IJFEAT
INTERNATIONAL JOURNAL FOR ENGINEERING APPLICATIONS AND TECHNOLOGY

BIODEGRADABLE LUBRICANT

NIHAL P. BELE[1], SHUBHAM W.HATWAR[2], OMKAR R. PATRE[3]
[1]*Student, Chemical Department, J.D.I.E.T Yavatmal, Maharashtra, India,* ***nihalbele000@gmail.com***
[1]*Student, Chemical Department, J.D.I.E.T Yavatmal, Maharashtra, India,* ***shubhamhatwar503@gmail.com***
[3]*Student, Chemical Department, J.D.I.E.T Yavatmal, Maharashtra, India,* ***omkarpatre95@gmail.com***

Abstract
Petroleum based lubricants had a significant cost advantage over bio-lubricants and so petroleum has been the base oil of economic choice. Increase in crude oil prices, depletion of crude oil reserves and growing environmental concerns has brought in now more interest in Bio-lubricants. Bio-lubricants have capability of being utilized in various industrial and maintenance applications like hydraulic fluids, metal working fluids, grease, two-stroke engine oil, concrete mould release agents, chainsaw oils and are mainly used in machinery and equipments operating in environmentally sensitive areas (e.g. agriculture and forestry machinery, jet-skis, snow mobiles etc). Bio-lubricants for industrial and maintenance application, by contrast, may lead to a decrease in costs and to guarantee competitiveness. It is thus to be expected that environmentally sound applications of lubricants will be of great interest to all manufacturing companies. By the use of Bio-lubricants, it is possible to reduce the use of petroleum based lubricants both in industrial and maintenance applications and also cut down the serious environmental problems caused.

Keywords: *Bio-lubricants, Industrial & Maintenance Applications, Friction, Toxicity, Biodegradability, Environment.*

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1. INTRODUCTION

The primary purpose of this is to describe the differences among Bio-lubricants and Petroleum-based lubricants, especially their production and physical and chemical Properties. Established production methodology will be described, especially those using Chemical catalysis that have been developed at the laboratories of Brazil.

Today there is growing concern about the future availability of petroleum-based products. In addition, millions of tons of lubricants are dumped into the environment through leakage, exhaust gas and careless disposal. Some of these wastes are resistant to biodegradation and are threats to the environment. Thus, there are two major issues confronting the lubricant industries today: the search for raw materials that are renewable and products that are biodegradable. [11]

The main research emphasis has been placed on ways to produce Bio-lubricants with suitable viscosity and liquid-state temperature range. In addition, these lubricants must not corrode the machinery they lubricate and they must be stable under the conditions of their use.

Vegetable oils are chemically triglycerides of fatty acids, and have excellent qualities like enhanced flash and fire points , higher viscosity and viscosity index, high biodegradability, high lubricity, and very less toxicity. Vegetable oils are of two types, Edible and Non edible. Edible vegetable oils: A liquid fat that is capable of being eaten as a food or food access, like Coconut, Olive, Soybean, Sunflower, Palm, Peanut, Rapeseed, Corn etc. Various countries import edible oils for their food requirements. Non edible vegetable oils: As a substitute non edible vegetable oil can prove to be valuable. Non-edible vegetable oils like Neem, castor, Mahua, rice bran,karanja, Jatropha, and linseed oils. [2]

1.1 History

As was found to be the case at the time of the 1997 study, there are still no regulations to mandate adoption of vegetable oils in environmentally sensitive application areas to replace mineral oils as is increasingly the case in Europe. The soybean oil replacement product that has achieved the most success is transformer dielectric fluid, also referred to as transformer oil.

The acceptability has been high as the product shows both a performance and an economic advantage over mineral oil products in terms of a much increased fire point, increased service life of the transformer due to extended life of the insulating paper and the potential for much lower cost spill remediation due to favorable biodegradability and lower toxicity characteristics. The largest single potential market for lubricants, crankcase oils, has not yet developed a product qualified to meet industry standards. Work still goes on in this area due to the potential cost advantage opportunity and products are close to being qualified although the soybean oil only represents a small percentage at present of the total formulated oil product.

The market for 2-cycle oils for marine engines, where the lubricant is used in combination with the fuel, was expected to be an application that would be regulated. The EPA has proposed and is about to issue regulations for the emissions from these engines.

The major castor seeds and oil producing nations in order of their production are India, China and Brazil. Germany and Thailand are the greatest castor beans importers (94%), but the United States consumes the most castor oil.

2. SYNTHESIS OF BIO-LUBRICANT

According to (Solomons, 1983), the carboxylic acids react with alcohols to produce esters, through a condensation reaction called esterification .This reaction is catalyzed by acids and the equilibrium is achieved in a few hours, when an alcohol and an acid are heated under reflux with a small amount of sulfuric acid or hydrochloric acid. Since the equilibrium constant controls the amount of produced ester, an excess of the carboxylic acid or of the alcohol increases the yield of the ester. The compound choice to use in excess will depend on its availability and cost. The yield of an esterification reaction may be increased also through the removal of one of the products, the water, as it is formed. The typical mechanism of esterification reactions is the nucleophilic substitution in acyl-carbon, as illustrated on figure.

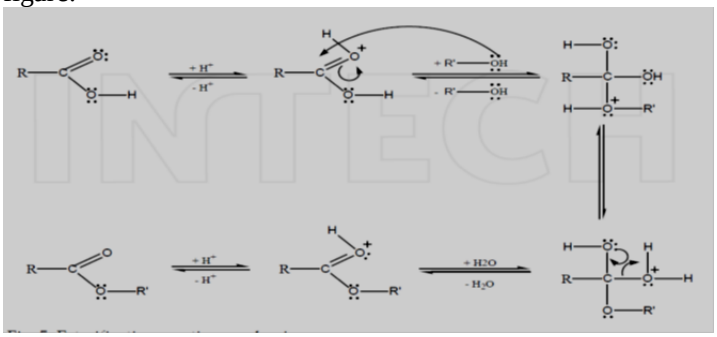

Figure 2: Transesterification reaction

The decisive fact is that the specially designed fatty acid esters which are use re properties, but also a comparable or even better performance than that of conventional products. That this is possible can be demonstrated very clearly by an example from the crude oil production sector particularly high. [9]

The drilling fluid is pumped to the surface together with the drill cuttings and after coarse separation disposed directly into the sea. Apart from a good lubricating effect, the biodegradability assumes a particular importance in this application acid ester (developed by Cognis GmbH) fulfills not only the requirement regarding biodegradability but also has a better lubricating effect than products based on mineral oil.

When one follows the reaction clockwise, this is the direction of a carboxylic acid esterification, catalyzed by acid. If, however, one follows the counterclockwise, this is the mechanism of an ester hydrolysis, catalyzed by acid. The final result will depend on the choice conditions to the reaction. If the goal is to ersterify an acid, one uses an alcohol excess and if it is possible, one promotes the water removal as it is formed. However, if the goal is the hydrolysis, one uses a large water excess. The steric hindrance strongly affects the reaction rates of the ester hydrolysis catalyzed by acids. The presence of large groups near to the reaction center in the alcohol component or in the acid component retards the reaction.

Esters can be synthesized through transesterification reactions. In this process, the equilibrium is shifted towards the products, allowing the alcohol, with the lower boiling point, to be distilled from the reactant mixture. The transesterification mechanism is similar to the one of a catalyzed by acid esterification (or to the one of a catalyzed by acid ester hydrolysis).To increase the transesterification reactions yield one must promote the reaction equilibrium shift towards the products. This can be reached by using a vacuum, which will remove the formed alcohol from the mixture.

Chemical or enzymatic catalysts may be used on the Bio-lubricants esters synthesis. The chemical catalysis occurs in high temperatures (> 150oC), with the usage of homogeneous or heterogeneous chemical catalysts, with acid or alkaline nature (Abreu et al., 2004). The typical acid homogeneous catalysts are acid p-toluenesulfonic, phosphoric acid and sulfuric acid, while the alkaline are caustic soda, sodium ethoxide and sodium methoxide. The more popular heterogeneous catalysts are tin oxalate and cationic exchange resins. If on the one hand one must remove the produced water to increase the reaction yield; on the other hand the water has a positive effect on the dissociation of the strong acid groups of the resin. Thus, a completely dry resin does not present any catalytic activity, due to the impossibility of the sulfonic group dissociation.

2.1 PROPERTIES OF LUBRICANT

The main properties of a lubricant oil, which are basic requirements to the good performance

Of it will be described as follows: [12]

1. Viscosity: The viscosity of lubricants is the most important property of these fluids, due to it being directly related to the film formation that protects the metal surfaces from several attacks.
2. Viscosity index (VI): It is an arbitrary dimensionless number used to characterize the range of the kinematic viscosity of a petroleum product with the temperature. A higher viscosity index means a low viscosity decrease when it increases the temperature of a product. Normally, the viscosity index value is determined through calculation (ASTM D2270 method), which takes in account the product viscosities at 40 and 100°C. Oils with VI values higher than 130 find a wide diversity of applications.
3. Corrosion: Bio-lubricants, as mineral lubricants, must not be corrosives. Because of that, they must present 1B result (maximum) on the test ASTM D130, which consists on the observation of the corrosion in a copper plate after this plate is taken out from an oven, where it has been for 3 hours, immersed in the lubricant sample, at 150°C. The values 1A, 1B, etc., are attributed based on comparison with standards.
4. Biodegradability: Many vegetable oils and synthetic esters are inherently biodegradable. This means that they are not permanent and undergo physical and chemical changes as a result of its reaction with the biota, which leads to the removal of not favorable environmental characteristics. The negative characteristics are water immiscibility, eco toxicity, bioaccumulation in live organisms and biocide action

against such organisms. For some applications, the lubricants must be readily biodegradable.

2.2INDUSTRIAL AND MAINTENANCE APPLICATION OF BIO-LUBRICANTS

Bio-lubricants provide significant advantages as an alternative lubricant for industrial and maintenance applications due to their superior inherent qualities. Bio-lubricants due to their environmental benefits enable their use in sensitive environments and provide pollution prevention. Bio-lubricants have capability of being utilized in various industrial and maintenance applications. Some of the applications are listed below [2]

Hydraulic fluids: Hydraulic fluids or hydraulic liquids are used to transmit power in hydraulic machinery. Mainly hydraulic fluids are based on petroleum oil. Petroleum oil can pollute drinking water, with the agricultural and mining industries being major consumers of hydraulic fluid. Bio based hydraulic fluids are used in environmentally sensitive applications when there is the risk of an oil spill.[12] Vegetable oils from Canola used as base stocks for fluids where biodegradability is considered important.[11] Some of the significant advantages of using biodegradable hydraulic fluids are Viscosity for film maintenance, Low temperature fluidity, Cleanliness and filterability, Antiwear characteristics, Corrosion control, Adequate viscosity and viscosity index, Shear stability, Low volatility, Proper viscosity to minimize internal leakage, High viscosity index.

Concrete Mould Release Agents: Biolubricant prevents freshly poured concrete from sticking to its mould or formwork and thereby facilitates removal of the formwork once it has cured. It can be used for environmentally sensitive areas.

Marine lubricants: Lubricants that is used in various types of machinery situated on ships. A new technology that is increasing is biodegradable marine lubricants, because of the environmental advantages these lubricants can provide.

Water Soluble Coolants: In machining biolubricant offer features that can lead to cost savings, quality improvements, improved lubricity for better tool life, better surface finish, reduce friction, reduce heat and increased productivity (OSHA 1999). Bio based coolants are easy to maintain due to excellent sump stability and reduced toxicity. No inflammation of the skin is experienced by operators.

Coolants: Bio based coolants can be used on all metals like stainless steels, alloy, and tool steel. Bio based coolants improve tool life, long sump life, and low maintenance.

Health & Safety: Bio-lubricants are not ecologically hazardous; OSHA (Occupational Safety and Health Administration**)** limits for bio based vapors are much higher than for petroleum based vapors.[10] No skin problem as the operator's skin doesn't dry out after contact with these oils. Vegetable oil is far less toxic than petroleum based lubricant, glycols and synthetic oils. Vegetable oil has much higher flash point (approximately 275-290 °C) which reduce the risk of accidental ignition, eliminating all injuries, unsafe practices, occupational illnesses and incidents of environmental pollution.

2.3 EFFECT OF BIOLUBRICANT ON INDUSTRIES AND ENVIRONMENT

It is very clear that Bio-lubricants are the best solution for the toxic effects that are caused by petroleum based lubricants on our ecosystem. No environmental problems will be caused from hydraulic leaks, no injuries at the job so no lost in work which will decrease maintenance between oil changes more production increases profits. Employees no longer have to experience the inflammation of the skin caused by petroleum based lubricants. Furthermore Bio-lubricants in industry provides significant advantages as shown in figure below due to their super high inherent characteristics. [4]

1. TECHNOLOGY ADVANCE

The oxidative instability of soybean oil as well as rapeseed oil and other vegetable oils is due to the presence of polyunsaturated fatty acids, as in linoleic acid and linolenic acid. Efforts have been made to modify the soybean oil to moderate the effects of these materials to provide a more stable material and a product more competitive in performance to mineral oil-based lubricants. The different approaches to this end include:

3.1 ADDITIVE TECHNOLOGY

Oil formulations, whether they are bio-based or mineral oil, are generally regarded as proprietary information. It is difficult to know the identity of the additives added to the soybean oil in those products that have been developed. Patents do not always give the answers.[10] There are some indications from the patent literature that some investigators have developed stable products based on additive technology. An interesting study by Tribsys on the interaction of soybean oils with EP additives has been published.[9]

OIL TREATMENT-CHEMICAL TRANSFORMATIONS AND POLYMERIZATION

There are many different ways to modify the multifunctional vegetable oils. Some reported changes that address the polyunsaturated problem include alkylation, acylation, hydroformylation, hydrogenation, oligomerization (polymerization) and epoxidation. *Anarticle has been published by* Manfred Schneider entitled *Review – Plant-oil-basedLubricants and Hydraulic Fluids–* available at",".

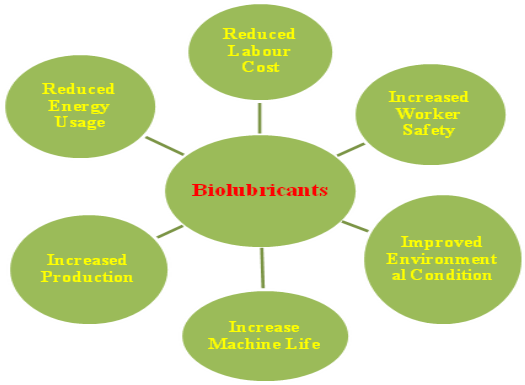

Figure: Significant Advantages of Biolubricant

No commercially available products based on these modifications have been identified, except perhaps on polymerization. There is some indication that polymerization is used to produce a stable hydraulic oil for elevator applications.[5] Although it is possible that the end product oils are acceptably stable in the intended applications for some of these reported transformations, the added processing cost is likely to be a hurdle limiting broad commercial adoption, except perhaps in the case of polymerization.[6]

4. FUTURE FOR BIO-LUBRICANT

Today green tribology is an essential concept and knowledge for all modern industries, ranging from manufacturing to aerospace program, in order to optimize the energy efficiency as well as minimize the environmental impacts and the loss in materials.[4] The utilization of renewable source, such as plant oils, as green alternatives in lubricant science is the key to promote a sustainable earth as the ultimate goal of this research. However, balancing the resources and the industrial use offers a major challenge in sustainable resource management. The adaptive management is crucial to achieving this balance.[11]

As the shortage of petroleum is becoming a global concern, the promotion of lubricants made of renewable biomass is another major objective of this research because using Bio-lubricants has many benefits to the environment and human health:[8]

- The biomass used for producing bio-based oils is renewable and genetically- changeable..
- Bio-lubricants are more stable with temperature change because of lower viscosity of bio-based oils.
- Bio-lubricants are safer to use because they are not toxic to skin and low in evaporation losses, which leads to less inhalation of oil vapor into the lung.
- Bio-lubricants require less maintenance and are easy to handle.

The applications of Bio-lubricants lead to significant cost saving.

5. CONCLUSION

- Firstly, bio-lubricants have a higher lubricity and thus a much lower coefficient of friction when used when compared to petrobased lubricants.
- Bio-lubricants have high flash points, which makes then effective in high temperature environments to preclude evaporation or dissipation.
- They have relatively stable viscosity indexes, so that they are useful over a large range of temperatures.
- Bio-lubricants are generally derived from vegetable oils, and processing can be clean and renewable.
- Lastly, bio-lubricants are easily disposed of as they are non-toxic and biodegradable.
- Tlubricants. hese properties make bio-lubricants an attractive alternative to petro based.

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