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Physicochemical properties of Biodiesel from *Ricinus communis* oil

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Abstract
Ricinus communis crude oil was converted to Biodiesel using a two-step trans esterification reaction. The produced biodiesel was identified using GC-MS techniques, the results show that the total ester content in the biodiesel was 98.86% of the total components of produced Ricinus communis biodiesel. The physical and chemical properties of Ricinus communis biodiesel were compared with the ASTM D 7467 requirements. B20 blend of biodiesel with Diesel were all within the level of ASTM D 7467. Biodiesel-Diesel-Ethanol blends were investigated and compared also with standard method ASTM D 7467 and all the results were found with the standard requirements. The flashpoint of pure biodiesel was 143 C, reduced to 77.5 C in the B20 blend and reduced to 16 C in D60 B20 E20.

Keywords: biodiesel, Ricinus, converted, crude, Biodiesel

1. Introduction

The scarcity of known petroleum reserves will make renewable energy resources more attractive. The most feasible way to meet this growing demand is by utilizing alternative fuels. Biodiesel is defined as the monoalkyl esters of vegetable oils or animal fats [1]. Biodiesels are the best candidate for diesel fuels in diesel engines. Biodiesel burns similar to petroleum diesel but has low pollutant emission [2].

One of the advantages of using biodiesel and its blends with diesel oil is the lower levels of emissions of particulate matter, sulfur dioxide, carbon monoxide, among others, making it less harmful to the environment and humans, some studies on these fuels life cycle have shown that biodiesels release-less CO_2 into the environment than diesel, a petroleum-derived compound. Therefore, biofuels contribute to the reduction of greenhouse gases. Also, the combustion emissions of biodiesel have lower levels of particulate matter, polyaromatic hydrocarbons, sulfur dioxide, carbon monoxide, aldehydes and ketones than fossil fuels, thus making it less harmful to humans [3]. It has similar physicochemical properties of conventional fossil fuel and can consequently, entirely or partially substitute fossil diesel fuel in compression ignition engines [4]. Biodiesel satisfy the ASTM and EN limits, it cannot be used alone in diesel engine due to its high kinematic viscosity and density and also lower oxidation stability and heating value [5]. To improve those properties, it is blended with diesel. Physicochemical properties such as kinematic viscosity, calorific value, density, flash point, cloud point, pour point, CFPP, effected with the varying blended percentage, Biodiesel, B20, B20E20. Viscosity is an important property of biodiesel since it affects the operation of fuel injection equipment (at low temperatures affects the fluidity of biodiesel) [6]. Higher viscosity leads to a higher drag in the injection pump and thus causes higher pressures and injection volumes, especially at low engine operating temperatures [7]. Density and therefore specific gravity is another important parameter of biodiesel quality. Fuel injection equipment operates on a volume metering system, hence a higher density for biodiesel results in the delivery of a slightly greater mass of fuel [6]. The cloud point is the lowest temperature at which the smallest observable cluster of wax crystal first appears [8]. The Pourpoint is the lowest temperature at which the wax becomes semisolid and loses its flow characteristics. In general, biodiesel has higher CP and PP than diesel. The CP and PP of biodiesel feedstock largely depend on fatty acid composition [9]. Flashpoint is a measure of the flammability of fuels and thus, an important parameter for assessing hazards during fuel transport and storage [10].

2. Material and methods

2.1 Biodiesel production

Ricinus communis oil was acid-treated to reduce high fatty acid composition using 2% Sulfuric acid in 0.60 w/w methanol, the mixture was added to the heated oil at (60 **C**), and kept on steering at 2500 rpm for 2 hours, then the content was kept in separation funnel for 24 hours. The upper layer of treated oil with low fatty acid was transferred to 500 ml beaker and heated up to 60 **C** at a steering speed of 2500 rpm, methanolic NaOH was added in a ratio of 6:1 methanol to oil, and the mixture was left steering for 2 hours. The mixture was removed from the hot plate and transferred to a separation funnel [11].

2.2 Identification of *Ricinus communis* Biodiesel and Ester content using Gas

Chromatography - mass spectrometry (GC-MS) Shimadzu GC-MS model (QP2010- Ultra) equipped with a capillary column (Rtx-5ms- 30m×0.25 mm×0.25µm) was used to verify the conversion of the lipids to methyl ester qualitatively and quantitatively. The Sample was injected using split mode, helium was used as carrier gas with flow rate 1.61 ml/min, the temperature program was started from 60 C with rate 10°C/min to 300 C. The sample was analyzed using the scan mode in the range of m/z 40-550, the total run time was 24 minutes. Sample components were identified by comparing their retention times and mass fragments with those available in the National Institute of Standards and Technology (NIST) library.

2.3 Biodiesel blending

2.3.1 Diesel-Biodiesel blend (B20)

B20 blend with contains 20% biodiesel and 80% fossil diesel.

2.3.2 Diesel-Biodiesel-Ethanol blends (B20, E20

Diesel-Biodiesel-Ethanol blends was prepared by the same procedure of biodiesel-diesel blend. Blend were produced with (%, v/v) 20 ml of biodiesel and 20 ml of ethanol the volumes were completed with diesel and kept in tightly closed bottles to minimize ethanol evaporation.

2.4 Physical and chemical properties of *Ricinus communis* Biodiesel and its blends

Physical and chemical properties of Fossil diesel and B 100 (Pure Biodiesel) were determined according to ASTM D 6751. B20 and Diesel-Biodiesel-Ethanol blends were characterized according to ASTM D7467 "Standard Specification for Diesel Fuel Oil, Biodiesel Blend (B6 to B20)" following additional tests were carried out also for the set of the samples; water content, density at 15 **C**, Color, pour point (PP) and cold filter plugging point (CFPP). Table 1 shows the methods and instruments used for physical and chemical properties [11, 12, 13].

Table 1: Methods and Instruments used for physical and chemical properties

Test	Method	Instrument	Instrument Model
CFPP, °C	ASTM d 6371	Normalab analis	Cloud and Pour test cabinet
Total Acid Number, mgKOH/g	ASTM d 974	Si analytic	TitroLine 7000
Calorific Value, MJ/Kg		Parr	6400 Isoperibol Calorimeter
Flash Point, °C	ASTM d93	Stanhope-seta	1366-3 P
Copper Strip Corrosion (3 Hours @ 100ºC), Rating	ASTM d130	Stanhope-seta	15157-0 T
Phosphorus content, mg/kg	ASTM d4951	Agilent icp	5110 ICP-OES
Sulfur Content, mg/kg	ASTM d 4294	Oxford	TWIN-X

3. Results and discussion

3.1 Identification of *Ricinus communis* Biodiesel using Gas Chromatography - Mass Spectrometry (GC-MS)

The ester composition in biodiesel is an important factor as it is affecting many properties of biodiesel such as; Cetane number, cold properties and stability. Table 2 shows the fatty acid methyl esters which were found in the *Ricinus communis* biodiesel, and their yield. The total ester content in the biodiesel was 98.86% of the total components of produced *Ricinus communis* biodiesel which indicate successful biodiesel production and prove that the triglycerides were converted to methyl ester. The methyl esters with a higher percentage were in the order 9-Octadeeenoic acid, 12- hydroxyl, methyl ester, [R-(Z)], 9,12-Octadeeenoic acid (Z, Z)-, methyl ester and 1-Glyceryl ricinoleate ester with percentage of 63.94 %, 8.69%, and 7.64% respectively.

Table 2: Ester content of *Ricinus communis* Biodiesel

No.	GC % Yield	Common Name	Formula
1	63.92	9-Octadecenoic acid, 12-hydroxy-, methyl ester, [R-(Z)]-	$C_{19}H_{36}O_3$
2	8.69	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	$C_{18}H_{32}O_2$
3	7.64	1-Glyceryl ricinoleate	$C_{21}H_{32}O_5$
4	4.04	Methyl stearate	$C_{19}H_{38}O_2$
5	3.33	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$
6	2.45	9-Octadecenoic acid (Z)-, methyl ester	$C_{19}H_{36}O_2$
7	2.25	.gamma.-Sitosterol	$C_{29}H_{52}O_2$
8	2.09	13-Docosenoic acid, methyl ester, (Z)-	$C_{23}H_{44}O_2$
9	2.00	9-Octadecenoic acid, methyl ester, (E)-	$C_{19}H_{36}O_2$
10	1.57	Octadecanoic acid, 9,10-dihydroxy-, methyl ester	$C_{19}H_{38}O_4$
11	0.86	Cholest-22-ene-21-ol, 3,5-dehydro-6-methoxy-, pivalate	$C_{33}H_{54}O_3$
Total	98.86		

3.2 Physical and chemical properties of biodiesel blends

Table 3 shows the physical and chemical properties of Fossil diesel in comparison with the limits of standard method ASTM D 7467. The results show that all parameters of Fossil diesel within the limit of ASTM D 7467.

Table 3: Physical and Chemical properties of Diesel

Tests	ASTM D 7467	Fossil Diesel
Kinematic Viscosity @ 40ºC, cSt	1.9 – 4.1	4.106
Cloud Point, °C	REPORT	7.6
Color, ASTM	-	0.6
Density @15ºC, g/ml	-	0.838
Total Acid Number, mgKOH/g	Max. 0.3	0.26
Flash Point, °C	Min. 52	77.5
Water Content, wt%	Max. 0.05	<0.03

Copper Strip Corrosion (3 Hours @ 50ºC), Rating	Max. 3	1 a
Sulfated Ash, Wt%	Max. 0.02	0.002
Sulfur Content, % mass	Max. 0.05	0.0106

Table 4 shows the physical and chemical properties of Biodiesel and biodiesel blends in comparison with ASTM D 7467. The results show that the Kinematic viscosity of Biodiesel, B20 and B20E20 were obtained at 17.37, 4.02 and 3.92 respectively which the Ricinus communis methyl ester had met the kinematic Viscosity is out of the standard level. The density of Biodiesel, B20 and B20E20 were obtained at 0.9314, 0.8572 and 0.85502 g/cm^3 respectively. The total acid number of Biodiesel, B20 and B20E20 was 0.6, 0.21 and 0.23 mgKOH/g respectively also here the Ricinus communis methyl ester is out of limits of the standard method level but it is within the limits in the blends. The cloud point of Biodiesel, B20 and B20E20 were obtained at -13.6, 5.7 and 19 C respectively. Water content is an important parameter and it is within the limit in Biodiesel, B20 and B20E20 as shown in table 4. Color is an important feature of a quality indicator. In the ASTM D 7467, the Sulfur Content must be less than 0.05 and the result of Biodiesel, B20 and B20E20 was all within the standard limit. Flashpoint was obtained 143 C for Biodiesel, B20 was obtained to be 77.5 C and the Ethanol blend is 16 C.

Table 4: Physical and Chemical properties of *Ricinus communis* biodiesel and blends

Tests	ASTM D 7467	Biodiesel	D80%B20%	D60%B20%E20%
Kinematic Viscosity @ 40ºC, cSt	1.9 – 4.1	17.37	4.02	3.92
Density @15ºC, g/ml	-	0.9314	0.8572	0.8552
Total Acid Number, mgKOH/g	Max. 0.3	0.61	0.21	0.23
Cloud Point, °C	-	-13.6	5.7	19
Color, ASTM	-	0.5	0.5	0.5
Water Content, wt%	Max. 0.05	< 0.05	< 0.05	< 0.05
Copper Strip Corrosion (3 Hours @ 100ºC), Rating	Max. 3	1 a	1 a	1a
Sulfur Content, % mass	Max. 0.05	0.026	0.0102	0.0179
Flash Point, °C	Min. 52	143	77.5	16

4. Conclusion

From the result of this study of fossil diesel, Biodiesel and biodiesel blends in comparison with the limits of standard method ASTM D 7467. The results show that *Ricinus communis* methyl ester had met the requirements of the standard method limits except the Kinematic viscosity and the total acid number. The fossil diesel all parameters were within the limit of ASTM D 7467.

B20 blend of Biodiesel-Diesel and B20E20 Biodiesel-Diesel-Ethanol all parameters were within the limit of ASTM D 7467. Including color which is an important feature since the color is easily noted by the user of the product and mainly used to manufacture quality. The flashpoint is very low in Ethanol blend it is less than the room temperature due to the volatility of ethanol will assist the combustion of the blend in the CI engine but it will be dangerous for storing and transporting. Successful biodiesel production and prove that the triglycerides were converted to methyl ester.

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