US 20190284499A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2019/0284499 A1

Mori et al. (43) Pub. Date: Sep. 19, 2019

(54) **LUBRICANT COMPOSITION**

(71) Applicant: **ExxonMobil Research and Engineering Company**, Annandale, NJ (US)

(72) Inventors: **Takafumi Mori**, Kawasaki-shi (JP); **Takehisa Sato**, Kawasaki-shi (JP); **Takahiro Fukumizu**, Toyota-shi (JP); **Masashi Ogawa**, Toyota-shi (JP); **Junichi Nishinosono**, (US)

(73) Assignee: **ExxonMobil Research and Engineering Company**, Annandale, NJ (US)

(21) Appl. No.: **16/347,258**

(22) PCT Filed: **Nov. 6, 2017**

(86) PCT No.: **PCT/IB2017/001330**

§ 371 (c)(1),
(2) Date: **May 3, 2019**

(30) **Foreign Application Priority Data**

Nov. 4, 2016 (JP) 2016-216039

Publication Classification

(51) **Int. Cl.**
C10M 169/04 (2006.01)

(52) **U.S. Cl.**
CPC ***C10M 169/044*** (2013.01); *C10M 2203/1006* (2013.01); *C10M 2203/1025* (2013.01); *C10M 2205/0285* (2013.01); *C10M 2207/042* (2013.01); *C10M 2207/24* (2013.01); *C10N 2260/14* (2013.01); *C10M 2219/102* (2013.01); *C10N 2230/02* (2013.01); *C10N 2230/06* (2013.01); *C10N 2230/76* (2013.01); *C10N 2240/045* (2013.01); *C10N 2260/06* (2013.01); *C10M 2209/084* (2013.01)

(57) **ABSTRACT**

The present disclosure is directed to a lubricant composition that achieves extended anti-shudder durability without causing a decrease in the metal-to-metal friction coefficient, even when the viscosity of the composition is reduced. A lubricant composition comprises (A) a lubricant base oil, (C) (C-1) a succinimide compound or boronated succinimide compound having a weight-average molecular weight of 4,000 to 7,000, (C-2) a succinimide compound or boronated succinimide compound having a weight-average molecular weight of more than 7,000 to 10,000, and (D) (D-1) an amide-based friction modifier.

LUBRICANT COMPOSITION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is the National Phase entry of International Patent Application No. PCT/IB2017/001330 filed on Nov. 6, 2017, which claims priority to Japanese Patent Application No. 2016-216039 filed on Nov. 4, 2016, the entire contents of which are hereby incorporated by reference into this application.

FIELD

[0002] The present disclosure relates to a lubricating oil composition, especially suitable for use in an automobile transmission. More specifically, the present disclosure relates to a lubricating oil composition for a non-stage transmission.

BACKGROUND

[0003] Lubricating oil compositions are widely used in the automotive field for internal combustion engines, automatic transmission, gear oil, etc. The demand for low-viscosity lubricating oil compositions has recently increased, in order to achieve fuel efficiency. In addition, as a non-stage transmission (CTV) has been replacing stepped automatic transmission and becoming widely used, metal belt CVT, in which a metal belt and a pulley are used for power transmission, has become generally used.

[0004] One method of improving the fuel economy of non-stage transmission automobiles is expanding the operating conditions of the lock-up clutch, and it requires extension of the lock-up clutch shudder prevention lifespan. Nevertheless, if the quantity of the friction conditioner is increased, in order to extend the shudder prevention lifespan, the intermetallic friction coefficient between the metal belt and the pulley decreases, the belt grip performance decreases, and the torque transmission ability decreases. Considering such a trade-off between the shudder prevention and the intermetallic friction coefficient, compatibility of both sufficient torque and shudder prevention performance at a high level has been sought after. When the viscosity of a lubricating oil composition for transmission is lowered, satisfactory intermetallic friction coefficient cannot be achieved, nor can sufficiently large torque be secured.

[0005] Examples of conventional lubricating oil compositions for a non-stage transmission are described in Patent Literatures 1 to 5. Patent Literature 1 describes a lubricating oil composition which comprises a specific boron-free succinimide compound and a phosphorus compound, and does not comprise a zinc dialkyl dithiophosphate, which significantly increases the friction coefficient between the metal belt or chain and the pulley, is capable of maintaining a high friction coefficient over a long period of time, and does not cause clogging of the clutch plates. Patent Literature 2 describes a lubricant composition comprising a sulfonate-based detergent, a salicylate-based detergent and a boron-containing succinimide-based additive at specific quantities and specific quantity ratios, which maintains satisfactory torque transmission capacity and transmission properties and excels in its shudder prevention performance. Patent Literature 3 describes a lubricating oil composition comprising specific quantities of a boronated alkylsuccinimide and/or boronated alkenylsuccinimide having a specific weight-average molecular weight and a metallic detergent having a linear alkyl group, which has a high intermetallic friction coefficient and excellent transmission properties and shudder prevention performance. Patent Literature 4 describes a lubricating oil composition comprising specific quantities of at least one selected from a specific sulfolane derivative, calcium sulfonate and calcium phenate, and a specific viscosity index improver, which has both a high intermetallic friction coefficient and combines fuel efficiency, due to low viscosity, and component durability. Patent Literature 5 describes that by combining at least 4 additives, namely calcium salicylate, phosphorus anti-wear agent, friction conditioner and dispersion-type viscosity index improving agent, as essential components, both a high intermetallic friction coefficient and shudder prevention can be achieved.

CITATION LIST

Patent Literature

[PTL 1]

[0006] JP 2006-056934 A

[PTL 2]

[0007] JP 2007-126541 A

[PTL 3]

[0008] JP 2009-215395 A

[PTL 4]

[0009] JP 2010-180278 A

[PTL 5]

[0010] JP 2000-255695 A

SUMMARY

Technical Problem

[0011] In light of the above circumstances, the present disclosure may provide a lubricating oil composition, whose intermetallic friction coefficient does not decrease and which has extended shudder prevention lifespan, even if the viscosity thereof is lowered.

Solution to Problem

[0012] As a result of painstaking research, the inventors arrived at the subject matter of the present disclosure after discovering that the shudder prevention lifespan can be extended without decreasing the intermetallic friction coefficient, even at low viscosity, if two types of succinimide compounds having specific weight-average molecular weights are combined as an ashless dispersant and used together with a specific friction modifier.

[0013] That is, the present disclosure is directed to a lubricating oil composition comprising (A) a lubricant base oil,

[0014] (C) (C-1) a succinimide compound or boronated succinimide compound having a weight-average molecular weight of 4,000 to 7,000, and (C-2) a succinimide

compound or boronated succinimide compound having a weight-average molecular weight of more than 7,000 and not more than 10,000, and

[0015] (D) (D-1) an amide friction modifier.

[0016] Moreover, in order to improve fuel economy, the viscosity may be maintained at an elevated temperature (for example, 100° C.) while decreasing the viscosity at a low temperature (for example, 40° C.), which has an effect on the fuel economy, that is, a high viscosity index, but in conventional lubricating oil compositions for a non-stage transmission, the polymer chains of the base oil and the viscosity index improver are broken by the mechanical shear, and as a result the high temperature viscosity decreases with operation.

[0017] The inventors discovered that by further specifying the compositions of the lubricant base oil (A) and the viscosity index improver in the above lubricating oil composition, the shear stability can be improved, in addition to an effect of extending the shudder prevention lifespan without decreasing the intermetallic friction coefficient.

[0018] The lubricating oil composition of the present may further comprise, as a part or all of component (A), 5 to 30 percent by weight, based on a total weight of the lubricating oil composition, of a poly-α-olefin or α-olefin copolymer having a kinematic viscosity at 100° C. of 6 to 80 mm^2/s, and further comprising (B) a polymethacrylate having a weight-average molecular weight of 15,000 to 40,000.

[0019] In addition, some embodiments of the lubricating oil composition of the present disclosure have at least one following features (1) to (11).

[0020] (1) It further comprises (D-2) a friction modifier composed of a reaction product of boric acid or boron oxide with an epoxide.

[0021] (2) A part or all of component (C-1) and component (C-2) is a boronated succinimide compound.

[0022] (3) Each of component (C-1) and/or component (C-2) contains 0.1 to 3 percent by weight of boron based on a weight of component (C-1) or component (C-2).

[0023] (4) A weight ratio of component (C-1) to component (C-2), i.e., (C-2)/(C-1), is 1 to 10.

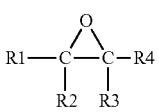
[0024] (5) The lubricating oil composition has a kinematic viscosity at 100° C. of 3 to 10 mm^2/s.

[0025] (6) The lubricating oil composition has a viscosity index of not less than 150.

[0026] (7) Component (D-1) is at least one selected from amide compounds derived from fatty acids having an alkyl or alkenyl group having 6 to 30 carbon atoms.

[0027] (8) Component (D-2) is at least one selected from reaction products of an epoxide represented by the following formula:

[Chem. 1]



wherein R1, R2, R3, and R4 each independently represent a hydrogen atom or a hydrocarbon group having 1 to 30 carbon atoms, and at least one of R1, R2, R3, and R4 is a hydrocarbon group,

[0028] with boric acid or boron oxide, or ring-opened products thereof.

[0029] (9) The lubricating oil composition further comprises (E) a metallic detergent.

[0030] (10) The lubricating oil composition further comprises (F) an ether sulfolane compound.

[0031] (11) The lubricating oil composition is for a non-stage transmission.

[0032] In particular, in some embodiments, the lubricating oil composition comprises, as a part or all of component (A), 5 to 30 percent by weight, based on a total weight of the lubricating oil composition, of a poly-α-olefin or α-olefin copolymer having a kinematic viscosity at 100° C. of 6 to 80 mm^2/s, and (E) an ether sulfolane compound. Compared with mineral oil, synthetic base oil has low affinity to the oil seal rubber called packing and gasket, and the affinity is lower as the base oil has a higher molecular weight, i.e., higher viscosity. When the affinity is low, the swelling property of the seal rubber decreases, and conversely it is easy to shrink. This causes the sealing to decrease and oil spill to occur. The lubricating oil composition of the present disclosure ensures that the seal rubber can sufficiently swell.

[0033] Moreover, the lubricating oil composition is characterized in that it has superior initial anti-shudder properties, if it further comprises (D-2) a friction modifier composed of a reaction product of boric acid or boron oxide with an epoxide.

[0034] The lubricating oil composition of the present disclosure may be capable of extending the shudder prevention lifespan without decreasing the intermetallic friction coefficient. This effect can be achieved even when the kinematic viscosity at 100° C. of the lubricating oil composition is lowered to about 5.0. In addition to the above effect, the lubricating oil compositions of the present disclosure can provide a lubricating oil composition having increased shear stability. Furthermore, it ensures that the seal rubber can sufficiently swell. Moreover, it can improve the initial anti-shudder properties. The lubricating oil composition of the present disclosure can be suitably used especially as a lubricating oil composition for a non-stage transmission.

DESCRIPTION

[0035] Each component will now be described.

[0036] (A) Lubricant Base Oil

[0037] Various types of lubricant base oils can be used as the lubricant base oil in the lubricating oil compositions of the present disclosure. The lubricant base oil includes a mineral oil, a synthetic oil or a mixture thereof. In particular, the lubricating oil composition may comprise, as a part or all of the lubricant base oil, 5 to 30 percent by weight, based on a total weight of the lubricating oil composition, of a poly-α-olefin or α-olefin copolymer having a kinematic viscosity at 100° C. of 6 to 80 mm^2/s. The lower limit of the content of the poly-α-olefin or α-olefin copolymer is 6 percent by weight or 8 percent by weight, and the upper limit is 25 percent by weight or 20 percent by weight. If the content of the above base oil is below the above lower limit, there is a possibility that a satisfactory viscosity index, i.e., a combination of fuel efficiency and protection of the machine elements, cannot be achieved, and if it exceeds the above upper limit, there is a possibility that the shear stability may decrease and the rubber adaptability may deteriorate, i.e., the rubber shrinks.

[0038] The poly-α-olefin or α-olefin copolymer has a kinematic viscosity at 100° C. of 6 to 80 mm^2/s, from 8 to 80 mm^2/s, from 8 to 60 mm^2/s, or from 9 to 40 mm^2/s. If the kinematic viscosity at 100° C. is below the above lower limit, a satisfactory viscosity index, i.e., a combination of fuel efficiency and protection of the machine elements, cannot be achieved, and if the kinematic viscosity at 100° C. exceeds the above upper limit, the shear stability decreases and the rubber adaptability deteriorates, i.e., the rubber shrinks.

[0039] The poly-α-olefin or α-olefin copolymer is a (co) polymer or a (co)oligomer of α-olefin. Various poly-α-olefin or α-olefin copolymers may be used as the lubricant base oil, as long as they have the above kinematic viscosity. The α-olefin is selected, for example, from a C_{2-14} or C_{4-12}, linear or branched olefinic hydrocarbon. Examples of the poly-α-olefin or α-olefin copolymer include 1-octene oligomer, 1-decene oligomer, ethylene-propylene oligomer, isobutene oligomer, and hydrogenated products thereof. Moreover, the poly-α-olefin or α-olefin copolymer may be manufactured using a metallocene catalyst. The weight-average molecular weight of the (co)polymer or (co)oligomer should only be such that the kinematic viscosity at 100° C. is within the above range. Its weight-average molecular weight may be, for example, from 1,000 to 10,000 or from 1,100 to 7,000. One type of poly-α-olefin or α-olefin copolymer may be used, or two or more types thereof may be used together.

[0040] The lubricating oil composition of the present disclosure may comprise other lubricant base oils in combination with the above poly-α-olefin or α-olefin copolymer. The other lubricant base oils include, but are not limited to, mineral oil-based base oils and synthetic base oils other than the above poly-α-olefin or α-olefin copolymer.

[0041] Examples of the mineral oil-based base oil include paraffinic or naphthenic lubricant base oils, obtained by distilling a crude oil at a normal atmospheric pressure and under vacuum to prepare a lubricating oil fraction and subjecting the lubricating oil fraction to a suitable combination of purification treatments such as solvent deasphalting, solvent extraction, hydrogenolysis, solvent dewaxing, catalytic dewaxing, hydrorefining, sulfuric acid treatment and clay treatment, and lubricant base oils obtained by isomerizing a wax obtained by solvent dewaxing and dewaxing the isomerized product. The kinematic viscosity of the mineral oil-based base oil is, but is not limited to, 1 to 5 mm^2/s in order to obtain a low-viscosity lubricating oil composition.

[0042] Examples of the synthetic base oil include isoparaffins, alkylbenzenes, alkylnaphthalenes, monoesters, diesters, polyol esters, polyoxyalkylenglycols, dialkyldiphenyl ethers, polyphenyl ethers, and GTL base oils. No particular restrictions are placed on the kinematic viscosity of the synthetic base oil. Furthermore, a poly-α-olefin or α-olefin copolymer having a kinematic viscosity at 100° C. of less than 6 mm^2/s or more than 80 mm^2/s can also be used. In order to obtain a low-viscosity lubricating oil composition, the kinematic viscosity of the synthetic base oil is may be from 1 to 6 mm^2/s.

[0043] The other base oils used in combination with the poly-α-olefin or α-olefin copolymer may be used alone or two or more types thereof may be used together. When two or more types thereof are used, two or more types of mineral oil-based base oils may be used, two or more types of synthetic base oils may be used, or a combination of a mineral oil-based base oil and a synthetic base oil may be used. Among them, the use of a single mineral oil-based base oil, the use of two or more types of mineral oil-based base oils, the use of a single synthetic base oil having a kinematic viscosity at 100° C. of not less than 1 mm^2/s and less than 6 mm^2/s, and the use of two or more types of synthetic base oils having a kinematic viscosity at 100° C. of not less than 1 mm^2/s and less than 6 mm^2/s may be used.

[0044] Moreover, in order to obtain a low-viscosity lubricating oil composition, the whole lubricant base oil may have a kinematic viscosity at 100° C. of 2 to 7 mm^2/s, from 2.3 to 6 mm^2/s, or from 2.5 to 5.6 mm^2/s.

[0045] (B) Viscosity Index Improver

[0046] The lubricating oil composition of the present disclosure may also comprise a viscosity index improver. The lubricating oil composition may comprise a polymethacrylate having a weight-average molecular weight of 15,000 to 40,000 as the viscosity index improver. The lower limit of the weight-average molecular weight may be 17,000 or 18,000. The upper limit of the weight-average molecular weight is 38,000 or 36,000. If the weight-average molecular weight is less than the above lower limit, the effect of the viscosity index improver is insufficient, and if the weight-average molecular weight is more than the above upper limit, the effect of viscosity index improvement is achieved, but the shear stability deteriorates. The content of the polymethacrylate is, but is not limited to, from 0.1 to 20 percent by weight, from 0.1 to 15 percent by weight, or from 2 to 10 percent by weight, based on the lubricating oil composition.

[0047] One type of the polymethacrylate may be used alone or two or more types thereof may be used in combination.

[0048] The lubricating oil composition of the present disclosure may also comprise other viscosity index improvers in combination with the polymethacrylate. Examples of other viscosity index improvers include a polymethacrylate having a weight-average molecular weight of less than 15,000, a polymethacrylate having a weight-average molecular weight of more than 40,000, a polyisobutylene and hydrogenated products thereof, a hydrogenated styrene-diene copolymer, a styrene-maleic anhydride ester copolymer, and a polyalkylstyrene. If other viscosity index improvers are contained, the content thereof may be 0.1 to 15 percent by weight based on the lubricating oil composition.

[0049] (C) Succinimide Compound

[0050] The lubricating oil composition of the present disclosure comprises, as an ashless dispersant, two types of specific succinimide compounds. In other words, the lubricating oil composition comprises (C-1) a succinimide compound having a weight-average molecular weight of from 4,000 to 7,000 or from 5,000 to 7,000, and (C-2) a succinimide compound having a weight-average molecular weight of more than 7,000 and not more than 10,000, or from 7,100 to 9,600. Hereinafter, above component (C-1) is also referred to as "the 1st succinimide compound" and above component (C-2) is also referred to as "the 2nd succinimide compound."

[0051] A part or all of component (C-1) and component (C-2) may be, but not limited to, a boronated succinimide compound.

[0052] The content of component (C) in the composition may be from 0.5 to 3.0 percent by weight, from 0.6 to 2.5

percent by weight, or from 0.9 to 2.0 percent by weight, based on the total weight of the composition. If its content is less than the above lower limit, the shudder prevention may not be secured. If the content of component (C) is more than the above upper limit, the viscosity may increase at a low temperature.

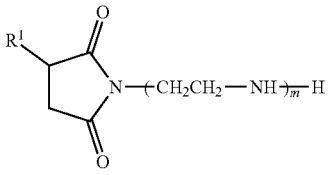
[0053] The weight ratio of component (C-1) to component (C-2), i.e., (C-2)/(C-1), may be, but is not limited to, from 1 to 10, from 1.5 to 8, or from 2 to 6. When the weight ratio is within the above range, both a favorable friction coefficient and favorable anti-shudder properties can be achieved. If the quantity of (C-1) is insufficient, the shudder prevention becomes insufficient at a low temperature, e.g., at 40° C., which is evident early in endurance testing. If the quantity of (C-2) is insufficient, the shudder prevention becomes insufficient at a high temperature, e.g., at 120° C., which is evident early in endurance testing.

[0054] The 1st and 2nd succinimide compounds the present disclosure may be a succinimide compound known publicly as an ashless dispersant.

[0055] More specifically, the succinimide compound is a compound obtained by adding succinic anhydride to polyamine. There are monotype succinimide compounds and bis-type succinimide compounds, and either can be used. The monotype succinimide compound can be represented by formula (1) below. The bis-type succinimide compound can be represented by formula (2) below.

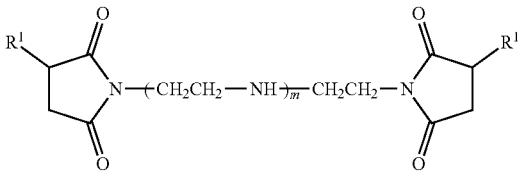
[Chem. 2]

(1)



[Chem. 3]

(2)



[0056] wherein R^1 is each independently an alkyl or alkenyl group having 40 to 400 carbon atoms, m is an integer of 1 to 20, and n is an integer of 0 to 20. In some embodiments, the succinimide compound may be a bis-type succinimide compound. As boronated succinimide compounds, a monotype succinimide compound and a bis-type succinimide compound may be used in combination, or two or more monotype succinimide compounds may be used in combination, or two or more bis-type succinimide compounds may be used in combination. The nitrogen content in the succinimide compound is, but not limited to, from 0.3 to 10 percent by weight, from 0.5 to 5 percent by weight, or from 0.8 to 2.5 percent by weight, based on the weight of the compound.

[0057] The optional boronated succinimide compound is more specifically a compound obtained by reacting a succinimide compound represented by the above formula with a boron compound. Examples of a boron compound include boric acid, boric anhydride, an ester of boric acid, boron oxide, boron halide, etc. Moreover, an example of a boronated succinimide compound is a product obtained by modifying (boronating) a succinimide compound containing in its molecule at least one alkyl or alkenyl group with boric acid, borate, or the like. Examples of the alkyl or alkenyl group include monovalent groups derived from an oligomer of an olefin such as propylene, 1-butene, and isobutylene, a co-oligomer of ethylene and propylene, or the like.

[0058] The 1st succinimide compound (C1) has a weight-average molecular weight of 4,000 to 7,000. The weight-average molecular weight may be from 5,000 to 7,000 or from 5,200 to 6,800. If the molecular weight of the 1st succinimide compound is less than the above lower limit, the anti-shudder properties deteriorate.

[0059] In the present disclosure, the weight-average molecular weight of the 1st succinimide compound is measured using an RI (differential refractometry) detector, with a solvent of THF (tetrahydrofuran), a packed column of styrene-divinyl benzene copolymer, a set temperature of 40° C., and a set flow rate of 1.0 mL/min, and is expressed in polystyrene-converted value.

[0060] When a boronated succinimide compound is used as the 1st succinimide compound, the boron content is, but not limited to, from 0.1 to 3 percent by weight, from 0.2 to 2.5 percent by weight, from 0.2 to 2 percent by weight, or from 0.2 to 1.5 percent by weight, based on the weight of the compound.

[0061] The content of the 1st succinimide compound in the lubricating oil composition is, but not limited to, from 0.05 to 2.00 percent by weight, from 0.08 to 1.80 percent by weight, or from 0.10 to 1.50 percent by weight, based on the total weight of the lubricating oil composition. If the content is less than the above lower limit, there is a possibility that sufficient washability may not be secured, and if it is more than the above upper limit, there is a possibility that sludge may be generated.

[0062] The 1st succinimide compound can be at least one selected from a succinimide compound which is not boronated and a boronated succinimide compound. Therefore, it may be selected from a single succinimide compound which is not boronated, and two or more succinimide compounds which are not boronated, a single boronated succinimide compound, two or more boronated succinimide compounds, and a combination of at least one succinimide compound which is not boronated and at least one boronated succinimide compound.

[0063] The 2nd succinimide compound (C-2) has a weight-average molecular weight of more than 7,000 and not more than 10,000. The weight-average molecular weight is 7,100 to 9,600 or from 7,500 to 9,200. If the molecular weight of the 2nd succinimide compound is more than the above upper limit, the low-temperature viscosity of the compound becomes inconveniently high.

[0064] In the present disclosure, the weight-average molecular weight of the 2nd succinimide compound is measured using an RI (differential refractometry) detector, with a solvent of THF (tetrahydrofuran), a packed column of styrenedivinyl benzene copolymer, and a set temperature of 40° C. set flow rate of 1.0 mL/min, and is expressed in polystyrene-converted value.

[0065] When a boronated succinimide compound is used as the 2nd succinimide compound, the boron content is, but not limited to, from 0.1 to 3 percent by weight, from 0.2 to 2.5 percent by weight, from 0.2 to 2 percent by weight, or from 0.2 to 1.5 percent by weight, based on the weight of the compound. The nitrogen content in the succinimide compound is, but not limited to, from 0.2 to 5.0 percent by weight, from 0.3 to 2.5 percent by weight, or from 0.5 to 2.0 percent by weight.

[0066] The content of the 2nd succinimide compound in the lubricating oil composition is, but not limited to, from 0.2 to 3.0 percent by weight, from 0.4 to 2.5 percent by weight, or from 0.6 to 2.0 percent by weight, based on the total weight of the lubricating oil composition. If the content is less than the above lower limit, there is a possibility that sufficient washability may not be secured, and if it is more than the above upper limit, the low-temperature viscosity of the composition becomes inconveniently high.

[0067] The 2nd succinimide compound can be at least one selected from a succinimide compound which is not boronated and a boronated succinimide compound. Therefore, it may be selected from a single succinimide compound which is not boronated, two or more succinimide compounds which are not boronated, a single boronated succinimide compound, two or more boronated succinimide compounds, and a combination of at least one succinimide compound which is not boronated and at least one boronated succinimide compound.

[0068] The lubricating oil composition of the present disclosure may further comprise other ashless dispersants in combination with above component (C-1) and above component (C-2). A typical example of the other ashless dispersant includes a succinimide compound.

[0069] The lubricating oil composition of the present disclosure further comprises (D)(D-1) an amide friction modifier as a component, and optionally (D-2) a friction modifier composed of a reaction product of boric acid or boron oxide with an epoxide in addition to above components (A) to (C).

[0070] (D) Friction modifiers

[0071] The lubricating oil composition comprises an amide friction modifier (D-1), and a friction modifier composed of a reaction product of boric acid or boron oxide with an epoxide (D-2) is optionally used.

[0072] The amide friction modifier (D-1) includes, but is not limited to, fatty acid amide compounds. In particular, amides of a linear fatty acid and an aliphatic monoamine or aliphatic polyamine can be used. Among them, fatty acid amide compounds having an C6-30 alkyl or alkenyl group having 6 to 30 carbon atoms can be used. Examples thereof include lauramide, lauric acid diethanolamide, lauric acid monopropanol amide, myristamide, myristic acid diethanolamide, myristic acid monopropanol amide, palmitamide, palmitic acid diethanolamide, palmitic acid monopropanol amide, stearamide, isostearamide, stearic acid dimethanolamide, isostearic acid dimethanolamide, stearic acid diethanolamide, isostearic acid diethanolamide, stearic acid monopropanol amide, isostearic acid monopropanol amide, isostearic acid tris(hydroxymethol)methylene amide, oleamide, oleic acid dimthanolamide, oleic acid diethanolamide, oleic acid monopropanol amide, coconut oil fatty acid amide, coconut oil fatty acid diethanolamide, coconut oil fatty acid monopropanol amide, C_{12-13} synthetic mixed fatty amides, C_{12-13} synthetic mixed fatty acid diethanolamides, C_{12-13} synthetic mixed fatty acid monopropanol amides, and mixtures thereof.

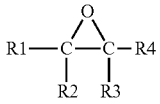
[0073] While the lubricating oil composition of the present disclosure comprises an amide friction modifier (D-1), it may also comprise other friction modifiers. It may comprise, for example, other ester friction modifiers, amine friction modifiers, alcohol friction modifiers, molybdate friction modifiers and other optional friction modifiers.

[0074] Of these, a friction modifier composed of a reaction product of boric acid or boron oxide with an epoxide (D-2) may be used, since the initial anti-shudder properties is improved by using it.

[0075] (D-2) a friction modifier composed of a reaction product of boric acid or boron oxide with an epoxide.

[0076] Friction modifiers composed of said reaction products are disclosed, for example, in JP 2000-87068 A. Examples of boric acid include various types of boric acid (including metaboric acid, HBO_2, orthoboric acid, H_3BO_3 and tetraboric acid $H_2B_4O_7$), and alkyl borates represented by the formula $(RO)_xB(OH)_y$ where x is 1 to 3, y is 0 to 2, the total of x and y is 3 and R is an alkyl group having 1 to 6 carbon atoms. Examples of the epoxide include epoxides themselves, and equivalents thereof from the reaction viewpoint, for example, diols and halohydrins. As described in detail in U.S. Pat. No. 4,584,115, it is generally prepared by reacting an epoxide (such as hydrocarbyl epoxide) with boric acid or boron trioxide. An epoxide can be represented by the following formula:

[Chem. 4]



wherein R1, R2, R3 and R4 each independently represent a hydrogen atom or a hydrocarbon group having 1 to 30 carbon atoms, and at least one of R1, R2, R3 and R4 is a hydrocarbon group. Any two of R1, R2, R3 and R4 may form a cyclic group, which may be alicyclic or heterocyclic, together with the same bonding atom.

[0077] In some embodiments, one of R1, R2, R3 and R4 is a hydrocarbon group having 6 to 30 carbon atoms, and the rest are hydrogen atoms, to which they are not limited. The hydrocarbon group having 1 to 30 carbon atoms includes, but is not limited to, an alkyl group, alkenyl group, alkynyl group, and aryl group, as well as saturated or unsaturated fatty acid residues.

[0078] Examples of saturated fatty acid residues include a caproic acid residue, caprylic acid residue, capric acid residue, lauric acid residue, myristic acid residue, palmitic acid residue, stearic acid residue and isostearic acid residue.

[0079] Examples of unsaturated fatty acid residues include linoleic acid residue, α-linolenic acid residue, γ-linolenic acid residue, arachidonic acid residue, docosapentaenoic acid residue, palmitoleic acid residue, vaccenoic acid residue, paullinic acid residue, oleic acid residue (oleyl group), elaidic acid residue, erucic acid residue and nervonic acid residue.

[0080] Such epoxides can be commercially available mixtures of C_{14-16} or C_{14-18} epoxides, which are available from ELF-Atochem or UnionCarbide, or prepared from the cor-

responding olefins using known methods. The reaction product can be prepared by mixing boric acid or boron oxide (hereinafter referred to collectively as "boric acid") and an epoxide or an equivalent thereof (hereinafter referred to collectively as "epoxide") and heating them at an appropriate temperature (typically 80° C. to 250° C.). The molar ratio of boric acid to an epoxide is generally from 4:1 to 1:4, from 1:1 to 1:3, or 1:2. When conducting the reaction, an inert liquid may be used as the reaction media. Examples of such a liquid include toluene, xylene, chlorobenzene and dimethyl formamide. Water forms during the reaction and is typically evaporated during the reaction process. Hydroxide may be used in order to facilitate the reaction. In the reaction product, the epoxide ring may have been opened. A preparation method of the reaction product is disclosed also in JP S57-200496 A.

[0081] The thus-obtained compound may be effectively used as a friction modifier and provides excellent anti-shudder properties.

[0082] Examples of component (D-2) include, but are not limited to, a borate chloride of a fatty acid epoxy ester or a ring-opened product thereof. Specific examples thereof include a borate chloride of glycidyl caprate, borate chloride of glycidyl caproate, borate chloride of glycidyl myristate, borate chloride of glycidyl palmitate, borate chloride of glycidyl oleate, borate chloride of ethyleneoxide oleate, borate chloride of glycidyl stearate, borate chloride of glycidyl isostearate and borate chloride of glycidyl laurate.

[0083] The added quantity of component (D-1) is, but not limited to, from 0.01 to 5 percent by weight, from 0.02 to 4 percent by weight, or from 0.1 to 3 percent by weight, based on the total weight of the lubricating oil composition.

[0084] Component (D-2) is optional, but when it is added, the added quantity thereof is from 0.01 to 5 percent by weight, from 0.02 to 4 percent by weight, or from 0.1 to 3 percent by weight, based on the total weight of the lubricating oil composition.

[0085] In some embodiments, the lubricating oil composition of the present disclosure further comprises (E) a metallic detergent and/or (F) an ether sulfolane compound in addition to above components (A) to (D).

[0086] (E) Metallic Detergent

[0087] A metallic detergent includes a detergent containing an alkali metal or alkaline earth metal. Examples thereof include, but are not limited to, sulfonates containing an alkali metal or alkaline earth metal, salicylates containing an alkali metal or alkaline earth metal, and phenates containing an alkali metal or alkaline earth metal. Examples of an alkali metal or alkaline earth metal include, but are not limited to, magnesium, barium, sodium and calcium.

[0088] Examples of a sulfonate containing an alkali metal or alkaline earth metal include, but are not limited to, calcium sulfonate and magnesium sulfonate.

[0089] Examples of a salicylate containing an alkali metal or alkaline earth metal include, but are not limited to, calcium salicylate and magnesium salicylate.

[0090] Examples of a phenate containing an alkali metal or alkaline earth metal include, but are not limited to, calcium phenate and magnesium phenate.

[0091] The quantity of the alkali metal or alkaline earth metal in the metallic detergent is, but not limited to, from 0.1 to 20 percent by weight, from 0.5 to 15 percent by weight, or from 1.0 to 15 percent by weight, based on the weight of the metallic detergent.

[0092] The metallic detergent has a total base number of, but not limited to, from 10 to 500 mgKOH/g, from 50 to 400 mgKOH/g, from 150 to 400 mgKOH/g, from 200 to 400 mgKOH/g, from 300 to 400 mgKOH/g, or from 310 to 400 mgKOH/g. When the total base number is within the above range, the washability effect is high and sludge generation can be prevented.

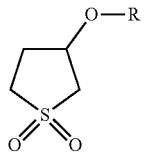
[0093] The metallic detergent may be contained at any ratio in the lubricating oil composition. The content thereof is, for example, from 0 to 5 percent by weight, from 0.1 to 2 percent by weight, or from 0.2 to 1 percent by weight, based on the total weight of the lubricating oil composition.

[0094] A single metallic detergent may be used alone, or two or more metallic detergents may be used in combination. When two or more metallic detergents are used in combination, examples of the combination include, but are not limited to, a combination of two or more sulfonate compounds, a combination of two or more salicylate compounds, a combination of two or more phenate compounds, a combination of at least one sulfonate compound and at least one salicylate compound, a combination of at least one sulfonate compound and at least one phenate compound, and a combination of at least one salicylate compound and at least one phenate compound.

[0095] (F) Ether Sulfolane Compound

[0096] By comprising an ether sulfolane compound, the lubricating oil composition of the present disclosure can secure moderate seal rubber swelling properties. The ether sulfolane compound is a compound represented by the following formula:

[Chem. 5]



wherein R is an alkyl group having 1 to 20 carbon atoms, or an alkyl group having 8 to 16 carbon atoms.

[0097] The content of the ether sulfolane compound is from 0 to 5 percent by weight, from 0.1 to 2 percent by weight, or from 0.2 to 1 percent by weight, based on the total weight of the lubricating oil composition.

[0098] The lubricating oil composition of the present disclosure may further comprise additives other than above components (B) to (F). Examples of the other additive include oiliness agents, anti-wear agents, extreme pressure agents, rust-preventive agents, friction modifiers other than the above friction modifiers, antioxidants, corrosion inhibitors, metal deactivators, pour point depressants, antifoaming agents, coloring agents, and package additives for automatic transmission fluid. Package additives for lubricating oil containing at least one of the above additives can be added.

[0099] The extreme pressure agent includes, but is not limited to, a phosphorus-based extreme pressure agent. The phosphorus-based extreme pressure agent is at least one selected from acidic phosphate, acidic phosphate phosphite, phosphate, phosphite, amine salts thereof, phosphoric acid, and phosphorous acid.

[0100] In some embodiments, the extreme pressure agent is a combination of at least one selected from acidic phosphate, acidic phosphate phosphite, phosphate, phosphite, and amine salts thereof, and at least one selected from phosphoric acid and phosphorus acid.

[0101] In some embodiments, the extreme pressure agent is a combination of at least one selected from acidic phosphate, acidic phosphate phosphite, phosphate, phosphite, amine salts thereof, and at least one selected from phosphoric acid and phosphorus acid.

[0102] In addition, a combination of an acidic phosphate and at least one compound selected from phosphoric acid and phosphorous acid may also be included. Examples of an acidic phosphate include acidic butyl phosphate, acidic hexyl phosphate, acidic octyl phosphate, and acidic dodecyl phosphate.

[0103] The quantity of the phosphorus-based extreme pressure agent is, but not limited to, from 0.01 to 2.5 percent by weight, from 0.02 to 1.5 percent by weight, or from 0.02 to 1.0 percent by weight, based on the total weight of the lubricating oil composition.

[0104] The kinematic viscosity at 100° C. of the lubricating oil composition of the present disclosure is, but not limited to, from 3 to 10 mm^2/s, from 3 to 8 mm^2/s, from 4 to 7.5 mm^2/s, or from 4 to 6 mm^2/s. When the kinematic viscosity at 100° C. of the lubricating oil composition is less than the above lower limit, it may not be possible to secure the friction coefficient. When it is more than the above upper limit, the anti-shudder properties may deteriorate.

[0105] The viscosity index of the lubricating oil composition of the present disclosure is, but not limited to, not less than 150 or not less than 160. When the viscosity index of the lubricating oil composition is less than the above lower limit, it may not be possible to sufficiently secure the fuel cost at 40° C. The upper limit thereof is, but not limited to, 250.

[0106] In spite of its low viscosity, the lubricating oil composition of the present disclosure has not only a sufficiently high intermetallic friction coefficient but also anti-shudder properties. In addition, as described above, by specifying the constitutions of the base oil and the viscosity index improver in accordance with the present disclosure, the shear stability can also be secured. Furthermore, by comprising an ether sulfolane compound, it can secure moderate seal rubber swelling properties. In addition, by using a metallic detergent having a total base number of 200 to 400 mgKOH/g, it can favorably secure washability while preventing sludge generation. The lubricating oil composition of the present disclosure can be suitably used for a non-stage transmission.

EXAMPLES

[0107] The present disclosure will now be described in greater detail by means of examples and comparative examples, but the present disclosure is not limited to these examples.

[0108] The components used in the examples and comparative examples are as follows. Lubricating oil compositions were prepared by mixing the components shown below at the amounts shown in Table 1 or Table 2. Hereinafter, KV100 means a kinematic viscosity at 100° C., VI means the viscosity index, and PMA means polymethacrylate.

[0109] (A) Lubricant Base Oil

[0110] Mineral oil 1: highly hydrorefined paraffinic base oil (KV100=3.1 mm^2/s, VI=112)

[0111] Mineral oil 2: highly hydrorefined paraffinic base oil (KV100=4.2 mm^2/s, VI=122)

[0112] Mineral oil 3: highly hydrorefined paraffinic base oil (KV100=4.2 mm^2/s, VI=134)

[0113] Mineral oil 4: hydrorefined paraffinic base oil (KV100=2.2 mm^2/s, VI=109)

[0114] Mineral oil 5: hydrorefined paraffinic base oil (KV100=2.5 mm^2/s, VI=99)

[0115] Synthetic base oil 1: poly-α-olefin (KV100=10 mm^2/s, VI=137)

[0116] Synthetic base oil 2: poly-α-olefin (KV100=40 mm^2/s, VI=147)

[0117] Synthetic base oil 3: ethylene-α-olefin copolymer (KV100=10 mm^2/s, VI=150)

[0118] Synthetic base oil 4: ethylene-α-olefin copolymer (KV100=40 mm^2/s, VI=155)

[0119] (B) Viscosity Index Improver

[0120] PMA-based viscosity index improver 1 having an Mw of 30,000 and a structure of $—(CH_2—C(CH_3)(COOR))_n—$

[0121] (C) Boronated succinimide compound

[0122] (C-1)

[0123] Boronated succinimide compound 1 (Mw=5,600, B: 0.34 percent by weight, N=1.58 percent by weight, a mixture of compounds represented by above formula (2), wherein R^1 is a polyisobutenyl group, and n is 4 to 12)

[0124] Boronated succinimide compound 3 (Mw=4,600, B: 1.8 percent by weight, N=2.35 percent by weight, a mixture of compounds represented by above formula (2), wherein R^1 is a polyisobutenyl group, and n is 4 to 12)

[0125] (C-2)

[0126] Boronated succinimide compound 2 (Mw=8,500, B: 0.23 percent by weight, N=0.88 percent by weight, a mixture of compounds represented by above formula (2), wherein R^1 is a polyisobutenyl group, and n is 4 to 12)

[0127] (D) Friction Modifiers

[0128] (D-1) Amide friction modifier

[0129] (D-1a) Reaction product of isostearic acid and tris(hydroxymethyl)aminomethane

[0130] (D-1b) Isostearic acid diethanolamide

[0131] (D-1c) Stearic acid diethanolamide

[0132] (D-1d) Oleic acid diethanolamide

[0133] (D-1e) Lauric acid diethanolamide

[0134] (D-2) Friction modifier composed of a borate of epoxide or a ring-opened product thereof

[0135] (D-2a) Borate of ethylene oxide oleate

[0136] (D-2b) Borate of ethylene oxide stearate

[0137] (D-2c) Borate of glycidyl oleate

[0138] (D-2d) Borate of glycidyl laurate

[0139] (E) Metallic Detergent

[0140] Ca sulfonate (total base number: 350 mgKOH/g)

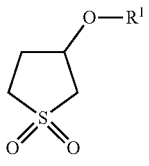
[0141] Ca salicylate (total base number: 300 mgKOH/g)

[0142] Mg salicylate (total base number: 400 mgKOH/g)
[0065]

[0143] (F) Ether Sulfolane Compound

[0144] LUBRIZOL 730 (a compound represented by the following formula, wherein R^1 is $C_{10}H_{21}$)

[Chem. 6]



[0145] (F) Other Additives

[0146] Anti-wear agent, friction modifier, antioxidant, antifoaming agent, metal deactivator, and coloring agent.

TABLE 1

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8
(A) Base oil	Mineral oil 1	70.39	70.39	83.08	83.08				70.99
	Mineral oil 2					34.28			
	Mineral oil 3						25.13		
	Mineral oil 4					36.11			
	Mineral oil 5						45.26	71.82	
	Synthetic base oil 1	20.95				20.95	20.95	20.95	20.95
	Synthetic base oil 2				8.26				
	Synthetic base oil 3		20.95						
	Synthetic base oil 4			8.26					
(B) Viscosity index improver	PMA-based viscosity index improver	3.08	3.08	3.08	3.08	3.08	3.08	1.65	3.08
(c) Ashless dispersant	Boron-containing succinimide compound 1	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
	Boron-containing succinimide compound 2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	Boron-containing succinimide compound 3								
Metallic detergent	Calcium sulfonate	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	Calcium salicylate								
	Magnesium salicylate								
(D) Friction modifier (D-1) Amide friction modifier	(D-1a) Reaction product of isostearic acid and tris(hydroxymethyl) aminomethane	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	(D-1b) Isostearic acid diethanolamide								
	(D-1c) Stearic acid diethanolamide								
	(D-1d) Oleic acid diethanolamide								
	(D-1e) Lauric acid diethanolamide								
(D) Friction modifier (D-2) Friction modifier composed of a borate of epoxide or a ring-opened product thereof	(D-2a) Borate of ethylene oxide oleate	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	(D-2b) Borate of ethylene oxide stearate								
	(D-2c) Borate of glycidyl oleate								
	(D-2d) Borate of glycidyl laurate								
(D) Friction modifiers (other than the above friction modifiers)	Glycerin monooleate								
	N-(2-hydroxyhexadecyl) diethanolamine								
Rubber swelling agent	Ether-containing sulfolane	0.60	0.60	0.60	0.60	0.60	0.60	0.60	
Additive package	Other additives (Anti-wear agent, friction modifier, antioxidant, antifoaming agent, metal deactivator, and coloring agent)	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05
Base oil performance									
KV100		4.0	4.0	4.0	3.7	4.0	4.0	3.5	4.0
Composition performance									
[C2]/[C1]		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
KV100		5.5	5.5	5.5	5.2	5.5	5.5	4.5	5.5
VI		163	168	170	168	170	168	151	163
Shear stability		4	4	4	4	4	4	4	4
Shudder		450	450	450	450	450	450	450	450
Initial shudder		1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Friction coefficient		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Swelling performance		5	5	5	5	5	5	5	1

TABLE 1-continued

		Example 9	Example 10	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16	Example 17	Example 18
(A) Base oil	Mineral oil 1	70.39	70.39	70.39	70.39	70.39	70.39	70.39	70.39	70.39	70.39
	Mineral oil 2										
	Mineral oil 3										
	Mineral oil 4										
	Mineral oil 5										
	Synthetic base oil 1	20.95	20.95	20.95	20.95	20.95	20.95	20.95	20.95	20.95	20.95
	Synthetic base oil 2										
	Synthetic base oil 3										
	Synthetic base oil 4										
(B) Viscosity index improver	PMA-based viscosity index improver	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08
(c) Ashless dispersant	Boron-containing succinimide compound 1	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
	Boron-containing succinimide compound 2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	Boron-containing succinimide compound 3										
Metallic detergent	Calcium sulfonate	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16		
	Calcium salicylate									0.16	
	Magnesium salicylate										0.16
(D) Friction modifier (D-1) Amide friction modifier	(D-1a) Reaction product of isostearic acid and tris(hydroxymethyl) aminomethane					0.95	0.75	0.75	0.75	0.75	0.75
	(D-1b) Isostearic acid diethanolamide	0.75									
	(D-1c) Stearic acid diethanolamide		0.75								
	(D-1d) Oleic acid diethanolamide			0.75							
	(D-1e) Lauric acid diethanolamide				0.75						
(D) Friction modifier (D-2) Friction modifier composed of a borate of epoxide or a ring-opened product thereof	(D-2a) Borate of ethylene oxide oleate	0.20	0.20	0.20	0.20					0.20	0.20
	(D-2b) Borate of ethylene oxide stearate						0.20				
	(D-2c) Borate of glycidyl oleate							0.20			
	(D-2d) Borate of glycidyl laurate								0.20		
(D) Friction modifiers (other than the above friction modifiers)	Glycerin monooleate										
	N-(2-hydroxyhexadecyl) diethanolamine										
Rubber swelling agent	Ether-containing sulfolane	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Additive package	Other additives (Anti-wear agent, friction modifier, antioxidant, antifoaming agent, metal deactivator, and coloring agent)	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05
Base oil performance											
KV100		4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Composition performance											
[C2]/[C1]		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
KV100		5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
VI		163	163	163	163	163	163	163	163	163	163
Shear stability		4	4	4	4	4	4	4	4	4	4
Shudder		400	300	300	250	450	450	450	450	450	450
Initial shudder		1.3	1.3	1.3	1.3	0.3	1.3	1.3	1.3	1.3	1.3

TABLE 1-continued

Friction coefficient (TC ratio)	1.02	1.03	1.03	1.04	1.01	1.00	1.00	1.00	1.00	1.00
Swelling performance	5	5	5	5	5	5	5	5	5	5

TABLE 2

		Comp. Example 1	Comp. Example 2	Comp. Example 3	Comp. Example 4	Comp. Example 5	Comp. Example 6	Comp. Example 7
(A) Base oil	Mineral oil 1 Mineral oil 2 Mineral oil 3 Mineral oil 4 Mineral oil 5	70.39	70.39	70.39	70.20	70.39	70.39	70.39
	Synthetic base oil 1 Synthetic base oil 2 Synthetic base oil 3 Synthetic base oil 4	20.95	20.95	20.95	20.95	20.95	20.95	20.95
(B) Viscosity index improver	PMA-based viscosity index improver	3.08	3.08	3.08	3.08	3.08	3.08	3.08
(c) Ashless dispersant	Boron-containing succinimide compound 1		1.49	1.49	1.49	1.49	1.49	1.49
	Boron-containing succinimide compound 2	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	Boron-containing succinimide compound 3	1.49						
Metallic detergent	Calcium sulfonate Calcium salicylate Magnesium salicylate	0.16	0.16	0.16	0.35	0.16	0.16	0.16
(D) Friction modifier (D-1) Amide friction modifier	(D-1a) Reaction product of isostearic acid and tris(hydroxymethyl) aminomethane (D-1b) Isostearic acid diethanolamide (D-1c) Stearic acid diethanolamide (D-1d) Oleic acid diethanolamide (D-1e) Lauric acid diethanolamide	0.75						
(D) Friction modifier (D-2) Friction modifier composed of a borate of epoxide or a ring-opened product thereof	(D-2a) Borate of ethylene oxide oleate	0.20	0.95					
	(D-2b) Borate of ethylene oxide stearate			0.95				
	(D-2c) Borate of glycidyl oleate				0.95			
	(D-2d) Borate of glycidyl laurate					0.95		
(D) Friction modifiers (other than the above friction modifiers)	Glycerin monooleate						0.95	
	N-(2-hydroxyhexadecyl) diethanolamine							0.95
Rubber swelling agent	Ether-containing sulfolane	0.60	0.60	0.60	0.60	0.60	0.60	0.60

TABLE 2-continued

Additive package	Other additives (Anti-wear agent, friction modifier, antioxidant, antifoaming agent, metal deactivator, and coloring agent)	2.05	2.05	2.05	2.05	2.05	2.05	2.05
		Base oil performance						
KV100		4.0	4.0	4.0	4.0	4.0	4.0	4.0
		Composition performance						
[C2]/[C1]		0	4.5	4.5	4.5	4.5	4.5	4.5
KV100		5.2	5.5	5.5	5.5	5.5	5.5	5.5
VI		161	163	163	163	163	163	163
Shear stability		4	4	4	4	4	4	4
Shudder		20	200	200	200	200	50	50
Initial shudder		−1.7	2.8	2.8	2.8	2.8	−1.1	−1.1
Friction coefficient		1.0	0.96	0.96	0.96	0.96	0.94	0.94
Swelling performance		5	5	5	5	5	5	5

	Comp. Example 8
KV100	7.2
VI	201
Shear stability	21
Shudder	200
Initial shudder	not measured
Friction coefficient	1.0
Swelling performance	6

1. A lubricating oil composition comprising

(A) a lubricant base oil,

(C) (C-1) a succinimide compound or boronated succinimide compound having a weight-average molecular weight of 4,000 to 7,000, and (C-2) a succinimide compound or boronated succinimide compound having a weight-average molecular weight of more than 7,000 and not more than 10,000, and

(D) (D-1) an amide friction modifier.

2. The lubricating oil composition according to claim **1**, further comprising (D) (D-2) a friction modifier composed of a reaction product of boric acid or boron oxide with an epoxide.

3. The lubricating oil composition according to claim **1**, comprising, as a part or all of component (A), 5 to 30 percent by weight, based on a total weight of the lubricating oil composition, of a poly-α-olefin or α-olefin copolymer having a kinematic viscosity at 100° C. of 6 to 80 mm^2/s, and further comprising (B) a polymethacrylate having a weight-average molecular weight of 15,000 to 40,000.

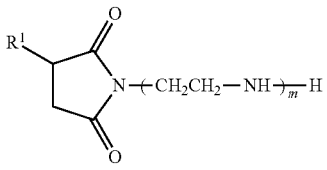
4. The lubricating oil composition according to claim **1**, wherein a part or all of component (C-1) and component (C-2) is a boronated succinimide compound.

5. The lubricating oil composition according to claim **4**, wherein each of component (C-1) and/or component (C-2) contains 0.1 to 3 percent by weight of boron, based on a weight of component (C-1) or component (C-2).

6. The lubricating oil composition according to claim **1**, wherein the weight ratio of component (C-1) to component (C-2), i.e., (C-2)/(C-1), is 1 to 10.

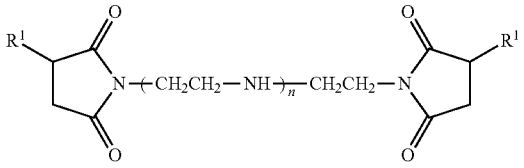
7. The lubricating oil composition according to claim **1**, wherein the succinimide compound is represented by following formula (1) or (2):

[Chem. 1]



(1)

[CHEM. 2]



(2)

wherein R1 is each independently an alkyl or alkenyl group having 40 to 400 carbon atoms, m is an integer of 1 to 20, and n is an integer of 0 to 20.

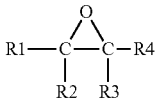
8. The lubricating oil composition according to claim **1**, having a kinematic viscosity of 100° C. of 3 to 10 mm^2/s.

9. The lubricating oil composition according to claim **1**, having a viscosity index of not less than 150.

10. The lubricating oil composition according to claim **1**, wherein compound (D-1) is at least one selected from amide compounds derived from a fatty acid having an alkyl or alkenyl group having 6 to 30 carbon atoms.

11. The lubricating oil composition according to claim 2, wherein compound (D-2) is at least one selected from reaction products of an epoxide represented by the following formula:

[Chem. 3]



wherein R1, R2, R3, and R4 each independently represent a hydrogen atom or a hydrocarbon group having 1 to 30 carbon atoms, and at least one of R1, R2, R3, and R4 is a hydrocarbon group,

with boric acid or boron oxide, or ring-opened products thereof.

12. The lubricating oil composition according to claim 1, further comprising (E) a metallic detergent.

13. The lubricating oil composition according to claim **1**, further comprising (F) an ether sulfolane compound.

14. The lubricating oil composition according to claim **1**, which is for a non-stage transmission.

15. The lubricating oil composition according to claim **2**, comprising, as a part or all of component (A), 5 to 30 percent by weight, based on a total weight of the lubricating oil composition, of a poly-α-olefin or α-olefin copolymer having a kinematic viscosity at 100° C. of 6 to 80 mm^2/s, and further comprising (B) a polymethacrylate having a weight-average molecular weight of 15,000 to 40,000.

16. The lubricating oil composition according to claim **2**, wherein a part or all of component (C-1) and component (C-2) is a boronated succinimide compound.

17. The lubricating oil composition according to claim **16**, wherein each of component (C-1) and/or component (C-2) contains 0.1 to 3 percent by weight of boron, based on a weight of component (C-1) or component (C-2).

18. The lubricating oil composition according to claim **2**, wherein the weight ratio of component (C-1) to component (C-2), i.e., (C-2)/(C-1), is 1 to 10.

19. The lubricating oil composition according to claim **2**, wherein compound (D-1) is at least one selected from amide compounds derived from a fatty acid having an alkyl or alkenyl group having 6 to 30 carbon atoms.

20. The lubricating oil composition according to claim **3**, wherein compound (D-1) is at least one selected from amide compounds derived from a fatty acid having an alkyl or alkenyl group having 6 to 30 carbon atoms.

* * * * *