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BIOLUBRICANT BASE STOCK SYNTHESIS FROM NON-TRADITIONAL (MAHUA) OIL USING MODIFIED GLYCEROL

DR. V.Y. KARADBHAJNE
Head of the Department, Dept. of Oil Fats and Surfactants, LIT Nagpur, Maharashtra, India
drvijaylit@gmail.com

PROF. A.J. AGRAWAL
Asst. Professor, Dept. of Petroleum Refining and Petroleum Technology, LIT Nagpur, Maharashtra, India
amitjagrawal@gmail.com

DR. P.S. AGRAWAL
Associate Professor, Dept. of Chemistry, LIT Nagpur, Maharashtra, India
Pratibha3674@gmail.com

MEHERESH GUPTA
Student, Dept. of Oil Fats and Surfactants, LIT Nagpur, Maharashtra, India
meheru1410@gmail.com

YASH DHOBLE
Student, Dept. of Oil Fats and Surfactants, LIT Nagpur, Maharashtra, India
yashdhoble099@gmail.com

TUSHAR THAKUR
Student, Dept. of Petroleum Refining and Petroleum Technology, LIT Nagpur, Maharashtra, India
tushar.thakur140496@gmail.com

ABSTRACT

With the increasing demand of mineral-oil based lubricants, they are burdened by environmental issues and depleting supplies. Constantly efforts are made by the technologists to reduce the use of fossil fuels for sustainable development. Due to this, the renewable sources of lubricants have gained significant importance in this environmental-concerned world. India is endowed with over 100 species of non-traditional oils that have not been focused for the commercial applications till the date. Though these oils are in abundance, their potential has not been utilized. Such oils with the high oleic acid content are considered to be the best alternative source to substitute the mineral oil based lubricating oils. In this paper mahua oil was selected as a raw material to produce biolubricant. It was initially transesterified to yield mahua methyl esters and further converted to biolubricant using trimethylolpropane (TMP). The biolubricant thus prepared was analyzed for its properties and was compared with a commercial 2T Engine oil. This chemically modified ester is relevant for performance as a lubricant in various industrial applications. In addition to this, an alternative to TMP in the form of modified glycerol was found and the properties of the biolubricants produced using TMP and modified glycerol were compared.

KEYWORDS: Non-traditional oil ; Transesterification ; Biodiesel ; Biolubricant ; TMP.

INTRODUCTION

The environmental threats posed by the fossil fuels are currently a major global concern. Major ecological problems the world is facing today is due to emission of green house gases mainly CO_2 and these emissions are closely related to the use of fossil fuels. It has been widely reported that not less than ten major oil fields from the 20 largest world oil producers are already experiencing decline in oil reserves. Depletion of the world's crude oil reserve coupled with the consumption rate, increase in petroleum prices and issues related to conservation has brought about renewed interest in the use of bio-based materials.

Various virgin oils such as soybean, rapseed, sunflower etc. are constantly being worked upon the production of methyl esters and their characterization. Biofuels are being given serious considerations as potential sources of energy in the future, particularly in developing countries like India. As India is endowed with over 100 species of non-traditional oils, some development works have been carried out by the government of India for producing biodiesel from non traditional oils like Jatropha, Mahua and Karanja. Biodiesel from mahua is important because most of the states of India are tribal where it is found abundantly. 30-40% of fatty oil can be extracted from mahua seeds. Nature of the oil used significantly affects the properties of the biodiesel.[4]These oils have good lubricating properties and high viscosity indices and therefore, they are being more closely examined as base oil for biolubricants.[1]

Bio-lubricants are primarily triglyceride esters derived from plant and animal sources. Oils with the high oleic acid content are considered to be the best alternative to substitute the mineral oil based lubricating oils which are non-biodegradable in nature. Studies have revealed that complex esters which were synthesized from high molecular weight fatty acids, trimethylolpropane and dicarboxylic acids have a variety of applications such as hydraulic oils, refrigeration oils, chainsaw lubricants, metal working fluids, engine oils, two-stroke oil etc.[2]The advantages such as high lubricity, viscosity index, low lubricant consumption, energy efficiency combined with public health, safety and environmental contamination, overpower the disadvantages of initial costs in many of these applications.[3]

Oils like palm and jatropha have also been focused upon for the synthesis of biolubricants. This was achieved by two step transesterification. In the first step these oils were treated with methanol to yield biodiesel and further with trimethalolpropane to obtain biolubricant.

In this paper a non-traditional oil namely Mahua is used as a raw-material for bio-lubricants. The objectives of this work are to obtain methyl esters from mahua oil and further to convert these mahua methyl esters into bio-lubricant and subsequently to find an alternative to TMP in bio-lubricant synthesis.

EXPERIMENTAL PROCEDURE

Mahua oil containing 46% oleic acid was selected and analyzed for its physico-chemical properties. Since the acid value was found to be high, two step transesterification process was adopted.

01) ESTERIFICATION

500 g Mahua oil was taken in a two neck round -bottomed flask and measured amount of methanol and sulphuric acid were added. Heat was supplied with the help of an electric heater and the reaction mass was continuously stirred to maintain a constant temperature for 1-1.5 hours. Samples were collected at regular intervals and acid value was determined. Once the acid value had reduced to the required value, the products were cooled and separated by gravity settling.[7].

02) TRANSESTERIFICATION

The esterified oil with required amount of methanol and sodium methoxide as a catalyst were charged into the reactor. It was heated to maintain a temperature near the boiling point of the alcohol(65^{o}C). The reaction kinetics was similar to that in the first step. Excess amount of methanol was used to ensure complete conversion of the oil into esters. Care was taken to prevent the loss of methanol vapours. After completion of the reaction, the contents of the reactor were cooled and the transferred into a separating funnel . The top fraction was collected, water washed and heated to obtain mahua methyl esters.[6]

03) BIOLUBRICANT SYNTHESIS

The mahua methyl ester produced in the above process was treated with trimethylolpropane (TMP) in a proper molar ratio in the presence of sodium methoxide.

The reaction was carried out in 50 ml batches. The reactants were continuously mixed and heated at around 100-140^{o}C using magnetic stirrer with heater in a 250 ml conical flask. Partial vacuum was applied to the assembly for continuous removal of methanol and the vapors were condensed using a water condenser. After 2-3 hours of reaction time, completion of reaction was confirmed when methanol was obtained in condenser. TMP triesters (biolubricant) were obtained which were tested for their properties. A comparative study was done between the biolubricant and a commercial 2T Engine oil.[5]

04) MODIFICATION OF GLYCEROL

The bottom fraction obtained from the transesterification process containing mainly glycerol was modified using maleic anhydride. 19 parts of glycerol and 1 part of maleic anhydride were heated together at 40-50^oC. To this slurry, sodium bisulphate and sodium bisulphite were added at 60^oC and was kept for settling. It was then heated at 120-150^oC for 2-3 hours. On reaching a desirable value of pH and viscosity, the modification was confirmed.[7]

This modified glycerol was then used as an alternative to TMP for biolubricant synthesis keeping the similar reaction conditions. The product obtained from this process was analyzed for its properties and the results were reported.

RESULTS AND DISCUSSIONS

In the entire process, all the intermediate products were characterized and the results were tabulated in Table 1 and Table 2.

Table 1. Comparison of properties of Biolubricant using TMP with commercial 2T Engine Oil.

Sr. No.	Properties	Mahua Oil	Mahua Methyl Esters	Biolubricant using TMP	2T Engine Oil
1.	Density (g/ml)	0.91	0.784	0.79	0.97
2.	Viscosity @ 40^oC (cSt)	37.18	19.91	23.8	45
3.	Viscosity @ 100^oC (cSt)	11.66	5.185	6.34	6.5
4.	Viscosity Index	325.6	213	204	105
5.	Pour Point (^oC)	18.00	9.00	15.00	-15.00
6.	Acid Value (mg KOH/ g of oil)	84.00	1.87	3.75	0.49

Table 2. Comparison of properties of Biolubricant using modified glycerol with commercial 2T Engine Oil.

Sr. No.	Properties	Mahua Oil	Mahua Methyl Esters	Modified Glycerol(MG)	Biolubricant using TMP	Biolubricant using MG	2T Engine Oil
1.	Density (g/ml)	0.91	0.784	1.1	0.79	0.79	0.97
2.	Viscosity at 40^oC (cSt)	37.18	19.91	90	23.8	23.8	45
3.	Viscosity at 100^oC (cSt)	11.66	5.185	2	6.34	5.84	6.5
4.	Viscosity Index	325.6	213	85	204	240	105
5.	Pour Point (^oC)	18.00	9.00	-12	15.00	11.67	-15.00
6.	Acid Value (mg KOH/ g of oil)	84.00	1.87	1.07	3.75	1.05	0.49

Densities of the 2T Engine oil and the synthesized biolubricants were close enough. Viscosity index of biolubricant using TMP as well as modified glycerol was found to be better than that of the commercial product.A significant fall in the pour point was observed in the biolubricant samples as compared to the raw material.An enormous decrease in the acid value was observed when the mahua oil was converted to biolubricant.

CONCLUSIONS

The following conclusions were drawn from the results and discussions.

- The synthesized biolubricants using TMP and modified glycerol had higher viscosity index compared to the mineral oil based lubricant, therefore viscosity index improvers are not required.
- Though, decrease in pour points were observed in the biolubricant compared to mahua oil, pour point depressant additives need to be added to further reduce the pour point.
- Since properties of the biolubricant using modified glycerol were found to be better than that using TMP, it can be used as an alternative to TMP. Also, the additional cost of TMP can be completely eliminated by effective utilization of glycerol, which is the by-product of transesterification step.
- The biolubricant base oil produced is biodegradable as the raw material is derived from plant based source.

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