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(54) SYNTHETIC LUBRICANT

(57) The object of the present invention is to provide a synthetic lubrication oil which shows low viscosity, is excellent in viscosity properties at high temperature and shows stable lubricating properties in a wide range of temperature. The synthetic lubricating oil is one comprising an ionic liquid containing an organic cation selected from the group consisting of an imidazolium cation, a pyridinium cation, a quaternary ammonium cation and a quaternary phosphonium cation and a bis(fluorosulfonyl) imide anion, and one comprising an ionic liquid composition which comprises an ionic liquid (A) containing a 1-ethyl-3-methylimidazolium cation and an ionic liquid (B1) containing a 1-methyl-3-propylimidazolium cation and/or an ionic liquid (B2) containing a 1-methyl-3-isopropylimidazolium cation.

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Description

TECHNICAL FIELD

[0001] The present invention relates to a synthetic lubricating oil comprising an ionic liquid selected from an organic cation and a bis(fluorosulfonyl)imide anion, and to a synthetic lubricating oil comprising an ionic liquid composition which is a mixture of two or more ionic liquids containing a 1,3-substituted imidazolium cation.

BACKGROUND ART

[0002] As a lubricating oil used in a machinery installment, a power transmission device, a metallurgical processing oil, grease and the like, base oil selected from a poly α-olefin, a diester, a polyol ester, silicone and the like as the best ingredient has so far been used under optionally mixing with a suitable additive. However, those lubricating oils are accompanied with a danger of flash ignition or evaporation under specific conditions such as high temperature and highly vacuum pressure, and thus more suitable lubricating oil has been desired. Further, in accordance with high functionality and high efficacy of a device, a lubricating oil having more excellent anti-oxidation property, anti-evaporation property and long-released excellent lubricating property has been desired.

[0003] As means for solving the above problems, it is reported in R .A. Reich et al., Journal of the Society of Tribologists and Lubrication Engineers, July 2003, p.16 to 21, for instance, that a compound comprising a combination of an organic cation and an inorganic anion (ionic liquid, melted salt at normal temperature) can be adopted as lubricating oil, and it has recently been known that the ionic liquid is possibly usable as a material of a lubricating oil because the ionic liquid is excellent in non-volatility, stability in a wide temperature range and fire-resistance, and also it has a high viscosity index and sufficient properties of a coefficient of friction and an abrasion trace diameter which are required for lubricating oil.

[0004] However, many of the ionic liquids have generally show high viscosity, and thus it is necessary for practical use as a lubricating oil to find out an ionic liquid having low viscosity, and under the situation, further development has been continued.

[0005] And, in a Japanese Patent Publication No. 2005-89667, an ionic liquid containing bis(trifluoromethanesulfonyl) imide anion as an anion is mentioned as an ionic liquid having low viscosity. However, it has been said that the ionic liquid comprising this combination of an anion is not sufficient in reduction of viscosity.

DISCLOSURE OF INVENTION

[0006] Under the situation, the object of the present invention is to provide a synthetic lubricating oil having a stable lubricating property in a wide temperature range.

[0007] Thus, the present inventors have made extensive study under considering the above situation to find surprisingly that an ionic liquid having remarkably low viscosity and excellent viscosity stability can be obtained by using a bis (fluorosulfonyl)imide anion as an anion seed in an ionic liquid using an organic cation selected from an imidazolium cation, a pyridinium cation, a quaternary ammonium cation and a quaternary phosphonium cation and this ionic liquid can suitably be used as a synthetic lubricating oil.

[0008] Further, it is found that an ionic liquid composition having a low viscosity and excellent viscosity stability and moreover having a lower melting point compared with a single use can be obtained by mixing an ionic liquid with an ionic liquid containing an imidazolium cation having a specific alkyl group of relatively short alkyl chain and at the same time by incorporating therein two or more kind of compounds having an eutectic point, and consequently the present invention has been completed.

[0009] Namely, the present invention relates to a synthetic lubricating oil comprising an ionic liquid composition which comprises an ionic liquid (A) containing an organic cation selected from the group consisting of an imidazolium cation, a pyridinium cation, a quaternary ammonium cation and a quaternary phosphonium cation and a bis(fluorosulfonyl)imide anion and an ionic liquid (B1) containing a 1-ethyl-3-methylimidazolium cation, and an ionic liquid (B2) containing a 1-methyl-3-propylimidazolium cation and/or a 1-methyl-3-isopropylimidazolium cation.

[0010] The ionic liquid and the ionic liquid composition used in the present invention are useful as lubricating oil which is excellent in anti-abrasion property and further has stable flowability, and viscosity characteristics required for lubricating oil, and still further has stable lubricating properties in a wide temperature range and a wide using condition.

BEST MODE FOR CARRYING OUT THE INVENTION

[0011] In the following, the present invention is explained in details.

[0012] In the following, the ionic liquid of the present invention means an ionic substance which is in melted state at

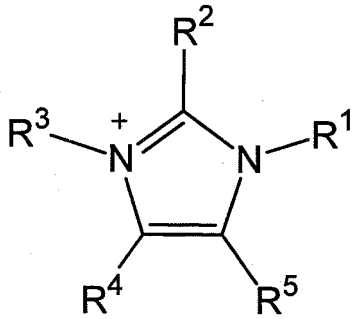
normal temperature (25°C).

[0013] The present invention relates to a synthetic lubricating oil comprising an ionic liquid composition which comprises an organic cation selected from the group consisting of an imidazolium cation, a pyridinium cation, a quaternary ammonium cation and a quaternary phosphonium cation and a bis(fluorosulfonyl)imide anion and to a synthetic lubricating oil comprising an ionic liquid (A) containing a 1-ethyl-3-methylimidazolium cation, and an ionic liquid (B1) containing a 1-methyl-3-propylimidazolium cation and/or an ionic liquid (B2) containing a 1-methyl-3-isopropylimidazolium cation.

[0014] Explanation is given first on the synthetic lubricating oil comprising an ionic liquid which comprises an organic cation selected from the group consisting of an imidazolium cation, a pyridinium cation, a quaternary ammonium cation and a quaternary phosphonium cation, and a bis(fluorosulfonyl)imide anion.

[0015] The organic cation used in the present invention is exemplified by an imidazolium cation, a pyridinium cation, a quaternary ammonium cation and a quaternary phosphonium cation. By combining the organic cation with a bis (fluorosulfonyl)imide anion, viscosity of the ionic liquid as a synthetic lubricating oil can be reduced to a great extent.

[0016] The imidazolium cation is not specifically limited and can be exemplified by one having a structure shown by the following general formula (1).



(1)

(in the formula (1), the substituents R^1 to R^5 are each independently a hydrogen atom, a halogen atom, a straight chained or branched alkyl group, an alkenyl group, an alkinyl group, an alkoxyl group or an acyl group, which has 1 to 16 carbon atoms, or an amide group, a cyano group, a nitro group, or an amino group, and the alkyl group, the alkenyl group, the alkinyl group, the alkoxyl group and the acyl group may contain a hetero atom selected from N, S and O, and further may contain a conjugate or independent double bond or triple bond.).

[0017] In a case where the substituents R^1 to R^5 are an alkyl group, an alkenyl group, an alkinyl group, an alkoxyl group or an acyl group, a carbon atom number thereof is preferably 1 to 16, particularly preferably 1 to 12, and still particularly preferably 1 to 6. Those substituents may be straight chained or branched, and a carbon atom number over the above maximum value is not preferable because of trend of viscosity increase by intermolecular interaction on side chains.

[0018] The above alkyl group, alkenyl group, alkinyl group, alkoxyl group and acyl group may contain a hetero atom selected from N, S and O, and the number of the hetero atom to be contained is not specifically limited. Further, they may contain a conjugate or independent double bond or triple bond, and the number of those unsaturated bonds is not specifically limited.

[0019] Those alkyl groups are specifically exemplified by a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, an isobutyl group, a secondary butyl group, a tertiary butyl group, a pentyl group, a hexyl group, a cyclopropyl group, a cyclopentyl group, a cyclohexyl group, etc. The alkenyl group is exemplified by a vinyl group, an allyl group, an 1-propenyl group, an isopropenyl group, a 2-butenyl group, an 1,3-butadienyl group, a 2-pentenyl group, a 2-hexenyl group, etc. Further, the alkinyl group is exemplified by an ethynyl group, an 1-propinyl group, a 2-propinyl group, etc., and the alkoxyl group is exemplified by a methoxy group, an ethoxy group, an n-propoxy group, an isopropoxy group, a t-butoxy group, etc., the acyl group is exemplified by an acetyl group, a propionyl group, a butylyl group, a benzoyl group, etc., and the amino group is exemplified by an N,N-dimethylamino group, an N,N-diethylamino group, etc. From a viewpoint of industrial use, easy decomposition by enzymes and increased biodegrability are valuable, and thus an alkoxyl group, an acyl group, an amide group, a cyano group, a nitro group, an amino group, etc. can be mentioned.

[0020] As the imidazolium cation shown by the above formula (1), 1,3-substituted imidazolium cation, and 1,2,3-substituted imidazolium cation is preferably used from a viewpoint of easy synthesis. The substituent in the derivatives may be same or different, and a substituent which may contain a multiple bond or a branched chain is preferable.

[0021] The above substituent is same with one in the above general formula (1), and one optionally selected therefrom is used.

[0022] Further, in the present invention, a pyridinium cation, a quaternary ammonium cation and a quaternary phos-

phonium cation are mentioned as well as the above imidazolium cation, and the pyridinium cation is exemplified by a pyridinium cation substituted by an alkyl group of 1 to 16 carbon atoms such as N-methylpyridinium, N-ethylpyridinium, N-butylpyridinium and N-propylpyridinium.

[0023] The quaternary ammonium cation is exemplified by an ammonium cation substituted by an alkyl group of 1 to 16 carbon atoms such as tetramethylammonium, tetraethylammonium and tetrabutylammonium.

[0024] The quaternary phosphonium cation is exemplified by a phosphonium cation substituted by an alkyl group of 1 to 16 carbon atoms such as tetramethylphosphonium, tetraethylphosphonium and tetrabutylphosphonium.

[0025] And, in the present invention, the anion used as an anion part constituting the ionic liquid together with the above organic cation is a bis(fluorosulfonyl)imide anion, and by using this anion, an ionic liquid having remarkably low viscosity and excellent viscosity stability can be obtained.

[0026] A method for producing the ionic liquid of the present invention is not specifically limited, and a conventional method such as an ion exchange method or a metathesis reaction can be applied. For instance, the ionic liquid can be obtained by an anion exchange reaction using a halogenated salt of an organic cation to be used and an alkaline metal salt of a bis(fluorosulfonyl)imide anion. The halogen in the halogenated salt is exemplified by chlorine or bromine. The alkaline metal in the alkaline metal salt is exemplified by sodium, potassium, etc.

[0027] Amounts of the halogenated salt of the organic cation and the alkaline metal salt of a bis(fluorosulfonyl)imide anion to be used in the above reaction are not specifically limited, and 0.5 to 2 equivalents, still preferably 0.8 to 1.2 equivalent of the alkaline metal salt of bis(fluorosulfonyl)imide anion relative to the halogenated salt of the organic cation is preferable. In a case of over the above range, economical effect tends to be lowered because the amount over the range does not give influence upon a reaction yield, and in a case of less than the range, on the other hand, a large amount of non-reacted starting material remains to bring about tendency of lowering a reaction yield.

[0028] The synthetic lubricating oil containing the ionic liquid comprising the above organic cation and bis(fluorosulfonyl) imide anion may contain, as well as the above ionic liquid, a base oil for a lubrication oil, which has been conventionally used, and further optionally other additives such as an anti-rusting agent and a flow-point depressant can be used. An amount of the additives is not specifically limited so far as the effect of the present invention is not disturbed, and it is preferably 0.001 to 50 % by weight relative to the ionic liquid in order to utilize the characteristics owned by the ionic liquid itself.

[0029] Then, explanation is given on the synthetic lubricating oil comprising the ionic liquid composition which comprises the ionic liquid (A) containing a 1-ethyl-3-methylimidazolium cation and the ionic liquid (B1) containing a 1-methyl-3-propylimidazolium cation and/or the ionic liquid (B2) containing a 1-methyl-3-iospropylimidazolium cation.

[0030] Those ionic liquid compositions have been found as a result of studying combinations of ionic liquids containing various kind of imidazolium cation. The compositions comprising combinations of those ionic liquids have low viscosity and excellent viscosity stability, and further have lower viscosity than each of the ionic liquids themselves, and thus it has been found that those compositions can be used as lubricating oil at a low temperature in a wider range.

[0031] The anion parts of the ionic liquids (A), (B1) and (B2) used in the present invention are not specifically limited, and anions so far used in conventional ionic liquids can be used. Among them, use of a hydrophobic organic anion or inorganic anion is preferable from a viewpoint of keeping hydrophobicity, and as the hydrophobic organic anion, a bis (trifluoromethanesulfonyl)imide anion, a (fluorosulfonyl)(trifluoromethanesulfonyl)imide anion, a (trifluoroacetyl)(trifluoromethanesulfonyl)imide anion, etc. are preferably used, and as the hydrophobic inorganic anion, a hexafluorophosphate anion, a bis(fluorosulfonyl)imide anion, etc. are preferably used, among which a bis(fluorosulfonyl)imide anion is most preferably used.

[0032] The anion parts of each ionic liquid constituting the ionic liquid composition of the present invention may be same with or different from each other, and the same anion parts are particularly desirable because of easier production compared with different anion parts.

[0033] A mixing ratio (weight ratio) of the ionic liquid (A) to the ionic liquid (B1) and/or the ionic liquid (B2) to be used in the present invention can be selected suitably according to the desired viscosity and low temperature for its use, and generally, a ratio (A):(B1) and/or (B2)=8:2 to 2:8 is preferable. Over the maximum in the ionic liquid (A) tends to cause increase of a melting point, and less than the range tends to cause increase of viscosity.

[0034] Particularly in a case of incorporating the ionic liquid (A) and the ionic liquid (B1), its mixing ratio (weight ratio) of (A):(B1)=7:3 to 2:8 is preferable, and in a case of incorporating the ionic liquid (A) and the ionic liquid (B2), its mixing ratio (weight ratio) of (A):(B2)=8:2 to 6:4 is preferable. Over the maximum in the ionic liquid (A) tends to cause increase of a melting point, and less than the range tends to cause increase of viscosity.

[0035] In the ionic liquid composition of the present invention, it is possible to co-use the ionic liquid (A) with (B1), co-use the ionic liquid (A) with (B2) and to co-use of the ionic liquid (A) with (B1) and (B2), and also it is possible to co-use an optional ionic liquid (C) other than the ionic liquids (A), (B1) and (B2) in a range not inhibiting the effect of the present invention. The optional ionic liquid (C) is exemplified by an ionic liquid containing a 1-allyl-3-alkylimidazolium cation, an ionic liquid containing a 1,3-diallylimidazolium cation, an ionic liquid containing a 1,3-dimethylimidazolium cation, etc., but not limited thereto.

[0036] An amount of the ionic liquid (C) is, in general, preferably 0 to 20 % by weight, more preferably 0 to 10 % by weight.

[0037] A method for producing the ionic liquid (A), (B1), (B2) and (C) is not specifically limited, and a conventional method such as an anion exchange method, an acid ester method, a neutralizing method, etc. can be applied. For instance, they can be produced by alkylating with the use of N-alkyl imidazole and an alkylating agent such as an alkyl halide, and then conducting an anion exchange reaction using an alkyl metal salt of bis(fluorosulfonyl)imide.

[0038] The synthetic lubricating oil containing the ionic liquid composition may contain a conventional base oil of a lubricating oil as well as the above ionic liquid component, and further optionally other additives such as an anti-rusting agent and a flow-point depressant can be used. An amount of the additives to be used is not specifically limited so far as not disturbing the effect of the present invention, and preferably 0.001 to 50 % by weight relative to the above ionic liquid in order to utilize the characteristics owned by the ionic liquid itself.

[0039] In this way as above, the synthetic lubricating oil comprising the ionic liquid or the ionic liquid composition of the present invention can be produced.

[0040] Viscosity of the synthetic lubricating oil of the present invention is, in general, preferably 30 mPa·s or lower at 25°C, still preferably 20 mPa·s or lower. Over the maximum of viscosity is not preferable because energy loss is caused by viscosity of the lubricating oil itself, and the minimum of the viscosity is generally 2 mPa·s, and less than the minimum tends to fly easily due to low viscosity.

[0041] Further, the kinematic viscosity of the synthetic lubricating oil of the present invention is preferably 2 to 20 mm^2 / sec at 40°C, still preferably 4 to 10 mm^2/sec, and the kinematic viscosity at 100°C is preferably 1 to 13 mm^2/sec, still preferably 2 to 7 mm^2/sec. Over the maximum in each temperature tends to cause energy loss by viscosity of the lubricating oil itself, and less than the minimum tends to fly easily due to low viscosity.

[0042] Viscosity index of the synthetic lubricating oil is preferably 180 or more, still preferably 200 or more, particularly preferably 220 or more. The maximum viscosity index is generally 700. Herein, viscosity index means an index showing a relation of temperature and viscosity, and calculated by a method stipulated in JIS K2283 (a test method for kinematic viscosity of crude oil and petroleum products and a viscosity index calculation method of petroleum products).

[0043] Higher viscosity index means less change by temperature, and thus means that the product is excellent as a lubricating oil.

[0044] As the objects to be applied by the lubricating oil, there can be imaged those wherein high absolute viscosity is important and those wherein other properties such as contact angle to a metal is considered to be more important than absolute viscosity. In such cases, upon necessity, the properties are controlled by selecting the organic cation among an imidazolium cation, a pyridinium cation, a quaternary ammonium cation and a quaternary phosphonium cation and further optionally changing the substituent. Also in this case, the above viscosity index is a property considered to be important. Less than the minimum viscosity index tends to bring about too much high changing degree of viscosity by temperature.

[0045] The synthetic lubricating oil of the present invention has excellent viscosity properties at low viscosity and high temperature, and is excellent in non-volatility, heat stability and other properties, and thus it has possibility of using in a wide range as lubricating oil for machinery installments such as automobiles and electrical products, power transmission devices and precision machines, as metallurgical processing oil, as lubricating oil under special conditions, and the like.

EXAMPLE

[0046] In the following, the present invention is further explained referring to Examples, but the present invention is not limited to the following Examples unless it is beyond its gist. In Examples, "part" and "%" mean on the basis of weight unless otherwise stated. Viscosity was obtained by the following method.

[0047] Conditions for measuring viscosity are as follows. Machine: AR-1000 type rotary rheometer (TA Instruments). Measuring method: The machine was set forth at 25°C, and 0.6 ml sample was put on a sample desk, and a cone was set forth, and viscosity upon rotating the cone at predetermined force (20 Pa) was measured.

[0048] The kinematic viscosity at 40°C and 100°C was obtained by measuring viscosity at each of the above temperature using the above machine and measuring method and calculating from thus obtained viscosity. Further, the viscosity index was obtained by calculating from the kinematic viscosities.

SYNTHESIS EXAMPLE 1

[0049] In a flask equipped with a refluxing column were charged 19.1 g (0.10 mol) of 1-ethyl-3-methylimidazolium bromide and 20 ml of water, and further 21.9 g (0.10 mol) of potassium salt of bis(fluorosulfonyl)imide, followed by stirring at 40°C for 5 hours. After the reaction, 80 ml of methylene chloride was added, followed by well stirring and fractionating. The methylene chloride layer was washed five times each with 40 ml of water, and the methylene chloride layer is concentrated under reduced pressure to give 23.8 g (0.08 mol, yield: 81.8 %) of 1-ethyl-3-methylimidazolium bis(fluorosulfonyl)imide.

SYNTHESIS EXAMPLE 2

[0050] The same procedure as the above Synthesis example 1 excepting using 20.5 g of 1-methyl-3-propylimidazolium bromide in place of 19.1 g of 1-ethyl-3-methylimidazolium bromide was conducted to give 27.5 g (0.09 mol, yield: 90.1 %) of 1-methyl-3-propylimidazolium bis(fluorosulfonyl)imide. Viscosity of this compound was 29 mPa·s (25°C).

SYNTHESIS EXAMPLE 3

[0051] The same procedure as the above Synthesis example 1 excepting using 20.5 g of 1-methyl-3-isopropylimidazolium bromide in place of 19.1 g of 1-ethyl-3-methylimidazolium bromide was conducted to give 27.1 g (0.09 mol, yield: 88.8 %) of 1-methyl-3-isopropylimidazolium bis(fluorosulfonyl)imide. Viscosity of this compound was 27 mPa·s (25°C).

EXAMPLE 1

[0052] Result of measuring various properties of 1-ethyl-3-methylimidazolium bis(fluorosulfonyl)imide in the Synthesis example 1 is shown in Table 1.

COMPARATIVE EXAMPLE 1

[0053] 11.0 Grams (60.6 mmol) of 1-ethyl-3-methylimidazolium bromide obtained by the same method as Example 1 was reacted with 20.3 g (63.7 mmol) of potassium salt of bis(trifluoromethanesulfonyl)imide anion in 20 g of water-methylene chloride at 40°C for 4 hours, and an aqueous layer was fractionated by a separating funnel and discarded, and an organic layer was washed with water, followed by drying under reduced pressure to give 22.5 g (57.6 mmol, yield: 95.0 %) of 1-ethyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide.

[0054] Measurement of properties of the obtained 1-ethyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide was conducted by the same manner as the Example 1. The result is shown in Table 1.

COMPARATIVE EXAMPLE 2 (polyα-olefin)

[0055] Properties were measured by the same manner as the Example 1 using polyα-olefin (SYNFLUID 801 (Chevron phillips). The result is shown in Table 1.

COMPARATIVE EXAMPLE 3 (diester)

[0056] Properties were measured by the same manner as the Example 1 using diester (dioctyl adipate: Plasthall DOA (The C.P. Hall)). The result is shown in Table 1.

COMPARATIVE EXAMPLE 4 (polyol ester)

[0057] Properties were measured by the same manner as the Example 1 using polyol ester (polyester (trivalent): KAOLUBE 190 (Kao Corporation)). The result is shown in Table 1.

COMPARATIVE EXAMPLE 5 (liquid paraffin)

[0058] Properties were measured by the same manner as the Example 1 using liquid paraffin (Cosmo Neutral 150: (Cosmo Oil Lubricants co LTD)). The result is shown in Table 1.

TABLE 1

	Viscosity (25°C, mPa·s)	Kinematic viscosity (40°C, mm^2/s)	Kinematic viscosity (100°C, mm^2/s)	Viscosity index
Ex. 1	19	9.4	4.9	623
Com. Ex. 1	28	12	3.7	206
Com. Ex. 2	62	46	7.8	130
Com. Ex. 3	36	25	5.2	140
Com. Ex. 4	65	48	9.7	151
Com. Ex. 5	44	33	5.6	108

EXAMPLES 2 to 7

[0059] Using 1-ethyl-3-methylimidazolium bis(fluorosulfonyl)imide in the Synthesis example 1 as the ionic liquid (A) and 1-methyl-3-propylimidazolium bis(fluorosulfonyl)imide in the Synthesis example 2 as the ionic liquid (B1), ionic liquid compositions of the formulations in Table 2 were produced. Result of measuring properties thereon is shown in Table 2.

TABLE 2

	Ionic liquid (A) EMIFSI (%)	Ionic liquid (B1) MPIFSI (%)	Viscosity (25°C, mPa·s)	Kinematic viscosity (40°C, mm^2/s)	Kinematic viscosity (100°C, mm^2/s)	Viscosity index
Ex. 2	80	20	20	10.3	4.7	503
Ex. 3	70	30	21	10.7	4.7	473
Ex. 4	60	40	22	11.1	4.8	463
Ex. 5	50	50	22	11.5	4.8	438
Ex. 6	40	60	23	11.8	4.9	437
Ex. 7	20	80	25	12.2	5.4	490

EMIFSI: 1-ethyl-3-methylimidazolium bis(fluorosulfonyl)imide
MPIFSI: 1-methyl-3-propylimidazolium bis(fluorosulfonyl)imide

EXAMPLES 8 and 9

[0060] Using 1-ethyl-3-methylimidazolium bis(fluorosulfonyl)imide in the Synthesis example 1 as the ionic liquid (A) and 1-methyl-3-isopropylimidazolium bis(fluorosulfonyl)imide in the Synthesis example 3 as the ionic liquid (B2), ionic liquid compositions were produced. Result of measuring properties thereon is shown in Table 3.

TABLE 3

	Ionic liquid (A) EMIFSI (%)	Ionic liquid (B2) MiPIFSI (%)	Viscosity (25°C, mPa·s)	Kinematic viscosity (40°C, mm^2/s)	Kinematic viscosity (100°C, mm^2/s)	Viscosity index
Ex. 8	80	20	20	10.3	4.7	503
Ex. 9	60	40	21	10.9	4.8	477

EMIFSI: 1-ethyl-3-methylimidazolium bis(fluorosulfonyl)imide
MiPIFSI: 1-methyl-3-isopropylimidazolium bis(fluorosulfonyl)imide

[0061] As understood from results of Table 1 to Table 3, the synthetic lubricating oil of the present invention, which comprises the specific organic cation and bis(fluorosulfonyl)imide anion and the synthetic lubricating oil containing the ionic liquid composition comprising a mixture of two or more ionic liquids containing 1,3-substituted imidazolium cation has lower viscosity and higher viscosity index compared with an ionic liquid comprising a bis(trifluoromethyl sulfonyl) imide anion which has been known as being low viscosity, and other conventional base oil, and thus they are remarkably excellent in properties as a synthetic lubricating oil.

[0062] Further, by making the cation easily degradable by introducing a substituent for increasing biodegradability, the remaining anion becomes an inorganic compound and thus no attention to biodegradability of the anion is necessary, and consequently the oil becomes suitable also from environmental point of view.

INDUSTRIAL APPLICABILITY

[0063] The synthetic lubricating oil of the present invention is suitable as a lubricating oil for machinery installments such as automobiles, marine structures and electrical products, a lubricating oil for power transmission devices and precision machines, metallurgical processing oil, a lubricating oil under special conditions, and the like.

Claims

1. A synthetic lubricating oil comprising an ionic liquid containing an organic cation selected from the group consisting of an imidazolium cation, a pyridinium cation, a quaternary ammonium cation and a quaternary phosphonium cation and a bis(fluorosulfonyl)imide anion.

2. The synthetic lubricating oil of Claim 1, wherein the organic cation is an imidazolium cation.

3. The synthetic lubricating oil of Claim 2, wherein the imidazolium cation is a 1,3-disubstituted imidazolium cation in which the substituents on the position-1 and the position-3 may be same or different, or a 1,2,3-trisubtituted imidazolium cation in which the substituents on the position-1, the position-2 and the position-3 may be same or different.

4. A synthetic lubricating oil comprising an ionic liquid composition comprising an ionic liquid (A) containing a 1-ethyl-3-methylimidazolium cation and an ionic liquid (B1) containing a 1-methyl-3-propylimidazolium cation and/or an ionic liquid (B2) containing a 1-methyl-3-isopropylimidazolium cation.

5. The synthetic lubricating oil of Claim 4, wherein an anion part of the ionic liquid (A) and an anion part of the ionic liquid (B1) and/or the ionic liquid (B2) are same.

6. The synthetic lubricating oil of Claim 4 or Claim 5, wherein the anion parts of the ionic liquid (A) and the ionic liquid (B1) and/or the ionic liquid (B2) are bis(fluorosulfonyl)imide or (fluorosulfonyl)(trifluoromethanesulfonyl)imide.

7. The synthetic lubricating oil of any of Claim 4 to Claim 6, wherein a mixing ratio (weight ratio) of the ionic liquid (A) to the ionic liquid (B1) and/or the ionic liquid (B2) is (A):(B1) and/or (B2) = 8:2 to 2:8.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/322477

A. CLASSIFICATION OF SUBJECT MATTER
C10M105/58(2006.01)i, *C10M105/70*(2006.01)i, *C10M105/72*(2006.01)i, *C10M105/74*(2006.01)i, *C10N30/00*(2006.01)n, *C10N30/02*(2006.01)n, *C10N30/06*(2006.01)n, *C10N30/08*(2006.01)n, *C10N40/00*(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)
C10M105/58, C10M105/70, C10M105/72, C10M105/74, C10N30/00, C10N30/02, C10N30/06, C10N30/08, C10N40/00, C10N40/06, C10N40/08, C10N40/20

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 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
CA(STN), REGISTRY(STN)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2005/35702 A1 (Idemitsu Kosan Co., Ltd.), 21 April, 2005 (21.04.05), Full text & EP 1672051 A1	4,5,7
Y	JP 2005-314467 A (Mitsubishi Materials Corp.), 10 November, 2005 (10.11.05), Full text (Family: none)	4,5,7
Y	JP 2005-154755 A (Kyodo Yushi Co., Ltd.), 16 June, 2005 (16.06.05), Full text (Family: none)	4,5,7

☒ 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	Date of mailing of the international search report
29 January, 2007 (29.01.07)	06 February, 2007 (06.02.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/322477

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-89667 A (Sanko Kagaku Kogyo Kabushiki Kaisha), 07 April, 2005 (07.04.05), Full text (Family: none)	4,5,7
Y	Ngo H. L. et al., 'Thermal properties of imidazolium ionic liquids' Thermochimica Acta, 2000, Vol.357-358, p.97-102	4,5,7
A	WO 1999/40025 A1 (ACEP INC.), 12 August, 1999 (12.08.99), & WO 1999/28292 A1 & JP 2001-527505 A & JP 2002-500678 A & EP 971854 A1 & EP 968181 A1 & EP 1626041 A1 & US 2002/55045 A1 & US 2002/9635 A1 & US 2005/84763 A1	1-7
A	Hiemisch O. et al., 'Polysulfonylamine LXXII Triphenylcarbenium- und Triphenylphosphonium-di(fluorsulfonyl)amid: Zwei Kristallstrukturen mit geordneten $(FSO_2)_2N^-$-Lagen' Zeitschrift fuer Anorganische und Allgemeine Chemie, 1996, Vol.622, No.5, p.829-836	1-7
A	WO 2002/53494 A1 (HYDRO-QUEBEC), 11 July, 2002 (11.07.02), & JP 2004-522681 A & EP 1347938 A1 & US 2004/97757 A1	1-7
P,A	JP 2006-278167 A (Dai-Ichi Kogyo Seiyaku Co., Ltd.), 12 October, 2006 (12.10.06), & EP 1707265 A1 & US 2006/223995 A1	1-7
P,A	JP 2006-291011 A (Idemitsu Kosan Co., Ltd.), 26 October, 2006 (26.10.06), (Family: none)	1-7

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/322477

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

C10N40/06(2006.01)n, *C10N40/08*(2006.01)n, *C10N40/20*(2006.01)n

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

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Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee..

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

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INTERNATIONAL SEARCH REPORT

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Claims 1-7 of this international application are considered to contain the following two inventions having different special technical features.

(1) A synthetic lubricant containing an organic cation selected from the group consisting of imidazolium cations, pyridinium cations, quaternary ammonium cations and quaternary phosphonium cations, and an ionic liquid composed of a bis(fluorosulfonyl)imide anion (Claims 1-3)

(2) A synthetic lubricant containing an ionic liquid (A) containing a 1-ethyl-3-methylimidazolium cation, and an ionic liquid composition composed of an ionic liquid (B1) containing a 1-methyl-3-propylimidazolium cation and/or an ionic liquid (B2) containing a 1-methyl-3-isopropylimidazolium cation (Claims 4-7)

Meanwhile, a lubricant mainly composed of an ionic liquid containing an imidazolium cation is publicly known to persons skilled in the art (JP 2005-314467 A).

Consequently, "a synthetic lubricant containing an ionic liquid containing an imidazolium cation", which is the technical feature common to all the claims 1-7, cannot be a special technical feature, and thus there is no technical relationship between the inventions of claims 1-7 involving a special technical feature.

Therefore, since there is no technical feature common to all the claims 1-7, this international application does not satisfy the requirement of unity of invention.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005089667 A **[0005]**

Non-patent literature cited in the description

- **R .A. REICH et al.** *Journal of the Society of Tribologists and Lubrication Engineers,* July 2003, 16-21 **[0003]**