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A Mini Review of Biodegradable Lubricants 2. Characterization, Current Status, and Future Improvement Trends

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Abstract—*The history of biodegradable lubricants has been presented in a series of articles, works and patents. These biodegradable lubricants are used to improve the properties of mineral oils or vegetable oils. To improve the properties of the oils, a wide range of biodegradable lubricants based on polymers were synthesized. A series of researches are related to the production of biodegradable lubricating oils that also possess a food-type non-toxic character.*

Keywords— *Lubricants, biodegradable, future, characterization*.

I. Introduction

The literature of recent years offers a wide range of articles, works and patents in the field of tribology, a field in which the performance criteria are becoming higher and higher, and the condition of biodegradability has become practically self-evident.

Thus, a series of studies have been carried out regarding the influence of lubricants on the environment and how their harmful effect can be eliminated or at least reduced [1].

Biodegradable lubricants intended for marine applications, are obtained from a biodegradable base oil (a polyol ester or a polyalkylene glycol), a thickening agent (calcium sulfonate respectively linear alkyl benzene sulfonic acid and 12-hydroxystearic acid and solid calcium carbonate) and an antiwear additive of the phospholipid type of natural origin such as lecithin. This base oil has a specific gravity greater than 1.0 at 15.60C (600F) and as a result, the lubricant settles when dispersed in water, avoiding the formation of a glossy surface and can be biodegraded [2].

The use of aqueous solutions of ethoxylated sorbitan monolaurate as an ecological lubricant is the subject of a series of papers. Aqueous solutions of sorbitan monolaurate ethoxylate (SMLE) were tested for surface tension, contact angle, light scattering and viscosity. In addition, investigation methods were used with the help of atomic force spectroscopy, polarized light microscopy and X-ray spectroscopy. The tests carried out sought to identify micellar structures and/or liquid crystals formed in the mass of the material or on its surface. The tribological tests were performed on the 4-ball machine and on the ball-on-disc type apparatus. Based on the tests carried out, it could be stated that the addition of SMLE to water improves its lubrication properties. A significant influence of the concentration on the tribological properties was found. The observed changes can be explained by the high affinity of SMLE for the surface, while the concentration effect on the tribological performances is due to the changes in the structure of the solution, the compounds being able to form different types of micelles and mesophases in the mass and on its surface [3].

The synthesis and biodegradability capacity of some synthetic oils based on adipic and sebacic esters is the subject of an extensive research study [4]. Oligomers with different degrees of polycondensation were synthesized from dimethyl adipate, dimethyl sebacate and neopentyl glycol, by transesterification catalyzed by calcium methoxide. The degree of oligomerization was closely related to the molar ratio of the system components. The resulting esters have the appropriate characteristics to be used as synthetic lubricants with a high biodegradability, little dependent on the degree of oligomerization

In creating a new generation of lubricants, the first step was to understand the need to eliminate or considerably reduce the content of toxic chemical compounds. The good lubricating properties as well as the high degree of biodegradability were the decisive criteria in the use of vegetable oils as a dispersion phase in lubricating greases. However, since vegetable oils have a low resistance to oxidation, a consistent effort is necessary in order to eliminate this deficiency. A solution could be the appropriate choice of non-toxic and white antioxidants [5].

The chemical modification of vegetable oils in order to make basic compositions for lubrication is an alternative, especially since they come from renewable resources, are non-toxic and biodegradable, have high flash points and have low volatility. But the reduced oxidation stability and poor properties at low temperatures limit their use as lubricants. For example, derivatives of vegetable oils having diesteric substituents at the unsaturated positions have properties comparable to those of the base mineral fluids [6]

The transesterification of methyl esters of fatty acids from animal fats and from various vegetable sources that mostly contain palmitic and stearic fractions, with C2-C8 type alcohols, leads to obtaining a biodegradable base lubricating oil [7].

Another example is the preparation and properties of basic lubricating compositions obtained from epoxidized soybean oil and 2-ethyl hexanol. The following catalysts were used: sulfuric acid, p-toluenesulfonic acid, boron trifluoride, ion exchange resins type DOWEX 50W-X8 and sodium methoxide. The products had cloud points between -210C and -300C. By esterifying the hydroxyl groups in these products with an anhydride, the cloud point values decreased appreciably. Alternatively, an attempt was made to reduce the cloudiness points by adding polyalphaolefins. The oxidative stability of the products, determined by differential scanning calorimetry (DSC) under pressure, was compared with that of other synthetic lubricant compositions, polyalphaolefins and synthetic esters [8].

Hydraulic fluids and lubricating oils are obtained from unsaturated fatty acids and fatty acid esters, through an epoxy-ketone rearrangement [9]. The products are obtained by epoxidation of the double bonds in unsaturated fatty acid esters and triglycerides rich in unsaturated fatty acids, followed by an acid-catalyzed rearrangement of the epoxides to ketones. Suitable are the trans isomers of unsaturated acids, from rapeseed, sunflower, palm, soybean, coconut and olive oils in the form of methyl esters or esters with polyols (glycerin, trimethylol propane, pentaerythritol) [10-22].

Different types of esters used for biodegradable lubricants

Adipic esters: isotridecyl and 2-(p-nonyl-phenoxy)ethyl adipate, isotridecyl and 2-(o-sec-butyl-phenoxy)ethyl adipate, isotridecyl and 2-phenoxy ethyl adipate, isodecyl and 2- (p-nonyl-phenoxy) ethyl, isodecyl and 2-(o-sec-butyl-phenoxy) ethyl adipate, isodecyl and 2-phenoxy ethyl adipate, 2-ethyl hexyl and 2-(p-nonyl-phenoxy) adipate) ethyl, 2-ethyl hexyl and 2-(o-sec-butyl-phenoxy) ethyl adipate and n-hexyl and 2-(p-nonyl-phenoxy) ethyl adipate.

II. CONCLUSIONS

Obtaining a new generation of lubricants was the understanding of the need to eliminate or considerably reduce the content of toxic chemical compounds. The good lubricating properties as well as the high degree of biodegradability were the decisive criteria in the use of vegetable oils as a dispersion phase in lubricating greases.

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