Characteristics of Biolubricant. – A Review.

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Abstract: Because of the environmental awareness that has been increasing, there are many types of research that have been done to produce and use environmentally friendly products. This review is to study the characteristics of two biolubricants which can provide a reference to make an efficient biolubricant in the future. In this study, we compare the Viscosity, Coefficient of Friction, and Wear Scar Diameter (WSD) in both biolubricants alone and also when added with some nanoparticle additives. TiO2 is the nanoparticle additive that is used TMP ester in the study. The result of the study is that to compare and identify the advantages and drawbacks of the biolubricants through viscosity, Coefficient of friction, and Wear Scar Diameter be determined and can be compared.

Index Terms **-Biolubricant, Viscosity,Tribiology Testing Coefficient of Friction, Wear Scar Diameter.**

I. Introduction

A lubricant is a substance that helps in improving efficiency and reducing wear and it is placed between two moving mechanical components. It cannot eliminate wear and heat from the material but it can reduce it to some extent. Lubrication reduces friction by replacing mechanical friction with fluid friction. Other principles also include liquid sealing, corrosion protection, heat transfer.

The primary goal of this research is to compare the tribological properties like Coefficient of Friction and Wear scar diameter (WSD) of three biolubricants

1. PRODUCTION OF BIOLUBRICANT

For the production of biolubricant, we use Jatropha oil as an example for raw material. The mineral oil lubricant and the Biolubricant are the two main types of lubricants depending on their origins. Mineral oil lubricants are derived from petroleum and are believed to be harmful to the atmosphere and, by implication, human life. Lubricants were synthesized from plant oils and other environmentally friendly materials, referred to as biolubricants, which are mostly triglyceride esters derived from plants and animals, for this and other purposes. Environmentally friendly lubricants are becoming more popular, particularly in areas where they can come into contact with water, foods, or humans.

Lubricants are made up of a majority of base oil and several additives that give them beneficial properties. While most lubricants are made from a single type of base oil, they can also be mixed to meet performance requirements. Jatropha is a non-edible plant that has recently been discovered to have substantial biodiesel and Biolubricant production potential. Because of its environmental benefits and the fact that it is made from renewable resources, plant oil-based lubricants can appeal to global consumers. Because of the presence of toxic esters, jatropha oil is considered non-edible. As a result, it could provide a reliable source of low-cost feedstock for fuel oil and derivatives without posing a threat to food supplies. Jatropha curcas is a subtropical and tropical plant that is widely used as a hedge crop in developing countries. It grows quickly and demands little water or nutrients, and it can thrive on barren land, as well as low quality or degraded land (Kandpal and Madan, 1995). Since then, the quest for renewable energy sources has dominated most manufacturing sectors, with a strong focus on bio-based goods. Several researchers have agreed that the sources could provide more reliable lubricants.

1.1. PRODUCTION PROCESS.

1.1.1. RAW MATERIAL PREPARATION

The following preparation steps were used for high oil content materials (oil content of 15% or more) to make the material suitable for solvent penetration into the oil cells as well as best percolation.

(i)To reduce the size of the seeds to around 3 mm, they are passed through corrugated roller mills with 3 mm flutes.

(ii) Heating the damaged material to about 80°C with open steam in and humidifying it to around 11 to 12 percent moisture content.

(iii)Flaking the humidified material between two plain rolls to a thickness of 0.25 mm or less.

(iv) After crisping the flakes, transport them to the extraction system.

1.1.2. OIL EXTRACTION

Solvent extraction has been used to remove the crude. The raw material (Jatropha seed) was prepared in such a way that the maximum amount of oil could be extracted.

1.2 PROCESS OF EXTRACTION

In a 5 L three-neck flask, a regular weight of crushed Jatropha seed was placed. Oil was extracted using hexane as a solvent. The volume of hexane required was calculated using a 6:1 ratio. The mixture was heated to 60°C and stirred for around 8 hours after being fitted with a reflux condenser. The suspended solids were washed out of the resulting oil and solvent mixture. The mixture was then put in a rotary evaporator to evaporate the solvent, yielding Jatropha oil.

1.2.1. OIL ESTERIFICATION

This is critical to decreasing the oil's free fatty acid content, which could result in excessive saponification. The oil's high FFA content was reduced by esterifying it with methanol and using sulphuric acid as a catalyst. 100 g of oil was weighed and transferred to a two-liter flask with three necks and around the rim. In a conical flask, 20 percent w/w methanol and 5% w/w sulphuric acid were weighed and mixed. The methanol acid mixture and the oil sample were both heated to 60 °C in a water bath. They were then mixed in a three-necked round bottom flask with a mechanical stirrer inserted into one of the necks and the other two necks stopped. The stirrer was set to 700 rpm, and the bath temperature was held at 60°C.The timing was started at this stage. After 60 minutes, the sample was removed with a picking pipette and titrated against a 0.1 N solution of KOH to determine the oil's free fatty acid content. Up until the fifth hour, the titration was repeated at one-hour intervals.

1.2.2. TRANSESTERIFICATION OF OIL

In the presence of a catalyst, triglycerides are converted to fatty acid alkyl esters (FAAE) and low molecular weight alcohols like methanol and ethanol (Demirbas, 2011; Sharma and Singh, 2009; Demirbas et al., 2009) A double transesterification is used in the production of biolubricants; the first produces an intermediate product, the methyl ester of the oil, and the second uses the methyl ester as a reactant to create the desired product, the polyol ester. The following that's how the two processes work.

2. TRIBOLOGY

Tribology – The science and technology of wear and friction between interacting surfaces in relative motion is crucial for determining mechanical component efficiency and durability. The running actions and working characteristics of mechanical systems – parts, assemblies, and machines – are harmed by friction and wear.
Tribology research provides valuable knowledge about mechanical component failure mechanisms, resulting in solutions that increase efficiency and/or reduce costs. This testing can be carried out in three different scenarios:

2.1. TESTING ON SAMPLE COUPONS

The test coupons and counterpart elements are made of the same material as the real component and have identical metallurgical and surface properties. Standard tribology testing equipment is used to examine these coupons. The Falex Pin & Vee Block test, the Block-on-Ring test, the Amsler twin-disk test, the Taber test, etc.

2.1.1 COMPONENT LEVEL TESTING ON SIMULATED TEST RIGS.

This research is carried out on real components that are put through the same wear and touch modes that they will face in everyday life. ·

2.1.2. COMPONENT LEVEL TESTING ON THE ACTUAL EQUIPMENT.

These experiments are carried out on the same equipment that the test part is used on. An actual automobile engine, for example, is completely instrumented to measure output parameters like loads, temperature, and is used to calculate relevant performance parameters like friction coefficient, wear rate, and so on. Runs of experiments that are as similar to the real thing as possible.

2.2. APPLICATIONS OF TRIBOLOGY:

2.2.1. LUBRICANT TESTING

The friction and wear characteristics of greases and other lubricants can be determined using a block on a ring tester. A sliding application with grease dispensers at controlled flow rates can be used to quantify these. During the test, the temperature (up to 500 degrees Celsius) and pressure (up to 10,000 N) can be adjusted. A stepwise or linear increase in load is applied before a seizure or sudden increase in the coefficient of friction occurs during an extreme pressure (EP) examination. During and after the exam, the sample's wear is assessed.
The Rtec MFT-5000 tribometer is a flexible block on ring tribology tester that can conduct a variety of customized block on ring wear tests, such as oscillating ring tests, to determine the efficiency of various lubricants, such as greases, solid lubricants, or oils. The module enables non-invasive testing of actual components such as shafts, power transmission components, tapered roller bearings, thrust bearings, and their equivalents.

2.2.1.1. FOUR BALL TRIBOTESTER

Four-Ball Tester, also known as Shell four-ball tester, is used to characterize lubricant properties, such as wear prevention (WP), extreme pressure (EP), and frictional behavior (various testing standards are listed below).
The tester is made up of four balls arranged in an equilateral tetrahedron as shown in the diagram below. The upper ball rotates and makes contact with the lower three balls, which remain stationary.

2.2.1.2. FOUR BALL EXTREME PRESSURE TEST

The capacity of a lubricant to work under extreme pressure conditions is determined by testing its extreme pressure properties. The test begins with ‘low' loads, which are loads in which the lubricant performs well, a proper lubricant film forms, and seizure is not detected. The load is increased significantly following the tested norm until the lubrication fails, at which point the lubricant film can no longer distinguish the surfaces, and surface to surface contact occurs. The load is increased before catastrophic failure occurs as a final stage. Welding is the term for the final failure, which is marked by increased noise levels, sharp shifts in the friction signal, and so on. Based on performance of Different formulations can be produced based on a lubricant's output in this test.

2.2.1.3. FOUR BALL WEAR TEST

Four ball tests can also be used to measure the performance of the lubricant concerning wear. During the test, the upper ball is rotated against the rest of the set balls. Unlike the extreme pressure test, the load is performed under fixed conditions (load, speed, temperature, etc.). Following the test, wear scar measurements are taken using, for example, optical profilometry, which can be used to assess a lubricant's wear efficiency. During this test, the friction force is also measured and can thus be analyzed.

2.3 LUBRICANT TESTING PROCEDURE

2.3.1. TESTING STANDARDS FOR FOUR BALL TESTS

The following research standards are focused on the use of a four-ball tester :

- ASTM D4172:
- Lubricating fluids undergo WP (Wear Prevention) checks (ASTM D2266 for greases)
- ASTM D5183: Coefficient of friction of lubricants

II. RESEARCH AND METHODOLOGY

VISCOSITY

Viscosity: The viscosity of a fluid is a measurement of its flow resistance. This word describes the internal friction of a moving fluid. A fluid with a high viscosity has a lot of internal friction due to its molecular composition.

At different temperatures (25–100 °C), the values of this parameter for sunflower and mineral oils were compared. The sample's temperature rose as its kinematic viscosity decreased. The viscosity levels of all the oils were comparable at high temperatures (100 °C). Mineral oil has a higher kinematic viscosity (54.15 and 12.14 mm2 /sec at 40 and 100 degrees Celsius, respectively) than sunflower oil (46.15 and 10.80 mm2 /sec at 40 and 100 degrees Celsius, respectively). In contrast to mineral oil, sunflower oil was discovered to have a higher viscosity index value.

WEAR SCAR DIAMETER

Although the disc receives the majority of the wear due to its softer nature, the wear scar on the ball is used to measure the test result. Under 100 magnification, the wear scar on the ball is calibrated to the nearest 0.01 mm. The wear scar diameter (WSD) is the combination of the wear scar's major and minor axes.
After the experiment was completed, the wear characteristics of the steel ball bearings were measured and studied using an optical and scanning electron microscope (high resolution) at a magnification of 50. (1-hour running).
The average value of the diameters was calculated using the ASTM D4172-B norm.
The wear scar diameter increased as the applied load increased. The adsorption layers are responsible for the substances' improved lubricating properties.

COEFFICIENT OF FRICTION

The coefficient of friction (COF) is the proportion of frictional force between two bodies to the force pushing them together. The friction coefficient is determined by the materials used.
Experimental conditions were held at 1200 rpm rotational speed, 75 °C bulk temperature of oil, and 1 hr running time to study the friction efficiency of the test samples (sunflower and mineral oils) under a range of load levels (30–45 kg).
Under different loads, the coefficients of friction for vegetable oil (sunflower) were nevertheless lower than those for mineral oil. Under 30 kg load, sunflower oil had the lowest coefficient of friction of 0.0590, compared to 0.0606 for mineral oil.

T (Temperature)	VISCOSITY		
	Sunflower oil	TMP ester (Trimethylolpropane)	
		(a) Pure	(b) With Additive
40º	41 (mm²/s)	101.86±1.53 (cSt)	108.75±1.22 (cSt)
100º	10 (mm²/s)	108.75±1.22 (cSt)	108.75±1.22 (cSt)

Table1.1 Viscosity of the biolubricant.

Table (1.1) compares the two experimented oil samples i.e. sunflower oil and TMP(trimethylolpropane) based on the viscosity of the respective fluid samples.

As it is expressed by the table that the sunflower oil has obtained a viscosity value of 41mm^2/s at 40ºC and 10 mm^2/s at 100º C and on the other hand TMP (trimethylolpropane) is been added with TiO2 as nanoparticle additive and we obtained two samples i.e.
(a) pure TMP 101.86 mm^2/s at 40ºC and 108.75 mm^2/s at 100ºC,
(b)TMP with nanoparticle additives got readings 108.75 mm^2/s at 40º C and 108.75 mm^2/s at 100º C.
TMP (trimethylolpropane) has a higher viscosity than sunflower oil at both operating temperatures, according to this table.

Normal Load (kg)	Wear Scar Diameter (WSD)		
	Sunflower oil	TMP ester (trimethylolpropane)	
		(a) Pure Sample	(b) With Additive
40	375 (µm)	610 (µm)	630 (µm)
45	397 (µm)	590(µm)	610(µm)

Table 1.2 Wear Scar Diameter of the Biolubricant.

Table (1.2) compares the Wear scar diameter of the two oil samples tested, sunflower oil and TMP (trimethylolpropane).
As it is expressed by the table that the sunflower oil has obtained a WSD value of 375 µm at 40kg load and 397µm at 45kg load is greater than the WSD value which has been obtained by TMP(Trimethylolpropane) which is been divided into two samples i.e
(a)pure TMP at 40kg load 610 µm and obtained 590 µm at 45kg load,
(b) and with the TiO2 additive added, it produced a reading of 630µm at 40 kg load and 610µm at 45 kg of load.

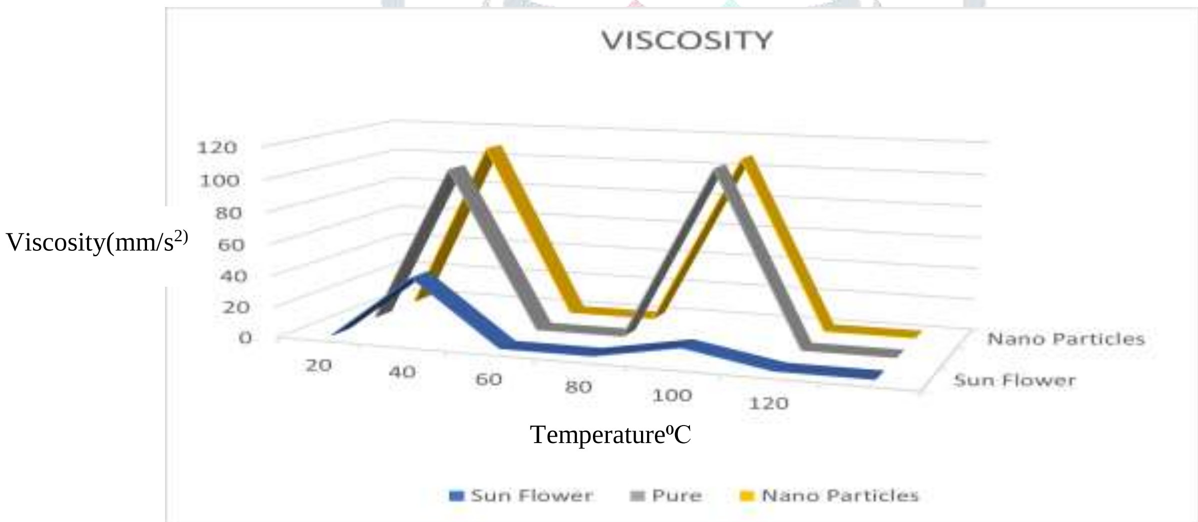
Normal Load (kg)	COEFFICIENT OF FRICTION		
	Sunflower oil	TMP Ester (trimethylolpropane)	
		(a) Pure Sample	(b) With Additive
40	0.0615	0.065	0.061
45	0.0620	0.067	0.063

Table 1.3 Coefficient of friction of the biolubricant.

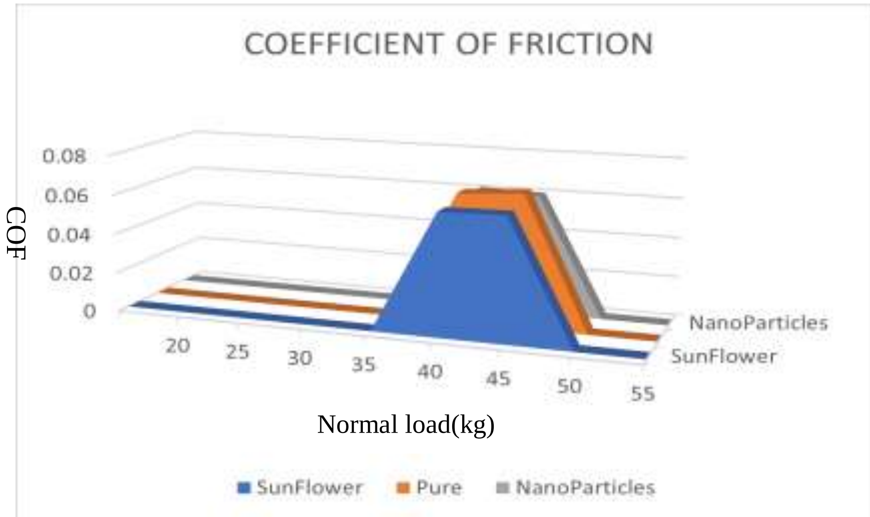
Table (1.3) this table compares the coefficient of friction (COF) between oil tests samples i.e. sunflower oil and TMP and TMP with nanoparticle additive

As the reading suggests the value of both the test samples is approximately similar to each other at different operating loads. COF of sunflower oil at 40kg load is 0.0615 and 0.0620 at 45 kg of load. And
(a) pure TMP, COF is 0.065 at 40 kg load and 0.067 at 45 kg load.
(b) TMP with additive (TiO_2), COF is 0.061 at 40 kg and 0.063 at 45 kg of load.

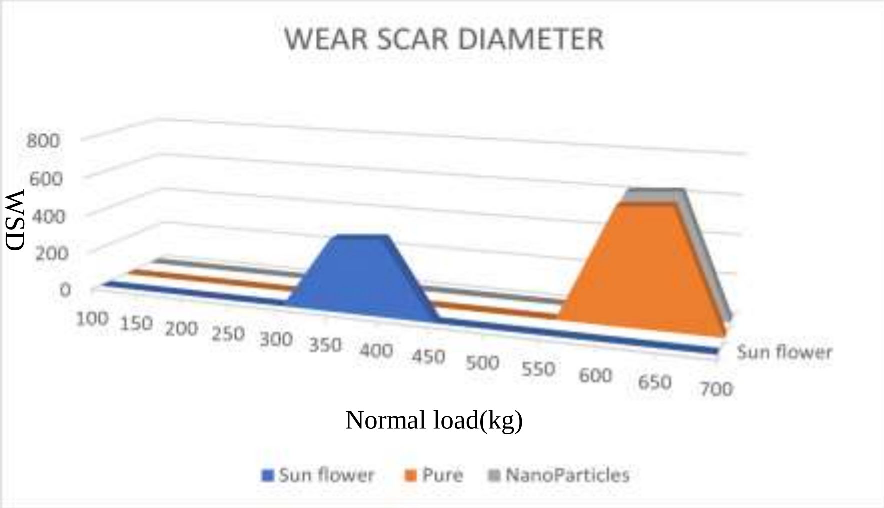
III. GRAPHS



Graph 1.1 Viscosity of the Biolubricants.



Graph 1.2 Coefficient of Friction of the Biolubricants.



Graph 1.3 Wear Scar Diameter of the Biolubricants.

IV. OVERVIEW

This comparison of the tribological properties of two different Biolubricant is to determine the progress of the research on biolubricants and the work that needs to be done in future researches to help make a close to ideal Biolubricant which can compete with the conventional mineral lubricants. As we can see that the particular tribological properties are very essential to determine the efficiency of the said Biolubricant. As we can see that the wear scar diameter (WSD) and Viscosity vary in both the biolubricants which are taken into consideration in this research. Not only sunflower or palm oil-based TMP is the current researching biolubricants but also biolubricants like palm oil, rapeseed oil, jatropha oil, and many future potential biolubricants need to have the basic tribological criteria to help make an environmental friendly biolubricant. This review works to highlight the differences, advantages, and disadvantages of the said biolubricants.

V. CONCLUSION

This review paper aims to provide an overview of the various methods and studies that are currently being undertaken in the field of bio lubricants. The two edible oils sunflower oil and palm oil are compared and discussed in this paper, and a brief study of their two tribological properties is proposed by putting them through fourball tribological tests. And, as the findings of the comparison indicate, both oils have benefits and disadvantages. As compared to sunflower oil, TMP (trimethylolpropane) has a higher viscosity, but sunflower oil has a lower WSD, which is advantageous. Both test oils have a COF that is quite similar to each other.

There are several more stones to be turned, just like these two edible oils. Future research in this area will focus on replacing traditional lubricants with biolubricants that are more environmentally friendly. This may be a small step toward making life better in our friendly world.

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