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Manufacturing of Bio-lubricant with Jatropha oil extracted from seed

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Abstract

The increasing demand for sustainable and eco-friendly products has led to the development of biodegradable lubricants. One such lubricant is bio-lubricant, which is made from renewable resources and is biodegradable, non-toxic, and non-hazardous. Jatropha oil is a potential feedstock for the production of bio-lubricants due to its high viscosity, excellent lubricity, and availability in large quantities. The manufacturing process of bio-lubricant from Jatropha oil involves several steps such as degumming, neutralization, bleaching, and deodorization. The resulting bio-lubricant has excellent lubricity, high viscosity index, and good oxidative stability. It is also biodegradable, non-toxic, and environmentally friendly, making it a promising alternative to petroleum-based lubricants. This paper discusses the manufacturing process of bio-lubricant from Jatropha oil, its properties, and potential applications in various industries.

Introduction

Bio-lubricants are a sustainable and environmentally friendly alternative to traditional petroleum-based lubricants. They are biodegradable, renewable, and produce lower emissions compared to their petroleum-based counterparts. One of the feedstocks that can be used to produce bio-lubricants is Jatropha oil [1]. Jatropha is a non-edible plant that is widely grown in arid and semi-arid regions. Its oil is a rich source of fatty acids and triglycerides, making it an ideal feedstock for bio-lubricant production.

The first stage of manufacturing bio-lubricant with Jatropha oil is the pretreatment stage [2]. This stage involves removing any impurities, such as water and free fatty acids, from the oil. The impurities are removed using a process known as degumming, which involves the addition of phosphoric acid followed by water washing. The oil is then heated to remove any remaining moisture. The pretreatment stage ensures that the oil is of high quality and can be used to produce a bio-lubricant that meets the required specifications.

The second stage of manufacturing bio-lubricant with Jatropha oil is the transesterification stage [3]. Transesterification involves reacting the Jatropha oil with an alcohol, such as methanol or ethanol, in the presence of a catalyst, typically sodium or potassium hydroxide. This reaction produces fatty acid methyl or ethyl esters, which are the main components of the bio-lubricant. The transesterification process is carried out at a controlled temperature and pressure to ensure that the reaction proceeds smoothly and that the resulting bio-lubricant is of high quality.

After transesterification, the third stage of manufacturing bio-lubricant with Jatropha oil is post-treatment [4]. Post-treatment involves removing any remaining impurities, such as catalyst residues, from the bio-lubricant. The post-treatment process includes neutralization, washing, drying, and filtration. The bio-lubricant is neutralized with an acid to remove any remaining catalyst residues. It is then washed with water to remove any remaining impurities, followed by drying to remove any remaining water. Finally, the bio-lubricant is filtered to remove any remaining solids. The resulting bio-lubricant has excellent lubricating properties and is suitable for a wide range of applications, including automotive and industrial lubrication. It has a high viscosity index, which means that it maintains its viscosity across a wide range of temperatures. It also has good oxidative stability, which means that it can withstand high temperatures and does not break down easily [5]. Additionally, it has a low pour point, which means that it remains fluid at low temperatures, making it suitable for use in cold environments.

In this paper, the manufacturing of bio-lubricant with Jatropha oil has been prepared with different thickeners for a sustainable and environmentally friendly alternative to traditional petroleum-based lubricants. The process involves three stages: pretreatment, transesterification, and post-treatment. By following the manufacturing process, high-quality bio-lubricants can be produced that meet the required specifications and are suitable for a wide range of applications.

Material and Method Used:

Chemical Used: Jatropha Oil, Calcium Stearate (Merk), Aluminium Stearate (Merk). **Apparatus Used:** Beaker, Conical Flask, Pipette, Stirrer, Mixer, Freezer, Digital Thermometer (-30 to 100 ^{o}C), Induction, Weighing Machine, Mixing Jar, Pan or Jar which is used to perform the whole mixing task as shown in figure 1.

Method Used:

Grease can be classified based on its thickener type, base oil type, application, and NLGI grade. Each classification has its own advantages and disadvantages, and the selection of the appropriate grease for a particular application depends on several factors, including the operating conditions, equipment requirements, and environmental factors.

Grease can be classified based on several criteria, including thickener type, base oil type, and application [6].

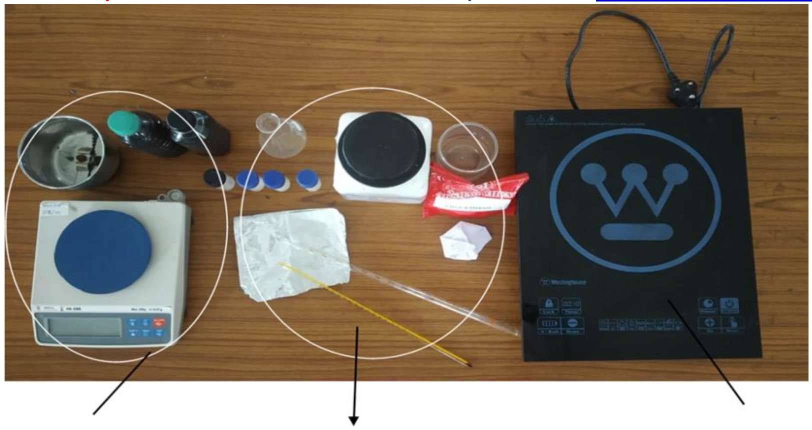
Thickener Type: The thickener is the primary component of grease that provides its structure and consistency. The most common types of thickeners used in grease are metal soaps, such as lithium, calcium, and aluminum. Greases can be classified based on the thickener type, such as lithium-based, calcium-based, and aluminum-based [8].

Base Oil Type: The base oil is the second primary component of grease, and it provides lubrication to the moving parts. Greases can be classified based on the type of base oil used, such as mineral oil, synthetic oil, and vegetable oil. Mineral oil is the most commonly used base oil in grease, while synthetic oil and vegetable oil are used in specialty applications.

NLGI Grade: Another way to classify grease is by its The National Lubricating Grease Institute (NLGI) grade, which is a measure of its consistency. NLGI has established a grading system that ranges from 0 (liquid) to 6 (semi-solid). Greases with a higher NLGI grade are thicker and more viscous than those with a lower NLGI grade [9].

Test Method: The analysis of bio grease is essential to ensure that it meets the required specifications and is suitable for its intended application. The most common test methods used for bio grease analysis include FTIR, dropping point test, penetration test, Four-Ball Wear Test, and water resistance test. These tests provide information on the chemical composition, thermal stability, consistency, wear resistance, and water resistance of the grease.

Plan of work: Initially take some amount of samples from lubricating oil and from metallic soap. Mix it in such a ratio such that base oil to Thickener ratio is base oil (45-95%), thickener (3-50%). Provide heat with the help of heater and adjust the temperature in between 50-80 °C. Now mix it well in a mixer jar constantly at around 15 minutes. After proper mixing, our final sample product will get ready.



Mixer Jar, Weighing Machine, Gear C   Weighing samples, Thickener, Pipette, Mercury Thermometer   Induction

Figure1: Material Used to perform experiment

Results and Discussion

Fuel Properties:

The free fatty acid (FFA) contents of raw oils were determined by using American Oil Chemists Society(AOCS), the moisture content of raw oils was quantitatively determined by oven drying method at (105 ~110°C) for 1 hour. Saponification value of raw oils were quantitatively determined by using AOCS [10]. The kinematic viscosity was determined by Redwood Viscometer.

Density: Measuring cylinder and beaker were taken, quantity of oil sample was measured through cylinder and was weighed in beaker. Then calculations were performed.

An empty beaker was weighed and the weight recorded, then 100 cm^3 of the sample (Jatropha oil) was poured into the beaker and weighed. From the sample weight obtained, the density was determined by taking the ratio of the weight of the oil to the known volume (100 cm^3) in SI units according to the equation below:

Density= $\frac{Sample\ weight}{Sample\ volume}$

The weight of the sample jatropha oil is 82.251 gm and volume of sample jatropha oil is 100 m^3. The calculated density of oil is 0.82251 gm/cm^3 or 822.51 kg/ m^3.

Volume taken=100 mL

Weight of oil sample= 82.251 gm

$$\text{Density}= \frac{\text{weight}}{\text{volume}} = \frac{82.251}{100} = 0.82251\,\frac{\text{gm}}{\text{mL}}$$

$$= \frac{0.82251\times(100)^3}{1000} = 822.51\ \text{kg/m}^3$$

Viscosity: For viscosity measurements Redwood Viscometer was used. The waste lubricating oil was filled outside for heating, and the sample oil that is Jatropha oil was filled inside. The viscometer was switched on and heated till desired temperature. Redwood viscometer consists of a cylindrical oil cup furnished with a gauge point, metallic orifice jet at the bottom having a concave depression from inside to facilitate a ball with stiff wire to act as a valve to start or stop oil flow. The outer side of the orifice jet is convex, so that the oil under test does not creep over the lower face of the oil cup. The oil cup is surrounded by an oil bath with a circular electrical immersion heater and a stirring device. A round flat-bottomed flask of 50 ml marking, to measure 50 ml of oil flow against time. The oil bath with oil cup is supported on a tripod stand with levelling screws.

The oil collected in 1 min at 50°C and at 100°C is 50 mL and 63 mL respectively.

The calculated viscosity are

The quantity of oil collected is 50 mL at 50°C and at 100°C is 63 mL as reported in table 1.

Table 1:

Temperature of oil (°C)	Quantity of oil collected(m^3)	Time (s)	Kinematic viscosity(γ)(m^2/s)	Dynamic viscosity(μ) (Pa/s)
50	50	60	0.0000126733	0.01042
100	63	50	0.0000094	0.00773

Use of thickeners: In the production of bio-greases, different thickeners are commonly used to improve the viscosity and lubricating properties of the final product. Thickeners are substances that increase the viscosity of a fluid without altering its other properties. Some common thickeners used in bio-grease production include lithium, calcium, and aluminum complex thickeners, as well as polyurea and bentonite clays [11]. Lithium and calcium complex thickeners are widely used in conventional greases, while aluminum complex thickeners are commonly used in high-temperature applications. Polyurea greases are known for their excellent stability and water resistance, and bentonite clay is used in environmentally friendly, biodegradable greases. The choice of thickener depends on the specific performance requirements of the grease, such as temperature range, water resistance, and load-carrying capacity.

Aluminium stearate thickener-based Grease:

Figure 2: After 30 minutes of continuous blending at 500 rpm

Aluminum stearate is another metallic soap that is commonly used as a thickener in grease formulations. Similar to calcium stearate, it is particularly effective in thickening mineral oil-based greases [12]. When aluminum stearate is added to a grease formulation, it also forms a fibrous network that helps to hold the oil in place and prevent it from leaking out of the grease as shown in figure 2. This network of fibers also helps to provide a cushioning effect, which can reduce wear and tear on moving parts. Aluminum stearate-based greases are often used in high-temperature applications, such as oven conveyors, drying ovens, and furnaces. They offer excellent thermal stability, high load-carrying capacity, and good mechanical stability. Additionally, they are resistant to water and chemicals, making them suitable for harsh environments. However, aluminum stearate-based greases may not be suitable for applications that require extreme pressure resistance or exposure to heavy loads. In such cases, alternative thickeners such as lithium or calcium complex soap may be more appropriate.

Calcium stearate thickener-based Grease:

Figure 3: Calcium stearate-based greases

Calcium stearate is a metallic soap that is commonly used as a thickener in grease formulations as shown in figure 3. It is particularly effective in thickening mineral oil-based greases. When calcium stearate is added to a grease formulation, it forms a network of fibers that helps to hold the oil in place and prevent it from leaking out of the grease. This network of fibers also helps to provide a cushioning effect, which can reduce wear and tear on moving parts. Calcium stearate-based greases are often used in automotive and industrial applications, such as wheel bearings, chassis components, and heavy-duty equipment. They are also commonly used in food processing and packaging equipment because they are non-toxic and do not contaminate food products.

Pour Point Test: Pour point was found to be -9 ^{o}C

Cloud Point Test: Cloud point was found to be 0^{o}C.

Impact Test:

The impact test is a type of performance test that can be used to evaluate the ability of a lubricating grease to protect bearings and other mechanical components against shock loads. This test is typically conducted using an impact tester, which is a machine that can simulate sudden impacts and measure the resulting changes in torque or other parameters. During the impact test, the grease sample is applied to a bearing or other test component and subjected to a series of impact loads. The impact tester measures the resulting changes in torque or other parameters, which can be used to evaluate the performance of the grease under shock load conditions. The impact test is particularly useful for evaluating the performance of greases in high-load, high-speed applications, such as those found in automotive and industrial equipment as shown in figure 4. Greases that perform well in the impact test are more likely to provide effective protection against shock loads, which can help to prevent premature wear and failure of bearings and other mechanical components.

Before Impact **After Impact**

Figure 4: Impact result before and after impact

Corrosion Test: The corrosion test is a type of performance test that can be used to evaluate the ability of a lubricating grease to protect metals against corrosion [13]. This test is typically conducted using a test apparatus that simulates exposure to corrosive environments, such as salt spray or humidity. During the corrosion test, the grease sample is applied to a metal surface and exposed to a corrosive environment for a specified period of time. After the exposure period, the metal surface is evaluated for signs of corrosion, such as rust or pitting as shown in figure 5.

The corrosion test is particularly useful for evaluating the performance of greases in applications where the equipment is exposed to corrosive environments, such as marine, mining, or chemical processing equipment. Greases that perform well in the corrosion test are more likely to provide effective protection against corrosion, which can help to prolong the life of the equipment and reduce maintenance costs. There are several different types of corrosion tests that can be used to evaluate the performance of lubricating greases. These include the salt spray test, the humidity test, and the copper strip corrosion test. Each of these tests has its own specific procedures and evaluation criteria, and the choice of test method will depend on the specific requirements of the application [8].

Normal Iron After coating of grease Effect of graese

Figure 5: Effect of grease coating on metal surface

Water Resistance test:

The water resistance test is a type of performance test that can be used to evaluate the ability of a lubricating grease to resist the effects of water and prevent the washing out of the grease from bearings and other mechanical components. This test is typically conducted using a test apparatus that simulates exposure to water or other fluids. During the water resistance test, the grease sample is applied to a test component and exposed to a stream of water or other fluid for a specified period of time[14]. After the exposure period, the test component is evaluated for signs of water penetration, such as a loss of lubrication or damage to the component as shown in figure 6. The water resistance test is particularly useful for evaluating the performance of greases in applications where the equipment is exposed to water or other fluids, such as marine, agricultural, or mining equipment. Greases that perform well in the water resistance test are more likely to provide effective protection against water washout and corrosion, which can help to prolong the life of the equipment and reduce maintenance costs.

At angle 45º At angle 30º At angle 15º

Figure 6: Water resistance test at different angle

Conclusions

Jatropha oil based bio-lubricants have demonstrated excellent physical properties in various tests, including the Water Resistance test, Corrosion Test, Impact Test, Pour Point Test, and Cloud Point Test. In the Water Resistance test, Jatropha oil based bio-lubricants have shown resistance to water and the ability to maintain their lubricating properties even in the presence of water. The Corrosion Test evaluates the ability of the lubricant to protect metal surfaces from corrosion, and Jatropha oil based bio-lubricants have demonstrated excellent corrosion protection properties. In the Impact Test, Jatropha oil based bio-lubricants have shown good resistance to mechanical stress and can withstand shock loads. The Pour Point Test measures the lowest temperature at which the lubricant can flow, and Jatropha oil based bio-lubricants have shown low pour points, indicating good low-temperature fluidity. Finally, in the Cloud Point Test, Jatropha oil based bio-lubricants have shown good resistance to the formation of wax crystals at low temperatures, which can cause blockages in lubrication systems. Overall, Jatropha oil based bio-lubricants offer excellent physical properties, making them a viable and sustainable alternative to traditional petroleum-based lubricants.

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