



(11)

**EP 4 682 229 A1**

(12)

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

(43) Date of publication:  
**21.01.2026 Bulletin 2026/04**

(21) Application number: **23926689.3**

(22) Date of filing: **13.03.2023**

(51) International Patent Classification (IPC):  
**C10M 105/32** <sup>(2006.01)</sup> **C10M 141/00** <sup>(2006.01)</sup>  
**C10N 30/08** <sup>(2006.01)</sup> **C10N 30/06** <sup>(2006.01)</sup>  
**C10N 30/10** <sup>(2006.01)</sup> **C10N 40/04** <sup>(2006.01)</sup>

(52) Cooperative Patent Classification (CPC):  
**C10M 105/32; C10M 141/00; C10N 2030/06;**  
**C10N 2030/08; C10N 2030/10; C10N 2040/04**

(86) International application number:  
**PCT/CN2023/080975**

(87) International publication number:  
**WO 2024/187330 (19.09.2024 Gazette 2024/38)**

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

Designated Extension States:  
**BA**

Designated Validation States:  
**KH MA MD TN**

(71) Applicant: **Klueber Lubrication München GmbH & Co. KG**  
**81379 München (DE)**

(72) Inventors:  
• **EGERSDOERFER, Karl**  
**Shanghai 201700 (CN)**

- **WANG, Wei**  
**Shanghai 201700 (CN)**
- **ZHANG, Fuqiang**  
**Shanghai 201700 (CN)**
- **SCHMIDT-AMELUNXEN, Martin**  
**Shanghai 201700 (CN)**
- **KILTHAU, Thomas**  
**Shanghai 201700 (CN)**

(74) Representative: **Kuhn, Daniela**  
**Freudenberg Technology**  
**Innovation SE & Co. KG**  
**Hoehnerweg 2-4**  
**69469 Weinheim (DE)**

(54) **LUBRICANT AND APPLICATION THEREOF, AND PREPARATION METHOD**

(57) A lubricant and a use and a preparation method thereof are disclosed. The lubricant comprises: (i) at least 45 wt% of an aromatic ester base material, based on a weight of the lubricant; (ii) from 10 wt% to 45 wt% of a polyisobutylene, based on the weight of the lubricant; (iii) an antioxidant comprising from 1 wt% to 15 wt% of a first antioxidant having a melting point higher than 75 °C, based on the weight of the lubricant; and (iv) not more than 4.5 wt% of an extreme pressure anti-wear agent, based on the weight of the lubricant. The present disclosure helps to reduce fume emissions and alleviate environmental pollution, while satisfying lubricants' main performance indicators at a relatively low cost.

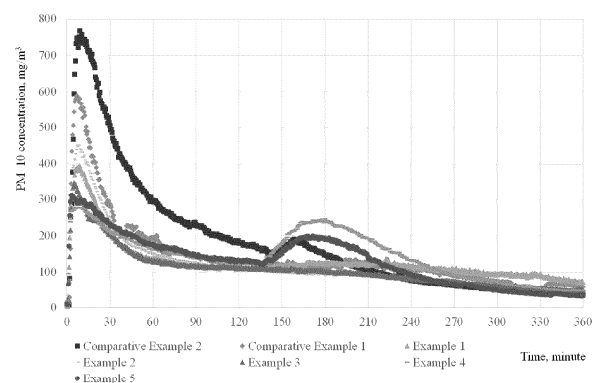


FIG. 1

**Description**

## TECHNICAL FIELD

- 5 **[0001]** The present disclosure relates to the field of lubrication technology, and in particular to a lubricant and a use and a preparation method thereof.

## BACKGROUND

- 10 **[0002]** Some existing lubricants are not very ideal. For example, some lubricants are relatively costly, which brings relatively big economic pressure to a relevant user. For another example, during use, especially in a high temperature environment of from 200°C to 250°C, some lubricants tend to produce relatively more fume, which pollutes the environment and does not meet relatively high environmental protection requirements. Correspondingly, preparation methods of the lubricants are often unsatisfactory. Furthermore, the defects often impose certain restrictions on uses of the
- 15 corresponding lubricants.

- [0003]** To solve the above problems, Chinese patent application publication Nos. CN105441164A, CN101240219A, CN105008500A, and CN105176638A, international patent application publication No. WO2008031393A2, and US patent application publication No. US20140200169A1 respectively disclose exploration and research results of their respective inventors. However, in practice, there is still room for improvement in the existing lubricants and uses and preparation
- 20 methods thereof.

- [0004]** Therefore, there is a need to improve existing lubricants and uses and preparation methods thereof.

## SUMMARY

- 25 **[0005]** Technical problems solved by the present disclosure include that there is room for improvement in the cost, fume emission and other aspects of the existing lubricants and uses and preparation methods thereof.

- [0006]** One aspect of embodiments of the present disclosure relates to a lubricant comprising: (i) at least 45.0 wt% of an aromatic ester base material based on a weight of the lubricant; (ii) from 10.0 wt% to 45.0 wt% of a polyisobutylene based on the weight of the lubricant; (iii) an antioxidant comprising from 1.0 wt% to 15.0 wt% based on the weight of the lubricant of
- 30 a first antioxidant having a melting point above 75°C; and (iv) not more than 4.5 wt% of an extreme pressure anti-wear agent based on the weight of the lubricant.

- [0007]** In some embodiments, the melting point of the first antioxidant is in a range of from 80°C to 165°C.

- [0008]** In some embodiments, the first antioxidant includes at least one first amine-based antioxidant.

- [0009]** In some embodiments, the first antioxidant includes at least one first amine-based antioxidant and at least one
- 35 first phenol-based antioxidant.

- [0010]** In some embodiments, the first antioxidant includes from 1.0 wt% to 3.0 wt% of the first phenol-based antioxidant based on the weight of the lubricant.

- [0011]** In some embodiments, a content of the first amine-based antioxidant is greater than that of the first phenol-based antioxidant.

- 40 **[0012]** In some embodiments, the antioxidant includes from 1.0 wt% to 8.0 wt% of the first amine-based antioxidant based on the weight of the lubricant.

- [0013]** In some embodiments, the antioxidant includes a second antioxidant having a melting point not higher than 75°C.

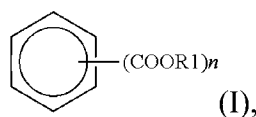
- [0014]** In some embodiments, the antioxidant is substantially free of a second antioxidant having a melting point not higher than 75°C.

- 45 **[0015]** In some embodiments, a weight of the antioxidant is in a range of from 3.0 wt% to 8.0 wt% based on the weight of the lubricant.

- [0016]** In some embodiments, the first amine-based antioxidant includes at least one selected from a group consisting of: 4,4'-diocetyldiphenylamine, 4,4'-di-( $\alpha,\alpha$ -dimethylbenzyl)diphenylamine, N-phenyl-N'-(p-toluenesulfonyl)-p-phenylenediamine, N-(4-tert-butylphenyl)- $\alpha$ -naphthylamine, N,N'-bis(1,4-dimethylpentyl)-p-phenylenediamine, 4,4'-bis-(phenylisopropyl)diphenylamine, and 4,4'-diheptyldiphenylamine.
- 50

- [0017]** In some embodiments, the first phenol-based antioxidant includes at least one selected from a group consisting of: pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate], 4,4'-thiobis(5-methyl-2-tert-butylphenol), 3-(3,5-di-tert-butyl-4-hydroxyphenyl) isooctyl acrylate, hexamethylenebis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], and 2-propionic acid 3-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]-1,6-hexanediol ester.

- 55 **[0018]** In some embodiments, the aromatic ester base material is an aromatic ester of formula (I):



wherein R1 is a linear or branched alkyl group having from 8 to 14 carbon atoms, and n is 3 or 4.

**[0019]** In some embodiments, the aromatic ester base material is selected from a group consisting of esters of trimellitic acid, pyromellitic acid, trimesic acid, and hemipyromellitic acid, wherein R1 is a linear or branched alkyl group having from 8 to 12 carbon atoms.

**[0020]** In some embodiments, the aromatic ester base material includes a trimellitate having a molecular weight in a range of from 500 g/mol to 1500 g/mol.

**[0021]** In some embodiments, the aromatic ester base material is in a range of from 55 wt% to 85 wt% based on the weight of the lubricant.

**[0022]** In some embodiments, the polyisobutylene is an unhydrogenated homopolymer having a number average molecular weight in a range of from 1000 g/mol to 3000 g/mol.

**[0023]** In some embodiments, the polyisobutylene is in a range of from 28 wt% to 35 wt% based on the weight of the lubricant.

**[0024]** In some embodiments, the extreme pressure anti-wear agent is in a range of from 0.1 wt% to 3.5 wt% based on the weight of the lubricant.

**[0025]** In some embodiments, the extreme pressure anti-wear agent comprises at least two or three selected from a group consisting of: alkylated triphenyl thiophosphates, a mixture of tert-butylphenyl phosphates, amine-neutralized phosphate esters, dithiophosphate derivatives, triphenyl phosphate derivatives, triphenyl thiophosphate derivatives, and acid phosphate amine salts.

**[0026]** In some embodiments, the lubricant is substantially free of a Type I base oil, a Type II base oil, a Type III base oil, and/or a poly- $\alpha$ -olefin.

**[0027]** In some embodiments, the lubricant has at least one property selected from a group consisting of: a) a cumulative fume amount of less than 25g/m<sup>3</sup> in first 120 minutes; b) a peak PM10 concentration of less than 500mg/m<sup>3</sup>, or less than 350mg/m<sup>3</sup>; c) a kinematic viscosity of at least 100mm<sup>2</sup>/s at 40°C measured based on ASTM D445; d) a viscosity index of at least 115 measured according to ASTM D 2270; e) a flash point of at least 280°C; and f) an evaporation loss of about 50% or less measured after evaporation at 230°C for 72 hours.

**[0028]** Another aspect of embodiments of the present disclosure relates to a lubricant comprising: (I) from 55.0 wt% to 70 wt% of an aromatic ester base material, based on a weight of the lubricant; (II) from 28.0 wt% to 35.0 wt% of a polyisobutylene, based on the weight of the lubricant; (III) from 3.0 wt% to 8.0 wt% of an antioxidant, based on the weight of the lubricant, the antioxidant comprising a first antioxidant having a melting point higher than 75°C; the first antioxidant comprising at least one first amine-based antioxidant and in some embodiments at least one first phenol-based antioxidant, and a content of the first amine-based antioxidant is greater than or equal to that of the first phenol-based antioxidant; and (IV) not more than 4.5 wt% of an extreme pressure anti-wear agent, based on the weight of the lubricant.

**[0029]** Yet another aspect of embodiments of the present disclosure relates to a use of the lubricant as described herein for lubricating a chain, a chain roller or a belt of a continuous press at a temperature in a range of from 200°C to 250°C.

**[0030]** Still another aspect of embodiments of the present disclosure relates to a method of preparing the lubricant as described in the present application, and the method comprises steps: A) blending the aromatic ester base material, the polyisobutylene, the antioxidant, and the extreme pressure anti-wear agent; and B) stirring at a temperature not lower than the melting point of the first antioxidant for at least 30 minutes to obtain the lubricant.

**[0031]** If technical conditions permit, technical features of various embodiments of the present application can be combined arbitrarily to obtain new technical solutions within the scope of protection.

**[0032]** The embodiments of the present disclosure will be further described below with reference to the accompanying drawings and detailed description.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0033]** FIG. 1 shows a curve of PM10 concentration over time in the fume test of lubricant samples of Experimental Examples 1-5 and Comparative Examples 1-2 of the present disclosure.

## DETAILED DESCRIPTION

**[0034]** One aspect of embodiments of the present disclosure relates to a lubricant comprising: (i) at least 45.0 wt% of an aromatic ester base material, based on a weight of the lubricant; (ii) from 10.0 wt% to 45.0 wt% of a polyisobutylene, based on the weight of the lubricant; (iii) an antioxidant comprising from 1.0 wt% to 15.0 wt% of a first antioxidant having a melting

point higher than 75°C, based on the weight of the lubricant; and (iv) not more than 4.5 wt% of an extreme pressure anti-wear agent, based on the weight of the lubricant.

**[0035]** The technical solution of the embodiment of the present disclosure can help to reduce fume emissions while meeting various major indicators of lubricants at a relatively low cost, to alleviate pollution to the environment and meet relatively higher environmental protection requirements.

**[0036]** For example, aromatic ester base materials, polyisobutylene, etc. have relatively low costs, so the cost of the lubricant of the embodiment of the present application is relatively low. The experimental examples described below show that the lubricant of the embodiment of the present application not only meets the various main properties of lubricants but also has relatively fewer fume emissions at high temperatures, and relatively less pollution to the environment, and meets relatively higher environmental protection requirements.

**[0037]** In the embodiments of the present disclosure, unless otherwise specified, the lubricant can play a role of lubrication, auxiliary cooling, rust prevention, cleaning, sealing, buffering, etc. The lubricant can be applied between two objects in relative motion to reduce the friction and wear caused by the contact between the two objects. The lubricant can be used on various types of mechanical equipment to protect the machinery and processed parts. The lubricant can be liquid or semi-solid.

**[0038]** In the embodiments of the present disclosure, unless otherwise specified, the weight percentage can be the percentage of the component weight to the total weight of the lubricant.

**[0039]** In the embodiments of the present application, the terms "first", "second" and similar terms are not intended to indicate order of precedence, priority, importance, etc., but are only used to help distinguish the materials, and should not be understood as improper limitations on the scope of protection.

**[0040]** The antioxidant can help to delay the oxidation of the base oil during storage and use, thereby extending the service life of the lubricant.

**[0041]** Referring to the experimental examples described hereinafter, when the antioxidant includes a first antioxidant having a melting point higher than 75°C, unexpectedly, the fume performance of the lubricant is significantly improved, and the amount of fume and the fume concentration generated at high temperatures are significantly lower. The content of the first antioxidant in the lubricant of the present disclosure can be in a range of from 1.0 wt% to 15.0 wt%, from 1.0 wt% to 12.0 wt%, from 1.0 wt% to 10.0 wt%, from 1.2 wt% to 10.0 wt%, from 1.5 wt% to 10.0 wt%, from 2.0 wt% to 10.0 wt%, from 2.0 wt% to 8.0 wt%, from 2.0 wt% to 6.0 wt%, from 2.0 wt% to 5.0 wt%, from 2.5 wt% to 5.0 wt%, from 3.0 wt% to 5.0 wt%, or in a range between any two of the foregoing values, based on the weight of the lubricant.

**[0042]** The first antioxidant can be a solid.

**[0043]** In some embodiments, the melting point of the first antioxidant is higher than 76°C, higher than 77°C, higher than 78°C, higher than 80°C, higher than 85°C, or higher than 90°C. In some embodiments, the melting point of the first antioxidant is not higher than 300°C, not higher than 280°C, not higher than 250°C, not higher than 220°C, not higher than 200°C, not higher than 180°C, not higher than 170°C, or not higher than 165°C. In some embodiments, the first antioxidant has a melting point in a range of from 76°C to 300°C, from 77°C to 280°C, from 78°C to 250°C, from 80°C to 250°C, from 80°C to 220°C, from 80°C to 200°C, from 80°C to 180°C, from 80°C to 165°C, or a range between any two of the foregoing values. In this way, it can help to effectively reduce the amount and concentration of fume of the lubricant.

**[0044]** The first antioxidant can include any suitable type of antioxidant.

**[0045]** In some embodiments, the first antioxidant includes at least one first amine-based antioxidant. The first amine-based antioxidant can be an amine-based antioxidant having a melting point higher than 75°C.

**[0046]** Unless otherwise specified, the term "at least" before a number in the present application means greater than or equal to the number, for example, at least one can include one, two, three...

**[0047]** In some embodiments, the first antioxidant includes at least one first amine-based antioxidant and at least one first phenol-based antioxidant. The first phenol-based antioxidant can be a phenol-based antioxidant with a melting point higher than 75°C.

**[0048]** The experimental examples described hereinafter show that the lubricant comprising at least one first amine-based antioxidant and at least one first phenol-based antioxidant has better fume performance, and produces less and lower concentration fume at high temperature than the lubricant having first amine-based antioxidant but without the first phenol-based antioxidant. It can be seen that the first amine-based antioxidant and the first phenol-based antioxidant can produce a synergistic effect and have a better fume reduction effect.

**[0049]** The first antioxidant can include any suitable amount of the first phenol-based antioxidant.

**[0050]** In some embodiments, the first antioxidant comprises from 1.0 wt% to 10.0 wt%, from 1.0 wt% to 8.0 wt%, from 1.0 wt% to 6.0 wt%, from 1.0 wt% to 5.0 wt%, from 1.0 wt% to 3.0 wt%, or from 1.0 wt% to 2.0 wt%, or in a range between any two of the foregoing values of the first phenol-based antioxidant, based on the weight of the lubricant. In some embodiments, the first antioxidant can be substantially free of the first phenol-based antioxidant.

**[0051]** The first antioxidant can include any suitable amount of the first amine-based antioxidant.

**[0052]** In some embodiments, the antioxidant includes from 1.0 wt% to 15.0 wt%, from 1.0 wt% to 12.0 wt%, from 1.0 wt% to 10.0 wt%, from 1.0 wt% to 8.0 wt%, from 1.0 wt% to 6.0 wt%, from 1.0 wt% to 5.0 wt%, or from 1.0 wt% to 4.0 wt%, or

in a range between any two of the foregoing values of the first amine-based antioxidant, based on the weight of the lubricant.

**[0053]** The first antioxidant can include any suitable amount of the first amine-based antioxidant and the first phenol-based antioxidant.

**[0054]** In some embodiments, a content of the first amine-based antioxidant is greater than that of the first phenol-based antioxidant.

**[0055]** The experimental examples show that compared with the lubricant in which the content of the first amine-based antioxidant is not greater than that of the first phenol-based antioxidant, the lubricant in which the content of the first amine-based antioxidant is greater than that of the first phenol-based antioxidant has better fume performance, and produces less and lower concentration fume at high temperature.

**[0056]** In some embodiments, the antioxidant includes a second antioxidant having a melting point not higher than 75°C. The second antioxidant can be an antioxidant having a melting point not higher than 75°C.

**[0057]** In some embodiments, the antioxidant is substantially free of a second antioxidant having a melting point not higher than 75°C.

**[0058]** Unless otherwise specifically stated, "substantially free of" and similar terms herein can mean: a content of 0, a content that is too low to be detected, or a content lower than or equal to a certain value, etc. The certain value can be a content value that does not affect the performance or state of the lubricant, such as 0.1 wt% based on the weight of the lubricant.

**[0059]** Depending on whether the second antioxidant and/or other antioxidant(s) are present, the weight of the antioxidant can be the weight of the first antioxidant, or a sum of the weights of the first antioxidant and the second antioxidant and/or other antioxidant(s).

**[0060]** In some embodiments, the weight of the antioxidant is in a range of from 1.0 wt% to 25.0 wt%, from 1.0 wt% to 20.0 wt%, from 1.0 wt% to 15.0 wt%, from 1.0 wt% to 12.0 wt%, from 1.5 wt% to 10.0 wt%, from 2.0 wt% to 10.0 wt%, from 2.0 wt% to 8.0 wt%, from 2.0 wt% to 6.0 wt%, from 2.0 wt% to 5.0 wt%, from 2.5 wt% to 5.0 wt%, from 3.0 wt% to 8.0 wt%, or between any two of the foregoing values, based on the weight of the lubricant.

**[0061]** In some embodiments, the antioxidant is selected from a group consisting of: N-phenyl-N'-isopropyl-p-phenylenediamine, N,N'-di(1,4-dimethylpentyl)-p-phenylenediamine, N-phenyl-N'-(p-toluenesulfonyl)-p-phenylenediamine, monononyl diphenylamine, dinonyl diphenylamine, trinonyl diphenylamine, butyloctyl-diphenylamine, 4,4'-di(phenylisopropyl)diphenylamine, 4,4'-diheptyl diphenylamine, 4,4'-dioctyl diphenylamine,  $\alpha$ -naphthylamine, N-phenyl- $\alpha$ -naphthylamine, N-phenyl-1,1,3,3-tetramethylbutyl- $\alpha$ -naphthylamine, N-butylphenyl- $\alpha$ -naphthylamine, N-pentylphenyl- $\alpha$ -naphthylamine, N-hexyl phenyl- $\alpha$ -naphthylamine, N-heptylphenyl- $\alpha$ -naphthylamine, N-octylphenyl- $\alpha$ -naphthylamine, N-nonylphenyl- $\alpha$ -naphthylamine, N-dodecylphenyl- $\alpha$ -naphthylamine, 4,4'-thiobis(5-methyl-2-tert-butylphenol), diethylene thiobis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], 3-(3,5-di-tert-butyl-4-hydroxyphenyl) isooctyl acrylate, pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], hexamethylenebis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], 2-propionic acid, 3-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]-1,6-hexanediol, and 3-(3',5'-di-tert-butyl-4'-hydroxyphenyl)propionic acid octadecyl ester.

**[0062]** The first amine-based antioxidant can include a p-phenylenediamine compound, a mono/polyalkyl diphenylamine compound, and/or a naphthylamine compound.

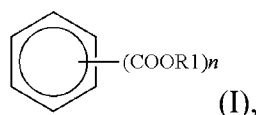
**[0063]** In some embodiments, the first amine-based antioxidant includes at least one selected from a group consisting of: 4,4'-dioctyl diphenylamine, 4,4'-di-( $\alpha,\alpha$ -dimethylbenzyl) diphenylamine, N-phenyl-N'-(p-toluenesulfonyl)-p-phenylenediamine, N-(4-tert-butylphenyl- $\alpha$ -naphthylamine), N,N'-bis(1,4-dimethylpentyl)-p-phenylenediamine, 4,4'-bis-(phenylisopropyl) diphenylamine, and 4,4'-diheptyl diphenylamine. The first amine-based antioxidant can include one, two, three or ... selected from the aforementioned group.

**[0064]** The first phenol-based antioxidant can be a high molecular weight phenol including a thioether group or other group.

**[0065]** In some embodiments, the first phenol-based antioxidant includes at least one selected from a group consisting of: pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate], 4,4'-thiobis(5-methyl-2-tert-butylphenol), 3-(3,5-di-tert-butyl-4-hydroxyphenyl) isooctyl acrylate, hexamethylene bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate], and 2-propionic acid 3-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]-1,6-hexanediol ester. The first phenol-based antioxidant can include one, two, three or ... selected from the aforementioned group.

**[0066]** In the embodiment of the present disclosure, the aromatic ester base material can be the base oil of the lubricant. The aromatic ester base material has excellent high and low temperature performance, low evaporation rate at high temperature, low carbon deposition, and good compatibility with other components of the lubricant.

**[0067]** In some embodiments, the aromatic ester base material is an aromatic ester of formula (I):



wherein R1 is a linear or branched alkyl group having from 8 to 14 carbon atoms, and n is 3 or 4.

**[0068]** In some embodiments, the aromatic ester base material is selected from a group consisting of esters of trimellitic acid, pyromellitic acid, trimesic acid, and hemipyromellitic acid, wherein R1 is a linear or branched alkyl group having from 8 to 12 carbon atoms. The aromatic ester base material can be selected from a group consisting of trimellitates, pyromellitates, trimesic acid esters, and hemipyromellitates.

**[0069]** In some embodiments, the aromatic ester base material includes a trimellitate with a molecular weight in a range of from 500 g/mol to 1500 g/mol. Trimellitates with different molecular weights can be used in correspondence with different viscosity grades of the lubricants.

**[0070]** In some embodiments, the aromatic ester base material is in a range of from 55 wt% to 85 wt%, from 55 wt% to 75 wt%, from 55 wt% to 70 wt%, from 56 wt% to 67 wt%, from 60 wt% to 65 wt%, or a range between any two of the foregoing values, based on the weight of the lubricant. Different weight percentages of aromatic ester base materials can be used in correspondence with different viscosity grades of the lubricants.

**[0071]** In the embodiment of the present disclosure, the polyisobutylene can function as the base oil of the lubricant and the viscosity improver of the lubricant. The polyisobutylene can hardly generate carbon deposits under high temperature conditions, but can have a tendency to decompose.

**[0072]** In some embodiments, the polyisobutylene is an unhydrogenated homopolymer having a number average molecular weight in a range of from 1000 g/mol to 3000 g/mol. Polyisobutylene with different molecular weights can be used in correspondence with different viscosity grades and viscosity indexes of the lubricants.

**[0073]** Selecting a reasonable amount of the polyisobutylene is of great significance to preventing the lubricant from dripping. Use of a polyisobutylene in an excessive amount can increase the viscosity of the lubricant at room temperature, which is not preferred in use; use of a polyisobutylene in a too small amount can reduce a thickness of the lubricant film and affect the adhesion performance.

**[0074]** In some embodiments, the polyisobutylene is present in a range of from 10 wt% to 45 wt%, from 15 wt% to 45 wt%, from 20 wt% to 45 wt%, from 20 wt% to 35 wt%, from 25 wt% to 35 wt%, from 28 wt% to 35 wt%, from 28 wt% to 33 wt%, from 30 wt% to 35 wt%, from 30 wt% to 33 wt%, or a range between any two of the foregoing values, based on the weight of the lubricant.

**[0075]** The extreme pressure anti-wear agent can prevent wear, scratch and even sintering of a metal surface when the metal surface bears a load. The extreme pressure anti-wear agent can generally form a protective film with the metal surface under local high temperature and high pressure conditions.

**[0076]** The extreme pressure anti-wear agent can include at least one of triphenyl phosphate derivatives, triphenyl thiophosphate derivatives, dithiophosphate derivatives, amine-neutralized phosphates, and acid phosphate amine salts.

**[0077]** Components of the extreme pressure anti-wear agent in certain content combinations can have a synergistic effect with each other and can have a good compatibility with other ingredients.

**[0078]** In some embodiments, the extreme pressure anti-wear agent is not more than 4.5 wt%, not more than 4.0 wt%, not more than 3.0 wt%, not more than 2.0 wt%, not more than 1.5 wt%, or not more than 1.0 wt%, based on the weight of the lubricant, for example, being in a range of from 0.1 wt% to 4.5 wt%, from 0.1 wt% to 4.0 wt%, from 0.5 wt% to 4.5 wt%, from 0.5 wt% to 4.0 wt%, from 0.5 wt% to 3.5 wt%, from 0.5 wt% to 1.5 wt%, or from 0.5 wt% to 1.0 wt%, or a range between any two of the foregoing values. In this way, it can help the lubricant to have a relatively strong load capacity and anti-wear ability.

**[0079]** In some embodiments, the extreme pressure anti-wear agent comprises at least two or three selected from a group consisting of: alkylated triphenyl thiophosphates, a mixture of tert-butylphenyl phosphates, amine-neutralized phosphate esters, dithiophosphate derivatives, triphenyl phosphate derivatives, triphenyl thiophosphate derivatives, and acid phosphate amine salts. In this way, the load capacity and anti-wear ability of the lubricant can be relatively strong.

**[0080]** In addition to the above components, the lubricant can include additives of any suitable type and amount, such as an anti-corrosion agent in a range of from 0.01 wt% to 2.0 wt%, from 0.01 wt% to 1.0 wt%, from 0.05 wt% to 0.5 wt%, from 0.05 wt% to 0.3 wt%, from 0.05 wt% to 0.2 wt%, or a range between any two of the foregoing values, based on the weight of the lubricant. The anti-corrosion agent can form a firm adsorption film on the metal surface, isolate the metal surface from contact with water or oxygen in the air, destroy conditions for electrochemical reactions, and thus prevent the occurrence of corrosion. The anti-corrosion agent can include benzotriazole derivatives. Benzotriazole derivatives can also be used as non-ferrous metal passivators, and mainly used to form a protective film layer on the surface of non-ferrous metals such as copper, thereby protecting parts made of copper and other non-ferrous metals and helping non-ferrous metals such as copper resist corrosion.

**[0081]** In some embodiments, the lubricant is substantially free of a type I base oil, a type II base oil, a type III base oil

and/or a poly- $\alpha$ -olefin, which can help the lubricant to be used in a relatively high temperature environment.

**[0082]** A Type I base oil can also be called a Group I base oil. A Type I base oil can have a sulfur content of greater than 0.03%, a saturated hydrocarbon content of less than 90%, and a viscosity index of from 80 to 120. Type I base oils are mainly used in light load conditions with relatively low requirements.

**[0083]** A Type II base oil can also be called a Group II base oil. A Type II base oil can have a sulfur content of less than 0.03%, a saturated hydrocarbon content of greater than 90%, and a viscosity index of from 80 to 120. Group II base oils' performance, purities, colors and oxidation resistances are improved compared to Group I base oils.

**[0084]** A Type III base oil can also be called a Group III base oil. A Type III base oil can have a sulfur content of less than 0.03%, a saturated hydrocarbon content of greater than 90%, and a viscosity index of greater than 120. Group III base oils have higher viscosities than Group II base oils and can be used in situations with relatively high requirements. At the same time, pollutants are reduced when a Type III base oil is used.

**[0085]** Poly- $\alpha$ -olefin is a synthetic base oil, and is also referred to as PAO. Poly- $\alpha$ -olefin can be prepared by polymerizing ethylene to obtain an alpha olefin, and then further polymerizing and hydrogenating such alpha olefin. If the alpha-olefin is a decene, it can be called a polydecene; if the alpha-olefin is a dodecene, it can be called a polydodecene. A poly- $\alpha$ -olefin can also be polymers of a mixed decene and a dodecene.

**[0086]** The lubricant of the embodiment of the present disclosure meets various main indicators of lubricants and has excellent fume performance.

**[0087]** The fume performance test of the lubricant in the embodiment of the present application can be performed using a TSI fume tester and an oven at a temperature of 240°C. A cumulative fume amount in first 120 minutes is obtained by integrating an area of a curve of a concentration of particulate matter with a particle size of not greater than 10 microns (PM10) over time, and a peak PM10 concentration is measured.

**[0088]** In some embodiments, the lubricant has at least one property selected from a group consisting of: a) a cumulative fume amount in first 120 minutes of less than 25g/m<sup>3</sup>, less than 23g/m<sup>3</sup>, less than 21g/m<sup>3</sup>, or less than 20g/m<sup>3</sup>; b) a PM10 concentration peak of less than 500 mg/m<sup>3</sup>, less than 450 mg/m<sup>3</sup>, less than 400 mg/m<sup>3</sup>, less than 350 mg/m<sup>3</sup>, or less than 300 mg/m<sup>3</sup>; c) a kinematic viscosity at 40° C measured based on ASTM D445 of at least 100 mm<sup>2</sup>/s, at least 200 mm<sup>2</sup>/s, at least 220 mm<sup>2</sup>/s, or at least 260 mm<sup>2</sup>/s, being in a range of for example, from 220 mm<sup>2</sup>/s to 460 mm<sup>2</sup>/s, from 260 mm<sup>2</sup>/s to 460 mm<sup>2</sup>/s, or from 260 mm<sup>2</sup>/s to 320 mm<sup>2</sup>/s; d) a viscosity index measured according to ASTM D 2270 of at least 115, at least 118, at least 119, or at least 120; e) a flash point of at least 280°C, at least 282°C, at least 285°C, at least 288°C, or at least 290°C; and f) an evaporation loss of about 50%, 40%, 35%, 30%, 25%, 20%, or less measured after evaporation at 230°C for 72 hours.

**[0089]** Another aspect of embodiments of the present disclosure relates to a lubricant comprising: (I) from 55.0 wt% to 70 wt% of an aromatic ester base material, based on a weight of the lubricant; (II) from 28.0 wt% to 35.0 wt% of a polyisobutylene, based on the weight of the lubricant; (III) from 3.0 wt% to 8.0 wt% of an antioxidant, based on the weight of the lubricant, the antioxidant comprising a first antioxidant having a melting point higher than 75°C; the first antioxidant comprising at least one first amine-based antioxidant and optionally at least one first phenol-based antioxidant, and a content of the first amine-based antioxidant being greater than or equal to that of the first phenol-based antioxidant; and (IV) not more than 4.5 wt% of an extreme pressure anti-wear agent, based on the weight of the lubricant.

**[0090]** Related descriptions of the lubricant, the aromatic ester base material, the polyisobutylene, the antioxidant, the first antioxidant, the first amine-based antioxidant, the first phenol-based antioxidant, and the extreme pressure anti-wear agent can be referred to above and are not repeated here.

**[0091]** The experimental examples show that a lubricant comprising at least one first amine-based antioxidant having a melting point over 75°C and optionally at least one first phenol-based antioxidant having a melting point over 75°C, and having a content of the first amine-based antioxidant greater than or equal to that of the first phenol-based antioxidant content, correspondingly exhibits better fume performance than lubricant samples comprising less first amine-based antioxidant than first phenol-based antioxidant, and samples comprising no first phenol-based antioxidant, and samples comprising no first antioxidant with a melting point over 75°C, and generates less and lower concentration of fume at high temperature.

**[0092]** The lubricant described in the present application can be used in scenarios with relatively high temperatures, such as from 200°C to 250°C, and with relatively high requirements on fume performance.

**[0093]** Yet another aspect of embodiments of the present disclosure relates to a use of the lubricant as described herein for lubricating a chain, a chain roller or a belt of a continuous press at a temperature in a range of from 200°C to 250°C.

**[0094]** The continuous press can be a continuous automatic press, can be equipped with a continuous automatic feeding robot, and delivers a workpiece to a next station in sequence by means of a movement of a chain, a chain roller or a belt, thereby enabling multi-step highspeed production.

**[0095]** The lubricant described in the present application can play a role of lubrication, auxiliary cooling, rust prevention, cleaning, sealing, buffering, etc. on a chain, a chain roller or a belt of a continuous press, and can reduce a friction and a wear of the chain, the chain roller or the belt to protect the chain, the chain roller or the belt.

**[0096]** The continuous press can be used in a stentering machine, wood processing, automobile coating lines, food

baking and canning industries, etc.

**[0097]** Still another aspect of embodiments of the present disclosure relates to a method of preparing the lubricant as described in the present application, and the method comprises steps: A) blending the aromatic ester base material, the polyisobutylene, the antioxidant, and the extreme pressure anti-wear agent; and B) stirring at a temperature not lower than the melting point of the first antioxidant for at least 30 minutes to obtain the lubricant.

**[0098]** The preparation method involved in the present application fully dissolves each component in the base oil and mixes the entire lubricant system evenly through sufficient stirring, has simple operation and low cost, and obtains a lubricant with an excellent performance.

**[0099]** In some embodiments, the temperature being not lower than the melting point of the first antioxidant is in a range of from 80°C to 165°C.

**[0100]** The following experimental examples can be used to help understand the embodiments of the present disclosure and are not intended to be used as limitations on the claims.

#### Experimental Examples

**[0101]** According to corresponding weight percentages of Comparative Example 1 and Examples 1-5 as shown in table 1 below, trimellitate, polyisobutylene, amine-based antioxidant, phenol-based antioxidant, extreme pressure anti-wear agent and corrosion inhibitor were blended respectively, and stirred at a constant temperature for 30 minutes at a temperature (e.g., in a range of from 80°C to 165°C) that is not lower than the melting point of the amine-based antioxidant and the phenol-based antioxidant to obtain lubricants of Comparative Example 1 and Examples 1-5. A composition of a certain brand of commercially available high-temperature chain lubricant as comparative Example 2 and melting points of various solid antioxidants are all listed in Table 1 below.



Table 1

|                                                   |                                                                             | melting point | Comparative Example 1 | Example 1 | Example 2 | Example 3 | Example 4 | Example 5 | Comparative Example 2 |
|---------------------------------------------------|-----------------------------------------------------------------------------|---------------|-----------------------|-----------|-----------|-----------|-----------|-----------|-----------------------|
| trimellitate, %                                   |                                                                             | /             | 66.9                  | 65.5      | 64.3      | 63.3      | 60.9      | 56.4      | 64.6                  |
| polyisobutylene, %                                |                                                                             | /             | 31.0                  | 31.0      | 31.0      | 31.0      | 31.0      | 31.0      | 30.7                  |
| amine-                                            | N-phenyl-                                                                   | 75°C          | 1.0                   | 1.0       |           | 1.0       |           |           | 1                     |
| based antioxidant                                 | 1,1,3,3-tetramethylbutyl - $\alpha$ -naphthylamine, %                       |               |                       |           |           |           |           |           |                       |
|                                                   | 4,4'-dioctyldiphenylamine, %                                                | 80-90°C       |                       | 1.0       | 1.0       | 1.0       |           | 2.0       |                       |
|                                                   | di-nonyl dianiline                                                          | N/A           |                       |           |           |           |           |           | 1                     |
|                                                   | 4,4'-di-( $\alpha$ , $\alpha$ -dimethylbenzyl) diphenylamine, %             | 98.5°C        |                       |           |           |           |           |           |                       |
|                                                   | N-dodecylphenyl - $\alpha$ -naphthylamine, %                                | N/A           |                       |           | 1.0       |           | 2.0       | 2.0       |                       |
| phenol-based antioxidant                          | N-phenyl-N'-(p-toluenesulfonyl)-p-phenylenediamine, %                       | 128-131°C     |                       |           |           | 1.0       | 2.0       | 2.0       |                       |
|                                                   | pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)]             | 110-120°C     |                       | 1.0       |           |           |           | 2.0       |                       |
| oxidant                                           | propionate], %                                                              |               |                       |           |           |           |           |           |                       |
|                                                   | 3-(3',5'-di-tert-butyl-4'-hydroxyphenyl) propionic acid octadecyl ester), % | 50-52°C       |                       |           | 1.0       |           |           |           | 1                     |
| extreme pressure anti-wear agent                  | 4,4'-thiobis(5-methyl-2-tert-butylphenol), %                                | 158-162°C     |                       |           |           | 1.0       | 1.0       |           |                       |
|                                                   | alkylated triphenyl thiophosphates %                                        | /             | 0.7                   |           | 1.5       | 1.5       | 1.5       | 1.5       |                       |
|                                                   | mixture of tert-butylphenyl phosphates, %                                   | /             |                       | 0.1       |           |           | 1.5       | 3.0       | 1.5                   |
|                                                   | amine-neutralized phosphate esters, %                                       | /             | 0.3                   | 0.3       |           |           |           |           |                       |
|                                                   | dithiophosphate derivatives, %                                              | /             |                       |           | 0.1       | 0.1       |           |           | 0.1                   |
| corrosion inhibitor: benzotriazole derivatives, % |                                                                             | /             | 0.1                   | 0.1       | 0.1       | 0.1       | 0.1       | 0.1       | 0.1                   |

**[0102]** The trimellitates, polyisobutylenes, amine-based antioxidants, phenol-based antioxidants, extreme pressure anti-wear agents, and corrosion inhibitors used in comparative example 1 and Examples 1-5 were all commercially available products. The molecular weight of trimellitate was 1177.72 g/mol. The polyisobutylene was an unhydrogenated homopolymer with a number average molecular weight  $M_n$  of 1300 g/mol, and a dispersion index (Polydispersity Index) obtained by dividing the weight average molecular weight  $M_w$  by the number average molecular weight  $M_n$  of 1.65.

**[0103]** Observed colors and performance results of lubricant samples of Examples 1-5 and Comparative Examples 1-2 are listed in Table 2 below.

Table 2

|                                                                                  | Comparative Example 1       | Example 1               | Example 2               | Example 3               | Example 4               | Example 5               | Comparative Example 2   |
|----------------------------------------------------------------------------------|-----------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| color                                                                            | light yellow                | yellow                  | yellow                  | yellow                  | orange                  | orange                  | yellow                  |
| flash point, °C                                                                  | 273                         | 285                     | 282                     | 291                     | 289                     | 293                     | 290                     |
| kinematic viscosity at 40° C, mm <sup>2</sup> /s                                 | 258                         | 261                     | 264                     | 263                     | 268                     | 275                     | 258                     |
| viscosity index                                                                  | 121                         | 120                     | 122                     | 122                     | 119                     | 118                     | 145                     |
| friction coefficient                                                             | about 0.21                  | about 0.18              | about 0.08              | about 0.10              | about 0.13              | about 0.12              | about 0.09              |
| evaporation loss, %                                                              | 45.9                        | 29.1                    | 30.7                    | 26.5                    | 21.7                    | 19.8                    | 37.8                    |
| lubricant shear viscosity after high temperature experiment, mPas                | 9790                        | 3290                    | 3470                    | 2720                    | 2250                    | 1930                    | 4580                    |
| coking performance                                                               | poor                        | medium                  | medium                  | quite good              | quite good              | quite good              | excellent               |
| carbon deposit solubility                                                        | semi-painted 60-80% soluble | powdery 80-100% soluble | powdery 80-100% soluble | powdery 80-100% soluble | powdery 80-100% soluble | powdery 80-100% soluble | powdery 80-100% soluble |
| cumulative fume amount (integrated area) in first 120 minutes, mg/m <sup>3</sup> | 27118.35                    | 20792.05                | 22848.6                 | 19287.8                 | 21521.25                | 22835.05                | 42442                   |
| PM10 concentration peak value, mg/m <sup>3</sup>                                 | 589                         | 393                     | 451                     | 345                     | 287                     | 312                     | 767                     |

**[0104]** The flash point, the kinematic viscosity at 40°C and the viscosity index of each lubricant sample in table 2 were obtained respectively according to the following lubricant testing national standards: ASTM D 92, ASTM D445 and ASTM D 2270.

**[0105]** The friction coefficient of each lubricant sample was tested according to the German Institute for Standardization standard DIN51834. The test conditions included: ball/disc, load 250N, temperature: from 50°C to 250°C, 1mm, 50Hz.

**[0106]** In the high temperature experiment, 5 grams of lubricant sample was placed in a closed aluminum pan, heated at 230°C and evaporated for 72 hours, and the remaining sample was weighed to measure an evaporation loss of the sample. Then, the shear viscosity of the remaining sample was tested using a model Physica MCR 302 Anton Paar rheometer at  $D = 300/s$  and  $T = 25^\circ C$  according to standard DIN 51810-1.

**[0107]** The coking performance test of each lubricant sample reproduced an interval lubrication method used when lubricating a chain using a Brückner central lubrication system. That is, in a high temperature environment of 240°C, the lubricant sample was controlled by an external peristaltic pump and dripped onto a 316L standard test steel plate with an inclination angle of 34° at fixed time intervals. The test cycle was 48 hours. After the experiment, the mass change of the test steel plate was weighed, and the coking performance of each lubricant sample was evaluated in combination with a surface appearance of the test steel plate.

**[0108]** In the carbon deposit solubility test, a certain mass of lubricant sample was placed in a curved steel plate and baked at 250°C in an oven for 72 hours to make the lubricant sample volatilize, decompose, and have no fluidity. The remaining carbon deposits in the plate were found to have a powdery or semi-painted appearance and characteristics. A same mass of carbon deposit was dispersed in a same volume of corresponding fresh lubricant sample that had not been baked, stirred and dissolved, and the soluble percentage of each lubricant sample was obtained based on the amount of soluble carbon deposit.

**[0109]** The fume test of each lubricant sample was conducted using a TSI fume tester and an oven at a temperature of 240°C. The concentration data curve of particulate matter with a particle size of equal to or less than 10 microns (PM10) obtained in 360 minutes is shown in FIG. 1. The cumulative fume amount (integrated area) and PM10 concentration peak value obtained in the first 120 minutes of the test are listed in Table 2 above.

**[0110]** Referring to Table 2, it can be seen that the lubricant samples of Examples 1-5 of the present disclosure had the color that was same as or similar to that of the commercially available product sample of Comparative Example 2, flash points each higher than 280°C, and relatively good high temperature resistances, and can meet temperature requirements of different market applications.

**[0111]** The lubricant samples of Examples 1-5 of the present disclosure were comparable to or better than the lubricant samples of Comparative Examples 1-2, or acceptable in terms of viscosity, friction coefficient, etc.

**[0112]** Evaporation losses of the lubricant samples of Examples 1-5 of the present disclosure were significantly lower than those of Comparative Examples 1-2, which can reduce the lubricant consumption, extend the lubrication cycle, reduce fume generation, reduce environmental pollution and harm to the health of on-site operators, and also save oil costs for users.

**[0113]** The coking performance and carbon deposit solubility of the lubricant samples of Examples 1-5 of the present disclosure were at least acceptable, which can reduce the probability of failure of lubricated machine components during operation, thereby reducing the cost of downtime maintenance and ensuring long-term stable operation of the equipment.

**[0114]** It can be seen from Table 2 and FIG. 1 that compared with Comparative Examples 1-2 that did not comprise a first antioxidant with a melting point higher than 75°C, Examples 1-5 of the present disclosure that contained at least one first antioxidant with a melting point higher than 75°C resulted to better fume performance, and significantly lowered cumulative fume amount and PM10 concentration peak data in the first 120 minutes.

**[0115]** As shown in FIG. 1, the lubricant samples of Examples 1-5 and the lubricant samples of Comparative Examples 1-2 generally produced relatively more fume in the first 30 minutes, most reached peak values, and generally had a tendency to gradually decrease with time. PM10 concentration peaks produced by the lubricant samples of Examples 1-5 were significantly lower than those of the lubricant samples of Comparative Examples 1-2, and the cumulative amounts of fume produced by the lubricant samples of Examples 1-5 in the first 120 minutes were also significantly lower than those of the lubricant samples of Comparative Examples 1 and 2. The fume performance of the lubricant samples of Examples 1-5 was improved by about 100% compared with the lubricant sample of the commercially available product of Comparative Example 2.

**[0116]** Comparing Example 2 of the present disclosure with Comparative Example 2, it can be found that when the lubricant comprised a first antioxidant having a melting point exceeding 75°C, unexpectedly, the fume performance of the lubricant was significantly improved.

**[0117]** Further, the lubricant samples of Examples 3-5 of the present disclosure had at least one first amine-based antioxidants having melting points exceeding 75°C and at least one first phenol-based antioxidants having melting points exceeding 75°C, the first amine-based antioxidant contents of at least 2 wt% and greater than the first phenol-based antioxidant contents, and accordingly, exhibited a better fume performance than that of the lubricant samples of Examples 1 and 2 of the present disclosure having the first amine-based antioxidant contents not higher than the first phenol-based antioxidant contents or no first phenol-based antioxidant.

**[0118]** It can be seen from the above experimental examples that the present disclosure can help to meet main properties of lubricants at a relatively low cost, while emitting relatively less fume at high temperatures, causing less pollution to the environment, and meeting relatively high environmental protection requirements.

**[0119]** Those skilled in the art can understand that the embodiments of the present disclosure include the following embodiments:

1. A lubricant comprises:

- (i) at least 45.0 wt% of an aromatic ester base material, based on the weight of the lubricant;
- (ii) from 10.0 wt% to 45.0 wt% of a polyisobutylene, based on the weight of the lubricant;
- (iii) an antioxidant comprising from 1.0 wt% to 15.0 wt% of a first antioxidant having a melting point above 75°C, based on the weight of the lubricant; and
- (iv) not more than 4.5 wt% of an extreme pressure anti-wear agent, based on the weight of the lubricant.

2. In the lubricant as described in embodiment 1, the melting point of the first antioxidant is in a range of from 80°C to 165°C.

3. In the lubricant as described in embodiment 1 or 2, the first antioxidant comprises at least one first amine-based antioxidant.

4. In the lubricant as described in any one of embodiments 1 to 3, the first antioxidant comprises at least one first amine-based antioxidant and at least one first phenol-based antioxidant.

5. In the lubricant as described in any one of embodiments 1 to 4, the first antioxidant comprises from 1.0 wt% to 3.0 wt% of the first phenol-based antioxidant based on the weight of the lubricant.

6. In the lubricant as described in any one of embodiments 1 to 5, a content of the first amine-based antioxidant is greater than that of the first phenol-based antioxidant.

7. In the lubricant as described in any one of embodiments 1 to 6, the antioxidant comprises a first amine-based antioxidant in a range of from 1.0 wt% to 8.0 wt% based on the weight of the lubricant.

8. In the lubricant as described in any one of embodiments 1 to 7, the antioxidant includes a second antioxidant having a melting point not higher than 75°C.

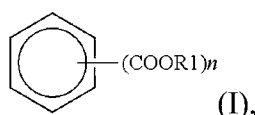
9. In the lubricant as described in any one of embodiments 1 to 8, the antioxidant is substantially free of a second antioxidant with a melting point not higher than 75°C.

10. In the lubricant according to any one of embodiments 1 to 9, a weight of the antioxidant is in a range of from 3.0 wt% to 8.0 wt% based on the weight of the lubricant.

11. In the lubricant as described in any one of embodiments 1 to 10, the first amine-based antioxidant includes at least one selected from a group consisting of: 4,4'-dioctyldiphenylamine, 4,4'-di-( $\alpha,\alpha$ -dimethylbenzyl)diphenylamine, N-phenyl-N'-(p-toluenesulfonyl)-p-phenylenediamine, N-(4-tert-butylphenyl)- $\alpha$ -naphthylamine, N,N'-bis(1,4-dimethylpentyl)-p-phenylenediamine, 4,4'-bis-(phenylisopropyl)diphenylamine, and 4,4'-diheptyldiphenylamine.

12. In the lubricant as described in any one of embodiments 1 to 11, the first phenol-based antioxidant includes at least one selected from a group consisting of: pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], 4,4'-thiobis(5-methyl-2-tertbutylphenol), 3-(3,5-di-tert-butyl-4-hydroxyphenyl) isooctyl acrylate, hexamethylenebis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], and 2-propionic acid 3-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]-1,6-hexanediol ester.

13. In the lubricant according to any one of technical solutions 1 to 12, wherein the aromatic ester base material is an aromatic ester of formula (I):



wherein R1 is a linear or branched alkyl group having from 8 to 14 carbon atoms, and n is 3 or 4.

14. In the lubricant as described in any one of embodiments 1 to 13, the aromatic ester base material is selected from

esters of trimellitic acid, pyromellitic acid, trimesic acid, and hemipyromellitic acid, wherein R1 is a linear or branched alkyl group having from 8 to 12 carbon atoms.

15. In the lubricant as described in any one of embodiments 1 to 14, the aromatic ester base material comprises a trimellitate having a molecular weight in a range of from 500 g/mol to 1500 g/mol.

16. In the lubricant as described in any one of embodiments 1 to 15, the aromatic ester base material is in a range of from 55 wt% to 85 wt% based on the weight of the lubricant.

17. In the lubricant as described in any one of embodiments 1 to 16, the polyisobutylene is an unhydrogenated homopolymer having a number average molecular weight in a range of from 1000 g/mol to 3000 g/mol.

18. In the lubricant as described in any one of embodiments 1 to 17, the polyisobutylene is in a range of from 28 wt% to 35 wt% based on the weight of the lubricant.

19. In the lubricant as described in any one of embodiments 1 to 18, the extreme pressure anti-wear agent is in a range of from 0.1 wt% to 3.5 wt% based on the weight of the lubricant.

20. In the lubricant as described in any one of embodiments 1 to 19, the extreme pressure anti-wear agent comprises at least two or three selected from a group consisting of: alkylated triphenyl thiophosphate, a mixture of tert-butylphenyl phosphate, amine-neutralized phosphate esters, dithiophosphate derivatives, triphenyl phosphate derivatives, triphenyl thiophosphate derivatives, and acid phosphate amine salts.

21. The lubricant as described in any one of embodiments 1 to 20 is substantially free of Type I, Type II and Type III base oils and/or poly- $\alpha$ -olefins.

22. The lubricant as described in any one of embodiments 1 to 21 has at least one property selected from a group consisting of:

- a) a cumulative fume amount in first 120 minutes of less than 25g/ m<sup>3</sup>;
- b) a peak PM10 concentration of lower than 500 mg/m<sup>3</sup>, or lower than 350 mg/m<sup>3</sup>;
- c) a kinematic viscosity at 40°C of at least 100 mm<sup>2</sup>/s as measured according to ASTM D445;
- d) a viscosity index of at least 115 as measured according to ASTM D 2270;
- e) a flash point of at least 280°C; and
- f) an evaporation loss measured after evaporation at 230°C for 72 hours of about 50% or less.

23. A lubricant comprises:

- (I) from 55.0 wt% to 70 wt% of an aromatic ester base material, based on a weight of the lubricant;
- (II) from 28.0 wt% to 35.0 wt% of a polyisobutylene, based on the weight of the lubricant;
- (III) from 3.0 wt% to 8.0 wt% of an antioxidant based on the weight of the lubricant, the antioxidant comprising a first antioxidant having a melting point higher than 75°C; the first antioxidant comprising at least one first amine-based antioxidant and optionally at least one first phenol-based antioxidant, and a content of the first amine-based antioxidant is greater than or equal to that of the first phenol-based antioxidant; and
- (IV) not more than 4.5 wt% of an extreme pressure anti-wear agent, based on the weight of the lubricant.

24. A use of the lubricant of any one of embodiments 1 to 23 in lubricating a chain, a chain roller or a belt of a continuous press at a temperature in a range of from 200°C to 250°C.

25. A method of preparing the lubricant as described in any one of embodiments s 1 to 23, comprises steps:

- A) blending the aromatic ester base material, the polyisobutylene, the antioxidant, and the extreme pressure anti-wear agent; and  
 B) stirring at a temperature not lower than the melting point of the first antioxidant for at least 30 minutes to obtain the lubricant.

**[0120]** Although the present disclosure is disclosed as above, the present disclosure is not limited thereto. Any person skilled in the art can make various changes and modifications without departing from the spirit and scope of the present disclosure. Therefore, the protection scope of the present disclosure shall be subject to the scope defined by the claims.

## Claims

### 1. A lubricant, comprising:

- (i) at least 45.0 wt% of an aromatic ester base material, based on a weight of the lubricant;
- (ii) from 10.0 wt% to 45.0 wt% of a polyisobutylene, based on the weight of the lubricant;
- (iii) an antioxidant comprising from 1.0 wt% to 15.0 wt% of a first antioxidant having a melting point higher than 75 °C, based on the weight of the lubricant; and
- (iv) not more than 4.5 wt% of an extreme pressure anti-wear agent, based on the weight of the lubricant.

2. The lubricant according to claim 1 **characterized in that** the melting point of the first antioxidant is in a range of from 80°C to 165°C.

3. The lubricant according to claim 1 **characterized in that** the first antioxidant comprises at least one first amine-based antioxidant.

4. The lubricant according to claim 1 **characterized in that** the first antioxidant comprises at least one first amine-based antioxidant and at least one first phenol-based antioxidant.

5. The lubricant according to claim 4 **characterized in that** the first antioxidant comprises from 1.0 wt% to 3.0 wt% of the first phenol-based antioxidant based on the weight of the lubricant.

6. The lubricant according to claim 4 **characterized in that** a content of the first amine-based antioxidant is greater than that of the first phenol-based antioxidant.

7. The lubricant according to any one of claims 3 to 6, **characterized in that** the antioxidant comprises from 1.0 wt% to 8.0 wt% of the first amine-based antioxidant based on the weight of the lubricant.

8. The lubricant according to claim 1 **characterized in that** the antioxidant comprises a second antioxidant having a melting point not higher than 75°C.

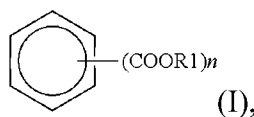
9. The lubricant according to claim 1 **characterized in that** the antioxidant is substantially free of a second antioxidant having a melting point not higher than 75°C.

10. The lubricant according to claims 1, 8 or 9 **characterized in that** a weight of the antioxidant is in a range of from 3.0 wt% to 8.0 wt% based on the weight of the lubricant.

11. The lubricant according to claims 3 or 4 **characterized in that** the first amine antioxidant comprises at least one selected from a group consisting of: 4,4'-dioctyldiphenylamine, 4,4'-di-( $\alpha,\alpha$ -dimethylbenzyl)diphenylamine, N-phenyl-N'-(p-toluenesulfonyl)-p-phenylenediamine, N-(4-tert-butylphenyl)- $\alpha$ -naphthylamine, N,N'-bis(1,4-dimethylpentyl)-p-phenylenediamine, 4,4'-bis-(phenylisopropyl)diphenylamine, and 4,4'-diheptyldiphenylamine.

12. The lubricant according to claim 4 **characterized in that** the first phenol-based antioxidant comprises at least one selected from a group consisting of: pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], 4,4'-thiobis(5-methyl-2-tert-butylphenol), 3-(3,5-di-tert-butyl-4-hydroxyphenyl) isooctyl acrylate, hexamethylenebis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], and 2-propionic acid 3-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]-1,6-hexanediol ester.

13. The lubricant according to claim 1 **characterized in that** the aromatic ester base material is an aromatic ester of formula (I):



10 wherein R1 is a linear or branched alkyl group having from 8 to 14 carbon atoms, and n is 3 or 4.

14. The lubricant according to claim 13 **characterized in that** the aromatic ester base material is selected from a group consisting of esters of trimellitic acid, pyromellitic acid, trimesic acid, and hemipyromellitic acid, wherein R1 is a linear or branched alkyl group having from 8 to 12 carbon atoms.

- 15 15. The lubricant according to claim 1 **characterized in that** the aromatic ester base material comprises a trimellitate having a molecular weight in a range of from 500 g/mol to 1500 g/mol.

16. The lubricant according to claim 1 **characterized in that** the aromatic ester base material is in a range of from 55 wt% to 85 wt% based on the weight of the lubricant.

17. The lubricant according to claim 1 **characterized in that** the polyisobutylene is an unhydrogenated homopolymer having a number average molecular weight in a range of from 1000 g/mol to 3000 g/mol.

18. The lubricant according to claim 1 **characterized in that** the polyisobutylene is in a range of from 28 wt% to 35 wt% based on the weight of the lubricant.

19. The lubricant according to claim 1 **characterized in that** the extreme pressure anti-wear agent is in a range of from 0.1 wt% to 3.5 wt% based on the weight of the lubricant.

20. The lubricant according to claim 19, **characterized in that** the extreme pressure anti-wear agent comprises at least two or three selected from a group consisting of: alkylated triphenyl thiophosphate, a mixture of tert-butylphenyl phosphate, amine-neutralized phosphate esters, dithiophosphate derivatives, triphenyl phosphate derivatives, triphenyl thiophosphate derivatives, and acid phosphate amine salts.

21. The lubricant according to claim 1, **characterized by** being substantially free of Type I, Type II and Type III base oils and/or a poly- $\alpha$ -olefin.

22. The lubricant according to claim 1 **characterized by** having at least one property selected from a group consisting of:

- 40 a) a cumulative fume amount of less than 25g/m<sup>3</sup> in a first 120 minutes;  
 b) a peak PM10 concentration of lower than 500 mg/m<sup>3</sup>, or lower than 350 mg/m<sup>3</sup>;  
 c) a kinematic viscosity of at least 100 mm<sup>2</sup>/s at 40°C as measured according to ASTM D445;  
 d) a viscosity index of at least 115 as measured according to ASTM D 2270;  
 e) a flash point of at least 280°C; and  
 45 f) an evaporation loss of about 50% or less measured after evaporation at 230°C for 72 hours.

23. A lubricant comprising:

- 50 (I) from 55.0 wt% to 70 wt% of an aromatic ester base material, based on a weight of the lubricant;  
 (II) from 28.0 wt% to 35.0 wt% of a polyisobutylene, based on the weight of the lubricant;  
 (III) from 3.0 wt% to 8.0 wt% of an antioxidant based on the weight of the lubricant, the antioxidant comprising a first antioxidant having a melting point higher than 75°C; the first antioxidant comprising at least one first amine-based antioxidant and optionally at least one first phenol-based antioxidant, and a content of the first amine-based antioxidant is greater than or equal to that of the first phenol-based antioxidant; and  
 55 (IV) not more than 4.5 wt% of an extreme pressure anti-wear agent, based on the weight of the lubricant.

24. A use of the lubricant according to any one of claims 1 to 23 for lubricating a chain, a chain roller or a belt of a continuous press at a temperature in a range of from 200°C to 250°C.

**25.** A method of preparing the lubricant according to any one of claims 1 to 23 comprising the steps of:

A) blending the aromatic ester base material, the polyisobutylene, the antioxidant, and the extreme pressure anti-wear agent; and

B) stirring at a temperature not lower than the melting point of the first antioxidant for at least 30 minutes to obtain the lubricant.

5

10

15

20

25

30

35

40

45

50

55



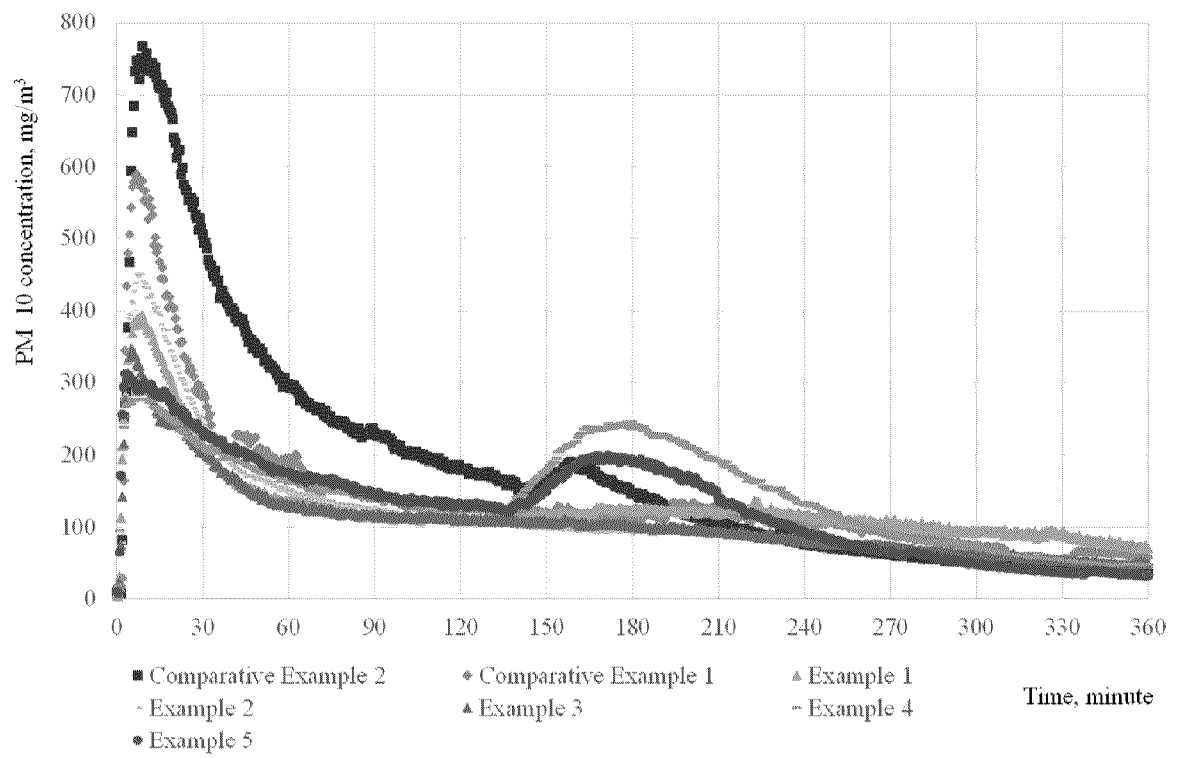


FIG. 1

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/080975

## A. CLASSIFICATION OF SUBJECT MATTER

C10M105/32(2006.01)i; C10M141/00(2006.01)i; C10N30/08(2006.01)n; C10N30/06(2006.01)n; C10N30/10(2006.01)n; C10N40/04(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)

IPC: C10M C10N30/- C10N40/-

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

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

CNXT, ENTXT, DWPI, CNKI: 润滑剂, 链条, 高温, 基础油, 芳族, 偏苯三酸, 酯, 聚异丁烯, 粘合剂, 抗氧, 胺, 酚, 烟雾, 挥发, lubricant, chains, high temperature, base oil?, aromatic, trimellitate, trimellitic acid, ester?, polyisobutylene, sticking agent, antioxidant?, amine?, phenol?, smoke, volatilization

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                        | Relevant to claim No. |
|-----------|---------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | DE 102006043747 A1 (ADDINOL LUBE OIL GMBH) 27 March 2008 (2008-03-27)<br>claims 1-18, and description, paragraph 23       | 1-25                  |
| A         | DE 202006014282 U1 (ADDINOL LUBE OIL GMBH) 23 November 2006 (2006-11-23)<br>entire document                               | 1-25                  |
| A         | CN 103409209 A (SHANGHAI HIRI LUBRICATING MATERIAL TECHNOLOGY CO., LTD.) 27 November 2013 (2013-11-27)<br>entire document | 1-25                  |
| A         | CN 108865360 A (ZHENGZHOU OUPUSHI TECHNOLOGY CO., LTD. et al.) 23 November 2018 (2018-11-23)<br>entire document           | 1-25                  |
| A         | WO 2008031393 A2 (ADDINOL LUBE OIL GMBH et al.) 20 March 2008 (2008-03-20)<br>entire document                             | 1-25                  |

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Special categories of cited documents:                                                                                                                                | "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                                              |
| "A" document defining the general state of the art which is not considered to be of particular relevance                                                                | "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                                                                     |
| "D" document cited by the applicant in the international application                                                                                                    | "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 |
| "E" earlier application or patent but published on or after the international filing date                                                                               | "&" document member of the same patent family                                                                                                                                                                                                    |
| "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                                                                  |                                                                                                                                                                                                                                                  |

Date of the actual completion of the international search

**30 November 2023**

Date of mailing of the international search report

**06 December 2023**

Name and mailing address of the ISA/CN

**China National Intellectual Property Administration (ISA/  
CN)  
China No. 6, Xitucheng Road, Jimenqiao, Haidian District,  
Beijing 100088**

Authorized officer

Telephone No.

**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.

**PCT/CN2023/080975**

5

10

15

20

25

30

35

40

45

50

55

| Patent document<br>cited in search report |              |    | Publication date<br>(day/month/year) | Patent family member(s) |              |    | Publication date<br>(day/month/year) |
|-------------------------------------------|--------------|----|--------------------------------------|-------------------------|--------------|----|--------------------------------------|
| DE                                        | 102006043747 | A1 | 27 March 2008                        | None                    |              |    |                                      |
| DE                                        | 202006014282 | U1 | 23 November 2006                     | DE                      | 102006059835 | A1 | 27 March 2008                        |
| CN                                        | 103409209    | A  | 27 November 2013                     | CN                      | 103409209    | B  | 24 December 2014                     |
| CN                                        | 108865360    | A  | 23 November 2018                     | None                    |              |    |                                      |
| WO                                        | 2008031393   | A2 | 20 March 2008                        | WO                      | 2008031385   | A2 | 20 March 2008                        |
|                                           |              |    |                                      | WO                      | 2008031385   | A3 | 26 June 2008                         |
|                                           |              |    |                                      | DE                      | 112007002754 | A5 | 20 August 2009                       |
|                                           |              |    |                                      | WO                      | 2008031393   | A3 | 10 July 2008                         |
|                                           |              |    |                                      | DE                      | 202006019075 | U1 | 12 April 2007                        |
|                                           |              |    |                                      | DE                      | 112007002768 | A5 | 20 August 2009                       |

Form PCT/ISA/210 (patent family annex) (July 2022)

**REFERENCES CITED IN THE DESCRIPTION**

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

**Patent documents cited in the description**

- CN 105441164 A [0003]
- CN 101240219 A [0003]
- CN 105008500 A [0003]
- CN 105176638 A [0003]
- WO 2008031393 A2 [0003]
- US 20140200169 A1 [0003]