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FALLEN MAHOGANY (*KHAYA SENEGALENSIS*) LEAVES, A POTENTIAL FEEDSTOCK FOR BIODIESEL PRODUCTION

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ABSTRACT

Due to the high cost of biodiesel feedstocks, fallen Mahogany leaves were investigated as alternate feedstock. The leaves were collected, cleaned, pulverized and sifted with a 200 µm sieve. The 50 g pulverized leaves were extracted with 1.5 g of calcium oxide and 500 ml of distilled water at 100 ^{o}C for 30 minutes. The extract was filtered and esterified with methanol and sulphuric acid for 60 minutes at 60 ^{o}C. The product was transferred into a separating funnel and left for an hour and was separated into two layers. The upper and lower layers weighed 34.96 g and 33.70 g respectively. They were analyzed with GC-MS to determine their chemical compositions. The upper layer suspected to be biodiesel contained 76.98% biodiesel, 14.27% free fatty acid and 8.75% other compounds. The lower layer suspected to be glycerol contained 45.1% biodiesel, 27.85%free fatty acid, 24.56% glycerol and 2.49% propanol. Total mass of biodiesel produced was 42.68 g making the leaves a promising biodiesel feedstock.

Keywords: biodiesel, fallen, feedstock, mahogany leaves, promising

INTRODUCTION

A search for alternative fuels for petroleum fuels is still receiving the attention of researchers due to diminishing reserves and environmental consequences of petroleum products [1]. The most promising alternative biofuels that can replace or blend with fossil fuels are biodiesel and

bioethanol for fossil diesel and premium motor spirit (PMS) respectively [2]. Biodiesel having similar and even superior properties to fossil diesel is considered to be the best alternative to fossil diesel while bioethanol is alternative to petrol. Biodiesel is a mono alkyl ester of a long-chain fatty acid produced by esterification of fatty acid with alcohol and mineral acid as catalyst or transesterification of triglycerides with alcohol and catalyst which could be a base or an acid. Compared with fossil diesel, biodiesel is renewable, eco-friendly, higher cetane rate and burns with fewer pollutant gases [3]. However, the conventional biodiesel feedstocks are very expensive making biodiesel production not commercially attractive.

Despite the numerous advantages of biodiesel over fossil diesel, it is not in commercial production competitively with petroleum diesel due to high cost of vegetable oil feedstocks. A lot of researches are ongoing to get the most feedstocks for biodiesel production. Many different feedstocks have been used for biodiesel production; the fact still remains that the cost of production is higher than fossil diesel. Most of the recommended feedstocks such as *Jatropha curcas* seed oil and *castor* seed oil have high free fatty acid [4]. Ibrahim *et al* [5], produced biodiesel from calabash seed oil with methanol and calcium oxide catalyst after series of degumming and esterification, the methyl ester content was below standard (96.5%). The purification of the raw feedstock raised the production cost making it unattractive. Kapok seed oil was transesterified with methanol and calcium oxide after degumming and esterification, the highest methyl esters yield were between 78% and 88 % [6, 7]. Leaves are part of a plant, expected to contain chiefly cellulose, hemicellulose and lignin [8]. Extraction of these leaves yields some quantity of fatty acids and their esterification would yield substantial biodiesel. Magaji and Ibrahim [9] produced biodiesel among other products when they extracted fallen *Gmelina* leaves with calcium oxide at 100 ^{o}C for 30 minutes.

In this research, dead leaves of Mahogany were used to produce biodiesel after extraction with calcium oxide catalyst. The leaves were collected from the premises of Umaru Musa Yar'Adua University, Katsina, Nigeria. The leaves were cleaned, pulverized, sieved and heated with 3% calcium oxide catalyst. The extract was esterified with sulphuric acid and methanol.

EXPERIMENTAL

Materials and Reagents

Pulverized leaves of *Khaya senegalensis*, bulk calcium oxide (CaO) catalyst supported on alumina, magnesium sulphate, sulphuric acid, methanol, distilled water, conical flask, beaker, Gallenkamp hot plate magnetic stirrer, separating funnel, Buchner funnel, measuring cylinder, pH meter, mortar and pestle, GC-MS machine.

Sample preparation

The dead leaves of *Khaya senegalensis* were collected within Umaru Musa Yar'adua University Campus, Katsina, Katsina State, Nigeria. The leaves were washed, dried and pulverized using ceramic mortar and pestle. The pulverized dead leaves were sieved to 200 µm and stored in airtight container.

Extraction of *Khaya senegalensis* Leaves,

The 1.5 g of bulk calcium oxide catalyst was poured into 500 ml distilled water. The 50 g of pulverized mahogany leaves was added to the catalyst and water mixture and placed on a hot plate magnetic stirrer. It was heated to 100 ^{o}C for 30 minutes. The products were filtered first with cotton wool and then with Whatman filter paper to obtain a clear solution. The filtrate was further treated with 0.02 % of magnesium sulphate to remove water. The extract was weighed and found to be 189.26 g.

Esterification of the Extract

The extracted product was poured into a conical flask.113.56 g (60% of extract) methanol and 1.9 g (1% of extract) sulphuric acid were mixed and added to the extract in a 500 ml conical flask. The whole mixture was placed on a Gallenkamp hot plate magnetic stirrer and heated to 60 ^{o}C for 1 hr. The mixture was washed until the pH was 7 and poured into a separating funnel and separated into two distinct layers suspected to be biodiesel and glycerol. The biodiesel layer weighed 34.96 g and glycerol weighed 33.7 g. Samples of the biodiesel and glycerol were taken for GC-MS analysis to determine their chemical constituents and compositions. Analysis was done using a Varian 3800 gas chromatograph equipped with an Agilent fused silica capillary CP-Sil 5 CB column (30 m × 0.25 mm i.d) connected to a Varian 4000 mass spectrometer operating

in the EI mode (70 eV; m/z 30– 600 amu; source temperature 230 °C and a quadruple temperature 150 °C) [9].

RESULTS AND DISCUSSION

The upper layer suspected to biodiesel contained biodiesel 76.89% (26.91 g), free fatty acid (FFA) 14. 27% (5.0 g) and others namely hexan-3-one (alkenone), 3-methyl penten-2-ene (alkene) and 2,6-Dimethoxy-4(2-propenyl) phenol (phenol) 8.75% (3.06 g) as shown Figure 1. The biodiesel compounds found in the upper layers were acetic acid methyl ester ($C_3H_6O_2$), methyl octanoate ($C_9H_{18}O_2$), methyl decanoate ($C_{11}H_{22}O_2$), methyl tetradecanoate ($C_{15}H_{30}O_2$), methyl hexadecanoate ($C_{17}H_{34}O_2$), methyl 9-octadecenoate ($C_{19}H_{36}O_2$), methyl linoleate ($C_{19}H_{34}O_2$), methyl stearate ($C_{19}H_{38}O_2$) and methyl ecosanoate ($C_{21}H_{42}O_2$). Their compositions are as depicted in Figure 2.

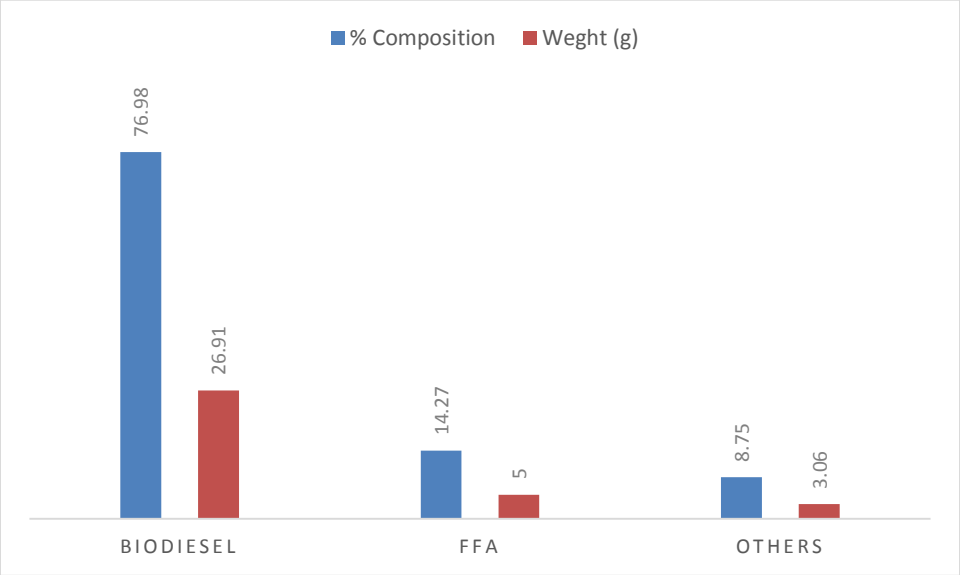

Figure 1: Components and their compositions of Upper layer (Biodiesel)

The component with the highest composition was methyl linoleate (22.24%) which is highly unsaturated with two double bonds per molecule [10]. Its composition is not enough to affect the stability of fuel as there were as many of saturated components like methyl octanoate (17.51%) and methyl hexanoate (13.33%) in addition to methyl tetradecanoate (4.97 %), methyl ecosanoate (3.87 %) and methyl decanoate (3.76%).

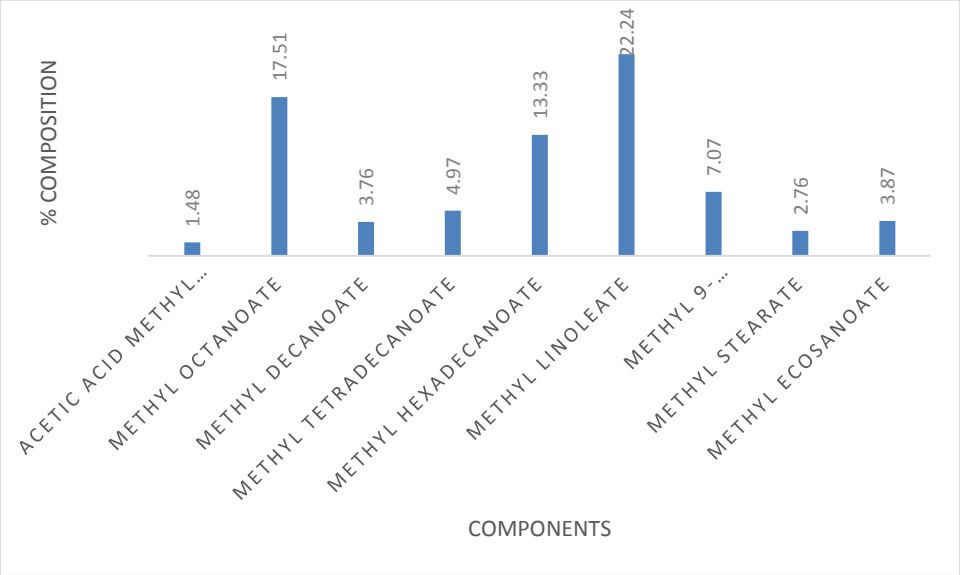

Figure 2: Chart of Biodiesel components in the upper layer

The lower layer suspected to be glycerol contained 45.1% (15.77 g) biodiesel, 27.85% (9.39 g) free fatty acid, 24.56% (8.28 g) glycerol and 2.49% (0.84 g) propanol. The three biodiesel compounds found in the glycerol layer were methyl decanoate, methyl tetradecanoate and methyl octanoate indicating that with careful separation more biodiesel would be obtained. A total of 42.68 g of biodiesel was produced from 50 g of pulverized leaves of Mahogany.

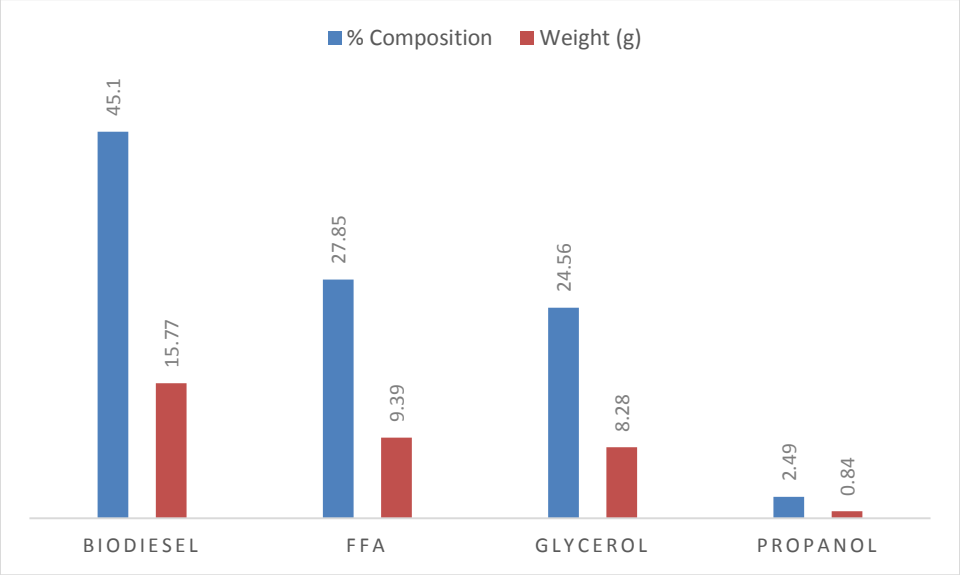

Figure 3: Components of the lower layer

If the biodiesel could be distinctly separated from the rest of the products, Mahogany leaf would be a very good source of biodiesel production that can compete favourably well with petroleum diesel. The leaves are just a waste, its collection cost was very low compared to the cost of conventional vegetable oils. This can encourage the planting of trees and at the long-run combat desert encroachment and also take care of waste disposal.

CONCLUSION

This study found that 42.68 g of biodiesel was produced from 50 g of fallen Mahogany leaves when the extract of the leaves was esterified with 113.56 g of methanol and 1.9 g of sulphuric acid. The presence of free fatty acid 5.0 g and 9.39 g in the biodiesel and glycerol layers respectively in the final products indicates that the esterification was not completed which would have yielded more biodiesel. The leaves were obtained free of charge. Hence, fallen (dead) Mahogany leaf is a promising biodiesel feedstock if its purification will not be expensive.

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