[1.]Nicholas Akhaze MUSA

PRODUCTION AND FUEL CHARACTERISATION OF BIOETHANOL FROM DIKA–NUT SHELL

[1.] Department of Mechanical Engineering, Federal University of Technology, Minna, Niger State, NIGERIA

Abstract: With a view to finding alternative fuel to fossil fuel for internal combustion engines as a result of its negative impact on the environment and energy crisis, bioethanol fuel was produced through fermentation and distillation process from dika–nut shell and characterized. The maximum yield of bioethanol was 36.8ml in 120hours of fermentation and the total quantity of bioethanol produced from 600g of the treated dika–nut shell was 127.7ml. The result of fuel characterization of the bioethanol indicated its density, specific gravity, water content, kinematic viscosity, flash point, pour point, cloud point and refractive index to be 0.89 g/cm^3, 0.89, 2.2, 4.1mm^2/s, 15^{0}C, 4.6^{0}C, 19.3^{0}C and 1.40 respectively.
Keywords: Dika–nut shell, fermentation, bioethanol, ASTM, fuel

INTRODUCTION

Energy consumption increase worldwide is caused by population increase and to close the gap between the energy supply and demand, crude oil has been extensively used (Shruti and Kalburgib, 2016). However, the emissions from the burning or combustion of crude oil derivatives and in general, fossil fuels pollute the environment thereby jeopardizing the lives of the inhabitants. It is being viewed to substantially promote environmental emergency worldwide (Hossain et al, 2011, Chandel et al, 2007). Besides the adverse environmental effects of the use of fossil fuel, its non–renewable nature makes it to be prone to exhaustion. Since the use of fossil fuel cannot be for gone, concerted efforts have been made to conserve its use and reduce its emission. One of the laudable ways of conserving it is the use of alternatives which are renewable and have positive effects on the environment. As a result of incessant energy crisis, occasioned by the mismatch between the energy demand and supply, governments of world nations have called for the utilization of other energy sources (Ingale et al 2014). So a daunting research for renewable energy sources based on biomass have been encouraged in order to reduce the rise in the energy demand in the globe and the speedy depletion of fossil fuel reserves (Balat et al 2008). The efficient utilization of pollution free energy source instead of fossil fuel is being sought and the most fascinating issues is the increasing awareness that ethanol is a substitute for fuel and liquid fuel based lubricants (Uthman and Jimoh, 2012). According to Jaiswal et al (2016), worldwide awareness about climate change and the dire need to cut down emissions have warranted the substitute of bioethanol for gasoline or the use of blends of bioethanol and gasoline.

Ethanol can be obtained from petroleum through chemical process and can also be obtained from plants or organic matter or sugar substrates fermentation. More so ethanol can be realized from the various classes of yeast (Jaiswal et al, 2016). The ethanol obtained from fermentation (ethyl alcohol) is simply called bioethanol and can be used as fuel besides its use as a solvent among others (Promon et al, 2018). Ethanol can be produced from eatable and non–eatable plants but producing from the former threatens food security, hence emphasis has been on its production from food waste and organic wastes. Notable examples are maize wastes and discarded newspapers (Akpan et al, 2008), sugarcane waste and maize waste(Braide et al, 2016), wastes, apple, kiwifruit, and peaches wastes (Cutzu and Bardi, 2017), peeled skins of carrot, onions, potatoes and sugar beet peels (Mushimiyimana and Tallapragada ,2016), waste from pine apple, barley, corn, copra cake (Hemalatha et al, 2015), apple, banana, papaya ,grapes(Janani et al 2013), sugar cane (Berhe and Sahu,2017), coffee (Kefale et al, 2012, Woldesenbet et al, 2016), rice, sweet sorghum, millet (Harinikumar et al, 2017) and groundnut shell (Nyachaka et al, 2013).

Dika–nut which is merely called African or bush or wild mango is a product of forest like timber. The trade on this product has become a remarkable income source to the rural dwellers and poor urban dwellers in Nigeria (Arowosoge, 2017). When the dika–nut are used as food, the nut is cracked or cut open and the shells are disposed of indiscrimately resulting in poor environmental conditions. Although the shells are being used in carbonized form for the reinforcement of natural and artificial rubber (Ohaeri and Ohaeri, 2015), saloon liquid waste treatment (Ewansiha et al, 2014) and fillers (Tenebe et al, 2013), so much is still being wasted. So the possibility of producing ethanol from the dika–nut shell which can used as alternative fuel in internal combustion engine, is being investigated in this research work.

MATERIALS AND METHOD

— Collection of dika–nut shell samples

The dika–nut shells were collected from refuse dump in some homes in Opoji community of Edo State, Nigeria. They were washed with water to remove dirts and dried in an electric oven (manufactured in England by Gallekamp) at 60^0 for 72hours (Nyachaka et al, 2013) to achieve reduction in the moisture content so as to enhance effective grinding.

— Bioethanol production from the dika–nut shell

The washed and oven dried dika–nut shells were ground with mortar and pestle and sieved to obtain particle sizes of 3mm. Weighed 100g of the ground dika–nut shells were put into each of six 500ml capacity conical flasks and 72% concentrated tetraoxosulphate VI acid was also introduced into each of the flasks and heated in a water bath at 30⁰C for a 2hour in accordance with the method described by Venkatramanan et al (2014). Thereafter, they were autoclaved for 18 minutes at a temperature of 121⁰C, cooled at normal room temperature, filtered with Whitman filter paper in order to obtain a solution containing a mixture of sugar and acid. The filtrate was treated with 0.4M NaOH thereby adjusting the pH to 4.5 in line with the method stated by Rabah et al (2014). Brewer's yeast (Saccharomycess cerevisiae) was added at concentrations of 0.05mg/l and pH of 4.5 and fermentation was allowed to occur in 24, 48, 72, 96,120 and144hours for the first, second, third, fourth, fifth and sixth flask respectively, at ambient temperature taking a cue from Olufemi and Oyetuji (2015). After each fermentation period, the flask was emptied into another flask with round bottom and put on isomantle attached to a refining column enclosed in flowing tap water. Another flask of the same type was secured at the other end of the refining column for the collection of the alcohol which is the distillate at the standard temperature for the production of ethanol (78⁰C) in line with the method described by Adetunji et al (2015). The quantity of alcohol collected was measured with a graduated cylinder.

— Characterization of bioethanol from dika–nut shell

The bioethanol produced from the dika–nut shell was characterized by determining its density, specific gravity, water content, kinematic viscosity, flash point, pour point, cloud point and refractive index. The specific gravity was obtained by using Digital density meter, DDM 2910 manufactured in USA in accordance with ASTM D4052–16 method. Kinematic viscosity was determined at 40⁰C by using Ubbeholde viscometer 7143 manufactured in India following ASTM D445–06 method. Flash point was determined by using Pensky Marten apparatus according to ASTM D93–06 standard method. Cloud point was determined in line with ASTM D2500–17a Method. Pour point was determined using ASTM 97–17b method. Refractive index was obtained using a Misco PA202 Palm Abbe Digital Handheld Refractometer manufactured in USA. Water content was determined by using ASTM E 1064–05 method (Coulometric Karl Fischer Titration).

RESULTS AND DISCUSSION

The variation of quantity of bioethanol produced from the dika–nut shell with the fermentation period is shown in Figure 1.

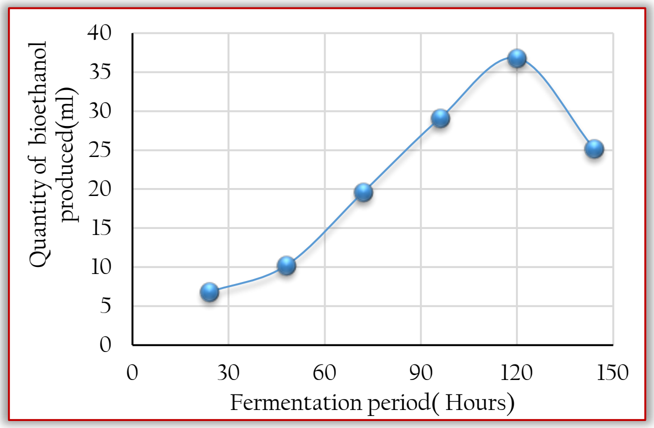

Figure 1: Variation of quantity of bioethanol produced from the dika–nut shell with fermentation period

It can be seen from figure 1 that as fermentation period increased from 24hours to 120hours, the quantity of ethanol produced increased from 6.8ml to 36.8ml. This progressive ethanol production with increase in fermentation period was also experienced by Oyeleke and Jibrin (2009) in the production of bioethanol from guinea cornhusk and millet husk and Olayide et al (2015) in the production of Bio–ethanol from Cassava Peels.

When the fermentation period was increased to 144hours, the quantity of ethanol produced dropped to 25.2ml. This drop in ethanol production should be attribute to decrease in the process of fermentation as a result of the reduction in sugar content (Kourkoutas et al, 2004), inhibition experienced by the ethanol as well as other by–products in the medium of fermentation (Akponah and Akpomie, 2011). However the total quantity of bioethanol produced from 600g of dika–nut shell was 127.7ml.

The experimentally determined fuel properties of the bioethanol produced from the dika–nut shell are shown in Table 1.

Table 1. Fuel properties of bioethanol produced from dika–nut shell

S/N	Properties	Experimental values	ASTM Standard values for bioethanol (Abdulkareem and Ogochukwu, 2015)
1	Density	0.89 g/cm³	0.99g/cm³
2	Specific gravity	0.89	0.87
3	Water content	2.2	NA
4	Kinematic viscosity	4.1mm²/s	5.0mm²/s (max)
5	Flash point	15⁰C	18.60⁰C
6	Pour point	4.6⁰C	5.2⁰C
7	Cloud point	19.3⁰C	23⁰C
8	Refractive index	1.40	1.36

The density and specific gravity of bioethanol is relatively close and slightly higher respectively than the standard density and specific density of bioethanol as evident in Table 1. The evaluation of fuel kinematic viscosity is required for the creation of actual fuel atomization and the engine power and combustion efficiency are affected by injection viscosity (Sirvio et al, 2018). The kinematic viscosity of the bioethanol was found to be 4.1mm²/s which is 0.9 mm²/s shy of the maximum standard value shown in Table 1. High injection pressure and pumping losses are experienced when highly viscous fuels are used and this result in poor combustion (Sirvio et al, 2018), emissions of unburned hydrocarbon (Heywood, 1998). Flash point which connotes fuel flammability also reveal the susceptibility of fuel to causing hazard during its storage or transit (Muhaji and Sutjahjo, 2018). The flash point of the bioethanol obtained was 15⁰C against the standard value of 18.60⁰C. However the flash point has no effect on the performance of an engine (Kheiralla et al, 2011). The pour point was evaluated to be 4.60C against the standard value of 5.2⁰C and the cloud point of the bioethanol was determined to be 19.3⁰C which is 3.7⁰C lower than the standard value of 23⁰C depicted in Table 2. The obtained cloud point is high enough not to cause fuel filter clogging (Bafghi et al, 2014). The pour and cloud points are of great importance in identifying the fuel behaviour as a result of cold weather condition

(Ajav and Akingbehin, 2002). The refractive index of the bioethanol was found to be 1.40 which is 0.04 higher than the standard value of 1.36 as evident in Table 2. For accurate measurement of the drop size and spray velocity of fuel an in–depth knowledge of the refractive index of the fuel are required (Fernandes, 2008). The values of the fuel properties of the bioethanol produced from dika–nut shells are very close to the standard values.

CONCLUSION

The depletion of fossil fuels as a result of high demand for use and the environmental pollution associated with its burning, has necessitated the search for substitute. On that note, dika–nut shell which are disposed indiscriminately in rural communities of southern part of Nigeria were studied for the production of bioethanol. Based on the result of the study, dika–nut shell is a good substrate for the production of bioethanol that can be used for internal combustion engines instead of fossil fuels that pollutes the environment with its emissions. The utilization and value of dika–nut shell has increased by using it to produce bioethanol.

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