Rheological Analysis on Joannesia Princeps Oil for Sustainable Bio-lubricant in Electric Vehicle Application

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Abstract: The Petroleum-based lubricants cause harmful effects on the environment due to its non-degradable and highly toxic properties. The shortage of mineral oil reserves leads to finding an alternative for petroleum and its product. The present study analyzes rheological properties of Joannesia Princeps oil for evaluate its potential to work as electric vehicle lubricant. Test samples prepared with multi wall carbon nanotubes (MWCNT) and Cerium oxide (CeO₂) nanoparticles to change the enhancement in rheological properties. It was observed that MWCNT and CeO₂ made 14% and 12% improvement in viscosity at lower shear rate respectively, however no significant change was observed at higher shear rate.

1. Introduction
To perform lubrication, there are two types of lubricating oil i.e. Grease lubrication and Oil lubrication. Grease lubrication is mainly three types 1)Lithium-based grease 2)Urea-based grease 3)Calcium-based grease. All these three lubricants are manufactured from chemicals [1]. Petroleum-based lubricants are made of 80–90% hydrocarbon distillate with 10–20% additives to provide specific properties to the oil. Other additives added are Hydroperoxides, free fatty acids, epoxides, etc.. These additives are harmful to nature and human beings [2].

The term bio ointment applies to all greases that are effectively biodegradable and non-harmful to people and the climate. The employment of bio-greases are still exceptionally restricted when contrasted with those of mineral oils, despite the fact that this pattern is expanding and relies upon interest in innovative work (R&D). Biolubricants can be produced from fusel oil. For this situation, longer chain corrosive mixes (unsaturated fats from, for instance, hydrolysis of plant oils) ought to be utilized in the esterification response. Biolubricants are useful liquids produced using vegetable oils and downstream esters. For instance, coconut oil as a bio ointment has been utilized in India for three-wheeled vehicles. Since the beginning of development, plant determined oils have consistently assumed a key function in a man's life by giving basic sustenance. Following a large number of long periods of training of oil plants, in the present world, they are endorsed for restricted human utilization, and also, their application is extending in numerous ways. Plant-inferred oils are presently utilized as bio-greases as well as biofuels, which are practical manageable hotspots for environmentally friendly power [5].

Properties of Bio-Lubricant [6]
1. Thermo-Oxidative Stability
2. Hydrolytic Stability
3. Thickness
4. Pour Point
To utilize vegetable oils as ointments, a few methodologies have been embraced to improve the properties of vegetable oils. The hereditary alteration, added substance treatment, transesterification, epoxidation, synthetic adjustment, auxiliary change, and additionally biotechnology is a portion of the methods that have been utilized. These strategies improve the presentation and security of vegetable oils for their immediate applications. Huge quantities of examinations have been done utilizing different methods with vegetable oils as an option for greasing up oil everywhere in the world. Some of them have been summed up beneath [6].

The tribological applications of different non-edible plant were examined by various studies such as moringaoleifera seed [7-9], Calophylluminophyllum [10-12] balanitesaegyptiaca [13], MicheliaChampaca [14], Shorea Robusta [15], Juliflora oil [16] and Jojoba oil [17-18]. Existing studies include the development of a biolubricant from non-edible plants by enhancing tribological properties through chemical modification and using nanoparticles.

Joannesia princeps commonly known as Arara Nut Tree is a native plant in Brazil. It is a species of the tree of the family Euphorbiaceae. It is a deciduous tree with an elongated, dense crown and it can grow 15 - 20 metres tall. The erect bole is 40 - 60 cm in diameter. The tree produces large fruits with 2 or 3 egg-shaped seeds. In the view of empowering and developing bio-lubricants we did thorough research on a form of plant which can serve as a biolubricant and that plant is called Arara Nut Tree scientifically known as Joannesia Princeps vell. According to some reports it is assumed that the number of vehicles will be increased from 8 million to 30 million, which will put pressure economically and environmentally on the lubricating oil usage across the world.

Now normally lubricating oils are developed chemically which is costly and harmful to nature. The seed has an oil with strong purgative action, and considered to be poisonous to humans. It has a self-supporting growth form. It is an autotroph which means it can transform light into chemical energy. The plant is cultivated in many tropical countries, especially in Asia but also in Africa, for the oil obtained from its seed, and also for ornamental purposes. The species has been in decline through forest conversion for agriculture, livestock and plantation projects. In addition, it is exploited for its valuable wood.

Some other properties of oil are:
1) Seeds contain 37% of a heavy yellow oil which is used as fuel.
2) Seeds and Barks are used as medicines to treat ascites, diarrhoea, cut wounds etc.
3) It can be easily sown and does not require any pre-treatment [3]. The seed is rinsed with water to remove other undesirable material and dried under normal temperature. The air-dried leaves (100gm.) of Joannesia princeps vell were crushed. Further, crushed leaves treated with petroleum/ether and extract evaporated to collect residue.

2. Materials and method

In present study, plain oil and with Multi-Walled Carbon Nanotubes (MWCNT) and cerium oxide (CeO2) nanoparticles were used for the modification of rheological properties of Jonnesia Princeps oil. Nanoparticles are taken at uniform concentration of 1 gm in 100 ml of tamanu oil. Nanoparticles are homogenized by intensive ultrasonication for 30 minutes. Rheological properties of samples are measured in shear rate ranging 0-200 s\(^{-1}\). Initially zero shear viscosity was measured for each sample by increasing shear rate and measuring the point of first moment of the rheometer bob.

3. Results and discussion

Viscosity shows the contaminant present in lubrication which helps to assess the life of lubrication oil. If the lubrication oil viscosity is high it indicates there are no of foreign particles accumulated in lubrication oil and if viscosity is less then it indicates shear thinning which shows
the lubrication oil is mixed with water or other fuel. Very high or low viscosity results in the damage of machinery.

Figure 1 shows change in viscosity with shear rate for plain Jonnesial Princeps oil. There was gradual reduction in viscosity with increasing shear rate, which indicates the shear reduction in lubrication strength. The reduction in viscosity indicative of shear thinning, which leads to exposure of metal-to-metal contact at higher speed.

![Fig 1. Viscosity vs shear rate for plain Jonnesial Princeps oil](image1)

Figure 2 displayed rheological properties of Jonnesial Princeps oil with MWCNT nanoparticles. In this, 1gm MWCNT is disperse in 100 ml sample to prepare biolubricant. The sample are prepared by magnetic stirrer and intensive ultrasonication for 30 minutes. The viscosity test was performed with the help of LMDV 200 viscometer. Lubrication oil sample was placed under the viscometer and speed set to 1 RPM at room temperature due to high viscosity it is unable to calculate. So reading was considered from 5 RPM and the rest of the results are conducted with equal intervals of time and constant temperature. The test was performed up to 200 RPM to know the efficiency of lubrication oil. The trend to shear thinning reduce in presence of MWCNT nanoparticles.
Figure 3 shows viscosity variation in Jonnesial Princeps oil/cerium (CeO$_2$ (IV)) nano biolubricant. It has been observed the presence of CeO$_2$ (IV) nanoparticle reduces the trend of reduction in viscosity with shear rate. This indicates improvement over shear thinning behaviour.

A comparative on plain, with MWCNT and with CeO2 is displayed in Figure 4. It can be observed that there was higher increment in viscosity with MWCNT as compared to CeO2. Also, at higher shear rate, there was insignificant variation with the dispersion of nanoparticles.
4. Conclusion

In the present study, shear viscosity of Jonnesia Princeps oil was experimentally analyzed. The samples are prepared with MWCNT and Cerium oxide (CeO$_2$) nanoparticles. There was 14% and 12% improvement in viscosity at lower shear rate was observed with MWCNT and CeO$_2$ nanoparticles respectively. Bio-lubricant provides a potential ecofriendly substitution of mineral oil based lubricant. Detailed analysis is required to establish its behavior. The presence of nanoparticles have significantly improve lubrication behaviour.

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