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Feasibility Study of Developing an Eco-Friendly Bio Lubricant from Flaxseed Oil

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Abstract

The increasing global demand for sustainable and environmentally friendly lubricants has led to the exploration of bio-based alternatives. This study focuses on the production of a bio- lubricant using Flax Seed oil as the feedstock through an epoxidation process followed by acid testing. The first step involves the epoxidation of Flax Seed, where the unsaturated fatty acids present in the oil are converted into epoxides. This process is carried out using a catalyst and a peroxide source. The reaction conditions, such as temperature, time, and reactant ratios, are optimized to achieve the highest conversion and selectivity of epoxidized Flax Seed oil. The epoxidized Flax Seed is then subjected to acid testing to evaluate its suitability as a bio- lubricant. The acid value, which measures the amount of acidic compounds present, is determined. A low acid value indicates good stability and resistance to oxidation. Additionally, the viscosity, flash point and other relevant properties are assessed to ensure that the bio- lubricant meets industry standards. The results of the acid testing provide valuable insights into the quality and performance of the produced bio-lubricant. By analyzing the acid value and other properties, the effectiveness of the epoxidation process and the feasibility of using Flax Seed oil as a sustainable feedstock for bio-lubricant production can be determined. This research contributes to the development of eco-friendly lubricants by utilizing Flax Seed oil as a renewable resource. The epoxidation process and subsequent acid testing serve as crucial steps in the production and evaluation of bio-lubricants, highlighting their potential as a viable alternative to conventional petroleum-based lubricants

Keywords: *Bio-Lubricant; Flax Seed Oil; Epoxidation; Acid testing; Sustainability*

1. Introduction

Lubricants have always been an integral part of our society. The function of an effective lubricant is to reduce friction, wear, and corrosion of the metal parts as well as to transmit heat from the surface. Based on their structure, lubricants can be classified into Solid lubricants, Semi liquid lubricants, and Liquid lubricants. Oils come under the category of liquid lubricants. The commonly used base oils are mineral oils, synthetic oils, and vegetable oils while the commonly used thickeners are soap-based and non-soap based. Since mineral resources are quickly being depleted, the use of mineral oils as base oils is being replaced by vegetable oils. The non-biodegradability, high toxicity, and scarcity of these mineral resources are the main reason why mineral oils are being replaced by vegetable oils as base oils [1]. The bearings used in electric motors, transmission systems, steering systems, gears, braking systems, etc. of electric motors are active areas where tribological benefits of oils can be observed [2]. Lubricants are most commonly used to reduce friction and wear in bearings, transmit heat from surfaces etc. Lubricants are generally made up of mineral oils and cause various environmental and health hazards. As an alternative vegetable oil can be used instead of mineral oils as lubricants [3]. In cold working and extrusion process, vegetable oils show the better surface roughness and extrusion load compared to mineral oils [4]. A major drawback of vegetable oils is that they tend to oxidize at high temperatures and pressure and this in turn weakens the structure of the metal. Although they show a high coefficient of friction and wear scar compared to other lubricants, vegetable oils can be used as lubricants with the addition of suitable additives [5]. Properties of vegetable oils like pour point can be improved by chemical modification processes like transesterification [6]. Due to these reasons, vegetable oils can actively be used as base oils for grease manufacturing compared to mineral oils. Many attempts have been done to produce eco-friendly lubricants with various base oils like Karanja oil [7], castor oil [8], jathropha oil [9], etc. Some of these oils have good lubricating properties compared to mineral oil greases. Very few studies based on lubricants focuses on flax seed oil as base oil. In this study flax seed oil is chemically modified for various property improvements and later tested for these properties to prove their lubricant applications.

2. Method

2.1.Materials Used

Flax seed oil was purchased from SBH Foods Pvt, Ltd. Thane, Sulphuric Acid was purchased from Qualikems Fine Chem Pvt. Ltd, Vadodara,Hydrogen Peroxide was supplied by Rajaji Chemicals, Chennai, Methanol was purchased from Nice Chemicals Pvt Ltd.

2.2. Chemical Modification

Chemical Modification of the oil was done by the process of epoxidation. To the oil suitable amount of sulphuric acid is added. Hydrogen Peroxide is then added to this mixture and stirred continuously for a period of 4.5 hours while maintaining the temperature at 70℃. The epoxidising agent reacts with the unsaturated fatty acids present in the flax seed oil, resulting in the formation of epoxy groups. This epoxidation process increases the lubricant properties of the flax seed oil.

2.3. Four Ball Tester

The coefficient of friction and wear characteristics of the greases have been evaluated as per ASTM D-2266 by using a four-ball tribometer (DUCOM TR-30L-KRL-PNU- IAS) as shown in Figure 1. The four-ball tester is used to test the tribological characteristics of lubricants. There are four balls of diameter 12.7 mm made of chromium steel with a hardness value of 64 HRC in which 3 balls are kept in a ball pot and a test sample is applied to it. The fourth ball is fixed on a collet which is attached to a rotating spindle. The load is given by a pneumatic source and is sensed by a load cell. As per ASTM D-2266, the spindle speed is 1200 rpm and the load applied is 392N. The test is carried out for 3600 seconds at a temperature of 75℃. After the test is conducted, wear scar diameter will be measured using an optical microscope.

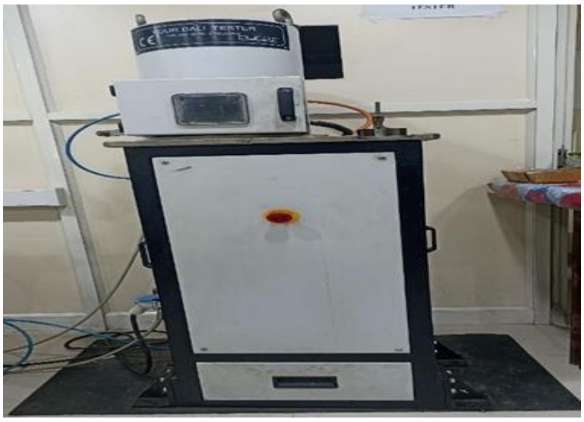

Figure 1 Four Ball Tester

2.4.Cloud and Pour Point Apparatus

The cloud and pour point apparatus is a laboratory instrument used to determine the cloud point and pour point of petroleum products, particularly oils and lubricants. These parameters are important in evaluating the low-temperature flow characteristics of such materials. The cloud point is the temperature at which waxy or solid particles begin to form in the fuel, causing it to appear cloudy or hazy. It is an indication of the temperature below which the fuel may start to clog filters and obstruct fuel lines. The pour point, on the other hand, is the lowest

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temperature at which the fuel will still flow under specific test conditions

Figure 2 Cloud and Pour Point Apparatus

2.5.Flash and Fire Point Apparatus

The flash and fire point apparatus is a laboratory instrument used to determine the fire point and flash point of petroleum products, particularly oils and lubricants. These parameters are important in evaluating the high temperature characteristics of such materials. The flash point and fire point are the temperature at which the oil starts to burn for a period for 3 seconds and for a continuous period of time respectively.

Figure 3 Flash and Fire Point Apparatus

2.6. Viscosity Testing Apparatus

A viscosity test apparatus is a device used to measure the viscosity of a fluid. Viscosity is a measure of a fluid's resistance to flow, and it is an important property for various applications in fields such as engineering, chemistry, and medicine. There are several types of viscosity test apparatus available, depending on the specific requirements of the fluid being tested and the desired accuracy of the measurement.

Figure 4 Viscosity Testing Apparatus

3. Results And Discussion

3.1. Four Ball Tester

Table 1 Coefficient of Friction and Wear Scar Diameter

TEST	RESULT
Coefficient of Friction	0.0837
Wear Scar Diameter	653 micro meters

A good lubricant should possess low values of coefficient of friction and wear scar diameter. From Table 1. it can be observed that the chemical modification of the oil has resulted in reduced coefficient of friction and low wear scar diameter. The results clearly indicate that the lubricant properties have improved and show good value after chemical modification.

3.2.Cloud, Pour, Flash, and Fire Points

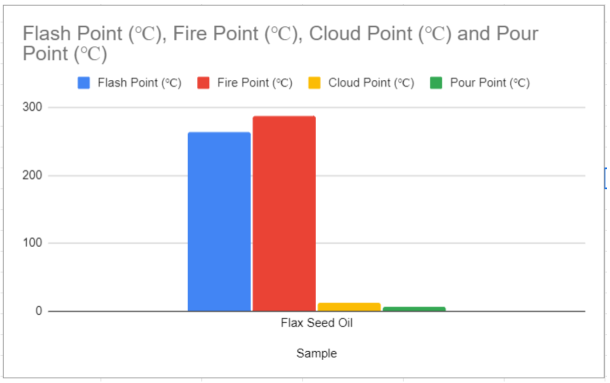

Figure 5 Cloud, Pour, Flash and Fire Points

The Cloud and Pour points as well as Flash and Fire

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Points are evaluated and Shown in Figure 5. The Flash and Fire points are observed to be 264℃ and 287℃ respectively after chemical modification indicating better high temperature properties post chemical modification. Similarly, the Cloud and Pour points are found to be 13℃ and 7℃ respectively indicating that the chemical modification of the oil has resulted in improved low temperature properties and thereby improved the storage capacity of the lubricant.

3.3.Viscosity

Table 2 Viscosity of The Modified Oil

TEST	RESULT
Viscosity	24.661 centistokes

The lubricating property of an oil is determined by its viscosity. From Table 2. It can be observed that the modified oil has god viscosity property which in turn proves its good lubricating ability. The chemical modification process has resulted in the removal of unsaturated fatty acids which is responsible for the increase in the viscosity of the oil. Figure 6. Shows the oil formed after chemical modification.

Figure 6 Modified oil

Conclusion

The present study focuses on the lubricating properties of chemically modified flax seed oil and how it can be viewed as a potential base stock for bio lubricant applications. The results of the study show that the chemically modified flax seed oil exhibited better coefficient of friction, low wear scar diameter, better flash and fire points, better cloud and pour points and better viscosity indicating that modified flax seed oil has the potential to be used as a base stock for bio lubricant applications.

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