials	Reactors		
	A	B	C
Soybean(ml)	50	50	50
Methanol(ml)	50	100	150
Sodium hydroxide(NaOH) (g)	0.5	0.5	0.5

Each mix was then centrifuged and left to settle for 24 hours, after which the mix produced an immiscible mixture of biodiesel and glycerol. The mixture was then decanted to get the biodiesel.

2.3 Determination of Selected Physicochemical Characteristics of the Biodiesel

The parameters determined were density, kinematic viscosity, refractive index and pH. Other parameters were cloud point, pour point, and flash point.

Density was determined manually by weight by weight difference of 10ml volume of the biodiesel in a conical flask, using a weighing balance, while kinematic viscosity was determined with a calibrated capillary viscometer at 40^0C as specified by American Society for Testing and Materials, D445–12, (2004). Refractive index was determined with a refractometer, while pH was determined with a WTW MULTI-340R pH meter as specified by American Public Health Association, (1998).

The methods outlined by American Society for Testing and Materials, D2024–09, (2004) and American Society for Testing and Materials, D97, (2005) were used to determine cloud point and pour point respectively, while flash point was determined by using the Pensky-Martens Closed Cup Tester as specified by American Society for Testing and Materials, D93, (2005).

3. RESULTS AND DISCUSSION

Table 2 shows the physico-chemical characteristics of the biodiesel produced, side by side with American Society for Testing and Materials, D6571, (2008).

Table 2: Physicochemical characteristics of the produced biodiesel

Physico-chemical property	Reactor A	Reactor B	Reactor C	ASTM D6571(2008) Quality Standard
Density (g/ml)	0.79	0.80	0.77	0.86-0.9
Kinematic viscosity @ 40^0C (mm^2/s)	4.4	4.6	4.1	1.9-6.0
Refractive index	1.34	1.34	1.33	-
pH	8.5	9.6	9.0	-
Cloud point (^{0}C)	<-32	<-32	<-32	-
Pour point (^{0}C)	-52	-52	-52	-
Flash point (^{0}C)	150	150	150	130

Reactor A contains 50ml of oil + 50 ml of methanol.
Reactor B contains 50ml of oil + 100ml of methanol.
Reactor C contains 50ml of oil + 150ml of methanol.

From the table, the values of the density obtained range from 0.77 to 0.80 g/ml. These values are slightly outside the range specified by American Society for Testing and Materials (ASTM) D6571, (2008). The values of the kinematic viscosity obtained at 40°C are within the limits specified by American Society for Testing and Materials (ASTM) D6571, (2008). This result also compares well with that of (Koc, et al., 2011), who obtained a kinematic viscosity of 4.66 mm^2/s in his research work. Although American Society for Testing and Materials (ASTM) D6571, (2008), does not have limits for refractive index, the values of the refractive index obtained range from 1.33 to 1.34.

The pH values of 8.5 to 9.6 obtained, showed that the base transesterification reaction was a neutralization reaction but American Society for Testing and Materials (ASTM) D6571, (2008) does not have limits for pH. Cloud point and pour point values were less than -32 and -52 respectively. Also, American Society for Testing and Materials (ASTM) D6571, (2008) does not have limits for cloud point and pour point. The biodiesel obtained in this study was found to have a constant flash point of 150°C, which was above the minimum value specified by American Society for Testing and Materials (ASTM) D6571, (2008). It is worth mentioning that (Koc, et al., 2011) also obtained a flash point of 150°C, as that obtained in this work.

It was observed that the yield of biodiesel increased with the quantity of methanol. Furthermore, Table 2, indicated that parameters such as density, kinematic viscosity, refractive index, and pH were affected by the quantity of methanol used during transesterification. However the variation of the quantity of methanol did not have a well defined trend on the properties. For example, the density of the biodiesel increased with quantity of methanol up to 100 ml before decreasing at 150 ml of methanol. A similar trend was observed for kinematic viscosity. The refractive index remained constant as the quantity of methanol increased up to 100 ml, but decreased as the quantity of methanol increased to 150 ml. Although the pH values almost took the same pattern as those of density and kinematic viscosity, the difference is that the pH value obtained at 50 ml of ethanol was lower than that obtained at 150 ml.

4. CONCLUSION

The TGX-1778 variety of soybeans available in Nigeria has the potential for the production of biodiesel by NaOH-catalyzed transesterification with methanol. The quality of the biodiesel produced from the TGX-1778 variety of soybeans when compared with [13] is acceptable except for density.

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