(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 031 887 A1

# (12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 153(4) EPC

(43) Date of publication:
**15.06.2016 Bulletin 2016/24**

(21) Application number: **14842020.1**

(22) Date of filing: **08.09.2014**

(51) Int Cl.:
***C10M 125/10*** *(2006.01)* ***C10M 159/22*** *(2006.01)*
***C10M 159/24*** *(2006.01)* ***C10M 169/04*** *(2006.01)*
***C10M 107/02*** *(2006.01)* ***C10N 10/04*** *(2006.01)*
***C10N 20/00*** *(2006.01)* ***C10N 20/02*** *(2006.01)*
***C10N 20/06*** *(2006.01)* ***C10N 30/06*** *(2006.01)*
***C10N 40/04*** *(2006.01)*

(86) International application number:
**PCT/JP2014/073695**

(87) International publication number:
**WO 2015/034091 (12.03.2015 Gazette 2015/10)**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA ME**

(30) Priority: **09.09.2013 JP 2013186767**

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## (54) TRANSMISSION FLUID

(57) A transmission fluid contains a base oil and calcium carbonate. The calcium carbonate is dispersed in a form of aggregations in the transmission fluid. A ratio of the aggregations having a particle diameter of 200 nm or more is in a range from 10 mass% to 35 mass% in terms of calcium based on a total amount of the aggregations. A base value of the transmission fluid is in a range from 0.5 mgKOH/g to 4 mgKOH/g by a hydrochloric acid method.

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## Description

TECHNICAL FIELD

**[0001]** The present invention relates to a transmission fluid.

BACKGROUND ART

**[0002]** An automatic transmission (AT) is a transmission having a mechanism in which a transmission torque ratio is automatically set according to a vehicle speed, a magnitude of load and the like. The automatic transmission includes a torque converter, gear mechanism, hydraulic mechanism, wet clutch and the like. Moreover, a continuously variable transmission (CVT) is also often used as the transmission. A method of transmitting torque by friction between a metallic belt or chain and a metallic pulley is well known. Further, in recent years, an automobile provided with a Dual Clutch Transmission (DCT) has begun to come on the market. In the DCT that is a kind of AT, dedicated clutches are respectively prepared in an odd-numbered stage and an even-numbered stage. Since gears in a next stage are engaged in advance at gear change, gear change can be quickly done just by switching the clutches.

**[0003]** Various transmission fluids usable for the above various transmissions have been proposed. Particularly, a transmission fluid having a high static friction coefficient ($\mu s$) and a high kinematic friction coefficient ($\mu d$) is required in order to increase a transmission torque volume. For instance, Patent Literature 1 discloses a lubricating oil composition that contains a lubricating base oil, polyol compound, alkali metal borate, ashless dispersant and alkaline earth metal sulfonate. This composition can simultaneously enhance the static friction coefficient ($\mu s$) and the kinematic friction coefficient ($\mu d$) of the wet clutch (see paragraph [0073] [Advantages of the Invention]).

CITATION LIST

PATENT LITERATURE(S)

**[0004]** Patent Literature 1: JP-A-2005-8695

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

**[0005]** In all of the above AT, CVT and DCT, a large static friction coefficient ($\mu s$) is desired for ensuring a transmission torque volume.

**[0006]** However, even the above transmission fluid disclosed in Patent Literature 1 is not always sufficient for improving the static friction coefficient ($\mu s$). In addition, the transmission fluid has a complicated structure, which entails a high production cost.

**[0007]** In all of the above AT, CVT and DCT, with longer use of the transmission fluid, the kinematic friction coefficient ($\mu d$) of the transmission fluid is decreased and vibration (shudder) of an entire vehicle body caused by stick-slip vibration of a clutch sliding portion is more likely to occur. Accordingly, a longer clutch lifetime, specifically, a longer shudder lifetime is demanded in practical use.

**[0008]** However, even the above transmission fluid disclosed in Patent Literature 1 is not always sufficient for maintaining the kinematic friction coefficient ($\mu d$) after the longtime use of the transmission fluid. In addition, the transmission fluid has a complicated structure, which entails a high production cost.

**[0009]** An object of the invention is to provide a transmission fluid having a large static friction coefficient ($\mu s$) and capable of maintaining a high kinematic friction coefficient ($\mu d$) for a long time and providing a long clutch lifetime with a simple structure.

MEANS FOR SOLVING THE PROBLEMS

**[0010]** In order to solve the above problem, the following transmission fluid is provided according to an aspect of the invention.

**[0011]** According to the above aspect of the invention, a transmission fluid contains comprising: a base oil; and calcium carbonate, in which the calcium carbonate is dispersed in a form of aggregations in the transmission fluid, a ratio of the aggregations having a particle diameter of 200 nm or more is in a range from 10 mass% to 35 mass% in terms of calcium based on a total amount of the aggregations, and a base value of the transmission fluid is in a range from 0.5 mgKOH/g to 4 mgKOH/g by a hydrochloric acid method.

**[0012]** According to the above aspect of the invention, a transmission fluid having a large static friction coefficient ($\mu s$) and capable of maintaining a high kinematic friction coefficient ($\mu d$) for a long time and providing a long clutch lifetime with a simple structure can be provided.

## DESCRIPTION OF EMBODIMENT(S)

**[0013]** In an exemplary embodiment of the invention, a transmission fluid is obtained by blending a base oil with calcium carbonate, in which the calcium carbonate is dispersed in a form of aggregations in the transmission fluid, a ratio of the aggregations having a particle diameter of 200 nm or more is in a range from 10 mass% to 35 mass% in terms of calcium based on a total amount of the aggregations, and a base value of the transmission fluid is in a range from 0.5 mgKOH/g to 4 mgKOH/g by a hydrochloric acid method. The transmission fluid of the invention (hereinafter, also referred to as "the present transmission fluid") will be described in detail below. Herein, the transmission fluid obtained by blending a base oil and calcium carbonate means not only a transmission fluid containing the base oil and calcium carbonate, but also a composition containing a modified substance obtained by modifying at least one of the base oil and calcium carbonate, and a composition containing a reactant obtained by reaction of the base oil and/or calcium carbonate.

**[0014]** The base oil usable in the present transmission fluid is not particularly limited, but may be at least one of the mineral oil and the synthetic oil. Specifically, the base oil may be one or a plurality of the mineral oil, one or a plurality of the synthetic oil, or a combination of the mineral oil and the synthetic oil.

**[0015]** The mineral oil and the synthetic oil are not specifically limited, but any mineral and any synthetic oil generally usable as a base oil for a transmission are suitable. Particularly, the base oil having a kinematic viscosity at 100 degrees C in a range from 1 $mm^2/s$ to 50 $mm^2/s$, particularly from 2 $mm^2/s$ to 15 $mm^2/s$ is preferably usable. When the kinematic viscosity at 100 degrees of the base oil is 1 $mm^2/s$ or more, an increase in abrasion at a sliding portion such as a gear bearing and a clutch of the transmission is restrained. When the kinematic viscosity at 100 degrees of the base oil is 50 $mm^2/s$ or less, deterioration of a low-temperature viscosity is expected to be restrained.

**[0016]** A pour point of the base oil, which is an index of a low-temperature fluidity, is not particularly limited, but is preferably minus 10 degrees C or less, particularly preferably minus 15 degrees C or less.

**[0017]** Further, although not particularly limited, the base oil preferably has a saturated hydrocarbon component of 90 mass% or more, a sulfur content of 0.03 mass% or less and a viscosity index of 100 or more. When the saturated hydrocarbon component is 90 mass% or more, an amount of deteriorated products is reducible. When the sulfur content is 0.03 mass% or less, an amount of deteriorated products is reducible. When the viscosity index of the base oil is 100 or more, abrasion at a high temperature is reducible.

**[0018]** Examples of the mineral oil include a naphthenic mineral oil, a paraffinic mineral oil and GTL WAX. Specific examples of the mineral oil include light neutral oil, intermediate neutral oil, heavy neutral oil, and bright stock, which are obtainable by solvent purification or hydrogenation purification.

**[0019]** On the other hand, examples of the synthetic oil include polybutene, a hydride thereof, polyalphaolefin (e.g., 1-octene oligomer, 1-decene oligomer), alkylbenzene, polyolester, diacid ester, polyoxyalkyleneglycol, polyoxyalkyleneglycolester, polyoxyalkyleneglycolether, hindered ester and silicone oil.

**[0020]** In the above base oil, it is preferable to blend (mix) polyalphaolefin (PAO) in use in order to efficiently achieve the advantages of the invention. Examples of PAO include alphaolefin homopolymers and alphaolefin copolymers. A ratio of PAO is preferably 30 mass% or more in the base oil, preferably 50 mass% or more. A kinematic viscosity at 100 degrees C of PAO is preferably in a range from 2 $mm^2/s$ to 200 $mm^2/s$.

**[0021]** The present transmission fluid contains calcium carbonate in a specific form (hereinafter, also referred to as "the present calcium carbonate"). The present calcium carbonate is dispersed in a form of aggregations in the transmission fluid. Among the aggregations, a ratio of an aggregation having a particle diameter of 200 nm or more (hereinafter, also referred to as a "large particle") is in a range from 10 mass% to 35 mass% in terms of calcium based on a total amount of the aggregations, preferably in a range from 15 mass% to 30 mass%. When the large particle exists at the above ratio in the aggregations, a resultant transmission fluid can achieve a high static friction coefficient ($\mu s$) and maintain a high kinematic friction coefficient ($\mu d$) for a long time. An average particle diameter of the above aggregations is preferably in a range from 10 nm to 180 nm, more preferably from 30 nm to 150 nm in order to efficiently achieve the advantages of the invention.

**[0022]** The particle diameter, a particle-diameter distribution and the average particle diameter of the above aggregations are measurable according to electrophoretic light scattering. For instance, a particle-diameter measurement system using ELSZ-1000S manufactured by Otsuka Electronics Co., Ltd. is suitably usable.

**[0023]** In order to obtain the transmission fluid containing the present calcium carbonate and the base oil, in which a predetermined amount of large particles are dispersed in the transmission fluid, for instance, the base oil or any transmission fluid may be blended with calcium carbonate having an aggregations with a predetermined particle size distribution or may be blended with an overbased organic acid calcium salt compound including a predetermined aggregation (e.g., an overbased detergent). In the latter case, the present calcium carbonate is derived from the overbased organic

acid calcium salt compound. A manufacturing method of calcium carbonate (aggregations) is not particularly limited, but, for instance, may include neutralizing an organic acid with basic calcium oxide and hydroxide and subsequently carbonating excessive basic calcium oxide and hydroxide.

**[0024]** A content of the present calcium carbonate is preferably in a range from 0.001 mass% to 0.3 mass% in terms of calcium based on a total amount of the present transmission fluid, more preferably from 0.001 mass% to 0.2 mass%, further preferably from 0.01 mass% to 0.2 mass%. When the content of the present calcium carbonate falls within the above range, a sufficiently high static friction coefficient ($\mu s$) can be obtained and a high kinematic friction coefficient ($\mu d$) can be maintained for a long time.

**[0025]** The ratio of the large particles in the present transmission fluid is preferably 0.056 mass% or less based on the total amount of the present transmission fluid, more preferably from 0.045 mass% or less. When the ratio of the large particles in the present transmission fluid falls within the above range, a sufficiently high static friction coefficient ($\mu s$) can be obtained and a high kinematic friction coefficient ($\mu d$) can be maintained for a long time.

**[0026]** Among the above-described overbased organic acid calcium salt compound, the overbased detergent is preferably at least one of a sulfonate detergent, a salicylate detergent and a phenate detergent in order to efficiently achieve the advantages of the invention.

**[0027]** A base value of the present transmission oil is in a range from 0.5 mgKOH/g to 4 mgKOH/g by a hydrochloric acid method (JIS K2501), more preferably in a range from 0.8 mgKOH/g to 3.5 mgKOH/g. When the base value falls within the above range, a sufficiently high static friction coefficient ($\mu s$) can be obtained and a high kinematic friction coefficient ($\mu d$) can be maintained for a long time.

**[0028]** The detergent itself only needs to contain calcium carbonate and be overbased. The base value of the detergent is not particularly limited, but a total base value thereof is preferably in a range from 10 mgKOH/g to 400 mgKOH/g by the hydrochloric acid method (JIS K2501).

**[0029]** The present transmission fluid preferably has the kinematic viscosity at 100 degrees C in a range from 3 $mm^2/s$ to 8 $mm^2/s$, more preferably in a range from 4 $mm^2/s$ to 7 $mm^2/s$ in order to efficiently achieve the advantages of the invention. A viscosity index of the present transmission fluid is preferably 100 or more.

**[0030]** The present transmission fluid can contain various additives as long as an object of the invention is not hampered. Examples of the additives usable as needed include a viscosity index improver, an antioxidant, a antiwear agent, a friction modifier, an ashless dispersant, a metal deactivator, a rust inhibitor an antifoaming agent, a pour point depressant, a surfactant and a coloring agent.

**[0031]** Examples of the viscosity index improver include polymethacrylate, dispersed polymethacrylate, olefin copolymer (e.g. ethylene-propylene copolymer), dispersed olefin copolymer and styrene copolymer (e.g. styrene-diene copolymer and styrene-isoprene copolymer). A content of the viscosity index improver is approximately in a range from 0.5 mass% to 15 mass% of the total amount of the present transmission fluid in view of the blending effect thereof.

**[0032]** An example of the pour point depressant is polymethacrylate having a mass average molecular weight of 10000 to 150000. A preferable content of the pour point depressant is approximately in a range from 0.01 mass% to 10 mass% of the total amount of the present transmission fluid.

**[0033]** Examples of the antioxidant include an aminic antioxidant, a phenolic antioxidant and a sulfuric antioxidant.

**[0034]** Examples of the aminic antioxidant may include monoalkyldiphenylamine compounds such as monooctyldiphenylamine and monononyldiphenylamine; dialkyldiphenylamine compounds such as 4,4'-dibutyldiphenylamine, 4,4'-dipentyldiphenylamine, 4,4'-dihexyldiphenylamine, 4,4'-diheptyldiphenylamine, 4,4'-dioctyldiphenylamine and 4,4'-dinonyldiphenylamine; polyalkyldiphenylamine compounds such as tetrabutyldiphenylamine, tetrahexyldiphenylamine, tetraoctyldiphenylamine and tetranonyldiphenylamine; and naphthylamine compounds such as alpha-naphthylamine, phenyl-alpha-naphthylamine, butylphenyl-alpha-naphthylamine, pentylphenyl-alpha-naphthylamine, hexylphenyl-alpha-naphthylamine, heptylphenyl-alpha-naphthylamine, octylphenyl-alpha-naphthylamine and nonylphenyl-alpha-naphthylamine. Particularly, the compounds having the alkyl group having 4 to 24 carbon atoms, particularly preferably 6 to 18 carbon atoms are usable. One of the aminic antioxidant as described above may be used alone or two or more thereof may be used in combination.

**[0035]** Examples of the phenolic antioxidant may include 2,6-di-t-butylphenol, 2,6-di-t-butyl-4-methylphenol, 4,4'-methylenebis(2,6-di-t-butylphenol), 4,4'-butylidenebis(3-methyl-6-t-butylphenol), 2,2'-methylenebis(4-ethyl-6-t-butylphenol), 2,2'-methylenebis(4-methyl-6-t-butylphenol), 4,4'-isopropylidene bisphenol, 2,4-dimethyl-6-t-butylphenol, tetrakis[methylene-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate]methane, 1,1,3-tris(2-methyl-4-hydroxy5-t-butylphenyl)butane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-t-butyl-4-hydroxybenzyl)benzene, and 2,6-di-t-butyl-4-ethylphenol.

**[0036]** Examples of the sulfuric antioxidant may include dialkylthiodipropionate, dialkylthiocarbamic acid derivative (except for a metal salt), bis(3,5-di-t-butyl-4-hydroxybenzyl)sulfide, mercaptobenzothiazole, a reactant of phosphorus pentasulfide and an olefin, and dicetyl sulfide.

**[0037]** One of various antioxidants as described above may be used alone or two or more thereof may be used in combination. Particularly, the aminic antioxidant, the phenolic antioxidant or zinc alkyldithio phosphate is preferably used. A preferable content of the antioxidant is approximately in a range from 0.05 mass% to 3 mass% of the total

amount of the present transmission fluid.

**[0038]** Examples of the antiwear agent may include a thiophosphoric acid metal salt (e.g., Zn, Pb and Sb), a thiocarbamic acid metal salt (e.g., Zn), a sulfur compound, phosphate ester (tricresyl phosphate) and phosphite ester. A preferable content of the antiwear agent is approximately in a range from 0.05 mass% to 5 mass% of the total amount of the present transmission fluid.

**[0039]** Examples of the friction modifier may include a polyhydric alcohol partial ester such as neopentyl glycol monolaurate, trimethyrol propanemonolaurate, glycerin monooleate (oleic acid monoglyceride). A preferable content of the friction modifier is approximately in a range from 0.05 mass% to 4 mass% of the total amount of the present transmission fluid.

**[0040]** Examples of the ashless dispersant may include succinimides, boron-containing succinimides, benzylamines, boron-containing benzylamines, succinic acid esters, and mono- or di-carboxylic acid amides respectively represented by a fatty acid or succinic acid. A preferable content of the ashless dispersant is approximately in a range from 0.1 mass% to 20 mass% of the total amount of the present transmission fluid.

**[0041]** One of the metal deactivators such as benzotriazole and thiadiazole may be used alone or two or more thereof may be used in a combination. A preferable content of the metal deactivator is approximately in a range from 0.01 mass% to 5 mass% of the total amount of the present transmission fluid.

**[0042]** Examples of the rust inhibitor may include a fatty acid, alkenylsuccinic acid half ester, fatty acid soap, alkyl sulfonate, fatty acid ester of polyhydric alcohol, fatty acid amide, oxidized paraffin and alkyl polyoxyethylene ether. A preferable content of the rust inhibitor is approximately in a range from 0.01 mass% to 3 mass% of the total amount of the present transmission fluid.

**[0043]** One of the antifoaming agents such as a silicone compound and an ester compound may be used alone or two or more thereof may be used in a combination. A preferable content of the antifoaming agent is approximately in a range from 0.05 mass% to 5 mass% of the total amount of the present transmission fluid.

**[0044]** The pour point depressant is exemplified by polymethacrylate. A preferable content of the pour point depressant is approximately in a range from 0.01 mass% to 10 mass% of the total amount of the present transmission fluid.

**[0045]** The surfactant is exemplified by polyoxyethylene alkyl phenyl ether. A preferable content of the surfactant is approximately in a range from 0.01 mass% to 10 mass% of the total amount of the present transmission fluid.

**[0046]** The present transmission fluid as described above can provide a high transmission torque volume due to a high static friction coefficient ($\mu s$) and can provide a long clutch lifetime since the present transmission fluid can maintain a high kinematic friction coefficient ($\mu d$) for a long time. Accordingly, the present transmission fluid is suitably applicable to various transmissions such as an automatic transmission (AT), a continuously variable transmission (CV) and a dual clutch (DCT).

## Examples

**[0047]** Next, the invention will be described in more detail with reference to Examples and Comparatives. It should be noted that the invention is not limited to description of the examples and the like.

### Example 1 and Comparatives 1 to 2

**[0048]** PAO (a kinematic viscosity at 100 degrees C of 4.0 $mm^2/s$) was used as the base oil. An overbased calcium sulfonate having properties shown in Table 1 was blended at 0.15 mass% in terms of calcium based on a total amount of each of the sample oils to prepare sample oils respectively having properties shown in Table 1 (all the sample oils are intended to be used for the transmission). The viscosity index of each of the sample oils in Example 1 and Comparatives 1 and 2 was 120.

**[0049]** The overbased calcium was dispersed in the base oil and checked in terms of a structure of the aggregations. Specifically, a dispersed state of the aggregations (including large particles) in each of the sample oils was measured by ELSZ-1000S manufactured by Otsuka Electronics Co., Ltd. A ratio (mass% relative to the aggregations) of the large particles in the aggregations formed of calcium carbonate and an average particle diameter of each of the large particles were calculated. The results are shown in Table 1.

Table 1

| | Sample Oil | | Calcium carbonate | | Sample Oil | |
|---|---|---|---|---|---|---|
| | Kinematic viscosity at 100°C ($mm^2/s$) | Base value by hydrochloric acid method (mgKOH/g) | Rate of large particles (mass%) | Average particle diameter (nm) | Friction coefficient | |
| | | | | | $\mu s$ | $\mu d$ |
| Ex. 1 | 4 | 1.39 | 23 | 100 | 0.103 | 0.134 |
| Comp. 1 | 4 | 3.90 | 40 | 200 | 0.121 | 0.048 |
| Comp. 2 | 4 | 1.07 | 73 | 800 | 0.149 | 0.009 |

Evaluation Method

**[0050]** A static friction coefficient ($\mu s$) and a kinematic friction coefficient ($\mu d$) (after the elapse of 120 hours) of each of the sample oils were measured under the following test conditions using an LVFA friction tester in accordance with JASO M349-2001. A friction coefficient at 3 rpm of a rotation speed was defined as $\mu s$. In practical use, $\mu s$ is preferably 0.08 or more and it is preferable to maintain $\mu d$ at 0.10 or more. The results are shown in Table 1.

Material: a cellulose clutch material used in an actual transmission
Face Pressure: 1.0 MPa
Oil Temperature: 120 degrees C
Rotation Speed: from 1 rpm to 10 rpm (in increments of 1 rpm), 20 rpm and 30 rpm

Evaluation Results

**[0051]** As is understood from the results shown in Table 1, the sample oil of Example 1 containing the large particles (aggregations having a particle diameter of 200 nm or more) exhibits the static friction coefficient ($\mu s$) sufficiently high in a practical use and a large kinematic friction coefficient ($\mu d$) maintained after the elapsed time. In other words, it is confirmed that a high torque volume and a long clutch lifetime are simultaneously achievable. On the other hand, in the sample oils of Comparatives 1 and 2, since the ratio of the large particles falls out of a predetermined range, although the sample oils having an approximately equivalent content of overbased calcium sulfonate and an approximately equivalent base value, a decrease in the kinematic friction coefficient ($\mu d$) is much larger than that in Example 1. Accordingly, the significance of the large particles contained in the transmission fluid in a predetermined range is understood.

## Claims

1. A transmission fluid comprising: a base oil; and
calcium carbonate, wherein
the calcium carbonate is dispersed in a form of aggregations in the transmission fluid,
a ratio of the aggregations having a particle diameter of 200 nm or more is in a range from 10 mass% to 35 mass% in terms of calcium based on a total amount of the aggregations, and
a base value of the transmission fluid is in a range from 0.5 mgKOH/g to 4 mgKOH/g by a hydrochloric acid method.

2. The transmission fluid according to claim 1, wherein
the calcium carbonate is derived from an overbased organic acid calcium salt compound, and
a content of the calcium carbonate is a range from 0.001 mass% to 0.3 mass% in terms of calcium based on a total amount of the transmission fluid.

3. The transmission fluid according to claim 2, wherein
the overbased organic acid calcium salt compound is an overbased detergent, and
the overbased detergent is at least one of a sulfonate detergent, a salicylate detergent and a phenate detergent.

4. The transmission fluid according to any one of claims 1 to 3, wherein

the base oil comprises polyalphaolefin.

**5.** The transmission fluid according to claim 4, wherein
a ratio of the polyalphaolefin in the base oil is 30 mass% or more.

**6.** The transmission fluid according to claim 4 or 5, wherein
the polyalphaolefin has a kinematic viscosity at 100 degrees C in a range from 2 $mm^2/s$ to 200 $mm^2/s$.

**7.** The transmission fluid according to any one of claims 1 to 6, wherein
the transmission fluid has a kinematic viscosity at 100 degrees C in a range from 3 $mm^2/s$ to 8 $mm^2/s$, and
the transmission fluid has a viscosity index of 100 or more.

**8.** The transmission fluid according to any one of claims 1 to 7, wherein
the transmission fluid is used for an automatic transmission or a continuously variable transmission.

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2014/073695

A. CLASSIFICATION OF SUBJECT MATTER
*C10M125/10*(2006.01)i, *C10M159/22*(2006.01)i, *C10M159/24*(2006.01)i, *C10M169/04*(2006.01)i, *C10M107/02*(2006.01)n, *C10N10/04*(2006.01)n, *C10N20/00*(2006.01)n, *C10N20/02*(2006.01)n, *C10N20/06*(2006.01)n, *C10N30/06*(2006.01)n,
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)
C10M125/10, C10M159/22, C10M159/24, C10M169/04, C10M107/02, C10N10/04, C10N20/00, C10N20/02, C10N20/06, C10N30/06, C10N40/04

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 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
JSTPlus/JST7580/JSTChina(JDreamIII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| A | JP 2003-155493 A (Matsumura Oil Research Corp.), 30 May 2003 (30.05.2003), (Family: none) | 1-8 |
| A | JP 2002-511520 A (Exxonmobil Chemical Patents Inc.), 16 April 2002 (16.04.2002), & US 6310010 B1 & GB 9807731 A & EP 1070112 A1 & WO 1999/053000 A1 | 1-8 |
| A | JP 2007-514038 A (Chemtura Corp.), 31 May 2007 (31.05.2007), & US 2005/0124510 A1 & EP 1699910 A2 & WO 2005/061683 A2 & CN 1890354 A | 1-8 |

☒ 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
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"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 | Date of mailing of the international search report |
|---|---|
| 26 September, 2014 (26.09.14) | 07 October, 2014 (07.10.14) |
| Name and mailing address of the ISA/ Japanese Patent Office<br>Facsimile No. | Authorized officer<br>Telephone No. |

Form PCT/ISA/210 (second sheet) (July 2009)

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2014/073695

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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Form PCT/ISA/210 (continuation of second sheet) (July 2009)

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2014/073695

Continuation of A. CLASSIFICATION OF SUBJECT MATTER
(International Patent Classification (IPC))

*C10N40/04*(2006.01)n

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

Form PCT/ISA/210 (extra sheet) (July 2009)

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


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