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(54) **Lubricating composition**

(57) A lubricating oil composition comprising:
(a) a base oil selected from Group III base oils, polyalphaolefins, and mixtures thereof;
(b) 0.3 wt% or less of sulphur; and
(c) 30 wt% or less of viscosity modifier;

wherein the lubricating oil composition has a kinematic viscosity at 40°C in the range of from 2 mm²/s to 220

mm²/s and wherein the lubricating oil composition provides a weld load of 150 Kg or greater in the 4 ball weld load test (ASTM D2596).

The lubricating oil composition of the present invention provides improved anti-wear and improved extreme-pressure properties.

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Description

[0001] The present invention relates to a lubricating composition comprising a base oil, in particular a Fischer-Tropsch derived base oil.

[0002] 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 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 aftertreatment device compatibility. Also the Fischer-Tropsch base oils allow to formulate low-viscosity energy conserving formulations.

[0003] Also, it has been found that Fischer-Tropsch derived base oils may be used as carrier oils for additive concentrates. As an example, WO 2009/074572 discloses the use of a Fischer-Tropsch derived base oil, in combination with an alkylated aromatic component such as an alkylated naphthalene, for use as a carrier oil for a viscosity modifier.

[0004] It is known to use sulphur-containing additives such as zinc dithiophosphate compounds selected from zinc dialkyl-, diaryl- and/or alkylaryl- dithiophosphates, molybdenum-containing compounds, boron-containing compounds and ashless anti-wear additives such as substituted or unsubstituted thiophosphoric acids, and salts thereof, to improve anti-wear properties and extreme-pressure performance of a lubricating composition.

[0005] However, it is also known that high levels of sulfur-containing additives, whilst providing some protection against wear, may also rapidly hydrolyze in the presence of acidic contaminants formed as a byproduct of the oxidative degradation of the hydrocarbon base fluid. This reaction may produce sulfuric acid and thus cause excessive corrosive damage of components, reducing the product lifetime and increasing maintenance costs.

[0006] It is therefore an objective of the present invention to develop alternative low sulfur compositions and more preferably compositions which are free of sulfur and which are capable of delivering improved anti-wear and extreme-pressure performance.

[0007] It is also known that such lubricating compositions comprise a viscosity index improver(s) to raise the viscosity index.

[0008] One or more of the above or other objects can be obtained by the present invention by a lubricating oil composition comprising:

- (a) a base oil selected from Group III base oils, polyalphaolefins, and mixtures thereof;
- (b) 0.3 wt% or less of sulphur; and
- (c) 30 wt% or less of viscosity modifier;

wherein the lubricating oil composition has a kinematic viscosity at 40°C in the range of from 2 mm²/s to 220 mm²/s and wherein the lubricating oil composition provides a weld load of 150 Kg or greater in the 4 ball weld load test (ASTM D2596).

[0009] It has surprisingly been found that the lubricating compositions according to the present invention exhibit improved anti-wear and extreme-pressure properties.

[0010] The base oil used in 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.

[0011] 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.

[0012] 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.

[0013] 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.

[0014] 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.%.

[0015] 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 25 mm²/s (cSt), preferably from 2 mm²/s to 12 mm²/s. 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").

[0016] 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 mm²/s.

[0017] 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.

[0018] 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.

[0019] 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.

[0020] 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.

[0021] The lubricating oil composition preferably comprises 80 wt% or greater of Fischer-Tropsch derived base oil.

[0022] 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 C₂ to C₃₂, preferably C₆ to C₁₆, alpha olefins. Particularly preferred feedstocks for said poly-alpha olefins are 1-octene, 1-decene, 1-dodecene and 1-tetradecene.

[0023] 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.

[0024] 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 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.

[0025] 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 30 cSt, preferably between 2 and 10.5 cSt (according to ASTM D 445).

[0026] In addition to the Group III base oil and/or polyalphaolefin 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 Institute (API). These API categories are defined in API Publication 1509, 15th Edition, Appendix E, July 2009.

[0027] 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.

[0028] There are no particular limitations regarding the viscosity modifier as used in the lubricating compositions according to the present invention. As a person skilled in the art is familiar with the term "viscosity modifier", this is not further discussed in detail. Viscosity modifiers (also known as VI improvers, viscosity index improvers or viscosity improvers) provide lubricants with high- and low-temperature operability; these additives impart acceptable viscosity at low temperatures and are preferably shear stable. Typically, and as meant according to the present invention, a viscosity modifier improves (e.g. by at least 5 units) the viscosity index (e.g. as determined by ASTM D 2270) by its incorporation in the lubricating composition.

[0029] According to the present invention, the lubricating composition 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 invention, the lubricating composition comprises 0 wt% of a viscosity modifier.

[0030] Examples of viscosity index improvers include copolymers of alpha-olefins and dicarboxylic acid esters such as those described in US 4 931 197. Commercially 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 polyisobutylenes include the Oloa (RTM) products available from Chevron Oronite.

[0031] Further examples of viscosity index improvers which may conveniently be used in the lubricating compositions of the present invention include the styrene-butadiene stellate copolymers, styrene-isoprene stellate copolymers and the polymethacrylate copolymers and ethylenepropylene copolymers (also known as olefin copolymers) of the crystalline and non-crystalline type.

[0032] Suitable olefin copolymers include those 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 (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".

[0033] The lubricating compositions herein comprise 0.3 wt% or less of sulphur, based on the total weight of the lubricating composition. In one embodiment of the present invention, the lubricating compositions comprise from 0.2 wt% to 0.3 wt% of sulphur by weight of the total lubricating composition. In another embodiment of the present invention, the lubricating compositions comprises 0.2 wt% or less of sulphur by weight of the total lubricating composition.

[0034] Suitable sulphur-containing additives include zinc dithiophosphate compounds selected from zinc dialkyl-, diaryl- and/or alkylaryl- dithiophosphates, molybdenum-containing compounds, and ashless anti-wear additives such as substituted or unsubstituted thiophosphoric acids, and salts thereof.

[0035] Examples of ashless thiophosphates are known in the art. These compounds are metal-free organic compounds. Suitable ashless thiophosphates for use in the 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 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 containing 2 and 3 hydrocarbyl groups.

[0036] The ashless thiophosphates can contain any number of sulphur atoms directly linked to the phosphorus atom. Preferably, the thiophosphates are monothiophosphates and/or dithiophosphates.

[0037] 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.

[0038] 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".

[0039] 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.

[0040] 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".

[0041] 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.

[0042] The lubricating composition according to the present invention may further comprise one or more 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.

[0043] As the person skilled in the art is familiar with the above and other additives, these are not further discussed here in detail.

[0044] Specific examples of such additives are described in for example Kirk-Othmer Encyclopedia of Chemical Technology, third edition, volume 14, pages 477-526.

[0045] 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.

[0046] The lubricating compositions of the present invention may be conveniently prepared by admixing the one or more additives with the base oil(s).

[0047] 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.

[0048] The present invention is described below with reference to the following Examples, which are not intended to limit the scope of the invention.

[0049] In another aspect the present invention provides a method for improving one or more of extreme pressure and anti-wear 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, in order to improve one or more of extreme-pressure and anti-wear properties, in particular according to ASTM D2596.

[0050] The lubricating oil composition of the present invention preferably provides a weld load of 150 Kg or greater, preferably 200 Kg or greater, more preferably 250Kg or greater, in the 4-ball weld load test according to ASTM D2596.

[0051] 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.

Examples

Lubricating Oil Compositions

[0052] Various combinations of additives and base oils were formulated. Table 1 indicates the properties of the base oils used. Table 2 indicates the amounts of additives as incorporated in the respective base oils; the amounts of the additives (the remainder being base oil) are given in wt.%, based on the total weight of additive(s) plus base oil. For example, as indicated in Table 2, Mixture 3 contains 0.1 wt% of additive A3. This means that the amount of BO in Mixture 3 will be 84.9wt% (i.e. 85wt%-0.1wt%). For ease of reference, Table 2 also includes references to "Mixtures 1-56" containing a combination of two or more additives and a base oil.

[0053] "Base oil 1" (or "BO1" or "GTL 4") was a Fischer-Tropsch derived base oil having a kinematic viscosity at 100°C (ASTM D445) of approximately 3.89 cSt (mm²s⁻¹). Base oil 1 (and Base oil 2 below) may be conveniently manufactured by the process described in e.g. WO-A-02/070631, the teaching of which is hereby incorporated by reference.

[0054] "Base oil 2" (or "BO2" or "GTL 8") was a Fischer-Tropsch derived base oil having a kinematic viscosity at 100°C (ASTM D445) of approximately 7.62 cSt (mm²s⁻¹).

[0055] "Base oil 3" (or "BO3") was a commercially available Group III base oil having a kinematic viscosity at 100°C (ASTM D445) of approximately 7.47 cSt. Base oil 3 is commercially available from e.g. SK Energy (Ulsan, South Korea) under the trade designation "Yubase 8".

[0056] "Base oil 4" (or "BO4") was a polyalphaolefin base oil ("PAO 6") having a kinematic viscosity at 40°C (ASTM D445) of approximately 31 cSt. Base Oil 4 is commercially available from INEOS under the trade designation "Durasyn 166 IMCD".

Table 1

	Base oil 1 (GTL 4)	Base oil 2 (GTL 8)	Base oil 3 (Yubase 8)	Base oil 4 (PAO 6)
Kinematic viscosity at 40°C ¹ [cSt]	16.91	43.71	44.14	31
Kinematic viscosity at 100°C ¹ [cSt]	3.89	7.62	7.47	n.d.
VI Index ²	127	143	135	135
Pour point ³ [°C]	-39	-24	-15	n.d.
Noack volatility ⁴ [wt.%]	11.2	2.6	4.8	n.d.
Saturates ⁵ [wt.%]	99.2	99.1	99.4	n.d.
Tertiary Carbon, % ⁶	18.1	15.9	n.d.	n.d.
Secondary Carbon, % ⁶	66.7	70.4	n.d.	n.d.
Primary Carbon, % ⁶	14.3	13.0	n.d.	n.d.

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(continued)

	Base oil 1 (GTL 4)	Base oil 2 (GTL 8)	Base oil 3 (Yubase 8)	Base oil 4 (PAO 6)
Epsilon carbon content, % ⁶	12.1	14.8	n.d.	n.d.
n- and iso-paraffins ⁷	92.35	72.1	n.d.	n.d.
Mono-naphthenics ⁷	6.85	27.6	n.d.	n.d.
di- and polynaphthenics ⁷	0.87	0.3	n.d.	n.d.
Aromatics ⁵	0.5	0.9	0.7	n.d.
Dynamic viscosity at -20°C ⁸ [cP]	n.d.	n.d.	2134	n.d.
Dynamic viscosity at -25°C ⁸ [cP]	n.d.	2908	3647	1300
Dynamic viscosity at -30°C ⁸ [cP]	948	n.d.	n.d.	n.d.
Dynamic viscosity at -35°C ⁸ [cP]	1580	n.d.	n.d.	n.d.
¹ According to ASTM D 445 ² According to ASTM D 2270 ³ According to ASTM D 5950 ⁴ According to CEC L-40-A-93 / ASTM D 5800 ⁵ According to IP 368 (modified) ⁶ According to ¹³ C NMR ⁷ According to FIMS ⁸ According to ASTM D 5293 n.d. = not determined				

[0057] The following additives A1-A42 were used, including viscosity modifiers A17-A27:

- A0: PAO 100, available from Chemtura under the trade designation "Synton PAO 100".
- A1: PAO 40 commercially available from Chemtura under the trade designation "Synton PAO 40".
- A2: alkyl naphthalene commercially available from King Industries under the tradename KR008
- A3: Dialkyl dithiophosphate ester commercially available from CIBA-Geigy (now BASF) under the trade designation Irgalube 353
- A4: Commercially available from CIBA-Geigy (now BASF) under the trade designation Irgalube 63
- A5: Amine thiophosphate commercially available from Lubrizol under the trade designation Lz5125
- A6: Dithiocarbamate commercially available from Vanderbilt Company Inc. under the trade designation Vanlube 7723
- A7: Chlorine-free alkyl polysulfide commercially available from Infineum under the trade designation Infineum C9002
- A8: Mixed phosphates commercially available from Chemtura under the trade designation Durad 310M.
- A9: Phosphorothionates commercially available from CIBA-Geigy (now BASF) under the trade designation Irgalube TPPT
- A10: Alkylated phosphorothionate (mixture of triphenylthiophosphate and tertiary butylated phenyl derivatives) commercially available from CIBA-Geigy (now BASF) under the trade designation Irgalube 232
- A11: Amine phosphate commercially available from CIBA-Geigy (now BASF) under the trade designation Irgalube 349.
- A12: Coalite CSP (phosphate) commercially available from Coalite.
- A13: Lz677A commercially available from Lubrizol
- A 14: Vanlube W324 commercially available from Vanderbilt.
- A15: Additive package commercially available from Afton under the trade designation Hitec 307
- A16: HVI650 commercially available from Shell
- A17: Ketjenlube 2700 (olefin copolymer ester) commercially available from Akzo Nobel
- A18: Pentaerythritol sebacate derived ester available from Cognis
- A19: Lz3130A (hydrocarbon polymer and copolymer ester) commercially available from Lubrizol
- A20: Lz87725 (methacrylate copolymer) commercially available from Lubrizol
- A21: Viscobase 11-520 (oil solution of acrylic polymer) commercially available from Evonik
- A22: Viscobase 11-522 (acrylic polymer without diluents) commercially available from Evonik
- A23: Viscobase 11-570 (alpha-olefin-polyalkyl methacrylate co-oligomer) commercially available from Evonik

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- A24: Viscobase 11-574 (alpha-olefin-polyalkyl methacrylate co-oligomer) commercially available from Evonik
- A25: Lucant HC-1100 (ethylene and alpha-olefin co-oligomer) commercially available from Mitsui
- A26: Lucant HC-2000 (ethylene and alpha-olefin co-oligomer) commercially available from Mitsui
- A27: UCON OSP 680 (poly alkylene glycol (base oil containing)) commercially available from Dow Chemicals
- A28: Infineum C9417 commercially available from Infineum
- A29: Lz1371 commercially available from Lubrizol
- A30: Lz1395 commercially available from Lubrizol
- A31: Irgacor L17 commercially available from CIBA-Geigy (now BASF)
- A32: Irgacor L17 commercially available from CIBA-Geigy (now BASF)
- A33: Sarkosyl O commercially available from CIBA-Geigy (now BASF)
- A34: Cobratex 939 commercially available from Raschig GmbH
- A35: Irgamet 42 commercially available from CIBA-Geigy (now BASF)
- A36: Irgamet 39 commercially available from CIBA-Geigy (now BASF)
- A37: Vanlube AZ commercially available from Vanderbilt
- A38: Cuvan 484 commercially available from Vanderbilt
- A39: Cuvan 303 commercially available from Vanderbilt
- A40: Vanlube 739 commercially available from Vanderbilt
- A41: Synative AC-AMH-2 anti-foam commercially available from Cognis
- A42: Irganox L57 commercially available from CIBA-Geigy (now BASF)

4-ball Weld Load Test

[0058] In order to measure the extreme-pressure properties of the various lubricating compositions set out in Table 2, the lubricating compositions were subjected to the 4-ball weld load test according to ASTM D2596. The Weld Load (in Kg) and the Wear Scar (mm) of each of the lubricating compositions are indicated in Table 2.

Table 2

Mixtures/additives	Wt%	4-Ball Weld Load Test			
		Wt% S	Wt% VM	Weld Load (kg)	Wear scar (mm)
BO2 + A0 + A2 (Mixture 1)	85+10+5	0	0	150	1.78
BO3 + A0 + A2 (Mixture 2)	85+10+5	0	0	150	0.62
Mixture 3 (Mixture 1 + A3)	0.1	0.02	0	170	0.47
Mixture 4 (Mixture 2 + A3)	0.1	0.02	0	170	0.52
Mixture 5 (Mixture 1 + A3)	0.5	0.02	0	200	0.58
Mixture 6 (Mixture 2 + A3)	0.5	0.10	0	200	0.63
Mixture 7 (Mixture 1 + A4)	0.1	0.02	0	180	0.57
Mixture 8 (Mixture 2 + A4)	0.1	0.02	0	170	0.53
Mixture 9 (Mixture 1 + A5)	0.5	0.03	0	230	0.56
Mixture 10 (Mixture 2 + A5)	0.5	0.03	0	240	0.57
Mixture 11 (Mixture 1 + A6)	0.075	0.02	0	200	0.53
Mixture 12 (Mixture 2 + A6)	0.075	0.02	0	170	0.73
Mixture 13 (Mixture 1 + A7)	0.05	0.02	0	180	0.46
Mixture 14 (Mixture 2 + A7)	0.05	0.02	0	170	0.58
Mixture 15 (Mixture 1 + A8)	0.2	0	0	160	1.73
Mixture 16 (Mixture 2 + A8)	0.2	0	0	150	1.57
Mixture 17 (Mixture 1 + A9)	0.2	0.02	0	150	1.61
Mixture 18 (Mixture 2 + A9)	0.2	0.02	0	150	1.58
Mixture 19 (Mixture 1 + A10)	0.15	0.01	0	160	0.93

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(continued)

	Mixtures/additives	Wt%	4-Ball Weld Load Test			
			Wt% S	Wt% VM	Weld Load (kg)	Wear scar (mm)
5	Mixture 20 (Mixture 2 + A10)	0.15	0.01	0	150	0.83
	Mixture 21 (Mixture 1 + A11)	0.2	0	0	180	0.59
	Mixture 22 (Mixture 2 + A11)	0.2	0	0	150	0.90
10	Mixture 23 (Mixture 1 + A12)	0.2	0	0	n.d.	n.d.
	Mixture 24 (Mixture 2 + A12)	0.2	0	0	n.d.	n.d.
	Mixture 25 (Mixture 1 + A13)	0.1	0.02	0	180	0.43
	Mixture 26 (Mixture 2 + A13)	0.1	0.02	0	190	0.40
15	Mixture 27 (Mixture 1 + A14)	0.3	0	0	n.d.	n.d.
	Mixture 28 (Mixture 2 + A14)	0.3	0	0	n.d.	n.d.
	Mixture 29 (BO2 + A1 + A15)	19.34 + 78.01 + 2.65	0.50	0	280	0.25
20	Mixture 30 (BO2 + A1 + A15)	20.86 + 76.49 + 2.65	0.50	0	270	0.23
	Mixture 31 (BO2 + A15 + A16)	23.7 + 2.65 + 73.65	1.40	0	280	0.23
	Mixture 32 (BO2 + A15 + A17)	52.85 + 2.65 + 44.50	0.50	44.5	290	0.24
25	Mixture 33 (BO2 + A15 + A18)	43.75 + 2.65 + 53.60	0.50	53.6	310	0.24
	Mixture 34 (BO2 + A15 + A19)	67.54 + 2.65 + 29.81	0.50	29.81	270	0.24
	Mixture 35 (BO2 + A15 + A20)	62.45 + 2.65 + 34.90	0.50	34.9	240	0.3
	Mixture 36 (BO2 + A15 + A21)	50.77 + 2.65 + 46.58	0.50	46.6	260	0.18
30	Mixture 37 (BO2 + A15 + A22)	56.35 + 2.65 + 41	0.50	41.0	n.d.	n.d.
	Mixture 38 (BO2 + A15 + A23)	46.08 + 2.65 + 51.27	0.50	51.3	270	0.21
	Mixture 39 (BO2 + A15 + A24)	59.11 + 2.65 + 38.24	0.50	38.2	280	0.26
35	Mixture 40 (BO2 + A15 + A25)	77.35 + 2.65 + 20	0.50	20	n.d.	n.d.
	Mixture 41 (BO2 + A15 + A26)	80.65 + 2.65 + 16.7	0.50	16.7	280	0.22
	Mixture 42 (BO2 + A15 + A27)	37 + 2.65 + 60.35	0.50	60.4	300	0.26
	Mixture 43 (BO2 + A19 + A13)	72.8 + 26 + 1.2	0.211	26	310	0.4
40	Mixture 44 (BO2 + A19 + A4)	72.8 + 26 + 1.1	0.26	26	270	0.43
	Mixture 45 (BO2 + A19 + A17 + A11)	63.9 + 15 + 20 + 1.1	0	15	270	0.34
45	Mixture 46 (BO2 + A19 + A17 + A4)	63.9 + 15 + 20 + 1.1	0.24	15	290	0.48
	Mixture 47 (BO3 + A19 + A13)	72.8 + 26 + 1.2	0.21	26	320	0.29
	Mixture 48 (BO2 + A19 + A29)	72.8 + 26 + 1.2	0.20	26	330	0.28
50	Mixture 49 (BO2 + A19 + A29)	72.8 + 26 + 1.2	0.25	26	330	0.28
	Mixture 50 (BO2 + A19 + A30)	72.8 + 26 + 1.2	0.24	26	n.d.	0.32
	Mixture 51 (BO1 + BO2 + A28)	31 + 68.4 + 0.6	0.10	0	220	1.71
	Mixture 52 (BO1 + BO2 + A29)	31 + 68.4 + 0.6	0.13	0	220	0.51
55	Mixture 53 (BO1 + BO2 + A30)	31 + 68.4 + 0.6	0.12	0	200	0.62
	Mixture 54 (BO1 + BO2 + A13)	31 + 68.4 + 1.2	0.21	0	260	0.57

(continued)

Mixtures/additives	Wt%	4-Ball Weld Load Test			
		Wt% S	Wt% VM	Weld Load (kg)	Wear scar (mm)
Mixture 55 (Mixture 1 + A16)	1.5	0.02	0	150	0.86
Mixture 56 (Mixture 2 + A16)	1.5	0.02	0	150	0.8
*Mixtures 29-42 are Comparative Examples					

Discussion

[0059] As can be learned from Table 2, the improvement of load bearing properties (increase in weld load and wear scar response) for in particular Mixtures 43 and 47-49 (containing the combination of a viscosity modifier and a sulphur-containing anti-wear/extreme pressure additive in a Fischer-Tropsch derived base base) was greater than expected on the basis of reduced sulphur content of the lubricating composition. As an example, Mixture 49 (containing 26 wt% of viscosity modifier and having 0.26 wt% total sulphur in a Fischer-Tropsch derived Base Oil 2) showed a weld load result of 330 kg and a wear scar diameter of 0.28 mm. This result is surprisingly better than, for example, Mixture 34 containing the same viscosity modifier (29.81%) and having approximately double the sulphur content (0.5 wt%) and thus demonstrates the ability to enhance weld load without the need for high-sulfur containing additive compositions comprising a Fischer-Tropsch derived base oil.

Claims

1. A lubricating oil composition comprising:

- (a) a base oil selected from Group III base oils, Group IV polyalphaolefins, and mixtures thereof;
- (b) 0.3 wt% or less of sulphur; and
- (c) 30 wt% or less of viscosity modifier;

wherein the lubricating oil composition has a kinematic viscosity at 40°C in the range of from 2 mm²/s to 220 mm²/s and wherein the lubricating oil composition provides a weld load of 150 Kg or greater in the 4 ball weld load test (ASTM D2596).

2. A lubricating oil composition according to Claim 1 wherein the Group III base oil is a Fischer-Tropsch derived base oil.

3. A lubricating oil composition according to Claim 1 or 2 wherein the composition comprises from 20 wt% to 30wt% viscosity modifier.

4. A lubricating oil composition according to Claim 1 or 2 wherein the composition is free of viscosity modifier.

5. A lubricating oil composition according to any of Claims 1 to 4 wherein the composition comprises from 0.2 wt% to 0.3wt% of sulphur.

6. A lubricating oil composition according to any of Claims 1 to 4 wherein the composition comprises less than 0.2 wt% of sulphur.

7. A lubricating oil composition according to any of Claims 1 to 6 wherein the lubricating oil composition provides a weld load of 200 Kg or greater in the 4 ball weld load test (ASTM D2596).

8. A lubricating oil composition according to any of Claims 1 to 7 wherein the lubricating oil composition provides a weld load of 250 Kg or greater in the 4 ball weld load test (ASTM D2596).

9. A lubricating oil composition according to any of Claims 1 to 8 wherein the lubricating oil composition has a kinematic viscosity at 40°C of from 32 mm²/s to 220 mm²/s.

10. A lubricating oil composition according to any of Claims 2 to 9 wherein the Fischer-Tropsch derived base oil has a

kinematic viscosity at 100°C of from 1 mm²/s to 25 mm²/s.

11. A lubricating oil composition according to any of Claims 2 to 10 wherein the Fischer-Tropsch derived base oil is present at a level of 70 wt% or greater, by weight of the lubricating oil composition.

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12. Use of a lubricating oil composition comprising:

- (a) a base oil selected from Group III base oils, Group IV polyalphaolefins and mixtures thereof;
- (b) 0.3 wt% or less of sulphur; and
- (c) 30 wt% or less of viscosity modifier;

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wherein the lubricating oil composition has a kinematic viscosity at 40°C in the range of from 2 mm²/s to 220 mm²/s, for providing improved extreme-pressure performance.

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EUROPEAN SEARCH REPORT

Application Number
EP 11 16 9873

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2009/074667 A1 (SHELL INT RESEARCH [NL]; FUJIWARA AKIMITSU [JP]; KANEKO HIROSHI [JP];) 18 June 2009 (2009-06-18) * page 31, lines 12-25 * * page 33, lines 6-16; claims 1,8,11; table 1 *	1-10	INV. C10M169/04 C10M171/02 C10M171/00
X	US 2009/298732 A1 (HOSTE KATTY S [BE] ET AL) 3 December 2009 (2009-12-03) * tables 1,2 *	1-10	
X	US 2007/203030 A1 (BUCK WILLIAM H [US] ET AL) 30 August 2007 (2007-08-30) * paragraphs [0024], [0028], [0029], [0036]; claim 1; table 3 *	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			C10M
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 September 2011	Examiner Bertrand, Samuel
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03/82 (P04/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 16 9873

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-09-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009074667 A1	18-06-2009	JP 2009161729 A	23-07-2009

US 2009298732 A1	03-12-2009	CA 2723292 A1	10-12-2009
		CN 102046763 A	04-05-2011
		EP 2285942 A2	23-02-2011
		JP 2011522089 A	28-07-2011
		WO 2009148837 A2	10-12-2009

US 2007203030 A1	30-08-2007	EP 1994125 A2	26-11-2008
		WO 2007084407 A2	26-07-2007

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2009074572 A [0003]
- EP 0776959 A [0013]
- EP 0668342 A [0013]
- WO 9721788 A [0013]
- WO 0015736 A [0013]
- WO 0014188 A [0013]
- WO 0014187 A [0013]
- WO 0014183 A [0013]
- WO 0014179 A [0013]
- WO 0008115 A [0013]
- WO 9941332 A [0013]
- EP 1029029 A [0013]
- WO 0118156 A [0013]
- WO 0157166 A [0013]
- US 4931197 A [0030]
- EP 0375324 A [0037]
- US 5922657 A [0037]
- US 4333841 A [0037]
- US 5093016 A [0037]
- WO 02070631 A [0053]

Non-patent literature cited in the description

- **D.J. WEDLOCK et al.** Gas-to-Liquids Base Oils to assist in meeting OEM requirements 2010 and beyond. *2nd Asia-Pacific base oil Conference*, 23 October 2007 [0002]
- Kirk-Othmer Encyclopedia of Chemical Technology. vol. 14, 477-526 [0044]