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Assessment of Fuel Properties of BIODIESEL Obtained From AFRICAN PEAR (*Dacryodeseludis*) Seeds Oil

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ABSTRACT: As a result of growing concerns such as increasing energy demand for domestic and industrial application and the environmental issues associated with the use of fossil fuels as a primary source of energy. There is a need to focus on nonedible oils from waste for biodiesel production. This research was conducted for the purpose of conversion of wastes - African pear seeds (Dacryodeseludis) to wealth (biodiesel) via a transesterification process. The African pear seeds were sundried for 72 hours, ground (milled) manually with mortar and pestle. The oil was extracted from the powdered seeds using n-hexane as a solvent and transesterified at a temperature of 60˚C for I hour with 1:6 mole ratio of the oil to methanol and 0.25g of NaOH as catalyst. The physico-chemically characterized biodiesel obtained revealed that the concentration of potassium, sodium, magnesium, calcium and phosphorus) were 3.2 ppm,0.10 ppm, 1.19 ppm, 0.20 ppm and 5.07 ppm respectively. The fuel properties measured were kinematic viscosity (5.6 mm^2/s), density (825kg/m^3), flash point (144 ˚C), pour point (15.2˚C) and cloud point (2.7˚C). These values were in close agreement with the ASTM/EN standards for biodiesel. Hence, African pear seeds oil is a potential feedstock for biodiesel production.

KEYWORDS: Assessment, Fuel, Properties, Transesterification, Biodiesel, African Pear, Seeds, Oil.

I. INTRODUCTION

We are in an era where acquisition and consumption of fossil fuels dominates the course of national and international politics worldwide, especially in the United States where 25% of the world's crude oil is consumed. Fossil fuels are derivatives of plants and animals remains that are million years old, primarily formed as a resultof decayed plants and animals of carboniferous era. The three main types are coal, natural gas and petroleum/oil.
Fossil fuels are the main source of energy for both domestic and industrial uses[1]. However, over dependence and consumption of fossil fuel has led to negative environmental impact. For example, combustion of fossil fuel led to the generation of greenhouse gases such as NO_X ,CO_2, SO_X, CO, water vapour etc. that are believed by scientists to be responsible for global warming, ozone layer depletion, unprecedented climate change, acid rain formation, excessive sun etc.Other secondary negative effects of the use of fossil fuels are in their exploration stages. Drilling of crude oil into pipes and tanks most times result into Oil spillages.[2] Spillages have been known to have very dramatic negative impacts on aquatic and geological organisms on land, seas and rivers.[3] In addition, fossil fuels are non-renewable and may one day be depleted completely. Thus, the concern for environmental protection requires that it is necessary to bring down the world's dependence on fossil fuel as a primary source of energy and move towards a renewable and sustainable type of energy sources such as solar energy,hydroelectric power, wind energy, fuel cells and bio-fuels.[4], [5]

Demirbras[6] defined bio-fuels (biodiesel) as a mixture of mono-alkylesters (long chain fatty acids) derived from a renewable lipid feedstock may be vegetable oil or animal fat. According to Romano and Sorichetti[7], biodiesel can be used in a diesel engine either alone or mixed with petro-diesel. It is non-toxic, biodegradable, has a higher flash point with lower health risk. The production is achieved through the process of transesterification, which is used to reduce the high viscosity of triglycerides. The vegetable oils or animal fats react with an alcohol in the presence of strong base

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as a catalyst (NaOH or KOH). This reaction yields a mixture of methyl esters along with a co-product called glycerol or glycerin.[8]

Different feedstock such as: Rapeseed oil, Soybean oil, Tallow oil, Palm oil, Sunflower oil, Peanut oil, Coconut oil, Palm kernel oil and Cotton seed oil have been used in the production of biodiesels. However, most of these oils are edible oils, expensive and may thus be counterproductive if used in large scale for the production of biodiesel. Since these oils serve as food to man and livestock, a continual usage for fuel production will lead to scarcity of food in the nearby future.

Hence, the need to look for non-edible oils for biodiesel production e.g. Mahua oil, jatropha oil and soap nut oil[9], oil from orange peels[4] and pear seed oil.[9], [10]

Native pear or African pear (*Dacryodesedulis*) is consumed traditionally in Nigeria when roast, boiled in hot water or even eaten raw,or used in garnishing fresh maize and the seeds discarded as waste. It is widely found in many sub-Saharan countries including Nigeria, Liberia, Cameroons and Zaire.[10]It may be available for up to 6 months of the year and has been reported as a good source of vegetable oil.[9]However, not much work has been done on the use of African pear seed oil as a feedstock for biodiesel production. This study was done to investigate the possibility of producing good quality biodiesel from African pear seed oil, the characterization of the produced biodiesel and comparison with ASTM/EN standards.

II. MATERIALS AND METHODS

The ripe "native pear" or African pear fruits (*Dacryodeseludes)* were purchased from a local market in Port Harcourt, Rivers state of Nigeria. They were washed clean and cut to remove the seeds, which were cut into small pieces and sundried (during summer) for 72hours. The seeds were milled (ground) manually to powder form with mortar and pistle. After milling, the powder was used immediately and the remaining ones packed in cellophane bags and stored in a refrigerator for further use.

3.9g of the milled seed powder sample was weighed into a 500cm^3 beaker containing n-hexane to extract the oil. The crude African pear seeds oil (APOS) was separated from the n-hexane by allowing the oil mixture (micelle) in an evaporating dish, to stand under a fan for the n-hexane to volatilize to a constant weight of the oil as well as use of thin layer chromatography in dichromethane to ensure that all n-hexane has volatilized. The dried oil was thentransesterified for the production of biodiesel.

The transesterification reaction was done in a well ventilated laboratory with oil to methanol ratio of 1:6.10 ml of the oil was measured and poured into a conical flask, heated to a temperature of 60 ˚Cfor 50 minutes, followed by the addition of 0.25 g of NaOH in 60 ml of methanol solution. The mixture was vigorously stirred using a magnetic stirrer for 1 hour at a temperature of 80 ˚C and allowed to settle for 24 hours in a separating funnel which separated into two layers. The upper layer was the biodiesel and lower layer the glycerin. The pH of the biodiesel was found to be 12.1 which was highly alkaline for biodiesel, and was reduced with a few drops of concentrated HCl to acceptable level of 9, for biodiesels. The volume of biodiesel produced was 8ml.The percentage yield was calculated using the formula below:

$$\%\, yield\ of\ Biodiesel = \frac{Vol. of\ Biodiesel\ produced}{Vol. of\ oil\ transesterified}\ X\ 100$$

$$= \frac{8}{10}\ X\ 100$$

= 80% yield.

Finally,the obtained biodiesel was physico-chemically characterized in accordance with ASTM/EN standards and the results presented in atabular form.

III.RESULTS AND DISCUSSION

The result revealed the percentage yield of the biodiesel fuel produced to be 80%. This is a very good yield, meaning African pear seeds oil is a good feedstock for production of biodiesel. The mechanism of transesterification reaction occurred under three stepwise reactions as indicated by equations (1) – (4) below. Each intermediate step of reaction use one mole of alcohol to react with n-glyceride compound, which further, produced one mole of alkyl ester.[11]Due

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Vol. 2, Issue 10 , October 2015

to the entire steps of reaction to produce methyl ester compound, all the intermediate compounds, e.g. monoglyceride and diglyceride can be negligible and the overall conversion reaction as one step described in equation (4).

$$TG + MeOH \rightarrow DG + ME \quad \text{Equ (1)}$$
$$DG + MeOH \rightarrow MG + ME \quad \text{Equ (2)}$$
$$MG + MeOH \rightarrow GL + ME \quad \text{Equ (3)}$$
$$TG + 3MeOH \rightarrow 3ME + GL \quad \text{Equ (4)}$$

The results of the chemical parameters (table1) revealed that the experimentally obtained values for magnesium, sodium, calcium, potassium and phosphorous were 1.19ppm, 0.10ppm, 0.20ppm, 3.2ppm and 5.07ppm respectively. When these values were compared with standards (ASTM/EN), it was revealed that these values were in agreement with standards since their values did not exceed the permissible or acceptable values of 5 ppm for magnesium, sodium, calcium and potassium. Similarly, phosphorous value (5.07) is also within the acceptable range of 10 ppm.
The low value of magnesium (1.19ppm), sodium (0.10ppm) and calcium (0.20ppm) could be attributed to several factors such as maturity and specie type of the fruits of African pear seeds.[10] This view of Isaac &Ekpa[10], who argued that the oil composition depends on fruit origin and ripening condition as well as the variety.

Table 1: Chemical characteristics of biodiesel fuel obtained from African pear seeds oil (APSO).

S/N	Parameters	Observed values (ppm)	ASTM/EN Standard
1	Magnesium (Mg)	1.19	5ppm EN 14538
2	Sodium (Na)	0.10	5ppm EN 14538
3	Calcium (Ca)	0.20	5ppm EN 14538
4	Potassium (K)	3.2	5ppm EN 14538
5	Phosphorus (P)	5.07	10ppm EN 14107

Table 2: Physical characteristics of biodiesel fuel obtained from African pear seeds oil (APSO).

S/N	Parameters	Observed Values (ppm)	ASTM/EN Standards
1	Density (D)	825 Kg/m^3	820 -845 Kg/m^3
2	Kinematic Velocity (KV)	5.6 mm^2/s; 40˚C	1.9-6.0 ASTM 3.5-5.0 EN
3	Flash Point (FP)	144 ˚C	93min;130 ˚C max ASTM 120 ˚C Min. EN
4	Pour Point (PP)	15.2 ˚C	15-18 ˚C ASTM
5	Cloud Point (CP)	2.7 ˚C	1 ˚C Winter ASTM 4 ˚C Summer ASTM

Again, pH of the system may also contribute. The values obtained was after reducing the pH from 12 to 9 by the addition of small amount of mineral acid, which may form a metallic chloride, to reduce the metallic content of the oil. Finally, de-fatting of the oil through transesterification could also account for the low values of the aforementioned metals, due to interaction between metals and organic acids (fatty acids), present in the oil.[1] This view was inagreement with the work of Ujowundu*et al.*,(2010),[12] who reported that heat treatment decreased both phytochemical and mineral contents of *D. eludis*. According to them, the aforementioned properties are mostly destroyed or removed by processing technique such as cooking or heating. Metals are leached during biodiesel processing wherein some chemical bonds are broken thus resulting in low values of their concentrations. However, these metallic values and the phosphorus value were in the acceptable or permissible levels by ASTM/EN standard. Hence, the fuel produced is considered good for use in diesel engines.The result in table 2 revealed that five physical parameters were investigated namely density(D), kinematic viscosity (KV), flash poin(FP), pour point(PP), and cloud

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points(CP) with values of 825kg/m^3, 5.6mm^2/s, 144˚C, 15.2˚C and 2.7˚C respectively. These values obtained were within the ASTM permissible or acceptable levels (table 2).

Airless combustion engine has been reported to be greatly depended on density and the standard for biodiesel requires a higher density between 820-845kg/m^3 in ASTM and 860 – 900kg/m^3 in EN 14214 standard respectively. The obtained result in ASTM standard revealed that the biodiesel of African pear seed oil (APSO) was 825 kg/m^3 which is within acceptable level.[13]

Kinematic viscosity represents the flow characteristics and the tendency of fluids to deform by either shear stress or tensile stress. This parameter is an important parameter of fuel atomization and fuel distribution.[14] Therefore, the KV at 40˚C for APSO was determined to be 5.6 mm^{2}s^{-1}and found to be within the ranges specified by the biodiesel standard (ASTM D 6751 and EN 14214). Another parameter of importance is the flash point. This is the temperature at which biodiesel ignites, when exposed to a flame or a spark. This parameter is considered in storage, handling and safety of fuel and other flammable materials. The temperature in this present investigation was 144˚C. This means the fuel will be very good in heating compression ignition engines and would not dry out easily or form thick smoke like diesel oils which undergo incomplete combustion to produce non-environmentally friendly products. Moreover, it will not easily catch fire or be flammable at the temperature used in driving diesel engine or gas.[1]

Some factors which determine the cold flow properties of fuels such as cloud point (CP) and pour point (PP) except cold filter plugging point (CF PP) was also investigated. The experimentally obtained values for CP and PP were 2.7 in summer and 15.2 ˚C respectively, as depicted in table 2. This value was within the acceptable levels of ASTM, thus making the fuel to have good fuel cold flow properties.

Finally,the biodiesel produced was in the liquid form, meaning that the freezing points will be < 21˚C. At this temperature, the liquid(oil) cannot freeze or congeal in a way that it can no longer be suitable for use.

IV.CONCLUSION

African pear seed oil (APSO) is a potential alternative source to diesel oil both for domestic and industrial purposes, and *Dacryodeseludis* is a good source of edible vegetable oil. However, the method used was simple and environmentally friendly. The oil will also increase the economic value of the crop and add to the varieties of vegetable oil available to consumers. Therefore, instead of discarding the seeds, as is presently done, they can be processed into valuable vegetable oil and subsequently to biodiesels.

Abbreviation used

APOS = African pear seeds oil
PPM = parts per million
TG = triglyceride
DG = diglyceride,
MG = monoglyceride,
GL = glycerol
ME = methyl ester.
MeOH = methanol
D = density
KV = kinematic viscosity
FP = flash point
PP = pour point
CP = cloud points

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