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(54) GREASE COMPOSITION, AND METHOD FOR LUBRICATING SLIDING PART USING SAID GREASE COMPOSITION

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(57) **ABSTRACT**

An object of the invention is to provide a grease composition that does not deteriorate resin, particularly, acetal resin, in contact therewith even under a high temperature condition. The object can be attained by a grease composition for resin, including (A) a lubricating base oil, (B) a thickener, and (C) at least one selected from the group consisting of an organic molybdenum compound and a sulfur-based extreme pressure agent, wherein when the grease composition includes the sulfur-based extreme pressure agent, a content of the sulfur-based extreme pressure agent is from 0.05 mass % to 2.5 mass % based on a total amount of the composition, and the grease composition is substantially free of zinc dialkyldithiophosphate.

GREASE COMPOSITION, AND METHOD FOR LUBRICATING SLIDING PART USING SAID GREASE COMPOSITION

TECHNICAL FIELD

[0001] The present invention relates to a grease composition. The invention also relates to a method for lubricating a sliding part using this grease composition.

RELATED ART

[0002] Resin molded products are used as various machine parts. Among others, molded products of polyacetal resin (acetal resin) have excellent characteristics in terms of mechanical properties and moldability, etc. Owing to such characteristics, the molded products of acetal resin are widely used in home electronics and electric or electronic products, etc.

[0003] Grease is mainly used in plain bearings, rolling bearings, or sliding parts. The grease used is selected according to conditions for use thereof.

[0004] The selection of base oils, thickeners, and additives has been variously proposed in order to improve the lubricity of grease and the compatibility thereof with sliding part materials. On the other hand, friction characteristics differ depending on conditions for sliding parts, such as materials. The grease used may deteriorate specific materials. It is thus necessary to select grease having the optimum composition, in consideration of a sliding part material or the like.

CITATION LIST

Patent Literature

[0005] Patent Literature 1: Japanese Patent Laid-Open No. 2011-157477

[0006] Patent Literature 2: International Publication No. WO2015/083695

SUMMARY OF INVENTION

[0007] Patent Literature 1 discloses a grease composition that prevents poor lubrication and is capable of preventing contamination without remaining on nearby equipment even if grease is splattered. Patent Literature 2 discloses a grease composition that has low sliding resistance and is capable of drastically reducing the power consumption of machine members, particularly, the power consumption at the time of bearing rotation. However, in these literatures, aptitude for resin has not been tested. Thus, whether to have aptitude for resin has been unknown. Particularly, sliding parts often become high temperatures. Thus, there has been a demand for a grease composition that does not deteriorate resin in contact therewith even under a high temperature condition.

[0008] The present inventors have conducted intensive research on a grease composition that does not deteriorate resin, particularly, acetal resin, in contact therewith, even under a high temperature condition. The inventors have found that the object can be attained by a grease composition containing components (A) to (C), wherein when the grease composition includes a sulfur-based extreme pressure agent, a content of the sulfur-based extreme pressure agent is from 0.05 mass % to 2.5 mass % based on the total amount of the composition or less, and the grease composition is substantially free of zinc dialkyldithiophosphate. The invention has been completed.

[0009] The invention is based on such findings and provided as follows.

<1>

[0010] A grease composition for resin, including

[0011] (A) a lubricating base oil,

[0012] (B) a thickener, and

[0013] (C) at least one selected from the group consisting of an organic molybdenum compound and a sulfur-based extreme pressure agent, wherein

[0014] when the grease composition includes the sulfur-based extreme pressure agent, a content of the sulfur-based extreme pressure agent is from 0.05 mass % to 2.5 mass % based on a total amount of the composition, and

[0015] the grease composition is substantially free of zinc dialkyldithiophosphate.

<2>

[0016] The grease composition for resin according to <1>, wherein the resin is acetal resin.

<3>

[0017] The grease composition for resin according to <1> or <2>, wherein the grease composition includes the organic molybdenum compound, and a content of the organic molybdenum compound is from 0.05 mass % to 5 mass % based on the total amount of the composition.

<4>

[0018] The grease composition for resin according to any of <1> to <3>, wherein the grease composition includes both the organic molybdenum compound and the sulfur-based extreme pressure agent.

<5>

[0019] The grease composition for resin according to any of <1> to <4>, wherein the thickener is a metal soap-based thickener.

<6>

[0020] The grease composition for resin according to any of <1> to <5>, wherein the grease composition has a penetration of from 265 to 475.

<7>

[0021] The grease composition for resin according to any of <1> to <6>, wherein

[0022] (A) a content of the lubricating base oil is from 50 mass % to 95 mass % based on the total amount of the composition, and

[0023] (B) a content of the thickener is from 2 mass % to 30 mass % based on the total amount of the composition.

<8>

[0024] The grease composition for resin according to any of <1> to <7>, wherein a content of the zinc dialkyldithiophosphate is 1 mass % or less based on the total amount of the composition.

<9>

[0025] The grease composition for resin according to any of <2> to <8> for use in a member containing acetal resin and a metal.

<10>

[0026] The grease composition for resin according to <9>, wherein the metal is copper.

<11>

[0027] A method for lubricating a sliding part, including allowing a grease composition according to any of <1> to <10> to be disposed on the sliding part.

Advantageous Effects of Invention

[0028] The grease composition of the invention can provide a grease composition that does not deteriorate resin, particularly, acetal resin, in contact therewith, even under a high temperature condition.

DESCRIPTION OF EMBODIMENTS

[Component (A): Lubricating Base Oil]

[0029] Any mineral or synthetic oil can be used as the lubricating base oil for use in the invention. The kinematic viscosity of the lubricating base oil at 40° C. is not particularly limited and is preferably 10 mm^2/s or more, more preferably 20 mm^2/s or more, and still more preferably 25 mm^2/s or more, and preferably 700 mm^2/s or less, more preferably 500 mm^2/s or less, and still more preferably 70 mm^2/s or less, from the viewpoint of safely preparing grease having excellent lubricity. In one embodiment, the kinematic viscosity of the lubricating base oil at 40° C. is preferably from 10 mm^2/s to 700 mm^2/s, more preferably from 20 mm^2/s to 500 mm^2/s, and still more preferably from 25 mm^2/s to 70 mm^2/s. The viscosity index of the lubricating base oil at 40° C. is not particularly limited and is preferably from 95 to 250 and more preferably from 95 to 150, from the viewpoint of preparing grease having excellent lubricity.

[0030] The viscosity index and the kinematic viscosity at 40° C. herein mean a viscosity index and a kinematic viscosity at 40° C., respectively, measured in accordance with JIS K 2283.

[0031] The flash point of the lubricating base oil is not particularly limited and is preferably 150° C. or more from the viewpoint of safety.

[0032] In the invention, a hydrocarbon oil (mineral or synthetic oil, etc.) is preferably used as the lubricating base oil, and a mineral oil is more preferably used. Examples of the mineral oil include distillate oil obtained by atmospheric distillation of crude oil, or a lubricating oil distillate obtained by further vacuum distillation of the distillate oil and by purifying the resulting distillate oil by various refining processes. The refining process can be a combination of, for instance, hydrogenation refining, solvent extraction, solvent dewaxing, hydrogenation dewaxing, sulfuric acid cleaning, and/or white clay treatment, if appropriate. These refining processes may be combined in an appropriate order to produce a lubricating base oil usable in the invention. It is also possible to use a mixture of several refined oils with different properties, as obtained by subjecting different crude oils or distillate oils to different combinations of refining processes.

[0033] A base excellent in hydrolytic stability can be used as the synthetic oil. Examples of such a base excellent in hydrolytic stability include polyolefin such as poly-α-olefin, polyester, polyalkylene glycol, alkylbenzene, alkylnaphthalene, and GTL base oil. Among the synthetic oils, poly-α-olefin is preferable in terms of availability, cost, viscosity characteristics, and compatibility with oxidative stability.

[0034] As the lubricating base oil, the mineral or synthetic oil can be used singly, or two or more kinds thereof can be used as a mixture. In the invention, only a mineral oil may be included as the lubricating base oil, or an additional lubricating base oil may also be included. Specifically, the content of the mineral oil in the grease composition of the invention can be, for example, 50 mass % or more, 60 mass % or more, 70 mass % or more, 80 mass % or more, 90 mass % or more, 95 mass % or more, or 99 mass % or more, based on the lubricating base oil.

[0035] In the invention, the content of the lubricating base oil is preferably 50 mass % or more and more preferably 60 mass % or more, and preferably 95 mass % or less and more preferably 90 mass % or less, based on the total amount of the grease composition. In one embodiment, the content is preferably from 50 mass % to 95 mass % and more preferably from 60 mass % to 90 mass %. When the content of the lubricating base oil falls within the above range, a grease composition having the desired penetration can be conveniently prepared.

[Component (B): Thickener]

[0036] The grease composition of the invention includes at least one selected from the group consisting of a metal soap-based thickener and a urea-based thickener.

[Metal Soap-Based Thickener]

[0037] Examples of the metal soap-based thickener include a single soap and a complex soap. The single soap is a metal soap obtained by saponifying a fatty acid or a fat/oil with alkali metal hydroxide or alkaline earth metal hydroxide. The complex soap is obtained by further complexing a fatty acid used in the single soap in combination with an organic acid having a different molecular structure. The fatty acid may be a fatty acid derivative having a hydroxy group or the like. The fatty acid may be aliphatic carboxylic acid such as stearic acid, or aromatic carboxylic acid such as terephthalic acid. As the fatty acid, monovalent or divalent aliphatic carboxylic acid, for example, aliphatic carboxylic acid of C_{6-20}, is used, and particularly, monovalent aliphatic carboxylic acid of C_{12-20} or divalent aliphatic carboxylic acid of C_{6-14} is preferably used. The fatty acid is preferably monovalent aliphatic carboxylic acid containing one hydroxy group. The organic acid to be combined with the fatty acid in the complex soap is preferably acetic acid, a dibasic acid such as azelaic acid or sebacic acid, benzoic acid, or the like.

[0038] An alkali metal such as lithium or sodium, an alkaline earth metal such as calcium, or an amphoteric metal such as aluminum is used as the metal in the metal soap-based thickener. Among them, an alkali metal, particularly, lithium, is preferably used. Note that "C_{6-20}" in the invention means having 6 to 20 carbon atoms.

[0039] One kind of the metal soap-based thickener may be used singly, or two or more kinds thereof may be used in combination. The content of the metal soap-based thickener is, for example, preferably 2 mass % or more, more preferably 3 mass % or more, and still more preferably 10 mass % or more, and preferably 30 mass % or less and more preferably 20 mass % or less, based on the total amount of the grease composition. In one embodiment, the content of the metal soap-based thickener is preferably from 2 mass % to 30 mass %, more preferably from 3 mass % to 20 mass %, and still more preferably from 10 mass % to 20 mass %.

[Urea-Based Thickener]

[0040] For example, a diurea compound obtained through the reaction between diisocyanate and monoamine, or a polyurea compound obtained through the reaction between diisocyanate and monoamine or diamine can be used as the urea-based thickener.

[0041] The diisocyanate is a compound obtained by replacing two hydrogen atoms of a hydrocarbon with isocyanate groups. The diisocyanate is preferably phenylene diisocyanate, tolylene diisocyanate, diphenyl diisocyanate, diphenylmethane diisocyanate, octadecane diisocyanate, decane diisocyanate, hexane diisocyanate, or the like. The hydrocarbon in the diisocyanate may be a noncyclic hydrocarbon group or a cyclic hydrocarbon group and may be an aromatic hydrocarbon group, an alicyclic hydrocarbon group, or an aliphatic hydrocarbon group. The number of carbon atoms thereof is preferably 2 to 20, particularly, 4 to 18.

[0042] The monoamine is a compound having one amino group in one molecule. The monoamine is preferably octylamine, dodecylamine, hexadecylamine, stearylamine, oleylamine, aniline, p-toluidine, cyclohexylamine, or the like. The diamine is a compound having two amino groups in one molecule. The diamine is preferably ethylenediamine, propanediamine, butanediamine, hexanediamine, octanediamine, phenylenediamine, tolylenediamine, xylenediamine, diaminodiphenylmethane, or the lie. The hydrocarbon group of the monoamine or the diamine may be a noncyclic hydrocarbon group or a cyclic hydrocarbon group and may be an aromatic hydrocarbon group, an alicyclic hydrocarbon group, or an aliphatic hydrocarbon group. The number of carbon atoms thereof is preferably 2 to 20, particularly, 4 to 18.

[0043] The urea-based thickener is preferably a diurea compound, particularly, diisocyanate having an aromatic hydrocarbon group, and more preferably alkylenediaryl diisocyanate such as methylenediphenyl diisocyanate. The number of carbon atoms thereof is preferably 12 to 24. As the monoamine, aromatic amine, alicyclic amine or aliphatic amine can be used, and mixed amine obtained by mixing these can be used.

[0044] One kind of the urea-based thickener may be used singly, or two or more kinds thereof may be used in combination. The content of the urea-based thickener is, for example, preferably 2 mass % or more, more preferably 3 mass % or more, and still more preferably 5 mass % or more, and preferably 30 mass % or less and more preferably 20 mass % or less, based on the total amount of the grease composition. In one embodiment, the content of the urea-based thickener is preferably from 2 mass % to 30 mass %, more preferably from 3 mass % to 20 mass %, and still more preferably from 5 mass % to 20 mass %.

[0045] The grease composition of the invention preferably includes a metal soap-based thickener and more preferably includes a lithium complex soap-based thickener. The grease composition of the invention may include both the metal soap-based thickener and the urea-based thickener and preferably includes one of them.

[0046] In the grease composition of the invention, one kind of the thickener listed above may be used singly, or two or more kinds thereof may be used in combination. The content of the thickener is, for example, preferably 2 mass % or more, more preferably 3 mass % or more, and still more preferably 5 mass % or more, and preferably 30 mass % or less and more preferably 20 mass % or less, based on the total amount of the grease composition. In one embodiment, the content of the thickener is preferably from 2 mass % to 30 mass %, more preferably from 3 mass % to 20 mass %, and still more preferably from 5 mass % to 20 mass %.

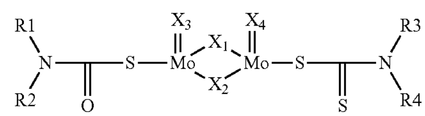
[Component (C): At Least One Selected from Group Consisting of Organic Molybdenum Compound and Sulfur-Based Extreme Pressure Agent]

[0047] The grease composition of the invention includes at least one selected from the group consisting of an organic molybdenum compound and a sulfur-based extreme pressure agent.

[Organic Molybdenum Compound]

[0048] Examples of the organic molybdenum compound include molybdenum dithiocarbamate (MoDTC), molybdenum dithiophosphate (MoDTP), and a Mo-amine complex. As the organic molybdenum compound, molybdenum dithiocarbamate is preferably used, and molybdenum dithiocarbamate represented by the following formula (1) is more preferably used.

Formula (1):



[0049] wherein, R1 to R4 may be the same or different and are each a C_{1-30} hydrocarbon group, and X_1 to X_4 may be the same or different and are each S or O.

[0050] R1 to R4 are each preferably a cycloalkyl group or a chain alkyl group and more preferably a chain alkyl group. R1 to R4 are each preferably a C_{1-5} chain alkyl group and, particularly, more preferably a C_4 chain alkyl group.

[0051] The content of the organic molybdenum compound is preferably 0.01 mass % or more, more preferably 0.05 mass % or more, and still more preferably 0.1 mass % or more, and preferably 15 mass % or less, more preferably 10 mass % or less, still more preferably 5 mass % or less, and most preferably 3 mass % or less, based on the total amount of the grease composition. In one embodiment, the content of the organic molybdenum compound is preferably from 0.01 mass % to 15 mass %, more preferably from 0.05 mass % to 10 mass %, still more preferably from 0.05 mass % to 5 mass %, and most preferably from 0.1 mass % to 3 mass %. The content of the organic molybdenum compound may be set to be the above lower limit value or more. This keeps a friction low. The content of the organic molybdenum compound may be set to be the above upper limit value or less. This can reduce production cost while a sufficient effect of reducing a friction can be obtained.

[0052] The molybdenum element content of the organic molybdenum compound is preferably from 5 mass % to 40 mass % and more preferably from 5 mass % to 30 mass %, based on the organic molybdenum compound.

[Sulfur-Based Extreme Pressure Agent]

[0053] A known sulfur-based extreme pressure agent such as fat/oil sulfide, sulfide of fatty acid, sulfurized ester, olefin sulfide, dihydrocarbyl (poly)sulfide, an alkylthiocarbamoyl compound, a thioterpene compound, a dialkylthio dipropionate compound, mineral oil sulfide, or a zinc dithiocarbamate compound can be used as the sulfur-based extreme pressure agent. One kind of the sulfur-based extreme pressure agent may be used singly, or two or more kinds thereof may be used in combination.

[0054] The fat/oil sulfide is a product obtained by reacting sulfur or a sulfur-containing compound with a fat/oil (lard, whale oil, plant oil, fish oil, etc.). The sulfur content of the fat/oil sulfide is not particularly limited and is usually from 5 mass % to 30 mass %.

[0055] A product obtained by sulfurizing an unsaturated fatty acid by an arbitrary method can be used as the sulfide of fatty acid. Specific examples thereof can include sulfide of oleic acid.

[0056] A product obtained by sulfurizing an unsaturated fatty acid ester (e.g., a product obtained by reacting an unsaturated fatty acid (oleic acid, linoleic acid, or a fatty acid extracted from the above animal or plant fat/oil) with various alcohols) by an arbitrary method can be used as the sulfurized ester. Specific examples thereof can include sulfurized methyl oleate and sulfurized octyl of rice bran fatty acid.

[0057] Examples of the olefin sulfide can include a compound represented by the general formula (2) given below. This compound can be obtained by reacting C_{2-15} olefin or a dimer to tetramer thereof with a sulfurizing agent such as sulfur or sulfur chloride. Propylene, isobutene, diisobutene, or the like can be used as the olefin.

R11-Sa-R12 Formula (2):

[0058] wherein R11 represents a C_{2-15} alkenyl group, R12 represents a C_{2-15} alkyl group or alkenyl group, and a represents an integer from 1 to 8.

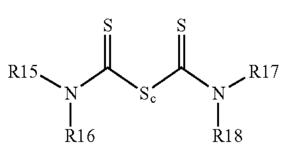
[0059] The dihydrocarbyl (poly)sulfide is a compound represented by the general formula (3) given below. In this context, when each of R13 and R14 is an alkyl group, this compound is also referred to as alkyl sulfide.

R13-Sb—R14 Formula (3):

[0060] wherein R13 and R14 may be the same or different and each independently represent a C_{1-20} alkyl group (which may be linear or branched and may have a cyclic structure), a C_{6-20} aryl group, a C_{7-20} alkylaryl group, or a C_{7-20} arylalkyl group, and b represents an integer from 1 to 8.

[0061] Examples of the alkylthiocarbamoyl compound can include a compound represented by the following general formula (4).

Formula (4):



[0062] wherein R15 to R18 may be the same or different and each independently represent a C_{1-20} alkyl group, and c represents an integer from 1 to 8.

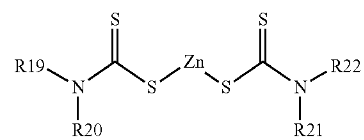
[0063] Examples of the thioterpene compound can include a reaction product of phosphorus pentasulfide and pinene.

[0064] Examples of the dialkylthio dipropionate compound can include dilaurylthio dipropionate and distearylthio dipropionate.

[0065] The mineral oil sulfide is a substance obtained by dissolving elemental sulfur in a mineral oil. Specific examples of the mineral oil for use in the mineral oil sulfide include, but are not particularly limited to, paraffin-based mineral oil and naphthene-based mineral oil obtained by atmospheric distillation or vacuum distillation of crude oil and by purifying the resulting lubricating oil distillate by an appropriate combination of known refining processes. Elemental sulfur in any form such as a bulk, powder, or a melted liquid form may be used. The sulfur content of the mineral oil sulfide is not particularly limited and is usually from 0.05 mass % to 1.0 mass % based on the total amount of the mineral oil sulfide.

[0066] A compound represented by the following general formula (5) can be used as the zinc dithiocarbamate compound.

Formula (5):



[0067] wherein R19 to R22 may be the same or different and each independently represent a hydrocarbyl group having one or more carbon atoms.

[0068] As the sulfur-based extreme pressure agent, dihydrocarbyl (poly)sulfide represented by the general formula (3) is preferably used, dialkyl polysulfide of the general formula (3) wherein both R13 and R14 are alkyl groups is more preferable, and dioctyl polysulfide is further preferable.

[0069] When the grease composition includes the sulfur-based extreme pressure agent, its content is from 0.05 mass % to 2.5 mass % based on the total amount of the grease composition from the viewpoint of imparting extreme pressure properties thereto and from the viewpoint of not deteriorating resin. The content of the sulfur-based extreme pressure agent is preferably 0.1 mass % or more, and preferably 2.0 mass % or less and more preferably 1.5 mass % or less. In one embodiment, the content is preferably from 0.05 mass % to 2.0 mass % and more preferably from 0.1 mass % to 1.5 mass %.

[0070] The grease composition of the invention preferably includes both the organic molybdenum compound and the sulfur-based extreme pressure agent. Note that organic molybdenum compounds such as molybdenum dithiocarbamate and molybdenum dithiophosphate contain a sulfur molecule. Thus, these organic molybdenum compounds also correspond to the sulfur-based extreme pressure agent. In this context, even when the organic molybdenum compound also corresponds to the sulfur-based extreme pressure agent, this organic molybdenum compound is not treated as the sulfur-based extreme pressure agent in the invention and the content of the organic molybdenum compound is not added to the content of the sulfur-based extreme pressure agent. "Including both" the organic molybdenum compound and the sulfur-based extreme pressure agent means including an organic molybdenum compound as well as a sulfur-based extreme pressure agent containing no molybdenum.

[Zinc Dialkyldithiophosphate]

[0071] The grease composition of the invention is substantially free of zinc dialkyldithiophosphate (hereinafter, also referred to as ZnDTP) in consideration of its influence on resin and a metal (specifically, copper). Zinc dialkyldithiophosphate is usually added to grease for the purpose of, for example, improving corrosion-inhibiting properties, load resistance, and anti-wear properties. The inventors have found that the addition of zinc dialkyldithiophosphate in addition to the sulfur-based extreme pressure agent and/or the organic molybdenum compound adversely influences resin and a metal in contact with grease.

[0072] As used herein, the wording "substantially free" means that zinc dialkyldithiophosphate is not contained in an amount for, for example, improving corrosion-inhibiting properties, load resistance, and anti-wear properties as usually expected. As used herein, the wording "substantially free" means that zinc dialkyldithiophosphate is contained in an amount of, for example, 1 mass % or less, preferably 0.1 mass % or less, and more preferably 0.01 mass % or less, based on the grease composition. Most preferably, the grease composition of the invention is free of zinc dialkyldithiophosphate.

[Other Additives]

[0073] The grease composition of the invention can be appropriately supplemented, if necessary, with a solid lubricant, an antioxidant, an anti-rust agent, a corrosion inhibitor, and the like which are generally used in grease, in addition to the components.

[0074] Examples of the solid lubricant include graphite, graphite fluoride, melamine cyanurate, polytetrafluoroethylene, antimony sulfide, and alkali (earth) metal borate. When the grease composition contains the solid lubricant, its content may be from 0.1 mass % to 20 mass % based on the total amount of the grease composition.

[0075] Examples of the antioxidant include phenolic compounds such as 2,6-di-t-butylphenol and 2,6-di-t-butyl-p-cresol, and amine compounds such as monobutylphenylmonooctylphenylamine, dialkyldiphenylamine, phenyl-α-naphthylamine, and p-alkylphenyl-α-naphthylamine. When the grease composition contains the antioxidant, its content may be from 0.1 mass % to 10 mass % based on the total amount of the grease composition.

[0076] Examples of the anti-rust agent include amines, neutral or overbased petroleum-based or synthetic oil-based metal sulfonate, carboxylic acid metal salts, esters, phosphoric acid, and phosphate. When the grease composition contains the anti-rust agent, its content may be from 0.005 mass % to 5 mass % based on the total amount of the grease composition.

[0077] It is possible to use, as the corrosion inhibitor, a known corrosion inhibitor, for example, a benzotriazole compound, a tolyltriazole compound, a thiadiazole compound, and an imidazole compound. When the grease composition contains the corrosion inhibitor, its content may be from 0.01 mass % to 10 mass % based on the total amount of the grease composition.

[0078] The grease composition of the invention can be obtained by mixing the components (A) to (C) as essential components and further, other additives, if necessary, and stirring the mixture, followed by passing through a roll mill or the like.

[Resin]

[0079] As used herein, the "resin" includes both natural resin and synthetic resin. The synthetic resin includes general-purpose plastics (polyethylene, polystyrene, polypropylene, polyvinyl chloride, etc.), and engineering plastics. The synthetic resin is preferably polyamide resin, acetal resin, polycarbonate resin, polysulfone resin, polyphenylene sulfide resin, polyamide imide resin, polyether ether ketone resin, phenol resin, polyester resin, epoxy resin, or the like, and more preferably acetal resin, from the viewpoint of heat resistance and mechanical strength.

[0080] Examples of the subject for which the grease composition of the invention is used include sliding parts for transport machines such as automobiles, trains, and aircrafts, industrial machines such as machine tools, home electronics such as washing machines, refrigerators, and vacuum cleaners, and precision measuring equipment such as clocks or cameras. The grease composition of the invention is preferably used in a bearing, a gear, a surface, a belt, a joint, and a cam, etc. which are included in such equipment and contain a resin material.

[Grease Composition]

[0081] The penetration of the grease composition of the invention is preferably from 265 to 475, more preferably from 265 to 385, and still more preferably from 310 to 340.

[0082] The penetration herein means a worked penetration measured in accordance with JIS K 2220. Specific measurement conditions are as follows: a pot for penetration measurement is filled with a sample and maintained at 25° C., and a specified plunger is then stroked 60 times per minute. Subsequently, an excess of the sample is removed with a spatula to smooth the surface of the sample. Then, a specified cone is placed on the sample so that the cone penetrates the sample for 5 seconds. A value of 10 times the penetration depth (mm) is regarded as a worked penetration.

[0083] The grease composition of the invention exerts a superior effect of not deteriorating resin, particularly, acetal resin, in contact therewith even under a high temperature condition. The high temperature condition is a condition under which, for example, resin is dipped in the grease composition at 90° C. or more for 100 hours or more, more specifically, a condition of 105° C. for 168 hours. The wording "not deteriorating resin" means that change in the mass of the resin is very small.

[0084] Specifically, it means that when resin is dipped in the grease composition under the high temperature condition, increase in the mass of the resin is from 0% to 0.20%.

[0085] The grease composition of the invention also has an effect of not deteriorating a metal because of its weak reactivity with the metal (e.g., copper) which is a material other than resin. Thus, the grease composition of the invention may be enclosed in a single member including both resin and a metal (e.g., copper). An embodiment in which the grease composition is in contact with a material other than a metal (e.g., copper) and resin is not excluded.

EXAMPLES

[0086] Next, the invention will be described with reference to Examples and Comparative Examples. However, the invention is not limited by Examples given below. Note that % refers to mass %, unless otherwise specified.

Examples 1 to 10 and Comparative Examples 1 to 3

<Grease Formulation>

[0087] In the respective Examples or Comparative Examples, thickeners, base oils and additives were blended at each formulation ratio designated in Tables 1 and 2 to prepare each test grease composition. Each test grease composition obtained was evaluated as shown below. Tables 1 and 2 show the evaluation results.

(1) Base Oil

[0088] Mineral oil 1: kinematic viscosity: 36.8 mm^2/s (40° C.)

[0089] Mineral oil 2: kinematic viscosity: 86.6 mm^2/s (40° C.)

[0090] Mineral oil 3: kinematic viscosity: 22.7 mm^2/s (40° C.)

[0091] Each lubricating base oil was prepared by mixing base oils at each mass ratio designated in Tables 1 and 2.

(2) Thickener

[0092] Urea-based thickener: reaction product of diphenylmethane diisocyanate and cyclohexylamine

[0093] Lithium complex thickener: reaction product of lithium 12-hydroxystearate and azelaic acid

(3) Additive

[0094] Additives were added as listed in Tables 1 and 2. The details of the additives were as follows. Note that the amount of the base oils (total) and the amounts of the thickener and the additives blended are based on the total amount of the grease composition.

[0095] MoDTC manufactured by ADEKA Corp. (product name: SAKURA-LUBE 515)

[0096] Dioctyl polysulfide manufactured by DIC Corp. (product name: DAILUBE GS440L)

[0097] ZnDTP1 manufactured by Chevron Oronite Co. LLC (product name: OLOA5283)

[0098] ZnDTP2 manufactured by Lubrizol Corp. (product name: LUBRIZOL1095)

[0099] Other additives: 2,6-di-t-butylphenol, dialkyldiphenylamine, benzotriazole compound, thiadiazole compound, tricresyl phosphate

<Evaluation>

(1) Change in Mass of Acetal Resin

[0100] A 2 mm thick, 40 mm long, and 20 mm wide test piece of acetal resin was produced, and this test piece was coated with each grease composition. Each test piece coated with the grease composition was heated under a condition of 105° C. for 168 hours. After the heating, the grease composition was removed, and change in the mass of the test piece between before and after the heating was measured. A sample that attained an amount of 0% to 0.2% increase was determined as not deteriorating acetal resin.

(2) Extreme Pressure Properties

[0101] A weld load (WL) was measured under conditions given below using a four-ball tester in accordance with ASTM D 2596. A sample that attained a weld load of 2452 N or more was determined as having extreme pressure properties.

[0102] The number of rotations: 1800 rpm

[0103] Temperature: room temperature

[0104] Test time: 10 sec

(3) Color Change of Copper Plate into Black

[0105] Corrosion of a copper plate was measured after maintenance in a constant-temperature air bath of 100° C. for 24 hours in accordance with JIS K 2220.

TABLE 1

				Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7
Base oil	Mineral oil 1	Component (A)	mass %	50	50	50	50	50	50	50
	Mineral oil 2	Component (A)	mass %	20	20	20	20	20	20	20
	Mineral oil 3	Component (A)	mass %	30	30	30	30	30	30	30
	Amount of base oils (total)		mass %	Balance	Balance	Balance	Balance	Balance	Balance	Balance
Thickener	Urea	Component (B)	mass %	—	14	—	—	—	—	—
	Lithium complex	Component (B)	mass %	11	—	2.2	16.5	11	11	11
Additive	MoDTC	Component (C)	mass %	1	1	1	1	—	0.1	0.5
	Dioctyl polysulfide	Component (C)	mass %	1	1	1	1	1	1	1
	ZnDTP1	Anti-wear agent	mass %	—	—		—	—	—	—
	ZnDTP2	Anti-wear agent	mass %	—	—	—	—	—	—	—
	Other additives	Antioxidant, etc.	mass %	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Evaluation results	Change in mass of acetal resin	105° C., 168 h	mass %	+0.1	+0.1	+0.1	+0.1	+0.2	+0.1	+0.15
	Extreme pressure properties		N	3923	2452	2452	3089	3923	3923	4903
	Corrosion of copper plate	100° C., 24 h		Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Worked penetration	60 W		311	318	448	280	321	317	323

TABLE 2

				Example 8	Example 9	Example 10	Comparative Example 1	Comparative Example 2	Comparative Example 3
Base oil	Mineral oil 1	Component (A)	mass %	50	50	50	50	50	50
	Mineral oil 2	Component (A)	mass %	20	20	20	20	20	20
	Mineral oil 3	Component (A)	mass %	30	30	30	30	30	30
	Amount of base oils (total)		mass %	Balance	Balance	Balance	Balance	Balance	Balance
Thickener	Urea	Component (B)	mass %	—	—	—	—	—	—
	Lithium complex	Component (B)	mass %	11	11	11	11	11	11
Additive	MoDTC	Component (C)	mass %	5	1	1	1	1	1
	Dioctyl polysulfide	Component (C)	mass %	1	—	0.1	1	1	3
	ZnDTP1	Anti-wear agent	mass %	—	—	—	5	—	—
	ZnDTP2	Anti-wear agent	mass %	—	—	—	—	5	—
	Other additives	Antioxidant, etc.	mass %	2.7	2.7	2.7	2.7	2.7	2.7
Evaluation	Change in mass of acetal resin	105° C., 168 h	mass %	+0.1	+0.05	+0.2	−0.05	−0.1	+0.45
results	Extreme pressure properties		N	3923	3089	3089	2452	2452	4903
	Corrosion of copper plate	100° C., 24 h		Absent	Absent	Absent	Present	Present	Absent
	Worked penetration	60 W		316	326	317	326	330	319

[0106] For each of the grease compositions of Examples 1 to 10, increase in the mass of acetal resin was between 0% and 0.2%, a value of extreme pressure properties was larger than 2452 N, and no corrosion of the copper plate was able to be confirmed.

[0107] For the grease compositions of Comparative Example 1 supplemented with ZnDTP1 and Comparative Example 2 supplemented with ZnDTP2, the mass of acetal resin was decreased, and the copper plate corroded.

[0108] For the grease composition of Comparative Example 3 supplemented with 3 mass % of dioctyl polysulfide, the mass of acetal resin was increased by more than 2.0%.

INDUSTRIAL APPLICABILITY

[0109] The grease composition of the invention can provide a grease composition that does not deteriorate resin, particularly, acetal resin, in contact therewith even under a high temperature condition.

1. A grease composition for resin, comprising

(A) a lubricating base oil,

(B) a thickener, and

(C) at least one selected from the group consisting of an organic molybdenum compound and a sulfur-based extreme pressure agent, wherein

when the grease composition comprises the sulfur-based extreme pressure agent, a content of the sulfur-based extreme pressure agent is from 0.05 mass % to 2.5 mass % based on a total amount of the composition, and

the grease composition is substantially free of zinc dialkyldithiophosphate.

2. The grease composition for resin according to claim **1**, wherein the resin is acetal resin.

3. The grease composition for resin according to claim **1**, wherein the grease composition comprises the organic molybdenum compound, and a content of the organic molybdenum compound is from 0.05 mass % to 5 mass % based on the total amount of the composition.

4. The grease composition for resin according to claim **1**, wherein the grease composition comprises both the organic molybdenum compound and the sulfur-based extreme pressure agent.

5. The grease composition for resin according to claim **1**, wherein the thickener is a metal soap-based thickener.

6. The grease composition for resin according to claim **1**, wherein the grease composition has a penetration of from 265 to 475.

7. The grease composition for resin according to claim **1**, wherein

(A) a content of the lubricating base oil is from 50 mass % to 95 mass % based on the total amount of the composition, and

(B) a content of the thickener is from 2 mass % to 30 mass % based on the total amount of the composition.

8. The grease composition for resin according to claim **1**, wherein a content of the zinc dialkyldithiophosphate is 1 mass % or less based on the total amount of the composition.

9. The grease composition for resin according to claim **2** for use in a member containing acetal resin and a metal.

10. The grease composition for resin according to claim **9**, wherein the metal is copper.

11. A method for lubricating a sliding part, comprising allowing a grease composition according to claim **1** to be disposed on the sliding part.

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