



(11) **EP 2 937 408 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.10.2015 Bulletin 2015/44

(21) Application number: **14165470.7**

(22) Date of filing: **22.04.2014**

(51) Int Cl.:
C10M 129/72 (2006.01) **C10M 105/36** (2006.01)
C10N 30/00 (2006.01) *C10N 30/02* (2006.01)
C10N 30/10 (2006.01) *C10N 40/25* (2006.01)
C10N 40/30 (2006.01) *C10N 40/04* (2006.01)
C10N 40/06 (2006.01) *C10N 40/08* (2006.01)
C10N 40/13 (2006.01) *C10N 40/16* (2006.01)
C10N 40/20 (2006.01) *C10N 40/32* (2006.01)
C10N 40/34 (2006.01) *C10N 40/36* (2006.01)

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME

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(54) **Lubricant composition comprising an ester of a C17 alcohol mixture**

(57) The present invention relates to a lubricant composition comprising an ester component derived from (a) an alcohol component, which is a C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7 and (b) an acid component, which is an aliphatic C₄-C₁₀ dicarboxylic acid or cyclohexanedicarboxylic acid.

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Description

[0001] The present invention relates to the field of lubricant compositions. In particular, the present invention relates to a lubricant composition comprising an ester component derived from (a) an alcohol component, which is a C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7 and (b) an acid component, which is an aliphatic C₄-C₁₀ dicarboxylic acid or cyclohexanedicarboxylic acid. In addition, the invention relates to the use of the above ester component for improving the seal compatibility of lubricant compositions. The lubricant compositions can be used in a variety of different formulations required in motor vehicles.

Technical background

[0002] Commercially available lubricant compositions are based on a multitude of different natural or synthetic components. The resulting properties of the various existing lubricant compositions are tailored to the specific technical requirements by the addition of further components and selected combinations thereof. In this way, lubricant compositions are obtained which can fulfill the complex requirements associated with the various special technical applications in the field of motor vehicles, automotive engines and other machinery.

[0003] Typically, lubricant compositions are needed that provide highest shear stability, improved low-temperature viscosity, minimum degree of evaporation loss, good fuel efficiency, acceptable seal compatibility and excellent wear protection.

[0004] One especially desired set of properties in high performance lubrication applications is a favorable low temperature viscosity in combination with excellent dynamic behavior. Known lubricants which are able to fulfill such performance characteristics have been developed in the prior art by the addition of special thickening agents (viscosity index improving agents) to high quality base oils. Preferably, polyalphaolefin (PAO)-type base components have been modified with thickeners like polyisobutenes (PIB), oligomeric co-polymers (OCPs), polymethacrylates (PMAs) or even high viscosity esters (complex esters) for achieving the desired set of properties.

[0005] US 5451630 describes the general dilemma when using thickening agents in lubricant compositions because the increase of viscosity is directly related to the molecular weight of the polymeric thickening agent while on the other hand the shear stability decreases due to the greater tendency of breakage under shear and high temperature conditions.

[0006] US 5451630 further suggests oligomeric copolymers which are demonstrated to provide good shear stability to lubricant compositions.

[0007] In WO 2007/144079, a larger number of lubricant compositions have been described including a variety of different thickening agents like PIBs, OCPs, PMAs and high viscosity esters which have been demonstrated to be useful as viscosity index improvers.

[0008] In addition, low viscosity esters like DIDA (diisodecyl adipate), DITA (diisotridecyl adipate) or TMTC (trimethylolpropane caprylate) have also been added to lubricant compositions as solubilizers for polar additive types while further providing lubricity and seal compatibility.

[0009] There is a continued need for lubricant compositions which are able to provide improved performance characteristics not found in the already existing ones. In particular, there is a need in the art for ester component for lubricants providing a good balance of thermal stability, low temperature viscosity, hydrolysis stability and seal compatibility. Ester components should ideally have a kinematic viscosity around 46 mm²/s, which is typical for hydraulic liquids. Current hydraulic liquids are normally formulated with ester components of lower viscosity and are then adjusted to the required viscosity using thickeners resulting in disadvantageous low temperature viscosities as well as higher complexity in formulating the lubricant compositions. One approach to solve the problem is to employ esters of dicarboxylic acids with 2-propylheptanol, which provide good thermal stability, hydrolysis stability and low viscosity at low temperature. However, these ester disadvantageously show a low seal compatibility. An alternative approach is to employ diesters of so-called Guerbet alcohols or mixtures thereof. The trivial name of Guerbet alcohol is used for 2-alkyl-substituted 1-alkanols whose industrial synthesis is described *inter alia* in H. Machemer, *Angewandte Chemie*, Vol. 64, pages 213-220 (1952) and in G. Dieckelmann and H.J. Heinz in "The Basics of Industrial Oleochemistry", pages 145-145 (1988). However, although such Guerbet diesters show a favorable seal compatibility, they have a kinematic viscosity significantly below the desired value of 46 mm²/s.

[0010] Thus, it is an object of the present invention to provide lubricant compositions including an ester component having a kinematic viscosity in the typical range of hydraulic fluids even without the additional use of thickeners and at the same time providing high seal compatibility, good hydrolysis or oxidation stability, favorable low temperature viscosity and a low pour point.

[0011] Surprisingly, it has been found that ester components derived from (a) an alcohol component, which is a C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7 and (b) an acid component, which is an aliphatic C₄-C₁₀ dicarboxylic acid or cyclohexanedicarboxylic acid exhibit the desired profile for lubricant compositions.

Description of the invention

[0012] The present invention relates to a lubricant composition comprising an ester component derived from (a) an alcohol component, which is a C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7 and (b) an acid component, which is an aliphatic C₄-C₁₀ dicarboxylic acid or cyclohexanedicarboxylic acid.

[0013] In an embodiment, the lubricant composition according to the present invention comprises the ester component derived from an alcohol component additionally comprising a polyol. The polyol may be selected e.g. from trimethylol propane, neopentyl glycol, pentaerythrit or dipentaerythrol. In another embodiment, the alcohol component is free from a polyol and essentially consists of the C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7.

[0014] In one embodiment, the ester component in the inventive lubricant composition has a kinematic viscosity determined according to DIN 51562-1 at 40°C of 20 to 70 mm²/s. In a preferred embodiment, the ester component has a kinematic viscosity of 35 to 55 mm²/s, preferably 40 to 50 mm²/s. Most preferably, the ester component has a kinematic viscosity of about 46 mm²/s.

[0015] In one embodiment, the C₁₇ alcohol mixture has an average iso-index of 2.9 to 3.6, preferably 3.01 to 3.5, more preferably 3.05 to 3.4.

[0016] In one embodiment, examples the acid component include but are not limited to cyclohexane-1,2-dicarboxylic acid, cyclohexane-1,3-dicarboxylic acid or cyclohexane-1,4-dicarboxylic acid or an aliphatic dicarboxylic acid selected from glutaric acid, adipic acid, pimelic acid, azelaic, sebacic, undecanoic and dodecanoic acid. In a preferred embodiment, the acid component is derived from an aliphatic C₅-C₇ dicarboxylic acid or cyclohexanedicarboxylic acid. Examples of preferred acids include cyclohexane-1,2-dicarboxylic acid, cyclohexane-1,3-dicarboxylic acid or cyclohexane-1,4-dicarboxylic acid or an aliphatic dicarboxylic acid selected from glutaric acid, adipic acid, pimelic acid, most preferably adipic acid.

[0017] In one embodiment, the lubricant composition comprises the above ester component, a base oil component and optionally an additive component.

[0018] In one embodiment, the lubricant composition comprises based on the total weight of the lubricant composition:

- (i) 5 to 99.9 wt%, preferably 80-99 wt% of the ester component,
- (ii) 0 to 75 wt%, preferably 0 to 19 wt% of a base oil component, and
- (iii) 0.1 to 20 wt%, preferably 1 to 20 wt% of an additive component.

[0019] In an alternative embodiment, the lubricant composition comprises based on the total weight of the lubricant composition:

- (i) 5 to 29 wt%, preferably 5 to 20 wt% of the ester component,
- (ii) 20 to 80 wt%, preferably 40 to 60 wt% a base oil component, and
- (iii) 1 to 50 wt%, preferably 10 to 45 wt% of an additive component.

[0020] In an embodiment, the additive component may be selected from the group consisting of antioxidants, dispersants, foam inhibitors, demulsifiers, seal swelling agents, friction reducers, anti-wear agents, detergents, corrosion inhibitors, extreme pressure agents, metal deactivators, rust inhibitors, pour point depressants and mixtures thereof. In one embodiment, the additive component includes antioxidants, corrosion inhibitors for nonferrous metals and steel, additives for modifying air separation behavior, foam behavior and demulsifying power and EP/AW additives. In a further embodiment, the base oil component may be selected from the group consisting of a Group I mineral oil, a Group II mineral oil, a Group III mineral oil, a Group IV oil, a Group V oil, and mixtures thereof. In a preferred embodiment, the base oil component comprises a polyalphaolefin (Group IV oil), more preferably a polyalphaolefin 4, polyalphaolefin 6 and/or polyalphaolefin 8, preferably a polyalphaolefin 6.

[0021] According to a preferred embodiment of the present invention, the lubricant composition comprises said ester component in an amount of 50 to 99 wt%, preferably 80 to 99 wt%, based on the total weight of the lubricant composition.

[0022] In another preferred embodiment, the lubricant composition comprises said base oil component in an amount of 0 to 30 wt%, preferably 0 to 19 wt%, based on the total weight of the lubricant composition.

[0023] In a further preferred embodiment, the lubricant composition comprises said additive component in an amount of 0.1 to 20 wt%, preferably 1 to 20 wt%, based on the total weight of the lubricant composition.

[0024] The present invention also relates to the use of the ester component as defined above for improving the seal compatibility of lubricant compositions. In one embodiment, the lubricant composition shows a seal compatibility with nitrile-butadiene-copolymer determined according to ISO 1817 at 100°C for 168 hours resulting in a mass change of 20% or lower, preferably 10% or lower. In another embodiment, the lubricant composition shows a seal compatibility with nitrile-butadiene-copolymer determined according to ISO 1817 at 100°C for 168 hours resulting in a volume change of 30% or lower, preferably 15% or lower. In a further embodiment, the lubricant composition shows a seal compatibility

with nitrile-butadiene-copolymer determined according to ISO 1817 at 100°C for 168 hours resulting in a hardness change of 12% or lower, preferably 8% or lower. The data regarding the mass change, volume change or hardness change is obtained from a comparison of the nitrile-butadiene-copolymer based seal before being subjected to the lubricant composition and after being exposed to the lubricant composition for 168 hours at 100°C.

[0025] The lubricant compositions and uses according to the invention may in one embodiment be implemented in the context of a light, medium and heavy duty engine oil, industrial engine oil, marine engine oil, automotive engine oil, crankshaft oil, compressor oil, refrigerator oil, hydrocarbon compressor oil, very low-temperature lubricating oil and fat, high temperature lubricating oil and fat, wire rope lubricant, textile machine oil, refrigerator oil, aviation and aerospace lubricant, aviation turbine oil, transmission oil, gas turbine oil, spindle oil, spin oil, traction fluid, transmission oil, plastic transmission oil, passenger car transmission oil, truck transmission oil, industrial transmission oil, industrial gear oil, insulating oil, instrument oil, brake fluid, transmission liquid, shock absorber oil, heat distribution medium oil, transformer oil, fat, chain oil, minimum quantity lubricant for metalworking operations, oil to the warm and cold working, oil for a water-based metalworking liquid, oil for a neat oil metalworking fluid, oil for a semi-synthetic metalworking fluid, oil for a synthetic metalworking fluid, drilling detergent for the soil exploration, hydraulic oil, biodegradable lubricant or lubricating grease or wax, chain saw oil, release agent, moulding fluid, gun, pistol and rifle lubricant or watch lubricant and food grade approved lubricant.

[0026] In a preferred embodiment, the invention relates to the use of the inventive lubricant as a hydraulic oil, especially a biohydraulic oil. A biohydraulic oil in the sense of the present invention is a biodegradable hydraulic oil. This is determined, for example, by the standard OECD 301 test or by the EPA 560/6-82-003 test, and preferably by OECD test 301 B. The biohydraulic oil shows a biological degradability of at least 60%, preferably at least 70% and, more particularly, at least 75%. This can be achieved according to the invention e.g. by employing the ester component in high amounts such as 80 to 99.9 wt% in addition to the additive component in amounts of 0.1 to 20 wt% in the absence of base oil component.

[0027] The lubricant compositions according to the present invention include the following components which are described below in more detail.

[0028] As outline above, the lubricant composition of the present invention comprises an ester component derived from (a) an alcohol component, which is a C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7 and (b) an acid component, which is an aliphatic C₄-C₁₀ dicarboxylic acid or cyclohexanedicarboxylic acid.

[0029] The alcohol component can be obtained as described in WO 2009/124979. In one embodiment, the alcohol component is obtained by

- (i) providing a hydrocarbon starting material containing at an olefin having 2 to 6 carbon atoms,
- (ii) subjecting the hydrocarbon starting material to oligomerization in the presence of a transition metal catalyst,
- (iii) separating the oligomerization product obtained in step (ii) using distillation to obtain an olefin stream enriched in C₁₆ olefins, and
- (iv) subjecting the olefin stream enriched in C₁₆ olefins obtained in step (iii) to hydroformulation by reacting with CO and H₂ in the presence of a cobalt hydroformulation catalyst and subsequent hydrogenation.

[0030] Further details for obtaining the C₁₇ alcohol component are described in WO 2009/124979 which is incorporated herein by reference.

[0031] For adjusting the resulting viscosity of the ester component, the above C₁₇ alcohol component may be used in combination with one or more polyols. Suitable polyols include e.g. trimethylol propane, neopentyl glycol, pentaerythrit, or dipentaerythrol. In one embodiment, the alcohol component includes up to 15 wt%, such as 10 wt% of polyol. In another embodiment, the alcohol component is free from a polyol and essentially consists of the C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7.

[0032] In a preferred embodiment, the C₁₇ alcohol mixture has an average iso-index of 2.9 to 3.6, more preferably 3.01 to 3.5, still more preferably 3.05 to 3.4, such as 3.1.

[0033] The acid component in the ester component of the inventive lubricant composition is derived from an aliphatic C₄-C₁₀ dicarboxylic acid, preferably C₅-C₇ dicarboxylic acid, or cyclohexanedicarboxylic acid. The present inventors surprisingly have found that esters of such acids with the above C₁₇ alcohol component have a desired kinematic viscosity and high hydrolysis and oxidation stability and at the same time provide superior seal compatibility. In one embodiment, the cyclohexanedicarboxylic acid is cyclohexane-1,2-dicarboxylic acid, cyclohexane-1,3-dicarboxylic acid or cyclohexane-1,4-dicarboxylic acid. In another embodiment, the aliphatic dicarboxylic acid is selected from glutaric acid, adipic acid, pimelic acid, azelaic, sebacic, undecanoic and dodecanoic acid. More preferably, the aliphatic dicarboxylic acid is selected from glutaric acid, adipic acid, and pimelic acid. Most preferably, the acid component is derived from adipic acid.

[0034] Esterification can be effected as well known in the art. For example, the acid component may be reacted with an excess of alcohol component at elevated temperature in the presence of a suitable catalyst. Water generated during esterification is continually removed. After completion of the reaction excess alcohol is separated from the ester and the

product is dried and/ or purified as needed.

[0035] The kinematic viscosity of the resulting ester component at 40 °C is preferably from 20 to 70 mm²/s. In a more preferred embodiment, the ester component has a kinematic viscosity of 35 to 55 mm²/s, still more preferably 40 to 50 mm²/s. Most preferably, the ester component has a kinematic viscosity of about 46 mm²/s.

[0036] The ester component is present in the inventive lubricant composition in an amount of preferably 5 to 99.9 wt%, more preferably 50 to 99 wt%, such as 80 to 99 wt%.

[0037] The lubricant composition of the present invention may also comprise a base oil component. In one embodiment of the present invention, the lubricant composition comprises 0 to 75 wt%, preferably 0 to 19 wt% of a base oil component.

[0038] Alternatively, the base oil component may be included in higher amounts. For example, an alternative lubricant composition may comprise 20 to 80 wt%, preferably 40 to 60 wt% of base oil component. Such alternative lubricant compositions may comprise the ester component in an amount of 5 to 29 wt%, preferably 5 to 20 wt%, and additive component in an amount of 1 to 50 wt%, preferably 10 to 45 wt%.

[0039] Optionally, the lubricant compositions according to the present invention further comprise base oils selected from the group consisting of mineral oils (Group I, II or III oils), polyalphaolefins (Group IV oils), polymerized and inter-polymerized olefins, alkyl naphthalenes, alkylene oxide polymers, silicone oils, phosphate esters and carboxylic acid esters (Group V oils). The base oil (or base stock) to be used in the lubricant compositions according to the present invention is an inert, solvent-type oil component in the lubricant compositions according to the present invention. In preferred embodiments of the present invention, the base oil component of the lubricant composition comprises a PAO and/or a group II and/or Group III mineral oil, preferably a PAO 4, PAO 6 and/or PAO 8, wherein a PAO 6 is especially preferred base oil.

[0040] Definitions for the base oils according to the present invention are the same as those found in the American Petroleum Institute (API) publication "Engine Oil Licensing and Certification System", Industry Services Department, Fourteenth Edition, December 1996, Addendum 1, December 1998. Said publication categorizes base stocks as follows:

a) Group I base oils contain less than 90 percent saturates and/or greater than 0.03 percent sulfur and have a viscosity index greater than or equal to 80 and less than 120 using the test methods specified in the following table.

b) Group II base oils contain greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and have a viscosity index greater than or equal to 80 and less than 120 using the test methods specified in the following table.

c) Group III base oils contain greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and have a viscosity index greater than or equal to 120 using the test methods specified in the following table

[0041] Analytical Methods for Base Stock:

Property	Test Method
Saturates	ASTM D 2007
Viscosity Index	ASTM D 2270
Sulfur	ASTM D 2622
	ASTM D 4294
	ASTM D 4927
	ASTM D 3120

d) Group IV base oils contain polyalphaolefins. Synthetic lower viscosity fluids suitable for the present invention include the polyalphaolefins (PAOs) and the synthetic oils from the hydrocracking or hydro-isomerization of Fischer Tropsch high boiling fractions including waxes. These are both base oils comprised of saturates with low impurity levels consistent with their synthetic origin. The hydro-isomerized Fischer Tropsch waxes are highly suitable base oils, comprising saturated components of iso-paraffinic character (resulting from the isomerization of the predominantly n-paraffins of the Fischer Tropsch waxes) which give a good blend of high viscosity index and low pour point. Processes for the hydro-isomerization of Fischer Tropsch waxes are described in U.S. Patents 5,362,378; 5,565,086; 5,246,566 and 5,135,638, as well in EP 710710, EP 321302 and EP 321304.

[0042] Polyalphaolefins suitable for the lubricant compositions according to the present invention, include known PAO

materials which typically comprise relatively low molecular weight hydrogenated polymers or oligomers of alphaolefins which include but are not limited to C₂ to about C₃₂ alphaolefins with the C₈ to about C₁₆ alphaolefins, such as 1-octene, 1-decene, 1-dodecene and the like being preferred. The preferred polyalphaolefins are poly-1-octene, poly-1-decene, and poly-1-dodecene, although the dimers of higher olefins in the range of C₁₄ to C₁₈ provide low viscosity base stocks.

[0043] Terms like PAO 4, PAO 6 or PAO 8 are commonly used specifications for different classes of polyalphaolefins characterized by their respective viscosity. For instance, PAO 6 refers to the class of polyalphaolefins which typically has viscosity in the range of 6 mm²/s at 100°C. A variety of commercially available compositions are available for these specifications.

[0044] Low viscosity PAO fluids suitable for the lubricant compositions according to the present invention, may be conveniently made by the polymerization of an alphaolefin in the presence of a polymerization catalyst such as the Friedel-Crafts catalysts including, for example, aluminum trichloride, boron trifluoride or complexes of boron trifluoride with water, alcohols such as ethanol, propanol or butanol, carboxylic acids or esters such as ethyl acetate or ethyl propionate. For example, the methods disclosed by U.S. Patents 4,149,178 or 3,382,291 may be conveniently used herein. Other descriptions of PAO synthesis are found in the following U.S. Patents: 3,742,082 (Brennan); 3,769,363 (Brennan); 3,876,720 (Heilman); 4,239,930 (Allphin); 4,367,352 (Watts); 4,413,156 (Watts); 4,434,408 (Larkin); 4,910,355 (Shubkin); 4,956,122 (Watts); and 5,068,487 (Theriot).

e) Group V base oils contain any base stocks not described by Groups I to IV. Examples of Group V base oils include alkyl naphthalenes, alkylene oxide polymers, silicone oils, and phosphate esters.

[0045] Carboxylic acid esters which are also widely considered in the literature to belong to the Group V base oils are not understood according to the present invention as base oils (base stocks) or even group V base oils but are separately listed as the ester component being essential to the present invention.

[0046] Synthetic base oils include hydrocarbon oils and halo-substituted hydrocarbon oils such as polymerized and interpolymers of olefins (e.g., polypropylenes, propylene-isobutylene copolymers, chlorinated polybutylenes, poly(1-hexenes), poly(1-octenes), poly(1-decenes)); alkylbenzenes (e.g., dodecylbenzenes, tetradecylbenzenes, dinonylbenzenes, di(2-ethylhexyl)benzenes); polyphenyls (e.g., biphenyls, terphenyls, alkylated polyphenols); and alkylated diphenyl ethers and alkylated diphenyl sulfides and derivative, analogs and homologs thereof.

[0047] Alkylene oxide polymers and interpolymers and derivatives thereof where the terminal hydroxyl groups have been modified by esterification, etherification, etc., constitute another class of known synthetic base oils. These are exemplified by polyoxyalkylene polymers prepared by polymerization of ethylene oxide or propylene oxide, and the alkyl and aryl ethers of polyoxyalkylene polymers (e.g., methyl-polyiso-propylene glycol ether having a molecular weight of 1000 or diphenyl ether of polyethylene glycol having a molecular weight of 1000 to 1500); and mono- and polycarboxylic esters thereof, for example, the acetic acid esters, mixed C₃-C₈ fatty acid esters and C₁₃ Oxo acid diester of tetraethylene glycol.

[0048] Silicon-based oils such as the polyalkyl-, polyaryl-, polyalkoxy- or polyaryloxysilicone oils and silicate oils comprise another useful class of synthetic base oils; such base oils include tetraethyl silicate, tetraisopropyl silicate, tetra-(2-ethylhexyl)silicate, tetra-(4-methyl-2ethylhexyl)silicate, tetra-(p-tert-butyl-phenyl) silicate, hexa-(4-methyl-2-ethylhexyl)disiloxane, poly(methyl)siloxanes and poly(methylphenyl)siloxanes. Other synthetic base oils include liquid esters of phosphorous-containing acids (e.g., tricresyl phosphate, trioctyl phosphate, diethyl ester of decylphosphonic acid) and polymeric tetrahydrofurans.

[0049] The relative amount of base oil in the lubricant compositions according to the present invention is in the range of 0 to 75 wt%, preferably 0 to 19 wt%, based on the total amount of lubricant composition.

[0050] The lubricant composition according to the present invention may further comprise an additive component. In a preferred embodiment, the additive component is selected from the list consisting of antioxidants, dispersants, foam inhibitors, demulsifiers, seal swelling agents, friction reducers, anti-wear agents, detergents, corrosion inhibitors, extreme pressure agents, metal deactivators, rust inhibitors, pour point depressants and mixtures thereof.

[0051] The additive component as used in the present invention also includes an additive package and/or performance additives.

[0052] The additive package as used in the present invention as well as the compounds relating to performance additives are considered mixtures of additives that are typically used in lubricant compositions in limited amounts for mechanically, physically or chemically stabilizing the lubricant compositions while special performance characteristics can be further established by the individual or combined presence of such selected additives.

[0053] Additive packages are separately defined in the present invention since a variety of such additive packages are commercially available and typically used in lubricant compositions. One such preferred additive package that is commercially available is marketed under the name Anglamol6004J®.

[0054] However, the individual components contained in the additive packages and/or the compounds further defined in the present invention as so-called performance additives include a larger number of different types of additives including

dispersants, metal deactivators, detergents, extreme pressure agents (typically boron- and/or sulfur- and/or phosphorus-containing), anti-wear agents, antioxidants (such as hindered phenols, aminic antioxidants or molybdenum compounds), corrosion inhibitors, foam inhibitors, demulsifiers, pour point depressants, seal swelling agents, friction modifiers and mixtures thereof.

[0055] The additive component as the sum of all additives contained in the lubricant compositions according to the present invention also including all additives contained in an additive package or added separately is present in the lubricant compositions of the present invention in an amount of 0.1 to 20 wt%, preferably 1 to 20 wt%, such as 2 to 15 wt%, and 3 to 12 wt%.

[0056] Extreme pressure agents include compounds containing boron and/or sulfur and/or phosphorus. The extreme pressure agent may be present in the lubricant compositions at 0 % by weight to 15 % by weight, or 0.05 % by weight to 10 % by weight, or 0.1 % by weight to 8 % by weight of the lubricant composition.

[0057] In one embodiment according to the present invention, the extreme pressure agent is a sulfur-containing compound. In one embodiment, the sulfur-containing compound may be a sulfurised olefin, a polysulfide, or mixtures thereof. Examples of the sulfurised olefin include a sulfurised olefin derived from propylene, isobutylene, pentene; an organic sulfide and/or polysulfide including benzyldisulfide; bis-(chlorobenzyl) disulfide; dibutyl tetrasulfide; di-tertiary butyl polysulfide; and sulfurised methyl ester of oleic acid, a sulfurised alkylphenol, a sulfurised dipentene, a sulfurised terpene, a sulfurised Diels-Alder adduct, an alkyl sulphenyl N'-N'-dialkyl dithiocarbamates; or mixtures thereof.

[0058] In one embodiment the sulfurised olefin includes a sulfurised olefin derived from propylene, isobutylene, pentene or mixtures thereof.

[0059] In one embodiment according to the present invention, the extreme pressure agent sulfur-containing compound includes a dimercaptiothiadiazole or derivative, or mixtures thereof. Examples of the dimercaptiothiadiazole include compounds such as 2,5-dimercapto-1,3,4-thiadiazole or a hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole, or oligomers thereof. The oligomers of hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole typically form by forming a sulfur-sulfur bond between 2,5-dimercapto-1,3,4-thiadiazole units to form derivatives or oligomers of two or more of said thiadiazole units. Suitable 2,5-dimercapto-1,3,4-thiadiazole derived compounds include for example 2,5-bis(tert-nonyldithio)-1,3,4-thiadiazole or 2-tert-nonyldithio-5-mercaptop-1,3,4-thiadiazole. The number of carbon atoms on the hydrocarbyl substituents of the hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole typically include 1 to 30, or 2 to 20, or 3 to 16.

[0060] In one embodiment, the dimercaptiothiadiazole may be a thiadiazole-functionalised dispersant. A detailed description of the thiadiazole-functionalised dispersant is described in paragraphs [0028] to [0052] of International Publication WO 2008/014315.

[0061] The thiadiazole-functionalised dispersant may be prepared by a method including heating, reacting or complexing a thiadiazole compound with a dispersant substrate. The thiadiazole compound may be covalently bonded, salted, complexed or otherwise solubilised with a dispersant, or mixtures thereof.

[0062] The relative amounts of the dispersant substrate and the thiadiazole used to prepare the thiadiazole-functionalised dispersant may vary. In one embodiment the thiadiazole compound is present at 0.1 to 10 parts by weight relative to 100 parts by weight of the dispersant substrate. In different embodiments the thiadiazole compound is present at greater than 0.1 to 9, or greater than 0.1 to less than 5, or 0.2 to less than 5: to 100 parts by weight of the dispersant substrate. The relative amounts of the thiadiazole compound to the dispersant substrate may also be expressed as (0.1-10):100, or (>0.1-9):100, (such as (>0.5-9):100), or (0.1 to less than 5): 100, or (0.2 to less than 5): 100.

[0063] In one embodiment the dispersant substrate is present at 0.1 to 10 parts by weight relative to 1 part by weight of the thiadiazole compound. In different embodiments the dispersant substrate is present at greater than 0.1 to 9, or greater than 0.1 to less than 5, or about 0.2 to less than 5: to 1 part by weight of the thiadiazole compound. The relative amounts of the dispersant substrate to the thiadiazole compound may also be expressed as (0.1-10):1, or (>0.1-9):1, (such as (>0.5-9):1), or (0.1 to less than 5): 1, or (0.2 to less than 5): 1.

[0064] The thiadiazole-functionalised dispersant may be derived from a substrate that includes a succinimide dispersant (for example, N-substituted long chain alkenyl succinimides, typically a polyisobutylene succinimide), a Mannich dispersant, an ester-containing dispersant, a condensation product of a fatty hydrocarbyl monocarboxylic acylating agent with an amine or ammonia, an alkyl amino phenol dispersant, a hydrocarbyl-amine dispersant, a polyether dispersant, a polyetheramine dispersant, a viscosity modifier containing dispersant functionality (for example polymeric viscosity index modifiers containing dispersant functionality), or mixtures thereof. In one embodiment the dispersant substrate includes a succinimide dispersant, an ester-containing dispersant or a Mannich dispersant.

[0065] In one embodiment according to the present invention, the extreme pressure agent includes a boron-containing compound. The boron-containing compound includes a borate ester (which in some embodiments may also be referred to as a borated epoxide), a borated alcohol, a borated dispersant, a borated phospholipid or mixtures thereof. In one embodiment the boron-containing compound may be a borate ester or a borated alcohol.

[0066] The borate ester may be prepared by the reaction of a boron compound and at least one compound selected from epoxy compounds, halohydrin compounds, epihalohydrin compounds, alcohols and mixtures thereof. The alcohols

include dihydric alcohols, trihydric alcohols or higher alcohols, with the proviso for one embodiment that hydroxyl groups are on adjacent carbon atoms, i.e., vicinal.

[0067] Boron compounds suitable for preparing the borate ester include the various forms selected from the group consisting of boric acid (including metaboric acid, orthoboric acid and tetraboric acid), boric oxide, boron trioxide and alkyl borates. The borate ester may also be prepared from boron halides.

[0068] In one embodiment suitable borate ester compounds include tripropyl borate, tributyl borate, tripentyl borate, trihexyl borate, triheptyl borate, trioctyl borate, trinonyl borate and tridecyl borate. In one embodiment the borate ester compounds include tributyl borate, tri-2-ethylhexyl borate or mixtures thereof.

[0069] In one embodiment, the boron-containing compound is a borated dispersant, typically derived from an N-substituted long chain alkenyl succinimide. In one embodiment the borated dispersant includes a polyisobutylene succinimide. Borated dispersants are described in more detail in US Patents 3,087,936; and Patent 3,254,025.

[0070] In one embodiment the borated dispersant may be used in combination with a sulfur-containing compound or a borate ester.

[0071] In one embodiment the extreme pressure agent is other than a borated dispersant.

[0072] The number average molecular weight M_n (GPC; kg/mol) of the hydrocarbon from which the long chain alkenyl group was derived includes ranges of 350 to 5000, or 500 to 3000, or 550 to 1500. The long chain alkenyl group may have a number average molecular weight M_n of 550, or 750, or 950 to 1000.

[0073] The N-substituted long chain alkenyl succinimides are borated using a variety of agents including boric acid (for example, metaboric acid, orthoboric acid and tetraboric acid), boric oxide, boron trioxide, and alkyl borates. In one embodiment the borating agent is boric acid which may be used alone or in combination with other borating agents.

[0074] The borated dispersant may be prepared by blending the boron compound and the N-substituted long chain alkenyl succinimides and heating them at a suitable temperature, such as, 80 °C to 250 °C, or 90 °C to 230 °C, or 100 °C to 210 °C, until the desired reaction has occurred. The molar ratio of the boron compounds to the N-substituted long chain alkenyl succinimides may have ranges including 10:1 to 1:4, or 4:1 to 1:3; or the molar ratio of the boron compounds to the N-substituted long chain alkenyl succinimides may be 1:2. Alternatively, the ratio of moles B : moles N (that is, atoms of B : atoms of N) in the borated dispersant may be 0.25:1 to 10:1 or 0.33:1 to 4:1 or 0.2:1 to 1.5:1, or 0.25:1 to 1.3:1 or 0.8:1 to 1.2:1 or about 0.5:1. An inert liquid may be used in performing the reaction. The liquid may include toluene, xylene, chlorobenzene, dimethylformamide or mixtures thereof.

[0075] In one embodiment, the additive component in the lubricant composition according to the present invention further includes a borated phospholipid. The borated phospholipid may be derived from boronation of a phospholipid (for example boronation may be carried out with boric acid). Phospholipids and lecithins are described in detail in Encyclopedia of Chemical Technology, Kirk and Othmer, 3rd Edition, in "Fats and Fatty Oils", Volume 9, pages 795-831 and in "Lecithins", Volume 14, pages 250-269.

[0076] The phospholipid may be any lipid containing a phosphoric acid, such as lecithin or cephalin, or derivatives thereof. Examples of phospholipids include phosphatidylcholine, phosphatidylserine, phosphatidylinositol, phosphatidylethanolamine, phosphotidic acid and mixtures thereof. The phospholipids may be glycerophospholipids, glycerol derivatives of the above list of phospholipids. Typically, the glycerophospholipids have one or two acyl, alkyl or alkenyl groups on a glycerol residue. The alkyl or alkenyl groups may contain 8 to 30, or 8 to 25, or 12 to 24 carbon atoms. Examples of suitable alkyl or alkenyl groups include octyl, dodecyl, hexadecyl, octadecyl, docosanyl, octenyl, dodecenyl, hexadecenyl and octadecenyl.

[0077] Phospholipids may be prepared synthetically or derived from natural sources. Synthetic phospholipids may be prepared by methods known to those in the art. Naturally derived phospholipids are often extracted by procedures known to those in the art. Phospholipids may be derived from animal or vegetable sources. A useful phospholipid is derived from sunflower seeds. The phospholipid typically contains 35 % to 60 % phosphatidylcholine, 20 % to 35 % phosphatidylinositol, 1 % to 25 % phosphatidic acid, and 10 % to 25 % phosphatidylethanolamine, wherein the percentages are by weight based on the total phospholipids. The fatty acid content may be 20 % by weight to 30 % by weight palmitic acid, 2 % by weight to 10 % by weight stearic acid, 15 % by weight to 25 % by weight oleic acid, and 40 % by weight to 55 % by weight linoleic acid.

[0078] In another embodiment, the performance additive in the lubricant compositions according to the present invention may include a friction modifier. A friction modifier is any material or materials that can alter the coefficient of friction of a surface lubricated by any lubricant or fluid containing such material(s). Friction modifiers, also known as friction reducers, or lubricity agents or oiliness agents, and other such agents that change the ability of base oils, formulated lubricant compositions, or functional fluids, to modify the coefficient of friction of a lubricated surface may be effectively used in combination with the base oils or lubricant compositions of the present invention if desired. Friction modifiers may include metal-containing compounds or materials as well as ashless compounds or materials, or mixtures thereof. Metal-containing friction modifiers may include metal salts or metal-ligand complexes where the metals may include alkali, alkaline earth, or transition group metals. Such metal-containing friction modifiers may also have low-ash characteristics. Transition metals may include Mo, Sb, Sn, Fe, Cu, Zn, and others. Ligands may include hydrocarbyl derivative

of alcohols, polyols, glycerols, partial ester glycerols, thiols, carboxylates, carbamates, thiocarbamates, dithiocarbamates, phosphates, thiophosphates, dithiophosphates, amides, imides, amines, thiazoles, thiadiazoles, dithiazoles, diazoles, triazoles, and other polar molecular functional groups containing effective amounts of O, N, S, or P, individually or in combination. In particular, Mo-containing compounds can be particularly effective such as for example Mo-dithiocarbamates, Mo(DTC), Modithiophosphates, Mo(DTP), Mo-amines, Mo (Am), Mo-alcoholates, Mo-alcohol-amides, and the like.

[0079] Ashless friction modifiers may also include lubricant materials that contain effective amounts of polar groups, for example, hydroxyl-containing hydrocarbyl base oils, glycerides, partial glycerides, glyceride derivatives, and the like. Polar groups in friction modifiers may include hydrocarbyl groups containing effective amounts of O, N, S, or P, individually or in combination. Other friction modifiers that may be particularly effective include, for example, salts (both ash-containing and ashless derivatives) of fatty acids, fatty alcohols, fatty amides, fatty esters, hydroxyl-containing carboxylates, and comparable synthetic long-chain hydrocarbyl acids, alcohols, amides, esters, hydroxy carboxylates, and the like. In some instances fatty organic acids, fatty amines, and sulfurized fatty acids may be used as suitable friction modifiers.

[0080] In one embodiment, the performance additive in the lubricant compositions according to the present invention may include phosphorus- or sulfur-containing anti-wear agents other than compounds described as an extreme pressure agent of the amine salt of a phosphoric acid ester described above. Examples of the anti-wear agent may include a non-ionic phosphorus compound (typically compounds having phosphorus atoms with an oxidation state of +3 or +5), a metal dialkyldithiophosphate (typically zinc dialkyldithiophosphates), amine dithiophosphate, ashless dithiophosphates and a metal mono- or di-alkylphosphate (typically zinc phosphates), or mixtures thereof.

[0081] The non-ionic phosphorus compound includes a phosphite ester, a phosphite ester, or mixtures thereof.

[0082] In one embodiment, the performance additive in the lubricant composition according to the present invention may further include at least one antioxidant. Antioxidants retard the oxidative degradation of base stocks during service. Such degradation may result in deposits on metal surfaces, the presence of sludge, or a viscosity increase in the lubricant. One skilled in the art knows a wide variety of oxidation inhibitors that are useful in lubricating oil compositions. Useful antioxidants include hindered phenols. These phenolic antioxidants may be ashless (metal-free) phenolic compounds or neutral or basic metal salts of certain phenolic compounds. Typical phenolic antioxidant compounds are the hindered phenolics which are the ones which contain a sterically hindered hydroxyl group, and these include those derivatives of dihydroxy aryl compounds in which the hydroxyl groups are in the o- or p-position to each other. Typical phenolic antioxidants include the hindered phenols substituted with C₆₊ alkyl groups and the alkylene coupled derivatives of these hindered phenols. Examples of phenolic materials of this type 2-t-butyl-4-heptyl phenol; 2-t-butyl-4-octyl phenol; 2-t-butyl-4-dodecyl phenol; 2,6-di-t-butyl-4-heptyl phenol; 2,6-di-t-butyl-4-dodecyl phenol; 2-methyl-6-t-butyl-4-heptyl phenol; and 2-methyl-6-t-butyl-4-dodecyl phenol. Other useful hindered mono-phenolic antioxidants may include for example hindered 2,6-di-alkyl-phenolic propionic ester derivatives. Bis-phenolic antioxidants may also be advantageously used in combination with the instant invention. Examples of ortho-coupled phenols include: 2,2'-bis(4-heptyl-6-t-butyl-phenol); 2,2'-bis(4-octyl-6-t-butyl-phenol); and 2,2'-bis(4-dodecyl-6-t-butyl-phenol). Para-coupled bisphenols include for example 4,4'-bis(2,6-di-t-butyl phenol) and 4,4'-methylene-bis(2,6-di-t-butyl phenol).

[0083] Non-phenolic oxidation inhibitors which may be used include aromatic amine antioxidants and these may be used either as such or in combination with phenolics. Typical examples of non-phenolic antioxidants include: alkylated and non-alkylated aromatic amines such as aromatic monoamines of the formula R⁸R⁹R¹⁰N, where R⁸ is an aliphatic, aromatic or substituted aromatic group, R⁹ is an aromatic or a substituted aromatic group, and R¹⁰ is H, alkyl, aryl or R¹¹S(O)_xR¹², where R¹¹ is an alkylene, alkenylene, or aralkylene group, R¹² is a higher alkyl group, or an alkenyl, aryl, or alkaryl group, and x is 0, 1 or 2. The aliphatic group R⁸ may contain from 1 to about 20 carbon atoms, and preferably contains from about 6 to 12 carbon atoms. The aliphatic group is a saturated aliphatic group. Preferably, both R⁸ and R⁹ are aromatic or substituted aromatic groups, and the aromatic group may be a fused ring aromatic group such as naphthyl. Aromatic groups R⁸ and R⁹ may be joined together with other groups such as S.

[0084] Typical aromatic amines antioxidants have alkyl substituent groups of at least about 6 carbon atoms. Examples of aliphatic groups include hexyl, heptyl, octyl, nonyl, and decyl. Generally, the aliphatic groups will not contain more than about 14 carbon atoms. The general types of amine antioxidants useful in the present compositions include diphenylamines, phenyl naphthylamines, phenothiazines, imidodibenzyls and diphenyl phenylene diamines. Mixtures of two or more aromatic amines are also useful. Polymeric amine antioxidants can also be used. Particular examples of aromatic amine antioxidants useful in the present invention include: p,p'-dioctyldiphenylamine; t-octylphenyl-alpha-naphthylamine; phenyl-alphanaphthylamine; and p-octylphenyl-alpha-naphthylamine. Sulfurized alkyl phenols and alkali or alkaline earth metal salts thereof also are useful antioxidants.

[0085] In one embodiment, the performance additive in the lubricant compositions according to the present invention further includes a dispersant. The dispersant may be a succinimide dispersant (for example N-substituted long chain alkenyl succinimides), a Mannich dispersant, an ester-containing dispersant, a condensation product of a fatty hydrocarbyl monocarboxylic acylating agent with an amine or ammonia, an alkyl amino phenol dispersant, a hydrocarbyl-amine dispersant, a polyether dispersant or a polyetheramine dispersant.

[0086] In one embodiment the succinimide dispersant includes a polyisobutylene-substituted succinimide, wherein the polyisobutylene from which the dispersant is derived may have a number average molecular weight of 400 to 5000, or 950 to 1600. Succinimide dispersants and their methods of preparation are more fully described in U.S. Patents 4,234,435 and 3,172,892. Suitable ester-containing dispersants are typically high molecular weight esters. These materials are described in more detail in U.S. Patent 3,381,022.

[0087] In one embodiment the dispersant includes a borated dispersant. Typically the borated dispersant includes a succinimide dispersant including a polyisobutylene succinimide, wherein the polyisobutylene from which the dispersant is derived may have a number average molecular weight of 400 to 5000. Borated dispersants are described in more detail above within the extreme pressure agent description.

[0088] Dispersant viscosity modifiers (often referred to as DVMs) are considered additives in the context of the present invention due to their additional functionalisation and are therefore not considered viscosity improving agents according to the present invention. Dispersant viscosity modifiers include functionalised polyolefins, for example, ethylene-propylene copolymers that have been functionalized with the reaction product of maleic anhydride and an amine, a polymethacrylate functionalised with an amine, or esterified styrene-maleic anhydride copolymers reacted with an amine.

[0089] As another type of performance additives, corrosion inhibitors can be described as any materials (additives, functionalized fluids, etc.) that form a protective film on a surface that prevents corrosion agents from reacting or attacking that surface with a resulting loss of surface material. Protective films may be absorbed on the surface or chemically bonded to the surface. Protective films may be constituted from mono-molecular species, oligomeric species, polymeric species, or mixtures thereof. Protective films may derive from the intact corrosion inhibitors, from their combination products, or their degradation products, or mixtures thereof. Surfaces that may benefit from the action of corrosion inhibitors may include metals and their alloys (both ferrous and non-ferrous types) and non-metals.

[0090] Corrosion inhibitors may include various oxygen-, nitrogen-, sulfur-, and phosphorus-containing materials, and may include metal-containing compounds (salts, organometallics, etc.) and nonmetal-containing or ashless materials. Corrosion inhibitors may include, but are not limited to, additive types such as, for example, hydrocarbyl-, aryl-, alkyl-, arylalkyl-, and alkylaryl- versions of detergents (neutral, overbased), sulfonates, phenates, salicylates, alcoholates, carboxylates, salixarates, phosphites, phosphates, thiophosphates, amines, amine salts, amine phosphoric acid salts, amine sulfonic acid salts, alkoxylated amines, etheramines, polyetheramines, amides, imides, azoles, diazoles, triazoles, benzotriazoles, benzothiadiazoles, mercaptobenzothiazoles, tolyltriazoles (TTZ-type), heterocyclic amines, heterocyclic sulfides, thiazoles, thiadiazoles, mercaptothiadiazoles, dimercaptothiadiazoles (DMTD-type), imidazoles, benzimidazoles, dithiobenzimidazoles, imidazolines, oxazolines, Mannich reactions products, glycidyl ethers, anhydrides, carbamates, thiocarbamates, dithiocarbamates, polyglycols, etc., or mixtures thereof.

[0091] Corrosion inhibitors are used to reduce the degradation of metallic parts that are in contact with the lubricant composition. Suitable corrosion inhibitors include thiadiazoles. Aromatic triazoles, such as tolyltriazole, are suitable corrosion inhibitors for non-ferrous metals, such as copper.

[0092] Metal deactivators include derivatives of benzotriazoles (typically tolyltriazole), 1,2,4-triazoles, benzimidazoles, 2-alkyldithiobenzimidazoles, thiadiazoles or 2-alkyldithiobenzothiazoles.

[0093] Foam inhibitors may also advantageously be added as a performance additive to the lubricant compositions according to the present invention. These agents retard the formation of stable foams. Silicones and organic polymers are typical foam inhibitors. For example, polysiloxanes, such as silicon oil, or polydimethylsiloxane, provide foam inhibiting properties. Further foam inhibitors include copolymers of ethyl acrylate and 2-ethylhexyl acrylate and optionally vinyl acetate.

[0094] Demulsifiers include trialkyl phosphates, and various polymers and copolymers of ethylene glycol, ethylene oxide, propylene oxide, or mixtures thereof.

[0095] As pour point depressants, esters of maleic anhydride-styrene, or polyacrylamides are included.

[0096] As a further performance additive to be used in the lubricant compositions according to the present invention, seal compatibility agents help to swell elastomeric seals by causing a chemical reaction in the fluid or physical change in the elastomer. Suitable seal compatibility agents for lubricant compositions include organic phosphates, aromatic esters, aromatic hydrocarbons, esters (butylbenzyl phthalate, for example), and polybutenyl succinic anhydride. Such additives may preferably be used in an amount of 0.01 to 3 % by weight, more preferably 0.01 to 2 % by weight of the total amount of the lubricant composition.

[0097] Another aspect of the present invention relates to the use of the ester component derived from (a) an alcohol component, which is a C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7 and (b) an acid component, which is an aliphatic C₄-C₁₀, preferably C₅-C₇ dicarboxylic acid or cyclohexanedicarboxylic acid for improving the seal compatibility of lubricant compositions. Ester components are typically employed in lubricant compositions e.g. as a solubilizer or cosolvent for other components assisting in solubilization of polar additives and modifying rheological properties of the lubricant composition. Replacing conventional ester components with an ester component derived from (a) an alcohol component, which is a C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7 and (b) an acid component, which is an aliphatic C₄-C₁₀, preferably C₅-C₇ dicarboxylic acid or cyclohexanedicarboxylic acid surprisingly provides a better

seal compatibility. In one embodiment, the ester component as described herein is used for improving compatibility towards nitrile-butadiene-copolymer. In one embodiment, lubricant compositions modified using said ester component show a seal compatibility with nitrile-butadiene rubber determined according to ISO 1817 at 100°C for 168 hours resulting in a mass change of 20% or lower, preferably 10% or lower. In another embodiment, the lubricant composition shows a seal compatibility with nitrile-butadiene-copolymer determined according to ISO 1817 at 100°C for 168 hours resulting in a volume change of 30% or lower, preferably 15% or lower. In a further embodiment, the lubricant composition shows a seal compatibility with nitrile-butadiene-copolymer determined according to ISO 1817 at 100°C for 168 hours resulting in a hardness change of 12% or lower, preferably 8% or lower. The data regarding the mass change, volume change or hardness change is obtained from a comparison of the nitrile-butadiene-copolymer based seal before being subjected to the lubricant composition and after being exposed to the lubricant composition for 168 hours at 100°C.

[0098] The lubricant compositions according to the present invention may be used in light, medium and heavy duty engine oils, industrial engine oils, marine engine oils, automotive engine oils, crankshaft oils, compressor oils, refrigerator oils, hydrocarbon compressor oils, very low-temperature lubricating oils and fats, high temperature lubricating oils and fats, wire rope lubricants, textile machine oils, refrigerator oils, aviation and aerospace lubricants, aviation turbine oils, transmission oils, gas turbine oils, spindle oils, spin oils, traction fluids, transmission oils, plastic transmission oils, passenger car transmission oils, truck transmission oils, industrial transmission oils, industrial gear oils, insulating oils, instrument oils, brake fluids, transmission liquids, shock absorber oils, heat distribution medium oils, transformer oils, fats, chain oils, minimum quantity lubricants for metalworking operations, oil to the warm and cold working, oil for water-based metalworking liquids, oil for neat oil metalworking fluids, oil for semi-synthetic metalworking fluids, oil for synthetic metalworking fluids, drilling detergents for the soil exploration, hydraulic oils, in biodegradable lubricants or lubricating greases or waxes, chain saw oils, release agents, moulding fluids, gun, pistol and rifle lubricants or watch lubricants and food grade approved lubricants.

Examples

Methods

[0099] The iso-index is determined by derivatizing an alcohol sample with trichloroacetylisocyanate (TAI), thus transferring the alcohols into carbamine esters. ¹H-NMR signals of esterified primary alcohols can be found at $\delta = 4.7$ to 4.0 ppm. Signals of esterified secondary alcohols, if present, can be found at about $\delta = 5$ ppm. Water, which may be present in a sample as an impurity, reacts with TAI to carbaminic acid. All methyl, methylene and methine protons can be found in the range of $\delta = 2.4$ to 0.4 ppm. Signals below 1 ppm are assigned as methyl groups. The iso-index (average branching degree) is then calculated as

$$\text{Iso-index} = ((A(\text{CH}_3) / 3) / (A(\text{CH}_2\text{-OH}) / 2)) - 1$$

wherein $A(\text{CH}_3)$ represents the area under the signal curve relating the methyl protons and $A(\text{CH}_2\text{-OH})$ represents the area under the signal curve relating to methylene protons in the $\text{CH}_2\text{-OH}$ group.

[0100] For determining the iso-index, the alcohol sample is dissolved in CDCl_3 and a small amount of TMS is added as frequency standard in accordance is common practice. Then 0.2 ml TAI are added to the solution before a ¹H-NMR spectrum is recorded.

Measurement conditions:

[0101]

Frequency: 400 MHz
Relaxation delay: 10 s
Puls angle: 30°
Recorded data points: 64000
Scan number: 64
Transformed data points: 64000
Exponential multiplication: 0.2 Hz

[0102] After Fourier transformation, automatic phase and base line correction manual integration of the ranges $\delta = 4.7$ to 3.7 ppm (relating to primary alcohols esterified with TAI) and $\delta = 2.4$ to 0.4 ppm (all methyl, methylene and methine

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protons) is carried out. Integral phases of zero order are selected such that the beginning and the end of the integral curves are substantially horizontal.

[0103] The total acid number is determined by titrating a sample with KOH according to DIN 51558-1.

[0104] The kinematic viscosity is determined in accordance with DIN 51562 (kinematic viscosity at 40°C and 100°C: DIN 51562-1, at 20°C: DIN 51562-2, at 0°C: DIN 51562-3).

[0105] The viscosity index is determined according to DIN ISO 2909.

[0106] The pour point is determined according to ASTM D97.

[0107] Parameters in connection with the seal compatibility are determined with nitrile-butadiene-rubber (NBR) as sealing material according to ISO 1817 at 100°C for 168 hours.

Inventive Example 1 (IE1)

[0108] An excess of a heptadecanol mixture having an average iso-index of 3.1, obtained according to WO 2009/124979, was reacted at elevated temperature with adipic acid in the presence of tin oxalate as a catalyst, while monitoring the resulting acid number. After reaching an acid number of lower than 0.5 mg KOH/g excess alcohol was distilled off, the catalyst was precipitated using H₂O, and the obtained ester was dried under vacuum and filtered.

Comparative Example (CE)

[0109] An ester component typically used in conventional lubricant compositions was obtained by esterification of adipic acid with an excess of an alcohol mixture containing 2-propylheptanol and 15 wt% of trimethylol propane resulting in an ester having similar viscosity than the ester in the inventive example.

Test results

Rheological profile and seal compatibility

[0110]

Table 1

		IE1	CE
Kinematic viscosity			
at +100°C	[mm ² /s]	7.7	7.39
at +40°C	[mm ² /s]	46.81	42.9
at +20°C	[mm ² /s]	128	114
at 0°C	[mm ² /s]	496	428
Viscosity index	-	132	137
Density at 15°C	[g/cm ³]	0.9018	0.9621
Total acid number	[mg KOH/g]	0.48	0.28
Pour point	[°C]	-60	-57
Seal compatibility			
Mass change		8.9	26.5
Volume change		12.5	34.3
Hardness change		-5.0	-15.0

[0111] The ester component according to the invention exhibits a rheological profile similar to ester components currently employed in lubricant compositions. In particular, the ester component has a kinematic viscosity at 40°C of about 46 mm²/s. However, the ester component according to the inventive example shows significantly improved seal compatibility. Thus, the ester component can advantageously be employed for replacing conventional ester components in lubricant compositions.

Hydrolysis stability

[0112] The ester component of the inventive example was tested for hydrolysis stability by determining the acid value in a reaction with water at 100°C. An acid value of 1 or lower, preferably 0.5 or lower after a 12-day reaction is considered sufficient for practical use.

Table 2

Hours	Acid number [mg KOH/g]	Total increase [mg KOH/g]
0	0.02	-
120	0.06	0.04
192	0.10	0.08

[0113] The ester component of the inventive example shows excellent hydrolysis stability.

Oxidation stability

[0114] The oxidation stability of the ester component of the inventive example including 2 wt% additives was determined using the turbine oil stability test (TOST) Dry according to ASTM-D 943. The additives present included antioxidants, corrosion inhibitors for nonferrous metals and steel, additives for modifying air separation behavior, foam behavior and demulsifying power and EP/AW additives.

Table 3

Hours	Ethanol	Ethanol increase
0	0.44	-
168	0.43	-0.01
336	0.42	-0.02
504	0.41	-0.03
672	0.39	-0.05

[0115] The ester component of the inventive example shows sufficient oxidation stability for practical use.

Inventive Example 2 (IE2)

[0116] An inventive lubricant suitable is exemplified in the following:

Table 4

Lubricant composition		IE2
Ester component	[wt%]	10
Base oil component	[wt%]	50.6
Additive component		
Thickener 1	[wt%]	12.7
Thickener 2	[wt%]	12.7
Additive package	[wt%]	14.0

[0117] The ester component described in inventive example 1 was used. The base oil component is a polyalphaolefin 6 available from Neste Oil under the trade designation Nexbase® 2006. The additive component comprises two thickeners and an additive package. Thickener 1 is Lubrizol® 8406 available from Lubrizol. Thickener 2 is Lubrizol® 8407 from Lubrizol. The additive package is Anglamol® 6004 available from Lubrizol.

Claims

1. Lubricant composition comprising an ester component derived from (a) an alcohol component, which is a C₁₇ alcohol mixture having an average iso-index of 2.8 to 3.7 and (b) an acid component, which is an aliphatic C₄-C₁₀ dicarboxylic acid or cyclohexanedicarboxylic acid.
2. Lubricant composition according to claim 1, wherein the alcohol component further comprises a polyol, preferably selected from trimethylol propane, neopentyl glycol, pentaerythritol or dipentaerythritol.
3. Lubricant composition according to claim 1 or 2, wherein the ester component has a kinematic viscosity determined according to DIN 51562-1 at 40°C of 20 to 70 mm²/s, preferably 35 to 55 mm²/s, more preferably 40 to 50 mm²/s, yet more preferably about 46 mm²/s.
4. Lubricant composition according to any one of claims 1 to 3, wherein the alcohol component has an average iso-index of 2.9 to 3.6, preferably 3.01 to 3.5, more preferably 3.05 to 3.4.
5. Lubricant composition according to any one of claims 1 or 4, wherein the acid component is derived from cyclohexane-1,2-dicarboxylic acid, cyclohexane-1,3-dicarboxylic acid or cyclohexane-1,4-dicarboxylic acid or an aliphatic dicarboxylic acid selected from glutaric acid, adipic acid, pimelic acid, azelaic, sebacic, undecanoic and dodecanoic acid, preferably wherein the acid component is derived from an aliphatic C₅-C₇ dicarboxylic acid or cyclohexanedicarboxylic acid, more preferably cyclohexane-1,2-dicarboxylic acid, cyclohexane-1,3-dicarboxylic acid or cyclohexane-1,4-dicarboxylic acid or an aliphatic dicarboxylic acid selected from glutaric acid, adipic acid, pimelic acid, most preferably adipic acid.
6. Lubricant composition according to any one of claims 1 to 5, wherein the lubricant composition comprises the ester component, an additive component and optionally a base oil component.
7. Lubricant composition according to claim 6, comprising based on the total weight of the lubricant composition:
 - (i) 5 to 99.9 wt% of the ester component,
 - (ii) 0 to 75 wt% of a base oil component, preferably selected from the group consisting of a Group I mineral oil, a Group II mineral oil, a Group III mineral oil, a Group IV oil, a Group V oil, and mixtures thereof, and
 - (iii) 0.1 to 20 wt% of an additive component, preferably selected from the group consisting of antioxidants, dispersants, foam inhibitors, demulsifiers, seal swelling agents, friction reducers, anti-wear agents, detergents, corrosion inhibitors, extreme pressure agents, metal deactivators, rust inhibitors, pour point depressants and mixtures thereof.
8. Lubricant composition according to any one of claims 1 to 7, wherein said ester component is comprised in an amount of 50 to 99 wt%, preferably 80 to 99 wt%, based on the total weight of the lubricant composition.
9. Lubricant composition according to claim 6 or 7, wherein the base oil component comprises a polyalphaolefin (Group IV oil), more preferably a polyalphaolefin 4, polyalphaolefin 6 and/or polyalphaolefin 8, preferably a polyalphaolefin 6.
10. Lubricant composition according to any one of claims 6 to 9, wherein said base oil component is comprised in an amount of 0 to 19 wt%, based on the total weight of the lubricant composition.
11. Lubricant composition according to any one of claims 6 to 10, wherein said additive component is comprised in an amount of 1 to 20 wt%, based on the total weight of the lubricant composition.
12. Use of the ester component as defined in any one of claims 1 to 5 for improving the seal compatibility of lubricant compositions.
13. The use of claim 12, wherein the lubricant composition shows a seal compatibility with nitrile-butadiene-copolymer determined according to ISO 1817 at 100°C for 168 hours of
 - (i) a mass change of 20% or lower, preferably 10% or lower, and/or
 - (ii) a volume change of 30% or lower, preferably 15% or lower, and/or

(iii) a hardness change of 12% or lower, preferably 8% or lower.

14. The use of claim 12 or 13, wherein the lubricant composition is defined as in any one of claims 6 to 11.

5 15. The use of any one of claims 11 to 14, wherein the lubricant composition is a light, medium and heavy duty engine
oil, industrial engine oil, marine engine oil, automotive engine oil, crankshaft oil, compressor oil, refrigerator oil,
hydrocarbon compressor oil, very low-temperature lubricating oil and fat, high temperature lubricating oil and fat,
10 wire rope lubricant, textile machine oil, refrigerator oil, aviation and aerospace lubricant, aviation turbine oil, trans-
mission oil, gas turbine oil, spindle oil, spin oil, traction fluid, transmission oil, plastic transmission oil, passenger car
transmission oil, truck transmission oil, industrial transmission oil, industrial gear oil, insulating oil, instrument oil,
brake fluid, transmission liquid, shock absorber oil, heat distribution medium oil, transformer oil, fat, chain oil, minimum
15 quantity lubricant for metalworking operations, oil to the warm and cold working, oil for a water-based metalworking
liquid, oil for a neat oil metalworking fluid, oil for a semi-synthetic metalworking fluid, oil for a synthetic metalworking
fluid, drilling detergent for the soil exploration, hydraulic oil, biodegradable lubricant or lubricating grease or wax,
chain saw oil, release agent, moulding fluid, gun, pistol and rifle lubricant or watch lubricant and food grade approved
lubricant.



EUROPEAN SEARCH REPORT

Application Number
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Place of search Munich		Date of completion of the search 17 September 2014	Examiner Renoth, Heinz
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