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COMPARATIVE STUDIES BETWEEN BIO LUBRICANTS FROM JATROPHA OIL, NEEM OIL AND MINERAL LUBRICANT (ENGEN SUPER 20W/50)

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ABSTRACT

Neem oil and extracted Jatropha oil were modified to produce bio-lubricant. The bio-lubricant were analyzed for their chemical and physical properties such as density, acid value, sulphated ash content, refractive index, pour point, flash point as well as viscosities at 40 and 100^oC and viscosity index for comparison with the characteristics of a mineral lubricant (engen super 20w/50). The result of the analysis reveals that Jatropha curcas oil bio-lubricant has high flash point (274^oC), viscosity index (539), lubricity, and an acid value of 3.9, sulphated ash content was 0.038 wt%, and low pour point of 0.23 ^0C, neem oil bio-lubricant also has a flash point of (262^oC) higher than the characteristic of the commercial lubricant, an acid value of 1.9, high viscosity index (397), sulphated ash content of 0.018 wt% and low pour point of 1.3 ^0C. It was found that the bio-lubricants produced are comparable to the commercial standards for engen super 20w/50 lubricant.

1. INTRODUCTION

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[1]. Lubricants consumed worldwide are commonly originated from petroleum, coals or natural [2&3] gases. However, these sources are infinite and keep depleting due to high fuel consumption over the world [4]. This situation has raised interests among ambitious researchers and scientists on finding the renewable green materials for lubricants as replacements to the fossil [5]. 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. There are enormous potential of oilseeds of tree origin like Jojoba (Simmondsiachinesis), Karanja (Pongamiapinnata), Mahua (Madhucaindica), Neem (Azadirachtaindica), Simarouba (Simaroubaglauca), Wild apricot (Prunusarmeniaca), Rubber Seed (HeviaBrasiliensis, Kusum (Schleicheratrijuga Wild), Sea mango tree (Cerberamanghas), Linseed (Linumusitatissimum, Linaceae), Rice Bran (Oryza sativa) etc. [6]. Very less or no work is done on this oil producing seed species. These species are having great potential to be used as a resource of bio-lubricant production [7].

A number of advantages have been exhibited by bio-lubricants which give them an edge over the conventional lubricants. These advantages have been highlighted by a number of researchers [8, 9]. Bio-lubricants possess lower volatility, higher flash/ fire points, less vapor emissions and oil mist, and constant viscosity that make them offer better safety. 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 [10]. Study has equally been carried out to indicate the demerits of bio-lubricants [11]; bio-lubricants have several disadvantages in the use phase of the product life cycle, although additives designed specifically for plant-based lubricants eliminate

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stability issues related to extreme high and low temperatures. If bio lubricant is untreated, it lacks oxidation stability and will have high pour points [12, 13]. However, the two main factors are the costs of feedstock and the cost of processing into bio lubricant [14].

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.[15] Bio-based lubricant is an attractive alternative because of their useful physical properties, they are clean and renewable [16]. Although petroleum based lubricants possess many useful physical properties, but they are nonrenewable and toxic to the environment [15]. 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. These properties make bio based lubricants an attractive alternative to petro based lubricants [17].

2. MATERIALS AND METHOD

This project is based on comparative study between bio lubricant from neem and jatropha seeds oil and mineral lubricant (ENGEN SUPER 20W/50). The integral steps required are the extraction of oil (crude) from neem and jatropha seeds and chemical modification of properties, characterization of bio lubricants, as well as comparison with mineral lubricant (ENGEN SUPER 20W/50).

2.1. Materials

The materials and reagents used in carrying out the research are as follows: Jatropha seeds, neem seed oil, ethanol, sodium hydroxide, sulphuric acid, diethyl, phenolphthalein indicator, n-hexane (extraction solvent), glycerin, and charcoal. The instruments and equipment to be used in carrying out the process are: deep freezer, analytical balance capable of determining weights to three decimal places, soxhlet extractor, conical flasks, graduated cylinders, 100 and 500 ml beakers, round bottom flasks, stirrer, refractometer, viscometer, retort stand and clamps, thermometer, furnace, crucible, temperature controlled water bath, pipettes, burette, and test tubes.

2.2. Methodology

2.2.1. Sourcing raw materials

In sourcing of the raw oil seeds (jatropha) and neem seed oil, these supplies were sourced in Kaduna metropolis. Jatropha seeds were sourced in Faringida, a community situated in Kaduna north local government area of Kaduna state. Neem seed oil was purchased from Kaduna central market along Ahmadu Bello way, Kaduna. Standard mineral lubricant (ENGEN SUPER 20W/50) was also purchased from a lube store in Faringida, Kaduna. Prior to use, the jatropha seeds were cleaned to remove dirt and other impurities, and subsequently sun dried until it reaches constant moisture content.

2.2.2 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.

(i) Grinding the seeds (jatropha) to reduce the size of the different seeds to about 3 mm.

(ii) Heating the broken materials to about 80°C with open steam in and humidifying the material to raise the moisture content to about 11 to 12%.

(iii) Conveying the flakes to the extraction system after crisping them firm.

2.2.3 Oil extraction

The seeds oil were extracted using n-hexane (extraction solvent) using a soxhlet extractor. After many cycles the desired compound was concentrated in the distillation flask. After extraction the solvent was removed, typically by means of a rotary evaporator, yielding the extracted compound. The non-soluble portion of the extracted solid remains in the thimble, and was discarded. As described by [18]. Meanwhile, the solution was then heated to evaporate the remaining traces of n-hexane using a temperature controlled water bath and finally, the oil was collected for modification.

2.2.4. Modification

The development process of bio-lubricant was carried out using bioprocess method at the Chemical Engineering laboratory, University of Maiduguri. The reaction took place in a beaker, maintained at desired stirring speed using a manual stirrer. Chemical modifications to produce bio lubricant of the oils were carried out thus:

The extracted *Jatropha curcas* oil and the purchased neem seed oil were modified by the introduction of additives as describe by [19]

2.3. Characterization

The properties of the bio-lubricant were measured. All the testing was based on ASTM standards NTUT, (2008).

2.3.1. Viscosity

The viscosity was tested using a Cannon Viscometer at 40 and 100^{o}C respectively in the drug laboratory, NAFDAC Maiduguri, Borno state. The viscosity of the oil samples were determined at temperatures of 40 and 100°C, in the following way; first, spindle 63 was selected; the samples were transferred into a 250 ml beaker each. The temperatures of the oil samples were raised to the desired value using a heating mantle with constant stirring. The spindle was attached to the upper coupling by holding the coupling between the thumb and forefinger while cautiously rotating the spindle counterclockwise. The spindle was immersed into the samples up to the middle of the indentation in the shaft. The viscometer was then turned on and allowed to run until a constant reading was attained; these readings were taken as the viscosity of the samples in centi poise (cp).

2.3.2. Viscosity index

The viscosity index of oil is calculated from its viscosities at 40 and 100°C. The procedure for the calculation is given in ASTM Method D 2270-74 for Calculating Viscosity Index from Kinematic Viscosity at 40 and 100^{0}C.

2.3.3. Refractive index

The refractive index is a dimensionless number, between 1.3000 and 1.7000 for most compounds, and is normally determined to five digit precision[20]. Since the index of refraction depends on both the temperature of the sample and the wavelength of light used these are both indicated when reporting the refractive index. This test was carried out in the food laboratory, NAFDAC Maiduguri, Borno state.

2.3.4. Sulphated ash

This was carried out in the food laboratory, NAFDAC Maiduguri, Borno state. Since lubricants are liquids, there was need first to ash both oils; under high temperature of about 550^{0}C in a furnace. After which concentrated sulphuric acid was added to the ash from the oils. The solution(s) were also heated in a furnace at 550^{0}C to evaporation and weighed.

$$\text{Sulphated ash} = \frac{W6 - W1}{W2 - W1} \tag{1}$$

W1 is the weight of crucible
W2 is the weight of crucible + weight of sample
W6 is the weight ash + sulphuric acid after heating

2.3.5. Acid value

Acid value test was carried out in the food laboratory, NAFDAC Maiduguri, Borno state. This is the number of milligram of NaOH required to neutralize the free fatty acid in 2 g of the sample. 2 g of the sample (Jatropha oil and neem oil bio lubricant) were weighed and transferred into a conical flask. The weights were recorded. 25 ml of diethyl was mixed with 25ml of ethanol in a 125 ml beaker. 1ml of 1% phenolphthalein indicator solution was added. 0.1 g Sodium hydroxide solution was used to neutralize the solution(s). The solution(s) were then used to dissolve the samples and were titrated drop by drop with constant shaking until a faint pink end point appears and persisted for 30 s. The volume of titrant used to reach this endpoint was recorded and from the readings obtained, the acid value is evaluated using the equation below [10]:

$$\text{Acid value} = \frac{\text{titre value} * 5.61}{\text{weight of sample}} \quad (2)$$

2.3.6. Pour point

The oil Samples were poured into a medium sized plastic containers and (the plastics with the content) 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 0^{O}C – 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 as described by [10].

2.3.7. Density

An empty beaker was weighed and the weight recorded, then 162ml of Jatropha oil bio lubricant and 324ml of neem oil bio lubricant were poured into the beaker and weighed. From the sample weights obtained, the density was determined by taking the ratio of the weight of the oil to the known volume (162ml, 324ml respectively) in SI units according to the equation below [10]:

$$\text{Density} = \frac{\text{Sample weight}}{\text{Sample volume}} \quad (3)$$

2.3.8. Colour

Colour is one important property that can be used to differentiate oil products. In most cases the colours ranges from light brown, black, orange etc. The colour of lubricants are influenced by the additives used .

2.3.9. 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, poducts in response to heat and an ignition source under controlled conditions. The result of the test may be used for risk assesment which takes into account all factors that are pertinent to an assesment of the fire harzards of a particular end use. American society for testing and materials, (1975)

3. RESULTS AND DISCUSSION

3.1. Results

The properties of the bio-lubricant which are pertinent to lubricity are the viscosities at 40 and 100°C, viscosity index, flash point and the pour point (°C). Table 1 shows these parameters.

Table 1 Characteristics of Neem Oil, Jatropha Oil Bio-Lubricant and Engen Super 20w/50

S/NO	PROPERTIES	NEEM OIL BIO LUBE	JATROPHA BIO LUBE	ENGEN SUPER
1	VISCOSITY @ 40°C	190	230	175
2	VISCOSITY @ 100°C	70	140	19.4
3	VISCOSITY INDEX	397	539	127
4	REFRACTIVE INDEX	1.4672	1.4689	1.4815
5	SULPHATED ASH	0.018	0.038	1.000
6	ACID VALUE/TOTAL BASE	1.6	3.9	10.5
7	POUR POINT	1.3	0.2	-30
8	DENSITY	138.8	154.3	90
9	COLOUR	Light brown	black	Light brown
10	FLASH POINT	262	274	234

3.2. Discussions

Neem oil bio lubricant was discovered to have a viscosity of 190cp at 40^{0}C and 70 cp at 100^{0}C, while jatropha oil bio lubricant was having a viscosity of 230cp at 40^{0}C and 140 cp at 100^{0}C. The viscosities of the bio-lubricants were found to be slightly higher than those of the mineral lubricant but could meet the requirement of the ISO VG 46 since its viscosities are within the standard ISO VG 46 range [10]. The viscosity index obtained for Jatropha bio lubricant was 539.57, neem oil bio lubricant was 397.62 and it is comparable to other plant based bio lubricant.

At default the RFM340 refractometer (Bellingham + stanley) is at 1.43786, samples were tested at 32.8^0C. Neem oil bio-lubricant was discovered to be 1.46717, jatropha oil bio lubricant was 1.46894. The refractive index of the oils are satisfactory as it lies within the range 1.3000 and 1.7000 [20]. The mineral lubricant, Engen super 20w/50 was also discovered to be 1.48150 at 20^0C. Sulphated Ash, from the results obtained, jatropha oil bio lubricant has more sulphated ash content than neem oil bio lubricant. Both lubricants have lesser sulphated ash compared to the engen super 20w/50.

Acid value from neem oil bio lubricant was discovered to be 1.6, jatropha oil bio lubricant to be 3.9 and engen super is 10.5 from standard. It can be said that neem oil bio lubricant has higher quality or yield than jatropha oil bio lubricant and will be a better substitute for engen super 20w/50. The lower the acid value, the higher the quality or yield. Jatropha oil bio lubricant has an acid value of 29.06. Compared to [10], it can be said that the produced bio lubricants are of a good quality, with neem oil bio lubricant being most preferred. The pour point of the bio lubricants was significantly high when compared to that of the mineral lubricant. Jatropha oil bio lubricant was having a pour point of 0.23 ^{0}C, and neem oil bio lubricant was having 1.3 ^{0}C.This values are also comparable to the pour point value of other plant based oils [21] The densities were found to be: 154.3 kg/m^3, 138.8 kg/m^3, 90 kg/m^3 respectively for jatropha, neem bio-lubricant and engen super 20w/50. The flash points are 274oC, 262^oC and 234^oC for jatropha, neem bio-lubricant and engen super 20w/50.

4. CONCLUSION

Renewable, biodegradable and environmentally friendly bio-lubricant has been produced from non-edible Jatropha curcas oil and neem seed oil. Jatropha bio-lubricant has high flash point (274^oC), viscosity index (539), lubricity, and an acid value of 3.9, density of 154.3 kg /m^3, sulphated ash content as 0.038 wt%, and low pour point of 0.23 ^{0}C, while the modified neem oil bio-lubricant also has a flash point (262^oC) higher than the characteristic of the commercial lubricant, an acid value of 1.9, high viscosity index (397), density of 138.8 kg/m^3, sulphated ash content as 0.018 wt% and low pour point of 1.3 ^{0}C. The bio-lubricants produced are more viscous than the standard engen super 20w/50; bio-lubricants from neem and jatropha oil have lower acid values than the mineral lubricant which makes it of higher yield or quality. Jatropha oil bio-lubricant was discovered to be denser than both neem oil bio-lubricant and the standard engen super 20w/50. 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. The high flammability limit of the produced bio-lubricant suggests their potential for high temperature applications.

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