



(11) **EP 1 878 784 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
16.01.2008 Bulletin 2008/03

(21) Application number: **06731987.1**

(22) Date of filing: **17.04.2006**

(51) Int Cl.:
C10M 141/08 (2006.01) **C10M 129/76** (2006.01)
C10M 133/12 (2006.01) **C10M 135/18** (2006.01)
C10N 10/12 (2006.01) **C10N 30/06** (2006.01)
C10N 30/08 (2006.01) **C10N 30/10** (2006.01)
C10N 40/25 (2006.01)

(86) International application number:
PCT/JP2006/308058

(87) International publication number:
WO 2006/115097 (02.11.2006 Gazette 2006/44)

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR**

(30) Priority: **20.04.2005 JP 2005122372**

(71) Applicants:
• **JAPAN ENERGY CORPORATION**
Tokyo 105-0001 (JP)
• **Toyota Motor Corporation**
Toyota-shi, Aichi 471-8571 (JP)

(72) Inventors:
• **NAITO, Yasushi**
Toda-shi, Saitama 3350026 (JP)
• **YAMASHITA, Minoru**
Toyota-shi, Aichi 4718571 (JP)
• **MIYAJIMA, Kazuhiro**
Toyota-shi, Aichi 4718571 (JP)

(74) Representative: **Wakerley, Helen Rachael**
Reddie & Grose
16 Theobalds Road
London WC1X 8PL (GB)

(54) **LONG-LIFE FUEL-SAVING ENGINE OIL COMPOSITION**

(57) A long-life fuel-saving engine oil composition which comprises a mineral and/or synthetic base oil; an amine antioxidant and a phenolic antioxidant added to the oil in a total amount of 1.2 mass % or larger in which the ratio of the mass amount of nitrogen (N) contained in the amine antioxidant to the mass amount of oxygen (O) contained in the phenolic antioxidant, (N/O), is

0.20-0.50; and MoDTC incorporated in an amount of 0.055 mass % or larger as molybdenum element amount. There is provided the long-life fuel-saving engine oil composition which has excellent oxidative stability at high temperatures and retains low-frictional properties over long.

EP 1 878 784 A1

Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a long-life fuel-saving engine oil composition which exhibits excellent high-temperature oxidation stability and maintain low friction property for a long time.

BACKGROUND ART

10 **[0002]** In recent years, there has been an increasing demand for improving the fuel mileage of automobiles and suppressing emission of CO₂ in order to prevent global warming. It is important to improve the efficiency of engines in order to improve the fuel efficiency of automobiles. Therefore, lean-burn technology and direct-injection technology have been employed for gasoline engines. On the other hand, since a reduction in friction of engines can contribute to a reduction in fuel consumption, use of a low-friction material for sliding parts and use of a fuel-saving engine oil have been attempted.

15 **[0003]** In order to prepare a fuel-saving engine oil, it is known that it is effective to reduce the viscosity of engine oil to low viscosity of 5W-20 or 0W-20 specified in the Society of Automotive Engineers (SAE) J300 viscosity classification and to simultaneously blend an organomolybdenum friction modifier such as molybdenum dithiocarbamate (MoDTC) as an additive (friction modifier, hereinafter may be abbreviated as "FM") which reduces friction (see Non-patent Document 1).

20 **[0004]** Since a lean-burn engine or a direct-injection engine exhibits high efficiency as compared with conventional engines, the combustion temperature tends to increase and the piston and the like are exposed to a higher temperature. Therefore, it is necessary to improve the high-temperature oxidation stability of engine oil. Specifically, a fuel-saving engine oil in the future will be required to exhibit more excellent high-temperature oxidation stability as compared with conventional engine oil.

25 On the other hand, MoDTC deteriorates during use and disappears in the oil. As a result, the fuel-saving effect of MoDTC also deteriorates together with duration of use. Therefore, it is an important subject to improve the sustainability of the fuel-saving effect.

[Patent Document 1] JP-A-10-17883

30 [Non-patent Document 1] K. Hoshino et al., Fuel Efficiency of SAE 5W-20 Friction Modified Gasoline Engine Oil, SAE Technical Paper 982506 (1998)

DISCLOSURE OF THE INVENTION

35 [Problems to be Solved by the Invention]

[0005] In view of the above situation, an object of the present invention is to provide an engine oil which exhibits excellent high-temperature oxidation stability and excellent fuel-saving sustainability.

40 [Means for Solving the Problems]

[0006] The inventors of the present invention have conducted extensive studies in order to achieve the above object. As a result, the inventors have found that a composition containing a mineral oil and/or a synthetic base oil and a specific antioxidant in a specific ratio and containing MoDTC in a certain amount or more is useful as a long-life fuel-saving engine oil which exhibits an excellent high-temperature oxidation stability. This finding has led to the completion of the present invention.

45 **[0007]** Specifically, the present invention provides an engine oil composition comprising: a mineral oil and/or a synthetic base oil; an amine antioxidant and a phenolic antioxidant in an amount of 1.2 mass % or more in total and in the ratio (mass: N/O) of the nitrogen content (N) of the amine antioxidant to the oxygen content (O) of the phenolic antioxidant being 0.20 to 0.50; and molybdenum dithiocarbamate (MoDTC) in an amount of 0.055 mass % or more as molybdenum element (Mo).

50 Particularly, it is preferable that the composition comprises the amine antioxidant and the phenolic antioxidant in an amount of 1.5 mass % or more in total and in the ratio (mass: N/O) of the nitrogen content (N) of the amine antioxidant to the oxygen content (O) of the phenolic antioxidant being 0.20 to 0.35, and the molybdenum dithiocarbamate (MoDTC) in an amount of 0.055 mass % or more as molybdenum element (Mo).

[Effect of the Invention]

[0008] The long-life fuel-saving engine oil composition according to the present invention having the above-described configuration exhibits excellent high-temperature oxidation stability, shows a small increase in viscosity even if after long period use, and maintains low friction for a long time. Therefore, the composition can be utilized for internal combustion engines such as a lean-burn gasoline engine and a direct-injection gasoline engine in particular. It exhibits a particular effect that the composition thus reduces fuel consumption and maintains this good mileage for a long time.

[Best Mode for Carrying out the Invention]

[0009] As the base oil used in the engine oil composition according to the present invention, a mineral oil, a synthetic base oil, or a mixture thereof may be used. The kinematic viscosity of the base oil at 100°C is preferably 3.5 to 5.0 mm²/s, and more preferably 4.0 to 4.5 mm²/s. The viscosity index of the base oil is preferably 110 to 160, and more preferably 120 to 140. As the mineral oil, a high-viscosity-index lubricant base oil having a viscosity index of 120 or more is desirable. A high-viscosity-index lubricant base oil having a viscosity index of 120 or more may be obtained by subjecting an oil produced by hydroisomerization of wax or hydrocracking of heavy oil to solvent dewaxing or hydrodewaxing. An example of these production methods is concretely described in detail below.

[0010] Hydroisomerization of wax may be carried out by causing wax having a boiling point of 300 to 600°C and containing 20 to 70 carbon atoms (e.g., slack wax obtained during solvent dewaxing of a mineral oil lubricant, or wax obtained by Fischer-Tropsch synthesis which synthesizes a liquid fuel from a hydrocarbon gas or the like) as a raw material to come in contact with a hydroisomerization catalyst (e.g., a catalyst in which at least one of the group 8 metals such as nickel and cobalt and the group 6A metals such as molybdenum and tungsten is supported on an alumina or silica-alumina support, a zeolite catalyst, or a catalyst in which platinum or the like is supported on a zeolite-containing support) under the hydrogen atmosphere of a hydrogen partial pressure of 5 to 14 MPa, at a temperature of 300 to 450°C, and a liquid hourly space velocity (LHSV) of 0.1 to 2 hr⁻¹. It is preferable that the conversion rate of the linear paraffin be 80% or more and the conversion rate to the light fraction be 40% or less.

[0011] Meanwhile, hydrocracking may be carried out by causing a atmospheric distillate, vacuum distillate, or bright stock having a boiling point of 300 to 600°C and optionally obtained through hydrodesulfurization and hydrodedenitrification to come in contact with a hydrocracking catalyst (e.g., catalyst in which at least one of the group 8 metals such as nickel and cobalt and the group 6A metals such as molybdenum and tungsten is supported on a silica-alumina carrier) under the hydrogen atmosphere of a hydrogen partial pressure of 7 to 14 MPa, at a temperature of 350 to 450°C, and a liquid hourly space velocity (LHSV) of 0.1 to 2 hr⁻¹. It is preferable that the decomposition rate (reduction rate (mass %) of fractions having a boiling point of 360°C or more in the product) be 40 to 90%.

[0012] A lubricant fraction is obtained by distilling off the light fraction from the oil obtained by the above hydroisomerization or hydrocracking. Since this fraction generally has a high pour point and high viscosity and does not have a sufficiently high viscosity index, wax is removed by dewaxing to obtain a lubricant base oil having a %Cp according to n-d-M analysis of 80% or more, a pour point of -10°C or less, and a viscosity index of 120 or more.

[0013] When removing the wax by solvent dewaxing, it is preferable to separate the light fraction by distillation using a precision distillation device so that the content of the fraction having a boiling point, determined by gas chromatography distillation, of 371°C or more and less than 491°C is 70 mass % or more in order to efficiently perform solvent dewaxing. The solvent dewaxing may be performed at a temperature of -15 to -40°C and a solvent/oil ratio of 2/1 to 4/1 using methyl ethyl ketone/toluene (volume ratio: 1/1) as a dewaxing solvent.

[0014] When removing the wax by hydrodewaxing, it is preferable that the light fraction is distilled off to such an extent that hydrodewaxing is not disturbed, and the light fraction is separated by distillation using a precision distillation device so that the content of the fraction having a boiling point, determined by gas chromatography distillation, of 371°C or more and less than 491°C is 70 mass % or more after hydrodewaxing from the viewpoint of efficiency. Hydrodewaxing may be carried out by causing the fraction to come in contact with a zeolite catalyst under the hydrogen atmosphere of a hydrogen partial pressure of 3 to 15 MPa, at a temperature of 320 to 430°C, and a liquid hourly space velocity (LHSV) of 0.2 to 4 hr⁻¹ so that the pour point of the resulting lubricant base oil is -10°C or less.

[0015] A lubricant base oil having a viscosity index of 120 or more can be obtained using the above method. The lubricant base oil may be optionally subjected to solvent refining or hydro treating.

[0016] As the synthetic oil, an alpha-olefin oligomer, a diester synthesized from a dibasic acid such as adipic acid and a monohydric alcohol, a polyol ester synthesized from a polyhydric alcohol such as neopentyl glycol, trimethylolpropane, or pentaerythritol and a monobasic acid, a mixture thereof, and the like can be given.

Furthermore, a mixed oil obtained by blending an appropriate mineral oil with a synthetic oil may also be used as the base oil for the engine oil of the present invention.

[0017] MoDTC used in the engine oil according to the present invention is shown by the following general formula (1).



15

20

20

25



34



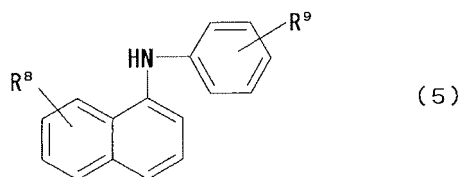
50



4

group may be the same or different. A linear or branched alkyl group ranging from a butyl group to a nonyl group is more preferable.

[0021]



wherein R^8 and R^9 represent hydrocarbon groups having 3 to 20 carbon atoms.

Although the formula (5) shows that the naphthyl group and the phenyl group are replaced with a substituent, at least one of these groups may be replaced with one or more substituents, or each group may be replaced with one or more substituents. When two or more R^8 s and R^9 s exist, the R^8 s and R^9 s may be the same or different each other. R^8 and R^9 are preferably alkyl groups having 6 to 12 carbon atoms, and particularly preferably the compound has either the naphthyl group or the phenyl group replaced with a substituent of a linear or branched octyl group to nonyl group.

As the amine antioxidant, the compounds shown by the general formulas (4) and (5) may be used in combination.

[0022] The phenolic antioxidant and the amine antioxidant are preferably blended so that the total content is 1.5 mass % or more and the mass ratio (N/O) of the nitrogen content (N) of the amine antioxidant and the oxygen content (O) of the phenolic antioxidant is 0.20 to 0.35, and particularly preferably 0.25 to 0.30. The total content of the antioxidant is preferably 1.5 mass % or more, and particularly preferably 1.5 to 3 mass %. If the total content of the antioxidant is less than 1.5 mass %, the desired high-temperature oxidation stability (e.g., a viscosity increase rate in Sequence III G test of 150% or less, and particularly preferably 0 to 100%) may not be obtained. If the ratio of the nitrogen content of the amine antioxidant and the oxygen content of the phenolic antioxidant is less than 0.20, the desired high-temperature oxidation stability may not be obtained. If the ratio of the nitrogen content of the amine antioxidant and the oxygen content of the phenolic antioxidant exceeds 0.35, the desired low-friction life due to MoDTC may not be obtained.

[0023] The engine oil according to the present invention may be optionally added with additives such as detergents such as zinc alkyldithiophosphate (ZnDTP), sulfonates, phenates, and salicylates of metals such as Ca, Mg, Ba, and Na, ashless dispersants such as alkenylsuccinimide, viscosity index improvers, pour-point depressants, metal deactivators, rust preventives, and anti-foaming agents.

[Examples]

[0024] The present invention will be described below in more detail by way of examples.

As the base oil, a mineral base oil (kinematic viscosity: 20.3 mm²/s (40°C), 4.34 mm²/s (100°C); viscosity index: 124) obtained by subjecting an oil produced by hydrocracking heavy oil to hydrodewaxing was used.

[0025] A phenolic antioxidant A, an amine antioxidant B, MoDTC, and another additive described below were blended to the base oil in a ratio shown in Table 1 to prepare engine oils of Example 1 and Comparative Examples 1 to 3. Table 1 also shows the ratio (mass: N/O) of the nitrogen content (N) of the amine antioxidant to the oxygen content (O) of the phenolic antioxidant and the Mo content. The other additive was an additive mixture containing zinc alkyldithiophosphate (ZnDTP), calcium sulfonate, alkenylsuccinimide, a viscosity index improver, a pour-point depressant, and an anti-foaming agent. The additive was added in an equal amount in the example and the comparative examples.

[0026] As the phenolic antioxidant A, a phenolic antioxidant (oxygen content: 12.3 mass %) shown by the general formula (2) in which the substituent R^5 was an octyl group was used.

As the amine oxidant B, an amine antioxidant (nitrogen content: 4.5 mass %) which is a reaction product of N-phenylbenzeneamine and 2,4,4-trimethylpentene was used.

As the MoDTC, a compound shown by the general formula (1) in which R^1 to R^4 were a mixture of a 2-ethylhexyl group and an isotridecyl group and the oxygen atom/sulfur atom ratio was 1/1 was used.

[0027]

EP 1 878 784 A1

[Table 1]

			Example	Comparative example		
			1	1	2	3
Base oil		Mass %	84.06	84.71	83.76	84.45
Additive		Mass %	15.94	15.29	16.24	15.55
	Antioxidant	Mass %	1.75	1.1	2.05	1.75
	(A)phenolic	Mass %	1.0	1.1	0.8	1.0
	(B)amine	Mass %	0.75	-	1.25	0.75
	MoDTC	Mass %	1.44	1.44	1.44	1.05
	Molybdenum (Mo)	Mass %	0.065	0.065	0.065	0.047
	Other additives	Mass %	12.75	12.75	12.75	12.75
Ratio (N/O) of N-content in amine antioxidant to O-content in phenol antioxidant		(Mass)	0.27	0	0.58	0.27

[0028] The engine oils of the example and the comparative examples shown in Table 1 were subjected to a Sequence III G test to evaluate the engine oil performance. The test includes an item of evaluating high-temperature oxidation stability by means of the viscosity increase rate. A viscosity increase rate of 150% or less is defined as an acceptable level (see Suzuki, Latest Trend of Gasoline Engine Oil Standard, Monthly Tribology, 2003. 5, page 17). Each engine oil subjected to the Sequence III G test for 100 hours was compared with the corresponding engine oil at the time of starting the engine test (0 hours) to determine the viscosity increase rate. The results are shown in Table 2.

[0029] The engine oils shown in Table 1 were subjected to an engine test (a bench durability test on chassis dynamometer) and an SRV friction test under the following conditions to determine the test time at which the friction coefficient of the engine oil became 0.070. Fuel-saving efficiency sustainability was evaluated in comparison with a standard oil (test time at which the friction coefficient became 0.070: 165 hours, driving distance corresponding to this time: 10,000 km). The results are shown in the bottom of Table 2 as low friction sustainable life (km).

Engine test conditions

[0030]

Engine: 2 liter straight six-cylinder gasoline engine
Oil pan capacity: 3.4 liter was reduced to 2 liter (the severity of the test was accelerated)
Oil temperature in the oil pan: 100°C
Test mode: AMA travel mode (repetition)
Oil sampling: every 24 hours (SRV friction test sample)

SRV friction test conditions

[0031]

Contact conditions: cylinder on block
Sliding conditions: load: 400N; frequency: 50 Hz; amplitude: 1.5 mm; and temperature: 120°C

The test time at which the friction coefficient of the engine oil became 0.070 was determined by interpolating the sampling times of two samples sandwiched the friction coefficient of 0.070 of the sample (engine oil) sampled every 24 hours. The low friction sustainable life (driving distance, km) was determined based on the resulting test time at which the friction coefficient of the engine oil became 0.070, the test time (165 hours) at which the friction coefficient of the standard oil became 0.070, and the driving distance (10,000 km).

[0032]

[Table 2]

		Example	Comparative example		
		1	1	2	3
Viscosity increase rate in Sequence...test	%	83	270	88	120
MoDTC Low-friction sustainable life	km	10000	11000	8000	7000

[0033] As is clear from the above results, the engine oil composition shown as an example blending the mineral oil and/or the synthetic base oil, the amine antioxidant and the phenolic antioxidant in an amount of 1.5 mass % or more in total and in the mass ratio (N/O) of the nitrogen content (N) of the amine antioxidant to the oxygen content (O) of the phenolic antioxidant being 0.20 to 0.35, and MoDTC in an amount of 0.055 mass % or more as Mo element content exhibited a low viscosity increase rate of the Sequence III G test of 83% to be anticipated excellent high-temperature oxidation stability. Further, since the MoDTC low friction sustainable life calculated from the SRV friction test of the oil used in the engine durability test was as large as 9000 km or more, it is known that the engine oil composition exhibited excellent fuel-saving sustainability.

[0034] The engine oil composition of Comparative Example 1 to which only the phenolic antioxidant was added exhibited a long low friction sustainable life, but showed a very high viscosity increase rate and thus may exhibit inferior high-temperature oxidation stability. The engine oil composition of Comparative Example 2 in which the mass ratio of the nitrogen content of the amine antioxidant to the oxygen content of the phenolic antioxidant was high exhibited excellent high-temperature oxidation stability, but showed an inferior low friction life. The engine oil composition of Comparative Example 3 in which the amount of MoDTC was reduced showed a high viscosity increase rate and inferior high-temperature oxidation stability as compared with Example 1 and exhibited an inferior low friction life.

Claims

1. A long-life fuel-saving engine oil composition comprising: a mineral oil and/or a synthetic base oil; an amine antioxidant and a phenolic antioxidant in an amount of 1.2 mass % or more in total and in the ratio (mass: N/O) of the nitrogen content (N) of the amine antioxidant to the oxygen content (O) of the phenolic antioxidant being 0.20 to 0.50; and molybdenum dithiocarbamate (MoDTC) in an amount of 0.055 mass % or more as molybdenum element (Mo).
2. The composition according to claim 1, wherein the ratio (mass: N/O) of the nitrogen content (N) of the amine antioxidant to the oxygen content (O) of the phenolic antioxidant is 0.20 to 0.35.
3. The composition according to claim 1, wherein the total content of the amine antioxidant and the phenolic antioxidant is 1.5 mass % or more, the ratio (mass: N/O) of the nitrogen content (N) of the amine antioxidant to the oxygen content (O) of the phenolic antioxidant is 0.20 to 0.35, and the content of molybdenum dithiocarbamate (MoDTC) is 0.055 mass % or more as molybdenum element (Mo).
4. The composition according to claim 1, wherein the amine antioxidant is diphenylamine and/or phenylnaphthylamine, and the phenolic antioxidant is a phenol compound having a substituent with an ester bond.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/308058

A. CLASSIFICATION OF SUBJECT MATTER C10M141/08 (2006.01), C10M129/76 (2006.01), C10M133/12 (2006.01), C10M135/18 (2006.01), C10N10/12 (2006.01), C10N30/06 (2006.01), C10N30/08 (2006.01), C10N30/10 (2006.01), C10N40/25 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C10M141/08 , 129/10-129/14 , 129/76 , 133/04-133/14 , 135/18 , C10N10/12 , 30/06-30/10 , 40/25-40/28 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2006 Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2000-192066 A (Asahi Denka Kogyo Kabushiki Kaisha), 11 July, 2000 (11.07.00), (Family: none)	1-4
A	JP 9-506119 A (Exxon Research and Engineering Co.), 17 June, 1997 (17.06.97), & CA 2171299 C & DE 69409818 T2 & EP 719315 A1 & ES 2115256 T3 & KR 237075 B1 & US 5925600 A & WO 95/07966 A1	1-4
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 04 July, 2006 (04.07.06)		Date of mailing of the international search report 11 July, 2006 (11.07.06)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/308058

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 8-176579 A (Asahi Denka Kogyo Kabushiki Kaisha), 09 July, 1996 (09.07.96), & CA 2165997 A1 & DE 69515166 T2 & EP 719851 A2 & US 5627146 A	1-4
A	JP 3-269094 A (Nippon Oil Co., Ltd.), 29 November, 1991 (29.11.91), & DE 69102172 T2 & EP 447916 A1 & US 2001/0044387 A1	1-4
A	JP 2003-336089 A (Chevron Texaco Japan Ltd.), 28 November, 2003 (28.11.03), (Family: none)	1-4
A	JP 2000-192068 A (Asahi Denka Kogyo Kabushiki Kaisha), 11 July, 2000 (11.07.00), & CA 2292988 A1 & DE 69915232 T2 & EP 1013749 A2 & US 6245725 B1	1-4
A	JP 2002-53888 A (Chevron Oronite Japan Ltd.), 19 February, 2002 (19.02.02), & CA 2349411 A1 & EP 1167497 A2 & JP 2004-131742 A & US 2002/0019320 A1	1-4

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 10017883 A [0004]

Non-patent literature cited in the description

- **K. HOSHINO et al.** Fuel Efficiency of SAE 5W-20 Friction Modified Gasoline Engine Oil. *SAE Technical Paper 982506*, 1998 [0004]