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(54) Title: LUBRICATING COMPOSITION

(57) Abstract: A lubricating oil composition comprising: (a) base oil selected from Group III base oils, Group IV polyalphaolefins, or a combination thereof; (b) 30 wt% or less solvency booster; (c) antioxidant selected from aminic antioxidants, phenolic antioxidants, and mixtures thereof; (d) detergent comprising (i) an alkaline earth metal salicylate having a TBN (total base number equivalent, as determined by ASTM D2896) in the range of from 50 to 150; (ii) an alkaline earth metal salicylate having a TBN in the range of from 150 to 250; and (iii) an alkaline earth metal salicylate having a TBN in the range of from 250 to 400. The lubricating oil composition of the present invention provides improved oxidation and improved piston cleanliness properties.

LUBRICATING COMPOSITION

The present invention relates to a lubricating composition, in particular a lubricating composition having improved oxidation stability and deposit reduction.

5 As is disclosed in for example D.J. Wedlock et al., "Gas-to-Liquids Base Oils to assist in meeting OEM requirements 2010 and beyond", presented at the 2nd Asia-Pacific base oil Conference, Beijing, China, 23-25 October 2007, the use of Fischer-Tropsch derived base 10 oils in lubricating compositions such as engine oils, transmission fluids, and industrial lubricants results in various performance benefits. Examples of performance benefits by the use of Fischer-Tropsch derived base oils mentioned in the above article are: improved oxidation properties, improved engine cleanliness, improved wear protection, improved emissions and improved after-treatment device compatibility. Also the Fischer-Tropsch base oils allow to formulate low-viscosity energy 15 conserving formulations.

20 Fischer-Tropsch derived base oils are highly paraffinic API group III base oils (API Base Oil Interchangeability Guidelines) exhibiting very good cold flow properties, high oxidative stability and high viscosity indices. However, due to the high paraffin 25 content the solvency of the base oils is generally low, resulting in incompatibility with other lubricant components and additives.

30 Fischer-Tropsch base oils have relatively low solvency. As used herein the term "solvency" in relation to a base oil means the ability of that base oil to

dissolve performance additives. It would be desirable to develop lubricating compositions having acceptable solvency at the same time as exhibiting the other performance benefits mentioned above, in particular improved oxidation stability and reduced piston deposits.

5 One or more of the above or other objects can be obtained by a lubricating oil composition comprising:

(a) base oil selected from Group III base oils, Group IV polyalphaolefins, or a combination thereof;

10 (b) 30 wt% or less solvency booster;

(c) antioxidant selected from aminic antioxidants, phenolic antioxidants, and mixtures thereof;

(d) detergent comprising (i) an alkaline earth metal salicylate having a TBN (total base number equivalent, as determined by ASTM D2896) in the range of from 50 to 150;

15 (ii) an alkaline earth metal salicylate having a TBN in the range of from 150 to 250; and (iii) an alkaline earth metal salicylate having a TBN in the range of from 250 to 400.

20 It has surprisingly been found that the lubricating compositions according to the present invention exhibit improved oxidation stability and improved piston cleanliness properties.

The base oil used in the lubricating composition according to the present invention is selected from a Group III base oil, a polyalphaolefin and mixtures thereof. The base oil used in the present invention may conveniently comprise mixtures of one or more Group III base oils and/or polyalphaolefins, thus, according to the present invention, the term "base oil" may refer to a mixture containing more than one base oil.

30 Suitable base oils for use in the lubricating oil composition of the present invention are Group III

mineral base oils, Group IV poly-alpha olefins (PAOs), Group III Fischer-Tropsch derived base oils and mixtures thereof.

By "Group III" and "Group IV" base oils in the present invention are meant lubricating oil base oils according to the definitions of American Petroleum Institute (API) for category III and IV. These API categories are defined in API Publication 1509, 15th Edition, Appendix E, April 2002.

Fischer-Tropsch derived base oils are known in the art. By the term "Fischer-Tropsch derived" is meant that a base oil is, or is derived from, a synthesis product of a Fischer-Tropsch process. A Fischer-Tropsch derived base oil may also be referred to as a GTL (Gas-To-Liquids) base oil. Suitable Fischer-Tropsch derived base oils that may be conveniently used as the base oil in the lubricating composition of the present invention are those as for example disclosed in EP 0 776 959, EP 0 668 342, WO 97/21788, WO 00/15736, WO 00/14188, WO 00/14187, WO 00/14183, WO 00/14179, WO 00/08115, WO 99/41332, EP 1 029 029, WO 01/18156 and WO 01/57166.

Typically, the aromatics content of a Fischer-Tropsch derived base oil, suitably determined by ASTM D 4629, will typically be below 1 wt.%, preferably below 0.5 wt.% and more preferably below 0.1 wt.%. Suitably, the base oil has a total paraffin content of at least 80 wt.%, preferably at least 85, more preferably at least 90, yet more preferably at least 95 and most preferably at least 99 wt.%. It suitably has a saturates content (as measured by IP-368) of greater than 98 wt.%. Preferably the saturates content of the base oil is greater than 99 wt.%, more preferably greater than 99.5 wt.%. It further preferably has a maximum n-paraffin

content of 0.5 wt.%. The base oil preferably also has a content of naphthenic compounds of from 0 to less than 20 wt.%, more preferably of from 0.5 to 10 wt.%.

Typically, the Fischer-Tropsch derived base oil or base oil blend has a kinematic viscosity at 100°C (as measured by ASTM D 7042) in the range of from 1 to 35 ~~irattvs~~ (cSt), preferably from 1 to 25 mm²/s (cSt), more preferably from 2 mm²/s to 12 ~~mmvs~~. Preferably, the Fischer-Tropsch derived base oil has a kinematic viscosity at 100°C (as measured by ASTM D 7042) of at least 2.5 mm²/s more preferably at least 3.0 mm²/s. In one embodiment of the present invention, the Fischer-Tropsch derived base oil has a kinematic viscosity at 100 °C of at most 5.0 mm²/s, preferably at most 4.5 mm²/s, more preferably at most 4.2 mm²/s (e.g. "GTL 4"). In another embodiment of the present invention, the Fischer-Tropsch derived base oil has a kinematic viscosity at 100 °C of at most 8.5 mm²/s, preferably at most 8 mm²/s (e.g. "GTL 8") .

Further, the Fischer-Tropsch derived base oil typically has a kinematic viscosity at 40 °C (as measured by ASTM D 7042) of from 10 to 100 mm²/s (cSt), preferably from 15 to 50 ~~ram~~²/s.

Also, the Fischer-Tropsch derived base oil preferably has a pour point (as measured according to ASTM D 5950) of below -30°C, more preferably below ~40°C, and most preferably below -45°C .

The flash point {as measured by ASTM D92} of the Fischer-Tropsch derived base oil is preferably greater than 120°C, more preferably even greater than 140°C.

The Fischer-Tropsch derived base oil preferably has a viscosity index (according to ASTM D 2270) in the range of from 100 to 200. Preferably, the Fischer-Tropsch

derived base oil has a viscosity index of at least 125, preferably 130. Also it is preferred that the viscosity index is below 180, preferably below 150.

5 In the event the Fischer-Tropsch derived base oil contains a blend of two or more Fischer-Tropsch derived base oils, the above values apply to the blend of the two or more Fischer-Tropsch derived base oils.

10 Poly-alpha olefin base oils (PAOs) and their manufacture are well known in the art. Preferred poly-alpha olefin base oils that may be used in the lubricating compositions of the present invention may be derived from linear C_2 to C_{32} , preferably C_6 to C_{16} , alpha olefins. Particularly preferred feedstocks for said poly-alpha olefins are 1-octene, 1-decene, 1-dodecene and 15 1-tetradecene.

20 According to the present invention, the base oil as used in the lubricating composition according to the present invention comprises at least a base oil selected from the group consisting of a poly-alpha olefin base oil and a Fischer-Tropsch derived base oil or a combination thereof.

25 There is a strong preference for using a Fischer-Tropsch derived base oil over a PAO base oil, in view of the high cost of manufacture of the PAOs. Thus, preferably, the base oil contains more than 50 wt.%, preferably more than 60 wt.%, more preferably more than 70 wt.%, even more preferably more than 80 wt.%. most preferably more than 90 wt.% Fischer-Tropsch derived base oil. In an especially preferred embodiment not more than 30 5 wt.%, preferably not more than 2 wt.%, of the base oil is not a Fischer-Tropsch derived base oil. It is even more preferred that 100 wt% of the base oil is based on one or more Fischer-Tropsch derived base oils.

Preferably the base oil or base oil blend comprising the Fischer-Tropsch derived base oil has a kinematic viscosity at 100°C of between 2 and 35 cSt, preferably between 2 and 10.5 cSt (according to ASTM D 445).

5 In addition to the Group III base oil and/or polyalphaolef in base oil, the lubricating composition may comprise one or more other types of mineral derived or synthetic base oils, including Group I, II, IV and V base oils according to the definitions of American Petroleum 10 Institute (API). These API categories are defined in API Publication 1509, 15th Edition, Appendix E, July 2009.

15 The total amount of base oil incorporated in the lubricating composition of the present invention is preferably an amount in the range of from 60 to 99 wt.%, more preferably an amount in the range of from 65 to 90 wt.% and most preferably an amount in the range of from 70 to 85 wt.%, with respect to the total weight of the lubricating composition.

20 Another essential component of the lubricating oil compositions of the present invention is a solvency booster. As used herein, the term "solvency booster" means a component which enhances the solvency of the Group III/PAO base oil, for example as measured by improvement of deposit reduction properties, as measured 25 by the TEOST test method (thermo-oxidation engine oil simulation test) according to ASTM D7097-09) and the KHTT test method (Komatsu Hot Tube Test according to JPI-5S-55-99). The use of a solvency booster in the lubricating composition of the present invention is particularly useful when the base oil is selected from a Fischer-Tropsch derived base oil.

30 The solvency booster is present at a level of 30 wt% or less, preferably 20 wt% of less, more preferably 15

wt% or less, by weight of the lubricating oil composition. The solvency booster is preferably present at a level of 1 wt% or more, more preferably 3 wt% or more, even more preferably 5 wt% or more, by weight of the lubricating oil composition.

Suitable solvency boosters for use herein are preferably selected from alkylated aromatic compounds, naphthenic base oils and ester base oils, and mixtures thereof.

Preferred alkylated aromatic compounds for use as a solvency booster herein include alkylated benzenes, alkylated anthracenes, alkylated phenanthrenes, alkylated biphenyls, and alkylated naphthalenes and mixtures thereof.

Alkylated naphthalenes may be produced by any suitable means known in the art, from naphthalene itself or from substituted naphthalenes which may contain one or more short chain alkyl groups having up to about eight carbon atoms, such as methyl, ethyl, or propyl, etc.

Suitable alkyl-substituted naphthalenes include alphamethylnaphthalene, dimethylnaphthalene, and ethylnaphthalene. Naphthalene itself is especially suitable since the resulting mono-alkylated products have better thermal and oxidative stability than the more highly alkylated materials. Suitable alkylated naphthalene lubricant compositions are described in US-B-3812036, and US-A-5602086. The preparation of alkyl naphthalenes is further disclosed in US-A-4714794.

The alkylated aromatic compound for use herein is preferably selected from alkylbenzene compounds, alkyl naphthalene compounds, and mixtures thereof.

The alkylaromatic component preferably has a kinematic viscosity at 100°C in the range of from 3 to 12

mmVs, more preferably in the range of from 3.8 to 7 mmVs. Preferably the viscosity index of the alkylaromatic component is above 40, more preferably at or above 70.

5 An especially preferred alkylated aromatic compound for use herein is an alkyl naphthalene compound. Examples of commercially available alkyl naphthalene compounds are those available from King Industries under the tradename NA-Lube such as NA-Lube KR 008, NA-Lube KR019, and the
10 like, and those available from ExxonMobil under the tradename Mobil MCP.

15 Examples of commercially available alkyl benzenes include that available from Formasan under the tradename Fusyn-22, those available from Janex under the tradename Janex HAL, and those available from Shrieve Chemical Products, Inc. (SCP) under the tradename ZEROL.

20 Suitable naphthenic base oils for use as a solvency booster herein includes naphthenic base oils having low viscosity index (VI) (generally 40-80} and a low pour point. Such base oils are produced from feedstocks rich in naphthenes and low in wax content. There is no particular limitation on the type of mineral-derived naphthenic base oil which can be used in the base oil composition herein. Any mineral-derived naphthenic base
25 oil which is suitable for use in a lubricating oil composition can be used herein.

Naphthenic base oils are defined as Group V base oils according to API.

30 Such mineral-derived base oils are obtained by refinery processes starting from naphthenic crude feeds. Mineral-derived naphthenic base oils for use herein preferably have a pour point of below -20 °C and a viscosity index of below 70. Such base oils are produced

from feedstocks rich in naphthenes and low in wax content. Mineral-derived naphthenic base oils are well known and described in more detail in "Lubricant base oil and wax processing", Avilino Sequeira, Jr., Marcel Dekker, Inc, New York, 1994, ISBN 0-8247-9256-4, pages 28-35.

Methods of manufacture of naphthenic base oils can be found in "Lubricants and Lubrication (Second, Completely Revised and Extended Edition)", published by 10 Wiley-VCH Verlag GmbH & Co. KgaA, Chapter 4, pages 46-48.

An example of a suitable naphthenic base oil for use as a solvency booster herein is that commercially available from China National Petroleum Corporation under the tradename KN4006. Other examples of suitable 15 naphthenic base oils for use as a solvency booster herein include those available from Calumet Specialty Products under the tradenames Hydrocal, Hydrosol and HR Tufflo, and those commercially available from Nynas Oil Company under the tradename Nynas.

Suitable esters for use as a solvency booster herein 20 include natural and synthetic esters such as diesters and polyol esters. An example of a suitable ester for use as a solvency booster herein is the saturated polyol ester commercially available from Croda International PLC under the tradename Priolube 3970. Other suitable esters for 25 use as a solvency booster herein include those available from Oleon under the tradename Radialube, those available from Emery under the tradename Emery and those available from ExxonMobil Chemical under the tradename Esterex.

The lubricating oil compositions of the present 30 invention comprise detergent, wherein the detergent comprises (i) an alkaline earth metal salicylate having a TBN (total base number equivalent, as determined by ASTM

D2896) in the range of from 50 to 150; (ii) an alkaline earth metal salicylate having a TBN in the range of from 150 to 250; and (iii) an alkaline earth metal salicylate having a TBN in the range of from 250 to 400.

5 It has been found that this particular combination of alkaline earth metal salicylates, together with the specified base oil, solvency booster and antioxidant has been found to be especially helpful in providing improved oxidation stability and reduced deposits.

10 Suitable alkaline earth metal salicylates include calcium, magnesium and barium salicylates, and mixtures thereof, preferably calcium salicylates.

15 The lubricating oil compositions of the present invention preferably comprises from 0.01 wt% to 9 wt%, more preferably from 1 wt% to 6 wt%, even more preferably from 3.5 wt% to 5.5 wt%, of detergent, by weight of the lubricating oil composition.

20 The level of an alkaline earth metal salicylate having a TBNE (total base number equivalent, as determined by ASTM D2896) in the range of from 50 to 150 is preferably in the range of 0.01 wt% to 5 wt%, more preferably from 1 wt% to 4 wt%, by weight of the lubricating oil composition.

25 The level of an alkaline earth metal salicylate having a TBN in the range of from 150 to 250 is preferably in the range of 0.01 wt% to 5 wt%, more preferably from 1 wt% to 3 wt%, by weight of the lubricating oil composition.

30 The level of alkaline earth metal salicylate having a TBN in the range of from 250 to 400 is preferably in the range of 0.01 wt% to 3 wt%, more preferably from 1 wt% to 2 wt%, by weight of the lubricating oil composition .

The lubricating oil compositions of the present invention comprises one or more anti-oxidants. Suitable anti-oxidants for use herein include phenolic antioxidants and/or aminic antioxidants.

5 In a preferred embodiment, said antioxidants are present in an amount in the range of from 0.1 to 5.0 wt. %, more preferably in an amount in the range of from 0.3 to 3.0 wt. %, and most preferably in an amount of in the range of from 0.5 to 1.5 wt. %, based on the total weight
10 of the lubricating oil composition.

Examples of aminic antioxidants which may be conveniently used include alkylated diphenylamines, phenyl-a-naphthylamines, phenyl-p-naphthylamines and alkylated a-naphthylamines .

15 Preferred aminic antioxidants include dialkyldiphenylamines such as p,p '-dioctyl-diphenylamine, p,p '-di-a-methylbenzyl-diphenylamine and N-p-butylphenyl-N-p '-octylphenylamine, monoalkyldiphenylamines such as mono-t-butyldiphenylamine and mono-octyldiphenylamine,
20 bis (dialkylphenyl) amines such as di-{2,4-diethylphenyl) amine and di (2-ethyl~4-nonylphenyl} amine, alkylphenyl~1-naphthylamines such as octylphenyl-1-naphthylamine and n-t-dodecylphenyl-1-naphthylamine, 1-naphthylamine, arylnaphthylamines such as phenyl-1-naphthylamine, phenyl-2-naphthylamine, N-hexylphenyl-2-naphthylamine and N-octylphenyl-2-naphthylamine,
25 phenylenediamines such as N,N'-diisopropyl-p-phenylenediamine and N,N '-diphenyl-p-phenylenediamine, and phenothiazines such as phenothiazine and 3,7-dioctylphenothiazine .

Preferred aminic antioxidants include those available under the following trade designations: "Sonoflex OD-3" (ex. Seiko Kagaku Co.), "Irganox L-57" (ex. Ciba

Specialty Chemicals Co.) and phenothiazine (ex. Hodogaya Kagaku Co.).

Examples of phenolic antioxidants which may be conveniently used include C7-C9 branched alkyl esters of 5 3,5-bis (1, 1-dimethyl-ethyl) -4-hydroxy-benzenepropanoic acid, 2-t-butylphenol, 2-t-butyl-4-methylphenol, 2-t-butyl-5-methylphenol, 2,4-di-t-butylphenol, 2,4-dimethyl-6-t-butylphenol, 2-t-butyl-4-methoxyphenol, 3-t-butyl-4-methoxyphenol, 2,5-di-t-butylhydroquinone, 2,6-di-t-butyl-10 4-alkylphenols such as 2,6-di-t-butylphenol, 2,6-di-t-butyl-4-methylphenol and 2,6-di-t-butyl-4-ethylphenol, 2,6-di-t-butyl-4-alkoxyphenols such as 2,6-di-t-butyl-4-methoxyphenol and 2,6-di-t-butyl-4-ethoxyphenol, 3,5-di-t-butyl-4-hydroxybenzylmercaptooctylacetate, alkyl-3- {3, 5-15 di-t-butyl-4-hydroxyphenyl} propionates such as n-octadecyl-3- (3, 5-di-t-butyl-4-hydroxyphenyl) propionate, n-butyl-3- (3, 5-di-t-butyl-4-hydroxyphenyl) propionate and 2'-ethylhexyl-3- (3, 5-di-t-butyl-4-hydroxyphenyl) propionate, 2,6-d-t-butyl- α -dimethylamino-p-cresol, 2,2'-methylene-20 bis (4-alkyl-6-t-butylphenol) such as 2,2'-methylenebis (4-raethyl-6-t-butylphenol, and 2,2-methylenebis (4-ethyl-6-t-butylphenol} , bisphenols such as 4,4'-butylidenebis {3-methyl-6-t-butylphenol, 4,4'-methylenebis (2,6-di-t-butylphenol) , 4,4'-bis (2,6-di-t-butylphenol) , 2,2-(di-p-hydroxyphenyl) propane, 2,2-bis (3,5-di-t-butyl-4-hydroxyphenyl) propane, 4,4'-cyclohexylidenebis (2,6-t-butylphenol) , hexamethyleneglycol-bis [3- (3,5-di-t-butyl-4-hydroxyphenyl) propionate] , triethyleneglycolbis [3- (3-t-butyl-4-hydroxy-5-methylphenyl) propionate] , 2,2'-thio-25 [diethyl-3- (3,5-di-t-butyl-4-hydroxyphenyl) propionate] , 3,9-bis {1,1-dimethyl-2- [3- (3-t-butyl-4-hydroxy-5-methylphenyl) propionyloxy] ethyl }2,4,8,10-tetraoxaspiro [5,5]undecane, 4,4'-thiobis (3-methyl-6-t-30

butylphenol) and 2,2'-thiobis (4,6-di-t-butylresorcinol), polyphenols such as tetrakis [methylene-3- {3,5-di-t-butyl-4-hydroxyphenyl} propionate] methane, 1,1,3-tris (2-methyl-4-hydroxy-5-t-butylphenyl) butane, 1,3,5-trimethyl-2,4,6-tris (3,5-di-t-butyl-4-hydroxybenzyl) benzene, bis- [3,3'-bis {4'-hydroxy-3'-t-butylphenyl} butyric acid] glycol ester, 2-(3',5'-di-t-butyl-4-hydroxyphenyl)methyl-4-(2",4"-di-t-butyl-3"-hydroxyphenyl)methyl-6-t-butylphenol and 2,6-bis (2'-hydroxy-3'-t-butyl-5'-methylbenzyl)-4-methylphenol, and p-t-butylphenol - formaldehyde condensates and p-t-butylphenol - acetaldehyde condensates.

Preferred phenolic antioxidants include those available under the following trade designations: "Irganox L-135" (ex. Ciba Specialty Chemicals Co.), "Yoshinox SS" (ex. Yoshitomi Seiyaku Co.), "Antage W-400" (ex. Kawaguchi Kagaku Co.), "Antage W-500" (ex. Kawaguchi Kagaku Co.), "Antage W-300" (ex. Kawaguchi Kagaku Co.), "Irganox L-109" (ex. Ciba Speciality Chemicals Co.), "Tominox 917" (ex. Yoshitomi Seiyaku Co.), "Irganox L-115" (ex. Ciba Speciality Chemicals Co.), "Sumilizer GA80" (ex. Sumitomo Kagaku), "Antage RC" (ex. Kawaguchi Kagaku Co.), "Irganox L-101" (ex. Ciba Speciality Chemicals Co.), "Yoshinox 930" (ex. Yoshitomi Seiyaku Co.).

The lubricating oil composition of the present invention may comprise mixtures of one or more phenolic antioxidants with one or more aminic antioxidants.

According to the present invention, the lubricating composition preferably comprises 30 wt% or less of a viscosity modifier, based on the total weight of the lubricating composition. In one embodiment, the lubricating composition comprises from 20 wt% to 30 wt% of viscosity modifier. In another embodiment, the lubricating composition comprises 20 wt% or less of

viscosity modifier. In a preferred embodiment of the present invention, the lubricating composition is essentially free of viscosity modifier. In a particularly preferred embodiment of the present 5 invention, the lubricating composition comprises 0 wt% of a viscosity modifier.

Examples of viscosity index improvers include copolymers of alpha-olefins and dicarboxylic acid esters such as those described in US 4 931 197. Commercially 10 available copolymers of alpha-olefins and dicarboxylic acid diesters include the Ketjenlube polymer esters available from Italmatch {and previously Akzo Nobel Chemicals). Other suitable examples of viscosity index improvers are polyisobutylenes; commercially available 15 polyisobutylenes include the Oloa (RTM) products available from Chevron Oronite.

Further examples of viscosity index improvers which may conveniently be used in the lubricating compositions of the present invention include the styrene-butadiene 20 stellate copolymers, styrene-isoprene stellate copolymers and the polymethacrylate copolymers and ethylene-propylene copolymers (also known as olefin copolymers) of the crystalline and non-crystalline type.

Suitable olefin copolymers include those 25 commercially available from Chevron Oronite Company LLC under the trade designation "PARATONE (RTM)" (such as "PARATONE (RTM) 8921" and "PARATONE (RTM) 8941"); those commercially available from Afton Chemical Corporation under the trade designation "HiTEC (RTM)" (such as "HiTEC 30 (RTM) 5850B"); and those commercially available from The Lubrizol Corporation under the trade designation "Lubrizol (RTM) 7067C". Suitable polyisoprene polymers include those commercially available from Infineum

International Limited, e.g. under the trade designation "SV200". Suitable diene-styrene copolymers include those commercially available from Infineum International Limited, e.g. under the trade designation "SV 260".

5 The compositions herein may include one or more anti-wear additives. Suitable anti-wear additives for use herein include zinc dithiophosphate compounds selected from zinc dialkyl-, diaryl- and/or alkylaryl-dithiophosphates, molybdenum-containing compounds, and
10 ashless anti-wear additives such as substituted or unsubstituted thiophosphoric acids, and salts thereof.

Examples of ashless thiophosphates are known in the art. These compounds are metal-free organic compounds. Suitable ashless thiophosphates for use in the
15 lubricating oil composition of the present invention may include esters and/or salts of thiophosphoric acids, and substituted thiophosphoric acids. Preferably, the ashless thiophosphates are substituted by one or more hydrocarbyl groups which hydrocarbyl groups can
20 optionally contain an acid, a hydroxy and/or an ester group. The hydrocarbyl moiety preferably is an alkyl group containing up to 12 carbon atoms. The hydrocarbyl-substituted thiophosphate preferably contains 2 or 3 hydrocarbyl groups, or is a mixture of thiophosphates
25 containing 2 and 3 hydrocarbyl groups.

The ashless thiophosphates can contain any number of sulphur atoms directly linked to the phosphorus atom. Preferably, the thiophosphates are monothiophosphates and/or dithiophosphates .

30 Examples of ashless thiophosphates which may be conveniently used in the lubricating oil composition of the present invention are described in EP-A-0375324 , US-A-5922657, US-A-4333841 and US-A-5093016 and may be

conveniently made according to the methods described therein.

Examples of commercially available ashless thiophosphates that may be conveniently used in the lubricating oil composition of the present invention include those available from Ciba Specialty Chemicals under the trade designations "IRGALUBE L~63" and "IRGALUBE 353" and that available from Lubrizol under the trade designation "LZ 5125".

In a preferred embodiment, the lubricating composition comprises one or more anti-wear additives selected from one or more zinc dithiophosphates. The or each zinc dithiophosphate may be selected from zinc dialkyl-, diaryl- or alkylaryl-dithiophosphates.

Examples of zinc dithiophosphates which are commercially available include those available from Lubrizol Corporation under the trade designations "Lz 677A", "Lz 1095", "Lz 1097", "Lz 1370", "Lz 1371", "Lz 1373" and "Lz 1395", those available from Chevron Oronite under the trade designations "OLOA 260", "OLOA 262", "OLOA 267" and "OLOA 269R", and those available from Afton Chemical under the trade designation "HITEC 7169" and "HITEC 7197".

Preferably, the lubricating composition according to the present invention comprises a phosphorus containing compound, preferably selected from the group consisting of phosphonates, phosphates, phosphites, phosphorothionates and dithiophosphates, and combinations thereof. Examples of commercially available dithiophosphates and phosphates are "IRGALUBE 63" and "IRGALUBE 349", respectively, both available from Ciba Specialty Chemicals.

The lubricating oil composition of the present

invention has a kinematic viscosity at 40°C in the range of from 2 mm²/s to 220 mm²/s, preferably in the range of from 32 mm²/s to 220 mm²/s.

In addition to the components mentioned above, the lubricating composition according to the present invention may further comprise one or more additional additives such as anti-oxidants, dispersants, detergents, extreme-pressure additives, friction modifiers, viscosity index improvers, pour point depressants, metal passivators, corrosion inhibitors, demulsifiers, anti-foam agents, seal compatibility agents and additive diluent base oils, etc.

As the person skilled in the art is familiar with the above and other additives, these are not further discussed here in detail.

Specific examples of such additives are described in for example Kirk-Othmer Encyclopedia of Chemical Technology, third edition, volume 14, pages 477-526.

The above-mentioned additives are typically present in an amount in the range of from 0.01 to 35.0 wt.%, based on the total weight of the lubricating composition, preferably in an amount in the range of from 0.05 to 25.0 wt.%, more preferably from 0.1 to 20.0 wt.%, based on the total weight of the lubricating composition.

The lubricating compositions of the present invention may be conveniently prepared by admixing the one or more additives with the base oil(s).

The lubricating composition according to the present invention may be used in various applications, such as in internal combustion engines (as an engine oil), as a transmission oil, a grease, a hydraulic oil, an industrial gear oil, a turbine oil, a compressor oil, and the like.

5 In another aspect the present invention provides a method for improving one or more of oxidation stability and deposit reduction properties, which method comprises lubricating with a lubricating composition according to the invention. In another aspect, the present invention provides the use of a lubricating composition as described herein, for improving one or more of oxidation stability properties (in particular as determined by ASTM 10 D6186-98) and deposit reduction properties, in particular as determined according to ASTM D7097-09 or JPI-5S-55-99 .

The present invention is described below with reference to the following Examples, which are not intended to limit the scope of the present invention in any way.

15 Examples

Lubricating Oil Compositions

20 Various combinations of additives, base oils and solvency boosters were formulated. Table 1 shows the properties of the base oils. Table 2 indicates the amounts of additives, base oils and solvency boosters incorporated into the respective formulations; the amounts are given in wt.%, based on the total weight of the 25 lubricating composition.

"Base oil 1" (or "B01" or "GTL 4") was a Fischer-Tropsch derived base oil having a kinematic viscosity at 100°C (ASTM D445) of approximately 3.89 cSt (mm^2s^{-1}). Base oil 1 may be conveniently manufactured by the process described in e.g. WO-A-02/070631, the teaching of which is hereby incorporated by reference.

30 "Base oil 2" (or "B02") was a commercially available Group III base oil having a kinematic viscosity at 100 °C (ASTM D445) of approximately 4.3 cSt. Base oil 2 is commercially available from e.g. SK Energy (Ulsan, South

- 19 -

Korea) under the trade designation "Yubase 4".

"Base oil 3" (or "B03") was a polyalphaolefin base oil ("PAO 4") having a kinematic viscosity at 100°C (ASTM D445) of approximately 4 cSt. Base Oil 3 is commercially available from INEOS under the trade designation **"Durasyn D164"**.

5

Table 1

	Base oil 1 (GTL 4)	Base oil 2 (Yubase 4)	Base oil 3 (PAO 4)
Kinematic viscosity at 40 °C ¹ [cSt]	16.91	19.49	17.37
Kinematic viscosity at 100 °C ¹ [cSt]	3.89	4.3	3.94
VI Index ²	127	126	124
Pour point ³ [°C]	-39	-18	-68
Noack volatility ⁴ [wt. %]	11.2	14.2	12.9
Saturates ⁵ [wt. %]	99.2	99.3	n.d.
Tertiary Carbon, % ⁶	18.1	n.d.	n.d.
Secondary Carbon, % ⁶	66.7	n.d.	n.d.
Primary Carbon, % ⁶	14.3	n.d.	n.d.
Epsilon carbon content, % ⁶	12.1	n.d.	n.d.
n- and iso- paraffins ⁷	92.35	n.d.	n.d.
Mono-naphthenics ⁷	6.85	n.d.	n.d.
di- and poly- naphthenics ⁷	0.87	n.d.	n.d.
Aromatics ⁵	0.5	n.d.	n.d.
Dynamic viscosity at -20 °C ⁸ [cP]	n.d.	713	n.d.
Dynamic viscosity at -25 °C ⁸ [cP]	n.d.	931	620
Dynamic viscosity at -30 °C ⁸ [cP]	948	n.d.	930
Dynamic viscosity at -35 °C ⁸ [cP]	1580	n.d.	n.d.
According to ASTM D 445			
According to ASTM D 2270			
According to ASTM D 5950			
According to CEC L-40-A-93 / ASTM D 5800			
According to IP 368 (modified)			
According to 13C NMR			
According to FIMS			
According to ASTM D 5293			
n.d. = not determined			

HPDSC-OIT Test

5 In order to measure the oxidation stability properties of the various lubricating compositions set out in Table 2, the lubricating compositions were subjected to the HPDSC-OIT (High Pressure Differential Scanning Calorimetry) test according to ASTM D6186-08, at a temperature of 200°C, and oxygen at 200 psig) .

10 Improved anti-oxidation properties are evidenced by greater oxidation induction time (OIT) .

TEOST Test

15 In order to measure the oxidation stability properties of the various lubricating compositions set out in Table 2, the lubricating compositions were subjected to the TEOST test (thermo-oxidation engine oil simulation test) according to ASTM D7097-09. Improved deposit control properties are evidence by reduced deposit weights.

KHTT Test

20 In order to measure deposit reduction properties of the various lubricating compositions set out in Table 2, the lubricating compositions were subjected to the KHTT test (Koraatsu Hot Tube Test) at 280°C according to JPI-5S-55-99. Improved deposit reduction properties are evidenced by both a higher merit rating average, and a 25 lower weighted deposit average.

Table 2

Example:	1	2	3	4	5	6	7
BO1	89.5	89.475	84.5	85.5	88	86	0
BO2	0	0	0	0	0	0	89.5
BO3	0	0	0	0	0	0	0
Alkyl naphthalene ¹	10	10	10	10	10	10	10
Dialkyl benzene ²	0	0	0	0	0	0	0
Irganox L57 ³	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Irganox L135 ⁴	0	0	0	0	0	0	0
Infineum C9455 ⁵	0	0.025	0	0	0	0	0
Infineum M7102 ⁶	0	0	5	3	2	1	0
Infineum M7121 ⁷	0	0	0	1	1	2	0
Infineum M7125 ⁸	0	0	0	0	0.5	0.5	0
Results:							
HPDSC	9.09	83.87	171.46	183.26	176.44	208.98	10.15
TEOST	134.5	129	34.9	27.9	29.9	14.7	123.65
KHTT 280 results:							
Total Merit Average	0	1.05	0	0	8.65	9	3.8
Total Deposit Average	34.5	2.75	50.45	22.85	0.5	0.85	9.6
KHTT 290 results:							
Total Merit Average	0	0.4	0	0	7.4	7.5	0
Total Deposit Average	64.6	4	44.95	57.2	0.3	2.35	44.9

Table 2 continued

Example:	8	9	10	11	12	13	14
BO1	0	0	0	0	0	0	0
BO2	89.475	84.5	85.5	88	86	0	0
BO3	0	0	0	0	0	89.5	89.475
Alkyl naphthalene ¹	10	10	10	10	10	10	10
Dialkyl benzene ²	0	0	0	0	0	0	0
Irganox L57 ³	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Irganox L135 ⁴	0	0	0	0	0	0	0
Infinium C9455 ⁵	0.025	0	0	0	0	0	0.025
Infinium M7102 ⁶	0	5	3	2	1	0	0
Infinium M7121 ⁷	0	0	1	1	2	0	0
Infinium M7125 ⁸	0	0	0	0.5	0.5	0	0
Results:							
HPDSC	n.d.	172.48	181.2	168.3	97.01	7.45	92.63
TEOST	n.d.	3.3	4.2	15.6	8	121.8	86.1
KHTT 280 results:							
Total Merit Average	n.d.	9.25	8.9	8.3	8.65	1.5	3
Total Deposits Average	n.d.	0.55	0.6	0.3	0.4	2	1.35
KHTT 290 results:							
Total Merit Average	n.d.	8.75	8.05	6.9	7.15	1.3	2
Total Deposits Average	n.d.	0.55	2.15	3.1	0.5	3.2	3.3

Table 2 continued

Example:	15	16	17	18	19	20	21
BO1	0	0	0	89.5	89	89	89.475
BO2	0	0	0	0	0	0	0
BO3	84.5	85.5	88	86	0	0	0
Alkyl naphthalene ¹	10	10	10	0	0	0	0
Dialkyl benzene ²	0	0	0	10	10	10	10
Irganox L57 ³	0.5	0.5	0.5	0.5	0.5	0	0.5
Irganox L135 ⁴	0	0	0	0	0	1	0
Infineum C9455 ⁵	0	0	0	0	0	0	0.025
Infineum M7102 ⁶	5	3	2	1	0	0	0
Infineum M7121 ⁷	0	1	1	2	0	0	0
Infineum M7125 ⁸	0	0	0.5	0.5	0	0	0
Results:							
HPDSC	150.79	160.67	148.05	169.87	4.8	6.775	70.8
TEOST	15.5	14.1	20.3	21	143.95	175.8	139.3
KHTT 280 results:							
Total Merit Average	7.65	8.75	8.75	9	9.9	10	2.8
Total Deposits Average	1.1	0.9	0.5	0.65	0.1	0.25	1.3
KHTT 290 results:							
Total Merit Average	8.9	7	7	6.55	0	0	0
Total Deposits Average	0.45	1.4	1.7	2.3	241.7	101.8	53.9

Table 2 continued

Example:	22	23	24	25	26	27	28
BO1	84.5	85.5	88	86	0	0	0
BO2	0	0	0	0	89.5	89	89.475
BO3	0	0	0	0	0	0	0
Alkyl naphthalene ¹	0	0	0	0	0	0	0
Dialky1 benzene ²	10	10	10	10	10	10	10
Irganox L57 ³	0.5	0.5	0.5	0.5	0.5	0	0.5
Irganox L135 ⁴	0	0	0	0	0	1	0
Infineum C9455 ⁵	0	0	0	0	0	0	0.025
Infineum M7102 ⁶	5	3	2	1	0	0	0
Infineum M7121 ⁷	0	1	1	2	0	0	0
Infineum M7125 ⁸	0	0	0.5	0.5	0	0	0
Results:							
HPDSC	159.39	187.065	181.505	203.54	5.98	n.d.	n.d.
TEOST	35.85	41.25	50.15	18.9	132.9	n.d.	n.d.
KHTT 280 results:							
Total Merit Average	8.75	8.5	8.25	8.5	10	n.d.	n.d.
Total Deposits Average	1	1.9	0.85	0.25	0.4	n.d.	n.d.
KHTT 290 results:							
Total Merit Average	7.5	7.3	0	7.3	0	n.d.	n.d.
Total Deposits Average	0.65	1.9	5.1	1.4	83.55	n.d.	n.d.

Table 2 continued

Example:	29	30	31	32	33	34	35
BO1	0	0	0	0	0	0	0
BO2	84.5	85.5	88	86	0	0	0
BO3	0	0	0	0	89.5	89	89.475
Alkyl naphthalene ¹	0	0	0	0	0	0	0
Dialkyl benzene ²	10	10	10	10	10	10	10
Irganox L57 ³	0.5	0.5	0.5	0.5	0.5	0	0.5
Irganox L135 ⁴	0	0	0	0	0	1	0
Infineum C9455 ⁵	0	0	0	0	0	0	0.025
Infineum M7102 ⁶	5	3	2	1	0	0	0
Infineum M7121 ⁷	0	1	1	2	0	0	0
Infineum M7125 ⁸	0	0	0.5	0.5	0	0	0
Results:							
HPDSC	n.d.	n.d.	n.d.	4.655	5.595	70.39	
TEOST	n.d.	n.d.	n.d.	125.85	149.4	131.55	
KHTT 280 results:							
Total Merit Average	n.d.	n.d.	n.d.	8.15	8.4	2.9	
Total Deposits Average	n.d.	n.d.	n.d.	0.65	0.4	1.55	
KHTT 290 Results:							
Total Merit Average	n.d.	n.d.	n.d.	0	9	1.75	
Total Deposits Average	n.d.	n.d.	n.d.	66.05	1.6	4.4	

Table 2 continued

Example:	36	37	38	39	40	41	42
BO1	0	0	0	0	89.5	0	89
BO2	0	0	0	0	0	0	0
BO3	84.5	85.5	88	86	0	89.5	0
KR008 ¹	0	0	0	0	0	0	0
Fusyn-22 ²	10	10	10	10	0	0	0
Irganox L57 ³	0.5	0.5	0.5	0.5	0.5	0.5	0
Irganox L135 ⁴	0	0	0	0	0	0	1
Infineum C9455 ⁵	0	0	0	0	0	0	0
Infineum M7102 ⁶	5	3	2	1	0	0	0
Infineum M7121 ⁷	0	1	1	2	0	0	0
Infineum M7125 ⁸	0	0	0.5	0.5	0	0	0
Results:					10	10	10
HPDSC	145.54	168.75	160.455	199.84	0	0	0
TEOST	22.6	31.95	25.35	21.3			
KHTT 280 results:							
Total Merit Average	8.5	8.75	5.9	8.9	156.4	5.70	5.02
Total Deposits Average	0.8	0.45	1.85	0.95			
KHTT 290 results:							
Total Merit Average	7	6.65	7.65	8	168.3	180.2	
Total Deposits Average	0.4	1.85	1.55	1.75			
					9.4	9.65	9.5
					1.05	1	0.95

Table 2 continued

Example:	43	44	45	46	47	48	49
BO1	89.475	84.5	85.5	86	86	0	0
BO2	0	0	0	0	0	89.5	89
BO3	0	0	0	0	0	0	0
Alky1 naphthalene ¹	0	0	0	0	0	0	0
Dialkyl benzene ²	0	0	0	0	0	0	0
Irganox L57 ³	0.5	0.5	0.5	0.5	0.5	0.5	0
Irganox L135 ⁴	0	0	0	0	0	0	1
Infineum C94555	0.025	0	0	0	0	0	0
Infineum M7102 ⁶	0	5	3	2	1	0	0
Infineum M7121 ⁷	0	0	1	1	2	0	0
Infineum M7125 ⁸	0	0	0	0.5	0.5	0	0
Ester ⁹	10	10	10	10	10	10	10
Naphthenic base oil ¹⁰	0	0	0	0	0	0	0
Results:							
HPDSC	84.02	164.69	181.66	184.66	200.43	4.85	4.87
TEOST	163.4	5.7	5.3	30.0	7.9	163.3	211.1
KHTT 280 results:							
Total Merit Average	3.00	9.50	9.00	9.00	9.30	9.00	0.00
Total Deposits Average	0.80	0.45	0.60	0.90	0.70	0.80	15.10
KHTT 290 Results:							
Total Merit Average	1.5	9.15	8.5	7.5	7.5	0	0
Total Deposits Average	0.8	0.3	0.7	0.8	0.3	34.7	44.1

- 29 -

Table 2 continued

Example:	50	51	52	53	54	55	56
BO1	0	0	0	0	0	89.5	0
BO2	89.475	84.5	85.5	86	86	0	0
BO3	0	0	0	0	0	0	89.5
Alkyl naphthalene ¹	0	0	0	0	0	0	0
Dialkyl benzene ²	0	0	0	0	0	0	0
Irganox L57 ³	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Irganox L135 ⁴	0	0	0	0	0	0	0
Infineum C9455 ⁵	0.025	0	0	0	0	0	0
Infineum M7102 ⁶	0	5	3	2	1	0	0
Infineum M7121 ⁷	0	0	1	1	2	0	0
Infineum M7125 ⁸	0	0	0	0.5	0.5	0	0
Ester ⁹	10	10	10	10	10	0	0
Naphthenic base oil ¹⁰	0	0	0	0	0	10	10
Results:							
HPDSC	49.69	145.15	128.96	156.48	159.88	7.95	9.50
TEOST	158.2	38.9	27.9	30.6	18.4	142.8	141.9
KHTT 280 results:							
Total Merit Average	2.80	9.50	9.50	9.00	9.00	0.00	0.00
Total Deposits Average	1.20	0.25	0.85	0.55	2.00	26.85	57.65
KHTT 290 Results:							
Total Merit Average	1.75	8.5	8	0	0	0	0
Total Deposits Average	1.15	0.45	0.8	112.45	54.55	62.1	45.8

Table 2 continued

Example:	57	58	59	60	61	62	63
BO1	89	89.475	84.5	85.5	86	86	0
BO2	0	0	0	0	0	0	89.5
BO3	0	0	0	0	0	0	0
Alkyl naphthalene ¹	0	0	0	0	0	0	0
Dialkyl benzene ²	0	0	0	0	0	0	0
Irganox L57 ³	0	0.5	0.5	0.5	0.5	0.5	0.5
Irganox L135 ⁴	1	0	0	0	0	0	0
Infineum C9455 ⁵	0	0.025	0	0	0	0	0
Infineum M7102 ⁶	0	0	5	3	2	1	0
Infineum M7121 ⁷	0	0	0	1	1	2	0
Infineum M7125 ⁸	0	0	0	0	0.5	0.5	0
Ester ⁹	0	0	0	0	0	0	0
Naphthenic base oil ¹⁰	10	10	10	10	10	10	10
Results:							
HPDSC	8.25	64.88	130.49	145.08	131.01	135.53	8.04
TEOST	152.6	147.8	39.7	53.6	45.5	37.1	136.2
KHTT 280 results:							
Total Merit Average	0.00	2.80	8.75	8.50	8.00	8.75	0.00
Total Deposits Average	46.95	1.15	0.20	1.30	0.90	0.60	12.45
KHTT 290 Results:							
Total Merit Average	0	1.75	3.5	6.5	5.25	8	0
Total Deposits Average	159.2	3.45	13.15	1.1	5.55	0.4	50.6

Table 2 continued

Example:	64	65	66	67	68	69
BO1	0	0	0	0	0	0
BO2	89	89.475	84.5	85.5	86	86
BO3	0	0	0	0	0	0
Alkyl naphthalene ¹	0	0	0	0	0	0
Dialkyl benzene ²	0	0	0	0	0	0
Irganox L57 ³	0	0.5	0.5	0.5	0.5	0.5
Irganox L135 ⁴	1	0	0	0	0	0
Infineum C9455 ⁵	0	0.025	0	0	0	0
Infineum M7102 ⁶	0	0	5	3	2	1
Infineum M7121 ⁷	0	0	0	1	1	2
Infineum M7125 ⁸	0	0	0	0	0.5	0.5
Ester ⁹	0	0	0	0	0	0
Naphthenic base oil ¹⁰	10	10	10	10	10	10
Results:						
HPDSC	5.53	71.00	126.82	139.99	130.45	142.88
TEOST	146.5	144.1	28.0	20.8	53.7	18.1
KHTT 280 results:						
Total Merit Average	0.00	2.35	8.25	8.00	8.00	8.00
Total Deposits Average	26.50	2.10	0.35	0.30	0.20	0.40
KHTT 290 Results:						
Total Merit Average	0	0	0	1.6	7.35	7.5
Total Deposits Average	62.15	79.05	52.4	2.95	0.5	0.5

In Table 2 above Examples 1-4, 7-10, 13-16, 19-23, 26-30, 33-37, 40-45, 48-52, 55-60 and 63-67 are Comparative Examples.

In Table 2 above, n.d. means "not determined".

5 In Table 2, the components marked with superscripts 1-10 are as follows:

1. Alkylated naphthalene commercially available from King Industries

10 2. Dialkyl benzene commercially available from Formosan Chemicals

3. Octylated/butylated (DPA), available from CIBA Speciality Chemicals, Basel, Switzerland

15 4. Liquid high molecular weight phenolic antioxidant commercially available from CIBA Speciality Chemicals, Basel, Switzerland

5. Dinuclear molybdenum-sulphur compound, available from Infineum International Ltd (Abingdon, UK)

6. Low BI (Basicity Index) salicylate detergent (Ca-based) commercially available from Infineum International Ltd (Abingdon, UK)

20 7. Medium BI salicylate detergent (Ca-based) commercially available from Infineum International Ltd, Abingdon, UK

8. High BI salicylate detergent (Ca-based) commercially available from Infineum International Ltd, Abingdon, UK

25 9. Polyol ester commercially available from Croda International PLC under the tradename Priolube 3970.

10. Naphthenic base oil commercially available from China National Petroleum Corporation under the tradename KN 4006.

Discussion

As can be seen from the results in Table 2, as a general trend, the lubricating compositions according to

the present invention show improved oxidation stability and deposit control properties, in comparison to the lubricating compositions falling outside the scope of the present invention.

5 The formulation examples in Tables 3~7 below are examples of Group III-based lubricating oil compositions. Such compositions could be reformulated to contain a solvency booster, antioxidant and detergent as per examples 5, 6, 11, 12, 17, 18, 24, 25, 31, 32, 38, 39, 10 46, 47, 53, 54, 61 and 62 above, and would be expected to show similar performance benefits in terms of oxidation stability and deposit control.

Table 3

Table 3 gives details of a typical HDDEO lubricant formulation .

	Wt%
Medium TBN salicylate	0.1 - 4
High TBN salicylate	0.1 - 3
Low TBN salicylate	0.1 - 6
High mw, high N dispersant	0.1 - 12
ZDTP	0.05 - 2
Phenolic antioxidant	0.1 - 3
Aminic antioxidant	0.01 ~2
Corrosion inhibitor	0.1 - 2
Dispersant PMA	0.01 - 4
Viscosity Modifier	0.1 - 10
GTL 4 and/or GTL 8	Balance
PAO 4	0.0 - 10

Table 4

Table 4 gives details of a typical PCMO formulation.

	Wt%
Medium TBN salicylate	0.1 - 4
High TBN salicylate	0.1 - 3
Low TBN salicylate	0.1 - 6
High mw, high N dispersant	0.1 - 12

ZDTP	0.05 - 2
Phenolic antioxidant	0.1 - 3
Aminic antioxidant	0.01 - 2
Corrosion inhibitor	0.1 - 2
Dispersant PMA	0.01 - 4
Viscosity Modifier	0.1 - 10
Organic friction modifier	0-2
Molybdenum containing Friction Modifier	0-2
Borated succinimide dispersant	0-4
Low TBN phenate	0-3
High TBN sulphonate	0-3
Non-dispersant PMA pour point depressant	0.1-2.0
GTL 4 and/or GTL 8	Balance
PAO 4	0.0 - 10

Table 5

Table 5 gives details of a typical grease formulation.

Component	Wt %
GTL 4 and/or GTL 8	Balance
Lithium hydroxide thickener component	1.0-4.0
Hydrogenated castor oil fatty acid thickener component	7.1-28.0
Castor Oil Lubricity Enhancer	0.5-3.0
Glycerol Lubricity Enhancer	0.5-3.0
Phenolic antioxidant	0.1-2.0
Aminic antioxidant	0.1-2.0
Zinc naphthenate corrosion inhibitor	0.5-5.0
Overbased calcium salicylate	0.2-7.0
Sulphurised ester	1.0-13
Zinc oxide	0.2-1.0
Total	100

Table 6

Component	Wt %
GTL 4 and/or GTL 8	Balance
Lithium hydroxide thickener component	1.0-4.0
Hydrogenated castor oil fatty acid thickener component	3.0-18.0

Boric Acid thickener component	0.4-3.0
Castor Oil Lubricity Enhancer	0.5-3.0
Glycerol Lubricity Enhancer	0.5-3.0
Phenolic antioxidant	0.1-2.0
Aminic antioxidant	0.1-2.0
Zinc naphthenate corrosion inhibitor	0.5-5.0
Overbased calcium salicylate	0.2-7.0
Sulphurised ester	1.0-13
Zinc oxide	0.4
Total	100

Table 7

Component	Wt%
GTL 4 and/or GTL 8	Balance
MDI (methylene diisocyanate) (4,4'~ diphenylmethane diisocyanate) thickener component	2.0-8.0
Octylamine thickener component	2.3-9.0
Dodecylamine thickener component	0.8-3.5
Aminic antioxidant	0.1-2.0
Zinc naphthenate corrosion inhibitor	0.5-5.0
Methylenebis (dibutylthiocarbamate)	0.2-3.0
ZDTP	0.05-5.0
N-alkylated tolutriazole	0-0.2
Total	100

It will be appreciated by those skilled in the art that the thickener components in the grease formulations in Tables 5, 6 and 7 need to be used in the correct stoichiometric ratios.

C L A I M S

1. A lubricating oil composition comprising:
 - (a) base oil selected from Group III base oils, Group IV polyalphaolefins, or a combination thereof;
 - (b) 30 wt% or less solvency booster;
 - 5 (c) antioxidant selected from aminic antioxidants, phenolic antioxidants, and mixtures thereof;
 - (d) detergent comprising (i) an alkaline earth metal salicylate having a TBN (total base number equivalent, as determined by ASTM D2896) in the range of from 50 to 150;
 - 10 (ii) an alkaline earth metal salicylate having a TBN in the range of from 150 to 250; and (iii) an alkaline earth metal salicylate having a TBN in the range of from 250 to 400,
2. A lubricating oil composition according to Claim 1 wherein the Group III base oil is a Fischer-Tropsch derived base oil.
- 15 3. A lubricating oil composition according to Claim 1 or 2 wherein the solvency booster is selected from alkylated naphthalenes, alkyl benzenes, naphthenics, esters, and mixtures thereof.
- 20 4. A lubricating oil composition according to any of Claims 1 to 3 wherein the solvency booster is present at a level of from 1 wt% to 20 wt%, by weight of the lubricant composition.
- 25 5. A lubricating oil composition according to any of Claims 1 to 4, wherein the antioxidant is an aminic antioxidant, preferably a diphenylamine.
6. A lubricating oil composition according to Claim 1 to 5 wherein the alkaline earth metal salicylates are calcium salicylates.

7. A lubricating oil composition according to any of Claims 1 to 6 wherein the lubricating oil composition has a kinematic viscosity at 100°C of from 1 mm²/s to 35 mm²/s .

5 8. A lubricating oil composition according to any of Claims 1 to 8 wherein the Fischer-Tropsch derived base oil has a kinematic viscosity at 100°C of from 1 mm²/s to 35 mm²/s .

10 9. A lubricating oil composition according to any of Claims 1 to 9 wherein the base oil contains more than 50 wt.%, preferably more than 60 wt.%, more preferably more than 70 wt.%, even more preferably more than 80 wt.%, most preferably more than 90 wt.% Fischer-Tropsch derived base oil.

15 10. Use of a lubricating oil composition according to any of Claims 1 to 10 for providing improved anti-oxidation properties, in particular as determined by ASTM D6186-08 .

20 11. Use of a lubricating oil composition according to any of Claims 1 to 10 for providing improved deposit reduction properties, in particular as determined according to ASTM D7097-09 or JPI-5S-55-99 .

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/076850

A. CLASSIFICATION OF SUBJECT MATTER

INV. C10M169/04

ADD. C10N30/04 C10N30/10 C10N10/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

CIOM

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/191032 A1 (DECKMAN DOUGLAS E [US] ET AL) 9 October 2003 (2003-10-09) paragraphs [0078] - [0079], [0121]; tables 4-6 ----- US 6 140 282 A (CAPJWRIGHT STANLEY JAMES [CA] ET AL) 31 October 2000 (2000-10-31) table 1 ----- EP 2 194 114 A2 (SHELL INT RESEARCH [NL]) 9 June 2010 (2010-06-09) paragraphs [0042], [0045]; table 2 -----	1-7,10, 11 1-11 1-11
A		
X		



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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