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Use of Vegetable Oils as Bio-Lubricants: Review

Varun Kumar G R[1], Vasanth[2], Syed Azamuddin[3], Thyagraj L[4]

UG Scholar, Department of Mechanical Engineering, SVCE, Bengaluru, India[1,2,3,4]

Abstract: The vegetable oil being a biodegradable and nontoxic to environment also possess some desirable properties that can be used as an alternative substitute for petroleum lubricant. The production of bio-lubricant from non-edible vegetable seed involves two stage of transesterifation process. First stage is conversion of crude oil to biodiesel and second stage involves conversion of produced biodiesel into bio-lubricant. The produced bio-lubricants are tested for basic lubrication properties.And it can be tested for its wear and extreme pressure characteristics of oil under different loads, using four ball tester.Based on the result, the bio-lubricantis suggested as the substitute for petroleum lubricants for different application.

Keywords: Bio-lubricant, Methyl ester, Transesterification, Trimethylolpropane ester.

I. INTRODUCTION

The world market for environmental friendly lubricants is poised to grow in the upcoming years due to adverse effects of petroleum based lubricants which are non-biodegradable and toxic to the environmental. The main purpose of this paper is to suggestnon-edible vegetable oil as an alternative substitute for petroleum lubricant.

Vegetable oils are mainly triglycerides which contain three hydroxyl groups and long chain unsaturated free fatty acids attached at the hydroxyl group by ester linkages[1, 2]. The unsaturated free fatty acid which is defined as the ratio and position of carbon-carbon double bond, one, two and three double bonds of carbon chain is named as a oleic, linoleic, and linolenic fatty acid components respectively[3].Although vegetable oils possess many desirable characteristics, currently they are not widely used as lubricant base oils. Largely this is due to undesirable physical properties of most vegetable oils, which include both a high melting point andinsufficient thermal oxidative stability[4]. Chemical modifications may improve the thermal, oxidative and hydrolytic stabilities of the vegetable oils. The most important modifications occur on the carboxyl groups of the fatty acids, approximately 90%, while oleo-chemicalreactions on the fatty acid chain are approximately 10% [1].

The modification on the carboxyl group is performed by two stage of Transesterification process. The first stage involves the conversion of crude vegetable oil into bio-diesel i.e. methylester using methanol with base catalyst KOH and second stage involves the conversion of produced bio-diesel into bio-lubricant using trimethylolpropane with sodium methoxide as catalyst[5]. The produced bio-lubricant is tested for basic properties of lubricants and suggested as an alternative substitute for petroleum lubricants depending on different applications.

II. MATERIALS AND METHODOLOGY

The raw materials used during the experimentation are non-edible oil, methanol, and potassium hydroxide as a homogeneous catalyst. Test study chemicals like sodium hydroxide, methanol alcohol, distilled water(acid value test), sodium hydroxide for oil neutralization are employed respectively.For extraction of lubricant from biodiesel chemicals used are trimethylolpropane, sodium methoxide as a catalyst and ethyl acetate for removal of solid particles from the final product. The equipment used during the experimentations were mechanical oil extractor machine, beaker, centrifuge, Glass reactor equipped with mechanical stirrer, thermostat, condenser, separating funnel, Rotary Evaporator, balance, burette, water bath, conical flask, vibro viscometer, test tube, vacuum pump.

A. SYNTHESIS OF BIODIESEL

The vegetable seeds are collected and dried to remove the moisture content. Oil from these seeds is extracted using mechanical expeller. Oil is then filtered and FFA% is calculated.

Based on FFA %, the vegetable oil is transesterified using methanol with KOH as catalyst to produce methylester(bio diesel).The by-product from the reaction, methanol is removed by distillationfollowed by different purification processes.

The basic properties of crude and biodiesel are found and compared with ASTM are tabulated in Table1 [7]

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Table 1: Properties of palm oil and its biodiesel.

Specifications	Palm oil	Biodiesel	ASTM
Yield wt.%	-	98.5	
Density at 20 ^{o}C g/cm3	0.9134	0.8731	ASTMD-1298
Viscosity at 40 ^{o}CcSt	52.13	4.59	ASTMD-445
Cloud point	-	15	ASTMD-97
Flash point,	-	150	ASTMD-92
Calorific value, kj/kg	-	45212	ASTMD-240
Molecular weight	463.07	221.61	ASTMD-2503
Ash content, wt%	-	Nil	ASTMD-482
Copper corrosion	-	L a	ASTMD-130
Total acid number (mg KoH/g)	6.35	0.54	ASTMD-664

B. SYNTHESIS OF BIOLUBRICANTS

The produced bio diesel is heated to remove moisture content since trimethylolpropane is hydroscopic in nature. The biodiesel is then transesterified in second stage to produce bio-lubricant.

Transesterification process involvesmolar concentration of methyl ester with trimethylolpropane in ratio of 3.9:1.A three neck round bottom flask of 1000ml with condenser and vacuum setup is used for the process.At 60^{o}C the solid crystals dissolve in biodiesel with constant stirring action[5].

Then the temperature is gradually increased to optimum temperature of 130^{o}C and sodium methoxide(0.9-1% of total reactant weight) is added, reaction is forwarded by applying pressure gradually (-50mm of Hg) for 2hours.After completing the reaction the reactants are cooled to room temperature and ethyl acetate is added to remove the catalyst and vacuum distilled to remove methanol which is a by-product of the reaction.The final product obtained is trimethylolpropane ester which is Bio-lubricant is tested for basic lubricant properties and compared with ISO VG which are tabulated in Table 2[7].

Table 2 Properties of palm oil based Bio lubricant

Specifications	Vacuum pressure at 50 mmHg		Vacuum pressure at 10 mmHg	
	Palm oil TMP ester	ISO VG32	Palm oil TMP ester	ISO VG46
Yield, wt.%	97.4		97.8	
Kinematic viscosity cSt 40 ^{o}C	38.25	>28.8	50.33	>41.4
Kinematic viscosity cSt 100 ^{o}C	7.58	>4.1	10.87	>4.1
Viscosity index	171	>90	214	>90
Pour point	5	-6	5	-6
Flash point	240	204	253	220

C. CHARACTERIZATION OF CRUDE OIL, DIESEL AND LUBRICANT

1) **Density:**Density is found by measuring the empty beaker weight and it is noted, now a known volume of fluid(crude oil/biodiesel/lubricant) of 50cm^3 into the beaker and it is weighted. Now the density is calculated by taking the ratio of weight of the oil to the known volume (50cm^3)

2) **Viscosity:**viscosity if found by using Ostwald's viscometer. Transfer 10ml of liquid to dry viscometer into the wider limb. Suck the liquid with the help of rubber tube till it reaches above the upper mark and start the stop watch. Stop the watch when the liquid just crosses the lower mark. Record the flow time

3) **Pour Point:**The specimen is cooled inside a cooling bath to allow the formation of paraffin wax crystals. After every 3°C, the test jar is removed and tilted to check for surface movement. When the specimen does not flow when tilted, the jar is held horizontally for 5 seconds. If it does not flow, 3°C is added to the corresponding temperature, since this is the last measurement when flow was observed, and the result is the pour point temperature

4) **Cloud Point:** The temperature at which the wax crystals form is known as cloud point. The test sample is poured into the jar to approximate level. A test thermometer is used to close the jar with the help of cork. The entire setup is then placed in the cooling bath of constant temperature. At every 1^{o}C, the test sample is taken out and inspected for cloud formation

5) **Flash Point:**About 50ml of oil sample is poured into open cup apparatus and a test setup is made to measure the temperature. For every 5^{o}C rise in temperature of oil the fire is brought into the contact with the vapours. The procedure is repeated for every 5^{o}C rise until a momentary flash is absorbed

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6) **Fire Point:** About 50ml of oil sample is poured into open cup apparatus and a test setup is made to measure the temperature. For every 5^{o}C rise in temperature of oil the fire is brought into the contact with the vapours. The procedure is repeated for every 5^{o}C rise until the oil catches the flame

7) **Acid Value:**Acid number is used to quantify the amount of acid present in test sample. Acid value is inverse of percentage of free fatty acid

8) **% FFA:**1g of test sample is taken in a conical flask and 10ml of alcohol is added. The mixture is heated upto 60^{o}C and cooled to room temperature. The reactants is titrated against 0.1N NaOH solution using phenolphthalein as indicator

$$\%FFA=\frac{\text{titrevalue}\ *28.2*\text{NormalityofNaOH}}{\text{weightofoilsample}\quad(g)}$$

9) **Calorific Value:**Bomb calorimeter is used to find the CV of sample. A known quantity of sample is added to crucible with stirring and initial temperature of water is noted. Power is supplied and sample is burned in the presence of oxygen. Heat released by the combustion of sample is taken away water. Note the steady state temperature of water

$$HCV=\frac{(m1+m2)*(Tc+T1-T2)*CW}{mf}$$

III.CONCLUSION

The produced Bio-lubricant is tested for its basic lubrication properties and for its wear and extreme pressure characteristics under different loads using four ball testermachines. Based on the resultthe Bio-lubricant can be suggested as a substitute for petroleum lubricants for different applications.

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