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Production of Bio Lubricant from Jojoba Oil

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***Abstract* – Lubricant is a substance used to reduce friction between surfaces, reduce the heat generated from moved surface. Regarding to the increasing of the price of base oil extracted from crude oil and to protect the environment from pollution although the depletion of crude oil, we searching for alternative bio source. A bio lubricant is renewable and nontoxic source for base oil, the objective of using Jojoba as base oil to get renewable source and solve environmental issues. Jojoba Oil used in a variety of products including pharmaceuticals, cosmetics, lubricants and bio-fuel. In this study was successfully use base oil come from Jojoba seed. The extracted oil was modified to be bio-lubricant. There is analysis done regarding to the chemical and physical properties such as density, pour point, flash point as well as viscosities at 40 and 100oC and viscosity index for the base oil and bio lubricant, although there is comparison done with the characteristics of a mineral lubricant (Hydraulic oil SAE 10W). The result of the analysis revealed that Jojoba oil has high viscosity index (247.9) and pour point of (9 ºC), also has a flash point of (150 ºC), Viscosity @40 c (22.51 Cst), Viscosity @100 c (6.16 Cst), and density @15c (0.8640). The result from jojoba lubricant has good specification in term of commercial standards for 10 W products with engine additive all result in the range, bio lubricant has high flash point (238 ºC), viscosity index (242.2), lubricity, and low pour point of (5 ºC), also has a flash point of higher than the characteristic of the commercial lubricant, high viscosity index (397), and low pour point of (5 ºC). It was found that the bio-lubricants produced were comparable to the commercial standards for Hydraulic oil SAE 10W lubricant.**

***Keywords* – Bio Lubricant, Jojoba Oil, Renewable, Base Oil, Additive.**

I. INTRODUCTION

1.1 *Background Study*

Bio-lubricants got a number of advantages compared to conventional lubricants [1]. Bio lubricants have higher flash, lower volatility, less vapor emissions, and good viscosity [2]. The increased use of bio-based products will also be expected to reduce petroleum consumption, increase the use of renewable resources, better manage the carbon cycle, and may contribute to reducing adverse environmental and health impacts [2]. Study has equally been carried out to indicate the demerits of bio-lubricants; bio-lubricants have several disadvantages in the use phase of the product life cycle, although additives designed specifically for plant-based lubricants eliminate [2]. If bio lubricant is untreated, it lacks oxidation stability and will have high pour points [3].

Jojoba (Simmondsia chinensis) is mostly evergreen, perennial shrub that produces small seeds, which contains liquid wax very similar to whale sperm in value. The oil is used in the pharmaceutical industry, cosmetics, bio lubricants, and bio-fuel production [4]. There are several benefits in the jojoba plant is drought resistant, appears to tolerate soil salinity and Jojoba needs little water for survival. Also, treated sewage water and saline water could be used to irrigate Jojoba. Jojoba plants originated in the Sonoran Desert of Northern Mexico and the United States. Now, due to its high economic value, it is cultivated as a commercial plant in different parts of the world like Argentina, Australia, India, Egypt, Israel, Mexico, Peru, Kenya, Brazil, South Africa, Costa Rica, Haiti, Paraguay, Chile and Iran [4].

Jojoba is used as a bio diesel fuel as well as biodegradable lubricants. It is a new solution of fuel in coming d-

-ays. Jojoba oil has been mainly focused on the alcoholics of this oil and NOx, CO and CO2 emissions related to the use of different blends of Jojoba oil and conventional fuel in a diesel engine. Jojoba has a promising future because it offers a bunch of opportunities in chemical and environmental sectors, and also in oil extraction and products purification after trans esterification [4].

Various types of lubricants are available all over the world including mineral oils, synthetic oils, re-refined oils, and vegetable oils. Most of the lubricants which are available in the market are based on mineral oil derived from petroleum oil which are not adaptable with the environment because of its toxicity and non-biodegradability [5]. Very less or no work is done on this oil producing seed species. These species are having great potential to be used as are source of bio-lubricant production [6].

Petro based lubricants share many similar physical properties with bio based lubricants, but have a much different environmental impact. Petro based lubricants are more commonly used than bio based lubricants because they are cheap, and can satisfy lubricant demands [7]. Bio-based lubricant is an attractive alternative because of their useful physical properties, they are clean and renewable [8]. Although petroleum based lubricants possess many useful physical properties, but they are nonrenewable and toxic to the environment. If improperly disposed, petro based lubricants may leech into water systems, cause infections and possibly death to organisms. Industrial machines used in offshore drilling or agriculture require machinery to be in close proximity with a water source, and using petro based lubricants can potentially be dangerous to the environment. There are many petro lubricant alternatives available, such as synthetic or animal fat lubricants, but lubricants derived from vegetable oil have received the most attention due to a number of their useful physical properties. Moreover, researchers have reported that bio lubricants provide better lubricity than petroleum-based oils [9].

1.2 *Problem Statement*

At present, the increasing prices of crude oil, the depletion of crude oil reserves in the world, and global concern in protecting the environment from pollution have renewed interest in developing and using environment-friendly lubricants derived from alternative sources. Bio based materials are manufactured using feedstock's originating from plants and/ or animals [10]. They differ from petroleum-based materials in that they have an unlimited and renewable raw material base. An important area of application for bio based products is in lubrication, particularly with plant-based oils or seed oils. Certain physical and chemical properties of seed oils make them attractive as lubricants [11]. Bio lubricants are potential alternative lubricants because of their low toxicity, good lubricant high viscosity index, high ignition temperature, increased equipment service life, high load-carrying abilities, good anti-wear characteristic, excellent coefficient of friction, natural multi- grade properties, low evaporation rates, and low emissions into the atmosphere [10].

The non-biodegradability of mineral lubricants, their non-renewability, contamination of soil, water, and air, poses threatening conditions for danger and damage to human health and well-being, welfare of plants and animals as well as the environment as a whole [12]. Lubricants consumed worldwide are commonly originated from petroleum, coals or natural gases. However, these sources are infinite and keep depleting due to high fuel consumption over the world [1]. This situation has raised interests among ambitious researchers and scientists on finding the renewable green materials for lubricants as replacements to the fossil [13]. Bio-lubricant is derived from natural resources. Compared to the conventional lubricants, bio-lubricant is more preferable due to its rapid biodegradability and low environmental toxicity [1].

1.3 *Objectives & Scope of Study*

1.3.1 *The Objectives of this Study are:*

This study presents the potential of a bio lubricant based on jojoba oil as an alternative lubricant, this will include: the source, properties, as well as advantages and disadvantages of the bio lubricant the potential of jojoba oil-based bio lubricants as alternative lubricants for automobile applications.

This study is aimed at the replacement of petroleum based lubricants, by biodegradable and renewable lubricant which is going to be processed from non-edible plant, so the first beneficial will be farmers who are going to prepare a farm of this plant [14]. Environmentally it has also advantage of decreasing the deposits from automobiles that use petroleum based products, wastes that are going to be released after usage.

This type of project will initiate the country to minimize importing petroleum based lubricants by replacing them with biodegradable and renewable lubricant which has better characteristic than the recent one which will in turn decrease cost of importing, transportation. In this way the country will become energetically self-sufficient, no fear for the depletion of petroleum reservoirs it also brings the county to green economy system [14].

1.3.2 *Scope of Study:*

The scope of this study as follow: -

1. To extract the Oil from jojoba seeds.
2. To measure Viscosity, density and pour point and flash point of jojoba oil.
3. To product bio lubricant using jojoba oil as base oil and add additive.
4. To evaluate viscosity, pour point, flash point, TBN and density of bio lubricant.

II. MATERIAL AND METHOD

2.1 *Material*

2.1.1 *Raw Material Preparation*

For high oil content materials, the following preparation steps were employed to make the material suitable for solvent penetration into the oil cells as well as for best percolation.

1. Grinding the seeds to reduce the size of the different seeds.
2. Heating the broken materials to about 80°C.
3. Conveying the flakes to the extraction system after crisping them firm.

2.1.2 *Oil Extraction*

The seeds oil was extract by using n-hexane (extraction solvent) using a sox let extractor. After many cycles the desired compounds were concentrating in the distillation flask. After extraction the solvent was remove, typically by means of a rotary evaporator, yielding the extracted compound. The non-soluble portion of the extract solid remains in the thimble, and was discard. Meanwhile, the solution was then heated to evaporate the remaining traces of n-hexane using a temperature control water bath and finally, the oil was collect for modification.

2.1.3 *Modification*

The development process of bio-lubricant was carried out by using bioprocess method at the Libya oil company laboratory. A good combination between base oil and additives was the key to improve this process [15]. There were many kinds of additives, such as antioxidants, detergents, dispersants, extreme pressure (EP) and anti-wear (AW). The latter two were important at severe frictional conditions, such as high temperature, load and sliding speed. Sulfur, chlorine and phosphorus are traditional Expand AW additives; they cover chemical metal surfaces by forming easily sheared layers of sulfides, chlorines or phosphides, preventing severe wear and seizure [16]. The reaction took place in a beaker, maintain at desired stirring speed using a manual stirrer. Chemical modifications were made to produce bio lubricant of the oils were carried out thus the extracted oil was modify by additives.

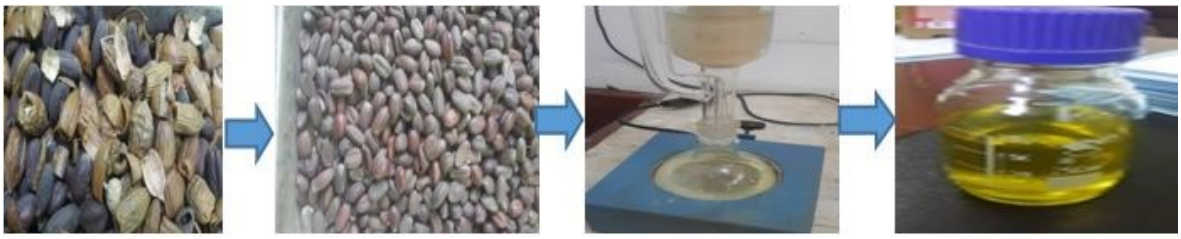

Fig. 1. Process of jojoba oil extraction.

2.2. *Characterization*

The properties of the bio-lubricant were measure. All the testing was based on ASTM standards,

2.2.1. *Viscosity and Viscosity index*

The viscosity was tested using a stabinger Viscometer at 40 and 100oC and VI respectively in the laboratory. Viscosity index showed the characteristic of the lubricants viscosities when temperature changes were applied. Using ASTM D 7042.

Fig. 2. Stabinger Viscomete

2.2.2. *Pour Point*

Pour point is the lowest temperature at which oil flows as its container is tilted for a prescribed period. It is crucial for oils that must flow at low temperatures [2]. The oil Samples were poured into a medium sized containers and placed in a test tube holder. The set up was placed in a refrigerator and allowed to solidify. After it solidifies, the test tubes were removed and a thermometer capable of measuring temperatures from 0OC – 100 **^{o}C** was used to read the temperature at which the solidified samples began to melt and flow. This temperature was noted and recorded as the pour point of the oil samples. Using ASTM D 97.

Fig. 3. Pour point refrigerator

2.2.3. *Density*

The density is test using a density meter at 15 **ºC**. Using ASTM 4052.

Fig. 4. Digital density meter

2.2.4. *Flash point*

The flash point temperature is one measure of the tendency of the test specimen to form a flammable mixture with air under controlled conditions. It is one of the properties that must be considered in assessing the overall flammability hazard of a material. It measures and describes the properties of materials, products in response to heat and an ignition source under controlled conditions. The result of the test may be used for risk assessment which takes into account all factors that are pertinent to an assessment of the fire hazards of a particular end use. Using ASTM D 93.

Fig. 5. Flash point

2.2.5 *Total Base Number (TBN)*

TBN is a measure of the alkalinity of the oil. It is a measure of the effective additive content and thus reflects the oil's detergent, dispersant and anti-rust properties. Using ASTM D 4739.

Fig. 6. Titro785

2.3 *Process Flow Chart*

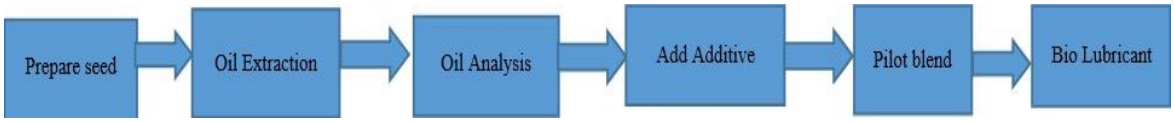

Fig. 7. Process flow diagram of bio lubricant production

III. Results and Discussion

The result of the main specification for base oil come from Jojoba oil and bio lubricant was shown in table 1 below:

Table 1. Characteristics of Jojoba Oil, jojoba Oil Bio-Lubricant and Engine Oil SAE 10w range

No	Test	Test Method	Unit	Jojoba Oil	Jojoba bio lubricant	Rang for Engine Oil SAE 10w
1	VISCOSITY @ 40oC	ASTM D 7042	Cst	22.507	27.384	
2	VISCOSITY @ 100oC	ASTM D 7042	Cst	6.1637	7.1167	4.1 to 7.2
3	VISCOSITY INDEX	ASTM D 7042	-	247.9	242.2	Min 90
4	DENSITY @ 15oC	ASTM D4052	g/ml	0.8640	0.8723	
5	POUR POINT	ASTM- D 5950	Deg C	+9	+5	Max -6
6	FLASH POINT	ASTM D 92	Deg C	150	238	Min 200
7	TBN	ASTM D 4739	mg KOH/g	-	4.53	4.07 to 4.78

The product of the jojoba oil and jojoba bio lubricant was subjected to certain property tests to be its applicable as base oil and lubricating oil. The major lubricating properties of the bio lubricant produced are presented in result Table no 1, alongside that the bio-lubricants produced are comparable to the commercial standards for lubricant (Engine Oil SAE 10w). Compared with mineral oils, jojoba oil-based bio lubricants generally exhibit high lubricity, high viscosity index (VI), high flash point, and low evaporative losses [17]. Engine Oil SAE 10w can be used in a variety of hydraulic system as recommended by OEM. In terms of viscosity, almost jojoba bio lubricants met the SAE viscosity grade requirement, Viscosity is the most important property of oil, indicates resistance to flow, and is directly related to temperature, pressure, and film formation. High viscosity indicates high resistance to flow and low viscosity implies low resistance to flow. Viscosity was measured at 40 and 100°C as a function of shear rate, jojoba was discovered to have a viscosity of 22.5 Cst at 40 ^{0}C and 6.2 Cst at 100 ^{0}C, while jojoba bio lubricant was having a viscosity of 27.4 Cst at 40 0C and 7.1 Cst at 100 0C. Viscosities of the

bio-lubricants were found to be slightly higher than those of the mineral lubricant but could meet the requirement of the SAE 10W since its viscosities are within the standard SAE 10W range [16]. The viscosity index obtained for Jojoba bio lubricant is 242.2 and it was comparable to the rang of lubricant it was very good result where the min VI required is minimum 90°C. The high viscosity index of the bio lubricant is an indication that changes in viscosities at higher temperatures are going to be minimal. Viscosity index was also a very important lubricity property and the higher its value, the more preferable is the lubricant. Bio-based fluids must have high and low temperature stability as well as excellent lubricating properties [11].

Pour point is one of the most critical properties which determine the performance of lubricants. The pour point of the jojoba bio lubricant was significantly improved when compared to that of jojoab oil. Improved from originally +9 to +5 °C. This value is also comparable to the pour point value it is out of range but can be consider it is good because in Sudan the temperature will not be less tat 20 oC

Regarding to the density, the higher the density of a lubricant, the thicker it becomes; which increases the amount of time it takes for particles to settle out of suspension [1]. The density of the lubricant was also observed to increase when compared with the crude oil sample from 0.8640 become 0.8723. This may be attributed to the series of modifications it passed through the processes, thereby making the lubricant to be higher than the crude oil, hence improving its lubricity.

Flash point is the lowest temperature at which a lubricant must be heated before it vaporizes. When mixed with air, a lubricant will ignite but will not burn, higher flashpoints higher safety on shop floor [10]. The result of the analysis of Jojoba oil had low flash point (150°C) but it showed high improve when compared to bio lubricant (238°C) and it was higher than the rang (Min 200 °C). For the total base number, it showed good result (4.53 mg KOH/g) and this actually depend on the additives had been add.

IV. Conclusion

Renewable, biodegradable and environmentally friendly bio-lubricant had been produced from nonedible jojoba oil. Therefore, Jojoba has a promising future because it offered a bunch of opportunities in chemical and environmental sectors. These properties when compared with standards as specified by the international standards conform to those of Engine oil SAE 10W. Hence, the synthesized bio lubricant can favorably serve as substitute for petroleum based lubricants for high performance hydraulic oil applications. Formulation of bio lubricant was done by blending it with some engine additives.

V. Recommendations

The following recommendations have been suggested to enable better understanding and improve the results obtained from such research:

(i) Recommend to produce especial additives for bio lubricant in order to improve the bio lubricant properties.

(ii) I prefer to make especial plate for bio lubricant for bio base oil especially the jojoba oil because has a lot of benefits in many sector.

(iii) I recommend to extremely using of jojoba oil especially in Sudan in Port Sudan because there is good environment to be plant in arkawit.

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