

[Title of the Invention]

A Lubricant Additive and Process for Manufacturing the Same

[0001]

This patent application has been filed on the basis of the priority claim that is based on Patent Application No. 2017-31602 filed to Patent Office of Japan on February 22, 2017, and it should be noted that the details of the invention disclosed in said priority patent application is referred to this patent application.

Field of the Invention

[0002]

This invention relates to a lubricant additive and a process for manufacturing the lubricant additive.

Background Art

[0003]

To date, various types of lubricating oils that function to smoothen the performance of the engines, gears, differential gears, etc. of vehicles including cars, have been known. As well, various types of additives have been blended to a base oil in response to the specific intended use of a lubricant product for aiming at reinforcing and improving the lubricating performance of the lubricant product. The additives used to be blended to a base oil (hereinafter simply referred to as “lubricant additives”) are classified to several groups including anti-friction agents, friction modifiers, detergent-dispersants, viscosity index improvers, extreme pressure agents, antioxidants and so on. Then, lubricant additives those which are suitable to an intended use of a lubricating oil are chosen from several types of additives in accordance with the aptitude to such intended use and are blended to a lubricating oil. With regard to such lubricating additives, various inventions have been accomplished to date (e. g. Patent Documents 1 and 2).

[0004]

In Patent Document 1, a lubricant additive provided with a lubricating part having a high molecular weight and being soluble to the base oil of the lubricant product and a pair of adsorptive parts having functional moieties adsorptive to the part of the material of the unit to be applied and being bonded to the lubricating part such that the lubricating part is pinched between the absorptive parts is disclosed. According to the invention disclosed in Patent Document 1, the said pair of adsorptive

parts is adsorbed to the part of the material of the applied unit and the lubricating part having a high molecular weight and being soluble to the base oil, which is pinched between the adsorptive parts, also remains in the part of the materials. In this way, the lubricating part remained and the adsorptive parts adsorbed in the material function to improve the property of the base oil, thus providing the base oil with excellent friction-lowering performance.

[0005]

In Patent Document 2, a lubricant composition with the kinetic viscosity at 100°C being equal to or less than 6.00 mm²/s which is prepared by blending at least a base oil that contains dialkylmonoether (A), the kinetic viscosity of which at 100°C is in a range of from 0.50 to 2.50 mm²/s, and poly- α -olefin (B), the kinetic viscosity of which at 100°C is equal to or higher than 50mm²/s, is disclosed. According to the invention disclosed in Patent Document 2, with use of this lubricant composition, the performance of providing excellent viscosity-temperature property, fluidity at low temperatures and evaporation characteristic even though the viscosity of the lubricant composition is low, and good shear stability and oxidation stability, and additionally making an organic material, such as rubber, less swellable can be achieved.

Prior Art

Patent Documents

[0006]

Patent Document 1: Patent Gazette of Published Patent No. 2016-210941

Patent Document 2: Patent Gazette of Published Patent No. 2016-011384

Summary of Invention

Problem to be solved by the Invention

[0007]

As described above, the lubricant additive is generally prepared by selecting proper additives that suit to the intended application of the lubricating oil from various types of additives and blending the selected additives to the lubricating oil. Therefore, the composition of a lubricant additive for engine use will be different from that of a lubricant additive for gear use, and the lubricant additive for engine use is not always suitable as the lubricant additive for gear use. As a consequence, it has been a problem for the user of a vehicle who needs to arrange

different types of lubricant products in order to use a suitable lubricant to the respective units of a vehicle.

[0008]

On the other hand, as recognizable from the inventions of Patent Documents 1 and 2, the problem mentioned hereinabove has not been solved till now since the inventions having been filed in the past had generally directed to the performance improvement of an individual lubricant additive.

[0009]

Note that this invention was accomplished for aiming at solving the above-mentioned problem, and it is an object of this invention to provide such a lubricant additive that is applicable for blending integrally with any different types of lubricating oils respectively used for different specific applications and a process for manufacturing such lubricant additive.

Means for Solving the Problem

[0010]

In order to achieve the above-mentioned object, the lubricant additive according to this invention is characterized in that it is prepared as a lubricant additive adapted to be blended to a lubricating oil and is produced by blending all of a synthetic base oil of the polyolester type, calcium sulfonate containing calcium carbonate having the calcite crystal structure, poly- α -olefin oligomer, anti-oxidant of the zinc dithiophosphate type, succinimide, extreme pressure agent of the thiadiazole type and anti-oxidant of the phenol type.

[0011]

Furthermore, in order to achieve another object of this invention, the process for manufacturing the lubricant additive according to this invention is configured as a method for manufacturing the lubricant additive adapted to be blended to a lubricating oil and is characterized by comprising the first step to mix a synthetic base oil of the polyolester type and poly-alpha-olefin oligomer in a routine container under temperature of from 50 to 90°C, the second step to add an oxidant of the zinc dithiophosphate type, succinimide, an extreme pressure agent of the thiadiazole type and an oxidant of the phenol type to the mixture obtained in the first step to dissolve them in said mixture, and the third step to mix calcium sulfonate containing calcium carbonate formed in the calcite crystal structure to the mixture obtained in the second step.

Advantageous Effect of the Invention

[0012]

With use of this invention, it is made possible to provide a lubricant additive that is applicable integrally to any of different types of lubricating oils to be used for various applications and a process for manufacturing said lubricant additive.

Brief Explanation of the Drawings

[0013]

Fig. 1 is a flowchart showing an example of the process for manufacturing the lubricant additive according to this invention.

Embodiments for Carrying out the Invention

[0014]

Now, the embodiments for carrying out this invention will be described in the following.

[0015]

[Composition of the Lubricant Additive]

The lubricant additive prepared according to the embodiment of this invention comprises the following components A to G.

[0016]

[Component A]

The component A to be used for the lubricant additive according to this embodiment is a synthetic base oil of the polyolester type, which is one of base oils of the ester type and is characterized by its property of low fluidity, high viscosity index, high flash point, and excellent thermal stability and oxidation stability. Specifically, said synthetic base oil of the polyolester type is decanoic acid, mixed esters with hexanoic acid, octanoic acid and trimethylolpropane, which is a fatty acid ester being a single substance resulted from bonding of two different kinds of fatty acids.

[0017]

The content of the component A in the lubricant additive is in a range of from 25.0 w/w% to 75.0 w/w%, and more preferably in a range of from 35.0 w/w% to 60.0 w/w%.

[0018]

However, it should be noted that the component A is not confined to the above-described decanoic acid, mixed esters with hexanoic acid, octanoic acid and trimethylolpropane. The component A may also be a synthesized base oil prepared by

mixing decanoic acid, mixed esters with hexanoic acid, octanoic acid and trimethylolpropane with the other fatty acid, e.g. a normal saturated fatty acid comprising 8 to 18 carbon atoms, such as pelargonic acid, undecanoic acid, lauric acid, tridecylic acid, myristic acid, pentadecylic acid, palmitic acid, margaric acid and stearic acid, “note that caprylic acid (IUPAC systematic name: octanoic acid) comprising 8 carbon atoms and capric acid (IUPAC systematic name: decanoic acid) comprising 10 carbon atoms are excluded”, or with a normal unsaturated fatty acid comprising 8 to 18 carbon atoms, such as caproleic acid, undecylenic acid, linderic acid, lauroleic acid, tsuzuic acid, physeteric acid, myristoleic acid, zomarinic acid, petroselin acid, oleic acid and elaidic acid. Furthermore, the composition A may also be a base oil of the diester type having excellent oxidation stability at high temperature, though it has low friction reduction performance in comparison with polyolester.

[0019]

[Component B]

The component B to be used for the lubricant additive according to the embodiment of this invention is a poly-alpha-olefin (PAO) oligomer obtained by polymerizing known alpha olefins, and a poly-alpha-olefin oligomer having a high viscosity index (high viscosity index PAO) in particular is used in this embodiment. The known alpha-olefins include e.g. alpha-olefins comprising 2 to 20 carbon atoms, such as ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 1-peptene, 1-octene, 1-nonene, 1-decene, 1-undecene, 1-dodecene, 1-tridecene, 1-tetradecene, 1-pentadecene, 1-hexadecene, 1-heptadecene, 1-octadecene, 1-nonadecene and 1-icocene, and each of these alpha-olefins are used alone or in combination.

[0020]

The poly-alpha-olefin oligomer has a homogeneous molecular structure that contains neither a double bond nor sulfur while it has a composition similar to mineral oils and has characteristics of good thermal stability at high temperature, good shear stability, low pour point (good fluidity at low temperatures), high viscosity index and high flash point. Specifically, the component B is preferably a poly-alpha-olefin oligomer formed in a three-dimensional structure, which is manufactured with use of metallocene catalyst, and this poly-alpha-olefin oligomer is resistant to decrease in the viscosity in comparison with a poly-alpha-olefin oligomer formed in a linear structure manufactured with use of the other catalyst.

[0021]

The content of the component B in the lubricant additive is in a range of from

10.0 w/w% to 50.0 w/w%, more preferably in a range of from 10.0 w/w% to 30.0 w/w%.
[0022]

Note that the component B is not confined to the above-described poly-alpha-olefin oligomer formed in a three-dimensional structure, and it can be blended with the other viscosity index improvers, e.g. polyalkylmethacrylate, ethylene-propylene copolymer and styrene-butadiene copolymer.

[0023]

[Component C]

The component C to be used for the lubricant additive according to the embodiment of this invention is an anti-oxidant of the zinc dithiophosphate type comprising zinc dithiophosphate as the main component, which has characteristic of exerting its performance in comparatively low temperature region. In this embodiment, the component C is particularly an anti-oxidant, the main component of which is zinc dithiophosphate comprising primary alkyl groups. The zinc dithiophosphate comprising primary alkyl groups is especially superior in wear resistance performance compared to zinc dithiophosphate comprising either secondary alkyl groups or tertiary alkyl groups. Specifically, the component C is preferably zinc 2-ethylhexyldithiophosphate.

[0024]

The content of the component C in the lubricant additive is in a range of from 0.5 w/w% to 3.0 w/w%, and more preferably in a range of from 1.0 w/w% to 2.0 w/w%.

[0025]

Note that the component C is not confined to zinc 2-ethylhexyldithiophosphate. The other anti-oxidants, e.g. zinc dialkyl dithiophosphate (ZnDTP), such as zinc dipropyl dithiophosphate, zinc dibutyl dithiophosphate, zinc dipentyl dithiophosphate, zinc diheptyl dithiophosphate, zinc dioctyl dithiophosphate, zinc didecyl dithiophosphate and zinc didodecyl dithiophosphate, may be used either alone or in combination as the component C. Note that, when a synthesized base oil of the diester type is blended as the component A in particular, it is preferable to mix it with zinc dipropyl dithiophosphate, dibutyl dithiophosphate or dioctyl dithiophosphate either alone or in combination.

[0026]

[Component D]

The component D to be used for the lubricant additive according to the embodiment of this invention is a dispersing agent consisting of either alkenyl succinimide or alkyl succinimide, which functions to disperse sludge and soot generated under low

temperature into the lubricating oil. Each of alkenyl succinimide and alkyl succinimide has performance of improving solubility and increasing performance sustainability of the respective additives mixed. Particularly in this embodiment, poly-isobutenyl succinimide, the nitrogen content of which is in a range of from 1.0 w/w% to 2.0 w/w%, is used as the component D.

[0027]

The content of the component D in the lubricant additive is in a range of from 3.0 w/w% to 10.0 w/w%, and more preferably in a range of from 4.0 w/w% to 6.0 w/w%.

[0028]

Note that the component D is not confined to poly-isobutenyl succinimide. Any of the other alkenyl succinimide or alkyl succinimide may be used either alone or in combination as the component D.

[0029]

[Component E]

The component E to be used for the lubricant additive according to the embodiment of this invention is an extreme pressure agent of the thiadiazole type, which is classified as thiadiazole-(benzobis) derivative and is also characterized as an wear prevention agent that exerts wear resistance performance of reducing friction and wear caused in between the respective surfaces of contacting metals and of preventing metals from being burned. The thiadiazole derivative to be used in this embodiment is a dimercaptothiadiazole derivative, and is specifically 2,5-dimercapto-1,3,4-thiadiazole, 4,5-dimercaptothiadiazole, 3,5-dimercapto-1,2,4-thiadiazole and 3,4-dimercapto-1,2,5-thiadiazole, those which are respectively used either alone or in combination.

[0030]

The content of the component E in the lubricant additive is in a range of from 1.0 w/w% to 6.0 w/w%, and more preferably in a range of from 2.0 w/w% to 4.0 w/w%.

[0031]

Note that the component E is not confined to dimercaptothiadiazole derivative. The other extreme pressure agent, e.g. triazole derivatives may be used as the substitute. When a synthesized base oil of the diester type is used as the component A, it is preferable to add a sulfur-based extreme pressure agent, such as sulfurized fatty acid ester containing a sulfur atom, instead of thiadiazole derivative from a terms of simplification of the production and the manufacturing cost reduction. In this respect, the content of the sulfurized fatty acid ester in the lubricant additive is set to a range of from 1.0 w/w% to 9.0 w/w%, and more preferably to a

range of from 4.0 w/w% to 8.0 w/w%.

[0032]

[Component F]

The component F to be used for the lubricant additive according to the embodiment of this invention is an anti-oxidant of the phenol type, which is blended for aiming at preventing oxidation and sludge formation from occurring, and is specifically 2,6-di-tert-butyl-4-methylphenol being widely used as the anti-oxidant of the phenol type.

[0033]

The content of the component F in the lubricant additive is in a range of from 0.1 w/w% to 2.0 w/w%, and more preferably in a range of from 0.1 w/w% to 1.5 w/w%.

[0034]

Note that the component F is not confined to 2,6-di-tert-butyl-4-methylphenol, and it may be replaced with any of the other anti-oxidants of the phenol type including e.g. 2,6-di-tert-butyl-4-ethylphenol, 4,4'-methylenebis(2,6-di-tert-butylphenol), 2,2'-methylenebis(4-ethyl-6-tert-butylphenol) and the like.

[0035]

[Component G]

The component G to be used for the lubricant additive according to the embodiment of this invention is a detergent consisting of overbased calcium sulfonate, which is commonly used for lubricants for industrial use and contains calcium carbonate and calcium hydroxide. Specifically, calcium sulfonate containing a lot of calcium carbonate formed in the calcite crystal structure is used as the component G. Namely, calcium sulfonate used in this embodiment is the one that contains calcium carbonate formed in the calcite crystal structure, the content of metal calcium contained therein is in a range of from 2.0 w/w% to 12.0 w/w%, and TBN (Total Basic Number) thereof is in a range of from 15 to 500. The calcium sulfonate containing a substantial amount of calcium carbonate formed in the calcite crystal structure has better lubricating performance than commonly-used calcium sulfonate containing calcium carbonate formed in the aragonite crystal structure.

[0036]

The content of the component G in the lubricant additive is in a range of from 5 w/w% to 30 w/w%, and more preferably in a range of from 10 w/w% to 20 w/w%.

[0037]

[Process for manufacturing the lubricant additive of this invention]

Now, the process for manufacturing the lubricant additive according to the

embodiment of this invention will be explained hereinbelow.

[0038]

Fig. 1 is a flowchart showing an example of the process for manufacturing the lubricant additive according to an embodiment of this invention. The lubricant additive according to this embodiment is manufactured via the steps S1 to S3 (step 1 to step 3) as shown in Fig. 1.

[0039]

Specifically, in the step S1 (the first step), the components A and B are mixed in a routine container under heating at a temperature ranging from approximately 50°C or higher to approximately 90°C or lower (Step S1). In the next step S2 (the second step), the component C, the component D, the component E and the component F are added to the mixture of the components A and B obtained in the step S1 in the order written and are dissolved into the mixture of the components A and B in the routine container mentioned above (Step S2). Then, in the step S3 (the third step), after having confirmed that the components A through F have dissolved completely into the mixture of the step 2, the component G is further added to said mixture obtained in the step 2 (Step S3).

[0040]

Namely, the lubricant additive according to this embodiment is manufactured via the first step (S1) through the third step (S3) as described above.

[0041]

[Examples]

Next, the examples of the lubricant additive manufactured according to the embodiment of this invention will be explained in the following. The lubricant additives P1 through P4 are manufactured by blending the components A to G at the respective blending ratios specified in the respective columns of P1 to P4 presented in Table 1 shown below. Note that the lubricant additive Sa as the example for reference is manufactured by blending the components A to G at the blending ratio specified in the column of Sa in Table 1, provided the ratio for the component G is fixed to 0 w/w%.

[Table 1]

	P1	P2	P3	P4	Sa
Component A (w/w%)	57.0	52.0	42.0	32.0	62.0
Component B (w/w%)	28.0	28.0	28.0	28.0	28.0
Component C (w/w%)	1.5	1.5	1.5	1.5	1.5
Component D (w/w%)	5.0	5.0	5.0	5.0	5.0

Component E (w/w%)	3.0	3.0	3.0	3.0	3.0
Component F (w/w%)	0.5	0.5	0.5	0.5	0.5
Component G (w/w%)	5.0	10.0	20.0	30.0	0.0

[0042]

[Comparative Example 1]

The comparative example 1, where the lubricant additives P1 through P4 are respectively added to each of commercially available fluids/oils for vehicle use described below, namely ATF (Automatic Transmission Fluid), CVTF (Continuous Variable Transmission Fluid), Diesel engine oil and Suspension oil, is presented in Table 2 through Table 5, respectively.

[Table 2]

Test Parameters	Unit	Commercially available ATF alone	Additive of Other Source	Sa	P1	P2	P3	P4
Kinematic Viscosity at 40°C	mm ² /s	35.42	35.4	37.06	37.5	38.09	38.88	39.66
Kinematic Viscosity at 100°C	mm ² /s	7.185	7.17	7.444	7.51	7.605	7.727	7.846
Viscosity Index		172	171	173	173	173	175	173
Four-ball Wear	mm	0.51	0.41	0.36	0.32	0.29	0.29	0.34

[Table 3]

Test Parameters	Unit	Commercially available CVTF alone	Additive of Other Source	Sa	P1	P2	P3	P4
Kinematic Viscosity at 40°C	mm ² /s	28.85	36	32.2	32.62	32.79	33.55	34.46
Kinematic Viscosity	mm ² /s	7.181	8.251	7.492	7.56	7.636	7.755	7.902

at 100°C								
Viscosity Index		229	215	212	212	214	213	212
Four-ball Wear	mm	0.44	0.4	0.37	0.3	0.29	0.29	0.29

[Table 4]

Test Parameters	Unit	Commercially available Diesel engine oil alone	Additive of Other Source	Sa	P1	P2	P3	P4
Kinematic Viscosity at 40°C	mm ² /s	44.37	53.09	47.33	48.17	48.93	50.52	52.12
Kinematic Viscosity at 100°C	mm ² /s	9.53	10.81	9.922	10.04	10.15	10.38	10.59
Viscosity Index		207	200	203	202	201	200	199
Four-ball Wear	mm	0.43	0.42	0.44	0.4	0.32	0.31	0.32

[Table 5]

Test Parameters	Unit	Commercially available Suspension oil alone	Sa	P1	P2	P3	P4
Kinematic Viscosity at 40°C	mm ² /s	33.4	36.31	36.85	37.66	38.9	40.55
Kinematic Viscosity at 100°C	mm ² /s	5.701	6.232	6.299	6.432	6.614	6.797
Viscosity Index		111	120	121	122	125	125
Four-ball Wear	mm	0.47	0.62	0.46	0.31	0.3	0.3

In Table 2 through Table 5, the measurements of the test parameters, namely kinematic viscosity at 40°C (mm²/s), kinematic viscosity at 100°C (mm²/s), viscosity index and wear scar diameters (mm) as a result of publicly-known four-ball wear test, obtained from the test on the lubricant additives P1 to P4 according to the embodiment of this invention when respectively blended to any of commercially available are presented separately in comparison with each of these transmission fluids and engine/suspension oils alone. Hereunder are the explanations on the respective tables.

[0044]

Table 2 presents a comparison with regard to the measurements of the four test parameters obtained from a commercially available vehicle ATF alone and the same vehicle ATF blended with each of a conventional vehicle oil made by the other manufacturer, the lubricant additive Sa for the reference, and the respective lubricant additives P1 to P4 according to the embodiment of this invention, each in an amount equivalent to 7% of the total amount of the vehicle ATF. Note that the test condition for the four-ball load capacity test presented in Table 2, namely number of rotations, load, duration and temperature, are 1,200 rpm, 294N (30 kg), 60 min. and 75°C, respectively.

[0045]

Table 3 presents a comparison with regard to the measurements of the four test parameters obtained from a commercially available vehicle CVTF alone and the same vehicle CVTF blended with each of a conventional vehicle oil made by the other manufacturer, the lubricant additive Sa for the reference, and the respective lubricant additives P1 to P4 according to the embodiment of this invention, each in an amount equivalent to 7% of the total amount of the vehicle CVTF. Note that the test condition for the four-ball load capacity test presented in Table 3, namely number of rotations, load, duration and temperature, are 1,200 rpm, 294N (30 kg), 60 min. and 75°C, respectively.

[0046]

Table 4 represents a comparison with regard to the measurements of the four test parameters obtained from a commercially available diesel engine oil alone and the same diesel engine oil blended with each of a conventional vehicle oil made by the other manufacturer, the lubricant additive Sa for the reference, and the respective lubricant additives P1 to P4 according to the embodiment of this invention, each in an amount equivalent to 10% of the total amount of the diesel engine oil. Note that the test condition for the four-ball load capacity test presented in Table 4, namely

number of rotations, load, duration and temperature, are 1,200 rpm, 392N (40 kg), 60 min. and 75°C, respectively.

[0047]

Table 5 presents a comparison with regard to the measurements of the four test parameters obtained from a commercially available vehicle suspension oil alone and the same vehicle suspension oil blended with each of the lubricant additive Sa for the reference and the respective lubricant additives P1 to P4 according to the embodiment, each in an amount equivalent to 10% of the total amount of the diesel engine oil. Note that the test condition for the four-ball load capacity test presented in Table 5, namely number of rotations, load, duration and temperature, are 1,200 rpm, 392N (40 kg), 60 min. and 75°C, respectively.

[0048]

As shown in Table 2 to Table 5, in case of blending the respective lubricant additives P1 to P4 according to the embodiment of this invention to each of plural types of lubricating oils to be used for different applications, it was verified that the wear scar diameters as a result of the four-ball load capacity test when using a lubricating oil blended with the respective lubricant additives of this invention became shorter than the wear scar diameters when using either a lubrication oil blended with a conventional additive made by the other manufacturer or the lubricant additive Sa for the reference. As conclusion, it was made obvious that the lubricant additive prepared according to the embodiment of this invention exerts to provide each of the plural types of lubricating oils with excellent wear reduction performance.

[0049]

This performance of wear reduction can be particularly enhanced when the content of the component G, namely calcium sulfonate containing calcium carbonate made in the calcite crystal structure, in the lubricant additive is set to a range of from 5.0 w/w% to 30.0 w/w%. This is because that, when the content of the component G is greater than 5.0 w/w%, the wear scar diameter as a result of the four-ball wear test becomes remarkably smaller, meaning that the wear resistance has been clearly improved, comparing to the case of no blending of the component G. Moreover, the wear scar diameter as a result of the four-ball wear test in case of the component G content being 10 w/w% is shorter than that of the component G content being 5.0 w/w%, and the wear scar diameter in case of the component G content being 20 w/w% is equal to or shorter than that in case of the component G content being 10 w/w%. On the other hand, in case that the content of the component G is 30 w/w%, the wear scar diameter becomes equal to or longer than the wear scar diameter in case of the

component G content being 20 w/w%. Considering the results of the four-ball wear test, the content of the component G in the lubricant additive, when the lubricant additives according to this embodiment P1 to P4 are blended to each of plural types of lubricating oils for different applications, is thought to be preferably in a range of from 10.0 w/w% to 20.0 w/w%.

[0050]

Besides, in case of blending any of the lubricant additives according to the embodiment of this invention to CVTF, the secondary effect of preventing clutch judder of a vehicle from occurring has been observed several times, though such clutch judder was used to occur in case of no use of those lubricant additives.

[0051]

[Comparative Example 2]

Comparative example 2 that compares the measurements of the four test parameters obtained from a commercially-available gear oil for industrial machinery use alone and the same gear oil blended with each of the lubricant additive Sa for the reference and the respective lubricant additives P1 to P4 according to the embodiment of this invention is shown in Table 6.

[Table 6]

Test Parameters	Unit	Commercially available Gear Oil for Industrial Machinery use alone	Sa	P1	P2	P3	P4
Kinematic Viscosity at 40°C	mm ² /s	95.19	90.74	92.77	94.52	98.75	102.80
Kinematic Viscosity at 100°C	mm ² /s	10.85	10.96	11.14	11.3	11.66	11.99
Viscosity Index		98	106	106	106	106	106
Four-ball Wear	mm	0.39	0.44	0.36	0.35	0.35	0.36

[0052]

In Table 6, the measurements of kinematic viscosity (mm²/s) at 40°C, kinematic viscosity (mm²/s) at 100°C, viscosity index and wear scar diameter (mm) after subjected to the known four-ball load capacity test are shown.

[0053]

In Table 6, a commercially available gear oil for industrial machinery use and the same gear oil blended with each of the reference lubricant additive Sa and each of the lubricant additives P1 to P4 according to the embodiment of this invention, each in an amount equivalent to 10% of the total amount of the gear oil are compared in terms of the four test parameters mentioned above. Note that the test condition for the four-ball load capacity test (i.e. number of rotations, load, duration, and temperature) presented in Table 6 are 1,200 rpm, 392N (40 kg), 60 min. and 75°C, respectively.

[0054]

As shown in Table 6, in case of blending the respective lubricant additives P1 to P4 according to the embodiment of this invention to the gear oil for industrial machinery use, it was found that the wear scar diameters after subjected to the four-ball load capacity test when using the gear oils blended with any one of the lubricant additives P1 to P4 become shorter than the wear scar diameters when using the reference lubricant additive Sa. As a result, it is verified that the lubricant additives according to the embodiment of this invention provide the gear oil for industrial machinery use with excellent wear resistant performance. Note that this effect of wear reduction can be particularly enhanced when the content of the component G, namely calcium sulfonate containing calcium carbonate formed in the calcite crystal structure, in the lubricant additive is set to a range of from 5.0 w/w% to 30.0 w/w%.

[0055]

[Comparative Example 3]

Comparison in the performance of a predetermined No. 1 base oil and the same base oil blended with the lubricant additive P2 according to the embodiment of this invention is shown in Table 7 below.

[Table 7]

	No. 1 Base Oil	P2
La/Lo	5.45	25.4
La/La (Base Oil)	1.0	4.67
Number of Samples	4	3

[0056]

In Table 7, comparison in the performance of a commercially available No. 1 base oil and the same No. 1 base oil blended with the lubricant additive P2 according to the embodiment of this invention in an amount equivalent to 10% of the total amount

of the No. 1 base oil is presented. Specifically, the ratio of the measured value of the operating time L_a (unit: h) until bearing failure against theoretical life time of bearing L_o (unit: h) after subjected to the thrust ball bearing life time test, to which the Weibull distribution is applied, and the calculated value of L_a (actual measured value)/ L_a (measured value using No. 1 base oil only) are presented in Table 7. The test conditions (size of thrust ball bearing, number of rotations and load) for the bearing life time test in connection to Table 7 are #51104, 750 rpm and 4.4 kN, respectively.

[0057]

As seeable from Table 7, it was made obvious that the bearing life time is greatly improved by 4.67 times in addition to the improvement of the viscosity index by means of blending the lubricant additive P2 according to the embodiment of this invention to the No. 1 base oil.

[0058]

[Comparative Example 4]

Comparative example 4 that compares the performance of No. 2 base oil and the same No. 2 base oil blended with the lubricant additive P2 according to the embodiment of this invention is presented in Table 8.

[Table 8]

	No. 2 Base Oil	P2
L_a/L_o	2.53	36.7
L_a/L_o (Base Oil)	1.0	14.50
Power reduction rate (%)	0.0	8.0
Number of Samples	5	1

[0059]

In Table 8, a comparison in the performance of a commercially available No. 2 base oil and the same No. 2 base oil blended with the lubricant additive P2 according to the embodiment of this invention in an amount equivalent to 10% of the total amount of the No. 2 base oil is shown. Specifically, the ratio of the measured value of the operating time L_a (unit: h) until bearing failure against theoretical life time of bearing L_o (unit: h) after subjected to the thrust ball bearing life time test, to which the Weibull distribution is applied, the calculated value of L_a (actual measured value)/ L_a (measured value using No. 2 base oil only), and the power reduction rate obtained by dividing the required power with use of the additive-blended base oil by the required power with use of the base oil only are presented in Table 8.

The test conditions (size of thrust ball bearing, number of rotations and load) for the bearing life time test in connection with Table 8 are #51104, 750 rpm and 4.4 kN, respectively.

[0060]

As seeable from Table 8, it was made obvious that the bearing life time and the power reduction rate are greatly improved by 14.50 times and by 8 % respectively in addition to the improvement of the viscosity index by means of blending the lubricant additive P2 according to the embodiment of this invention to the No. 2 base oil.

[0061]

As described above, the lubricant additive by itself according to the embodiment and examples of this invention is applicable integrally to both lubricants for vehicle use and lubricants for industrial machinery use (except metalworking oils). With use of the lubricant additive of this invention, such a problem that several different types of lubricant additives are separately required for lubricating the plural different units of a vehicle, when the user desires to apply lubricating oil to those various units, can be solved, which leading to contribution to energy saving and resource saving that the modern society is seeking and improvement of global environment.

[0062]

Although the embodiment of this invention is described above, it should be noted that the described embodiment is only an example for carrying out this invention and that the scope of this invention is not confined to the described scope of the above-described embodiment.

What is claimed is:

1. A lubricant additive adapted to be blended to a lubricating oil, characterized in that the lubricant additive comprising:

a synthesized base oil of the polyolester type,
calcium sulfonate containing calcium carbonate formed in the calcite crystal structure,

a poly-alpha-olefin oligomer, an anti-oxidant of the zinc dithiophosphate type, succinimide, an extreme pressure agent of the thiadiazole type and an anti-oxidant of the phenol type.

2. A lubricant additive of claim 1 characterized in that:

the content of the synthesized base oil of the polyolester type to be contained in the lubricant additive is in a range of from 35.0 w/w% to 60.0 w/w%, and

the content of the calcium sulfonate to be contained in the lubricant additive is in a range of from 5.0 w/w% to 30.0 w/w%.

3. A lubricant additive of claim 1 characterized in that the synthesized base oil of the polyolester type comprises normal saturated fatty acids comprising 8 to 18 carbon atoms.

4. A lubricant additive of claim 1 characterized in that the synthesized base oil of the polyolester type comprises decanoic acid, mixed esters with hexanoic acid, octanoic acid and trimethylolpropane.

5. A lubricant additive of claim 1 characterized in that the poly-alpha-olefin oligomer has a three-dimensional structure that is manufactured with use of metallocene catalyst.

6. A lubricant additive of claim 1 characterized in that the content of the poly-alpha-olefin oligomer to be contained in the lubricant additive is in a range of from 10.0 w/w% to 50.0 w/w%.

7. A lubricant additive of claim 1 characterized in that the anti-oxidant of the zinc dithiophosphate type comprises an anti-oxidant, the main component of which is zinc dithiophosphate comprising primary alkyl groups.

8. A lubricant additive of claim 7 characterized in that the zinc dithiophosphate comprises zinc 2-ethylhexyldithiophosphate.

9. A lubricant additive of claim 1 characterized in that the content of the anti-oxidant of the zinc dithiophosphate type to be contained in the lubricant additive is in a range of from 0.5 w/w% to 3.0 w/w%.

10. A lubricant additive of claim 1 characterized in that the succinimide comprises poly-isobutenylsuccinimide.

11. A lubricant additive of claim 1 characterized in that the content of the succinimide to be contained in the lubricant additive is in a range of from 3.0 w/w% to 10.0 w/w%.

12. A lubricant additive of claim 1 characterized in that the extreme pressure agent of the thiadiazole type comprises at least one selected from a group consisting of 2,5-dimercapto-1,3,4-thiadiazole, 4,5-dimercaptothiadiazole, 3,5-dimercapto-1,2,4-thiadiazole and 3,4-dimercapto-1,2,5-thiadiazole.

13. A lubricant additive of claim 1 characterized in that the content of the extreme pressure agent of the thiadiazole type to be contained in the lubricant additive is in a range of from 1.0 w/w% to 6.0 w/w%.

14. A lubricant additive of claim 1 characterized in that the anti-oxidant of the phenol type comprises 2,6-di-tert-butyl-4-methylphenol.

15. A lubricant additive of claim 1 characterized in that the content of the anti-oxidant of the phenol type to be contained in the lubricant additive is in a range of from 0.1 w/w% to 2.0 w/w%.

16. A process for manufacturing the lubricant additive adapted to be blended to a lubricating oil characterized by comprising:

the first step to mix the synthesized base oil of the polyolester type and the poly-alpha-olefin oligomer in a routine container under heating at a temperature ranging from 50°C or higher to 90°C or lower,

the second step to mix the anti-oxidant of the dithiophosphate type, succinimide, the extreme pressure agent of the thiadiazole type and the anti-oxidant of the phenol type with the mixture obtained in the first step to dissolve these mixed components into the mixture obtained in the first step, and

the third step to mix calcium sulfonate containing calcium carbonate formed in the calcite crystal structure to the mixture obtained in the second step.