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# Study of Stearic acid as Additive for the Bio lubricant Formulations in Neem seed oil

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**ABSTRACT**

Vegetable oils are being considered as a potential source of renewable energy and environmentally favourable lubricant for future generations due to its good lubricity, high thermal property and its biodegradability. This paper evaluate and compare the lubricant properties and environmental effects of Neem seed oil with and without additive with that of commercially available mineral oil SAE20W40. The lubricant properties such as tribological, thermal, rheological properties and environmental effects like the biodegradability are evaluated and compared. The neem seed oil are mixed with various proportions of stearic acid. The coefficient of friction and wear scar diameter of neem seed oil in combination with stearic acid seems to be less and more efficient than the plain neem and the mineral oil separately. The viscosity improvement with the addition of stearic acid in neem seed oil is negligible, but stearic acid is found to a viscosity index booster in neem seed oil. The addition of stearic acid helps to improve the pour point of base oil. The biodegradability of neem seed oil with and without stearic acid were determined and compared with SAE20W40.

**Keywords -** Neem seed oil, Stearic acid, Thermal stability, Biodegradability, Viscosity.

## 1. INTRODUCTION

The lubricants used today are normally the mineral based, mainly obtained from petroleum products. The main use of them comes as an automotive fluid or as automotive gear lubricant. Vegetable oils are environmental friendly, non-toxic, renewable resources and are bio degradable. Today, a concern over the use of environment friendly lubricants has risen in public due to the environmental problems caused by the conventional mineral oils. Such lubricant may possess low toxicity but gets accumulated in the environment during a long run and may pollute the environment [1, 2].This led to the promotion of vegetable oils in all sectors of society as a base stock which act as an environment friendly bio lubricant formulation. The properties like low toxicity, anti-wear properties, biodegradability makes vegetable oil more favorable and still good efforts need to be kept worked on for its development and to maintain such properties for future.

A lot of past researches were focused on the development of vegetable oil as bio lubricant candidate. The anti-wear properties of soya been oil and olive oil was investigated by U.S. Choi et al. [3] with dibutyl 3.5-di-t-butyl 4-hydroxy benzyl phosphate (DBP) as additive and compared with Tri cresyl phosphate. S. rani [4] studied the tribological properties of rice bran oil with an additive mixture of polymers like Ethyl vinyl acetate (EVA), Low density polyethylene (LDPE) and anti-oxidants like butylated hydroxyl toluene (BHT), Tertiary- butyl hydroquinone and 12- hydroxyl stearic acid. The coefficient of friction was less than the SAE 20W40 and wear seemed to be higher than SAE20W40. A. Adhvaryu et al. considered the wear properties on Soybean oil, thermally modified soybean oil and chemically modified soybean oil.

Viscosity of oil is a major parameter to be considered which controls the variation in film thickness. The polar groups with the long fatty acid chain in vegetable oil structure allows to act as both hydrodynamic and boundary lubricant. Vegetable oil normally possess low viscosity in comparison to mineral oils. Addition of chemicals and polymers can change this viscosity property. S. Rani et al. [4] shows that the viscosity improving characteristics can be achieved by means of EVA co-polymer in rice bran oil.

S. Rani et al. [5] evaluated the biodegradability and toxicity for rice bran oil and also estimated the increase in turbidity with bacterial growth. The thermal properties were also investigated in this case.

## 2. EXPERIMENTS

### 2.1 Materials

The neem oil extracted from neem seeds were collected from National Oil Traders, Coimbatore, Tamil Nadu, India. The stearic acid pellets with 0.847g/cm$^3$ density, melting range 54-56°C was obtained from Nice Chemicals (P) LTD, Edappally, Kochi, Kerala, India.

### 2.2 Preparation of bio lubricating oil formulations

The main sample formulation of Neem seed oil was prepared using Stearic acid. The Stearic acid additive was added in a proportions ranging from 0.5% to 2.5% in weight percentage. The stearic acid was heated with Neem seed oil in an electric heater at 70ºC for 20 minutes and mixed thoroughly in an ultra-sonic probe, Vibra- cell VCX750 for next 10 minutes. A homogeneous clear solution is seen in this case.

### 2.3 Measurement of Coefficient of friction and Wear

The four ball tester was used to determine the tribologiacal properties like coefficient of friction of formulated oil samples. The four ball tester possess one rotating ball which comes in contact with other three balls fixed in a ball pot. The rotating ball rotates at a speed of 1200 rpm for 3600 seconds at a temperature of 75ºC. The ball is chromium steel ball of 12.7mm diameter with 64HN hardness. The standard ASTM D4172 B is used to evaluate the coefficient of friction followed by measurement of wear scar diameter by means of image acquisition system.

### 2.4 Measurement of Viscosity

The Brookfield LVDV2T viscometer was used to evaluate the dynamic viscosity of samples as per ASTM D2983-09 standard and ASTM D2270 for evaluating the viscosity index.

### 2.5 Measurement of Pour point

The thermal analysis involving the pour point evaluation the of best formulated sample, Neem+2% Stearic acid along with Plain Neem and SAE20W40 was performed using Differential scanning calorimetry (DSC).

### 2.6 Biodegradability

The biodegradability test in this case was conducted in a bacterial growth medium. The Pseudomonas aeruginosa is the bacteria cultivated in the oil sample mixture and with dimethyl sulphoxide (DMSO) at 100µg/ml of concentration. A temperature of 28ºC and humidity of 40% RH was used to incubate the samples. The increase in biodegradability shows the bacterial growth inside the medium by oxidizing the carbon chains contained in samples.

## 3. RESULTS AND DISCUSSIONS

The coefficient of friction and wear scar diameter are the tribological properties measured from the formulated oil. The variation in the values of coefficient of friction of neem seed oil, neem seed oil with various proportions of stearic acid and SAE20W40 is shown in Fig. 1. A clear decrease in the coefficient of friction can be seen from plain neem to neem with 2% stearic acid.

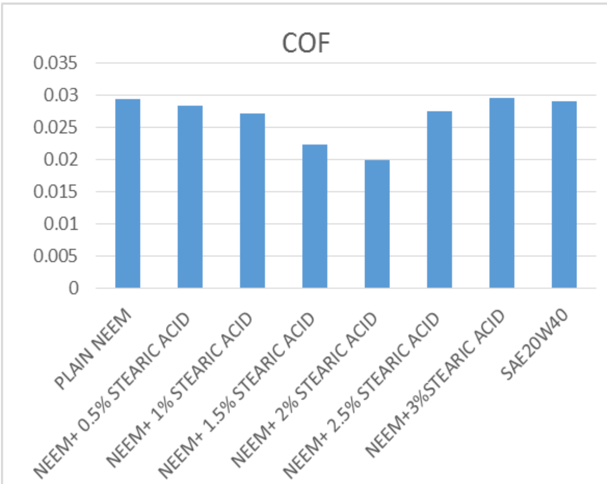


*Fig. 1 Variation of Coefficient of friction with various proportions of the neem oil*

The presence of fatty acids in Neem seed oil causes very less coefficient of friction for the formulated oil. The carboxylic group present in the fatty acids has a capability to be adsorbed on the metallic surfaces which causes low coefficient of friction [2]. The decrease in coefficient of friction rate can also be influenced by oil structure of oil content.

The Fig. 2 shows a similar trend like COF, where the wear scar diameter decreases up to a concentration of 2% stearic acid with base oil and goes increases. Such an initial decreasing and then increasing trend in coefficient of friction and wear scar diameter is due to the additive concentration.

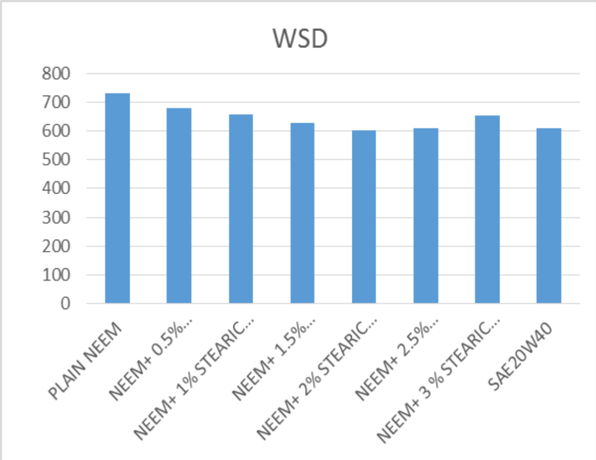


*Fig. 2 Variation of wear scar diameter with various proportions of the neem oil*

The neem oil is able to form a continuous protective film in between the contact surfaces due to the adsorption of additive on the metallic surface. The strength of film formed with adsorption of additives increases with concentration of additives up to a particular level from tin to thick. Beyond that level, the increase in additive concentration causes agglomeration effect of additives in neem oil rather than adsorption and result in the decrease in film strength and there by following to increase in COF and wear scar diameter. For neem + stearic acid, the best result was obtained at a concentration of 2% stearic acid at which both Coefficient of friction and Wear scar diameter of the neem oil with the respective additive concentration showed lower value than the mineral oil SAE 20W40.

The Brookfield viscometer LVDV2T was used to evaluate the viscosity of samples as per ASTM D 2983-09 standard. The viscosity enhancement of neem seed oil mixed with various proportions of stearic acid was evaluated at every 5ºC increment varying from 40°C to 100ºC.

It is evident that there was no significant improvement in viscosity of the oil while adding stearic acid. At the same time, mineral oil showed more than twice the viscosity of the neem+ stearic acid samples. The stearic acid being an anti-wear additive, it did not give an improvement in Viscosity as shown in Fig. 3.

From Fig. 4, while considering the viscosity index, neem oil + stearic acid is definitely superior to mineral oil SAE20W40.

Differential scanning calorimetry test was used to investigate the effect of anti-wear additive in neem seed oil and thus obtaining the thermal property of sample. The table 1 shows clearly that, the addition of anti-wear additive stearic acid reduces the pour point of base oil.

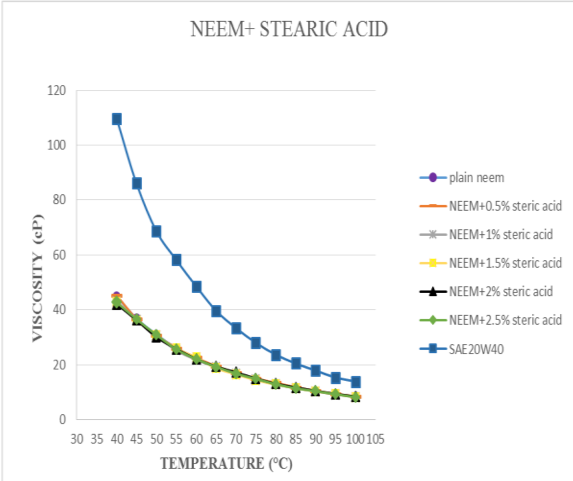


*Fig. 3 Variation of viscosity of neem oil with stearic acid*

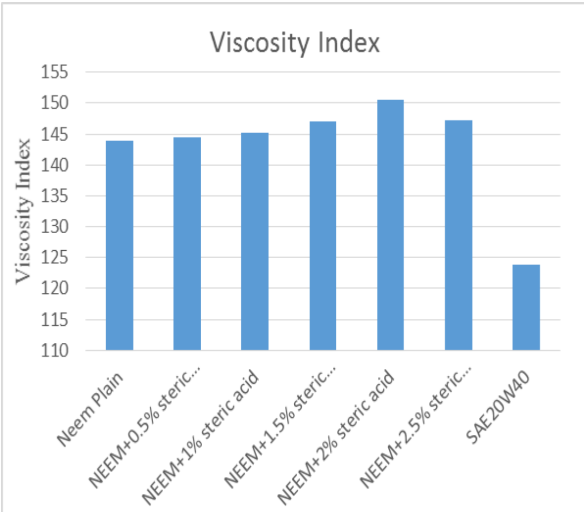


*Fig. 4 Viscosity Index of neem oil with stearic acid*

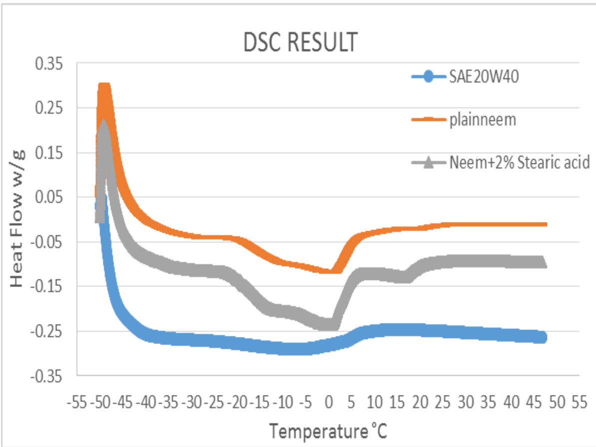


*Fig. 5 Differential scanning calorimetry of Plain neem, neem + 2% stearic acid and SAE20W40*

*Table 1 Pour points of the oil samples*

| Sample | Endothermic peak (Pour point) (°C) |
|---|---|
| Plain Neem | 2 |
| Neem+2% Stearic acid | -3 |
| SAE20W40 | -10 |

The biodegradability can be considered as the main parameter of bio lubricant. It is evaluated by means of the increase in percentage of turbidity of the bacterial growth in the samples [2].The figure 6 represents the result of biodegradability. Neem seed oil provides very good exposure for the bacterial growth. The turbidity of other sample with stearic acid has reduction in turbidity value. The SAE20W40 provides the lowest turbidity curve resulting in lower biodegradability. The test clearly shows the high biodegradability of neem plain oil.

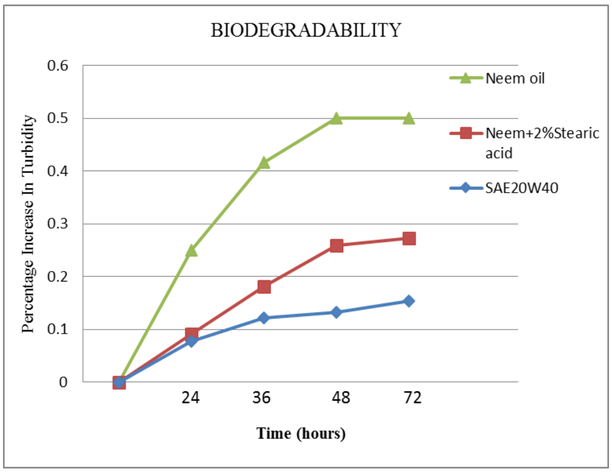


Fig. 6 Biodegradability of oil samples

## 5. CONCLUSION

The feasibility of bio lubricant development from neem seed oil using an anti-wear additive has been considered systematically. The wear and Coefficient of friction are enhanced by means of appropriate additive and has found that these properties of formulated oil is efficient than the SAE20W40 due to the presence of stearic acid.

The formulated sample possess nearly same viscosity throughout, which is less than the viscosity range SAE20W40 around the temperature range of 40°C - 100ºC. But, the addition of stearic acid improves the viscosity index and can be a supplier of viscosity improver along with an appropriate antiwear additive. Similarly, the addition of stearic acid decreases the pour point of plain neem but not less than SAE20W40. The biodegradability of neem seed oil seem to be highly bio degradable than mineral oil.

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