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DETERMINATION OF PHYSIO-CHEMICAL PROPERTIES OF OLEANDER SEED OIL FOR BIODIESEL PRODUCTION

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Abstract

The need for alternative feedstock for biodiesel production due to the competition in vegetable oil production for human consumption and biodiesel production necessitated a study in the physiochemical properties of Nerium Oleander seed, a non-edible ornamental plant. The objectives were to determine the physical, chemical properties of the Nerium Oleander seed suitable for biodiesel production. The mean major, minor and intermediate diameters of twenty Nerium Oleander seeds were 3.53 cm, 1.85 cm and 1.98 cm respectively. The volume, density and sphericity of the seeds were reported to as 7.70 cm³, 0.49 g/cm³ and 0.69 respectively. The seed oil exhibited good chemical properties for biodiesel production with a viscosity of 46.58mpa/s at 30°C, Free Fatty Acid (FFA) of 3.92%, cloud point of 2°C and a flash point above 200°C. The ash content, moisture content, melting point, density at 15°C, Cetane number and the heat of combustion were reported as 1.44%, 0.33%, 8°C, 0.898 g/cm³, 63.55 and 125.37 KJ/L, respectively. The cetane index of Nerium Oleander seed oil had high cetane index when compared to the ASTM standard for diesel fuels. It was concluded that the Oleander seed is an alternative feedstock for biodiesel production.

Keywords: oleander seed, oil, biodiesel, physio-chemical properties, cetane index, alternative feedstock.

1. Introduction

According to the American Society for Testing and Materials (ASTM), biodiesel is a mono-alkyl esters of long chain fatty acids derived from a renewable lipid feedstock such as vegetable oil, animal fat, waste cooking oil, etc. In other words, biodiesel is a diesel fuel made from vegetable oil, alcohol and a catalyst. It is the only alternative fuel that has passed all of the Environmental Protection Agency's (EPA) clean –air fuel requirements. Biodiesel was produced to achieve oil viscosity equivalent to that of diesel fuel and that does not clog the nozzles of the injector, thus removing impurities like sulphur oxide [1]. Vegetable oil and animal fats are the key feedstock in biodiesel production and the market for these stocks are on the growth in America and in the European Union. The demand for biodiesel feedstock both for industrial purpose and for human consumption is on the increase. Edible seed oils such as soy, canola and rapeseed are in high demand for biodiesel production than animal fats and used/blended oils and fats because of their low level of Free Fatty Acid (FFA). In recent years there has been much debate on food versus fuel concerning the risk of diverting farmland or crops for biodiesel production which could impact the vegetable oil supply on a global scale. This has necessitated an urgent research in alternative feedstock for biodiesel production especially in non-edible oils so as to reduce the competition in vegetable oil production for biodiesel production and food production.

Nerium Oleander is an ever – green ornamental dicotyledonous shrub that belongs to Apocyanaceae family [2]. It is commonly found in the tropics and sub – tropics but it is native to Central and South America. The plant fruits all the year round, producing between 400 – 800 fruits per annum depending on the rainfall pattern and plant age. The fruits are usually green in colour and become black on ripening. Each fruit contains a nut which is longitudinally and transversely divided. The fruit contains between one to four seeds in its kernel.

In Nigeria, Nerium Oleander has been grown for over fifty years as an ornamental plant in homes, schools and churches by missionaries and explorers [3]. All parts of the plant are toxic, due to the presence of glycosides. The seed is high in oil yield containing between 60 – 65% oil [4]. With its high oil yield, the seed could be a good non-edible feedstock for biodiesel production. The main objective of this study is to determine the physiochemical properties of Nerium Oleander seed oil for biodiesel production. The physical and chemical properties considered in this study include the major, minor and intermediate diameters, the density, volume, sphericity, ash content (%), moisture content (%), flash point (°C), Free Fatty Acid (%), cloud point (°C), pour point (°C), viscosity (poise), density (g/cm³), heat of combustion (KJ/L), Cetane Index and the p^H value.

2. Materials and Methods

Nerium Oleander fruits were randomly collected from its trees in Nsukka area, south eastern Nigeria. The fruits were sorted to separate mature fruits from immature ones and dirt. The clean and mature fruits were kept at room temperature for 7 days to soften the mesocarp for easy removal of the kernel.

2.1 Physical Properties

Twenty Nerium Oleander kernels were randomly picked; weighed using Denver digital weighing machine (X-3000) and the (a) major (b) minor (c) intermediate diameters measured with the use of a vernier caliper. The physical dimensions measured are as shown in Figure 1. The diameters for each kernel were measured and the average value recorded.

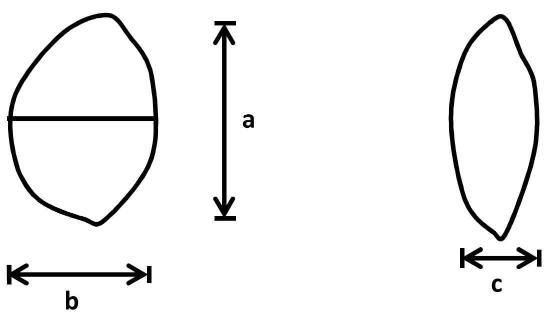

Figure 1: Physical dimensions of Leander kernel

The geometric mean diameter (GMD) was calculated as:

$$GMD = (a * b * c)^{1/3} \tag{1}$$

The sphericity was calculated using the equation described by [5]:

$$F = \frac{(a * b * c)^{1/3}}{a} \tag{2}$$

The volume was calculated using the formula described by [6]:

$$V = \left[\frac{(\pi * a * b * c)}{6}\right] \tag{3}$$

The density of was calculated using:

$$L = m/v \tag{4}$$

where, M is the mass (g) and V is the volume (cm³)

2.2 Fuel Properties

Clean Nerium Oleander kernels were randomly picked, cracked using a hammer and the seed obtained weighed using the Denver digital weighing machine (X-3000). The seeds were kept in an open air for 48 hours to reduce the moisture content and then crushed using a Corona mechanical grinder. The oil was extracted using a manually operated mechanical screw and weighed.

Laboratory tests were carried out at the National Center for Energy Research and Development, University of Nigeria, Enugu state, to determine the chemical properties of the extracted Nerium Oleander seed oil. The standard test methods used were ASTM D 445, D 2500, D 613, and D 93. The tests were carried out in three replicates and the average values recorded.

3. Results and discussions

3.1 Physical Properties

The physical properties of Nerium Oleander kernel is shown in Table 1. The mass of twenty Nerium Oleander kernels used was 3.778g. As shown in Table 1, the mean major, minor and intermediate diameters are 3.53 cm, 1.85 cm and 1.98 cm respectively. The geometric mean diameter was found to be 2.35 cm. These figures are important in the design of processing machines for Nerium Oleander fruit. The average volume and density were evaluated to be 7.70 cm³ and 0.49 g/cm³ respectively. These dimensions are useful in the design of storage facilities for the fruit. The average sphericity was evaluated to be 0.69 which is important in the design of conveying and transporting systems.

Table 1: Physical dimensions of Nerium Oleander Kernel

Dimension	Mean
Geometric mean diameter	2.35 cm
Major diameter (a)	3.53 cm
Intermediate diameter (b)	1.98 cm
Minor diameter (c)	1.85 cm
Volume	7.70 cm³
Density	0.49 g/cm³
Sphericity	0.69

3.2 Oil Properties

The Nerium Oleander seed oil extracted was brownish red in color and non- volatile. It is liquid at room temperature and if exposed to heat the oil darkens and gives a grey coloration. The properties of Nerium Oleander seed oil obtained are as shown in Table 2. The ash content, moisture content, flash point, FFA, cloud point, melting point, viscosity at 30°C, density at 15°C, heat of combustion, Cetane number and the pH value of the oil obtained are 1.44%, 0.33%, >200°C, 3.92%, 2°C, 8°C, 46.58

mpa/s, 0.898g/cm^3, 125.37KJ/L, 63.55 and 6.37 respectively. The oil yield was less than the range reported in literature and the variation may be due to the differences in cultivation climate, ripening stage, harvesting time of the seeds and the extraction method used [7]. Viscosity of the oil which is a measure of the resistance of the fluid to deform under shear stress or its perceived thickness or resistance to flow or friction was obtained as 46.58mpa/s at 30°C. The low Free Fatty Acid (FFA) recorded shows that the oil is stable and would experienced low oxidation rancidity in biodiesel production. The cloud point was within the limit suggested for vegetable oils [8]. The flash point was above 200°C which is in agreement with [9] who found that the flash point of vegetable oils was in the range of 300°C to 322°C. Comparing the cetane index of the Nerium Oleander seed oil with the recommended standard from ASTM, the value was higher than the minimum stated by ASTM with a value of 63.55. The cetane index is an important property of diesel fuels and determines the knock characteristics of the fuel.

Table 2: Fuel Properties of Oleander Seed Oil

Biodiesel oil properties	Nerium Oleander seed oil (Mean values)	Biodiesel standard
Mass of oil extracted from 193.8g of seed	53.42g (28%)	
Ash content	1.44%	
Moisture content	0.33%	
Flash point	> 200°C	130°C min ASTM 06751-03
Free Fatty Acid (FFA)	3.92%	
Cloud Point	2°C	
Melting point	8°C	
Viscosity at 30°C	46.58 mpa/s	
Density at 15°C	0.898 g/cm^3	0.88 g/cm^3 USNSDB *
Heat of combustion	125.37 KJ/L	128kJ/L
Cetane Index	63.55	47 min ASTM 06751-03
PH value	6.37	

* USNSDB: United States National Soy-diesel Development Board (1994)
* ASTM: American Society of Testing and Materials.

4. Conclusion

The study shows that Nerium Oleander seed oil exhibited good physiochemical properties for biodiesel production with a viscosity of 46.58mpa/s at 30°C, Free Fatty Acid (FFA) of 3.92%, cloud point of 2°C and a flash point above 200°C. The cetane index of Nerium Oleander seed oil had high cetane index which is a desired property. The oil could serve as a non-edible feed stock for biodiesel production.

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