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Biolubricants: Aspects and Prospects

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***Abstract*: A lubricant, basically performs the roll of anti-friction media, is necessary for smooth operations, to maintain reliable machine function and to prevent frequent failures and is an integral part in automotive and machinery industries. The conventional oil-based lubricants in most cases causes serious environmental threats. Bio-based lubricants have received significant interest in recent years as they have the ability to overcome the above problems. Such eco-friendly lubricants are now moving into a substantial competitive and mainstream position due to rising oil prices, increase in environmental awareness and global climate changes. In this regard, the goal of the present paper is to highlight the potential of biolubricants for a wide range of applications based upon the published researches over the past few years. This paper also aims to arise the interest to policy-makers about the prospects of using biolubricants as a potential alternative lubricant in automobiles and industry.**

***Keywords*: Bio-based lubricants, future perspectives. Lubrication and lubricants, lubricant properties.**

1. Introduction

The significant development in the field of various type of industries with the passage of time has increased the demand for energy. It is not a mere speculation that the total world energy consumption will be increased by 33.5% from 2010 to 2030 [1]. Conventional petroleum based products including fuel and lubricants are used to accommodate the high energy demand [2-3]. In recent times, more attention is focussed on developing eco-friendly and energy efficient automotive and machinery industries by introducing best technological solutions, using lightweight materials and less harmful fuels, optimizing fuel combustion, keeping in mind the hazards in environment brought by vehicles and machines [4]. The smooth and safe operation of every automobile as well as machine in industries require effective lubrication of moving parts to reduce friction while transferring motion from drive to driven mechanical links. The power is also transferred through lubricants. Universally lubricants are manufactured either from petroleum or synthetic esters as base oil. It is worthwhile to mention that mineral oil-based lubricants do not possess any lubricating properties and are provided by additives [5]. Being comparatively less expensive, they are used extensively in industry and transport sectors. However, they are not bio degradable, non-renewable and toxic, thereby causing toxic effects on environments and life. A recent study revealed that more than half of the used lubricant returns back in the Environment [6] that mostly comprises of petroleum based mineral oil [7], thereby causing a threat to the environment which is a matter of great concern. The day to day increase in oil prices, gradual depletion of crude oil source around the world and growing concern over environmental hazard has aroused a global widespread concern. Furthermore, the mineral oil based lubricants emit calcium, iron and zinc nanoparticles [8]. Several attempts have been taken in order to restrict this threat, to develop green energy systems as well as introduction of proper potential alternative to mineral-based products [1, 2,9]. In this context, bio-based-lubricant oils or biolubricants are perceived as alternatives to mineral oils. Bio-lubricants are derived from vegetable oils, animal fats or any other eco-friendly hydrocarbons [10]. They are biodegradable and renewable, good lubricity, high flash point, high viscosity index and good resistance to shear compared to mineral oils [11]. Due to the presence of long fatty acid chains and polar groups in their structure, both boundary and hydrodynamic lubrication can be obtained from biolubricants. The most promising point to mention in this context is that vegetable oils which is supposed to be the major source of biolubricants, can be obtained from oil-containing seeds which are available at all parts of the world. To mention a few are jatropha [12], karanja, neem, rice bran, rapeseed, castor, mahua [13]), palm [14], sunflower, coconut, soyabean and olive [15]. But still the usage of biolubricant is limited in view of their performance and production scale, although the performance can be enhanced to a greater extent by the use of proper additives, [16] which may be a matter of extensive study for researchers interested in bio-based lubricants. The main objective of the present paper is to share information as well as to arise the interest to engineers, industrialists and researchers, who are interested to develop some alternatives to oil based conventional lubricants. This paper also aims to arise the interest to policy-makers about the prospects of using biolubricants as a potential alternative lubricant in automobiles and industry.

2. Some Aspects about Lubrication and Lubricants

1) Lubrication and lubricants:

Lubrication can be defined as the application of some materials between two objects moving relative to each other, so that smooth operation may be allowed as much as practicable between the two. The basic purposes of lubrication are (a) to prevent wear and premature fatigue by forming the lubrication

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film on the surface between metals in contact (b) to lower the friction (c) to prevent overheating of bearings by transferring the generated heat outside (d) to prevent rust and corrosion.

On the other hand, lubricant is a substance which minimizes the friction and consequent destruction in materials by keeping the moving surfaces apart. The function of a lubricant is (a) to reduce expansion of metal due to frictional heat thereby also acts as coolant of metal (b) to avoid unsmooth relative motion (c) to reduce power loss in internal combustion engines.

2) Classification of lubricants

Depending upon their physical state, lubricants can be classified as (a) liquid lubricants or lubricating oils (b) semi solid lubricants or greases and (c) solid lubricants.

a) Liquid lubricants or lubricating oils: On the basis of base oil resources, they may be further classified into three categories: (i) Animal and vegetable oils (ii) Mineral or petroleum oils (iii) blended oils .

Animal and vegetable oils: They are extracted from crude fat and vegetable oils such as cotton seed oil and caster oils. They possess good oiliness bat suffer from the disadvantage that they undergo hydrolyse easily on contact with oil and water and also undergoes easy oxidation.

i. *Petroleum oils*: Owing to their availability and stability, they are widely used, although some additives are required to increase their oiliness.

ii. *Blended oils:* When lubricating oils are added with additives in proper proportion to increase their efficacy, they are called blended oils; e.g. addition of oleic acid or vegetable oils e.g. coconut oils (additives) to mineral oils (lubricants).

a) *Semi-solid lubricants or Grease*: When lubricating oil, mostly petroleum oil is mixed with thickeners which consists of soaps of Li, Na, Ca or carbon black, silica gel, Grease is obtained. Grease can support heavier load but the internal resistance is higher than lubricating oils and is effective at lower temperature.

b) *Solid lubricants:* The most common solid lubricants are graphite, molybdenum disulphide, tungsten disulphide and zinc oxide. They can withstand at very high temperature and is effective in continuously operating situations.

3) Bio lubricants

Biolubricants are regarded as any lubricant that is completely biodegradable and not harmful to the environment. In comparison to mineral oils they show a high degree of biodegradability and low toxicity. They are made from different crop oils, among which palm, soyabean, sunflower, coconut, rapeseed, cottonseed and peanut oils are considered as potential sources of biolubricants.

4) Properties of bio lubricants

The physicochemical properties of bio-based lubricants are primarily dictated by the composition of the constituent fatty acids. Viscosity is the most significant property of a lubricating oil, as the operating mechanism of a lubricant largely depend on its viscosity. For a low viscous lubricant, the oil film cannot be maintained between sliding surfaces. Castor oil, containing high degree of long chain fatty acid possess high viscosity, whereas, lubricants derived from other crude vegetable oils have moderate viscosity [17]. Thus, bio-based lubricants, containing a high content of monounsaturated fatty acids have superior lubricity at room temperature. Bio lubricants also have relatively high viscosity index, compared to oil-based lubricants, thus enables the former to operate in a wider temperature [18].

To consider the efficacy of a lubricant, we should also consider its operating ability at low temperature range. The efficiency of a lubricant in low temperature range is commonly associated with cloud point and pour point. The temperature at which a lubricant starts to become hazy in appearance is the cloud point. Pour point is the temperature below the cloud point at which the lubricant losses the flowing property. Thus, maintaining the temperature above the cloud point for a particular biolubricant is essential during its operation. Vegetable oil based lubricants, in general, possess lower pour point than mineral oils, thus used extensively under low temperature conditions. [19].

The volatility and fire resistance property of a lubricant is determined by flash point and fire point respectively. Flash point is the lowest temperature of a lubricant, at which it must be heated before vaporization starts; whereas, fire point is the temperature at which a lubricant undergo combustion. Bio-based lubricants have higher flash point than mineral oils, which is very important advantage, so far as the safety criteria is considered.

The suitability of a lubricant largely depends on the rust and corrosion phenomena. As vegetable oil-based lubricants are non-toxic as well as less reactive as compared to oil-based lubricants, they efficiently minimizes the rust and corrosion, during the process of lubrication [20]. It has been found that saturated vegetable oils have better oxidative stability than unsaturated oils at elevated temperature [21]. On the other hand, monounsaturated vegetable oils have better oxidation stability than polyunsaturated vegetable oils.

5) Advantages and Disadvantages of Biolubricants

Vegetable based oils required for the production of biolubricants possess some unique positive qualities that give them an advantage over conventional petroleum oils as the feedstock for biolubricants. Excellent biodegradability [22] and very low ecotoxicity of vegetable oil based lubricants are the two superior qualities and these two features are particularly important when lubricants are used in environmentally sensitive areas e.g. in river and marine ecosystems. Some other advantages of plant oil-based products for biolubricant production are (a) High viscosity and viscosity index (b) Low friction coefficients (c) Excellent lubricating properties (c) renewable, eco-friendly, biodegradable (d) Low ecotoxicity (e) improved fuel economy (f) Low cost production. Biolubricants can be used in various industrial and maintenance applications: e.g. metalworking fluids, hydraulic oils, automotive oils such as engine oils, transmission fluids, gear box oils as well as brake oils.

On the negative side, there are some few limitations of these natural oil-based lubricants: (a) Low oxidative stability (b) Limitations of operating temperature (c) Quick ageing and

degradation (d) Easy formation of sludge resulting in filter clogging and increased maintenance (e) Fluidity at low temperature is poor , thereby causing problems during winter months.

3. Use of Additives

While there are many advantages and disadvantages to biolubricants, chemistry provides a key role in the production of vegetable oil resources into a usable lubricant. However, the process and mechanism of conversion of green biomass resources to usable biolubricants is different from that of conventional lubricants made from mineral oil. Some chemicals which increases their favourable physical properties called additives need to be added or blended in different proportions. On average, most commonly available biolubricants consists of about 90% vegetable oils and 10% additives to help improve flow, ageing and anti-wear.

4. Conclusion

In recent times, demand in market and development for biolubricants and transportation fuels has increased environmental compatibility, reduced toxic emissions, improving longer life time and engine efficiency. The depletion of the world's crude oil reserves, increasing day to day oil prices, the issue of energy conservation and moreover the increase in environmental awareness grows renewed interest in the use of bio-based oils and fluids. The harmful effects of mineral oils on environmental and human health are now more and more obvious. In this context, the emphasis on the development of renewable, biodegradable and eco-friendly biolubricants has led to the increasing use of natural fats and oils for non-edible industrial purposes. However, the additional cost of chemical modification processes of biolubricants heavily limited their market penetration; but as the environmental regulations grow sticker and chemical modification processes will be cost effective as more researches are going on in this field, these cost concerns will be of less priority in comparison to demands of higher operating efficiency and biodegradability.

To include the biolubricants as successful in mainstream, the chemical industry should play a major role in view of consumer needs and thereby make an acceptable solution to society's problem. They have the ability to make a dramatic change in world's fuel market, by decentralising our fuel and chemical production, when one consider their ability to reduce the release of harmful gases into the atmosphere. In many countries bio-based lubricants are now being considered as critical to the economy, environment and national security. Such eco-friendly lubricants are now moving into a substantial competitive and mainstream position due to rising oil prices, increase in environmental awareness and global climate changes. The importance on conservation ultimately resulted in growing interest in the use of modified natural oils for non-edible, automotive and industrial purposes. There has been a significant development towards the use of biodegradable lubes and greases from renewable sources. Thus we hope that biolubricants will help to lubricate the whole world in natural way.

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