International Journal of Advanced Engineering and Technology
www.allengineeringjournal.com
ISSN: 2456-7655
Received: 04-12-2025, Accepted: 15-01-2026, Published: 02-02-2026
Volume 10, Issue 1, 2026, Page No. 37-39

Study esters with lubricant properties

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Abstract
The base oils, esters of trimethylol propane with fatty acids show an excellent lubrication capacity especially at low temperatures. Increasing the quality of lubricating oils can be achieved in other ways. Thus, it is stated that copolymers of methacrylates and alkyl acrylates can be used to improve the performance of lubricating oils: improving properties at low temperatures; increasing compatibility with additive components and improving the viscosity index. Base lubricating oils, of a synthetic nature, can be synthesized from dialcohols and monoacids.

Keywords: Lubricants, biodegradable, esters

Introduction

The preparation of linear aliphatic diesters based on 3-(4'-methylcyclohexyl) butanol that possess low cloud points is the concern of an applied study [91]. The production of an aliphatic diester such as di-3-(4'-methyl cyclohexyl) butyl adipate is presented, which exhibits both lubricant and plasticizer properties for thermoplastics. The synthesis of esters based on pentaerythritol and carboxylic acids from C5 to C9 aim to produce base oils for refrigeration units [1]. The materials for this purpose are obtained by esterifying a mixture of alcohols and a mixture of carboxylic acids, finally obtaining an ester with a hydroxyl index of ≤5.0 mg KOH/g, an acidity index of ≤0.05 mg KOH/g and a kinematic viscosity of 30-150 mm^2/s at 40^0C. The mixture of alcohols is composed of 65-99.95 mol% pentaerythritol and 0.05-35 mol% dipentaerythritol; the carboxylic acid mixture is composed of 25-55 mol% of C5-C8 monocarboxylic acids and 45-75 mol% of isononanoic acid which contains especially 88.5-99.95 mol% of 3,5,5 trimethylhexanoic acid. The lubricating composition is particularly suitable for refrigeration units that use chlorine-free hydrofluorocarbon derivatives.

Obtaining basic lubricating oils for refrigeration units is a very interesting topic. Thus, the base oil consists mainly of synthetic esters prepared by reacting pentaerythritol with C4-C18 saturated fatty acids to give an ester that has a Na content of ≤100 ppm and an ash content of ≤0.02% by weight. The oil has a high thermal resistance; high lubrication values and has a low degree of coloring [2].

Base oils, esters of trimethylol propane with fatty acids (viscosity ≤ 9000 mPa.s at -40^0C, cloud point ≤ -40^0C, volatilization level ≤ 35% by weight after heating at 180^0C for 500 hours and viscosity index ≥ 130) shows an excellent lubrication capacity especially at low temperatures [3].

Increasing the quality of lubricating oils can be achieved in other ways. Thus, it is stated that copolymers of methacrylates and alkyl acrylates can be used to improve the performance of lubricating oils:

a. improving properties at low temperatures;
b. increasing compatibility with additive components;
c. improving the viscosity index.

The composition of such copolymers is as follows: from 10 to 23% by weight C3-C7 alkyl acrylate or methacrylate, from 77 to 90% by weight C12-C14 alkyl methacrylate or acrylate and from 0 to 6% by weight from at least one C16-C20 alkyl acrylate or methacrylate [4].

Base lubricating oils, of a synthetic nature, can be synthesized from dialcohols and monoacids [5]. Fatty monocarboxylic acids (especially n-octanoic acid) with dihydroxy alcohols whose length varies between C2 and C36 (especially 2,4-diethyl-1,5-pentanediol) are mainly used. The oils thus obtained have the appropriate viscosity index and cold fluidity, a high thermal stability and lubrication qualities, being useful both as greases and as hydraulic fluids.

A Polish paper presents the results obtained as a result of the continuation of the study related to the synthesis and biosynthesis of sebacate oligomers considered as lubricating oils [6]. The syntheses were carried out by perfecting an alcoholysis reaction of dimethyl sebacate with neopentyl glycol and 2-ethyl hexanol. The preferred catalyst used was sodium methoxide. In the case of using the biosynthesis technique, the immobilized lipase gave high yields. The products thus obtained were tested as additives for fully synthetic oils. They determined the reduction of the cloud point and significantly improved the viscosity index. A possible influence of these esters on the lubricating properties of oil formulations was also observed [7]

The synthesis of a lubricating oil based on trimethylol hexane triheptyl ester is described in a Chinese paper [8]. A series of trimethylol hexanetriheptyl esters from trimethylol hexane were synthesized using a phosphotungstic acid type catalyst deposited on the support. The optimal esterification conditions were: reaction time 120 minutes; reaction temperature 220^0C; catalyst mass fraction 1.8%; molar ratio of heptanone and trimethylol hexane 3.7/1.0. Esterification conversion reached the level of 96% when optimal conditions were reached [9]. The state of research in the field of lubricating oils based on perfluoropolyalkyl ethers (PFPE) constitutes a reason for analysis. The performances of this class of lubricants under vacuum conditions, their evaluation technique, friction aspects, reaction possibilities under limit conditions, thermal and catalyzed degradation, appropriate antiwear additives, as well as the type of degradation inhibitors for perfluoropolyalkylethers are evaluated [10].

Lubricating oils have also been obtained from polyhydric alcohols (trimethylol propane, pentaerythritol, neopentyl glycol and 2-alkyl glycerine derivatives) and mixtures of aliphatic, linear or branched, saturated or unsaturated fatty acids showing heterogeneity in chain length in the C2 range -C24 [11].

Base oils with high viscosity from the class of synthetic esters were prepared by esterification of some neopentyl polyols with linear and branched carboxylic acids [12]. Thus, synthetic base oils with high viscosity were prepared by esterifying a polyol of the neopentyl type with a linear monocarboxylic acid of length C4-C10 and a branched monocarboxylic acid of length C5-C10, ensuring an excess of hydroxyl groups, in order to form a half-ester, the reaction being followed by the neutralization of the acid catalyst and the reaction of the esters with a supplement of linear and branched monocarboxylic acids. The synthetic esters produced in this way have a viscosity of 68-400 cSt at 400C. Pentaerythritol, trimethylol propane, trimethylol ethane and neopentyl glycol were used. Lubricating oils that can be formed using these base oils exhibit satisfactory miscibility with standard high or fully fluorinated refrigeration materials [13].

Synthetic lubricating oils were obtained from hydrogenated polyalphaolefins, esters and diesters and ethylene-propylene copolymer, respectively:

1. hydrogenated decene-dodecene copolymer (as polyalphaolefin);
2. diisodecyl adipate (as dieter);
3. calcium phenoxides and calcium sulfonates as a basic agent. In addition, lubricating base oils may incorporate 12-15% by volume of an additive package containing such additives as polybutenes, calcium phenolates and sulfates, zinc dialkyl dithiophosphates, antifoam agents, and molybdenum dithiocarbamates in an oil diluent [14].

In the literature of recent years, the effect of chemical structure on friction and wear is analysed. The first part of this study concerns fluids based on synthetic esters [15]. The study of the effect of the structure of different ester-type basic raw materials is carried out based on the results of the wear test on the 4-ball machine that measures both wear and friction. A series of esters with different chemical structures of alcohols (glycol, trimethylol propane and pentaerythritol) and acids (linear or branched with different chain lengths) used in its synthesis were evaluated. Different additives were also investigated to determine their interaction with the base fluids. Significant differences were observed in the limit lubrication regime, depending on the chemical structure [16-31].

A second part of this study considered vegetable oils and fatty acid esters [17]. Three vegetable oils (jojoba, corn and castor oil) and some synthetic esters (pentaerythritol tetraoleate and trimethylol propane trioleate) were examined. They showed a better wear behavior than in the case of additives, which did not increased performance. Through regression analysis, a correlation was established between the effects of the chemical structure and the results of the friction and wear tests. Additive polyunsaturated vegetable oils have higher values for friction and wear. The pendant hydroxyl groups of castor oil did not affect the interaction with the additives. Finally, it was found that the wear behavior was affected by the branching of the chain and the length of the acid part of the ester [18].

Lubricating oils suitable for roller bearings are made from an ester base oil by reacting a C7-16 monocarboxylic acid with a C8-16 monohydric alcohol. The ester has a molecular mass of ≥300, and a kinematic viscosity of 5.0-1000 mm^2/s, respectively 5.0-500 mm^2/s at 40^0C. These lubricating oils have good stability, thermal resistance, lubrication capacity and fluidity at low temperatures [19].

Lubricating oils for internal combustion engines contain a base oil (a mineral oil and/or a synthetic oil - a boric acid ester) of approximately 0.001 to 0.5% by mass, taking into account their element and an ashless antioxidant in the amount of 0.01 to 5% by mass (both percentages referring to the total amount of the composition, in which a metal salt of dithiophosphoric acid is not found and has a sulfur content of 0.2 % by mass or less).

The composition of the lubricating oil is excellent:

- keeps its base index;
- has cleaning capacity at high temperatures;
- prevents cam lifter wear;
- does not contain anti-wear additives containing phosphorus and/or sulfur [20]

Conclusions

In this review I presented a brief history of esters with biodegradable properties that were presented in a series of articles, works and patents.

The composition of lubricating oil is excellent if it maintains its base index; has cleaning capacity at high temperatures; prevents wear of the cam lifter and does not contain anti-wear additives containing phosphorus and/or sulfur.

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