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(54) **GREASE COMPOSITION**

(57) The invention provides a grease composition which contains (A) a base oil including a synthetic hydrocarbon oil and a highly purified mineral oil with a pour point of -35°C or less at a ratio by mass of 100:0 to 30:70; (B) a thickener represented by the following formula (1): R^1-NHCONH-R^2-NHCONH-R^3 (wherein R^2 is a bivalent aromatic hydrocarbon group having 6 to 15 carbon atoms, and R^1 and R^3, which may be the same or different represent cyclohexyl group or a straight-chain or branched alkyl group having 8 to 18 carbon atoms), with [((the number of moles of the alkyl groups) / (the number of moles of the alkyl groups + the number of moles of the cyclohexyl groups)) x 100] being 30 to 100%; and (C) an alkenylsuccinic anhydride and/or organic zinc sulfonate. The grease composition of the invention can exhibit low torque performance and excellent rust preventing properties.

EP 2 631 284 A1

Description

[Technical Field]

[0001] The present invention relates to a grease composition used for rolling bearings of the automotive electrical equipment and automotive auxiliaries.

[Background Art]

[0002] For the rolling bearings of the automotive electrical equipment and automotive auxiliaries, diurea based greases have been widely used, especially from the viewpoint of the heat resistance. In the diurea based greases, aromatic diurea compounds are frequently used on the grounds of their durability under high temperatures.

[0003] However, the aromatic diurea compounds should be added in larger amounts than other diurea compounds to render the same hardness to a resultant grease composition. The resistance to stirring of the resultant grease becomes too high to satisfy low torque performance.

[0004] As an example of a grease using any other diurea thickener than the aromatic diurea compound, JP 6-17079 A proposes a grease composition characterized by comprising a base oil which contains an ether type synthetic oil in an amount of more than 50 mass%; and at least one diurea compound represented by the following general formula as a gelling agent of one essential component:

$$R^2\text{-NHCONH-}R^1\text{-NHCONH-}R^3$$

wherein R^1 is a bivalent aromatic hydrocarbon group having 6 to 15 carbon atoms; and R^2 and R^3, which may be the same or different represent cyclohexyl group, a cyclohexyl-derived group having 7 to 12 carbon atoms, or an alkyl group having 8 to 20 carbon atoms, with the content of cyclohexyl group or the derived groups thereof, as expressed by formula: [((the number of the cyclohexyl groups or the derived groups thereof) / (the number of the cyclohexyl groups or the derived groups thereof + the number of the alkyl groups)) x 100] being 50 to 100%.

[0005] However, the phenyl ether oil used as the base oil has a pour point of about -30°C, so that the low temperature properties are not so satisfactory. This will increase the torque at low temperatures.

[0006] As another example using a diurea thickener that is not an aromatic diurea compound, JP 2008-239706 A proposes a grease composition characterized by comprising a base oil which contains an ester type synthetic oil; and a thickener represented by the following general formula as one essential component:

$$R^1\text{ -NHCONH-}R^2\text{-NHCONH-}R^3$$

wherein R^2 is a bivalent aromatic hydrocarbon group having 6 to 15 carbon atoms; and R^1 and R^3, which may be the same or different represent cyclohexyl group or an alkyl group having 8 to 22 carbon atoms, with the content of cyclohexyl group, as expressed by formula: [((the number of the cyclohexyl groups) / (the number of the cyclohexyl groups + the number of the alkyl groups)) x 100] being 60 to 95%.

[0007] In the above-mentioned grease composition, the ester type synthetic oil is subjected to hydrolysis when water penetrates from the outside and is mixed in, whereby the resultant acid component will unfavorably involve a risk of rust development.

[Summary of Invention]

[Technical Problem]

[0008] An object of the invention is to provide a low torque grease composition having excellent rust preventing properties.

[Solution to Problem]

[0009] To ensure the low torque performance, it is necessary to extremely decrease the amount of thickener that may become the major factor in determining the resistance to stirring, as previously mentioned. However, if the amount of thickener is excessively decreased, the resultant grease cannot be provided with an intended hardness. In addition, the application of a shear force changes the consistency so largely that the grease is softened, which will produce the problem of grease leakage from the bearing to the outside.

[0010] In the invention, the low torque performance can be ensured under the circumstances of low temperature by

using a low pour point synthetic hydrocarbon oil in an amount of 30 mass% or more of the base oil. When the synthetic hydrocarbon oil is used in combination with other type of base oil component, a highly purified mineral oil with a low pour point is employed.

[0011] With respect to the thickener, an aliphatic diurea is used alone or in combination with an alicyclic diurea to obtain a grease composition having a proper hardness even though the total amount of thickener is decreased.

[0012] The inventors of the invention have thus solved the above-mentioned problems by choosing and combining a particular base oil, a thickener and a rust inhibitor. Namely, the invention provides the following grease composition:

1. A grease composition comprising:

(A) a base oil which is a blend oil of a synthetic hydrocarbon oil and a highly purified mineral oil with a pour point of -35°C or less at a ratio by mass of 100:0 to 30:70;
(B) a thickener represented by the following formula (1):

$$R^1\text{-NHCONH-}R^2\text{-NHCONH-}R^3 \quad (1)$$

wherein R^2 is a bivalent aromatic hydrocarbon group having 6 to 15 carbon atoms; and R^1 and R^3, which may be the same or different represent cyclohexyl group or a straight-chain or branched alkyl group having 8 to 18 carbon atoms, with [((the number of moles of the above-mentioned alkyl groups) / (the number of moles of the above-mentioned alkyl groups + the number of moles of the above-mentioned cyclohexyl groups)) x 100] being 30 to 100%; and
(C) an alkenylsuccinic anhydride and/or an organic zinc sulfonate.

2. The grease composition described in the above-mentioned item 1, wherein the base oil has a kinematic viscosity at 40°C of 80 to 150 mm^2/s.
3. The grease composition described in the above-mentioned item 1 or 2, wherein the synthetic hydrocarbon oil comprises a synthetic hydrocarbon oil component having a kinematic viscosity at 40°C of 300 mm^2/s or more.
4. The grease composition described in any one of the above-mentioned items 1 to 3, wherein the thickener is contained in an amount of 10 to 20 mass% of the grease composition.
5. The grease composition described in any one of the above-mentioned items 1 to 4, which is used for a rolling bearing.
6. The grease composition described in the above-mentioned item 5, wherein the rolling bearing is for the automotive electrical equipment and automotive auxiliaries.

[Advantageous Effects of Invention]

[0013] The grease composition of the invention can exhibit low torque performance within a wide temperature range, thereby improving fuel economy to contribute to reduction of CO_2. In addition, the grease composition of the invention also shows excellent rust preventing properties. Further, the resistance to evaporation of the grease composition according to the invention is also excellent.

[Description of Embodiments]

(A) Base oil

[0014] The base oil used in the invention comprises a synthetic hydrocarbon oil and a highly purified mineral oil with a pour point of -35°C or less. The ratio by mass of the synthetic hydrocarbon oil to the highly purified mineral oil with a pour point of -35°C or less is 100:0 to 30:70. When the content of the synthetic hydrocarbon oil in the base oil is 30 mass% or more, the low torque performance can be satisfied.

[0015] Examples of the synthetic hydrocarbon oil include poly-α-olefin, polybutene, ethylene-α-olefin oligomer and the like. Particularly, poly-α-olefin is preferred.

[0016] The highly purified mineral oil used in the invention is referred to as a mineral oil provided with a pour point lower than the pour points (about -5 to -20°C) of unpurified mineral oils by carrying out a dewaxing step to control the wax components from precipitating at low temperatures. The highly purified mineral oil with a pour point of -35°C or less can be used without any adverse effect on the low torque performance at low temperatures and any problem in the resistance to evaporation.

[0017] The base oil may preferably have a kinematic viscosity at 40°C of 80 to 150 mm^2/s, more preferably 85 to 140 mm^2/s, and most preferably 90 to 130 mm^2/s. When the kinematic viscosity at 40°C of the base oil exceeds 150 mm^2/s,

the grease viscosity becomes too high to satisfy the low torque performance. When the kinematic viscosity at 40°C of the base oil is less than 80 mm^2/s, the resistance to evaporation will unfavorably be lowered although the requirement of low torque performance can be satisfied.

[0018] Preferably, the synthetic hydrocarbon oil may comprise the one having a kinematic viscosity at 40°C of 300 mm^2/s or more. In this case, the kinematic viscosity of the base oil can be adjusted within a predetermined range, with the low torque performance at low temperatures being satisfied without impairing the resistance to evaporation.

[0019] Preferably, the highly purified oil may comprise the one having a kinematic viscosity at 40°C of 80 to 130 mm^2/s, more preferably 80 to 110 mm^2/s. In this case, the low torque performance can be satisfied, and at the same time, the resistance to evaporation can be improved.

[0020] The pour point of the synthetic hydrocarbon oil may preferably be -35°C or less. In this case, the low torque performance at low temperatures is satisfactory.

[0021] Examples of other base oil components that can be used in combination with the synthetic hydrocarbon oil include ester type synthetic oils such as diester oils and polyol esters, ether type synthetic oils such as alkyldiphenyl ethers, polyglycol type synthetic oils such as polypropylene glycol, silicone type synthetic oils, and fluorine type synthetic oils. However, the ester type synthetic oils are not desirable because hydrolysis may be caused when water is mixed into the grease from the outside, as previously mentioned. The ester type synthetic oils have pour points of as high as about -30°C, so that the torque will become high at low temperatures. The polyglycol type synthetic oils, silicone type synthetic oils and fluorine type synthetic oils are poor in the lubricating properties and expensive.

(B) Thickener

[0022] Examples of the thickener generally used in the grease compositions include metallic soaps containing lithium, sodium or the like, and non-soaps such as Benton, silica gel, diurea compounds, fluorine-containing thickeners such as polytetrafluoroethylene and the like. The metallic soaps are not satisfactory in terms of the heat resistance, that is, the lubricating life of bearings at high temperatures; Benton and silica gel have poor water resistance; and the fluorine-containing thickeners are considerably expensive and lacking in versatility although the heat resistance is satisfactory.

[0023] In light of the above, the grease composition of the invention comprises a thickener represented by the above formula (1).

[0024] The content of alkyl groups in the above-mentioned formula (1), expressed as [(the number of moles of the alkyl groups) / (the number of moles of the alkyl groups + the number of moles of the cyclohexyl groups)] x 100 is 30 to 100%. When the content of alkyl groups is less than 30%, the amount of thickener will increase to unfavorably fail to achieve the low torque performance.

[0025] The amount of thickener (B) in the grease composition according to the invention may be preferably 10 to 20 mass%, and more preferably 12 to 17 mass%, from the viewpoint of low torque performance.

(C) Rust inhibitor

[0026] The grease composition of the invention comprises as the rust inhibitor an organic zinc sulfonate and/or alkenylsuccinic anhydride. The above-mentioned rust inhibitor can work to disperse water content even if water permeates into the grease from the outside.

[0027] The organic zinc sulfonate is a zinc salt of sulfonic acid having an organic lipophilic group. The sulfonic acid includes petroleum sulfonic acids obtainable by sulfonation from an aromatic hydrocarbon moiety in the lubricating oil distillate or a petroleum fraction with a high boiling point, synthetic sulfonic acids such as dinonylnaphthalene sulfonic acid, heavy alkylbenzene sulfonic acid and the like.

[0028] In particular, an organic zinc sulfonate represented by the following formula (2) is preferable.

$$[R^4 - SO_3]^2Zn \qquad (2)$$

(wherein R^4 is an alkyl group, alkenyl group, alkylnaphthyl group, dialkylnaphthyl group, alkylphenyl group or a residue from the high-boiling petroleum fraction, and the above-mentioned alkyl or alkenyl group may be a straight-chain or branched group having 2 to 22 carbon atoms.)

[0029] To be more specific, zinc dioctyl naphthalenesulfonate, zinc dinonyl naphthalene sulfonate, zinc didecyl naphthalenesulfonate, zinc petroleum sulfonate, zinc salt of highly basic alkylbenzenesulfonate and the like can be used. In particular, zinc dinonyl naphthalenesulfonate is most preferable.

[0030] As the alkenylsuccinic anhydride, alkenylsuccinic anhydrides having an alkenyl group with 6 to 18 carbon atoms can preferably be used. In particular, the alkenylsuccinic anhydrides having an alkenyl group with 10 to 15 carbon atoms are preferable.

[0031] The amount of rust inhibitor (C) in the grease composition according to the invention may be preferably 0.1 to

3 mass%, and more preferably 0.5 to 2 mass% in order to ensure the rust preventing properties under the circumstances where salt water may permeate.

[0032] When necessary, the grease composition of the invention may further comprise additives generally used in the conventional grease compositions. Examples of the additives include an antioxidant such as amine-based and phenol-based antioxidants; an inorganic passivator such as sodium nitrite or the like; a rust inhibitor such as amine-based and carboxylate-based rust inhibitors; a metallic corrosion inhibitor such as benzotriazole or the like, an oiliness improver such as fatty acids, fatty acid esters, phosphates and the like; a phosphorus-containing, sulfur-containing or organic metal-containing antiwear agent or extreme-pressure agent; and a solid lubricant such as oxidized metal salts, molybdenum disulfide or the like.

[0033] The grease composition of the invention can be used for rolling bearings, in particular the rolling bearings for automotive electrical equipment and automotive auxiliaries such as the electromagnetic clutch for car air conditioners, center pulley, idler pulley, tension pulley, alternator, water pump and the like. When the grease composition is used under the circumstances of high temperature, it is desirable to use the amine-based antioxidant and the phenol-based antioxidant in combination rather than to use singly in consideration of deterioration of the grease composition by oxidation.

[Examples]

<Sample Greases>

[0034] By using (A) a base oil as shown in Table 1, (B) a thickener as shown in Table 2, and (C) a rust inhibitor as shown in Table 3 at the ratios as shown in Table 4, grease compositions according to Examples and Comparative Examples were prepared. To be more specific, diphenylmethane diisocyanate was reacted with a predetermined amount of an amine in the base oil and the reaction mixture was diluted with the base oil to such a degree that the worked penetration (determined in accordance with the JIS K2220 7.) of the resultant product reached 240 to 280. The additives were then added, thereby preparing the grease compositions according to Examples and Comparative Examples. The kinematic viscosity of each base oil at 40°C was determined in accordance with JIS K2220 23.

[Table 1]

(A) Base oil

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6
Ratio by Mass	Synthetic hydrocarbon oil A	80	10	30	60	10	10
	Synthetic hydrocarbon oil B	20	20	--	40	20	20
	Mineral oil C	--	70	70	--	70	70
Content of synthetic hydrocarbon oil (mass%)		100	30	30	100	30	30
Kinematic viscosity (40°C) (mm^2/s)		96	127	83	141	127	127

[Table 1-continued]

		Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5	Comp. Ex. 6	Comp. Ex. 7
Ratio by Mass	Synthetic hydrocarbon oil A	20	10	40	10	10	10	10
	Synthetic hydrocarbon oil B	--	20	40	20	20	20	20
	Mineral oil C	80	--	--	70	70	70	70
	Mineral oil D	--	70	20	--	--	--	--
Content of synthetic hydrocarbon oil (mass%)		20	30	80	30	30	30	30
Kinematic viscosity (40°C) (mm^2/s)		86	127	152	127	127	127	127

Synthetic hydrocarbon oil A: poly(α-olefin) with a kinematic viscosity at 40°C of 70.2 mm^2/s and a pour point of -55°C.

Synthetic hydrocarbon oil B: poly(α-olefin) with a kinematic viscosity at 40°C of 395 mm^2/s and a pour point of -35°C.

Mineral oil C: highly purified mineral oil with a kinematic viscosity at 40°C of 91.0 mm^2/s and a pour point of -35°C.

Mineral oil D: mineral oil with a kinematic viscosity at 40°C of 96.6 mm^2/s and a pour point of -15°C.

[Table 2]

(B) Thickener

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6
Molar ratio	Diphenylmethane diisocyanate	5	5	5	5	5	5
	Octylamine	7	7	7	7	-	-
	Octadecylamine	3	3	3	3	3	3
	Cyclohexylamine	-	-	-	-	7	7
Content of alkyl group (mass%)		100	100	100	100	30	30

[Table 2-continued]

		Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5	Comp. Ex. 6	Comp. Ex. 7
Molar ratio	Diphenylmethane diisocyanate	5	5	5	5	5	5	5
	Octylamine	7	7	7	-	-	-	-
	Octadecylamine	3	3	3	2	-	3	3
	Cyclohexylamine	-	-	-	8	-	7	7
	Para-toluidine	-	-	-	-	10	-	-
Content of alkyl group (mass%)		100	100	100	20	0	30	30

[Table 3]

(C) Rust inhibitor	
Rust inhibitor a	Zinc dinonylnaphthalene sulfonate
Rust inhibitor b	Alkenylsuccinic anhydride (where alkenyl group has 12 carbon atoms)
Rust inhibitor c	Sorbitan trioleate

<Test methods>

1. Low torque performance

[0035] The low torque performance was determined in accordance with a low temperature torque test defined by JIS K2220 18.
Bearing type: 6204
Test temperatures: 25°C and -30°C
Rotational speed: 1 rpm
Evaluation item: rotational torque (defined as the average torque over a period of the last 15 seconds when the bearing was rotated for 10 minutes.)

[0036] Evaluation criteria
Rotational torque (25°C)
less than 40 mNm: acceptable (o)
40 mNm or more: unacceptable (x)
Rotational torque (-30°C)
less than 200 mNm: acceptable (o)
200 mNm or more: unacceptable (x)

2. Rust preventing properties

[0037] The rust preventing properties were evaluated in accordance with a rust prevention test for bearing in accordance with ASTM D1743-73 specifications.
Bearing type: HR32304J
Test conditions: 52°C, 48 hours, in the presence of a 0.1% salt water
Evaluation item: observation of the presence of rust spots
#1: no rust
#2: three rust sports or less
#3: worse than the state of #2

Evaluation criteria

[0038] Rust prevention on bearing
#1: acceptable (o)
#2 and #3: unacceptable (x)

3. Overall evaluation

[0039]

- When evaluated as acceptable in every test (the rotational torque test at 25°C, the rotational torque test at -30°C and the test for evaluating the rust prevention on bearing):

  Pass (o)

- When evaluated as unacceptable in any one of the tests (the rotational torque test at 25°C, the rotational torque test at -30°C and the test for evaluating the rust prevention on bearing):

  Fail (x)

[Table 4]

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6
(A) Base oil		Balance	Balance	Balance	Balance	Balance	Balance
(B) Thickener (mass%)		13	12	13	12	16	16
(C) Rust inhibitor (mass%)	Rust inhibitor (a)	1	1	1	1	1	-
	Rust inhibitor (b)	-	-	-	-	-	1
Low torque performance	Rotational torque (mNm) (25°C)	20	24	21	29	36	37
	Rotational torque (mNm) (-30°C)	45	120	120	70	160	150
	Evaluation	o	o	o	o	o	o
Rust preventing properties	Rust prevention on bearing (52°C, 48 h., 0.1% salt water)	#1	#1	#1	#1	#1	#1
	Evaluation	o	o	o	o	o	o
Overall evaluation		o	o	o	o	o	o

[Table 4-continued]

		Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5	Comp. Ex. 6	Comp. Ex. 7
(A) Base oil		Balance	Balance	Balance	Balance	Balance	Balance	Balance
(B) Thickener (mass%)		13	12	12	18	25	16	16
(C) Rust inhibitor (mass%)	Rust inhibitor (a)	1	1	1	1	1	-	-
	Rust inhibitor (c)	-	-	-	-	-	1	-
Low torque performance	Rotational torque (mNm) (25°C)	23	26	39	47	50	36	38
	Rotational torque (mNm) (-30°C)	220	1300<	210	160	190	150	150
	Evaluation	x	x	x	x	x	o	o
Rust preventing properties	Rust prevention on bearing (52°C, 48 h., 0.1% salt water)	#1	#1	#1	#1	#1	#2	#3
	Evaluation	o	o	o	o	o	x	x
Overall evaluation		x	x	x	x	x	x	x

[0040] In any of Examples 1 to 6, the low torque performance and the rust preventing properties were both within the acceptable levels. In contrast to this, the low torque performance was unacceptable in Comparative Example 1 where the content of the synthetic hydrocarbon oil was 30 mass% or less. Further, the low torque performance was unacceptable in Comparative Examples 2 and 3 where the mineral oil not highly purified was contained. The low torque performance was also unacceptable in Comparative Examples 4 and 5 where the content of alkyl groups was 30% or less.

[0041] The rust preventing properties were unacceptable in Comparative Example 6 where sorbitan trioleate was added as the rust inhibitor instead of alkenylsuccinic anhydride or organic zinc sulfonate, and in Comparative Example 7 where no rust inhibitor was added.

[0042] In light of the above-mentioned results, the grease compositions according to the invention are found to be excellent in terms of both low torque performance and rust preventing properties.

Claims

1. A grease composition comprising:

   (A) a base oil which is a blend oil of a synthetic hydrocarbon oil and a highly purified mineral oil with a pour point of -35°C or less at a ratio by mass of 100:0 to 30:70;
   (B) a thickener represented by formula (1):

   $$R^1\text{-NHCONH-}R^2\text{-NHCONH-}R^3 \quad (1)$$

   wherein R^2 is a bivalent aromatic hydrocarbon group having 6 to 15 carbon atoms; and R^1 and R^3, which may be the same or different represent cyclohexyl group or a straight-chain or branched alkyl group having 8 to 18 carbon atoms, with [((the number of moles of the alkyl groups) / (the number of moles of the alkyl groups + the number of moles of the cyclohexyl groups)) x 100] being 30 to 100%; and
   (C) an alkenylsuccinic anhydride and/or an organic zinc sulfonate.

2. The grease composition of claim 1, wherein the base oil has a kinematic viscosity at 40°C of 80 to 150 mm^2/s,

3. The grease composition of claim 1 or 2, wherein the synthetic hydrocarbon oil comprises a synthetic hydrocarbon oil component with a kinematic viscosity at 40°C of 300 mm^2/s or more.

4. The grease composition of any one of claims 1 to 3, wherein the thickener is contained in an amount of 10 to 20 mass% of the grease composition.

5. The grease composition of any one of claims 1 to 4, used for a rolling bearing.

6. The grease composition of claim 5, wherein the rolling bearing is for automotive electrical equipment and automotive auxiliaries.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/074109

A. CLASSIFICATION OF SUBJECT MATTER
See extra sheet.

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)
C10M169/00, C10M101/02, C10M105/02, C10M107/02, C10M115/08, C10M129/34, C10M129/42, C10M135/10, C10N10/04, C10N20/00, C10N20/02, C10N30/02, C10N30/12, C10N40/02, C10N50/10

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 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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 A	JP 2008-143979 A (NSK Ltd.), 26 June 2008 (26.06.2008), claims; example 1 (Family: none)	1-2,4-5 3,6
P,X P,A	WO 2011/046201 A1 (Kyodo Yushi Co., Ltd.), 21 April 2011 (21.04.2011), claims; example 7 & JP 2011-84646 A	1,4-5 2-3,6
A	JP 2006-300211 A (NTN Corp.), 02 November 2006 (02.11.2006), claims; paragraph [0001]; example 4 & CN 101163781 A & US 2008/0196995 A1 & WO 2006/112502 A1	1-6

☒ 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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"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
10 January, 2012 (10.01.12)	24 January, 2012 (24.01.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/074109

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2009/093685 A1 (Kyodo Yushi Co., Ltd.), 30 July 2009 (30.07.2009), claims & CN 101910386 A & EP 2239313 A1 & JP 2009-173751 A & KR 10-2010-0093035 A & US 2010/0298178 A1	1-6
A	JP 2010-48389 A (NSK Ltd.), 04 March 2010 (04.03.2010), claims (Family: none)	1-6
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A	WO 2009/104790 A1 (Kyodo Yushi Co., Ltd.), 27 August 2009 (27.08.2009), claims & CN 101952401 A & EP 2264132 A1 & JP 2009-197162 A & KR 10-2010-0103809 A	1-6

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/074109

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

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

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REFERENCES CITED IN THE DESCRIPTION

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- JP 6017079 A **[0004]**
- JP 2008239706 A **[0006]**