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WO 98/26030 A1 US 6010987 A US 5895779 A
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(54) Abstract Title

Lubricating oils having improved fuel economy retention properties

(57) A lubricating oil composition with improved fuel economy and fuel economy retention properties and comprising a major amount of an oil of lubricating viscosity and a minor amount of (a) an oil soluble organic friction modifier other than ashless alkyldithiodicarbamates and (b) trinuclear organomolybdenum compound of the generic formula Mo_3S_x-(Q)wherein x is from 4 to 10 and Q is a core which may be a ligand, the trinuclear molybdenum compound being present in such an amount as to provide 10-1000 ppm of molybdenum in the composition.

LUBRICATING OILS HAVING IMPROVED FUEL ECONOMY RETENTION PROPERTIES

This invention relates to lubricating oils particularly useful for passenger car engines. More particularly, the invention relates to lubricating oil compositions which exhibit improvements in fuel economy and fuel economy retention.

Fuel economy in engine oils is generally achieved by reducing engine friction. Friction is understood to be caused by two factors: the internal viscosity (internal fluid friction) and the external viscosity (surface to surface friction). The internal viscosity is reduced as the lubricant viscosity is reduced. Modern fuel economy lubricants are therefore formulated as low SAE viscosity grades such as 5W-30, 5W-20, OW-30 and OW-20. Surface to surface friction is controlled by surface friction modifiers which fall into two general categories: organic friction modifiers and metal-containing friction modifiers. Organic friction modifiers are typically based on fatty acid esters and some synthetic esters. Metal-containing friction modifiers are typically based on molybdenum containing compounds. Examples of suitable molybdenum compounds include molybdenum dialkyldithiocarbamates, such as those disclosed in prior published US-A-4,501,678 and US-A-4,479,883, and trimeric molybdenum alkyldithiocarbamates such as those diclosed in US-A-5,895,779. These compounds are believed to decompose under engine operating conditions to form molybdenum sulphides. Molybdenum sulphides and ester compounds are understood to reduce friction in the engine by being adsorbed on to the surface of the engine and forming a surface layer with lower friction.

Accordingly, the present invention comprises a lubricating oil composition capable of exhibiting improved fuel economy and fuel economy retention properties, said composition comprising a major amount of an oil of lubricating viscosity and a minor amount of

(a) 0.05-15% by weight of an oil soluble organic friction modifier other than ashless alkyldithiodicarbamates and

(b) an oil soluble trinuclear organomolybdenum compound of the generic formula:

$$Mo_3S_x\text{-}(Q) \qquad (I)$$

wherein x is from 4 to 10, preferably 7, Q a core group which may be a ligand, esters such as eg the oleates, especially the mono-oleates and the monoester of 1-methylenehydroxy-2,3,4-trihydroxy pyran, in which the methylene hydroxy group has been esterified with acetic acid.

The trinuclear molybdenum compounds of formula (I)

$$Mo_3S_x\text{-}(Q) \qquad (I)$$

wherein x is from 4 to 10, preferably 7, Q is a core group are relatively new and are claimed and described in our prior published US-A-5,906,968. The matter disclosed in this prior US patent on the structure, preparation and properties of the trinuclear molybdenum compounds is incorporated herein by reference. In these compounds the core group (Q) may be a ligand capable of rendering the organomolybdenum compound of formula (I) oil soluble and to ensure that said molybdenum compound is substantially charge neutral. The core group (Q) is generally associated with suitable ligands such as L_y wherein L is the ligand and y is of a sufficient number, type and charge to render the compound of formula (I) oil soluble and to neutralise the charge on the compound of formula (I) as a whole. Thus, more specifically, the trinuclear molybdenum compound used in the compositions of the present invention may be represented by the formula (II):

$$Mo_3S_xL_y \qquad (II)$$

The ligands "L" are suitably dihydrocarbyl dithiocarbamates of the structure ($-S_2CNR_2$) wherein the dihyrocarbyl groups, R_2 impart oil solubility to the molybdenum compound. In this instance, the term "hydrocarbyl" denotes a substituent having carbon atoms directly attached to the remainder of the ligand and is predominantly hydrocarbyl in character within the context of this invention. Such substituents include the following:

(1) hydrocarbon substituents, ie, aliphatic (for example alkyl or alkenyl), alicyclic (for example cycloalkyl or cycloalkenyl), aromatic-, aliphatic- and alicyclic-substituted aromatic nuclei and the like, as well as cyclic substituents wherein the ring is completed through another portion of the ligand (that is, any two indicated substituents may together form an alicyclic group);

(2) substituted hydrocarbon substituents, ie, those containing nonhydrocarbon groups which, in the context of this invention, do not alter the predominantly hydrocarbyl character of the substituent. Those skilled in the art will be aware of suitable groups (eg halo (especially chloro), amino, alkoxyl, mercapto, alkylmercapto, nitro, nitroso, sulphoxy etc.); and

Specific examples of nitrogen-containing organic friction modifiers falling into the above categories are:

(i) the monoethylene diamines, diethylene triamines, the triethylene tetraamines and the tetraethylene pentamines, and the N-alkyl derivatives thereof eg Duomeen®T, and N,N'-di(1-hydroxy-1,1-dimethyl methyl) ethylene diamine ie Kaneda® No. 6;

(ii) N-alkyl or the appropriate N,N-dialkyl derivatives of ethanol amines, diethanol amines, propanol amines, iso-propanol amines, butanol amines, the N-alkyleneaminoalkyl ethanolamine in which the alkyl group has 10-20 carbon atoms, di(polyalkyleneoxy) alkanolamines in which the total number of alkyleneoxy groups may range from 2-20, preferably from 5-15 groups, especially N-methyl ethanolamine (Kaneda® No. 1), N-hydrocarbyl diethanolamine (Kaneda® No. 2B), N,N-dibutyl ethanolamine (Kaneda® No. 4), N-dodecyl diethanolamine (Ethomeen®C12), N-hydrocarbyl diethanolamine (Ethomeen®S12), N-trimethyleneaminoalkyl diethanolamine in which the alkyl group has 12-18 carbon atoms (Ethoduomeen®), the N-alkyl-di(polyalkyleneoxy) diethanolamines which respectively have 5, 10 and 15 polyethyleneoxy groups (Tamno®-5, -10 and -15 respectively), and N,N'-dihydroxyethyl ethylenediamine (Kaneda® No. 5);

(iii) the alkyl amides in which the alkyl groups have from 1-30 carbon atoms, preferably from 5-20 carbon atoms and in which the alkyl groups may be straight or branched chain groups such as eg Armoslip®CP-P and Armoslip®E in which the alkyl groups have 17 and 21 carbon atoms respectively;

(iv) ethanolamides, the diethanolamides and the (polyalkyleneoxy) ethanolamides, and the N-alkyl derivatives thereof wherein the N-alkyl group has from 1-25 carbon atoms, preferably from 5-20 carbon atoms and wherein in the case of the (polyalkyleneoxy) ethanolamides said amides having from 5-20 polyoxyalkylene groups such as eg N-acyl-ethanol amine Kaneda® No. 9 (in which the alkyl group in the acyl moiety has 12 carbon atoms), diethanolamines eg. Amizole® ISDE (in which the alkyl group in the acyl moiety has 18 carbon atoms), Kaneda® No. 10 (in which the alkyl group in the acyl moiety has 12 carbon atoms), di(polyethyleneoxy) ethanol amide wherein the alkyl group in the acyl moiety has 17 carbon atoms and the total number of polyethyleneoxy groups in the molecule is 5 (eg Tamdo®-5).

Specific examples of oxygen-containing organic friction modifiers (B) are the mono-, di- and tri-esters of glycerol with an alkyl carboxylic acid such as oleic acid in which the carboxyl group has from 1-25 carbon atoms, the corresponding pentaerythritol performance of conventional molybdenum dithiocarbamate dimers in such compositions with respect to their fuel economy benefit. However, surprisingly, it has been found that the combination of trinuclear organomolybdenum compounds with organic friction modifiers unexpectedly improves the fuel economy benefit and fuel economy retention over compositions which contain either the trinuclear organomolybdenum compounds or the organic friction modifiers alone, especially in lower viscosity oil compositions.

EXAMPLES:

A. Measurement of Fuel Economy Improvement:

Fuel economy improvement is measured against reference lubricants in three standard industry tests: These are, the M111 European test; the Sequence VIA, Sequence VIB US tests. In the latter tests, fuel economy improvement under different operating regimes (boundary and hydrodynamic conditions) are separately measured and an estimated overall fuel economy improvement is then calculated. In the M111 test only an overall fuel economy improvement is calculated.

As mentioned previously, fuel economy improvement due to friction modifiers can be better measured in the bounday and mixed regimes, while the lubricant viscometric effects can be best examined in the hydrodynamic regimes.

In view of the above, and in order to estimate better the impact of friction modifiers on boundary conditions, the Sequence VIA and VIB engine tests were chosen to illustrate the present invention. The Sequence VIA is used to determine the initial fuel economy improvements. The Sequence VIB is used for initial and aged fuel economy. The two tests are described in Section **B** below. It is important to note that the calculation of overall fuel economy from the two tests are different in that they assign different weighting factors to the boundary and hydrodynamic stages. Therefore, the fuel economy improvement numbers from the two tests are not necessarily related.

B. Fuel Economy Improvement Tests:

Fuel economy is measured in different types of engine tests including Sequence VIA, Sequence VIB amd the M111 tests. Sequence VIA and the M111 tests evaulate

(3) hetero substituents, ie, substituents which, while predominantly hydrocarbon in character within the context of this invention, contain atoms other than carbon present in a chain or ring otherwise composed of carbon atoms.

The hydrocarbyl groups are preferably alkyl (e.g, in which the carbon atom attached to the remainder of the ligand "L" is primary, secondary or tertiary), aryl, substituted aryl and ether groups.

Importantly, the hydrocarbyl groups of the ligands should be such that they have a sufficient number of carbon atoms to render the compound (I) soluble or dispersible in the oil to which it is added. The total number of carbon atoms present among all of the hydrocarbyl groups of the compounds' ligands is suitably at least 21, preferably at least 25, more preferably at least 30 and even more preferably at least 35, typically e.g., 21 to 800. For instance, the number of carbon atoms in each hydrocarbyl group will generally range from 1 to 100, preferably from 1 to 40 and more preferably from 3 to 20.

The relative amounts of the trinucler organomolybdenum compound and the organic friction modifier is suitably in a ratio of from about 1 - 4000 to about 1 - 0.2 by weight respectively. In this context it should be noted that the precise amount of the two components used would depend upon the nature of the organic friction modifier used.

The antioxidant in the compositions of the present invention suitably also include at least one of a phenolic antioxidant and an aminic antioxidant. Among the phenolic antioxidants, hindered phenols such as 2,6-di-tert-butylphenol and derivatives thereof are preferred. Suitable aminic antioxidants for use in the compositions of the present invention are diaryl amines, aryl naphthyl amines and alkyl derivatives of diaryl amines and the aryl naphthyl amines.

In general, these lubricating compositions may include additives commonly used in lubricating oils especially crankcase lubricants, such as antiwear agents, detergents, rust inhibitors, viscosity index improvers, extreme-pressure agents, friction modifiers, corrosion inhibitors, emulsifying aids, pour point depressants, anti-foams and the like.

A feature of the lubricant compositions of the present invention is that hitherto, the presence of organic friction modifiers were believed not to significantly improve the economy portions of the test.

TABLE 1

Fuel Economy Measurement and Aging Condition				
FE Stage	**Speed (r/min)**	**Torque (N-M)**	**Oil Temp (°C)**	**Coolant Temp (°C)**
1	1500	98	125	105
2	800	26	105	95
3	800	26	70	60
4	1500	98	70	60
5	1500	98	45	45
Aging Stage	**Speed (r/min)**	**Torque (N-M)**	**Oil Temp (°C)**	**Coolant Temp (°C)**
1	1500	98	125	105
2	2250	98	135	105

Example 1:

Synergy between organic friction modifier and trinuclear organomolybdenum compound (PDN5203, an experimental sample containing 5% w/w of molybdenum

Abbreviations used:

SEQ VIB Engine Test: Sequence VIB Engine Test as described above.
OFM - Organic Friction Modifier (Glycerol Mono Oleate)
TMC - Trinuclear Molybdenum dithiocarbamate [PDN5203 containing 5% w/w molybdenum(ex Infineum)]
Base Case -
Basestock Gp II -
Hydrocracked. X120 - Exxon Group II
DI Package - Detergent Inhibitor package
VII-OCP - VI Improver-Paratone® 8451 (an olefin copolymer, Ex Oronite)
PPD-PF390 - Pour Point Depressant-Paraflow® 390 (ex Infineum)
Irgamet® 39 - Metal Deactivator (ex Infineum)
CALE 2 - a soluble complex alcohol ester (ex Exxon Chemicals)
EDM - alcohol amine friction modifier-Ethoduomeen® (ex Akzo-Nobel)
HHE2 - high hydroxy ester friction modifier(ex Exxon Chemicals)

initial fuel economy while Sequence VIB test determines initial and retained fuel economy after 96 hours.

In all engine tests, fuel economy is estimated as a function of the hydrodynamic and boundary contribution of the lubricant to fuel consumption. The lubricant contribution under hydrodynamic conditions is mostly governed by the lubricant viscometrics under both low and high shear conditions while the lubricant contributions under boundary conditions are most governed by the friction modifier technology.

For the purpose of illustrating this invention, we concentrate on the lubricant contribution to the boundary operating range of the engine, which in the Sequence VIB test is measured in Stage 1 of that test. The following Examples, therefore, refer to test performances in Stage 1, Stage 5 and the M111 tests as appropriate.

More specifically, the Sequence VIB is an engine dynamometer test that measures a lubricant's ability to improve the fuel economy of passenger cars and light-duty trucks. The method compares the performance of a test lubricant to the performance of a baseline lubricant over five different stages of operation.

A 1997 Ford 4.6L spark ignition, V-8 cylinder design, 4-cycle engine is used as the test apparatus. The engine incorporates overhead camshafts, a cross-flow, fast burn cylinder head design, two valves per cylinder, and an electronic port fuel injection.

The Sequence VIB test incorporates a flush and run type procedure. Each test consists of two 5-stage fuel economy measurements on baseline oil (BC), one at the beginning of the test and one at the end. The test oil is evaluated in between the two baseline runs. The test oil is initially aged during 16 hours of engine operation at 1500 r/min and 125°C oil temperature. After the initial aging, a 5-stage fuel economy measurement is taken. The test oil is then aged an additional 80 hours at an engine speed of 2250 r/min and 135°C oil temperature. Following this final aging, the test oil once again goes through a 5-stage fuel economy measurement. The two fuel economy measurements taken on the baseline oil (BC) and a final value for Fuel Economy Improvement is calculated for the test oil.

Below is a summary of the operating conditions for the aging and 5-stage fuel

TABLE 4

STAGE	Without OFM	OFM Alone	TMC Alone	OFM + TMC
1	-2.4	+0.5	+2.0	+2.3
4	+2.6	+2.7	+2.5	+2.9
Overall	+1.5	+1.9	+2.0	+2.3

These results show that the use of an organic friction modifier (glycerol monooleate) together with a trinuclear molybdenum dithiocarbamate is better than using either of these two friction modifiers alone.

Example 2:

This Example shows that the concepts of using mixed friction modifiers of the present invention is applicable to other organic friction modifiers irrespective of how good the performance of the organic friction modifier is when used alone.

TABLE 5

Example 2	Case 2		Case 3		Case 4	
	CALE 2 alone	CALE 2 + TMC	HHE2 alone	HHE2 + TMC	EDM alone	EDM + TMC
Stage 1	1.6	2.0	1.6	2.1	2.3	2.5
Stage 4	2.6	2.4	2.7	2.7	2.9	3.0
Overall FE	1.9	1.9	2.0	2.1	2.2	2.4

Initial AGed Fuel Economy Improvements in Sequence VIB:

It can be seen above that in Stage 1 of the Sequence VIB test we show improvements and that improvement is better for the combination . Further, the following will show that improvement is observed after 96 hours and hence overall fuel economy is better.

A. The lubricant formulation tested:

Viscosity grade - 5W-20 Oil

TABLE 2

Composition	Without OFM	OFM Alone	TMC Alone	OFM + TMC
Basestock Gp II Hydrocracked 120X	84.41	84.3	84.3	73.05
DI Package	8.29	0	8.29	0
DI Package + OFM	-	9.65	0	9.65
TMC	0	0	1.0	1.0
VII - OCP	6.10	6.10	6.10	6.10
PPD-PF390	0.2	0.2	0.2	0.2
Metal Deactivator Irgamet®39	-	-	0.05	-

B. Results (% Fuel Economy Improvement (%FEI)):

TABLE 3

% FEI	Without OFM	OFM Alone	TMC Alone	OFM + TMC
Initial 16 Hrs	1.20	1.8	1.96	2.26
Final 96 Hrs	-	1.0	1.19	1.95

These values of % fuel economy improvement achieved easily surpass the proposed minimum limits for a 5W-20 viscosity grade using a Sequence VIB test: i.e. a 16 hr limit %FEI of 2.0 and a 96 hr limit %FEI of 1.7, values not achieved when using either the trinuclear molybdenum compound alone or an organic friction modifier alone.

C. Stage 1 results - Initial Fuel Economy Improvement in the Sequence VIA test:

In this test, which is a boundary dominated stage of Sequence VIA, fuel economy is improved as follows for a 5W-20 viscosity grade oil.

TABLE 7

	Grade	5W-20	5W-20	5W-20	5W-20	5W-20	5W-20	5W-20	5W-20
	Blend	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Components	**Description**								
120X EHC45	Gp II Base Oil	84.41	84.41	69.91	68.91	68.51	67.51	84.01	83.01
DI Package	With organic FM	9.65	-	-	-	-	-	-	-
DI Package	No organic FM		9.65	9.65	9.65	9.65	9.65	9.65	9.65
Paratone®8451	OCP VI improver	5.74	5.74	5.24	5.24	6.64	6.64	5.74	5.74
Paraflow®390	Pour Point Depr.	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
PDN5203	Trinuclear Mo Cpd	-	-	-	1.00	-	1.00	-	1.0
Ethoduomeen® T-13	Organic FM	-	-	-	-	-	-	0.40	0.40
CALE-2	Complex Ester FM	-	-	15.00	15.00	-	-	-	-
HHE-2	Ester FM	-	-	-	-	15.00	15.00	-	-

TABLE 6

	Without OFM		OFM Alone		TMC Alone		OFM + TMC	
HOURS	16	96	16	96	16	96	16	96
OVERALL average of Stages 1,3 & 4 (Fuel Economy)	1.2	-	1.8	1.0	2.0	1.2	2.3	2.0

Example 3:

Two ester friction modifiers, one a high hydroxy ester-2 (HHE-2) and another a complex alcohol ester-2 (CALE-2) (both ex Exxon Chemicals), and an amine friction modifier (Ethoduomeen® T-13, ex Akzo Nobel (EDM)), were also evaluated with TMC. The esters were used at treat rates of 15 wt% and the amine was used at a treat rate of 0.4 wt%. All of these were used together with the same detergent inhibitor package (DI) which contained a molybdenum antioxidant in an amount of about 80 ppm but contained no organic friction modifiers (OFM). The DI was used to evaluate the effects of the organic friction modifiers alone and in combination with trinuclear organomolybdenum compounds as friction modifiers at top treat rates. The tests were carried out using SAE 5W-20 grade. In all the formulations tested, the olefin copolymer (OCP) viscosity modifier used was Paratone® 8451, the pour point depressant was Paraflow® 390 and the base oil was 120X EHC 45 (ex Imperial Oil, Sarnia). These formulations along with inspections and fuel economy results are tabulated below in Tables 7, 8 and 9 respectively:

The above results show that Stage 1, which is the Sequence VIA engine operating stage, is primarily influenced by the boundary lubrication regime and that the friction modifiers display their capabilities to affect fuel economy in this stage.

The two base formulations A and B show poor to negative friction modification capabilities respectively. Formulation A contains a commercial DI package that includes an organic friction modifier. When this organic friction modifier is removed, Stage 1 response declines dramatically, providing the only negative response observed in these tests. With the friction modifier top-treats included in the formulations, without the organic friction modifier in the commercial DI package, the Stage 1 response is substantially improved. The Stage 1 response of formulations C and D containing a complex alcohol ester, CALE-2, friction modifier is 1.62% and 1.97%BSFC respectively, with the latter response being improved still further by the inclusion of a trinuclear organomolybdenum compound according to the invention. Similarly, the formulations E and F containing the high hydroxy ester, HHE-2, friction modifier display improved Stage 1 response of 1.62% and 2.14%BSFC respectively with the latter response again being further improved by the inclusion of a trinuclear organomolybdenum compound according to the invention. Thus in the case of both CALE-2 and HHE-2, the combination thereof with a trinuclear organomolybdenum compound friction modifier shows a synergistic effect in their respective Stage 1 responses.

The best boundary response was observed with the formulations G and H which contained the Ethoduomeen®T-13 friction modifier. The Stage 1 response of these two formulations was measured to be 2.54% and 2.29% BSFC respectively. Whilst the inclusion of a trinuclear organomolybdenum compound marginally reduces the Stage 1 response, this response is still higher than that observed with the formulations D and F of which contains an organomolybdenum compound as friction modifier in addition to CALE-2 and HHE-2 respectively.

It can be seen from these results that in Example 1, initial FE is best with combinations of OFM and TMC which gives 400% and 15% over OFM and TMR when used separately. Example 2 shows that all combinations provide improvement of 24 to 8% irrespective of the OFM and that the components in the combination do not adversely affect each other's efficiency. Example 3 shows that in particular, retained fuel economy is 80-100% improved using the combination when compared either when used alone.

TABLE 8

Inspections	Units	A	B	C	D	E	F	G	H
KV_{100}	Centistokes	8.24	8.22	8.27	8.36	8.36	8.34	8.25	8.31
CCS @ -25	Centipoise	2138	2153	2384	2421	1909	1935	2184	2216
HTHS 150°C	Centipoise	2.48	2.48	2.55	2.57	2.54	2.51	2.48	2.51
HTHS 100°C	Centipoise	5.73	5.74	5.9	5.96	5.78	5.85	5.71	5.78

TABLE 9

VIA Screener	Basis	A	B	C	D	E	F	G	H
Stage 1	% BSFC	0.500	-2.408	1.617	1.972	1.619	2.146	2.543	2.294
Stage 4	% BSFC	2.664	2.598	2.556	2.432	2.714	2.728	3.028	2.895
VIA Pred (Overall)	% FEI	1.871	1.478	1.932	1.891	2.040	2.112	2.364	2.244

(ii) is the N-alkyl derivative of an alkanolamine selected from ethanolamine, propanolamine, isopropanolamine and butanolamine in which the N-alkyl groups have from 1-20 carbon atoms; an N,N-dialkanolamine; an N-alkyleneaminoalkyl dialkanolamine;, and a di(polyalkyleneoxy)alkanolamines;

(iii) is an alkylamide in which the N-alkyl groups have from 12-22 carbon atoms;

(iv). is selected from a mono-alkanolamide, a di-alkanolamide and a (polyalkyleneoxy)alkanolamide of an alkyl carboxylic acid; and

(v) is an ester of a di- or polyhydric alcohol selected from glycerol, trimethylol propane, pentaerythritol and polyhydroxy pyrans.

6. A composition according to any one of the preceding Claims wherein the oil soluble trinuclear molybdenum compound (b) is of formula (I)

$$Mo_3S_x\text{-}(Q) \qquad (I)$$

wherein and the core group (Q) is a ligand capable of rendering the organomolybdenum compound of formula (I) oil soluble and ensuring that said molybdenum compound is substantially charge neutral.

7. A composition according to any one of the preceding Claims wherein the organomolybdenum compound is of the general formula (II):

$$Mo_3S_xL_y \qquad (II)$$

wherein L is the ligand and y is of a sufficient number, type and charge to render the compound of formula (I) oil soluble and to neutralise the charge on the compound of formula (I) as a whole.

8. A composition according to any one of the preceding Claims wherein the ligands "L" is a dihydrocarbyl dithiocarbamate of the structure ($-S_2CNR_2$) wherein the dihyrocarbyl groups, R_2 impart oil solubility to the molybdenum compound such that the total number of carbon atoms present among all of the hydrocarbyl groups of the ligand(s) is at least 21.

9. A composition according to any one of the preceding Claims wherein the relative amounts of the trinucler organomolybdenum compound and the organic friction modifier is in a ratio of from about 1 - 4000 by weight to about 1 - 0.2 by weight respectively.

Claims :

1. A lubricating oil composition capable of exhibiting improved fuel economy and fuel economy retention properties said composition comprising a major amount of an oil of lubricating viscosity and a minor amount of

(a) 0.05-15% by weight of an oil soluble organic friction modifier other than ashless alkyldithiodicarbamates and

(b) an oil soluble trinuclear organomolybdenum compound of the generic formula:

$$Mo_3S_x\text{-}(Q) \qquad (I)$$

wherein x is from 4 to 10 and Q is a core which may be a ligand,

the trinuclear molybdenum compound being present in such an amount as to provide 10-1000 ppm of molybdenum in the composition.

2. A composition according to Claim 1 wherein the oil of lubricating viscosity is selected from synthetic oils and natural oils which form Group I to Group IV basestocks.

3. A composition according to Claim 1 or 2 wherein the basestock is a lubricating oil having a kinematic viscosity of 3.5 to 25 cSt at 100°C, a saturates level of between 90 and 99%, a viscosity index from 100-145 and a sulphur level below 0.03%.

4. A composition according to any one of the preceding Claims wherein the organic friction modifier (a) is selected from the group consisting of

(i) alkylene amines,

(ii) the alkanolamines,

(iii) the alkyl amides in which the N-alkyl groups have from 1-25 carbon atoms,

(iv) the alkanolamides, and

(v) full and partial esters of di- and/or polyhydric alcohols wherein the alkyl groups of the carboxylic acid forming the ester has from 1-25 carbon atoms.

5. a composition according to Claim 4 wherein

(i) is a monoalkylene diamine, a dialkylene triamine and/or a polyalkylene polyamines, a N,N'-dimethyl ethylene diamine which in turn may carry further alkyl and/or hydroxy substituents;

10. A composition according to any one of the preceding Claims wherein said composition contains in addition one or more further additives selected from antioxidants, antiwear agents, detergents, rust inhibitors, viscosity index improvers, extreme-pressure agents, friction modifiers, corrosion inhibitors, emulsifying aids, pour point depressants, anti-foams and the like.

The Patent Office

INVESTOR IN PEOPLE

Application No: GB 0008334.5
Claims searched: 1-10
Examiner: Dr William Thomson
Date of search: 8 May 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): C5F (FKK)

Int Cl (Ed.7):

Other: ONLINE: CAS-ONLINE, EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	WO 99/66013A1	(INFINEUM) See whole document, in particular page 11, lines 1-10 and claim 16	1-10
X	WO 99/47629A1	(INFINEUM) See whole document, in particular page 8, line 19 - page 9, line 7	1-10
X	WO 99/31113A1	(INFINEUM) See whole document, in particular page 6, lines 22-25 and claim 8	1-10
X	WO 98/26030A1	(EXXON) See whole document, in particular page 10, lines 1-8 and claim 16	1-10
X	US 6010987	(STIEFEL ET AL) See whole document, in particular column 4, line 66 - column 5, line 6	1-10

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Application No: GB 0008334.5
Claims searched: 1-10
Examiner: Dr William Thomson
Date of search: 8 May 2000

Category	Identity of document and relevant passage		Relevant to claims
X	US 5895779	(BOFFA) See whole document, in particular column 4, lines 34-57	1-10
X	US 5837657	(FANG ET AL) See whole document, in particular column 5, line 62 - column 6, line 4	1-10

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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