



Preparation and characterization of the biodiesel from *Balanites aegyptiaca* seeds oil

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Abstract

In this study Biodiesel was produced by transesterification of *Balanites aegyptiaca* seeds oil. The results show that physicochemical properties of the Biodiesel were viscosity at 40 C° was (5.041 mm²/s), at 100 C° was (1.916 mm²/s), the density was (885.0g/ml), the cloud point of Biodiesel was (-13.5 C°), copper corrosion was (1a), flash point was (130 C°), color was (0.7), cetane number was (54.6), sulfur m/m% was (0.011). The results for blend of Biodiesel and diesel show that the viscosity of blend at 40 C° was (3.855 mm²/sec), at 100 C° was (1.702 mm²/s), the cloud point of blend was (5.6 C°), copper corrosion was (1a), flash point was (77.5 C°), color was (0.7), cetane number was (55.2), sulfur m/m% was (0.011). When ethanol was added to the blend the results show that viscosity of mixed at 40 C° was (3.011 mm²/s), at 100 C° was (1.053 mm²/s), the density of mixed was (845.0g/ml), the cloud point of mixed was (15.7), copper corrosion was (1a), the flash point was (40.5 C°), the color was (0.5), the cetane number was (54.6), the sulfur m/m% was (0.011).

Keywords: biodiesel, transesterification, *Balanites aegyptiaca* oil, petro diesel

Introduction

The global politics of fossil fuel and its high cost mandated an investigation and production of an environmental friendly, cost effective and renewable fuel (biodiesel) obtained from animal fats and vegetable oils. The biodiesel has many attractive features over petro diesel most such as: Biodiesel is biodegradable, improves engine performance, non-toxic, It has a higher cetane number than ordinary diesel and therefore does not need any additives as in premium petro die. It has a higher flash point than ordinary diesel, It reduces net CO₂ emission by 70% compared with ordinary diesel cutting greenhouse gases that lead to global warming (Freedman, and Pryde, 1986 [7]). It is more lubricating than ordinary diesel reducing engine wear and ensuring longer fuel pump life. It is produced from local feedstock, reducing the need for foreign imports, while boosting the local economy and supporting the agricultural community. Biodiesel replaces the exhaust odor of ordinary diesel, Biodiesel blends of 20% with 80% ordinary diesel can be used without modifying diesel engines (Meher, et al, 2006) [11]. It can be used in its pure form but may require certain engine modifications to avoid maintenance and performance problems. Biodiesel requires virtually no additives. The advancements of biodiesel quality are developed globally to maintain the quality of the end product and to ensure better criteria of biodiesel storage and feedstock for consumers' confidence and successful commercialization. Since biodiesel is produced from quite different plants of varying origins and qualities, it is necessary to install a standardization of fuel quality to guarantee an engine performance without any difficulties (Balat, 2010) [3]. Austria was the first country to define and approve the standards for rapeseed oil methyl esters as a diesel fuel. The guidelines for standards and the quality of biodiesel have also been defined in other countries such as in Germany, Italy, France, the Czech Republic and the United States (Meher et al. 2006) [11]. Currently, the properties and qualities of biodiesel must comply with the

international biodiesel standard specifications. These specifications include the American Standards for Testing Materials (ASTM 6751-3) or the European Union (EN 14214) Standards for biodiesel fuel (Atadashi et al. 2008) [2]. However, there are some other standards available such as in Germany (DIN 51606), Austria (ON) and Czech Republic.

Acceptance of Kyoto protocol and clean development mechanism will lead to more Biodiesel production around the world. For instance, it is anticipated that this policy will lead to a total bio-fuel demand in EU of around 19.5 and 30.3 million tons in 2012 and 2020 respectively. Biodiesel production is expanding rapidly around the world, driven by energy security and other environmental concerns. Given geographic disparities between demand and supply potential, and supply cost, expanded trade in Biodiesel appears to make sense. Global potential in Biodiesel production is very unclear, but in the long run it could be a substantial percentage of transport fuel demand. Currently, Biodiesel can be more effective if used as a complement to other energy sources. With the increase in global human population, more land will be needed to produce food for human consumption. Thus, the insufficient lands could increase the production cost of Biodiesel plants. This problem already exists in Asia where vegetable oil prices are relatively high. The same trend will eventually happen in the rest of the world. This is the potential challenge to Biodiesel production. Therefore, non-edible oil, genetically engineered plants and microalgae feedstock can be proper solutions for this problem and can ensure the sustainability of biodiesel production in the future (Atabani et al, 2007).

Materials and methods

Materials

Extracted oil from *Balanites aegyptiaca* seeds

Methods

Preparation of Biodiesel

200ml of the oil sample were placed in a beaker; the 2g of sodium methoxide was added. The temperature was raised to 450C' on a hot plate and the mixture was stirred with magnetic stirrer for 25 minutes and allowed to stand overnight. A thick brown layer of glycerin settled at the bottom and liquid biodiesel lighter colored. The glycerin was drawn off through the bottom tap. The biodiesel was then washed with warm water to remove the remaining lye, soaps and methanol. A straw-yellow and a cloudy liquid layer were formed, the cloudy liquid was drained out and pH test was conducted to confirm the neutrality of the washed water/cloudy liquid. The Biodiesel was heated to 550C on a hot plate to allow the remaining water to evaporate and was finally filtered using a filter paper (Mondala *et al.* 2009) [8].

Determination of Density

2ml of liquid sample was introduced into an oscillating sample tube and the change in oscillating frequency caused by the change in the mass of the tube is used to determine the density of the sample. (ASTM D4052).

Determination of Viscosity

2ml of sample introduced into the measuring cells, which are at a closely controlled and known temperature. The measuring cells consist of a pair of rotating concentric cylinders and an oscillating U-tube. The dynamic viscosity is determined from the equilibrium rotational speed of the inner cylinder under the influence of the shear stress of the test specimen and an eddy current brake in conjunction with adjustment data. The density is determined by the oscillation frequency of the U-tube in conjunction with adjustment data. The kinematic viscosity is calculated by dividing the dynamic viscosity by the density. (ASTM D7042).

Cloud point

0.2ml Sample was cooled by a Peltier device at a constant rate of 1.5c /min while continuously being illuminated by a light source. The specimen is continuously monitored by an array of optical detectors for the first appearance of a cloud of wax crystals. The temperature at which the appearance of a cloud of wax crystals is first detected in the specimen is recorded to 0.1C' resolution. When the recorded temperature is rounded to the next lower integer temperature, it is designated as the D 2500/IP 219 equivalent cloud point per. (ASTM D5773).

Copper corrosion

A polished copper strip is immersed in a 15ml of the sample being tested and heated under conditions of temperature and time that are specific to the class of material being tested. At the end of the heating period, the copper strip is removed, washed and the color and tarnish level assessed against the ASTM Copper Strip Corrosion Standard (ASTM D130).

Flash Point

A brass test cup of 75ml of sample dimensions, filled to the inside mark with test specimen and fitted with a cover of specified dimensions, is heated and the specimen stirred at specified rates (ASTM D93).

Color

Using a standard light source, 45ml of a liquid sample is placed in the test container and compared with colored glass disks ranging in value from 0.5 to 8.0. When an exact match is not found and the sample color falls between two standard colors, the higher of the two colors is reported. (ASTM D1500).

Sulfur m/m%

A hydrocarbon sample is either directly injected or placed in a sample boat. 2ml of the sample are inserted into a high temperature combustion tube where sulfur is oxidized to sulfur dioxide (SO₂) in an oxygen rich atmosphere.

Water produced during the sample combustion is removed and the sample combustion gases are next exposed to ultraviolet (UV) light. SO₂ absorbs UV energy and is converted to excited sulfur dioxide (SO₂). The fluorescence emitted from the excited SO₂ as it returns to a stable state, SO₂, is detected by a photomultiplier tube and the resulting signal is a measure of the sulfur contained in the sample. (ASTM D5453).2.2.9. FT-IR:

Oil was characterized by FT-IR, using a Perkin Elmer oil analyzer equipped with the MIR TGS detector in the range 4000-650 cm⁻¹ and processed with the computer software program spectrum. Fig.1 shows the Fourier transform infrared (FT-IR) spectrum of the oil from *Banalitya aegyptiaca* seeds. The resolution was 4 cm⁻¹ and 8 scans.

GC-MS

The qualitative and quantitative analysis of the sample was carried out by using GC/MS technique model(GC/MS-QP2010-Ultra) japan 'Simadzu Company, serial number 020525101565SA and capillary column (Rtx-5ms-30m×0.25 mm×0.25μm).The sample was injected by using split mode, helium as the carrier gas passed with flow rate 1.61 ml/min, the temperature program was started from 60c with rate 10c/min to 300c as final temperature degree, the injection port temperature was 300c, the ion source temperature was 200c and the interface temperature was 250c.The sample was analyzed by using scan mode in the range of m/z 40-500 charges to ratio and the total run time was 26 minutes. Identification of components for the sample was achieved by comparing their retention times and mass fragmentation patterns with those available in the library, the National Institute of Standards and Technology (NIST), results were recorded.

Results and Discussions

Table 1: physicochemical Properties of biodiesel and blends

Properties	diesel	Biodiesel (B100)	Diesel+biodiesel (B20)	Diesel+bio+ethanol(B40)	Test method
Viscosity@40 C'	3.3511	5.041	3.855	3.011	ASTM D7042
Viscosity@100 C'	1.307	1.916	1.702	1.053	ASTM D7042
Density @15 C'	841.3	885.0	848.4	845.0	ASTM 4052
Cloud point C'	5.1	-13.5	5.6	15.7	ASTM D5773
Copper corrosion	1a	1a	1a	1a	ASTM D86
Flash point C'	77.0	130	77.5	40.5	ASTM D93

Color	0.5	0.7	0.7	0.5	ASTM D1500
Cetane number	53.9	54.6	55.2	54.6	ASTM D4737
Sulfur m/m%	0.011	0.011	0.011	0.011	ASTM D5453

The properties of Biodiesel are characterized by physicochemical properties. Some of these properties include; cetane number (54.6) A higher cetane number indicates shorter time between the ignition and the initiation of fuel injection into the combustion chamber (Lapuerta, et al 2008). Biodiesel has higher cetane number than diesel fuel, which results in higher combustion efficiency (Ragit et al Gill 2011). The cetane number of diesel is (53.9). the Viscosity of biodiesel 40 C' (5.041mm²/s), at 100C' (1.916 mm²/s) all of this degrees the viscosity of biodiesel is higher than diesel fuel that means Viscosity is the most important property of any fuel as it indicates the ability of a material to flow. The cloud point of biodiesel is (13.5 C') Cloud point is measured using ASTM D2500 EN ISO 23015 and D97 procedures. Generally, biodiesel has higher cetane number compared to conventional diesel (Masjuki, 2010). It used as indicator of low temperature operability of fuels and reflects their cold weather performance. Measured using a low operating temperature fuel maybe thicken and might not flow properly affecting the performance of fuel lines, fuel pumps and injectors. CFPP defines the fuels limit of filterability, having a better correlation than cloud point for biodiesel as well as diesel. CFPP is ASTM D6371 (Filemon.2010) [15]. The flash point of biodiesel is (130C'), Flash point of a fuel is the temperature at which it will ignite when exposed to a flame or a spark. Flash point varies inversely with the fuel's volatility. The flash point of biodiesel is higher than the prescribed limit of diesel fossil fuel, which is safe for transport, handling and storage purpose.

The copper corrosion test measures the corrosion tendency of fuel when used with copper, brass, or bronze parts. Corrosion resulting from biodiesel might be induced by some sulfur compounds by acids; hence this parameter is correlated with acid number.

Blends

Biodiesel can be blended with diesel fuel at different ratios. In this study, biodiesel diesel blends (B20eB40) were prepared and their influence on fuel properties (density, flash point, viscosity, cloud and pour point,) was examined and presented. It can be seen that the viscosities of all blends meet the ASTM D7042 specifications. Viscosity increases as the percentages of biodiesel in the blends

increases. Moreover, the viscosities of B20 and B100 are almost appear to the diesel fuel (3.885 mm²/s and 5.041 mm²/s). Therefore, it can be noticed that B20 and B100 can be used in the diesel engine without any modifications, then when we added ethanol to blend the viscosity dropped to (3.011 mm²/s).

Density increased as the percentage of *Balanities aegyptiaca* biodiesel increased in the blends. The densities of B20 and B100 are very higher to the density of diesel fuel (848.4 kg/m³ and 885.0 kg/m³), the ethanol creased the degree when it added. The cloud point to the B20 and B100 (5.6 / 13.5) noticed it is increased at B100, with ethanol there is no result. The copper corrosion it stables at all (1a). The Cetane index of blend B20 and B100 (55.2 / 54.6) this result is better than diesel (53.9) increased when we added the ethanol (54.6).

Table 2: FTIR Characteriztie peaks of *Balanitesaegyptiaca* biodiesel

Absorption bands (cm ⁻¹)	Functional group	Absorption intensity
3006.30	C-H Stretching vibration	strong
2925.65	C-H for CH ₃ antisymmetric	strong
2856.99	C-H for CH ₃ symetric	strong
1743.43	C=O for ester	strong
1452.52	C-H bending for CH ₂	strong
1363.91	C-CH ₃ bending	strong
1171.08	C-C Stretching vibration	strong
1018.84	C-C Stretching vibration	strong
871.61	-CH ₂)n- rocky	medium
721.49	(CH ₂) rocky	medium

Balanities aegyptiaca Biodiesel was characterized by FT-IR, using a Perkin Elmer biodiesel FAME analyzer equipped with the MIR TGS detector in the range 4000e650 cm⁻¹ and processed with the computer software program spectrum. Fig. 1 shows the Fourier transform infrared (FT-IR) spectrum of the Biodiesel. The resolution was 4 cm⁻¹ and 8 scans.

The FT-IR spectra for sample of the *Balanities aegyptiaca* in the region from 3006.30 cm⁻¹ it can be observed peaks that can be attributed to the stretching of C-H and the stretching C=O typical of ester thus are common in FT-IR in rang 1745.56 cm⁻¹, in range 2925.35—2856.85 cm⁻¹ stretching of C-H from alkane CH₃ also the range 1457.26 cm⁻¹ it C-H bending for CH₂, the other bands in the table (1) below:

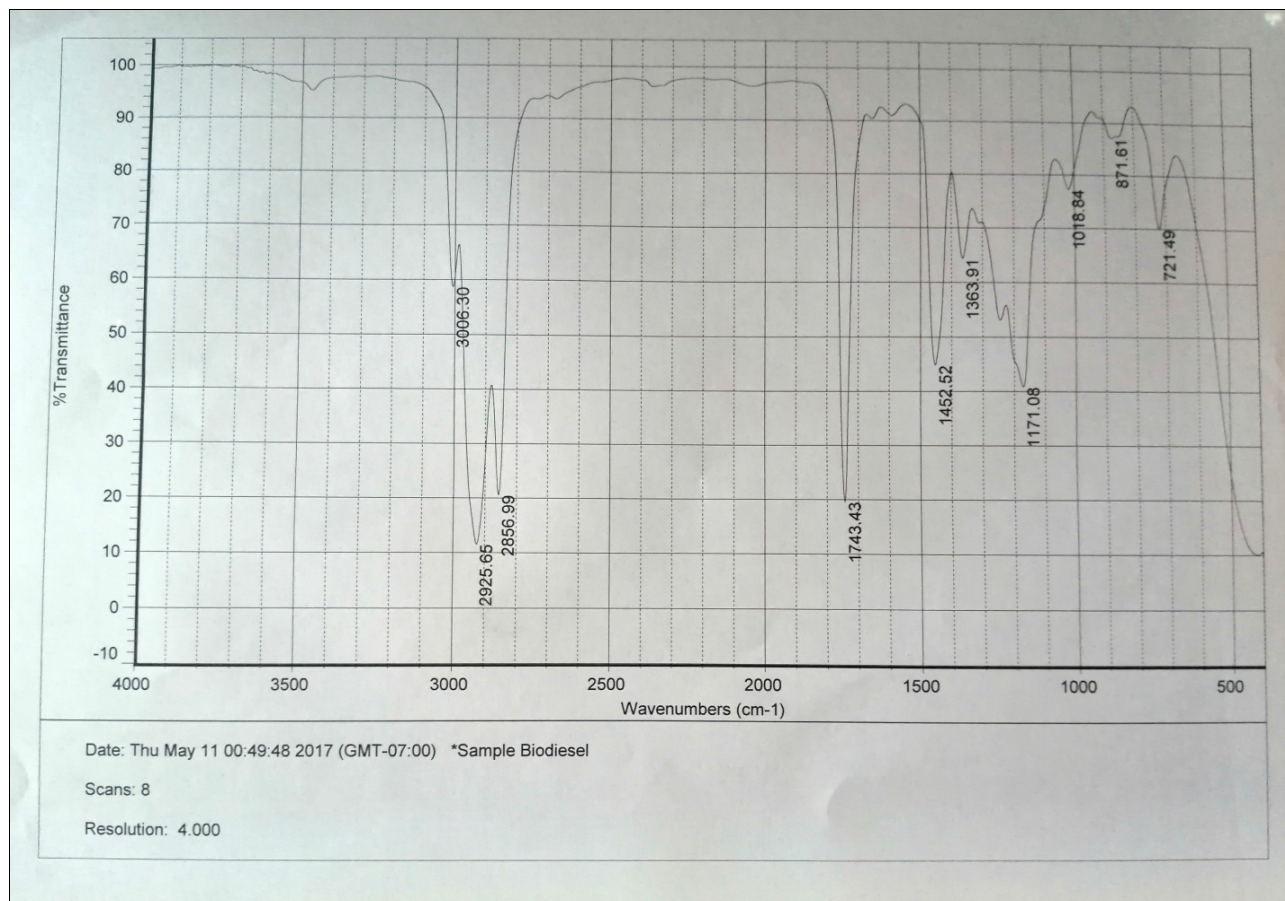


Fig 1

Table 3: GC-MS of Biodiesel

Peak	Name	R. Time	Area	Area%
1	9,12-Octadecadienonic acid	17.470	451745454	38.85
2	Methyl stearate	17.664	193015411	16.60
3	Hexadecanoic acid, methyl ester	15.724	182714764	15.71
4	9,Octadecenoic acid	17.503	172641974	14.85
5	Cyclopropanoic acid	18.960	48126795	4.14
6	PGHI, methyl ester	19.407	20188920	1.74

Biodiesel sample were analyzed using PerkinElmer GC –

MS in total scan mode to identify the fatty acid methyl ester composition.

The components in the sample such as hydrocarbons –ester –phenol – alcohol and others. These components 80% is unsaturated and the 20% is saturated. The major components are 9, 12- Octadecadienoic acid, Hexadecanoic acid, methyl ester, 9-Octadecenoic acid methyl ester, methyl stearate, Cyclopropanoic acid and Eicosanoid acid methyl ester constitute about 95%.

Figure (2):-

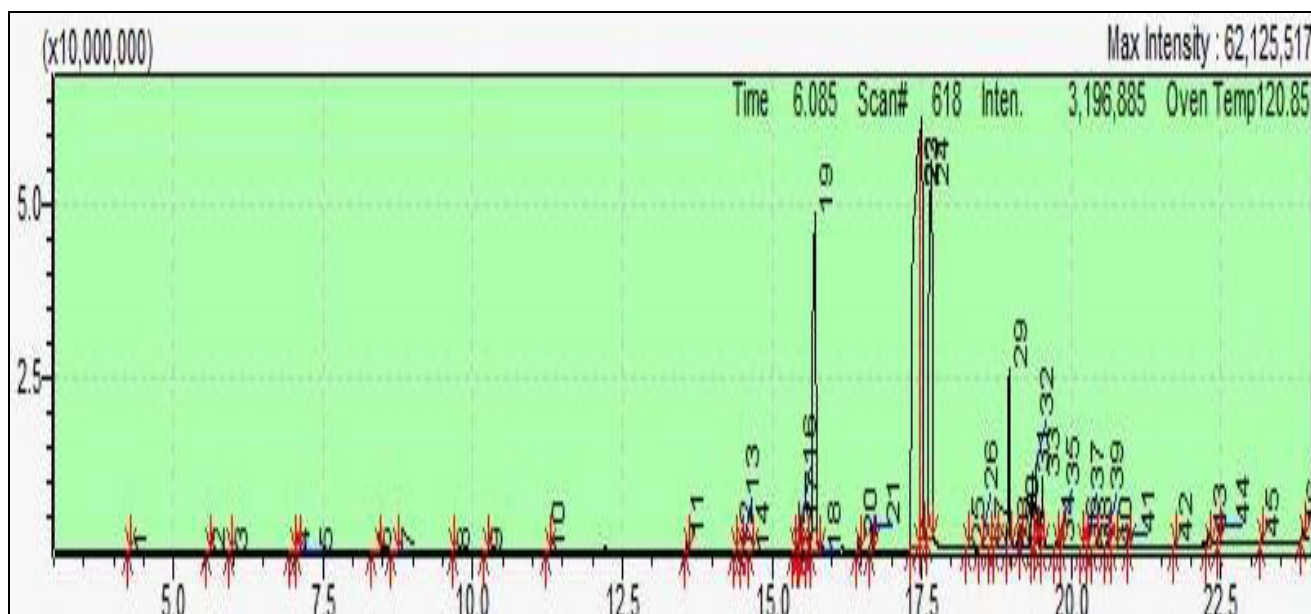


Fig 2

Conclusion

From the work conducted, the produced biodiesel fuel was within the recommended standards, and therefore, it can be used for any required purpose.

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