

Extraction of Jatropha Bio-base Oil for Two-Stroke Engines

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Abstract:- Bio-lubricant based oil was developed from Jatropha oil; it is considered the best alternative to traditional lubricants based on mineral oils and synthesis esters. This study intended ameliorating the environmental control measures of air pollutants by preparing base oil from local ingredients for two-stroke engines lubrication in Sudan. American Society for Testing and Materials has applied for analyzing the physiochemical characteristics of oil based on Jatropha. Based on the experiment conducted, we found that oil based on Jatropha as bio-lubricant has high flash point (266°C), viscosity index (354), American Petroleum Institute of 17, an acid number of 0.457 mg KOH/mg, carbon residue (0.001 w/w%), and low pour point of -13 °C. By comparing the obtained results with those of commercially used oils for two-stroke engines, the proposed alternative is far better in its quality and it meets the minimum requirements of international and local standards. Finally, it was recommended to use oil based on Jatropha oil for two-stroke engines to improve the environmental conditions by mitigating emissions from point sources. In addition, more research is needed to study future production and its quantities for the manufacture of bio-lubricants from local ingredients. One day, lubricants based on mineral oils will be replaced with biologically based products in environmentally sensitive applications.

Keywords: Jatropha oil, Bio-lubricant, Two-stroke engines, Trans-esterification, Aryl-alkylation

1 INTRODUCTION

Two-stroke engines are considered total-loss type lubricating systems therefore the oil is mixed with fuel [1]. Emissions from 2-stroke engines can be reduced by rigorous inspection and maintenance programs and used of lubricating oil of correct quality and quantity [2, 3, 4]. Bio-lubricant oils are perceived as alternatives to mineral oils because they possess certain natural technical properties and they are biodegradable [5, 6].

Jatropha is small evergreen tree and grows in the wildness [7]. The oil is not fit for human consumption or animals therefore it could be used to produce bio-fuel that burns without hazardous emissions to the environment [8].

2 MATERIALS AND METHODS

2.1 Materials

Jatropha seeds were acquired from National Center for Agricultural and Forests Researches. Jatropha oil was extracted mechanically using cold pressing method to avoid water added during extraction process. It was analyzed for free fatty composition using gas chromatography analyzer in the central laboratory at Khartoum University (Table 2-1). Bio-lubricant base oil is extracted from Jatropha oil using acetic anhydride, 2-Ethyl-1-hexanol, sodium, Toluene, aluminum chloride and hydrochloric acid.

Table 2-1: Fatty acid composition of Jatropha oil

Fatty acid		Composition %
Unsaturated	Palmitoleic (C16:1)	0.8
	cis-10-Heptadecanoic (C17:1)	0.2
	Oleic (C18:1)	36.5
	Linoleic (C18:2)	41.3
	cis-11-Eicosenoic (C20:1)	0.2
	cis-13,16-Docosadienoic (C22:2)	0.8
Saturated	Palmitic (C16:0)	10.0
	Heptadecanoic (C17:0)	0.1
	Stearic (C18:0)	8.8
	Tricosanoic (C23:0)	1.3

2.2 Preparation of base oil

2.2.1 Acetylation

Acetylation was needed to provide the hydrocarbon solubility of Jatropha oil [9]. 250g of Jatropha oil was reacted with 80g of acetic anhydride under constant stirring. Acetic anhydride was added dropwise during a period of 45 min at 40-50°C. Then, the temperature was slowly raised to 120°C during the next 160 min while the contents were stirred constantly. The mixture was washed with distilled water from excess acetic anhydride until pH 6-7 (Figure 2-1).

230g of acetylated Jatropa oil was mixed with 57.5g of toluene (25% of acetylated J. oil) and heated to 70°C, then the mixture was heated under vacuum (-0.6 bar, 66°C) in vacuum pan connected with distillation column to separate the water and toluene.

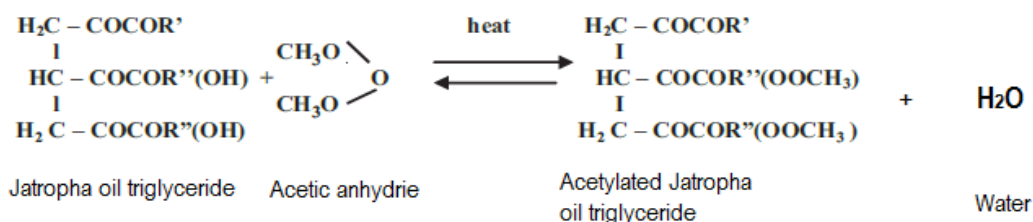


Figure 2-1: Acetylation of Jatropa oil

2.2.2 Trans-esterification

200g of 2-ethyl-1-hexanol was heated with 1g of sodium in magnetic heater with constant stirring. The temperature of mixture was slowly raised until all sodium dissolved to give clear solution at 90°C. This sodium ethyl hexanoate was added to 218g of acetylated Jatropa oil in magnetic heater at 80-110°C with continuous stirring. Then the temperature of reaction was raised to 163-172°C for 22 hrs. (Figure 2-2) [10, 6].

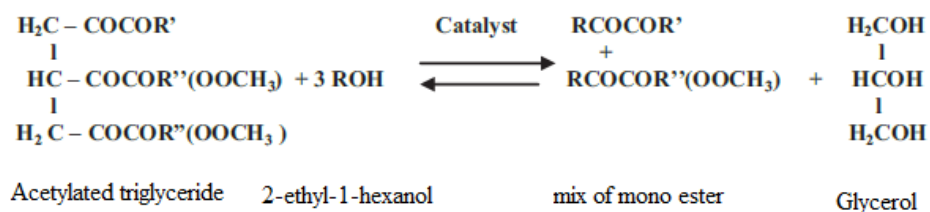


Figure 2-2: Trans-esterification of Jatropa oil

Steam with 1.2 bar and 100°C was passed through the mixture until sodium ethyl hexanoate hydrolyzed. After 20hrs at room temperature, two layers were totally separated that were glycerol and ester. The ester was dissolved in toluene to remove the traces of water in vacuum pan at 66°C and -0.6 bar.

2.2.3 Aryl-alkylation

174g of ester was dissolved in 430g of toluene and cooled to -11°C in a freezer. 10g of AlCl₃ was slowly added over a period of 55 min. During the addition, the temperature was allowed to rise to 3°C and the reaction mixture was maintained at 0°C for 12 and half hrs. with constant stirring. After that, the contents were poured into water with 10% hydrochloric acid and kept for 9 hrs. The upper layer was washed rapidly to remove the acidity. Then the upper layer was heated under vacuum (66°C and -0.6 bar) in vacuum pan to remove the washed water and the excess of toluene. The product was tolyl ethyl hexyl ester of Jatropa fatty acid (herein referred to JT) (Figure 2-3).

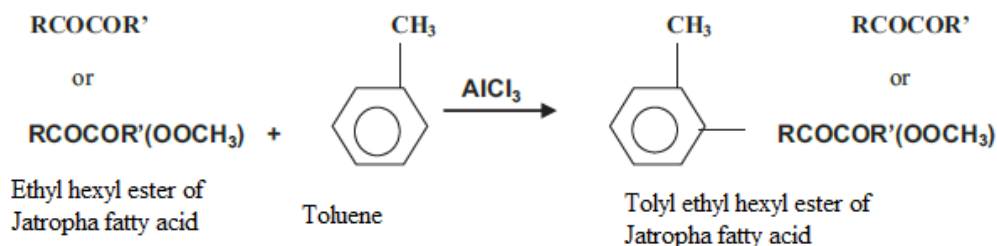


Figure 2-3: Alkylation of Ethyl hexyl ester of Jatropa oil fatty acid

2.3 Characterization of the base oil: laboratory analysis

For characterization of JT oil, standard methods were used that were given in Table 2-2 and the experimental values are reported in

Table 3-2. All tests were conducted in the professional laboratories of faculty of Engineering, Khartoum University.

Table 2-2: Standard methods used for JT oil analysis

Analysis	Methods
Kinematic viscosity	ASTM D445
Viscosity index	ASTM D2270
Density	ASTM D4052
API gravity	ASTM for density, relative density or API gravity of crude oil.
Pour point	ASTM D97
Flash point by Cleveland open cup	ASTM D92
Carbon residue	ASTM D4530
Water content	ASTM D6304
Copper corrosion	ASTM D130
Acid number and strong acid	ASTM D644

3 RESULTS AND DISCUSSION

3.1 Materials balance

In this study, lubricant based oil was prepared from Jatropha oil through three phases had been discussed in 2.2). The amount of chemicals that are required for those reactions had been calculated based on the stoichiometric equations Figure 2-1, Figure 2-2 and Figure 2-3 and was shown in Table 3-1.

Table 3-1: The amount of chemicals was reacted to prepare JT oil

The material	Mole required for reaction	Stoichiometric mass (g)	Amount reacted (g)
Jatropha oil	1	827.59	250
Acetic anhydride	1	102.09	80
Acetylated J. triglyceride	1	911.68	218.19
2-Ethyl-1-hexanol	3	390.69	200
Ethyl hexyl ester of J. fatty acid	1	1210.28	174
Toluene	1	92.14	430
Catalyst	Sodium	-	1
	Aluminum chloride	-	10

3.2 Physio-chemical characteristics of JT oil

Jatropha oil is high rich in oleic oil (C18:1) and Linoleic (C18:2), having around 77% of C18:1 and C18:2 (Table 2-1). Oleic is considered more stable than other un-saturated fatty acids [11]. However, hydroxyl group makes it insoluble in gasoline. Pour point and viscosity index below 95 also was not desirable therefore; raw Jatropha oil could not be used for 2T oil as such. Flash point was suitable for its application as lubricants. Considering all properties, it was needed to be converted to aryl-alkylated ethyl-hexyl ester [12]. After the conversion, its viscosity index of 354 (

Table 3-2) was met the minimum requirement of 90 and kinematic viscosities at 100°C was 26.12 cSt. JT oil had a flash point of above 250°C as measured, which it is considered safe product for storage and transportation. Pour point of it was -13°C as determined that means there is no trouble to use in Sudan during summer and winter without the addition of polymer or pour point depressant as due to metrological conditions of Sudan.

For Copper strip corrosion, JT oil was classified as 1a after the copper strip was heated at 120°C for 3 hrs. according to ASTM D130, which is met the minimum requirement of standard. The TAN- should not be more than 0.5 mg KOH/g as is prescribed by standard specifications for petroleum turbine lubricating oil's stability, which was possible due to chemical modification of Jatropha oil (

Table 3-2). Fatty acid monoesters are more stable than vegetable oils.

The developed base-stock (JT oil) of two-stroke engines from Jatropha oil was in conformity with specifications, which was a significant achievement.

Table 3-2: Physio-chemical characteristics of JT oil

Characteristic	Method of test	Actual specification	Targeted specs.
Density @ 30°C (g/ml)	ASTM D4052	0.943	To be reported
Density @ 15°C (g/ml)	ASTM D4052	0.953	To be reported
API	-	17.0	> 10
Kinematic viscosity @40°C (cSt)	ASTM D445	79.06	45 min
Kinematic viscosity @100°C (cSt)	ASTM D445	26.12	6.5 min
Viscosity index	ASTM D2270	354	90 min
Flash point (°C)	ASTM D92	266	70 min
Pour point (°C)	ASTM D97	-13	-6 max
Carbon residue (w/w %)	ASTM D4530	0.001	0.6 max
Water content (vol. %)	ASTM D6304	0	0.03 max
Copper strip corrosion (3h/120°C)	ASTM D130	1a	1 max
Total acid number (mg KOH/g)	ASTM D664	0.457	0.5 max
Strong acid number	ASTM D664	Nil	Nil

4 CONCLUSION

The bush "Jatropha" represents the most important trees, on which interest began to a large extent, within the framework of a new concept called the project of cultivating energy that can be an alternative to mineral oils, petroleum based oils and petroleum-derived fuel.

In response to reducing the amount of air pollutants, automobile fuels and lubricants offer the most plausible solution to obtaining renewable and eco-friendly lubricants. Renewable, biodegradable and environmentally friendly base oil was prepared from local an ingredient that is Jatropha oil. Jatropha based oil has high flash point (266°C), viscosity index (354), carbon residue (0.001wt%), an acid value of 0.457 mg KOH/g, density @15°C of 0.953 g/ml and low pour point of -13°C. Jatropha based oil is more viscous than the standard engine super 20w/50 and has lower acid values than the mineral lubricant, which makes it of higher yield or quality.

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