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(54) **LUBRICANT COMPOSITION BASED ON METAL NANOPARTICLES**

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(57) **ABSTRACT**

The present invention relates to a lubricant composition comprising a dispersant of high molecular weight and metal nanoparticles. The lubricant composition according to the invention simultaneously has good stability and good anti-flaking properties.

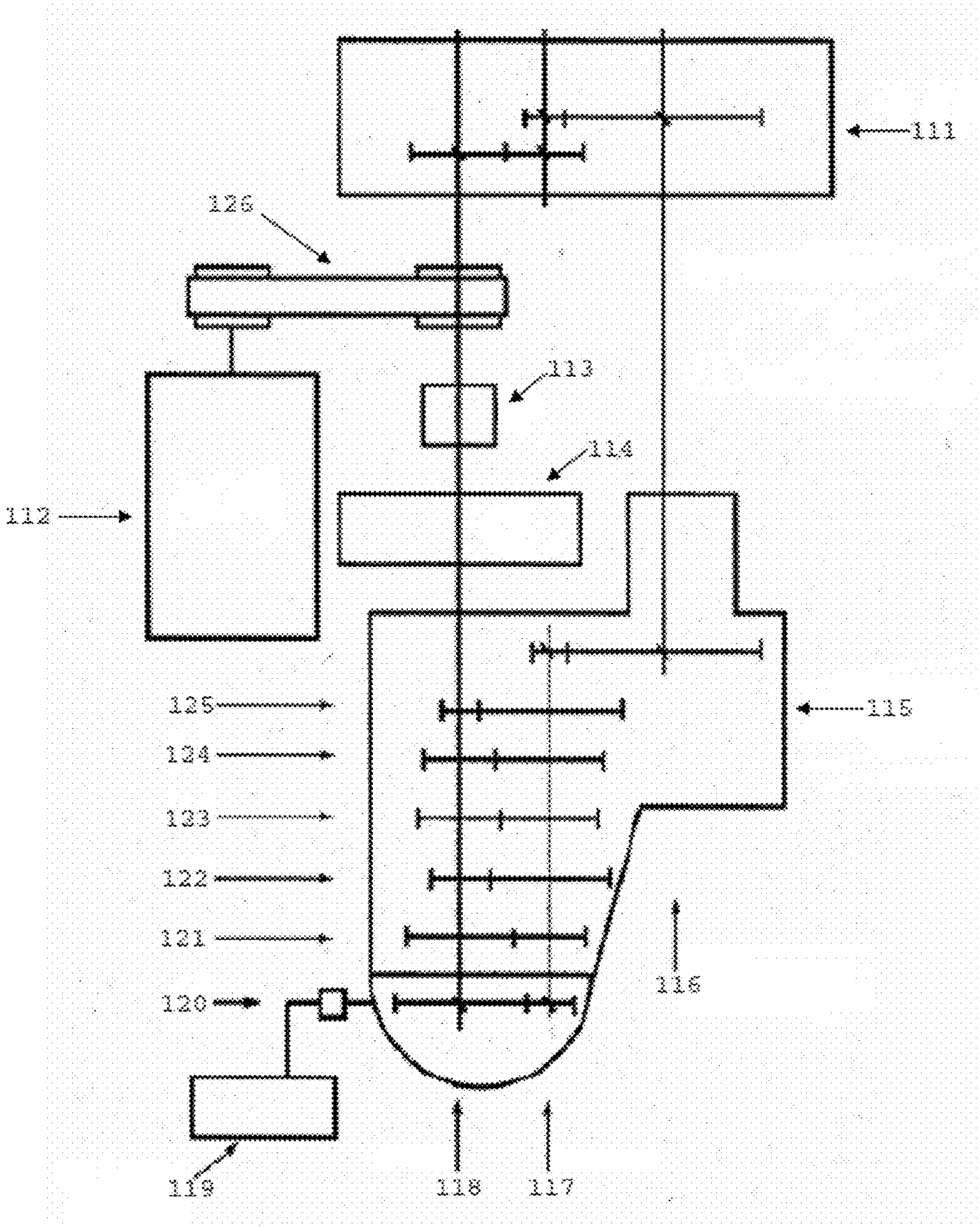
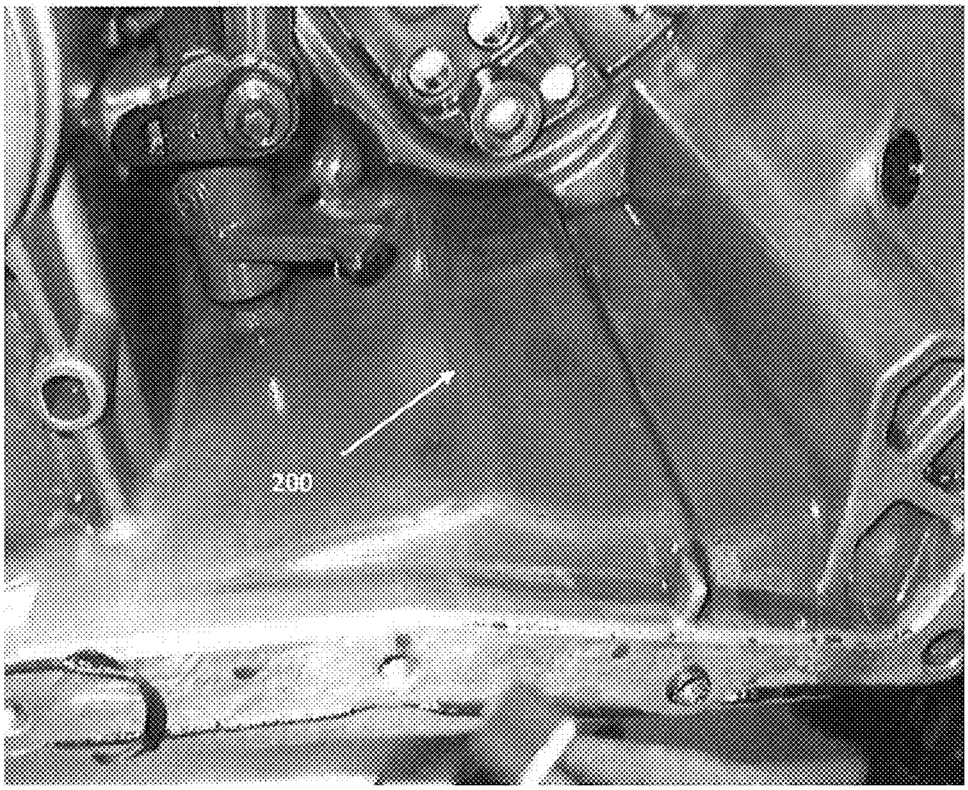


Fig 1



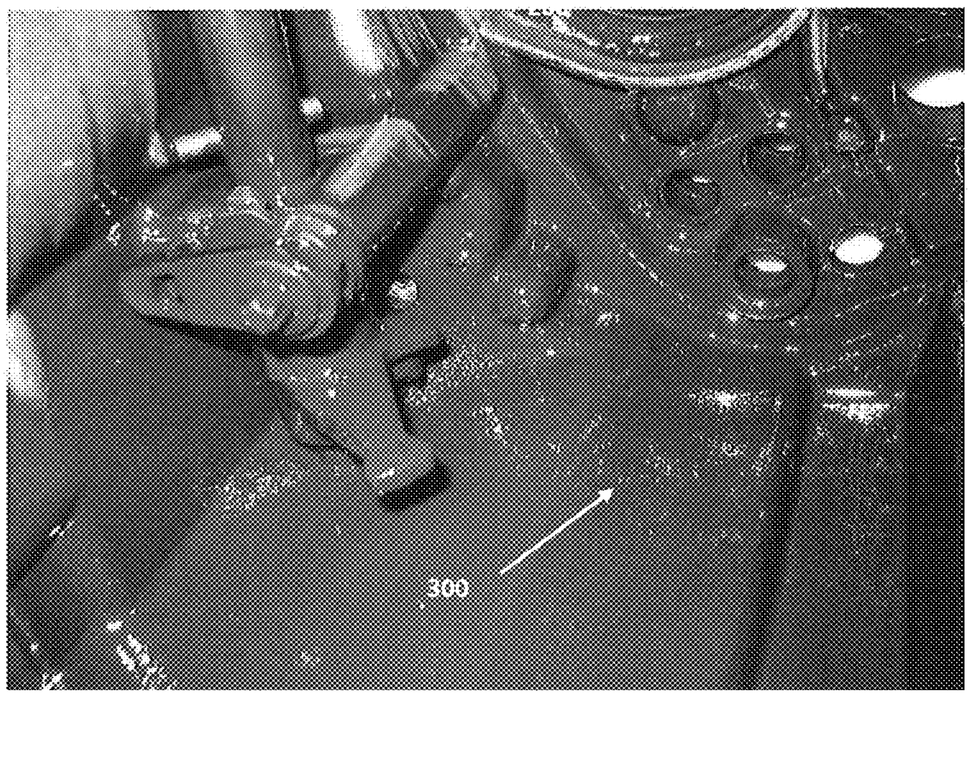


Fig 3

LUBRICANT COMPOSITION BASED ON METAL NANOPARTICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a National Phase Entry of International Patent Application No. PCT/EP2014/058013, filed on Apr. 18, 2014, which claims priority to French Patent Application Serial No. 1353561, filed on Apr. 19, 2013, both of which are incorporated by reference herein.

[0002] The present invention is applicable to the field of lubricants, and more particularly to the field of lubricants for motor vehicles, in particular to the field of lubricants for motor vehicle transmission components. The invention relates to a lubricant composition comprising metal nanoparticles. More particularly, the invention relates to a lubricant composition comprising a dispersant with a high weight-average molecular weight and metal nanoparticles. The lubricant composition according to the invention simultaneously has good stability and good anti-flaking properties.

[0003] The present invention also relates to a method for reducing the flaking of a mechanical part utilizing this lubricant composition. The present invention also relates to a composition of the additive-concentrate type comprising a dispersant with a high weight-average molecular weight and metal nanoparticles.

BACKGROUND

[0004] Motor vehicle transmission components operate under a high load and high speeds. The oils for these transmission components must therefore be particularly efficient at protecting parts against wear and fatigue, and in particular protect the gear teeth against the flaking phenomenon. The phenomenon of wear corresponds to the abrasion and fretting of metal at the surface during friction between the moving parts.

[0005] As for the flaking phenomenon, it differs from the phenomenon of wear. It corresponds to a degradation of the parts due to fatigue and is produced after a long period of ageing, preceding visible deterioration. It is known that this phenomenon starts by the initiation of cracks at a certain depth under the surface, these cracks propagate, and when normal cracks are created at the surface, flakes suddenly break off. This phenomenon is prevented by reducing the contact stresses by means of an appropriate geometry of the parts, and by reducing friction, while avoiding adhesion. The lubricant is involved in this prevention process, mainly due to the physico-chemical reactivity of its additives.

[0006] The sulphur-, phosphorus-, phosphorus/sulphur-, or borate-containing anti-wear and extreme-pressure additives are known to give the transmission oils protection properties against flaking. The other additives present in the lubricant can also have a positive or negative impact on the propagation of the cracks inside the parts and therefore on the flaking phenomenon.

[0007] In manual gearboxes, the presence of synchronizers leads to additional stresses. In fact, these components comprise a cone and ring device between which friction must be precisely controlled. Thus, the friction should be sufficient for synchronization of the gears, but the cone and the ring must then be able to disengage, otherwise there is a risk of blocking the synchronizer.

[0008] Moreover, if the friction level is not adapted to the geometry of the parts, wear occurs on the cone-ring assembly. The friction level can be adjusted by adding friction modifiers in these oils for gear boxes. Thus, in oils for manual gear boxes, anti-wear, extreme-pressure additives and friction modifiers can co-exist, all having an action at the surface of the parts and potentially an effect on both the friction level and the flaking phenomenon.

[0009] It is known to formulate lubricant compositions comprising friction modifier compounds of the organomolybdenum type with organophosphorus- and/or organosulphur- and/or organophosphorus/sulphur-containing anti-wear and extreme-pressure compounds, in particular in order to improve the anti-wear properties of these oils. Other compounds have been described as possibly being useful in the lubrication of mechanical parts, in particular of the parts of an engine.

[0010] The use of nanoparticles, in particular of metal nanoparticles, in a lubricant composition, has been described. Thus, the document WO 2007/035626 describes a lubricant composition comprising metal nanoparticles, in particular based on lithium, potassium, sodium, copper, magnesium, calcium, barium or mixtures thereof.

[0011] Document US2011/0152142 A1 discloses a composition comprising at least one base oil, at least one dispersant and nanoparticles of metal hydroxides in the form of crystals. These compositions are used for lubricating combustion engines and for neutralizing the acids formed during combustion.

[0012] Document US2006/0100292 A1 describes a method for manufacturing a grease in which at least one base oil, at least one dispersant and nanoparticles of metal hydroxides in the form of crystals are mixed. This method has the advantage of reducing the formation of foam, reducing environmental risks and reducing reaction time.

[0013] Document US2009/0203563 describes a method for manufacturing an ovebased or neutral detergent. This method utilizes a surfactant and an organic medium with a composition comprising at least one base oil, at least one dispersant and nanoparticles of metal hydroxides in the form of crystals.

[0014] Document WO2011/081538 A1 describes a method for manufacturing particles of molybdenum disulphide and tungsten disulphide, the method consisting of passing and pressing a mixture of molybdenum disulphide and tungsten disulphide between plates covered with glue. This document does not describe lubricant compositions.

[0015] As for document CN 101691517, it describes an engine oil comprising a dispersant and tungsten disulphide nanoparticles, making it possible to improve the service life of the engine and reduce fuel consumption. However, the content of tungsten disulphide nanoparticles ranges from 15 to 34%. Such a content can lead to instability of the composition and is therefore incompatible with a lubricant composition, in particular for transmissions. Furthermore, no indication is given in this document as to any anti-flaking properties of the oil, in particular vis-à-vis the transmission components of a motor vehicle.

[0016] Document EP 1 953 196 describes a dispersion of metal nanoparticles, in particular of metal oxides based on zinc, zirconium, cerium, titanium, aluminium, indium or tin in a organic solvent and in the presence of a polymeric dispersant of PIBSA (polyisobutenyl succinic anhydride) type. However, this document does not relate to the field of lubricant compositions and in particular discloses no lubricant composition comprising at least one base oil and metal nanoparticles. The organic solvents mentioned in this document have no lubricant properties. Furthermore, they have a flash point of less than 100° C. which makes them incompatible with use in lubricant applications in which the implementation temperature is greater than or equal to 100° C. Moreover, no indication is given in this document of any anti-flaking properties of mechanical parts, in particular vis-à-vis the transmission components of a motor vehicle.

[0017] It would therefore be desirable to have available a lubricant composition, in particular for motor vehicles, which is both stable and makes it possible to reduce, or even eliminate the flaking phenomenon, in particular in transmission components, and more particularly in gearboxes. It would also be desirable to have available a lubricant composition, in particular for motor vehicles having good anti-flaking properties while retaining satisfactory friction properties.

[0018] An objective of the present invention is to provide a lubricant composition overcoming some or all of the above-mentioned drawbacks. Another objective of the invention is to provide a lubricant composition that is stable and easy to utilize. Another objective of the present invention is to provide a lubrication method making it possible in particular to reduce the flaking phenomena of mechanical parts, and more particularly of transmission components of motor vehicles.

SUMMARY

[0019] A subject of the invention is thus a lubricant composition comprising at least one base oil, at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons and metal nanoparticles in a content by weight ranging from 0.01 to 2% with respect to the total weight of the lubricant composition, said metal nanoparticles being concentric polyhedrons with a multilayer structure or in sheets. According to the invention, the weight-average molecular weight of the dispersant is assessed according to the standard ASTM D5296. Surprisingly, the Applicant found that the presence of a dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons in a lubricant composition comprising at least one base oil and metal nanoparticles makes it possible both to improve the stability of the lubricant composition, and to give said composition very good anti-flaking properties.

[0020] Thus, the present invention makes it possible to formulate lubricant compositions comprising a reduced content of metal nanoparticles and having, however, remarkable anti-flaking properties. Advantageously, by the use of lubricant compositions according to the invention, the risk of residual deposition of metal nanoparticles on mechanical parts, and more particularly on transmission components of motor vehicles, is significantly reduced or even eliminated. Advantageously, the lubricant compositions according to the invention have an improved storage stability as well as a viscosity that does not vary, or only very slightly. Advantageously, the lubricant compositions according to the invention retain satisfactory friction properties.

[0021] In an embodiment, the lubricant composition essentially consists of at least one base oil, at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons and at least a content by weight of metal nanoparticles ranging from 0.01 to 2% with respect to the total weight of the lubricant composition. The invention also relates to a transmission oil comprising a lubricant composition as defined above. The invention also relates to the use of a lubricant composition as defined above for the lubrication of gearboxes or axles, preferentially of the gearboxes of motor vehicles, advantageously for the lubrication of manual gearboxes.

[0022] The invention also relates to the use of a lubricant composition as defined above for reducing the flaking of a mechanical part, preferentially of a transmission component, more preferentially of a gearbox, even more preferentially of a manual gearbox. The invention also relates to a process for reducing the flaking of a mechanical part, preferentially of a transmission component, advantageously of a gearbox or of an axle, comprising at least bringing the mechanical part into contact with a lubricant composition as defined above. The invention also relates to a composition of the additive-concentrate type comprising at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons and tungsten disulphide nanoparticles.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1** shows a closed-loop power circulation bench comprising a simulated gearbox (**111**), an electric motor (**112**), a torque meter (**113**), a torque producing device (**114**), a gearbox comprising the torque to be tested (**115**), a differential (**116**), a output shaft (**117**), an input shaft (**118**), a system for detecting the formation of flakes (**119**), fifth gear (**120**), reverse gear (**121**), fourth gear (**122**), third gear (**123**), second gear (**124**), first gear (**125**) and a drive belt (**126**).

[0024] FIG. **2** is a photograph of a gearbox housing after 600 h of testing on a closed-loop power circulation bench with a composition according to the invention.

[0025] FIG. **3** is a photograph of a gearbox housing after 400 h of testing on a closed-loop power circulation bench with a composition not according to the invention.

DETAILED DESCRIPTION

[0026] The percentages given below correspond to percentages by mass of active ingredient.

Metal Nanoparticles

[0027] The lubricant composition according to the invention comprises metal nanoparticles in a content by weight ranging from 0.01 to 2% with respect to the total weight of the lubricant composition. By metal nanoparticles, is meant in particular metal particles, generally solid, the average size of which is less than or equal to 600 nm. Advantageously, the metal nanoparticles are constituted by at least 80% by mass of at least one metal, or by at least 80% by mass of at least one metal alloy or by at least 80% by mass of at least one metal, in particular transition metal, chalcogenide with respect to the total mass of the nanoparticle.

[0028] Advantageously, the metal nanoparticles are constituted by at least 90% by mass of at least one metal, or by at least 90% by mass of at least one metal alloy or by at least 90% by mass of at least one metal, in particular transition metal, chalcogenide with respect to the total mass of the nanoparticle. Advantageously, the metal nanoparticles are constituted by at least 99% by mass of at least one metal, or by at least 99% by mass of at least one metal alloy or by at least 99% by mass of at least one metal, in particular transition metal, chalcogenide with respect to the total mass of the nanoparticle, the remaining 1% being constituted by impurities. Advantageously, the metal of which the metal nanoparticle is constituted can be selected from the group formed by tungsten, molybdenum, zirconium, hafnium, platinum, rhenium, titanium, tantalum, niobium, zinc, cerium, aluminium, indium and tin.

[0029] The metal nanoparticles can have the form of spheres, lamellas, fibres, tubes, and fullerene-type structures. Advantageously, the metal nanoparticles used in the compositions according to the invention are solid metal nanoparticles having a fullerene-type (or fullerene-like) structure and are represented by the formula MX_n in which M represents a transition metal, X a chalcogen, with n=2 or n=3 depending on the oxidation state of the transition metal M.

[0030] Preferably, M is selected from the group formed by tungsten, molybdenum, zirconium, hafnium, platinum, rhenium, titanium, tantalum and niobium. More preferably, M is selected from the group formed by molybdenum and tungsten. Even more preferably, M is tungsten.

[0031] Preferably, X is selected from the group formed by oxygen, sulphur, selenium and tellurium. Preferably, X is selected from sulphur or tellurium. Even more preferably, X is sulphur.

[0032] Advantageously, the metal nanoparticles according to the invention are selected from the group formed by MoS_2, $MoSe_2$, $MoTe_2$, WS_2, WSe_2, ZrS_2, $ZrSe_2$, HfS_2, $HfSe_2$, PtS_2, ReS_2, $ReSe_2$, TiS_3, ZrS_3, $ZrSe_3$, HfS_3, $HfSe_3$, TiS_2, TaS_2, $TaSe_2$, NbS_2, $NbSe_2$ and $NbTe_2$. Preferably, the metal nanoparticles according to the invention are selected from the group formed by WS_2, WSe_2, MoS_2 and $MoSe_2$, preferentially WS_2 and MoS_2, preferentially WS_2. The nanoparticles according to the invention advantageously have a fullerene-type structure.

[0033] Initially, the term fullerene denotes a closed convex polyhedron nanostructure, composed of carbon atoms. The fullerenes are similar to graphite, composed of sheets of linked hexagonal rings, but they contain pentagonal, and sometimes heptagonal rings, which prevent the structure from being flat.

[0034] Studies of the fullerene-type structures have shown that this structure was not limited to the carbon-containing materials, but was capable of being produced in all the nanoparticles of materials in the form of sheets, in particular in the case of the nanoparticles comprising chalcogens and transition metals. These structures are analogous to that of the carbon fullerenes and are called inorganic fullerenes or fullerene-type structures (or "Inorganic Fullerene-like materials", also denoted "IF"). The fullerene-type structures are described in particular by Tenne, R., Margulis, L., Genut M. Hodes, G. *Nature* 1992, 360, 444. The document EP 0580 019 describes in particular these structures and their synthesis process.

[0035] The metal nanoparticles are closed structures, of the spherical type, more or less perfect depending on the synthesis processes used. The nanoparticles according to the invention are concentric polyhedrons with a multilayer or sheet structure. This is referred to as an "onion" or "nested polyhedron" structure.

[0036] By concentric polyhedron having a multilayer or sheet structure, is meant more particularly substantially spherical polyhedrons, the different layers of which constitute several spheres having the same centre. The multilayer or sheet structure of the nanoparticles according to the invention can in particular be determined by transmission electron microscopy (TEM). In an embodiment of the invention, the metal nanoparticles are multilayer metal nanoparticles comprising from 2 to 500 layers, preferably from 20 to 200 layers, advantageously from 20 to 100 layers. The number of layers of the nanoparticles according to the invention can in particular be determined by transmission electron microscopy.

[0037] The average size of the metal nanoparticles according to the invention ranges from 5 to 600 nm, preferably from 20 to 400 nm, advantageously from 50 to 200 nm. The size of the metal nanoparticles according to the invention can be determined using images obtained by transmission electron microscopy or by high resolution transmission electron microscopy. It is possible to determine the average size of the particles from measurement of the size of at least 50 solid particles visualized on transmission electron microscopy photographs. The median value of the distribution histogram of the measured sizes of the solid particles is the average size of the solid particles used in the lubricant composition according to the invention.

[0038] In an embodiment of the invention, the average diameter of the primary metal nanoparticles according to the invention ranges from 10 to 100 nm, preferably from 30 to 70 nm. The average diameter of the nanoparticles according to the invention can in particular be determined by transmission electron microscopy. Advantageously, the content by weight of metal nanoparticles ranges from 0.05 to 2%, preferably from 0.1 to 1%, advantageously from 0.1 to 0.5% with respect to the total weight of the lubricant composition. As an example of metal nanoparticles according to the invention, the product NanoLub Gear Oil Concentrate marketed by the company Nanomaterials may be mentioned, being presented in the form of a dispersion of multilayer nanoparticles of tungsten disulphide in a mineral oil or oil of the PAO (Poly Alfa Olefin) type.

Dispersant

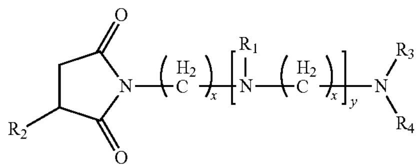
[0039] The lubricant composition according to the invention comprises at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons. According to the invention, the weight-average molecular weight of the dispersant is assessed according to the standard ASTM D5296. By dispersant within the meaning of the present invention, is meant more particularly any compound which ensures the maintenance in suspension of the metal nanoparticles.

[0040] In an embodiment of the invention, the dispersant can be selected from the compounds comprising at least one succinimide group, the polyolefins, the olefin copolymers (OCP), the copolymers comprising at least one styrene unit, the polyacrylates or their derivatives. By derivatives, is meant any compound comprising at least one group or a polymer chain as defined above. Advantageously, the dispersant according to the invention is selected from the compounds comprising at least one succinimide group.

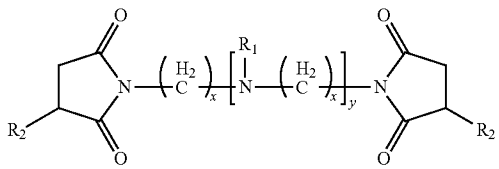
[0041] In a preferred embodiment of the invention, the dispersant can be selected from the compounds comprising at least one substituted succinimide group or the compounds comprising at least two substituted succinimide groups, the succinimide groups being linked at their vertex bearing a nitrogen atom by a polyamine group. By substituted succinimide group within the meaning of the present invention, is meant a succinimide group at least one of the carbon-containing vertices of which is substituted with a hydrocarbon-containing group comprising from 8 to 400 carbon atoms. In a preferred embodiment of the invention, the dispersant is selected from the polyisobutylene succinimide-polyamines

[0042] Advantageously, the dispersant is a substituted succinimide of formula (I) or a substituted succinimide of formula (II):

(I)



(II)



in which:

[0043] x represents an integer ranging from 1 to 10, preferably 2, 3, 4, 5 or 6;

[0044] y represents an integer ranging from 2 to 10;

[0045] R_1 represents a hydrogen atom, a linear or branched alkyl group comprising from 2 to 20 carbon atoms, a heteroalkyl group comprising from 2 to 20 carbon atoms and at least one heteroatom selected from the group formed by O, N and S, a hydroxyalkyl group comprising from 2 to 20 carbon atoms or a —$(CH2)_x$—O—$(CH2)_x$—OH group;

[0046] R_2 represents a linear or branched alkyl group comprising from 8 to 400 carbon atoms, preferably from 50 to 200 carbon atoms, an aryl group comprising from 8 to 400 carbon atoms, preferably from 50 to 200 carbon atoms, a linear or branched arylalkyl group comprising from 8 to 400 carbon atoms, preferably from 50 to 200 carbon atoms or a linear or branched alkylaryl group comprising from 8 to 400 carbon atoms, preferably from 50 to 200 carbon atoms;

[0047] R_3 and R_4, identical or different, represent independently a hydrogen atom, a linear or branched alkyl group comprising from 1 to 25 carbon atoms, an alkoxy group comprising from 1 to 12 carbon atoms, an alkylene group comprising from 2 to 6 carbon atoms, a hydroxylated alkylene group comprising from 2 to 12 carbon atoms or an aminated alkylene group comprising from 2 to 12 carbon atoms.

[0048] Advantageously, the dispersant is a substituted succinimide of formula (I) or a substituted succinimide of formula (II) in which R_2 represents a polyisobutylene group. Even more advantageously, the dispersant is a substituted succinimide of formula (II) in which R_2 represents a polyisobutylene group. Even more advantageously, the dispersant is a substituted succinimide of formula (II) in which:

[0049] R_1 represents a —$(CH2)_x$—O—$(CH2)_x$—OH group,

[0050] R_2 represents a polyisobutylene group,

[0051] x represents 2,

[0052] y represents 5.

[0053] Advantageously, the dispersant according to the invention has a weight-average molecular weight ranging from 2000 to 15000 Daltons, preferably ranging from 2500 to 10000 Daltons, advantageously from 3000 to 7000 Daltons. Advantageously, the dispersant also has, moreover, a number-average molecular weight greater than or equal to 1000 Daltons, preferably ranging from 1000 to 5000 Daltons, more preferentially from 1800 to 3500 Daltons, advantageously from 1800 to 3000 Daltons. According to the invention, the number-average molecular weight of the dispersant is assessed according to the standard ASTM D5296. In a preferred embodiment of the invention, the content by weight of dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons ranges from 0.1 to 10%, preferably from 0.1 to 5%, advantageously from 0.1 to 3% with respect to the total weight of the lubricant composition. As an example of a dispersant according to the invention, OLOA 13000 from the company Oronite may be mentioned.

Other Compounds

[0054] Base Oils

[0055] The lubricant compositions according to the invention can contain any type of lubricant base, mineral, synthetic or natural, animal or vegetable suited to their use. The base oil or oils used in the lubricant compositions according to the present invention can be oils of mineral or synthetic origin, of groups I to V according to the classes defined in the API classification (or their equivalents according to the ATIEL classification) as summarized below, alone or in a mixture. Moreover, base oil or oils used in the lubricant compositions according to the invention can be selected from the oils of synthetic origin of group VI according to the ATIEL classification. The API classification is defined in American Petroleum Institute 1509 "Engine oil Licensing and Certification System" 17th edition, September 2012.

	Saturates content	Sulphur content	Viscosity index (VI)
Group I Mineral oils	<90%	>0.03%	80 ≤ VI < 120
Group II Hydrocracked oils	≥90%	≤0.03%	80 ≤ VI < 120
Group III Hydrocracked or hydro-isomerized oils	≥90%	≤0.03%	≥120
Group IV	Poly Alpha Olefins (PAO)		
Group V	Esters and other bases not included in bases of Groups I to IV		
Group VI*	Poly Internal Olefins (PIO)		

*only for the ATIEL classification

[0056] The mineral base oils according to the invention include any type of bases obtained by atmospheric and vacuum distillation of crude oil, followed by refining operations such as solvent extraction, deasphalting, solvent dewaxing, hydrotreatment, hydrocracking and hydroisomerization, hydrofinishing. The base oils of the lubricant compositions according to the present invention can also be synthetic oils, such as the poly alpha olefins (PAO) or certain esters of carboxylic acids and alcohols, in particular polyol esters. The poly alpha olefins used as base oils, are for example obtained from monomers having from 4 to 32 carbon atoms (for example octene, decene), and have a viscosity at 100° C. comprised between 1.5 and 15 cSt measured according to the standard ASTM D445. Mixtures of synthetic and mineral oils can also be used.

[0057] There is no limitation on the use of any particular lubricant base for producing the lubricant compositions according to the invention, except that they must have properties, in particular viscosity, viscosity index, sulphur content, oxidation resistance, suited to use in a gearbox, in particular in a motor vehicle gearbox, in particular in a manual gearbox. Advantageously, the base oil has a flash point greater than or equal to 150° C., preferably greater than or equal to 170° C., even more preferentially greater than or equal to 190° C. Advantageously, the base oil is selected from the group formed by the bases of group I, the bases of group II, the bases of group III, the bases of group IV, the bases of group V of the API classification (or their equivalents according to the ATIEL classification) and mixtures thereof. Moreover, the base oil can be selected from the bases of group VI of the ATI EL classification.

[0058] In an embodiment of the invention the base oil is selected from the group formed by the bases of group III, the bases of group IV, the bases of group V of the API classification and mixtures thereof. In a preferred embodiment of the invention, the base oil is a mixture of bases of group IV and group V of the API classification. In a preferred embodiment of the invention, the base oil is selected from the poly alpha olefins (PAO) and the esters, preferably the polyol esters or mixtures thereof. In a more preferred embodiment of the invention, the base oil is a mixture of at least one poly alpha olefin and at least one ester, preferably a polyol ester.

[0059] In an embodiment of the invention, the base oil or the base oils can represent at least 50% by mass, with respect to the total mass of the lubricant composition, preferentially at least 60%, or also at least 70%. Typically, it (they) represent (s) between 75 and 99.89% by weight, with respect to the total weight of the lubricant compositions according to the invention. Preferentially, the lubricant compositions according to the invention have a kinematic viscosity at 100° C. measured according to the standard ASTM D445 comprised between 4 and 41 cSt, according to the classification SAE J 306, preferably between 4.1 and 32.5 cSt.

[0060] The preferred grades are all the grades comprised between the grades SAE 75W and SAE 140, in particular the grades SAE 75W, SAE 75W-80 and SAE 75W-90. Preferentially, the lubricant compositions according to the invention have a viscosity index (VI) greater than 95 (measured according to the standard ASTM 2270). In a preferred embodiment, a subject of the invention is a transmission oil comprising a lubricant composition according to the invention. All of the characteristics and preferences presented for the lubricant composition also apply to the transmission oil according to the invention.

[0061] Additional Additives

[0062] The lubricant compositions according to the invention can also contain any type of additives suitable for use in the formulations of transmission oils, for example one or more additives selected from the additional dispersants, polymeric viscosity index improvers, antioxidants, corrosion inhibitors, friction modifiers or anti-foaming agents, used alone or in mixtures, present in the usual contents required for the application. The additional dispersants are selected from dispersants different from the dispersants having a weight-average molecular weight greater than or equal to 2000 Daltons. These additional dispersants can in particular ensure the maintenance in suspension and the removal of the insoluble solid contaminants constituted by the by-products of oxidation and combustion residues (soots) which are formed when a lubricant composition is in service. In an embodiment of the invention, the additional dispersants can be selected from the groups formed by the succinimides that are different from the compounds of formula (I) or (II) having a weight-average molecular weight greater than or equal to 2000 Daltons or the Mannich bases.

[0063] In an embodiment, the lubricant composition according to the invention can also comprise at least one additional additive selected from the polymeric viscosity index improvers, the antioxidants and mixtures thereof. The polymeric viscosity index improvers can be selected from polymers other than the dispersant according to the invention.

[0064] The polymeric viscosity index improvers can be selected from the group of the shear-stable polymers, preferably from the group constituted by the ethylene and alpha-olefin copolymers, in particular the ethylene/propylene copolymers. In a preferred embodiment of the invention, the additional additive is a polymeric viscosity index improver selected from the ethylene and alpha-olefin copolymers.

[0065] The antioxidants can be selected from the amine-containing antioxidants, preferably the diphenylamines, in particular the dialkylphenylamines, such as the octadiphenylamines, phenyl-alpha-naphthyl amines, the phenolic antioxidants (dibutylhydroxytoluene BHT and derivatives) or sulphur-containing antioxidants (sulphurized phenates). In a preferred embodiment of the invention, the additional additive is an antioxidant selected from the dialkyphenylamines, the phenolic antioxidants, used alone and mixtures thereof.

[0066] The friction modifiers can be compounds providing metallic elements that are different from the metal nanoparticles according to the invention, or an ash-free compound. Among the compounds providing metallic elements, the complexes of transition metals such as Mo, Sb, Sn, Fe, Cu, Zn, the ligands of which can be hydrocarbon-containing compounds containing oxygen, nitrogen, sulphur or phosphorus atoms, such as molybdenum dithiocarbamates or dithiophosphates may be mentioned. The ash-free friction modifiers are of organic origin and can be selected from the monoesters of fatty acids and polyols, alkoxylated amines, alkoxylated fatty amines, amine phosphates, fatty alcohols, fatty epoxides, borated fatty epoxides, fatty amines or glycerol esters of fatty acid. By "fatty" is meant within the meaning of the present invention a hydrocarbon-containing group comprising from 8 to 24 carbon atoms.

[0067] In a preferred embodiment of the invention, the additional additive is a friction modifier selected from the molybdenum dithiocarbamates, amine phosphates and fatty alcohols, used alone or in a mixture. The anti-corrosion additives can be selected from the phenol derivatives, in particular ethoxylated phenol derivatives and substituted with alkyl groups in the ortho position. The corrosion inhibitors can be dimercaptothiadiazole derivatives.

[0068] In another preferred embodiment of the invention, the additional additive comprises a mixture of an anti-oxidant and a polymeric viscosity index improver selected from the group formed by the ethylene/alpha-olefin copolymers, in particular the ethylene/propylene copolymers. In another preferred embodiment of the invention, the additional additive comprises a mixture of an amine-containing antioxidant, a phenolic antioxidant and a polymeric viscosity index improver selected from the ethylene and alpha-olefin copolymers. In an embodiment of the invention, the mass ratio (metal nanoparticles:dispersant) ranges from 1/50 to 10/1, preferably from 1/50 to 5/1, more preferentially from 1/30 to 5/1, advantageously from 1/10 to 5/1.

[0069] A subject of the invention is also a lubricant composition comprising:

[0070] from 50 to 99.89% of at least one base oil,

[0071] from 0.01 to 2% of metal nanoparticles,

[0072] from 0.1 to 10% of at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons.

All of the characteristics and preferences presented above for the base oil, for the metal nanoparticles and for the dispersant also apply to the above lubricant composition.

[0073] In an embodiment, a subject of the invention is also a lubricant composition comprising:

[0074] from 50 to 99.79% of at least one base oil,

[0075] from 0.01 to 2% of metal nanoparticles,

[0076] from 0.1 to 10% of at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons,

[0077] from 0.1 to 10% of at least one additional additive, preferentially from 2 to 5%, specifically 3.5%.

All of the characteristics and preferences presented above for the base oil, for the metal nanoparticles, for the dispersant and for the additional additive also apply to the above lubricant composition.

[0078] A subject of the invention is also a lubricant composition consisting essentially of:

[0079] 50 to 99.9% of at least one base oil,

[0080] 0.01 to 2% of metal nanoparticles,

[0081] 0.1 to 10% of at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons.

All of the characteristics and preferences presented above for the base oil, for the metal nanoparticles and for the dispersant also apply to the above lubricant composition.

[0082] In an embodiment, a subject of the invention is also a lubricant composition essentially consisting of:

[0083] 50 to 99.79% of at least one base oil,

[0084] 0.01 to 2% of metal nanoparticles,

[0085] 0.1 to 10% of at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons,

[0086] 0.1 to 10% of at least one additional additive, preferentially from 2 to 5%, specifically 3.5%.

All of the characteristics and preferences presented above for the base oil, for the metal nanoparticles, for the dispersant and for the additional additive also apply to the above lubricant composition.

[0087] A subject of the invention is also a composition of the additive-concentrate type comprising:

[0088] from 1 to 15% of tungsten disulphide nanoparticles,

[0089] from 5 to 99% of at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons.

All of the characteristics and preferences presented above for the tungsten disulphide nanoparticles and for the dispersant also apply to the above composition. Advantageously, the tungsten disulphide nanoparticles have a fullerene-type structure.

[0090] In an embodiment, the invention relates to a composition of the additive-concentrate type comprising:

[0091] from 1 to 15% of tungsten disulphide nanoparticles,

[0092] from 15 to 89% of at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons,

[0093] from 10 to 59% of at least one additional additive.

All of the characteristics and preferences presented above for the tungsten disulphide nanoparticles, for the dispersant and for the additional additive also apply to the above composition. Advantageously, the tungsten disulphide nanoparticles have a fullerene-type structure.

[0094] In an embodiment of the invention, at least one base oil can be added to the composition of the additive-concentrate type according to the invention in order to obtain a lubricant composition according to the invention. Advantageously, the base oil is a base selected from the group formed by the bases of group III, the bases of group IV, the bases of group V of the API classification and mixtures thereof. In a preferred embodiment of the invention, the base oil is a mixture of bases of group IV and group V of the API classification, preferably the base oil is selected from the poly alpha olefins (PAO) and the esters and a mixture thereof. In a more preferred embodiment of the invention, the base oil is a mixture of at least one poly alpha olefin and at least one ester, preferably a polyol ester.

The Parts

[0095] The lubricant composition according to the invention can lubricate at least one mechanical part or mechanical component, in particular bearings, gears, universal joints, transmissions, the pistons/rings/liners system, camshafts, clutch, manual or automatic gearboxes, axles, rocker arms, housings etc. In a preferred embodiment, the lubricant composition according to the invention can lubricate a mechanical part or a metal component of the transmission, clutch, manual or automatic gearboxes, preferably manual.

[0096] A subject of the invention is also a process for reducing the flaking of a mechanical part, preferentially of a transmission component, advantageously of a gearbox or an axle, comprising at least bringing the mechanical part into contact with a lubricant composition as defined above or obtained from the composition of the additive-concentrate type as defined above. All of the characteristics and preferences presented for the lubricant composition also apply to the process for reducing the flaking of a mechanical part according to the invention.

[0097] A subject of the invention is also the use of a lubricant composition according to the invention for the lubrication of gearboxes or axles, preferentially the gearboxes of motor vehicles. In a preferred embodiment, the invention relates to the use of a lubricant composition according to the invention for the lubrication of manual gearboxes of motor vehicles. All of the characteristics and preferences presented for the lubricant composition also apply to the use for lubricating gearboxes according to the invention.

[0098] A subject of the invention is also the use of a lubricant composition according to the invention for reducing the flaking of a mechanical part, preferentially of a transmission component, more preferentially of a gearbox or an axle. In a preferred embodiment, the invention relates to the use of a lubricant composition according to the invention for reducing the flaking of a manual gearbox. All of the characteristics and preferences presented for the lubricant composition also apply to the use for reducing the flaking according to the invention.

[0099] The different subjects of the present invention and their implementations will be better understood on reading the following examples. These examples are given as an indication, without being limitative in nature.

EXAMPLES

Example 1

Assessment of the Stability of Lubricant Compositions According to the Invention

[0100] The stability of lubricant compositions according to the invention is assessed by monitoring, over time, the concentration of tungsten disulphide nanoparticles in the supernatant phase of the composition. To this end, different lubricant compositions were prepared from the following compounds:

- **[0101]** a base oil of group III,
- **[0102]** a mixture of 20% tungsten disulphide nanoparticles in active material in an oil (NanoLub Gear Oil Concentrate marketed by the company Nanomaterials),
- **[0103]** dispersant 1: dispersant of the PIB succinimide type with a weight-average molecular weight measured according to the standard ASTM D5296 equal to 1921 Da and a number-average molecular weight measured according to the standard ASTM D5296 equal to 1755 Da,
- **[0104]** dispersant 2: dispersant of the PIB succinimide type with a weight-average molecular weight measured according to the standard ASTM D5296 equal to 1514 Da and a number-average molecular weight measured according to the standard ASTM D5296 equal to 1328 Da,
- **[0105]** dispersant 3: dispersant of the succinimide ester type with a weight-average molecular weight measured according to the standard ASTM D5296 equal to 1132 Da and a number-average molecular weight measured according to the standard ASTM D5296 equal to 1046 Da,
- **[0106]** dispersant 4: dispersant according to the invention of the PIB succinimide type with a weight-average molecular weight measured according to the standard ASTM D5296 equal to 6370 Da and a number-average molecular weight measured according to the standard ASTM D5296 equal to 2850 Da (OLOA 13000 from the company Oronite),
- **[0107]** dispersant 5: dispersant according to the invention of the PIB succinimide type with a weight-average molecular weight measured according to the standard ASTM D5296 equal to 3085 Da and a number-average molecular weight measured according to the standard ASTM D5296 equal to 1805 Da. The different compositions L_1 to L_5 are described in Table I; the percentages indicated correspond to percentages by mass.

TABLE I

Compositions	L_1 (comparative)	L_2 (comparative)	L_3 (comparative)	L_4 (invention)	L_5 (invention)
Base oil of group III	89	89	89	89	89
Tungsten disulphide nanoparticles (NanoLub Gear Oil Concentrate)	1	1	1	1	1
Dispersant 1	10				
Dispersant 2		10			
Dispersant 3			10		
Dispersant 4				10	
Dispersant 5					10

[0108] Each of the compositions L_1 to L_5 was prepared according to the procedure below:

- **[0109]** addition of the dispersant,
- **[0110]** addition of the dispersion of tungsten disulphide nanoparticles,
- **[0111]** magnetic stirring for 1 h,
- **[0112]** addition of the base oil,
- **[0113]** stirring with heating at 60-70° C. for 1 h,
- **[0114]** stirring without heating overnight (approximately 16 h),
- **[0115]** ultrasound bath for 15 min.

[0116] The protocol for monitoring, over time, the concentration of tungsten disulphide nanoparticles in the supernatant phase for each of the compositions L_1 to L_5 is defined as follows:

- **[0117]** i) Calibration curve at t=0 h, giving the absorbance as a function of the content of tungsten disulphide nanoparticles,
- **[0118]** ii) 3 to 4 samples of different masses of the composition after stirring in the ultrasound bath for 15 min,
- **[0119]** iii) Addition of 20 ml of cyclohexane,
- **[0120]** iv) Measurement of the absorbance (wavelength fixed at 490 nm),
- **[0121]** v) Plotting the absorbance curve as a function of the concentration of tungsten disulphide nanoparticles (calculated from the sampled mass, the initial concentration of nanoparticles in the composition, the volume of cyclohexane added and density of the cyclohexane); the curve thus formed is a straight line representing the standard straight line characteristic of the composition tested,
- **[0122]** vi) Placing in a test-tube, 100 ml of composition and storage at ambient temperature,
- **[0123]** vii) Sampling a mass to be weighed and adding 20 ml of cyclohexane,
- **[0124]** viii) Measurement of the absorbance (wavelength fixed at 490 nm),
- **[0125]** ix) Calculation of the concentration of nanoparticles in the supernatant phase based on the standard straight line,
- **[0126]** x) Repetition of stages vi) to ix) at regular time intervals thus making it possible to determine the concentration of tungsten disulphide nanoparticles in the supernatant phase as a function of time.

[0127] The results are summarized in Table II and correspond to the mass concentration of tungsten disulphide nanoparticles in the supernatant phase; they are expressed as a percentage by mass. The higher the percentage and the closer it is to 1, the better the dispersion of the tungsten disulphide nanoparticles in the lubricant composition and thus the better the stability of the lubricant composition.

TABLE II

	9 to 15 d	29 to 35 d	49 to 55 d	More than 100 d
L_1	0.01	0.01	0	0
L_2	0.06	0.03	0.01	0.01
L_3	0.14	0.01	0.02	0.01
L_4	0.77	0.75	0.61	0.34
L_5	0.96	0.69	0.79	0.28

d = day

[0128] The results show that the lubricant compositions according to the invention L_4 and L_5, comprising 0.2% by weight of tungsten disulphide nanoparticles and a dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons, have an improved stability with respect to lubricant compositions comprising 0.2% by weight of tungsten disulphide nanoparticles and a dispersant having a weight-average molecular weight less than 2000 Daltons. It should be noted that this stability persists over time for the lubricant compositions according to the invention L_4 and L_5, which is not at all the case for the other compositions L_1, L_2 and L_3.

Example 2

Assessment of the Friction Properties of the Lubricant Compositions According to the Invention

[0129] The impact of the combination of tungsten disulphide nanoparticles and a dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons on the friction properties of a lubricant composition is assessed by a Cameron Plint Friction laboratory test using a reciprocating tribometer of the Cameron-Plint TE-77 type. To this end, two lubricant compositions were prepared from the following compounds:

- **[0130]** base oil 1: base oil of the poly-alpha-olefin PAO 8 type with a kinematic viscosity measured at 100° C. of 8 mm^2/s,
- **[0131]** base oil 2: polyol ester ('s Priolube 3970 from the company Croda),
- **[0132]** polymer 1: ethylene/propylene copolymer (Lucant HC600 from the company Mitsui Chemicals),
- **[0133]** polymer 2: Poly Alpha Olefin (Spectrasyn 1000 from the company Exxon),
- **[0134]** silicone-containing anti-foaming agent,
- **[0135]** a mixture of 20% tungsten disulphide nanoparticles as active ingredient in an oil (NanoLub Gear Oil Concentrate marketed by Nanomaterials),
- **[0136]** dispersant: dispersant according to the invention of the PIB succinimide type having a weight-average molecular weight measured according to the standard ASTM D5296 equal to 6370 Da and a number-average molecular weight measured according to the standard ASTM D5296 equal to 2850 Da (OLOA 13000 from the company Oronite),
- **[0137]** Friction modifier: molybdenum dithiocarbamate (Molyvan 855 from the company Vanderbilt),
- **[0138]** Additive package 1 (Anglamol 2198 from the company Lubrizol) also containing a mixture of an aminated anti-oxidant and a phenolic anti-oxidant.

[0139] The different lubricant compositions L_6 to L_7 are described in Table III; the percentages indicated correspond to percentages by mass.

TABLE III

Compositions	L_6 (comparative)	L_7 (invention)
Base oil 1	62.95	61.95
Base oil 2	15	15
Polymer 1	10	10
Polymer 2	5	5
Anti-foaming agent	0.05	0.05
Tungsten disulphide nanoparticles (NanoLub Gear Oil Concentrate marketed by Nanomaterials)		2
Dispersant		2
Friction modifier	0.5	0.5
Additive package 1	6.5	3.5
Kinematic viscosity at 100° C. measured according to the standard ASTM D445 (mm^2/s)	14.5	14.5

[0140] The composition L_6 is a lubricant composition conventionally used for lubricating transmissions, and in particular motor vehicle gearboxes. The kinematic viscosity at 100° C. of the compositions L_6 and L_7 was adjusted in order to be identical, in particular by the content of base oils 1, so as to be able to compare these two compositions.

[0141] The coefficient of friction of each composition was assessed by means of a Cameron Plint Friction laboratory test using a reciprocating tribometer of the Cameron-Plint TE-77 type. The test bench is constituted by a cylinder-on-flat tribometer immersed in the lubricant composition to be tested. The coefficient of friction is monitored throughout the test by measuring the tangential force over the normal force. A cylinder (SKF 100C6) having a length of 10 mm and diameter of 7 mm is applied to the steel flat immersed in the lubricant composition to be tested, the temperature of the lubricant composition is set at each test. A sinusoidal reciprocating movement is applied with a defined frequency. Each measurement is carried out over a period of 100 seconds during the test.

[0142] The values of the average coefficient of friction taken at different temperatures, loads and speeds, for each of the compositions L_6 and L_7 are indicated in Table IV.

TABLE IV

	L_6 (comparative)	L_7 (invention)
Average coefficient of friction at 60° C.	0.087	0.082
Average coefficient of friction at 100° C.	0.089	0.104
Average coefficient of friction under a load of 650 MPa	0.072	0.078

[0143] The average coefficient of friction at 60° C. was measured under different loads ranging from 300 MPa to 650 MPa and at different speeds ranging from 70 mm/s to 550 mm/s. The average coefficient of friction at 100° C. was measured under different loads ranging from 300 MPa to 650 MPa and at different speeds ranging from 70 mm/s to 550 mm/s. The average coefficient of friction under a load of 640 MPa was measured at different temperatures ranging from 60° C. to 140° C. and at different speeds ranging from 70 mm/s to 550 mm/s. The results show that the presence of the combination of tungsten disulphide nanoparticles and a dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons according to the invention in a lubricant composition do not alter, or only slightly alter, the friction properties of this composition.

Example 3

Assessment of the Anti-Flaking Properties of the Lubricant Compositions According to the Invention

[0144] The anti-flaking properties of a lubricant composition according to the invention are assessed by implementing a test on a closed-loop power circulation bench. To this end, the lubricant composition according to the invention L_8 and the composition L_9 not according to the invention, the compositions of which are described in Table V, were prepared; the percentages indicated correspond to percentages by mass.

TABLE V

Compositions	L_8 (invention)	L_9 (comparative)
Base oil 1	62.45	62.45
Base oil 2	15	15
Polymer 1	10	10
Polymer 2	5	5
Anti-foaming agent	0.05	0.05
Tungsten disulphide nanoparticles (NanoLub Gear Oil Concentrate marketed by Nanomaterials)	2	
Dispersant	2	
Additive package 1	3.5	3.5
Additive package 2		4

[0145] The base oils 1 and 2, the polymers 1 and 2, the anti-foaming agent, dispersant and additive package 1 are identical to those described in Example 2. The additive package 2 (Anglamol 2190 from the company Lubrizol) comprises a zinc dithiophosphate as friction modifier. The closed-loop power circulation bench is represented in FIG. **1**. A Renault JR5 gearbox is installed in a power recirculation loop and placed under load by means of a torsion system, the gearbox being engaged in 3rd gear. The machine is put into operation using an electric motor in order to obtain a rotation speed of 3000 rpm under a torque of 148 N.m at the gearbox input. The assessment criterion, and therefore the critical part to be assessed (because of the load supported), is the drive pinion of the output shaft.

[0146] The gearbox is inspected at regular intervals of approximately 150 h after dismantling and visual scoring. The visual scoring is carried out using the "Chrysler" scoring system for monitoring the presence of flakes on the teeth of the drive pinion with, moreover, continuous vibration monitoring in order to detect the appearance of flaking in the gearbox during operation. The "Chrysler" scoring system consists of noting the state of the teeth of the drive pinion after testing. Each tooth of the pinion is thus examined in order to monitor any presence of flaking(s) and a score is assigned to each flaking level.

[0147] The scoring system is defined as follows:

- **[0148]** Score=0 if the Flaking Surface (FS) on a tooth is equivalent to 0 mm^2
- **[0149]** Score=0.4 if $FS \leq 1$ mm^2
- **[0150]** Score=1.3 if $1 \leq FS \leq 3$ mm^2
- **[0151]** Score=4 if $3 < FS \leq 7$ mm^2
- **[0152]** Score=12 if $7 < FS \leq 16$ mm^2
- **[0153]** Score=36 if $16 < FS < 36$ mm^2
- **[0154]** Score=108 if $FS \geq 36$ mm^2

The total score is based on the following formula: $0.4 \times A + 1.3 \times B + 4 \times C + 12 \times D + 36 \times E + 108 \times F$ in which A, B, C, D, E and F represent the number of teeth with the same level of degradation, on one and the same pinion.

[0155] Vibration monitoring consists of placing an accelerometer close to the test piece and noting the intensity of the vibrations during operation. In the case of degradation of a part, the intensity of the vibrations increases. It is sufficient to set a threshold for stopping the device and verifying the appearance of flakes on the teeth.

[0156] In order to prevent untimely degradation of the pinion which would not be linked to the lubricant (but to metallic debris caused by the degradation of the other parts), the shaft bearings and the 3rd gear pinion are normally replaced every 150 h. The test is stopped when a flake of 12 mm^2 maximum is observed and/or when 80 mm^2 of flaked surface in total is observed and/or at 312 h when no flaking has appeared after this period.

[0157] The results of the test obtained with the lubricant composition L_8 are the following:

- **[0158]** the test has been running for 600 h without any replacement of parts in the gearbox and without observing the slightest flaking either on the drive pinion or on the 3rd gear pinion,
- **[0159]** no excessive deposit of tungsten disulphide nanoparticles has been observed in the housing.

As for the lubricant composition L9, the test had to be stopped after 125 h, several flakes having been observed.

Example 4

Assessment of the Stability Properties After Use of the Lubricant Compositions According to the Invention

[0160] The risk of deposit of nanoparticles contained in a composition according to the invention after the implementation of testing on a closed-loop power circulation bench is assessed. To this end, the lubricant composition according to the invention L_{10} and the composition L_{11} not according to the invention, the compositions of which are described in Table VI were prepared; the percentages indicated correspond to percentages by mass.

TABLE VI

Compositions	L_{10} (invention)	L_{11} (comparative)
Base oil 1	60.45	62.45
Base oil 2	15	15
Polymer 1	10	10
Polymer 2	5	5
Anti-foaming agent	0.05	0.05
Tungsten disulphide nanoparticles (NanoLub Gear Oil Concentrate marketed by Nanomaterials)	4	4
Dispersant	2	
Additive package 1	3.5	3.5

[0161] The base oils 1 and 2, the polymers 1 and 2, the anti-foaming agent, the dispersant and the additive package 1 are identical to those described in Example 2. The test conditions are identical to those described in Example 3.

[0162] FIG. **2** shows that no excessive deposit (**200**) of tungsten disulphide nanoparticles was observed in the housing after testing with the composition according to the invention L_{10}. As for the composition L_{11}, FIG. **3** shows an excessive deposit (**300**) of tungsten disulphide nanoparticles in the housing after testing with the composition L_{11}, which can thus give rise to a risk of obstructing the lubricating holes of the bearings or also of the synchronizers. Thus, the examples above show that the lubricant compositions according to the invention have both good stability over time and good anti-flaking properties, while retaining satisfactory friction reduction properties.

1. A lubricant composition comprising at least one base oil, at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons and metal nanoparticles in a content by weight ranging from 0.01 to 2% with respect to the total weight of the lubricant composition, the metal nanoparticles being concentric polyhedrons with a multilayer or sheet structure.

2. The lubricant composition according to claim **1** in which the metal of which the metal nanoparticle is constituted is selected from the group formed by tungsten, molybdenum, zirconium, hafnium, platinum, rhenium, titanium, tantalum, niobium, zinc, cerium, aluminium, indium and tin.

3. The lubricant composition according to claim **1** in which the metal nanoparticles are selected from the group formed by MoS_2, $MoSe_2$, $MoTe_2$, WS_2, WSe_2, ZrS_2, $ZrSe_2$, HfS_2, $HfSe_2$, PtS_2, ReS_2, $ReSe_2$, TiS_3, ZrS_3, $ZrSe_3$, HfS_3, $HfSe_3$, TiS_2, TaS_2, $TaSe_2$, NbS_2, $NbSe_2$ and $NbTe_2$.

4. The lubricant composition according to claim **1** in which the content by weight of metal nanoparticles ranges from 0.05 to 2% with respect to the total weight of the lubricant composition.

5. The lubricant composition claim **1** in which the average size of the metal nanoparticles ranges from 5 to 600 nm.

6. The lubricant composition according to claim **1** in which the dispersant is selected from the compounds comprising at least one succinimide group, the polyolefins, the olefin copolymers, the copolymers comprising at least one styrene unit, the polyacrylates or derivatives thereof.

7. The lubricant composition according to claim **1** in which the dispersant is selected from the compounds comprising at least one substituted succinimide group or the compounds comprising at least two substituted succinimide groups, the succinimide groups being linked at their carbon-containing vertex bearing a nitrogen atom by a polyamine group.

8. The lubricant composition according to claim **1** in which the dispersant has a weight-average molecular weight ranging from 2000 to 15000 Daltons.

9. The lubricant composition according to claim **1** in which the dispersant also has a number-average molecular weight greater than or equal to 1000 Daltons.

10. The lubricant composition according to claim **1** in which the content by weight of dispersant ranges from 0.1 to 10% with respect to the total weight of the lubricant composition.

11. The lubricant composition according to claim **1** in which the base oil is selected from the poly alpha olefins or the esters or mixtures thereof.

12. The lubricant composition according to claim **1** also comprising at least one additional additive selected from the polymeric viscosity index improvers and the antioxidants or mixtures thereof, the polymeric viscosity index improvers being selected from the ethylene and alpha-olefin copolymers.

13. The lubricant composition according to claim **12** in which the additional additive is an antioxidant selected from the dialkylphenylamines, phenolic antioxidants or mixtures thereof.

14. (canceled)

15. A method for lubricating gearboxes or axles, the method comprising adding a lubricant composition into gearboxes or axles, the lubricant composition comprising at least one base oil, at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons and metal nanoparticles in a content by weight ranging from 0.01 to 2% with respect to the total weight of the lubricant composition, the metal nanoparticles being concentric polyhedrons with a multilayer or sheet structure.

16. The method according to claim **15** for which wherein the gearbox is a manual gearbox.

17. A method for reducing the flaking of a mechanical part, the method comprising adding a lubricant composition into the mechanical part, the lubricant composition comprising at least one base oil, at least one dispersant having a weight-average molecular weight greater than or equal to 2000 Daltons and metal nanoparticles in a content by weight ranging from 0.01 to 2% with respect to the total weight of the lubricant composition, the metal nanoparticles being concentric polyhedrons with a multilayer or sheet structure.

18. The method according to claim **17** wherein the mechanical part is a manual gearbox.

19. (canceled)

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