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(54) **LUBRICANT**

(57) Provided is a lubricant including a deep eutectic solvent consisting of a hydrogen bond acceptor and a hydrogen bond donor, the lubricant having a halogen atom content of 0.1% by mass or less. The lubricant provided contains a carbon-neutral component, and shows a favorable lubricating property and low corrosiveness to metals.

[Fig. 1]

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Description

Technical Field

[0001] The present invention relates to a lubricant.

Background Art

[0002] In recent years, with increasing environmental awareness, efforts to break away from petrochemicals have been accelerating, as exemplified by the declaration of carbon neutrality. However, in the field of lubricating oils, mineral oils obtained by refinement of petroleum fractions are still widely used as lubricant base oils, which are used as base materials for various lubricating oil compositions. Therefore, studies on carbon-neutral materials are demanded.

[0003] PTL 1 discloses a lubricating oil composition containing an ionic liquid blended as a component.

Citation List

Patent Literature

[0004] PTL 1: JP 2021-161309 A

Summary of Invention

Technical Problem

[0005] However, there is concern that the lubricating oil composition containing an ionic liquid blended therein described in PTL 1 may be corrosive to metals. Thus, achievement of carbon neutrality and low corrosiveness at the same time has been difficult.

[0006] The present invention was made in view of the above problems, and an object of the present invention is to provide a lubricant containing a carbon-neutral component, and showing a favorable lubricating property and low corrosiveness to metals.

Solution to Problem

[0007] The present inventors discovered that the above problems can be solved with a lubricant including a deep eutectic solvent consisting of a hydrogen bond acceptor and a hydrogen bond donor, the lubricant having a halogen atom content of 0.1% by mass or less, thereby completing the present invention.

[0008] Specifically, the present invention provides the following [1] to [3].

[1] A lubricant including a deep eutectic solvent consisting of a hydrogen bond acceptor and a hydrogen bond donor, the lubricant having a halogen atom content of 0.1% by mass or less.
[2] A method for lubrication using the lubricant according to [1].
[3] A method for producing the lubricant according to [1], the method including a step of obtaining the deep eutectic solvent by mixing the hydrogen bond acceptor with the hydrogen bond donor.

Advantageous Effects of Invention

[0009] The present invention can provide a lubricant containing a carbon-neutral component, and showing a favorable lubricating property and low corrosiveness to metals.

Brief Description of Drawings

[0010]

Fig. 1 is a photograph of a surface of a steel plate (SPCC-SD) after carrying out a reciprocating dynamic friction test in Example 1.
Fig. 2 is a photograph of a surface of a steel plate (SPCC-SD) after carrying out a reciprocating dynamic friction test in Comparative Example 1.
Fig. 3 is a photograph of a surface of a steel plate (SPCC-SD) after carrying out a reciprocating dynamic friction test in

Comparative Example 2.
Fig. 4 is a photograph of a surface of a steel plate (SPCC-SD) after carrying out a reciprocating dynamic friction test in Comparative Example 3.

Description of Embodiments

[0011] In the present description, regarding a preferred numerical range (for example, a range of a content or the like), lower limit values and upper limit values described in a stepwise manner may be independently combined with each other. For example, the description "preferably 10 to 90, more preferably 30 to 60" may be meant to be "10 to 60" by the combination of a "preferred lower limit value (10)" and a "more preferred upper limit value (60)". Similarly, when a numerical range is described in the present description, numeral values accompanied by the terms "or more", "or less", "less than", or "more than" may be arbitrarily combined.

[Lubricant]

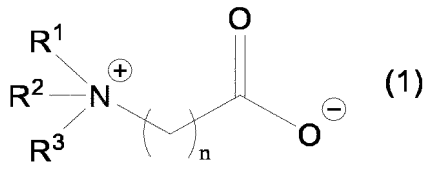
[0012] A lubricant of the present embodiment includes a deep eutectic solvent consisting of a hydrogen bond acceptor and a hydrogen bond donor, and has a halogen atom content of 0.1% by mass or less.
[0013] In cases where the halogen atom content in the lubricant is more than 0.1% by mass, the lubricant is highly corrosive to metals.
[0014] Each component contained in the lubricant of the present embodiment is described below.

<Deep Eutectic Solvent>

[0015] Unlike an ionic liquid containing a cationic species and an anionic species, the deep eutectic solvent contained in the lubricant of the present embodiment consists of a hydrogen bond acceptor and a hydrogen bond donor, and mixing of these two components results in a decrease in the eutectic melting point.
[0016] Although the deep eutectic solvent may be either a liquid or solid at normal temperature (25°C), the deep eutectic solvent is preferably a liquid at normal temperature (25°C) from the viewpoint of ease of handling as a lubricant.
[0017] In cases where the deep eutectic solvent of the present embodiment is used as a base material, the lubricant of the present embodiment contains the deep eutectic solvent at preferably 50% by mass or more, more preferably 70% by mass or more, still more preferably 90% by mass or more with respect to the total amount of the lubricant.
[0018] On the other hand, in cases where the deep eutectic solvent is used as an additive, the lubricant may contain the deep eutectic solvent at about 0.1 to 10% by mass with respect to the total amount of the lubricant.

<Hydrogen Bond Acceptor>

[0019] The hydrogen bond acceptor contained in the lubricant of the present embodiment is not limited as long as the hydrogen bond acceptor forms a eutectic with a hydrogen bond donor. However, since the halogen atom content in the lubricant of the present embodiment needs to be 0.1% by mass or less as mentioned above, the hydrogen bond acceptor preferably does not contain a halogen atom, and specific examples of the hydrogen bond acceptor include betaine.
[0020] More specifically, the betaine is preferably represented by the following General Formula (1).



(1)

In the General Formula, R^1 to R^3 each independently represent a hydrocarbon group having 1 to 5 carbon atoms, and n represents an integer of 1 to 3.
[0021] The above R^1 to R^3 are preferably independently an alkyl group having 1 to 3 carbon atoms, more preferably an alkyl group having 1 or 2 carbon atoms.
[0022] The n is preferably 1 or 2.
[0023] Specific examples of the betaine represented by the General Formula (1) include N,N,N-trimethylglycine.
[0024] One of the hydrogen bond acceptors described above may be used individually, or two or more of the hydrogen bond acceptors may be used in combination.

<Hydrogen Bond Donor>

[0025] The hydrogen bond donor contained in the lubricant of the present embodiment is not limited as long as the hydrogen bond donor forms a eutectic with a hydrogen bond acceptor. However, since the halogen atom content in the lubricant of the present embodiment needs to be 0.1% by mass or less as mentioned above, the hydrogen bond donor preferably does not contain a halogen atom. More specifically, the hydrogen bond donor is more preferably one or more selected from an alcohol, a carboxylic acid, and a nitrogen-containing compound.

[0026] The alcohol is preferably an alcohol having 1 to 20 carbon atoms, more preferably 2 to 6 carbon atoms.

[0027] Specific examples of the alcohol include polyols such as ethylene glycol, triethylene glycol, glycerin, pentaerythritol, dipentaerythritol, hexanediol, 1,4-butanediol, glucose, sucrose, xylose, mannitol, sorbitol, xylitol, D-sorbitol, and fructose; and aromatic alcohols such as phenol, cresol, resorcinol, hydroquinone, and phloroglucinol.

[0028] The carboxylic acid is preferably a carboxylic acid having 1 to 20 carbon atoms, more preferably 1 to 12 carbon atoms, still more preferably 2 to 6 carbon atoms.

[0029] Specific examples of the carboxylic acid include fatty acids such as formic acid, acetic acid, propionic acid, butanoic acid, pentanoic acid, hexanoic acid, heptanoic acid, octanoic acid, nonanoic acid, decanoic acid, dodecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid, octadecanoic acid, eicosanoic acid, docosanoic acid, tetracosanoic acid, hexacosanoic acid, octacosanoic acid, and triacontanoic acid; hydroxy acids such as lactic acid, tartaric acid, malic acid, ascorbic acid, and citric acid; dicarboxylic acids such as adipic acid, malonic acid, oxalic acid, succinic acid, suberic acid, and itaconic acid; tricarboxylic acids such as 1,2,3-propanetricarboxylic acid; aromatic carboxylic acids such as benzoic acid, phenylacetic acid, 3-phenylpropionic acid, 4-hydroxybenzoic acid, caffeic acid, p-coumaric acid, trans-cinnamic acid, and gallic acid; and keto acids such as levulinic acid.

[0030] The nitrogen-containing compound is preferably a nitrogen-containing compound having 1 to 20 carbon atoms, more preferably 1 to 12 carbon atoms, still more preferably 1 to 6 carbon atoms.

[0031] Specific examples of the nitrogen-containing compound include urea, thiourea, 1-methylurea, 1,3-dimethylurea, 1,1-dimethylurea, acetamide, benzamide, imidazole, and benzimidazole.

[0032] One of the hydrogen bond donors described above may be used individually, or two or more of the hydrogen bond donors may be used in combination.

[0033] In the lubricant of the present embodiment, preferably, the content of the hydrogen bond acceptor with respect to the total amount of the lubricant is 25 to 75% by mass, and the content of the hydrogen bond donor with respect to the total amount of the lubricant is 25 to 75% by mass. More preferably, the content of the hydrogen bond acceptor with respect to the total amount of the lubricant is 35 to 65% by mass, and the content of the hydrogen bond donor with respect to the total amount of the lubricant is 35 to 65% by mass. Still more preferably, the content of the hydrogen bond acceptor with respect to the total amount of the lubricant is 40 to 60% by mass, and the content of the hydrogen bond donor with respect to the total amount of the lubricant is 40 to 60% by mass.

[0034] Regarding the molar ratio between the content of the hydrogen bond acceptor and the content of the hydrogen bond donor in the lubricant of the present embodiment, the hydrogen bond donor is preferably at 0.1 to 20 moles, more preferably at 0.2 to 5.0 moles, still more preferably at 0.5 to 4.0 moles, especially preferably at 0.8 to 3.0 moles with respect to 1 mole of the hydrogen bond acceptor.

<Mineral Oils and Synthetic Oils>

[0035] The lubricant of the present embodiment preferably contains only the deep eutectic solvent from the viewpoint of carbon neutrality, but may contain one or more selected from a mineral oil and a synthetic oil, or may contain a mineral oil and a synthetic oil. Even in cases where the lubricant of the present embodiment contains one or more selected from a mineral oil and a synthetic oil, the amount of the mineral oil and the synthetic oil used can be reduced compared to conventional lubricating oils depending on the amount of the deep eutectic solvent blended. Therefore, the lubricant can contribute to the achievement of carbon neutrality.

[0036] Thus, from the viewpoint of carbon neutrality, the total content of the mineral oil and/or the synthetic oil in the lubricant of the present embodiment is preferably 0 to 50% by mass, more preferably 0 to 30% by mass, still more preferably 0 to 10% by mass with respect to the total amount of the lubricant.

[0037] Examples of the mineral oil include atmospheric residues obtained by atmospheric distillation of a crude oil, such as paraffinic crude oil, intermediate base crude oil, and naphthenic crude oil; distillates obtained by distillation of these atmospheric residues under reduced pressure; and mineral oils obtained by subjecting the distillates to one or more of refining treatments such as solvent deasphalting, solvent extraction, hydrogenolysis, solvent dewaxing, catalytic dewaxing, and hydrorefining.

[0038] Examples of the synthetic oil include poly-α-olefins such as α-olefin homopolymers and α-olefin copolymers (for example, α-olefin copolymers having 8 to 14 carbon atoms, such as ethylene-α-olefin copolymers); isoparaffin; esters such as polyol esters and dibasic acid esters; ethers such as polyphenyl ethers; polyalkylene glycol; alkyl benzene; alkyl

naphthalene; and GTL base oils obtained by isomerization of waxes (GTL waxes (Gas To Liquids WAX)) produced from natural gas by the Fischer-Tropsch process or the like.

[0039] The kinematic viscosity and the viscosity index of the lubricant of the present embodiment are not limited. For example, the kinematic viscosity at 100°C is preferably 1.0 mm^2/s or more, more preferably 2.0 mm^2/s or more, still more preferably 2.5 mm^2/s or more, and is preferably 50.0 mm^2/s or less, more preferably 30.0 mm^2/s or less, still more preferably 20.0 mm^2/s or less. These upper limit values and lower limit values may be arbitrarily combined. More specifically, the kinematic viscosity is preferably 1.0 to 50.0 mm^2/s, more preferably 2.0 to 30.0 mm^2/s, still more preferably 2.5 to 20.0 mm^2/s.

[0040] The viscosity index of the lubricant is preferably 80 or more, more preferably 90 or more, still more preferably 100 or more.

[0041] In the present description, the kinematic viscosity and the viscosity index mean those values measured or calculated according to JIS K 2283:2000.

[0042] The lubricant of the present embodiment may contain a lubricant additive in addition to the deep eutectic solvent.

[0043] Examples of the lubricant additive that may be selected include those conventionally used as lubricating oil additives, such as one or more selected from the group consisting of an antioxidant, a detergent dispersant, an extreme pressure agent, an oiliness agent, a pour point depressant, a viscosity index improver, a rust inhibitor, a copper deactivator, and an anti-foaming agent.

[0044] In the present description, the additives such as a pour point depressant, a viscosity index improver, and an anti-foaming agent may be in the forms of solutions in which the additives are diluted and dissolved in part of the lubricant, another base oil, or the like from the viewpoint of ease of handling and solubility in the lubricant.

[0045] In cases where the lubricant of the present embodiment contains a lubricant additive, the content of the deep eutectic solvent is not limited, and is, for example, preferably 60 to 99% by mass, more preferably 70 to 98% by mass, still more preferably 80 to 97% by mass, especially preferably 85 to 95% by mass with respect to the total amount (100% by mass) of the lubricant.

[0046] The lubricant of the present embodiment may be in the form of a grease composition containing a thickener as well as the lubricant additive.

[Method for Lubrication]

[0047] A method for lubrication of the present embodiment uses the lubricant, and is, more specifically, a method in which lubrication between metal components is achieved by the presence of the lubricant.

[Method for Producing Lubricant]

[0048] A method for producing the lubricant of the present embodiment includes a step of obtaining a deep eutectic solvent by mixing a hydrogen bond acceptor with a hydrogen bond donor.

[0049] Details of the hydrogen bond acceptor and the hydrogen bond donor are the same as those described above.

[0050] A method for producing the lubricant of the present embodiment includes: a step of mixing a lubricant additive at least one of a time during the step of obtaining the deep eutectic solvent in the method for producing the lubricant and a time after the step.

[0051] Details of the lubricant additive are the same as those described above.

[Uses of Lubricant]

[0052] Examples of uses of the lubricant of the present embodiment include application for internal combustion engines, application for driving systems, hydraulic oils, automatic transmission oils, manual transmission oils, shock absorber oils, gear oils, fluid bearing oils, rolling bearing oils, oil retaining bearing oils, slideway oils, refrigerator oils, cutting oils, plastic working oils and other metal processing oils, heat treatment oils, and heating medium oils.

Examples

[0053] The present invention is described below in more detail by way of Examples. However, the present invention is not limited by these examples. The components used in the Examples and Comparative Examples, and the properties of the lubricants obtained were measured by the following methods.

<Kinematic Viscosity and Viscosity Index>

[0054] Measurement or calculation was performed according to JIS K 2283:2000.

Example 1

[0055] In a beaker containing a stirring bar, 11.7 g of N,N,N-trimethylglycine in a solid form as a hydrogen bond acceptor and 18.4 g of glycerin in a viscous liquid form as a hydrogen bond donor were placed, and the resulting mixture was stirred at 80°C for 1 hour, to obtain an entirely uniform transparent liquid as a result.

[0056] The lubricant obtained was subjected to measurement of the kinematic viscosity at 40°C and the viscosity index, and a reciprocating dynamic friction test was carried out under the following conditions to measure the coefficient of dynamic friction at the 30th reciprocating sliding movement.

[Reciprocating Dynamic Friction Test]

[0057]

- Ball material: SUJ2 1/2 inch
- Sliding material: Stainless steel (SUS304), steel plate (SPCC-SD)
- Test temperature: 30°C
- Number of times of sliding movement: 30 times of reciprocating movement
- Sliding speed: 5 mm/s
- Stroke width: 20 mm
- Load: 1.0 kgf

Example 2

[0058] In a beaker containing a stirring bar, 11.7 g of N,N,N-trimethylglycine in a solid form as a hydrogen bond acceptor and 13.4 g of malic acid in a solid form as a hydrogen bond donor were placed, and the resulting mixture was stirred at 80°C for 1 hour, to obtain an entirely uniform transparent liquid as a result.

[0059] The lubricant obtained was subjected to measurement of the kinematic viscosity at 40°C and the viscosity index, and a reciprocating dynamic friction test was carried out to measure the coefficient of dynamic friction at the 30th reciprocating sliding movement.

Comparative Example 1

[0060] A mineral oil of 500 neutral fraction was subjected to measurement of the kinematic viscosity at 40°C and the viscosity index, and a reciprocating dynamic friction test was carried out to measure the coefficient of dynamic friction at the 30th reciprocating sliding movement.

Comparative Example 2

[0061] A lubricant was prepared in the same manner as in Example 1 except that 27.8 g of tetrabutylammonium chloride (TBAC) was used as a hydrogen bond acceptor, and that 20.0 g of dodecanoic acid was used as a hydrogen bond donor.

[0062] The lubricant obtained was subjected to measurement of the kinematic viscosity at 40°C and the viscosity index, and a reciprocating dynamic friction test was carried out to measure the coefficient of dynamic friction at the 30th reciprocating sliding movement.

Comparative Example 3

[0063] A lubricant was prepared in the same manner as in Example 1 except that 13.9 g of choline chloride was used as a hydrogen bond acceptor, and that 13.4 g of glycerin was used as a hydrogen bond donor.

[0064] The lubricant obtained was subjected to measurement of the kinematic viscosity at 40°C and the viscosity index, and a reciprocating dynamic friction test was carried out to measure the coefficient of dynamic friction at the 30th reciprocating sliding movement.

Table 1

	Hydrogen bond acceptor	Hydrogen bond donor	Reciprocating dynamic friction test	
			Stainless steel	Steel plate
Example 1	Trimethylglycine	Glycerin	0.25	0.15

(continued)

	Hydrogen bond acceptor	Hydrogen bond donor	Reciprocating dynamic friction test	
			Stainless steel	Steel plate
Example 2	Trimethylglycine	Malic acid	0.19	0.13
Comparative Example 1	None (500 N mineral oil)		0.35	0.26
Comparative Example 2	TBAC	Dodecanoic acid	0.16	0.13
Comparative Example 3	Choline chloride	Glycerin	0.25	0.15

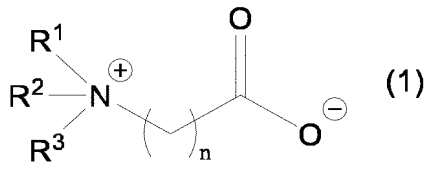
[0065] The lubricants prepared in Examples 1 and 2 had low coefficients of friction in the reciprocating dynamic friction test, and hence were found to have excellent lubricating properties.

Claims

1. A lubricant comprising a deep eutectic solvent consisting of a hydrogen bond acceptor and a hydrogen bond donor, the lubricant having a halogen atom content of 0.1% by mass or less.

2. The lubricant according to claim 1, wherein the hydrogen bond acceptor is betaine.

3. The lubricant according to claim 2, wherein the betaine is represented by the following General Formula (1):



(1)

wherein R^1 to R^3 each independently represent a hydrocarbon group having 1 to 5 carbon atoms, and n represents an integer of 1 to 3.

4. The lubricant according to any one of claims 1 to 3, wherein the hydrogen bond donor is one or more selected from an alcohol, a carboxylic acid, and a nitrogen-containing compound.

5. The lubricant according to any one of claims 1 to 4, wherein the hydrogen bond donor is glycerin or malic acid.

6. The lubricant according to any one of claims 1 to 5, further comprising one or more selected from the group consisting of a mineral oil and a synthetic oil.

7. The lubricant according to any one of claims 1 to 6, comprising the deep eutectic solvent at 50% by mass or more with respect to the total amount of the lubricant.

8. The lubricant according to any one of claims 1 to 7, wherein the content of the hydrogen bond acceptor with respect to the total amount of the lubricant is 25 to 75% by mass, and the content of the hydrogen bond donor with respect to the total amount of the lubricant is 25 to 75% by mass.

9. The lubricant according to any one of claims 1 to 8, further comprising a lubricant additive.

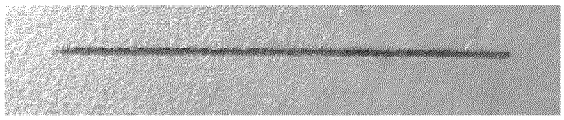
10. A method for lubrication using the lubricant according to any one of claims 1 to 9.

11. A method for producing the lubricant according to any one of claims 1 to 9, the method comprising a step of obtaining the deep eutectic solvent by mixing the hydrogen bond acceptor with the hydrogen bond donor.

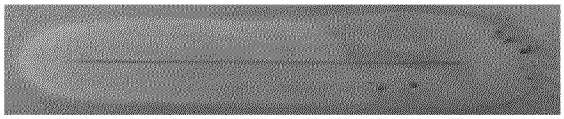
12. The method for producing the lubricant according to claim 11, further comprising a step of mixing a lubricant additive at least one of a time during the step of obtaining the deep eutectic solvent and a time after the step.

[Fig. 1]

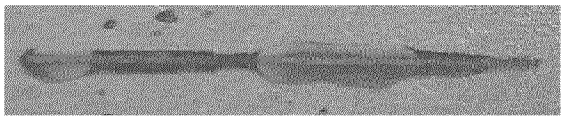
[Fig. 2]



[Fig. 3]



[Fig. 4]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/011986

A. CLASSIFICATION OF SUBJECT MATTER

C10M 177/00(2006.01)i; *C10N 30/00*(2006.01)n; *C10N 30/06*(2006.01)n; *C10N 30/12*(2006.01)n; *C10N 40/02*(2006.01)n; *C10N 40/04*(2006.01)n; *C10N 40/06*(2006.01)n; *C10N 40/08*(2006.01)n; *C10N 40/20*(2006.01)n; *C10N 40/22*(2006.01)n; *C10N 40/24*(2006.01)n; *C10N 40/25*(2006.01)n; *C10N 40/30*(2006.01)n; *C10N 70/00*(2006.01)n; ***C10M 105/08***(2006.01)i; ***C10M 105/14***(2006.01)i; ***C10M 105/22***(2006.01)i; ***C10M 105/26***(2006.01)i; ***C10M 105/60***(2006.01)i

FI: C10M105/60; C10M177/00; C10M105/22; C10M105/14; C10M105/26; C10M105/08; C10N40:24; C10N40:30; C10N70:00; C10N40:25; C10N40:04; C10N40:06; C10N40:08; C10N40:20 A; C10N40:22; C10N30:06; C10N30:00 Z; C10N30:12; C10N40:02

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)

C10M177/00; C10N30/00; C10N30/06; C10N30/12; C10N40/02; C10N40/04; C10N40/06; C10N40/08; C10N40/20; C10N40/22; C10N40/24; C10N40/25; C10N40/30; C10N70/00; C10M105/08; C10M105/14; C10M105/22; C10M105/26; C10M105/60

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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

JSTPlus/JMEDPlus/JST7580 (JDreamIII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2018/0223210 A1 (EXXONMOBIL CHEMICAL PATENTS INC.) 09 August 2018 (2018-08-09) claims 1, 20, 22, paragraphs [0030], [0040], [0057], [0082], [0112], examples 8-9, 17	1-12
Y	claim 22, paragraphs [0040], [0057], [0082], examples 8-9	5-6, 9, 12
X	MU, Liwen et al. Structural strategies to design bio-ionic liquid: Tuning molecular interaction with lignin for enhanced lubrication. Journal of Molecular Liquids. 2019, 280, pp. 49-57, https://doi.org/10.1016/j.molliq.2019.02.022 abstract, sections 2-4	1-4, 7-8, 10-11
Y	abstract, sections 2-4	6, 9, 12
A	entire text, all drawings	5

☑ 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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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 June 2023	**13 June 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/011986

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KHAN, Amzad et al. Aminoguanidine-based deep eutectic solvents as environmentally-friendly and high-performance lubricant additives. Journal of Molecular Liquids. 2021, 339, 116829, https://doi.org/10.1016/j.molliq.2021.116829 abstract, sections 2-4	1, 4, 6-8, 10-11
Y	abstract, sections 2-4	5, 9, 12
A	entire text, all drawings	2-3
X	ANTUNES, Monica et al. Deep eutectic solvents (DES) based on sulfer as alternative lubricants for silicon surfaces. Journal of Molecular Liquids. 2019, 295, 111728, http://doi.org/10.1016/j.molliq.2019.111728 abstract, sections 2-4	1, 4, 7-8, 10-11
Y	abstract, sections 2-4	5-6, 9, 12
A	entire text, all drawings	2-3
X	DONATO, T. Mariana et al. Eutectic systems containing an ionic liquid and PEG200 as lubricants for silicon surfaces: Effect of the mixture's molar ratio. Journal of Molecular Liquids. 21 January 2022, 350, 118572, http://doi.org/10.1016/j.molliq.2022.118572 abstract, sections 2-4	1, 4, 7-8, 10-11
Y	abstract, sections 2-4	5-6, 9, 12
A	entire text, all drawings	2-3

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/011986

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2018/0223210 A1	09 August 2018	(Family: none)	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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