

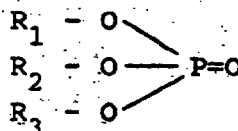
Description

The present process relates to the use of certain phosphate ester compounds as lubricants, in particular their use in traction drives.

These lubricants can be used in a variety of engineering applications, being of particular value in traction drives. Traction is broadly defined as the adhesive friction of a body on a surface on which it moves. A traction drive is a device in which torque is transmitted from an input element to an output element through nominal point or line contact typically with a rolling action by virtue of the traction between the contacting elements. While traction elements are commonly spoken of as being in contact, it is generally accepted that a fluid film is present therebetween. Almost all traction drives require fluids to remove heat, to prevent wear at the contact surfaces and to lubricate bearings and other moving parts associated with the drive. Thus, instead of metal to metal rolling contact there is a film of fluid introduced into the contact zone and interposed between the metal elements. The nature of this fluid determines to a large extent the limits in performance and the capacity of the drive. Most traction drives are designed to operate with a traction fluid which preferably has a coefficient of traction above about 0.06, a viscosity in the range of about 4-20,000 mPa.s over a temperature range of 40°C to -20°C and good thermal and oxidative stability. The fluid should also be noncorrosive to common materials of construction and have good load-bearing and low wear-rate properties.

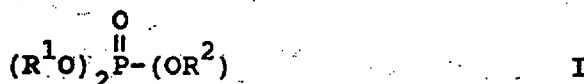
Mineral base oils are rather unsatisfactory lubricants for traction drives since in general their traction (friction) coefficient is low, which means that for any given load applied to the gears the maximal tangential force that may be transmitted by the friction wheels is low.

Research Disclosure, no. 207, July 1981, pages 258-259, abstract no. 20720, Havant Hampshire, GB, describes a traction fluid comprising a phosphate ester of the general formula



wherein R_1 , R_2 and R_3 may be different or the same aryl, alkyl or cycloalkyl groups. If any of R_1 , R_2 and R_3 are aryl or cycloalkyl groups they may be substituted with from 1 to 5 side groups, each of which may be a further cyclic group or an alkyl group of 1 to 20 carbon atoms. If any of R_1 , R_2 and R_3 are alkyl groups, they may be primary, secondary or tertiary species containing from 1 to 20 carbon atoms.

Accordingly, the present invention provides the use as lubricants, and especially as traction fluids, or organophosphate esters of the general formula I



wherein R^1 and R^2 are independently selected from 2-methylcyclohexyl and 3-methylcyclohexyl groups.

Organophosphate esters are known compounds, and therefore may be prepared by known procedures, such as the reaction of phosphoryl chloride with the appropriate alcohol in the presence of a base, such as pyridine or triethylamine, and suitably also a solvent.

It has been found that the viscosity characteristics of the above ester compounds are very suitable for use in e.g. friction wheel gears (traction drives) in which application they may be admixed with conventional grease thickeners. Such thickeners can be of any number of materials commonly used to thicken mineral oils to lubricating viscosity, including both organic and inorganic compositions such as metallic soaps, synthetic polymers, organosiloxanes, clays, bentonite, and colloidal silica. Suitably, the viscosity properties of compounds to be used in traction drives are such that the compounds are operable between -30 and 150°C.

The compounds can be used as lubricants in various engineering applications. Since the above ester compounds show excellent lubricating performance in traction drives, the invention in particular provides the use of these ester compounds as traction fluids, and also the operation of a traction drive wherein such esters form the traction fluid.

The ester compounds of the present invention can be used per se as lubricants. They can be mixed with other lubricants such as mineral or synthetic oils, and various additives can be added to the ester compounds, such as VI-improvers, pour point depressants, dispersants, detergents, anti-oxidants and the like. A mixture

that can be of particular interest for traction fluid applications is a blend with a polyolefin, in particular a poly-alpha-olefin, especially polyisobutylene, since the presence of the polymer can usefully enhance the traction coefficient of the fluid blend. The molecular weight of such polyolefin blend components is conveniently in the range 500-10,000, a specific example of a suitable polyisobutylene being "Hyvis", and the proportion of polyolefin may vary from zero to 70% by weight.

The following Examples illustrate the preparation of compounds used in the present invention (III and IV), and of comparative compounds (I, II and V), together with their frictional and other physical properties.

Example I Tricyclohexyl phosphate

A solution of cyclohexanol (751.2g, 7.5m) and pyridine (595.0g, 7.5m) in dichloromethane (3.5L) was stirred under an atmosphere of dry nitrogen and phosphoryl chloride (382.5g, 2.5m) was added dropwise over 1-2 hours, whilst maintaining the temperature of the reaction mixture at between 15 and 25°C throughout the addition period. On completion of the addition, stirring was continued at ambient temperature for a further 18 hours, and then the resultant mixture was filtered. The organic solution was washed with water (3 x 5L) and dried (over MgSO_4), and the solvent was evaporated off in vacuo at 30°C to give a pale-yellow viscous oil (730.3g) which slowly solidified on standing. The crude oil was dissolved with stirring in diethyl ether (750ml) and cooled with stirring to -40 to -50°C in a dry ice/acetone cooling bath. The precipitate was filtered and dried in vacuo at 25°C to give tri(cyclohexyl) phosphate (520.0g) as an off-white solid, m.p. 48-50°C.

Example II Tri(methylcyclohexyl) phosphate

A solution of methylcyclohexanol (technical grade, containing a mixture of isomers; 2.08 kg, 18.2m) and pyridine (1.44 kg, 18.2m) in dichloromethane (10L) was stirred under an atmosphere of dry nitrogen and phosphoryl chloride (930.2g, 6.07m) added dropwise over 1.5 hours, whilst maintaining the temperature of the stirred reaction mixture at between 15 and 25°C throughout the addition period. On completion of the addition, stirring was continued at ambient temperature for a further 18 hours, and then the resultant mixture was filtered, washed with water (4 x 6L) and dried (over MgSO_4), and the solvent was evaporated off in vacuo at 30°C to give the crude product as a viscous oil. The crude oil was allowed to stand at room temperature overnight, was then filtered and unreacted methylcyclohexanol and other volatile impurities were removed by evaporation on a KDL-4 thin-film evaporator (at 85°C and 0.8mmHg (107 Pa)) to give the product as a clear viscous oil (1.75 kg) containing a mixture of different isomers.

Examples III to V

By using the process of Example II, but substituting respectively 2-methylcyclohexanol, 3-methylcyclohexanol and 4-methylcyclohexanol (in each case mixtures of cis- and trans-isomers) in place of the technical grade methylcyclohexanol, there were prepared:-

III - Tri-(2-methylcyclohexyl)phosphate (oil)

IV - Tri-(3-methylcyclohexyl)phosphate (oil)

V - Tri-(4-methylcyclohexyl)phosphate (oil)

Example VI Friction coefficient measurement

All friction measurements were performed on a two-disc machine. Hardened steel discs are fixed on the ends of two shafts so as to make tangential contact with each other. Radial forces may be applied to press the discs together with loads of 0-200 kgf. Each disc is driven by an electric motor. The speeds of rotation of the two discs are different, such that there is a slip.

Between the electric motor and the shaft carrying the lower test specimen, a measuring device is fitted which indicates the transmitted friction torque. The measuring device is a gear dynamometer with a pendulum which is swung out of its vertical balanced position when power is transmitted, the sine of the angle of inclination being a measure of the torque. The torque measurement is pre-calibrated through the design and dimensions of the instrument. The friction coefficient is defined by the torque measured divided by the product of the radial force times the radius of the lower disc.

Both discs used had a diameter of 50.0mm, the upper disc having a width of 3mm, the lower one having a width of 10mm. The top shaft speed was 606rpm, and the mean tangential (or surface) velocity was 1.48 ms^{-1} . The slip employed was 9.1%.

All experiments were run at ambient temperature (21°C±2°C). The friction readings are provided at loadings

equivalent to Hertzian stresses of 0.69, 0.97, 1.19 and 1.38 GPa.

The friction coefficients of the compounds are indicated in the following Table. For the compound of Example I, whose m.pt. is 48-50°C, these coefficients were determined on a supercooled fluid at 21(±2)°C.

5 Example VIII Friction coefficient measurement

The kinematic viscosity properties of the compounds are also included in this Table.

It will be noted that the friction coefficients of the compounds are all good, but that those of Examples III and IV are very surprisingly superior.

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TABLE

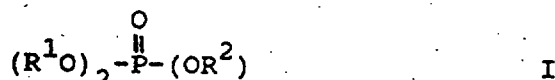
Example -

	I	II	III	IV	V
Kinematic Viscosity (40°C) cSt (mm ² /S)	Solid	106.8	60.7	44.6	110.3
Kinematic Viscosity (60°C) cSt (mm ² /S)	45.62				
Kinematic Viscosity (100°C) cSt (mm ² /S)	9.503	7.873	6.43	5.63	8.31
Viscosity Index	-32	-25	22	41	-7
Density (40°C) g cm ⁻³	Solid	1.0310			
Density (60°C) g cm ⁻³	1.0585				
Density (100°C) g cm ⁻³	1.0295	0.9880			
Pour Point °C	48				
Friction Coefficient (0.69GPa)	0.079	0.086	0.106	0.103	0.087
Friction Coefficient (0.97GPa)	0.088	0.097	0.111	0.108	0.094
Friction Coefficient (1.19GPa)	0.098	0.102	0.113	0.111	0.099
Friction Coefficient (1.38GPa)	0.108	0.104	0.113	0.111	0.102



Claims

- 5 1. Use as lubricants of organophosphate esters of the general formula I:-



10 wherein R¹ and R² are independently selected from 2-methylcyclohexyl and 3-methylcyclohexyl groups.

2. Use according to Claim 1 wherein the organophosphate ester of formula I is tri-(2-methylcyclohexyl)phosphate or tri-(3-methylcyclohexyl)phosphate.

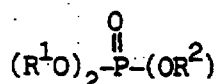
15 3. Lubricant composition which contains as the major component an organophosphate ester as defined in claim 1 or 2.

4. Use as a traction fluid of an organophosphate ester as defined in claim 1 or 2 or a composition as defined in claim 3.

5. Method of operating a traction drive wherein the traction fluid is an organophosphate ester as defined in claim 1 or 2 or a composition as defined in claim 3.

Patentansprüche

- 25 1. Verwendung von Organophosphatestern der allgemeinen Formel I:



30 worin R¹ und R² unabhängig voneinander aus 2-Methylcyclohexyl- und 3-Methylcyclohexyl-Gruppen ausgewählt sind, als Schmiermittel.

2. Verwendung nach Anspruch 1, worin der Organophosphatester der Formel I Tri-(2-methylcyclohexyl)phosphat oder Tri-(3-methylcyclohexyl)phosphat ist.

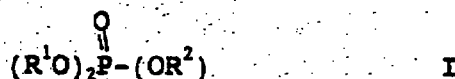
35 3. Schmiermittelzusammensetzung, welche als Hauptkomponente einen Organophosphatester, wie er in Anspruch 1 oder 2 definiert ist, enthält.

4. Verwendung eines Organophosphatesters, wie er in Anspruch 1 oder 2 definiert ist, oder einer in Anspruch 3 definierten Zusammensetzung als Reibungsfluid.

5. Verfahren zum Betreiben eines Reibungsantriebes, worin das Reibungsfluid ein Organophosphatester, wie er in Anspruch 1 oder 2 definiert ist, oder eine in Anspruch 3 definierte Zusammensetzung ist.

Revendications

- 45 1. Utilisation comme lubrifiants d'esters organophosphates de la formule generale I



50 dans laquelle R¹ et R² sont indépendamment choisis parmi les groupes 2-méthylcyclohexyle et 3-méthylcyclohexyle.

2. Utilisation selon la revendication 1, dans laquelle l'esther organophosphate de la formule I est le tri-(2-méthylcyclohexyle)phosphate ou le tri-(3-méthylcyclohexyle)phosphate.

55 3. Composition lubrifiante qui renferme, en tant que composé principal, un ester organophosphate tel que défini dans la revendication 1 ou 2.

4. Utilisation, en tant que fluide de traction, d'un ester organophosphate tel que défini dans la revendication 1 ou 2 ou bien d'une composition telle que définie dans la revendication 3.

5. Méthode de mise en oeuvre d'un mécanisme de traction à frottement, dans lequel le fluide anti-frottement



est un ester organophosphate tel que défini dans la revendication 1 ou la revendication 2 ou bien une composition telle que définie dans la revendication 3.

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