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Rheological analysis on tamanu oil for sustainable bio-lubricant in electric vehicle application

Abstract

The demand of automotive lubricant and challenge of its properly disposal after use is gradually increasing. The present study analyze rheological properties of tamanu oil, extracted from *Calophyllum iniphyllum* seed, to provide an alternative lubricant for electric vehicle. The oil samples are tested in plain and with MWCNT and Cerium oxide nanoparticles. The dispersion of nanoparticles provides reduction in shear thinning behavior and hence improving the lubrication properties.

Keywords: lubricants, bio-lubricants, electric vehicle, sustainability

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Introduction

The concern for sustainability drawn attention of research community to search for bio-lubricants. Bio-lubricant are usually organic molecules, introduce in mating surfaces to reduce friction and wear. Typical lubricant has elevated flash & fire point, good anti-friction and anti-wear properties. of the TMP ester; significant lubricity property.

Calophyllum inophyllum is a huge evergreen plant, generally called tamanu, mastwood, beach calophyllum, beauty leaf or Sinhala. It is local to tropical Asia and *Wallacea*. Because of its significance as a wellspring of wood for the customary shipbuilding of huge outrigger ships, it has been spread in ancient occasions by the relocations of the Austronesian people groups to the islands of Oceania and Madagascar, alongside different individuals from the variety Calophyllum. It has since been naturalized in areas in the East African coast. It is additionally a wellspring of the socially significant tamanu, it is an expansive leaved evergreen tree generally planted all through the jungles and without any problem developed along the coastal region. The tree is esteemed for its strength furthermore, magnificence as a fancy tree. Oil from the nuts has been generally utilized for medication and makeup. Yearly yield of Calophyllum is around 20100kg/tree of entire organic fruits. Trees start to manage essentially following 4-5 years. The nut portion contains 50-70% oil.[1–21] Adeyeye et al.,[19] chavan et al.,[20] has revealed that the calophyllum oil displayed great physico synthetic properties also, could be utilized as a biodiesel feedstock and as an industrial Application.

Electric vehicles are continuing to make major inroads into personal mobility and as a future transportation. Even though sales of new Electric Vehicles are increasing exponentially around the world over a still-small base – they have had little impact on lubricant formulations to date. The need for conventional engine oils may be eliminated in battery electric vehicles, but all electric vehicles still require numerous types of lubricants, fluids and greases, especially when one considers hybrids that still contain internal combustion engines. Many of those lubes have performance requirements in common with those of conventional vehicles. There is a general push toward lighter viscosities to help maximize efficiency, and anti-wear remain important parameters.

The high torque in the wheel bearings of an Electric vehicles need to be well controlled. The grease used in these need to perform consistently at elevated temperature fluctuations as there is instant torque and high-power is generated and will be instantly without any losses compared to conventional Diesel and petrol vehicles or also called as Internal Combustion Engines (ICE's). These requirements raising the need for Bio- based lubricants as conventional mineral Lubricants is causing huge damage to environment by releasing harmful residues and production of these lubricants reducing the rare earth metals and extraction of oils from these are tedious process these were the main concerns forcing to use Lubricants produced form natural materials like vegetable oils and naturally available resources which can be used without effecting the environment and Vehicle performance. In the present investigation biodiesel was obtained from *Calophyllum inophyllum* (tamanu oil) plant oil as an alternative to mineral based Lubricants due to its nature friendly properties and availability. Viscosity of tamanu oil is measured by shear rate with the help of viscometer apparatus. It also checks the compatibility of changing fossil based lubricant to bio based lubricant.

Materials

The *Calophyllum inophyllum* plants are widely dispersed throughout the tropics, including the Indian Peninsula, Hawaiian and other pacific islands. They typically grow into eight to twenty meters at maturity. The common habitats include strand or low-elevation riverine, 0–200 m in tropics, up to 800 m at the equator, mean annual temperatures 18–33°C, annual rainfall 1000–5000 mm. They are also commonly found on beaches and in coastal forests.[19] They grow best in sandy, well drained soils. They may initially grow up to 1 m in height per year on good sites, although usually much more slowly. The agro-forestry uses include mixed species woodlot, windbreak, and home garden; with their main products of timber and seed oil. Studies reveal that the annual yield of 100 kg nuts/tree/y[20] with a yields 5kg of oil on an average. These trees have low potential for being invasive. It is a member of *Clusiaceae* family, which is native to Australia and has many attributes to be used as a biodiesel feedstock. Productivity of tamanu oil is 3744 kg/ha within density 400 trees/ha. Seed yields 65% oil that contains 24.96% saturated fatty acid and 72.65% unsaturated fatty acid.[21] The tamanu seeds were dried at 40°C and crushed to certain particle size about 1-2 mm. Although, the oil have similar viscous properties, but there was significant variation acid values.

Extraction of oil

The Calophyllum-Inophyllum plants produces its seed in a nut casing. The nut then is taken from the Calophyllum-Inophyllum plants and we make those nuts to dry at the temperature of 40°C. After that the nut or the shells are been broken to remove the seed from shell. The seed which we get after removing from shells are then decorticated by wooden mallets or by decorticators or by pressing under planks. And then the kernals are pressed in wooden and stone ghani to yield 70-75% of greenish –yellow inedible oil.

Results and discussion

Experimental testing on physical properties of lubricating needed to ensure its satisfactory functioning. Existing studies shows the flashpoint, calorific value and other propertis of tamau as listed in Table 1. Tamanu oil are about 10% denser than diesel. Figure 1 shows the variation of shear stress with shear rate on plain tamanu oil. It can be observed that there is reduction in shear stress with shear rate, which is an indicative of shear thinning behavior. Figure 2 the rhelogical properties with the dispersion of 1 gm MWCNT nanoparticles in tamanu oil. Sample is prepared by 30 minute intensive ultrasonication (Figure 2). It was observed that the presence of MWCNT nanoparticles has reduce shear thinning behavior. Figure 3 shows the variation in shear stress with shear rate for cerioum (CeO_2 (IV)) nanoparticle based sample. it can be observed that shear thinning behavior decreases with dispersion of CeO_2. It can be observed from the test results that shear thinning behavior reduces with the dispersion of nanoparticles at lower shear rate. However at higher shear rate, there is almost not improvement over shear thinning behavior observed.

Table 1 Properties of tamanu oil

Properties	Tamanu oil
Saturated fatty acid	
Palmitic (C16:0)	12
Stearic (C18:0)	12.9
Total	24.9
Unsaturated fatty acid	
Oleic (C18:1)	34.1
Linoleic (C18:2)	38.3
Linolenic (C18:3)	0.3
Total	72.4
Cetane number	57.3
Oilseed content, %w	65
FFA %w	22
Specific gravity	0.9
Viscosity 40°C (mm² /s)	72
Flash point	221
Calorific value (Mj/kg)	39.3
Iodine value	93.8

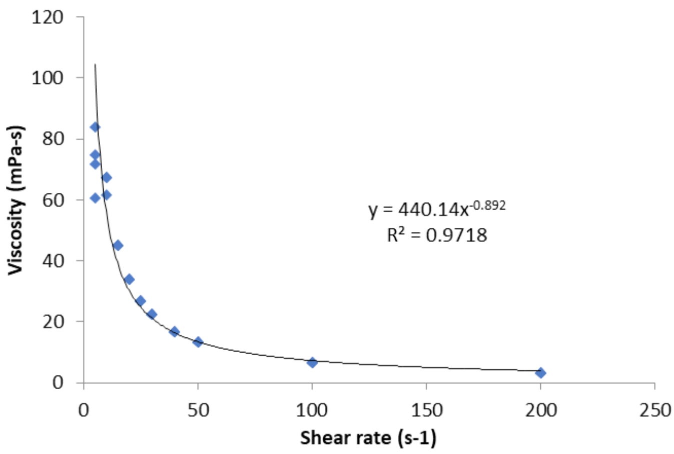

Figure 1 Variation in shear rate with shear stress for plain tamanu oil.

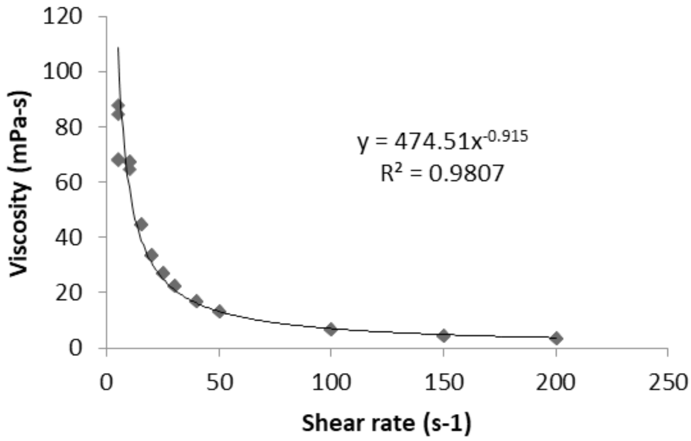

Figure 2 Variation in shear rate with shear stress for MWCNT-tamanu oil bio nanolubricant.

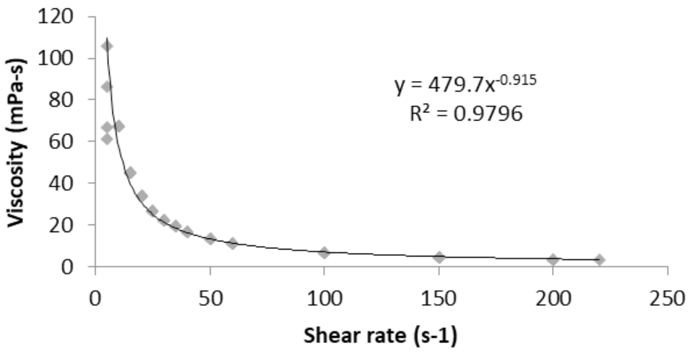

Figure 3 Variation in shear rate with shear stress for CeO_2-tamanu oil bio nanolubricant.

Conclusion

In conclusion when using Tamanu oil as an engine oil or in the parts of electrical vehicals tamanu oil comes out to be a very aggressive biolubricant as this tamanu oil has its shear thining property which does not tend any part of the Electric Vehicle to not to wear at any case and provide a very good lubricant property, as tamanu oil does not have sulphur like materials which when burnt inside any Internal Combustion engine provides very harmful gasses like sulphur dioxide , while in case of tamanu oil we are not having sulphur like harmful

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compounds hence we can use tamanu oil as the bio lubricant in Electric vehicles and as well as Engine oils.

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Conflicts of interest

There are no conflicts of interest.

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