PRODUCTION AND CHARACTERISATION OF BIODIESEL FROM WASTE VEGETABLE OIL OBTAINED FROM LOCAL SNACK IN OSUBI, OKPE LOCAL GOVERNMENT AREA OF DELTA STATE, NIGERIA.

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Abstract: The aim of this study was to evaluate the capability of using recycled waste vegetable oil from local snacks (puff puff) and fried fish as raw material for the production of biodiesel. The sample (waste vegetable oil) were collected into a one-liter keg from vendors at Osubi, Okpe local government area of Delta State, Nigeria and were filtered and characterized. The characterized recycled waste vegetable oil gave a density of 0.910 g/mL, specific gravity of 0.910 g/mL, acid value of 0.31 mgKOH/g, free fatty acid value of 0.62 mgKOH/g, viscosity of 31.15 mm^2/s, kinematic viscosity of 34.15 mm^2/s and acid value of 0.31 mgKOH/g .The biodiesel was produced through transesterification process with methanol and catalysed by sodium hydroxide. The biodiesel was produced according to principle outlined by American Society for Testing and Materials (ASTM) standards for biodiesel. The oil-methanol ratio was 5:1 (w/v). The produced biodiesel gave the following physico-chemical properties; density and specific gravity of 0.825 g/cm^2 and 0.825 g/cm^2. Acid value and free fatty acid value of 0.21 mgKOH/g and 0.105 mgKOH/g . Viscosity and kinematic viscosity gave 3.99mm^2/s and 5.99mm^2/s. Flashpoint of 73^{o}C, pour point of -6 ^{o}C, cloud point of 6 ^{o}C, and cetane number of 57.3 respectively. The physico-chemical properties of the biodiesel-produced values conform to American Society for Testing and Materials (ASTM) standards for biodiesel. In conclusion, biodiesel produced from recycled waste vegetable oil should be used independently or be blended with petro diesel in various proportions for internal combustion engine applications.

Keywords: Biodiesel, Characterization, Osubi, Puff puff, Transesterification, Waste vegetable Oil

Introduction

Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines, alone or blended with diesel oil (Tat, 2007; Sreenivas *et al*., 2011). According ASTM D 6304 (2008) ASTM International (formally known as the American Society for Testing and Materials) defines biodiesel as a mixture of long-chain mono alkylic esters from fatty acids obtained from renewable resources, to be used in diesel engines. Biofuels were introduced decades ago to overcome the environmental pollution caused by the use of ordinary fuels i.e.carbon (iv)oxide, sulphur(iv)oxides, carbon(iv)oxides, nitrogen oxids and heavy metals oxide (Muthukumar *et al*., 2012; Andualem and Gessesse, 2012; Sattanathan, 2015) . Ordinary fuels are fossil ones (Ashraful *et al*., 2014). Biodiesel is free of lead, contains almost no sulfur or aromatics (toxic compounds such as benzene, toluene and xylene), and substantially reduces emissions of unburned hydrocarbons, carbon monoxide and particulate matter (soot), which have been linked to respiratory disease, cancer and other adverse health conditions (Ogwuche and Obruche, 2020). Fossil fuel (ordinary fuel) depletion, concern for the environment and unstable crude oil prices have led to intensified search for alternative non-fossils fuels (Refaat *et al*., 2008; Samniang *et al*., 2014). To overcome these problems, vegetable oils or animals fats are reacted with simple alcohol (methanol, ethanol, propanol) to produce fatty acid methyl esters (FAME), fatty acid ethyl esters (FAEE) and fatty acid propyl esters (FAPE) which are also known as biodiesel. The methods to achieve such conversion include pyrolysis, micro-emulsion and trans-esterification (Asif and Muneer, 2007; Berchmans and Hirata, 2008). Among them, trans-esterification was found to be the best route with minimal engine complication (Graboski and McCormick, 1998; Maghraby and Fakhry, 2015) . Biodiesel is found to be the best substitute for petro-diesel, not only because of its comparable calorific value but also for its several other advantages such as: low toxic emissions, biodegradability, high flash point, excellent lubricity and environmental compatibility (Juan *et al*., 2011; Kumar and Sharma, 2011). Biodiesel has been promoted and reported as a promising long-term renewable energy source, which has the potential to address net emission of carbon dioxide to the atmosphere, security concerns and the fluctuating prices of fossil fuels. Triglycerides used for the production of biodiesel come from various sources: edible oils, non-edible oils, waste oils, used oils, animal fats and from microorganisms (Shrirame *et al.*, 2011; Chakrabarti *et al*., 2012). However, there is an economic sense in the use of waste oil. Another reason for the research on biofuels is to meet the world's requirement of fuel. Fossil fuel reserves are decreasing due to increase in fuel demands. The basic idea of researches is to go for alternative which yields as good efficiency as fossil fuels and economical as well. The most important is that biodisel can be produced from any vegetable oil including waste vegetable oil (Ejigu *et al*., (2010); Koh and Ghazi, (2011); Maceiras *et al*., 2011). The advantages of using feedstock coming from waste vegetable oil or commonly known as waste cooking oil is easily collected from industries, such as restaurants and they are also cheaper than the other oils (refine oils) hence, by the use of these oils as raw materials can reduce the cost of biodiesel production. Another advantages of using waste cooking oil as raw material for biodiesel production is its low cost and prevention of environmental pollution (Atabani *et al*., 2013; Bekirogullari *et al*., 2017). Waste cooking oil has sufficient potential to fuel the compression engines. The kinematics viscosity of waste cooking oil is about 10 times higher, and the density is about 10% higher than that of the common mineral diesel. These properties play vital role in the combustion; therefore, there is need for the use of biodiesel from waste cooking vegetables in our engines. Biodiesel can be blended with ordinary diesel with no emulsifier required to make them miscible (Mohammed *et al*., 2008; Mondal, 2014). Better lubrication is achieved by using biodiesel in the engine (Chhetri *et al*., 2008; Keppy and Allen, 2009). As far as fuel economy is concerned, biodiesel's fuel economy is same as conventional diesel. Biodiesel is environmental friendly and is biodegradable. This is a Transesterification reaction. Fatty acid reacts with methanol in the presence of alkali (Catalyst). Fatty acid methyl ester (FAME) and Glycerol are the products. Side reaction (i.e. saponification) can occur in the presence of moisture and excess amount of alkali. In saponification reaction the methyl group of FAME is replaced by metal ion of alkali (Balat, 2011; Mofijur *et al*., 2013; Dong *et al*., 2016). The aim of this research is to evaluation the feasibility of recycling waste oil from local snack (commonly known as pull pull) as raw material for biodiesel synthesis.

Materials and Methods

Materials

Recycled waste vegetable oil obtained from local snack vendors at Osubi, okpe local government area of Delta State, Nigeria. All solvents including methanol, Sodium hydroxide (NaOH), and sulfuric acid (98% pure) were of analytical grade and purchased from Sigma Aldrich (England).

Sample collection and preparation

Samples of waste cooking oil were collected from local vendors at Osubi, okpe local government area of Delta State, Nigeria. The samples were collected into a one-liter keg. Samples (waste cooking oil) are from mainly frying fish and snacks (puff puff), and were collected between the months of May to September in 2014. The waste vegetable oil was filtered to remove dirt and inorganic residues.

Methods

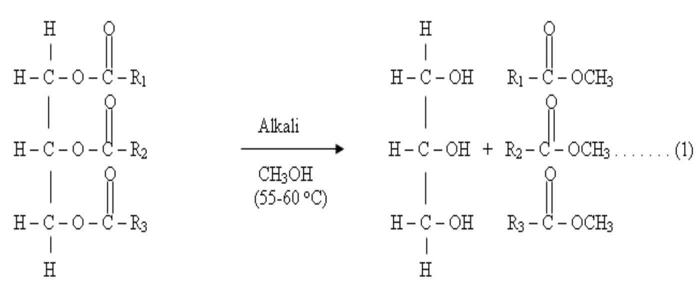
Two-Step Transesterification method was used in the Biodiesel Production Process as described by (ASTM D 6304, 2008). First, exactly 500 mL recycled waste cooking oil was precisely quantitatively transferred into the reaction flask and preheated by the hot plate to the desired reaction temperature before the reaction started. Sodium hydroxide-methanol solution was prepared freshly and heated to the reaction temperature. The methanol-NaOH solution volumetric ratio is 1:5. Finally the methanolic solution was added to the recycled waste cooking oil. The transesterifcation was carried out on the hot plate and constant stirring speed was maintained. Stirring was continued and the product was placed in a separating funnel, left over night for glycerin to settle to the bottom of the funnel as shown in figure 1, and then removed in a measuring cylinder. The impure methyl ester (biofuel) was washed with Sulfuric acid (98% concentration) and distilled water, prior to drying in the furnace at 150 °C for two hours.

Fig1: Produced binary mixture, biodiesel (upper layer) and the glycerol (Lower Layer)

The separation was done mainly by opening the cork and the lower layer (product) are allowed to run out, the Glycerol comes out first and followed by the Biodiesel as shown in figure 2. The second step is the impure methyl ester (biofuel) was washed with Sulfuric acid (98% concentration) and distilled water, prior to drying in the furnace at 150 °C for 2hrs hours. The washed biodiesel was then placed in an oven at 100 ºC for 6 h to evaporate any water that might be left during washing. Finally; the volume and weight of the biodiesel were measured, and the sample was stored for characterization.

Fig 2: Produced biodiesel

The mechanism of the reaction for the manufacturing of biodiesel using waste cooking oil (waste vegetable oil) is shown in figure 3



Triglycerides (Waste vegetable oil) Methanol Glycerol (Propane-1,2,3-triol) Biodiesel

Fig 3: Mechanism of biodiesel synthesis

Waste vegetable oil and produced Biodiesel characterization

The recycled waste oil and the biodiesel produced in this study were characterized in relation to the technical limits established by ASTM D 6751, using the following methods: ASTM D6751 for Density, ASTM D7651 for Kinematic viscosity, ASTM D 6751 for flash point, ASTM D 664 for acid number, ASTM D1284 for Specific Gravity, ASTM D7651 for Cloud Point, ASTM D7651 for Pour Point, ASTM D130 for Copper Strip, ASTM D D613 for Cetane Number and ASTM D 445 for Viscosity as shown in table 1 and 2

Table 1: Physicochemical Properties Values of the Waste Cooking Oil Used

Properties	Results Obtained
Color	2.5
Smell	Pungent
Density (g/mL)	0.910
Specific gravity (g/mL)	0.910
Viscosity (mm^2/sec)	31.15
Kinematic viscosity (mm^2/s)	34.15
Free fatty acid number (mgKOH/g)	0.62
Acid number (mgKOH/g)	0.31
Saponification value	___

Table 2. Physicochemical Properties of the Biodiesel

Properties	ASTM standards values for Biodiesels			Results Obtained
	Units	methods	limits	
Density @ 15oC	gcm^3	ASTM D6751	0.82-0.9	0.825
Specific Gravity @ 15°C	gcm^3	ASTMD1284	0.9max	0.825
Viscosity @ 40 °C	mm^2/sec	ASTM D7651	___	3.99
Kinematic viscosity @ 40 °C	mm^2/sec	ASTM D7651	1.9-6.0	5.99
Smell	___	___	___	Pungent
Color	___	___	___	Redish-brown
Acid Value	mgKOH/g	ASTM D664	0.8max	0.21
Free Fatty Acid Value	mgKOH/g	ASTM D664	___	0.105
Flashpoint	°C	ASTM D6751	130min	73
Cloud Point	°C	ASTM D7651	N/A	6
Pour Point	°C	ASTM D7651	___	-6
Copper Strip	ppm	ASTM D130	No. 3 max	No. 2a
Cetane Number	___	ASTM D613	47min	57.3

Discussion

The result for waste cooking oil in (table1) showed that specific gravity and density fell within the relative density of crude oil products or mixture of petroleum. The density and specific gravity of the waste cooking oil was found to be 0.910 g/mL and 0.910 g/mL (in table1) respectively and the results were compared to the oil gotten from thumbia oil which has density and specific gravity to be 0.833 and 0.833 respectively using ASTM D1298 test method (Chakrabarti and Ahmad, 2009). Viscosity is the resistance of flow of a liquid. It is the essential property which affect atomization. The viscosity and kinematic viscosity of the waste cooking oil was found to be 31.15mm^2/sec and 34.15mm^2/sec respectively in table 2. Acid number is the acidity constituents in lube oil. The acid value and free fatty acid number were 0.31 mgKOH/g and 0.62 mgKOH/g in table2. It was compared to the works of Sivaramakrishnan and Ravikumar (2011).

Which gave an acid value and free acid value of 0.77 and 0.39 for its cooking oil respectively.

Similarly, the specific gravity of the biodiesel from this study was found to be 0.825 gcm^3 (at the reference temperature 15.56 °C) in table2. The specific gravity obtained fall well within the limit specified for biodiesel fuels (870–900 gcm^3) by the ASTM Standard. Density of the biodiesel (0.825 gcm^3) also falls within ASTM Standard (ASTM Standard: 860-900) tolerable limit. The flash point is measurement or evaluation of flammability of any fuel. The higher the flash point, the more viable the fuel will be in storage and handling (Rashid and Anwar, 2008; Okullo *et al*., 2012). The flash point of produced biodiesel was found to be 73°C in table2, which fell within the ASTM standard of 130°C which indicates that the biodiesel fuel is an excellent biofuel. The higher value of flash point of biodiesel in comparison to diesel fuel suggests that the flammability hazard of biodiesel is much lesser than that of diesel fuel. Viscosity is the resistance of flow of a liquid. It is the essential property which affect atomization. The viscosity and kinematic viscosity of the biodiesel were found to be 3.99 mm^2/sec and 5.99 mm^2/sec in table2. The result was also compared with the work of Wagutu *et al*. (2009) of biodiesel produced from Thumbia oil, which has its viscosity to be 2.60 mm^2/sec and its kinematic viscosity to be 4.65 mm^2/sec respectively. The result also falls within the range of 1.9-6.0 mm^2/sec of ASTMD1284 standard in table2. The acid value indicates the degree of fuel ageing during storage. ASTM Standards allows a maximum acid value of 0.8max mgKOH/g. The acid value and free acid values were 0.21 mgKOH/g and 0.105 mgKOH/g of the biodiesel, which is in Agreement with the specified limit, implying that the waste oil biodiesel will not pose problem on the long-term performance of the engine. Cloud point (CP) and pour point (PP). CP is the temperature at which a liquid fatty material becomes cloudy due to formation of crystals while PP is the lowest temperature at which it will still flow. The cloud and Pour point of biodiesel was 6 and -6 °C, respectively in table2. The CP and PP values of the waste biodiesel in the present study, is much better than the CP and PP values of biodiesels derived from other feed. Copper strip corrosion test showed that the Biodiesel was not totally acid free. ASTM Standard value for Copper strip is No. 3 max. The value of the cetane number gotten was 57.3 in table1, which fell on the scale of the astm test method standards. This result was compared to the work of Refaat (2009), the result of the biodiesel obtained from palm oil and waste cooking used in frying chin chin which gave the values of 62 and 57.2 respectively. This result shows that the biodiesel produced from waste cooking oil in frying local puff puff has a good cetane value making it a good alternative fuel.

Conclusion

This study shows that production of methyl esters (biodiesel) through trans-esterification catalyst method led to higher yields of methyl esters from recycled waste vegetable oil as a feedstock. This higher yields demonstrates the alkaline strength of the sodium hydroxide in the production of biodiesel. Biofuels from waste cooking vegetable oil are an excellent and practical alternative to fossil fuels because all fuel properties were examined and they fell within the ASTM specification for B100. Besides the biodiesel some unreacted raw material was also present in the samples. The results clearly showed that the unreacted raw material was glycerol in a very little quantity. Therefore, as a cheap feedstock, recycled waste vegetable oil from local snacks(known as puff puff) can be potentially used as a raw feedstock for biodiesel production on a commercial scale.

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