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Determination of physico chemical properties of biodiesel from *Citrullus lanatus* seeds oil and diesel blends

S. Sani[a], M.U. Kaisan[b,*], D.M. Kulla[b], A.I. Obi[b], A. Jibrin[c], B. Ashok[d]

[a] Department of Energy Management, Training and Manpower Development, Energy Commission of Nigeria, Abuja, Nigeria
[b] Department of Mechanical Engineering, Ahmadu Bello University, Zaria, Nigeria
[c] Department of Agricultural Education, Federal College of Education, Zaria, Nigeria
[d] Department of Automotive Engineering, School of Mechanical Engineering, VIT University, Vellore, India

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ABSTRACT

Biodiesel from *Citrullus lanatus* was blended with petro-diesel, thereby forming blends of different percentages, 5%, 10%, 15%, 20%, and 25% denoted as B5, B10, B15, B20, and B25 respectively. The physico-chemical properties such as specific gravity, calorific value, cetane number, kinematic viscosity, flash point, Sulphur contents, copper strip corrosion, colour index, pour point and cloud point of each of these biodiesel with blends and pure diesel (B0) were determined. Most of the physico-chemical properties were found to be within the American Society for Testing and Materials'-ASTM standards for biodiesel. All the fuel samples are consistent with the ASTM standards with regards to viscosity and specific gravity except B100 which are slightly above the American Society for Testing and Materials standard with very insignificant values of 0.09 and 0.018 mm^2/s respectively. Therefore, the blends could be a better option to be used on compression ignition-CI engines for the improvement of quality of atomization, combustion, fuel droplets and air-fuel mixing. The calorific values of the biodiesel and blends were all within the ASTM standard with B20 value slightly below that of pure diesel; similarly, the flash point of the pure biodiesel and its blends were above the pure diesel value but falls within the ASTM range. The fuel is safe to handle during storage, because it cannot easily spark when exposed to flame and hence they are recommended for use in the CI engines. The pour points of all the fuel samples conform to the ASTM standards. The cetane numbers are all greater than that of pure diesel and conforms to ASTM standards. The biodiesel will be having shortest possible ignition delay when they burn in the CI engines.

1. Introduction

Energy is an essential driving factor to socioeconomic development in every nation. Its impact touches all aspect of human endeavor such as agriculture, health, education, transportation among others. The major sources of energy supplies in the world are fossil fuels such as petroleum, natural gas, oil and coal. However, fossil fuels are non-renewable and are projected to be exhausted in the near future (Sokoto et al., 2013). Increase in the world population, standard of living, urbanization and industrialization aggravated the depletion of fossil fuel reserves, price increase and more concentration of greenhouse gases emissions and therefore resulted to severe air contamination, environmental and ecological pollutions.

The major problems of using biodiesel in compression ignition (C.I) engines are their high viscosity and low volatility. These affect the atomization and spray patterns of fuel, leading to incomplete combustion and severe carbon deposits, injector chocking and piston ring sticking (Kaisan et al., 2013). Emulsification, Pyrolysis, Dilution and Transesterification were the methods used to reduce viscosity. Transesterification is the most commonly used commercial process to produced clean and environmental friendly fuel.

Conventional fossil fuels used in diesel engine releases higher exhaust emission of particulate matter (PM), carbon dioxides (CO_2), sulphur oxides (SO_X), unburned hydrocarbon (HC) and oxides of nitrogen (NO_X). Moreover, CO_2 emission causes the greenhouse effect while NO_X and SO_X causes' acid rain (Kaisan et al., 2017a,b,c,d,e). It has been established in the literature that biodiesel considerably decreases the CO and CO_2 emission but increases NO_X emission. Blending of biodiesel with additives and engine gas recirculation (EGR) were some of the verified methods to have reduced the NO_x emissions (Kanji and Pravin, 2013; Mofijur et al., 2013). In addition to that, the fast depletion of petro-diesel due to the rapid growth of world population causes more threat of climatic change and the tragedy of increasing cost (Izah and Ohimian, 2012). Therefore, researchers are seeking for more potential

* Corresponding author.
E-mail addresses: engineer.kaisan@gmail.com, mukaisan@abu.edu.ng (M.U. Kaisan).

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energy crops for biodiesel productions and biodiesel from watermelon seed oil has not been widely investigated (Varala et al., 2012; Oladejo et al., 2013).

Watermelon seed is a family of *Cucurbitaceae* and believed to have originated from Africa, also cultivated across the world (FOA, 2003). China was reported to be the leading country in the watermelon production followed by Turkey, United States, Iran and Republic of Korea (Huh et al., 2008). In Nigeria, cultivation of watermelon was originally limited to the Northern region, now gradually gaining ground in the southern part of the country (Gwana et al., 2014).

The abundance of watermelon during harvest and absence of its processing industries in Nigeria causes a lot of waste to the non-sweated watermelon and hence, ended up as a waste. The seed were discarded each year as cheap animal feed or simply thrown away and decay naturally (Gwana et al., 2014) and hence, this could be a great alternative source of biodiesel feedstock in Nigeria. However, various technical and economic aspects of watermelon biodiesel required further improvement (Varala et al., 2012; Oladejo et al., 2013). Therefore, this research work is justifiable by all the aforementioned problems.

This article has established how utilization of watermelon seed oil for biodiesel production can be used effectively to generate employment through its mass production/market, and may earn Nigeria the much needed foreign exchange and therefore, reducing poverty, rural-urban migration, environmental pollution as well as climate change associated problems.

Hundreds of scientific articles and various other reports from around the world dealing with biodiesel have appeared in print. However, various vegetable and plant based derived biodiesel that were tested for technical and economic aspects need further improvement. Watermelon seed is a quick maturing plant species that starts bearing fruits within few months of plantation. Although, a study to determine physicochemical properties of oil from watermelon seed and it is suitability for consumption, biodiesel production and other industrial applications were reported (Varala et al., 2012; Oladejo et al., 2013). However, the physico-chemical properties of blended biodiesel produced were hardly evaluated.

Compression ignition engines are classes of internal combustion engines in which the combustion is initialized spontaneously by the virtue of the rise in temperature during the compression process. (Kaisan and Pam, 2013). It works on diesel cycle. In diesel engines, the energy addition occurs at constant pressure but energy rejection is at constant volume. The role of the spark plug in petrol (Spark Ignition) engine is replaced by fuel injector. The compression ratio is from 12 to 25. The engine has low speed, low running cost, high maintenance cost. Compression ignition engines use less volatile liquid fuels (diesel), have compression pressure of 400–700 psi and have no ignition device and the speed/load are controlled varying the fuel quantity injected.

2. Methodology

2.1. Experimental plan and apparatus

2.1.1. Experimental plan

The discarded watermelon seed could be a great alternative source of raw material of biodiesel production. Though, some biodiesel properties such as flash point, viscosity, cetane number, cloud point, pour point, calorific value, acid value, ash content and cold flow properties had to meet certain standard and be comparable to petro-diesel in order to be regarded as biodiesel (Lee et al., 2008).

2.1.2. Apparatus

Table 1
List of equipment and apparatus.

Equipment/Apparatus	Model/Manufacturer
Bomb Calorimeter	SLFA-1598, HORIBA.
Pensky Martens Closed Cup	Man-stanhope-seta,model:13661-3p
Viscometre Bath	KV-8, STANHOPE-SETA.
Cetane/Octane Meter	SLFA-167, HORIBA.
Copper Strip Corrosion Tester.	STANHOPE-SETA, Model-K14670
Sulphur testing machine	SLFA-60, Man-Horida Scientific
Hydrometre (Size 0.6–1.0)	Japanese Industrial standard (disk 2830), Tokyo
X-fluorescence Sulphur in oil analyzer	SLFA-60, HORIBA.
Color Tester	ASTM D1500-1P 196 Color Tester,
API for Analine Point	Euip. No 212
Furnace	SXL-1008 Muffle Furnace Gallenkomp, England

2.2. Materials preparation

2.2.1. Raw materials

The material used in this research was Watermelon seed (*Citrullus lanatus*), it is widely cultivated in the Northern Nigeria. Oil was extracted through mechanical press expeller and the oil was processed to produce biodiesel through esterification process. Conventional diesel was obtained from Daurama filling station, Soba along Zaria-Jos road. The reagents used include: analytical grade methanol, potassium hydroxide, sodium hydroxide, sulphuric acid, propan-2-ol, phenolphthalein, calcium oxide, Alumina, distilled water, aluminum foil and tissue paper.

2.2.2. Sample collection and preparation

The sample was obtained from Bunkure Local Government Area of Kano state. The seeds were sun dried to reduce the moisture content and all the unwanted particles were removed.

The sample weight was measured and taken to milling machine for oil production. The oil produced was then trans-esterified to produce biodiesel.

2.2.3. Catalyst preparations

Heterogeneous based catalysts have been found to be more successful with high conversion and yield of biodiesel between 98–100%, Ibrahim et al. (2014). Catalysts such as calcium oxide, sulphated titanium oxide, zinc oxide, sulphated zirconia and sulphated tin oxide could easily replace conventional homogenous catalysts.

The catalyst was prepared by dissolving 20 g of calcium oxide into 40 cm^3 of distilled water in a beaker, 80 g of alumina power was then added to the solution and placed on a magnetic stirrer. The solution was stirs at 60 °C until the water completely evaporated. Furthermore, the powdered was dried-up in an oven at 60 °C for 90 min and further heated in a furnace at 900 °C for 90 min.

2.2.4. Oil extraction and biodiesel production

The weight of the seed sample was initially determined before the oil was extracted. The oil expelling machine was set into actions and allowed to worm up to a certain temperature, for a better oil yield. The machine choke was tightened and seed sample was admitted. The weight of the crude oil obtained was determined and allowed to settle then filtered for further analysis.

Esterification was done in accordance with Kaisan et al. (2013) when the percentage of free fatty acid (%FFA) of the watermelon oil was below 1%, this was to convert the fatty acid of the oil into an ester which makes it easy for almost all the oil to be offered for biodiesel production.

Transesterification reaction was carried out by mixing solid catalyst of 1.2% and methanol of 15% mass of filtered oil and stirred well to