Enhancing Rheological and Thermal Properties of a Biodegradable Lubricant Developed from Have a Brasiliensis (Rubber Seed) Oil using Additives

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Abstract

In the present context, mineral oils that we use for lubrication purposes in equipments are not ecofriendly or biodegradable. Most of them are hazardous to the microorganisms when they are spilt into the soil. This project aims to evaluate the possibility of developing a biolubricant with comparable rheological and thermal properties to that of the commercially available mineral oil. Estimation of rheological and thermal properties of Rubber Seed oil (RSO) and improving the properties by addition of nanoparticles and comparing with commercially available mineral oil (SAE10W30) are the main objectives of this project. Rheological properties include kinematic viscosity and density. Important thermal properties evaluated are flash point, fire point and temperature at which mass degradation starts (TGA temperature). Additives include nanoparticles like TiO2, MoS2, CuO, graphite.

Keywords: Biolubricant, Nanoparticles, Kinematic Viscosity, Flash Point, Fire Point, TGA

I. INTRODUCTION

Every mechanical system is associated with certain amount of friction which is inevitable in all cases. This cannot be eliminated but can only be controlled.

Lubricating in the region where friction is acting is the only possible way to reduce it and eliminate wear and tear. Lubrication is done with the help of lubricating oils or grease. Our aim is to enhance the properties of a vegetable oil and use it for lubrication purposes.

As far as the present situation is concerned, diminishing of mineral oils, escalating oil prices, pollution caused due to spillage of oils to earth are the major challenges faced by human kind. Conventional practice of creating lubricants from mineral oils and using hazardous additives are causing global environmental concerns. However friction and wear has to be reduced in some way in order to achieve better efficiencies. So the best alternative for mineral oils are environmentally obtained biodegradable oils. The recent researches around the globe deals with nanoparticles and their application in many areas including lubrication.

In the past large quantities of mineral oils were spilt on earth either accidentally or purposefully. Now these actions have come to great environmental concerns. There are two basic approaches for dealing with environmental safety with regards to lubricants. First is to find ways to eliminate disposal of used lubricants into environment and second is to develop eco-friendly biodegradable lubricants. In this scenario, the present work considers latter approach to design and develop eco-friendly biodegradable lubricant which is a sustainable way of approaching a prospective future. There are some more issues which suppresses the use of vegetable oils as biolubricants such as high temperature stability and wear rate. These can be controlled by the use of additives including nanoparticles.

II. LITERATURE REVIEW

AmithAravind et al. [1] evaluated physio-chemical properties like pour point, cloud point, flash point, acid number, saponification number, viscosity, viscosity index etc was determined with standard test conditions and are tabulated. Viscosity value has been

compared with standard SAE oil. TGA (Thermo Gravimetric Analysis) and DSC (Discrete Scanning Calorimetry) test results brings out the thermal stability and properties of the oil. The physio-chemical properties of RSO confirm that it can be effectively used to develop a biodegradable lubricant as an alternative to commercial lubricant. It is thermally stable upto 225°C which is the same as that of SAE 20W40. It has a better viscosity index and a lower coefficient of friction. Thus it can be concluded that RSO has immense potential to be developed into a biodegradable lubricant. Jayadas et al. [2] presents the thermo-gravimetric analysis of coconut oil, sesame oil, sunflower oil and commercial 2T oil under nitrogen and oxygen environment to study their thermal and oxidative degradation and analysis of low temperature properties of vegetable oils using differential scanning calorimetry (DSC). Coconut oil showed lower weight gain, an indication of oxidative stability, under oxidative environment and the highest pour point among the vegetable oils considered. This can be attributed to the predominantly saturated nature of its fatty acid constituents. Koshy C.P et al. [3] studied about tribofilms formed from Cupper oxide (CuO) nanoparticles in nano-lubricant under boundary or thin film lubrication conditions. The tribological performances are linked to tribofilm properties and consequently to lubrication conditions. Analysis of mineral oil (paraffin wax) or vegetable oils (coconut oil and mustard oil) as a nano-lubricant is carried out in perspective of its tribological behaviour using pin-on-disc tribometer. Small quantitiesofCuO nanoparticles are added to the base lubricating oil and ultrasonic shaking is carried out on the mixture, to formulate the corresponding nano-lubricant. The variation of its friction-reduction and anti-wear properties have been analysed at ambient and elevated temperatures. Surface structure of a worn surface obtained by Atomic Force Microscope (AFM) and Scanning Electron Microscope (SEM) shows that average roughness value decreased drastically when nano-lubricants are used rather than bade lubricants. Studies done by AmithAravind et al. [4] shows that RSO has a potential to be a lubricant base stock by lowering the acid value and by reducing the unsaturation. It has a high percentage of unsaturated fatty acids with oleic acid being most abundant and thermally stable up to 250℃ which is comparable to that of SAE 20W-40. It has the highest viscosity index and low pour point amount among vegetable oils investigated in the study which ensures that it can be used in cold temperatures. The BOD5/COD ratio conforms its biodegradability RSO has the lowest WSD when compared to coconut oil and sunflower oil. It has an appreciable COF.

III. METHODOLOGY AND MATERIALS USED

A. Materials Used

The basic components of the bio-lubricant are the base oil and additives. The density of RSO was determined using a pycnometer and different percentages of nanoparticles ranging from 0.5%-1.5% to the mass of 200 ml RSO was mixed using an ultrasonic agitator. The nanoparticles were added to the base oil and mixed in the ultrasonic agitator at 40 ^{0}C for 15 minutes. 200 ml of the base oil was considered because of the amount oil required for different tests

B. Flash and Fire Point

A Cleveland open cup apparatus was used for the measurement of flash and fire point as per ASTM D92.

C. Thermo Gravimetric Analysis (TGA)

TGA was employed to give an insight into the change in weight with respect to change in temperature. The measured weight loss curve analyses the thermal stability of the samples. TGA of samples were performed under an oxygen environment on a PerkinElmer STA6000 in a temperature range of 0–600◦C

D. Kinematic Viscosity

A Saybolt viscometer is used for to measure the viscosity of the samples. The efflux time of a specified volume of fluid is measured through fixed orifice at the bottom of a cup to represent the viscosity of the fluid. Since the viscosity of Newtonian liquid are independent of dimensions of viscometer used, it is possible to convert the efflux times to kinematic viscosities by conversion charts or by formulas suggested by the equipment manufacturers.

IV. RESULTS AND DISCUSSION

The flash and fire point of the samples were determined using Cleveland open cup apparatus. Six samples were uses for conducting the test. The temperatures of the samples are shown in Table 4.1

Table - 4.1
The flash and fire point of samples

Type	*Flash point (^{0}C)*	*Fire point(^{0}C)*
SAE 10W 300	*216*	*222*
RSO	*208*	*216*
RSO(0.5% TiO_2)	*210*	*216*
RSO(0.5% CuO)	*212*	*218*
RSO (1% TiO_2)	*214*	*220*
RSO(1.5% TiO_2)	*214*	*220*

1% TiO_2gave an increase in the flash and fire point temperatures and increasing its concentration beyond 1% did not increase the values.

TGA was employed to give an insight into the change in weight with respect to change in temperature. The measured weight loss curve analyses the thermal stability of the sample. The thermogram under oxygen environment of the samples in Fig.4.1 showed that the samples are thermally stable up to 250◦C. Weight loss starts after 250◦C and after 300◦C rapid degradation occurs.

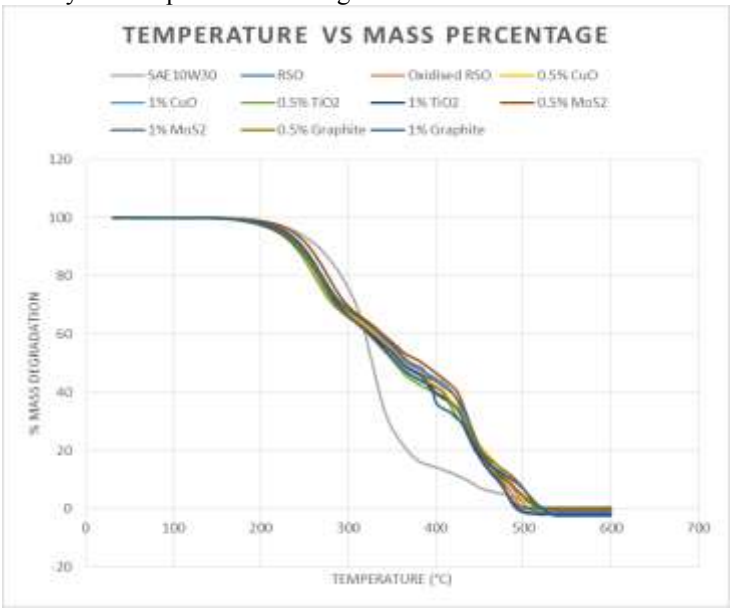

Fig. 5.1: TGA of samples

The thermal stability of RSO with different additives was analysis was done using the TGA and it was found that 0.5% MoS_2 gave an increased temperature of 259 °C. The result has been compared with those of other oil samples and a commercially available lubricant, SAE 10W30. The curve of RSO with 0.5% MoS_2 is similar to that of SAE 10W30 between 200°C to 300°C The kinematic viscosity test was conducted on a Saybolt viscometer in which the time of discharge of oil from the apparatus for every temperature from 40°C to 100°C for 10°C rise in temperature was recroded the value was considered in seconds or Saybolt seconds. The variation of kinematic viscosity with temperature of RSO with different additives is shown in Fig.4.2

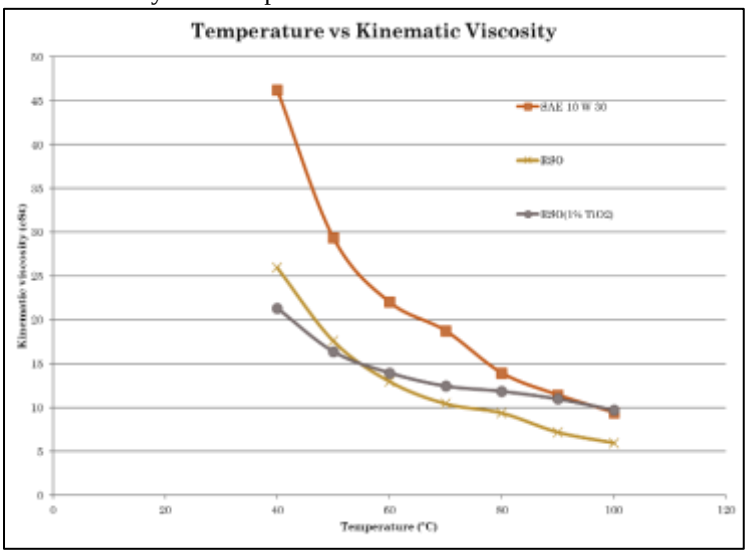

Fig. 5.2: Variation of kinematic viscosity with temperature

V. CONCLUSION

The studies show that RSO has a potential to be developed as a lubricant and is thermally stable upto 250^0C which is comparable to that of SAE10W30 which can be further increased by the addition of MoS_2 nanoparticle. The thermal properties like flash and fire were further enhanced by the addition of CuO and TiO_2 nanoparticles. The rheological property that was considered was kinematic viscosity and by the addition of TiO_2 it was found to increase at high temperatures and comparable to that of the commercially available reference oil SAE 10W30 so it is confirmed that the rheological properties can be enhanced by the addition

of proper nanoparticles Further work has to be carried out to exploit RSO and develop it into an eco-friendly lubricant to meet the rising needs of the world today and in future.

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