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(54) **Lubricating composition**

(57) The present invention provides a lubricating composition comprising:
- a base oil selected from the group consisting of a Fischer-Tropsch derived base oil and a poly-alpha olefin (PAO) base oil or a combination thereof;
- a detergent; and
- an amine compound.

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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 as 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 oils, in combination with an alkylated aromatic component such as an alkylated naphthalene, for use as a carrier oil for a viscosity modifier. The present applicant also found that SAE 0W-30, 0W-40, 5W-30 and 5W-40 engine oils containing an olefin copolymer (OCP) can be formulated, whilst using Fischer-Tropsch derived base oils as a carrier oil for the OCP.

[0004] It is an object of the present invention to improve the anti-oxidation properties of a lubricating composition.

[0005] It is another object of the present invention to provide alternative lubricating compositions.

[0006] One or more of the above or other objects can be obtained by the present invention by a lubricating composition comprising:

- a base oil selected from the group consisting of a Fischer-Tropsch derived base oil and a poly-alpha olefin (PAO) base oil or a combination thereof;
- a detergent; and
- an amine compound.

[0007] It has surprisingly been found that the lubricating compositions according to the present invention exhibit improved anti-oxidation properties.

[0008] There are no particular limitations regarding the base oil used in lubricating composition according to the present invention, and various conventional mineral oils, synthetic oils as well as naturally derived esters such as vegetable oils may be conveniently used, provided that at least a Fischer-Tropsch derived base oil or a poly-alpha olefin (PAO) base oil is present.

[0009] The base oil used in the present invention may conveniently comprise mixtures of one or more mineral oils and/or one or more synthetic oils; thus, according to the present invention, the term "base oil" may refer to a mixture containing more than one base oil. Mineral oils include liquid petroleum oils and solvent-treated or acid-treated mineral lubricating oil of the paraffinic, naphthenic, or mixed paraffinic/naphthenic type which may be further refined by hydrofinishing processes and/or dewaxing.

[0010] Suitable base oils for use in the lubricating oil composition of the present invention are Group I, Group II, Group III mineral base oils, Group IV poly-alpha olefins (PAOs), Group III Fischer-Tropsch derived base oils and mixtures thereof.

[0011] By "Group I", Group II", "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 I, II, III and IV. These API categories are defined in API Publication 1509, 15th Edition, Appendix E, April 2002.

[0012] 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.

[0013] Synthetic oils include hydrocarbon oils such as olefin oligomers (including polyalphaolefin base oils; PAOs), dibasic acid esters, polyol esters, polyalkylene glycols (PAGs), alkyl naphthalenes and dewaxed waxy isomerates. Synthetic hydrocarbon base oils sold by the Shell Group under the designation "Shell XHVI" (trade mark) may be conveniently used.

[0014] 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 1-tetradecene.

[0015] 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.

[0016] 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. 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 2.5 and 10 cSt (according to ASTM D 445).

[0017] The total amount of base oil incorporated in the lubricating composition of the present invention is preferably present in an amount in the range of from 60 to 99 wt.%, more preferably in an amount in the range of from 65 to 90 wt. % and most preferably in an amount in the range of from 70 to 85 wt.%, with respect to the total weight of the lubricating composition.

[0018] There are no particular limitations regarding the detergent used in the lubricating composition according to the present invention, and various conventional detergents may be used. Examples of detergents that may be used include oil-soluble neutral and overbased sulfonates, phenates, sulfurized phenates, thiophosphonates, salicylates and naphthenates and other oil-soluble carboxylates of a metal, particularly the alkali or alkaline earth metals, e.g. sodium, potassium, lithium, and in particular calcium and magnesium. Preferred metal detergents are neutral and overbased detergents having a TBN (Total Base Number; according to ASTM D2896) of from 20 to 450 mg KOH/g. According to a preferred embodiment, the detergent has a TBN value below 240 mg KOH/g, such as in the range of from 60 to 240, preferably below 200 mg KOH/g. Combinations of detergents, whether overbased or neutral or both, may be used.

[0019] Typically the detergent, or mixture of detergents, is present in the lubricating composition according to the present invention in an amount of from 0.01 to 5.0 wt.%, based on the total weight of the fully formulated lubricating oil composition.

[0020] According to a preferred embodiment of the present invention, the detergent is a salicylate-type detergent. Examples of suitable salicylate-type detergents include the products available from Infineum under the trade designations "Infineum C9012", "Infineum M7101" "Infineum M7102", "Infineum M7105", "Infineum M7121" and "Infineum M7125".

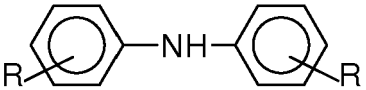
[0021] There are no particular limitations regarding the amine compound used in the lubricating composition according to the present invention, and various conventional amine compounds may be used. Examples of suitable amine compounds include monamines, diamines, and polyamines.

[0022] According to a preferred embodiment of the present invention, the amine compound is an aromatic amine compound. Examples of suitable aromatic amine compounds include diphenylamines, alkylated diphenylamines, phenyl-α-naphthylamines (PANA), phenyl-β-naphthylamines, and alkylated α-naphthylamines. Preferably the aromatic amine is selected from an optionally alkylated diphenylamine and an optionally alkylated phenyl-alpha-naphthylamine, more preferably an optionally alkylated diphenylamine.

[0023] The above-mentioned (optionally alkylated) diphenylamine (DPA) compounds are known in the art and widely commercially available. Examples of suitable diphenylamines and phenyl-alpha-naphthylamines that may be used include, but are not limited to, diphenylamine (DPA), butyldiphenylamine, dibutyldiphenylamine, octyldiphenylamine, dioctyldiphenylamine, nonyldiphenylamine, dinonyldiphenylamine, heptyldiphenylamine, diheptyldiphenylamine, methylstyryldiphenylamine, mixed butyl/octyl alkylated diphenylamines, mixed butyl/styryl alkylated diphenylamines, mixed nonyl/ethyl alkylated diphenylamines, mixed octyl/styryl alkylated diphenylamines, mixed ethyl/methylstyryl alkylated diphenylamines, phenyl-alpha-naphthylamine, octylphenyl-beta-naphtnylamine, t-octylphenyl-alpha-naphthylamine, phenyl-beta-naphthylamine, p-octylphenyl-alpha-naphthylamine, 4-octylphenyl-1-octyl-beta-naphthylamine, n-t-dodecylphenyl-1-naphthylamine, N-hexylphenyl-2-naphthylamine, and mixed alkylated phenyl-alpha-naphthylamines. Commercial examples of diphenylamines and phenyl-naphthylamines are available from CIBA Speciality Chemicals under the trade designations Irganox L-06 and Irganox L-57; from Chemtura under the trade designations Naugalube AMS, Naugalube 438, Naugalube 438R, Naugalube 438L, Naugalube 640, Naugalube 680, Naugalube APAN and Naugard PANA; from R.T. Vanderbilt Company, Inc under the trade designations Vanlube DND, Vanlube NA, Vanlube PNA, Vanlube SL, Vanlube SLHP, Vanlube SS, Vanlube 81, Vanlube 848, and Vanlube 849; from Albemarle under the trade designation AN-1225.

[0024] Typically, the amine compounds are present in an amount in the range of from 0.1 to 10.0 wt.%, preferably from 0.1 to 5.0 wt.%, more preferably from 0.2 to 4.0 wt.%, most preferably from 0.3 to 1.5 wt%, based on the total weight of the fully formulated lubricating oil composition.

[0025] According to an especially preferred embodiment of the present invention, the aromatic amine compound is a diphenylamine having the general formula (I)



(I)

wherein each R is independently an alkyl group having from 1 to 16 carbon atoms, preferably from 3 to 14 carbon atoms, more preferably from 4 to 12 carbon atoms.

[0026] The lubricating composition according to the present invention may further comprise one or more additives such as anti-oxidants, anti-wear additives, dispersants, detergents, overbased 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.

[0027] 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 1.0 to 20.0 wt.%, based on the total weight of the lubricating composition.

[0028] The lubricating compositions of the present invention may be conveniently prepared by admixing the one or more additives with the base oil(s).

[0029] The lubricating compositions according to the present invention preferably are so-called "low SAPS" (SAPS = sulphated ash, phosphorus and sulphur), "mid SAPS" or "regular SAPS" formulations.

[0030] For Passenger Car Motor Oil (PCMO) engine oils the above ranges mean:

- a sulphated ash content (according to ASTM D 874) of up to 0.5 wt.%, up to 0.8 wt.% and up to 1.5 wt.%, respectively;
- a phosphorus content (according to ASTM D 5185) of up to 0.05 wt.%, up to 0.08 wt.% and typically up to 0.1 wt.%, respectively; and
- a sulphur content (according to ASTM D 5185) of up to 0.2 wt.%, up to 0.3 wt.% and typically up to 0.5 wt.%, respectively.

[0031] For Heavy Duty Diesel Engine Oils the above SAPS ranges mean:

- a sulphated ash content (according to ASTM D 874) of up to 1 wt.%, up to 1 wt.% and up to 2 wt.%, respectively;
- a phosphorus content (according to ASTM D 5185) of up to 0.08 wt.% (low SAPS) and up to 0.12 wt.% (mid SAPS), respectively; and
- a sulphur content (according to ASTM D 5185) of up to 0.3 wt.% (low SAPS) and up to 0.4 wt.% (mid SAPS), respectively.

[0032] The lubricating composition may meet the above SAPS ranges for engine oils, even if the lubricating composition is intended for a different application.

[0033] Also, the lubricating composition may meet certain industry standards such as SAE J300 Specifications (as revised in January 2009). Preferably the lubricating composition according to the present invention meets the specifications of SAE J300 0W-20, 5W-30, 5W-40 and 10W-40 crankcase engine oils, preferably those of 10W-40. SAE stands for Society of Automotive Engineers.

[0034] It is especially preferred according to the present invention that the composition has:

- a dynamic viscosity at -25°C (according to ASTM D 5293) of below 7000 cP;
- a kinematic viscosity at 100°C (according to ASTM D 445) of at least 12.5 cSt and typically below 16.3;
- a high temperature, high shear viscosity ("HTHS"; according to ASTM D 4683) of at least 3.5 cP; and
- a Noack volatility (according to ASTM D 5800) of below 14 wt.%, preferably below 13.0 wt.%, more preferably below 11.0 wt.%, even more preferably below 10.5 wt.%, most preferably below 10.0 wt.%.

[0035] 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, a turbine oil, compressor oil, etc.

[0036] In another aspect, the present invention provides the use of a lubricating composition as described herein, in order to improve anti-oxidation properties (in particular as determined by HPDSC according to ASTM D 6186-08 and/or the ROBO test according to ASTM D 7528-09).

[0037] 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

[0038] 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 ease of reference, Table 2 also includes references to "Mixtures 1-21" containing a combination of two or more additives and a base oil.

[0039] "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 approx. 3.9 cSt (mm^2s^{-1}). Base oil 1 (and Base oil 3 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.

[0040] "Base oil 2" (or "BO2") was a commercially available Group III base oil having a kinematic viscosity at 100°C (ASTM D445) of approx. 4.3 cSt. Base oil 2 is commercially available from e.g. SK Energy (Ulsan, South Korea) under the trade designation "Yubase 4".

[0041] "Base oil 3" (or "BO3" or "GTL 8") was a Fischer-Tropsch derived base oil having a kinematic viscosity at 100°C (ASTM D445) of approx. 7.7 cSt (mm^2s^{-1}).

[0042] "Base oil 4" (or "BO4") was a commercially available Group III base oil having a kinematic viscosity at 100°C (ASTM D445) of approx. 6.5 cSt. Base oil 4 is commercially available from e.g. SK Energy under the trade designation "Yubase 6".

Table 1

	Base oil 1 (GTL 4)	Base oil 2 (Yubase 4)	Base oil 3 (GTL 8)	Base oil 4 (Yubase 6)
Kinematic viscosity at 40°C[1] [cSt]	16.91	19.49	43.36	36.06
Kinematic viscosity at 100°C[1] [cSt]	3.90	4.26	7.67	6.47
VI Index[2]	127	126	146	133
Pour point[3] [°C]	-39	-18	-24	-18
Noack volatility[4] [wt.%]	12.2	14.2	2.3	6.4
Saturates[5] [wt.%]	99.2	99.3	99.4	98.9
Dynamic viscosity at -20°C[6] [cP]	n.d.	713	n.d.	1526
Dynamic viscosity at -25°C[6] [cP]	704	931	2860	2572

[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 ASTM D 5293
n.d. = not determined

The following additives A1-A22 were used:

- A1: Octylated/butylated diphenylamine (DPA), available from CIBA Speciality Chemicals (Basel, Switzerland) under the trade designation "Irganox L-57".
- A2: Di-octylated diphenylamine, available from R.T. Vanderbilt (Norwalk, Connecticut, USA) under the trade designation "Vanlube 81".
- A3: 4,4'-bis(α,α,-dimethylbenzyl)diphenylamine, available from Chemtura (Middlebury, Connecticut, USA) under

the trade designation "Naugalube AMS".

- A4: Octylated phenyl-α-naphthylamine (PANA), available from CIBA Speciality Chemicals under the trade designation "Irganox L-06".
- A5: Liquid high MW phenolic antioxidant, available from CIBA Speciality Chemicals under the trade designation "Irganox L-135".
- A6: Oligomeric amine compound in a synthetic ester, available from R.T. Vanderbilt under the trade designation "Vanlube 9317".
- A7: Dinuclear molybdenum-sulphur compound, available from Infineum International Ltd (Abingdon, UK) under the trade designation "Infineum C9455".
- A8: Molybdenum dithiocarbamate available from Adeka under the trade designation "Sakura-Lube 515".
- A9: Ashless dithiocarbamate available from R.T. Vanderbilt under the trade designation "Vanlube 7723".
- A10: Thiodipropionic acid ester available from CIBA Speciality Chemicals under the trade designation "Irganox PS800 FL".
- A11: 2-ethyl-hexyl-dithiophosphate available from R.T. Vanderbilt under the trade designation "Vanlube 727".
- A12: Amine thiophosphate available from Lubrizol Corporation (Wickliffe, Ohio, USA) under the trade designation "Lz 5125".
- A13: Primary zinc dithiophosphate (ZDTP) available from Lubrizol Corporation under the trade designation "Lz 1395".
- A14: Secondary ZDTP available from Lubrizol Corporation under the trade designation "Lz 1371".
- A15: Mixed ZDTP available from Infineum International Ltd under the trade designation "Infineum C9417".
- A16: Low BI (Basicity Index) salicylate detergent (Ca-based) available from Infineum International Ltd under the trade designation "Infineum M7102". Properties: Vk40 (270); Vk100 (19); TBNE (Total Base Number Equivalent (ASTM D 2896); mgKOH/g) = 64; Ca (wt.%) = 2.3.
- A17: Medium BI salicylate detergent (Ca-based) available from Infineum International Ltd. under the trade designation "Infineum M7121". Properties: Vk40 (1130); Vk100 (95); TBNE (mgKOH/g) = 225; Ca (wt.%) = 8.0%; Mg (wt.%) = 0.24.
- A18: High BI salicylate detergent (Ca-based) available from Infineum International Ltd. under the trade designation "Infineum M7125". Properties: Vk40 (835); Vk100 (100); TBNE (mgKOH/g) = 350; Ca (wt.%) = 12.5; Mg (wt.%) = 0.3.
- A19: Reaction product of an acidic organic compound, a boron compound, and basic organic compound, available from Chemtura. See e.g. US 2005/0172543 and in particular paragraphs [0025]-[0077] thereof.
- A20: Sulfonate detergent, available from Infineum International Ltd under the trade designation "Infineum C9350". Properties: Vk40 (2300); Vk100 (130); TBN (mgKOH/g) = 16.5; Ca (wt.%) = 2.15.
- A21: Phenate detergent, available from Infineum International Ltd under the trade designation "Infineum C9394". Properties: TBN (mgKOH/g) = 258; Ca (wt.%) = 9.5.
- A22: Mg-based salicylate detergent, available from Infineum International Ltd under the trade designation "Infineum C9012". Properties: Vk100 (65); TBNE (mgKOH/g) = 345; Mg (wt.%) = 7.45.

Table 2

		OIT [min]		
ADDITIVE	[wt.%]	BO1 (GTL 4)	BO2 (Yubase 4)	BO3 (GTL 8)
A1 (DPA)	0.05	4.8	3.7	3.5
	0.5	8.0	7.0	7.3
	1.0	11.0	11.4	11.0
	1.5	18.3	14.2	14.6
A2 (DPA)	1.0	6.5	-	-
A3 (DPA)	0.7	6.2	-	-
A4 (PANA)	0.5	30.0	-	-
	1.0	81.0	-	-
	2.0	119.5	-	-
A5	1.0	6.9	6.5	-

(continued)

		OIT [min]		
ADDITIVE	[wt.%]	BO1 (GTL 4)	BO2 (Yubase 4)	BO3 (GTL 8)
A6	0.5	3.8	3.5	-
	1.0	4.7	4.4	-
	2.0	7.0	6.1	-
A2 + A4 **[Mixture 1]**	1.0 + 0.5	72.4	-	-
	1.0 + 0.75	83.8	-	-
	1.0 + 1.0	100.8	-	-
A2 + A3 + A4 **[Mixture 2]**	0.25 + 0.7 + 1.0	98.5	94.8	-
	0.5 + 0.7 + 1.25	111.9	108.9	-
	0.75 + 0.7 + 1.5	133.1	118.0	-
A1 + A5 **[Mixture 3]**	1.0 + 0.25	16.5	14.7	-
	1.0 + 0.5	18.5	16.6	-
	1.0 + 1.0	20.3	39.9	-
A7	0.25	< 3.0	< 3.0	< 3.0
A1 + A7 **[Mixture 4]**	0.5 + 0.25	82.1	70.0	82.6
	1.0 + 0.25	97.8	98.3	-
	1.5 + 0.5	132.7	124.2	-
	0.5 + 0.025	67.1	48.4	-
	1.0 + 0.025	94.5	91.4	-
A8	0.025	< 3.0	< 3.0	< 3.0
A1 + A8 **[Mixture 5]**	0.5 + 0.025	75.7	80.0	-
	0.75 + 0.025	97.4	95.6	-
	1.0 + 0.025	108.6	107.8	-
A1 + A5 + A7 **[Mixture 6]**	1.0 + 1.0 + 0.01	3.1	3.7	-
A9	1.5	< 3.0	< 3.0	-
A1 + A9 **[Mixture 7]**	1.0 + 0.075	29.1	33.4	-
	1.0 + 0.75	121.6	119.4	-
A10	1.5	< 3.0	< 3.0	-
A1 + A10 **[Mixture 8]**	1.0 + 0.075	14.2	-	-
	1.0 + 0.75	63.3	-	-
	1.0 + 1.5	59.4	-	-
A5 + A10 **[Mixture 9]**	1.0 + 0.075	7.0	-	-
	1.0 + 0.75	7.9	-	-
	1.0 + 1.5	8.3	-	-
A11	0.8	< 3.0	-	-
A1 + A11 **[Mixture 10]**	1.0 + 0.2	14.2	-	-
	1.0 + 0.6	32.6	-	-
	1.0 + 0.8	46.8	-	-

(continued)

		OIT [min]		
ADDITIVE	[wt.%]	BO1 (GTL 4)	BO2 (Yubase 4)	BO3 (GTL 8)
A12	0.75	< 3.0	-	-
A13	1.0	8.4	-	-
A1 + A13 **[Mixture 11]**	1.0 + 0.2	44.4	-	-
	1.0 + 0.6	134.1	-	-
	1.0 + 1.0	144.7		
A14	1.0	8.7	-	-
A1 + A14 **[Mixture 12]**	1.0 + 0.2	59.5	-	-
	1.0 + 0.6	92.1	-	-
	1.0 + 1.0	94.2	-	-
A15	1.0	8.4	-	-
A1 + A15 **[Mixture 13]**	1.0 + 0.2	44.4	-	-
	1.0 + 0.6	134.1	-	-
	1.0 + 1.0	144.7	-	-
A16 (detergent)	3.0	15.1	-	-
A1 + A16 **[Mixture 14*]**	0.5 + 3.5	109.5	68.2	-
A17 (detergent)	3.0	16.9	-	-
A1 + A17 **[Mixture 15*]**	0.5 + 2.5	131.4	-	-
A18 (detergent)	3.0	6.36	-	-
A1 + A18 **[Mixture 16]**	0.5 + 1.5	20.4		
A16 + A17 **[Mixture 17]**	3.0 + 0.75	51.8	43.7	-
A17 + A18 **[Mixture 18]**	2.0 + 1.0	20.1	19.8	-
A19 (detergent)	3.0	3.7	-	-
A1 + A19 **[Mixture 19*]**	0.5 + 5.0	109.7	85.1	-
A20 (detergent)	2.5	<3.0	<3.0	-
A1 + A20 **[Mixture 20*]**	0.5 + 2.5	14.5	-	-
A21 (detergent)	2.5	11.3	-	-
A1 + A21 **[Mixture 21*]**	0.5 + 2.5	34.7	-	-
A22 (detergent)	2.5	6.2	-	-
*Mixtures 14, 15 and 19-21 are according to the present invention				

HPDSC Oxidation Stability Test

[0043] In order to demonstrate the anti-oxidation properties of the lubricating compositions according to the present invention, Oxidation Induction Time (OIT) measurements were performed using High Pressure Differential Scanning Calorimetry (HPDSC) according to ASTM D 6186-08, at a temperature of 200°C and whilst subjecting to oxygen at 200 psig (instead of the prescribed 500 psig). Aluminium sample pans were used. Oxidation Induction Time can be used as an indication of oxidation stability.

SAE 10W-40 formulations

[0044] In addition, various low-SAPS SAE 10W-40 (PCMO) engine oils for use in a crankcase engine of a passenger car were formulated.

[0045] Table 3 indicates the composition and properties of the fully formulated engine oil formulations that were tested; the amounts of the components are given in wt.%, based on the total weight of the fully formulated formulations.

[0046] All tested engine oil formulations contained a combination of a base oil, an additive package, a detergent and an amine, which additive package was the same in all tested compositions.

[0047] The additive package was a so-called low SAPS (low sulphated ash, phosphorus and sulphur) PCMO formulation, i.e. having a sulphated ash content of up to 0.5 wt.%, a phosphorus content of up to 0.05 wt.% and a sulphur content of up to 0.2 wt.%. The additive package contained a combination of additives including anti-oxidants, a zinc-based anti-wear additives, an ashless dispersant, a pour point depressant, about 3 ppm of an anti-foaming agent and a conventional viscosity modifier concentrate.

[0048] The compositions of Examples 1-3 and Comparative Examples 1-3 were obtained by mixing the base oils with the additive package using conventional lubricant blending procedures.

Table 3

Component [wt.%]	Example 1	Example 2	Example 3	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3
Base oil 3 [Fischer-Tropsch derived]	83.6	83.4	83.2	-	-	-
Base oil 4 [mineral derived]	-	-	-	83.6	83.4	83.2
Additive package	12.4	12.4	12.4	12.4	12.4	12.4
Detergent [A16]	3.2	3.2	3.2	3.2	3.2	3.2
Detergent [A17]	0.4	0.4	0.4	0.4	0.4	0.4
Diphenylamine [A1]	0.4	0.6	0.8	0.4	0.6	0.8
TOTAL	100	100	100	100	100	100
Properties of the total composition						
Dynamic viscosity at -25°C[1] [cP]	5210	5219	5245	5175	5188	5269
Kinematic viscosity at 100°C[2] [cSt]	13.3	13.2	13.2	13.9	13.9	14.0
[1]According to ASTM D 5293. NB 1 cP (centi Poise) = 1 mPa.s [2]According to ASTM D 445						

ROBO Oxidation Test

[0049] In order to demonstrate the oil aging properties of the lubricating compositions according to the present invention, measurements were performed using the ROBO (Romaszewski Oil Bench Oxidation) test according to ASTM D 7528-09. This bench test method is intended to produce comparable oil aging characteristics to those obtained with ASTM TMC Sequence IIGA matrix reference oils 434, 435 and 438 after aging in the Sequence IIG engine test.

[0050] The measured values for viscosity increase, apparent viscosity and yield stress are indicated in Table 4 below.

Table 4

Property	Ex. 1	Ex. 2	Ex. 3	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3
Kinematic viscosity at 40°C[1] [% increase]	-1.9	-5.3	-5.8	36.4	21.3	28.9
Apparent viscosity EOT[2] [cP]	19900	12700	12800	43900	43800	71000

(continued)

Property	Ex. 1	Ex. 2	Ex. 3	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3
Yield stress[3] [Pa]	<35	<35	<30	<105	<70	<70
[1]According to ASTM D 445 [2]According to MRV (4684) [3]According to ASTM D 4684						

Discussion

[0051] As can be learned from Table 2, the improvement of anti-oxidation properties (increase in HPDSC response) for in particular Mixtures 14, 15 and 19 (containing the combination of an amine and a detergent in a Fischer-Tropsch derived base oil) was greater than expected on the basis of the performance of the separate components. As an example, Mixture 14 (containing 0.5 wt.% of amine A1 and 3.5 wt.% of detergent A16 in Fischer-Tropsch derived Base Oil 1) showed an OIT of 109.5 min (compared to 68.2 min in a mineral derived Group III base oil). This is surprisingly more than the sum of the contributions of 0.5 wt.% of amine A1 in BO1 (8.0 min) and 3.0 wt.% of detergent A16 in BO1 (15.1 min). Thus, the performances of in particular Mixtures 14, 15 and 19 in Fischer-Tropsch derived base oil are synergistic when compared with the sum of the individual OIT contributions. From Mixtures 14, 15 and 19 it can be learned as well that the performance of the same amounts of the same amine and same detergent in a Fischer-Tropsch derived base oil is significantly better (longer OIT) than the performance of the same amounts of the same components in a mineral derived Group III base oil. This is a clear indication of a synergistic effect.

[0052] Further, when comparing Mixtures 14 and 15 with Mixtures 16 and 21, it can be learned that there is a preference according to the present invention for detergents having a low or medium BI, i.e. having a TBN lower than 240 mg KOH/g such as in the range from 60-240 mg KOH/g, rather than high BI detergents, as the actual OIT value for Mixtures 14 and 15 is much higher.

[0053] Further, it was found (see Table 4) that the compositions of Examples 1-3 (containing a Fischer-Tropsch derived base oil) according to the present invention exhibit a (desirable) decreased viscosity thickening and lower end-of-test (EOT) viscosity than the compositions according to Comparative Examples 1-3 (containing a mineral derived base oil). In addition the yield stress is significantly lowered in the compositions according to the present invention when compared with the Comparative Examples. This further demonstrates the synergistic behaviour of the combination of a detergent, an amine compound and a Fischer-Tropsch derived base oil as claimed according to the present invention, as shown in Table 2 as well.

Claims

1. A lubricating composition comprising:

- a base oil selected from the group consisting of a Fischer-Tropsch derived base oil and a poly-alpha olefin (PAO) base oil or a combination thereof;
- a detergent; and
- an amine compound.

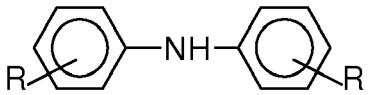
2. Lubricating composition according to claim 1, wherein the base oil contains more than 50 wt.%, preferably more than 60 wt.%, more preferably more than 70 wt.%, even more preferably more than 80 wt.%, most preferably more than 90 wt.% Fischer-Tropsch derived base oil.

3. Lubricating composition according to claim 1 or 2, wherein the detergent is a salicylate-type detergent.

4. Lubricating composition according to any one of claims 1 to 3, wherein the detergent has a TBN value below 240 mg KOH/g, preferably in the range of from 60 to 240 mg KOH/g.

5. Lubricating composition according to any one of claims 1 to 4, wherein the amine compound is an aromatic amine compound, preferably selected from a diphenylamine and a phenyl-alpha-naphthylamine.

6. Lubricating composition according to claim 5, wherein the aromatic amine compound is a diphenylamine having the general formula (I)



(I)

wherein each R is independently an alkyl group having from 1 to 16 carbon atoms, preferably from 3 to 14 carbon atoms, more preferably from 4 to 12 carbon atoms.

7. Lubricating composition according to any one of claims 1 to 6, wherein the composition has:

- a sulphated ash content of up to 0.5 wt.%;
- a phosphorus content of up to 0.05 wt.%; and
- a sulphur content of up to 0.2 wt.%.

8. Use of a lubricating composition according to any one of claims 1 to 7, in order to improve anti-oxidation properties (in particular as determined by HPDSC according to ASTM D 6186-08 and/or the ROBO test according to ASTM D 7528-09).

REFERENCES CITED IN THE DESCRIPTION

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