Proceedings of WTC2005
World Tribology Congress III
September 12-16, 2005, Washington, D.C., USA

WTC2005-63049

SYNTHETIC LUBRICANTS BASED ON SEBACIC COMPLEX ESTERS

Liviu E. Mirci[1], Sorina Boran[1], Paula Luca[2], and Victor Boiangiu[2]
[1]Univ. POLITEHNICA Timisoara, Faculty of Chemical Engineering, Timisoara, [2]ICERP SA Ploiesti, Romania

ABSTRACT

The paper present the results carried out in order to produce synthetic ester oils with a complex structure on the basis of sebacic acid with beneficial tribological properties. Three series of unsymmetrical diesters have been synthesized by taking into account superior aliphatic alcohols such as 2-ethyl-hexanol, isodecanol and isotridecanol along with special alcohols of a complex alkyl-aryl structure, namely 2-phenoxy-ethanol, 2-[(o sec butyl)-phenoxy] ethanol and 2-[(p-nonyl)-phenoxy] ethanol, respectively. There were also synthesized the symmetrical (homogeneous) esters based on these special aliphatic-aromatic alcohols.

INTRODUCTION

Synthetic lubricants were originally developed and used for applications where petroleum products were inadequate (e.g., at extremely high and low temperatures, under extreme wear conditions)or where special characteristics, such as long life, improved equipment efficiency, or non-flammability, were needed.

It is estimated that approximately 80% of the worldwide synthetic lubricants market is represented by three generic groups: polyalphaolefins (~45%), organic esters (~25%), and polyglycols (~10%) [1].

Within this general trend we have chosen a specific way to built complex esters with a mixed (unsymmetrical) structure taking into account special alkyl-aryl alcohols along with medium and long aliphatic (normal or branched) alcohols. In our previous papers we have reported the synthesis of such products on the basis of trimellitic, pyromellitic, citric, phosphoric and o-phtalic acids [2-7].

The present paper is in consequence a part of a large program started many years ago and this research is grounded in fact on two main principles that is of: (1) **Asymmetry** and of (2) **Polyfunctionality**.

This paper presents results concerning the synthesis and characterization of some diesters of sebacic acid built in such a manner to produce mixed structures or unsymmetrical derivatives, taking into account superior aliphatic alcohols and special alcohols of a complex alkyl-aryl structure, respectively. By varying the length of the aliphatic alcohols and also by modifying the length and position of an alkyl pendant group on the aromatic ring of the complex alkyl-aryl alcohols, three series of products have been realized. There have also been synthesized the symmetric (homogeneous) diesters by taking in consideration only the complex alkyl-aryl alcohols. These series are illustrated in the following general structures shown by the formulae I (A, B, C) and II (A, B, C):

R_2OOC-$(CH_2)_8$-$COOR_1$ (I); R_2OOC-$(CH_2)_8$-$COOR_2$ (II)

unsymmetrical (mixed) symmetrical (homogeneous)

where R_1 = 2-ethyl-hexyl (C2-6), isodecyl (iso C10) and isotridecyl (iso C13); R_2 = alkyl-aryl radical with the general formula $–CH_2$-CH_2-O-C_6H_4-R_3 where R_3 = H (series A), o-sec butyl (series B) and p-nonyl (series C).

On the basis of the above mentioned programme one may investigate the contribution of the aromatic ring to all properties through a relevant comparison within each series and between the three series. It becomes also possible to study the influence of the variation in length of the aliphatic chain (brought in by the aliphatic alcohol) as well as the influence of the length and position of the alkyl pendant group attached to the aromatic ring, on physical-chemical and tribological properties.

EXPERIMENTAL

The phenoxy-ethanols used in this work were: 2-phenoxy ethanol, 2-[(o-sec butyl) phenoxy] ethanol and 2-[(p-nonyl)-phenoxy] ethanol, respectively; these alcohols represent the special alcohols with a complex structure of an alkyl-aryl type and were synthesized by ethoxylation of the corresponding phenols through reaction with 1,3 dioxolane-2-one (ethylene carbonate) according to our previous stated procedures [8].

The synthesis of the diesters (mixed or homogeneous) was performed in a solution esterification process, using p-toluensulfonic acid as catalyst, the water being extracted azeotropically by means of a solvent (i.e. toluol), according, in general, to our standard procedures descriebed elsewhere [9] and in particular with our specific alternative stated for this case [10].

The purified products, with an essentially statistical structure and practically with no residual acidity, were characterized by chemical and physical indices specific to this class while their rheological and specific tribological features were determined by using standard techniques.

Note. In order to facilitate the reading of tables and the identification of the products, a coding system was used involving an abbreviation principle for the respective diesters. Thus, 2-phenoxy ethanol is identifiable as FE (phenol-ethoxylated), 2-[(o-sec butyl) phenoxy] ethanol as OSECBUT, 2-[(p-nonyl) phenoxy] ethanol as p-N. Similarly, 2 ethyl-hexanol was descriebed as 2ETHEX, isodecanol as izo10 and isotridecanol as izo13.

RESULTS AND DISCUSSION

Table 1 presents the principal physical and chemical indices of these products.

As regards the physico-rheological characteristics that are important with respect to the tribological properties, one must underline the excellent values of the flow (pour) point that reaches even a level of -43^{0}C. The flash points are really high, the best value recorded being of 284^{0}C, the other ones are ranged between 235^{0}C and 278^{0}C. The values of the viscosity index are remarkable good and are extended over a domain that lies between 101 and 138 for the unsymmetrical diesters; the symmetrical terms show only values of 43 and 75, respectively.

The lubricity properties determined by performing the four-ball test show general good values, the wear scar diameter presenting values from 0.62 mm up to 1.08 mm, at 40 daN and 60 min.

CONCLUSION

The complex esters of sebacic acid based on special alcohols of a complex alkyl-aryl structure and long aliphatic alcohols, respectively, show obvious features of synthetic lubricating oils.

One the basis of the representative tribological parameters one may assert that these products have a real and valuable potential to be considered as base oils, as a principal component of oils intended to be used at very low and very high temperatures, or in any application where the overall resistance and versatility viscosity are such desirable properties.

Table 1. Values of the main physical and chemical parameters

No.	Parameter / Code	Molecular Formula	Molecular Mass, M	Density, d_{20}^{20}, g/cm^3	Refractive Index, n_D^{20}	Dynamic Viscosity[(a)], mPa.s
1	2ETHEX-p-N	$C_{35}H_{60}O_5$	560	0.9646	1.4866	224-530
2	IZO 10-p-N	$C_{37}H_{64}O_5$	588	0.9598	1.4850	240-507
3	IZO 13-p-N	$C_{40}H_{70}O_5$	630	0.9493	1.4840	270-550
4	2ETHEX-	$C_{30}H_{50}O_5$	490	0.9744	1.4802	87-147
5	IZO 10-	$C_{32}H_{54}O_5$	518	0.9683	1.4800	116-193
6	IZO 13-	$C_{35}H_{60}O_5$	560	0.9550	1.4779	139-236
7	IZO 10-FE[(b)]	$C_{28}H_{46}O_5$	462	0.9778	1.4778	87-151
8	IZO 13-FE[(b)]	$C_{31}H_{52}O_5$	504	0.9652	1.4783	90-151
9	di-p-N	$C_{44}H_{70}O_6$	694	1.0041	1.5104	2973-3174
10	di-OSECBUT	$C_{34}H_{50}O_6$	554	1.0384	1.5134	457-1092

[(a)]Pseudoplastic behaviour; [(b)]Slow crystallization tendency

REFERENCES

[1] Murphy, W.R., Blain, D.A., Galiano-Roth, A.S. and Galvin, P.A., **2002** "Benefits of synthetic lubricants in industrial applications", J. Synth. Lubr., 18(4), pp. 301-325, also CA v. 136 (2002), 343018m

[2] Mirci, L.E. and Herdan, J., **1997**, "Pyromellitic esters with enhanced aromatic content and a mixed structure considered as tribologic fluids", First World Tribology Congress, 8-12 Sept., WTC, London, U.K., Syn. p 460

[3] Mirci, L.E. and Herdan, J., **1998**, "Pyromellitic esters with enhanced aromatic content and a mixed structure considered as tribologic fluids", Trib. Letters, 4, pp 293-297

[4] Mirci, L.E, Boran, S., Luca, P. and Boiangiu V., **2001**, "New citric esters with aromatic content and a complex structure considered for use as tribological fluids", 2nd WTC, Vienna, Austria, 3-7 Sept., Syn. p 238

[5] Mirci, L.E., and Herdan, J.M., **2000**, "Base oils of high aromatic, long branched aliphatic pyromellitic esters", J. Synth. Lubr. 17(1), pp 33-40

[6] Mirci, L.E, Herdan, J.M. and Boran, S., **2000/2001**, "New synthetic ester type base oils with biodegradability potential", J. Synth. Lubr., 17(4), pp 295-307

[7] Mirci, L.E, Herdan, J.M. and Ilia Gh., **2001**, "Phosphate esters with a complex structure of an alkyl-aryl type considered as base oils", J. Synth. Lubr., 18(2), pp 115-120

[8] Mirci, L.E., Romanian Patents, RO 100130, also CA 118 (1993) P 24102r; RO 100131, also CA 118 (1993) P 59411t; RO 103075 also CA 122 (1995) P 12499v; RO 105571, also CA, B1, 129 (1998) 15975c

[9] Mirci, L.E., Romanian Patents, RO 109644, also CA B1, 133 (2000), 5396h; RO 111760, also CA B1, 133 (2000), 31362p; RO 112611, also CA B1, 133 (2000), 90272g; RO 113851, also CA B1, 134 (2001), 254001s

[10] Mirci, L.E and Boran, S., Cerere Patent RO C.B.I. 00654/21.07.2004