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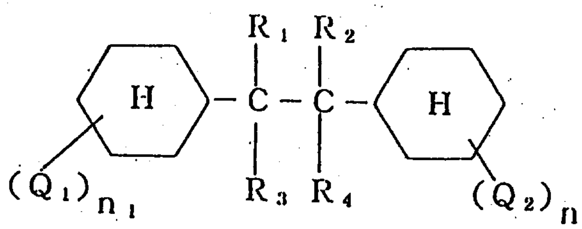
(54) Traction drive fluid composition

(57) A traction drive fluid composition comprising the following component (A),



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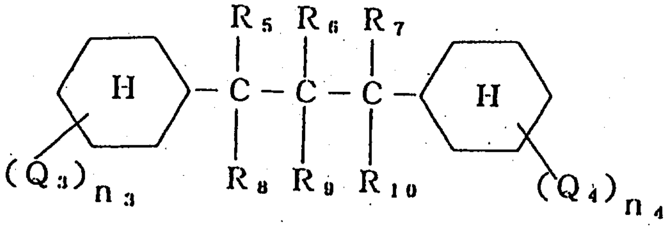

wherein R_1 to R_{10} are hydrogen, C_1-C_3 alkyl, or cyclohexyl, Q_1 to Q_4 are C_1-C_3 alkyl or cyclohexyl, and n1 to n4 are an integer from 0 to 5; component (B) which is a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of thereof having a softening point of 40°C or higher or a weight average molecular weight of 250 or larger; and, optionally, component (C) which is a compound with a viscosity smaller than that of component (A); a phosphorous compound; and a friction modifier. The composition exhibits a high traction

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coefficient over a wide temperature range and excellent friction characteristics required for a traction drive device.

Description

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a traction drive fluid composition exhibiting a high traction coefficient over a wide temperature range and excellent friction characteristics.

Discussion of the Background:

A traction drive device is a power transmission utilizing rolling-sliding friction induced by resistance against a shear produced by the hardening of a fluid oil film when the oil present in a cylindrical or conical rolling body loses fluidity. The traction drive device is widely used for continuously variable transmission for automobiles, continuously variable transmission for industrial vehicles, and for hydraulic equipment. Along with recent improvement in the performance of the traction drive devices and the development of small size, light weight devices, particularly those used for automobiles, demand for a traction drive fluid exhibiting high traction performance has increased.

In addition to a traction drive main body, a traction drive device includes a torque converter, an oil hydraulic mechanism, a wet clutch, and the like. The traction drive fluid for lubricating these parts must have excellent viscosity characteristics, friction characteristics, wear resistance, anti-seizure characteristics, corrosion resistance, low temperature fluidity, oxidation stability, rust prevention characteristics, sealing compatibility, anti-foaming characteristics, and shear stability, in addition to the above-mentioned high traction performance.

There have been various traction drive fluids heretofore proposed in the art, for example, in Japanese Patent Application Laid-Open No. 228599/1985, 96690/1985, and 58495/1985. Although these traction drive fluids have a comparatively high traction coefficient at around 30°C, the traction coefficient decreases with an increase in temperature. Over the high temperature range which occurs in actual runs of vehicles, the traction coefficient is so small that these traction drive fluids cannot be efficiently used. Japanese Patent Application Laid-Open No. 1292/1993 discloses a technique for improving the traction coefficient in the high temperature range (e.g. at about 120°C) by adding a thermal copolymerization product of a cyclopentadiene compound and an α-olefin compound to a composition which comprises trimers, tetramers, pentamers, and hexamers of cyclopentadiene as major components.

In a discussion on the effect of an increase in the traction coefficient at high temperatures by cyclopentadiene polymers, Japanese Patent Application Laid-Open No. 230696/1989 discloses that homopolymers of cyclopentadiene have a greater effect than copolymers of cyclopentadienes and other compounds and that only olefins or diens of aliphatic hydrocarbons can be used as the compounds to be copolymerized with cyclopentadiene.

Most of these prior art examples describe the traction performance as the important characteristic which must be possessed by a traction drive fluid, but are silent about other characteristics required for lubrication of the traction drive device which are discussed later.

The use of a traction drive device in automobiles is being studied because of its excellent characteristics in saving fuel consumption. Because the traction drive for automobiles is used over a wide temperature range, the traction drive fluid used for lubricating such a traction drive device must ensure excellent cold startability of that device. In addition, because the traction drive fluid is used for controlling the oil pressure, the fluid must have the characteristics required for a hydraulic oil. Specifically, putting emphasis on the viscosity at low temperatures, viscosity-temperature performance and low temperature fluidity are the characteristics which must be improved.

In addition, the use of a torque converter equipped with a lock-up mechanism using a wet clutch has been studied for this device. The lock-up mechanism is a mechanism for transmitting the engine output directly to the traction drive in accordance with running conditions. Introduction of a slip control using a lock-up clutch in a low-speed range is anticipated for improvement of fuel consumption at low speeds. Operation of the lock-up mechanism low speeds, however, may induce vibration of a chassis, a phenomenon called "shudder". A lubricating oil with an excellent μ(friction coefficient)-V (sliding speed) characteristic is required to suppress the shudder.

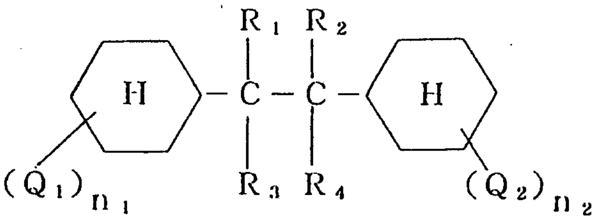
Furthermore, a low static friction coefficient tends to cause the wet clutch to slide, which may result in increased loss in the transmission torque during lock-up operation. For this reason, the static friction coefficient for the wet clutch must be kept high to decrease the loss in the transmission torque. This characteristic is defined as transmission torque capacity.

Although these two friction characteristics are contradictory, they must both be possessed by a traction drive fluid for automobiles. Conventional traction drive fluids heretofore proposed, however, are insufficient in both the shudder prevention characteristic and transmission torque capacity, and therefore are unsuitable for use as a lubricating oil for a traction drive device equipped with a lock-up converter for controlling slip.

SUMMARY OF THE INVENTION

An object of the present invention is therefore to provide a traction drive fluid composition having excellent friction characteristics and a traction coefficient which is high at a temperature of about 30°C but does not decrease at high temperatures.

The inventors of the present invention have conducted extensive studies to develop a traction drive fluid composition having a high traction coefficient at high temperatures and found that a composition comprising the following compounds (A-1) or (A-2) or both, as a component (A), and a thermally copolymerized product (hereinafter called "heat copolymer") of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product thereof having a softening point of about 40°C or higher or a weight average molecular weight of 250 or larger, as a component (B) at a weight ratio (A)/(B) of 85/15 to 97/3, or a composition comprising the components (A) and (B) at a weight ratio (A)/(B) of less than 85/15 and a hereinafter described component (C) with a viscosity lower than that of the component (A), exhibits excellent temperature characteristics and excellent low temperature fluidity due to a synergistic effect of these components.



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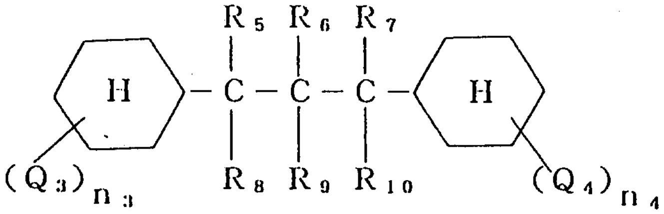

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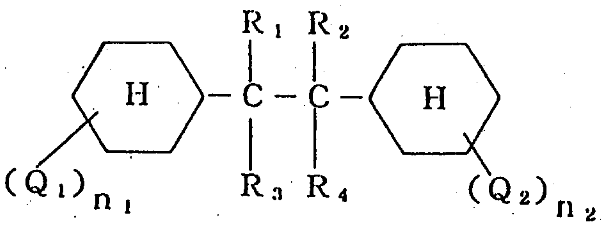
The inventors have further found that the friction characteristics of the composition is improved by the addition of at least one phosphorous compound, as a component (D), and at least one friction modifier, as a component (E).

Accordingly, a specific object of the present invention is to provide a traction drive fluid composition comprising the following component (A) and component (B) at a weight ratio (A)/(B) of 85/15 to 97/3:

(A) being at least one compounds represented by one of the following formulas,



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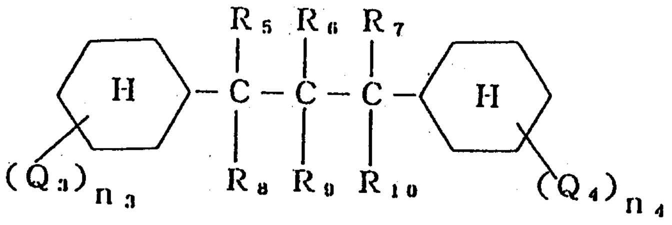


wherein R_1 to R_{10} individually represent a hydrogen, a C_1-C_3 alkyl group, or a cyclohexyl group; Q_1 to Q_4 individually represent a C_1-C_3 alkyl group or a cyclohexyl group; and n1 to n4 individually represent an integer from 0 to 5, wherein when n1 to n4 are integers from 2 to 5 a plurality of Q_1 to Q_4 may be the same or different, and

(B) being a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of the heat copolymer, the heat copolymer or the hydrogenated product thereof having a softening point of 40°C or higher or a weight average molecular weight of 250 or larger, or comprising said components (A) and (B) at a weight ratio of less than 85/15; and, as the component (C), at least one of the following compounds (i) to (iv) having a lower viscosity than that of the component (A) at 40°C:

(i) a hydrogenated product of dicyclopentadiene or a dicyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;
(ii) a hydrogenated product of tricyclopentadiene or a tricyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;
(iii) a hydrogenated product of tetracyclopentadiene or a tetracyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups; and
(iv) a decaline or a decaline derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups.

In a preferred embodiment of the present invention, the above composition further comprises 0.01-5.0% by weight of the component (D) which is at least one compound selected from a phosphate, an acidic phosphate, a phosphite, and an acidic phosphite, and 0.01-3.0% by weight of the component (E) which is an N-type friction modifier or an ester-type friction modifier.

Other objects, features and advantages of the invention will hereinafter become more readily apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the traction coefficients (μ) at various temperatures of the traction drive fluid compositions prepared in Examples 1-3 and Comparative Examples 1-4.

Figure 2 shows the traction coefficients (μ) at various temperatures of the traction drive fluid compositions prepared in Examples 4 and 5.

Figure 3 shows the traction coefficient (μ) at various temperatures of the traction drive fluid composition prepared in Example 6.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENTS

Included in specific examples of the C_1-C_3 alkyl groups in the present invention are methyl, ethyl, n-propyl, and i-propyl groups. In formulas (A-1), (A-2), and the other chemical formulas in the present invention, the hydrogen atoms bonded to cyclic hydrocarbon structures are omitted.

Compounds of the formula (A-1) or (A-2) having an integer from 0 to 5 for n1, n2, n3, and n4 are used in the present invention for various reasons.

R_1 to R_{10} in the formulas (A-1) or (A-2) are preferably hydrogen, a methyl group, or an ethyl group, with the hydrogen or methyl group being particularly preferred. In addition, the compound with an alkylated carbon atom adjacent to the cyclohexyl group is particularly preferred. In view of availability of the raw materials, the compounds with an integer from 0 to 2 for n1 to n4 in the formulas (A-1) or (A-2) are particularly preferred. Q_1 to Q_4, when these are present, are normally a methyl group.

Given as preferred examples of the compounds of the formulas (A-1) or (A-2) are 1,2-dicyclohexylpropane, 1,2-dicyclohexyl-2-methylpropane, 2,3-dicyclohexylbutane, 2,3-dicyclohexyl-2-methylbutane, 2,3-dicyclohexyl-2,3-dimethylbutane, 1,3-dicyclohexylbutane, 1,3-dicyclohexyl-3-methylbutane, 2,4-dicyclohexylpentane, 2,4-dicyclohexyl-2-methylpentane, 2,4-dicyclohexyl-2,4-dimethylpentane, 1,3-dicyclohexyl-2-methylbutane, 2,4-dicyclohexyl-2,3-dimethylbutane, and 2,4-dicyclohexyl-2,3-dimethylpentane. Also included are the compounds having a substituted ethyl, n-propyl, i-propyl, or cyclohexyl group for the methyl group in the above-listed compounds, and the compounds having one or more optional positions in the cyclohexyl ring of the above listed compounds alkylated with a methyl, ethyl, n-propyl, i-propyl, or cyclohexyl group. Either of the compounds of the formulas (A-1) or (A-2) may be used individually, or a mixture of a compound of the formula (A-1) and a compound of the formula (A-2) at an arbitrary proportion may be used.

For instance, a hydrogenated dimer of α-alkylstyrene which is one of the compounds of component (A) can be prepared by dimerization of α-alkylstyrene followed by hydrogenation of the resulting dimer. The dimerization and the hydrogenation can be carried out by any optional method with no specific limitations. aaa

For example, the dimerization of α-methylstyrene can be carried out in the presence of a catalyst, typically an acidic catalyst, with an addition of a solvent, a reaction controlling agent, and the like, as required. Specific examples of the acidic catalyst include clays such as activated clay or acid clay; mineral acids such as sulfuric acid, hydrochloric acid, or hydrofluoric acid; organic acids such as p-toluenesulfonic acid or triflic acid; Lewis acids such as aluminum chloride, ferric chloride, stannic chloride, boron trifluoride, boron tribromide, aluminum bromide, gallium chloride, and gallium bromide; and solid acids such as zeolite, silica, alumina, silica • alumina, cationic exchange resins, and heteropoly acids. The amount of acidic catalyst used is usually 0.1-100% by weight, preferably 1-20% by weight, of the α-methylstyrene, but not specifically limited to these ranges. A saturated hydrocarbon may be used as the solvent. Specific examples include n-pentane, n-hexane, heptane, octane, nonane, decane, cyclopentane, cyclohexane, methylcyclohexane, and decaline. A reaction controlling agent is used with the object of increasing the selectivity of the dimer produced in the reaction. Specific examples of the reaction controlling agent include carboxylic acids such as acetic acid; acid anhydrides such as acetic anhydride and phthalic anhydride; cyclic esters such as γ-butyrolactone and valerolactone; glycols such as ethylene glycol; mono-nitro compounds such as nitromethane and nitrobenzene; esters such as ethyl acetate; ketones such as mesityl oxide; aldehydes such as formalin and acetaldehyde; cellosolves; and polyalkylene glycol alkyl ethers such as diethylene glycol monoethyl ether. The dimerization reaction is carried out at a temperature of -30°C to 180°C, and preferably 0°C to 160°C.

The hydrogenation of the α-methylstyrene dimer thus produced can also be carried out in the presence of a catalyst, with the addition of a solvent or the like as required. A catalyst commonly known as a hydrogenation catalyst containing one or more metals such as nickel, ruthenium, palladium, platinum, rhodium, iridium, copper, chromium, molybdenum, cobalt, and tungsten, can be used as the catalyst. The amount of the catalyst used is usually 0.1 to 100% by weight, preferably 1 to 20% by weight, of the dimer, but not specifically limited to these ranges. A liquid saturated hydrocarbon, such as n-pentane, n-hexane, heptane, octane, nonane, decane, dodecane, cyclopentane, cyclohexane, and methylcyclohexane, may be used as the solvent. This hydrogenation reaction is carried out under common hydrogenation reaction conditions, e.g. at a temperature of 20 to 300°C, preferably 40 to 200°C, and under a hydrogen pressure ranging from normal pressure to 200 Kg/cm^2 (G), preferably 20 to 100 Kg/cm^2 (G).

It is obvious to a person skilled in the art that the above description of the preparation of the hydrogenated dimer of α-methylstyrene applies to the preparation of the hydrogenated dimer of styrene or the hydrogenated dimers of α-alkylstyrene replaced by an alkyl group other than methyl group or by a cycloalkyl group.

Because the hydrogenated dimers of α-alkylstyrene used in the present invention must contain a high proportion of linear components, the following processes for which patents have been applied by the inventors of the present invention are preferably used for the preparation of the same. That is, the dimerization reaction can be carried out by (i) reacting α-alkylstyrene in a solid-liquid non-homogeneous system using heteropoly acid in the amount of 1 to 100% by weight of the α-alkylstyrene in the absence of a solvent at 80 to 140°C (Japanese Patent Application Laid-open No. 242575/1995), (ii) reacting α-alkylstyrene in a solid-liquid non-homogeneous system using heteropoly acid in the amount of 1 to 200% by weight of the α-alkylstyrene in the presence of a solvent which does not dissolve the catalyst at 30 to 140°C (Japanese Patent Application Laid-open No. 242575/1995), or (iii) reacting α-alkylstyrene using heteropoly acid in the presence of water (Japanese Patent Application Laid-open No. 242573/1995). A product containing an extremely high proportion of linear components can be obtained by hydrogenating the dimers produced in these processes by the above-described, known hydrogenation process. The proportion of linear components in this hydrogenation product is so high that the dimerization processes have the advantage that the difficult step of separation of cyclic components can be eliminated. In addition, these dimerization processes proposed by the inventors of the present invention are economically advantageous due to the high conversion rate of raw materials into the dimers and significant reduction of the reaction time.

Octahydroindanes which are cyclic isomers may be produced as by-products when the hydrogenated dimers of α-alkylstyrene are produced. It is desirable that these by-products are not contained, inasmuch as they tend to reduce the traction coefficient. The purity of the hydrogenated dimers of α-alkylstyrene should be 70% by weight or higher, and preferably 90% by weight or higher.

In addition to the dimerization reaction, the component (A) can be obtained by the coupling reaction of aromatic hydrocarbons followed by the hydrogenation of a benzene ring according to the processes described, for example, in Japanese Patent Application Laid-open No. 258131/1985 or No. 262892/1985. A product with an alkyl group introduced into the cyclohexane ring can be obtained if the alkylation is carried out by an aromatic substitution reaction using a Friedel-Krafts catalyst prior to the hydrogenation.

The component (B) in the present invention is a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of this heat copolymer.

The cyclopentadiene compounds used for preparing the component (B) in the present invention include cyclopentadiene, oligomers of cyclopentadiene, cyclopentadienes into which alkyl groups are substituted, and mixtures of these compounds. For industrial manufacture, the use of cyclopentadiene fractions containing about 30% by weight, preferably about 50% by weight, of cyclopentadienes, produced by steam cracking of naphtha, is advantageous.

These cyclopentadiene fractions may contain olefinic monomers which can copolymerize with alicyclic dienes such as cyclopentadiene. Such olefinic monomers include aliphatic diolefins such as isoprene, piperilene, or butadiene, and alicyclic olefins such as cyclopentene. Although it is desirable that the content of these olefins be small, up to about 10% by weight for the cyclopentadienes is allowable.

In the present invention, a cyclopentadiene compound monomer is counted as one mol, while a dimer is counted as two mols.

Styrene, o-, m-, p-vinyltoluene, and α-, β-methylstyrene are given as examples of the vinyl aromatic hydrocarbons to be copolymerized with the cyclopentadiene compound for prrroducing the component (B). For industrial manufacture of the component (B), these vinyl aromatic hydrocarbons are preferably used in the amount of less than 3 mols for one mol of the cyclopentadiene compound. The vinyl aromatic hydrocarbons may contain indenes such as indene, methylindene, and ethylindene. Although C9 fractions produced by steam cracking of naphtha may be uaed for industrial purposes, the use of styrene monomer among various raw materials is particularly preferred from the viewpoint of ensuring good quality of the resulting product.

There are no specific limitations to the method for producing the component (B) of the present invention, inasmuch as the component (B) is a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product thereof. A preferred embodiment of a process for the heat copolymerization of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound will now be described.

In this process, a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound are copolymerized in the absence or presence of a solvent, preferably in an atmosphere of inert gas such as nitrogen, at about 160 to 300°C, preferably about 180 to 280°C, for about 0.1 to 10 hours, preferably about 0.5 to 6 hours, under a pressure sufficient to maintain the raw materials in liquid form. After evaporating inert components in the raw materials, unreacted raw materials, and a solvent, where necessary, by distillation of the like under atmospheric or reduced pressure, a second step polymerization is successively carried out about 160 to 280°C, for about 0.5 to 4 hours under reduced pressure. If necessary, fractions lighter than the target heat copolymer are removed by distillation or the like after the reaction.

The heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound thus produced has a softening point of 40°C or higher or a weight average molecular weight of 250 or greater; preferably a softening point of 100 to 200°C or a weight average molecular weight of 400 to 2,000.

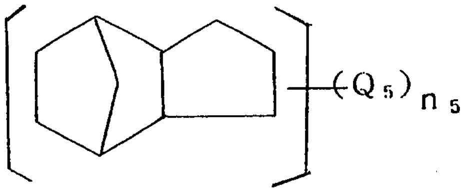
Although this heat copolymer exhibits a high effect as a traction drive fluid without a hydrogenation treatment, it is desirable to hydrogenate the copolymer, taking its performance such as oxidation stability into consideration.

The hydrogenation treatment can be carried out by a conventional method. For example, the copolymer is hydrogenated by a treatment using the same hydrogenation catalyst used for the hydrogenation of the component (A), such as nickel, palladium, or platinum in the presence or absence of a solvent at about 70 to 300°C, preferably about 100 to 250°C, under a hydrogen pressure of about 10 to 200 Kg/cm^2 (G), preferably about 20 to 120 Kg/cm^2 (G), for about 0.5 to 20 hours, preferably about 1 to 10 hours.

The aromatic ring of the copolymer before the hydrogenation treatment may be alkylated. In this instance, a methyl, ethyl, n-propyl, i-propyl, or cyclohexyl group is used for the alkylation.

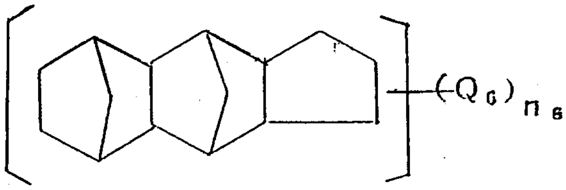
In the first embodiment of the present invention, the ratio by weight of the component (A) and the component (B), which is a copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of thereof, is (A)/(B) = 85/15 to 97/3, and preferably 85/15 to 95/5. If the proportion of the component (B) is too small, there is almost no effect exhibited on the increase in traction coefficient at high temperatures. An excess proportion of the component (B) is undesirable, because there would be a problem in handling the fluid or a problems of an energy loss during use, even though the viscosity and the traction coefficient may be increased. When it is desired to further decrease the viscosity while using the components (A) and (B) at a ratio within the above range, or when the amount of the component (B) used for the amount of the component (A) is larger than the above range which results in an increase in viscosity, as in the case of the second embodiment of the present invention, the viscosity of the fluid can be decreased by adding a compound having a viscosity lower than the viscosity of the component (A) at 40°C. If such a compound has a high traction coefficient, it is possible to decrease the viscosity while suppressing the reduction in the traction coefficient. Preferred examples of such a compound include the following compounds (i) to (v), of which the incorporation as the component (C) is also within the scope of the present invention. The compounds (i) to (v) may be used either individually or as a mixture of two or more.

(i) A hydrogenated product of dicyclopentadiene or a dicyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or a cyclohexyl group. The compound is represented by the following formula:



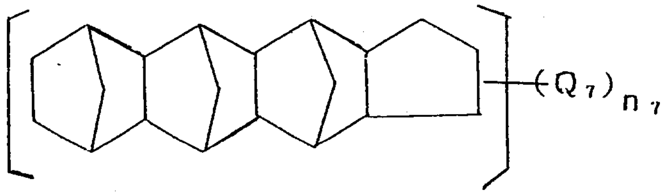
wherein Q_5 is a C_1-C_3 alkyl group or a cyclohexyl group and n5 is an integer from 0 to 10, and when n5 is an integer from 2 to 10 a plurality of Q_5 may be the same or different.

(ii) A hydrogenated product of tricyclopentadiene or a tricyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups. The compound is represented by the following formula:



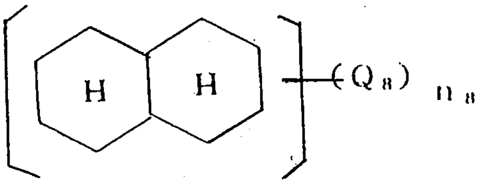
wherein Q_6 is a C_1-C_3 alkyl group or a cyclohexyl group and n6 is an integer from 0 to 15, and when n6 is an integer from 2 to 15 a plurality of Q_6 may be the same or different.

(iii) A hydrogenated product of tetracyclopentadiene or a tetracyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups. The compound is represented by the following formula:



wherein Q_7 is a C_1-C_3 alkyl group or a cyclohexyl group and n7 is an integer from 0 to 20, and when n7 is an integer from 2 to 20 a plurality of Q_7 may be the same or different.

(iv) Decaline or a decaline derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups. The compound is represented by the following formula:



wherein Q_8 is a C_1-C_3 alkyl group or a cyclohexyl group and n8 is an integer from 0 to 10, and when n8 is an integer from 2 to 10 a plurality of Q_8 may be the same or different.

(v) A branched poly-α-olefin compound with a weight average molecular weight of 100-1,000.

In view of the availability of raw materials and the cost, n5 to n7 representing the number of alkyl group in the compounds (i) to (iii), which are cyclopentadiene oligomers, are preferably integers from 0 to 4. The integer n8 in the decaline compound (iv) is preferably 0 to 8, and more preferably 0 to 4.

The poly-α-olefin compound (v) is a compound having a quaternary or ternary carbon atom in the main chain. Olefins having 3 or more carbon atoms may be used as the raw material. A monomer to tetramer of i-butylene or a monomer to pentamer of propylene are preferably used. These olefins may be used either individually or as a mixture of two or more.

The branched poly-α-olefin compound having a molecular weight in the range of 100 to 1,000 maybe used, with those having a molecular weight in the range of 150 to 500 being particularly preferred. If the molecular weight of the poly-α-olefin compound is less than 100, the traction drive fluid composition is too subject to evaporation and the oil film cannot be well retained; if more than 1,000, the low temperature fluidity of the composition is decreased.

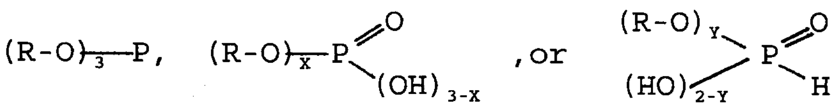
Poly-α-olefin compounds with no branch such as polyethylene, if used as the component (C), result in a traction drive fluid composition having a small traction coefficient, and therefore cannot achieve the effect intended in the present invention.

The amount of the component (C)(i) to (C)(v) to be added is 10 to 70 wt%, and preferably 30 to 50 wt%.

In all chemical formulas in the present invention, the symbol "-Q" extending from the parentheses denotes that the position of the substituent "Q" is optional.

Although the traction drive fluid composition illustrated above exhibits high traction performance over a wide temperature range, a traction drive fluid composition with excellent friction characteristics can be obtained by adding specific amounts of the component (D) and the component (E) which are hereinafter described.

The component (D) is a phosphate, an acidic phosphate, a phosphite, or an acidic phosphite. These compounds are represented by one of the following formulas,



$$(R\text{-}O)_3\text{—}P, \quad (R\text{-}O)_X\text{—}P(=O)(OH)_{3-X}, \text{ or } (R\text{-}O)_Y(HO)_{2-Y}P(=O)H$$

wherein a plurality of Rs are individually a hydrogen, a hydrocarbon group, or a sulfur-containing hydrocarbon group having 1 to 30 carbon atoms, X is 1, 2 or 3, and Y is 1 or 2.

Given as specific examples of the phosphate are triaryl phosphates and trialkyl phosphates, such as benzyldiphenyl phosphate, allyldiphenyl phosphate, triphenyl phosphate, tricresyl phosphate, ethyldiphenyl phosphate, tributyl phosphate, ethyldibutyl phosphate, cresyldiphenyl phosphate, dicresylphenyl phosphate, ethylphenyldiphenyl phosphate, diethylphenylphenyl phosphate, propylphenyldiphenyl phosphate, dipropylphenylphenyl phosphate, triethylphenyl phosphate, tripropylphenyl phosphate, butylphenyldiphenyl phosphate, dibutylphenylphenyl phosphate, and tributylphenyl phosphate.

Examples of the acidic phosphate include 2-ethylhexyl acid phosphate, isodecyl acid phosphate, lauryl acid phosphate, tridecyl acid phosphate, stearyl acid phosphate, iso-stearyl acid phosphate, oleyl acid phosphate, and di(2-ethylhexyl) phosphate.

Examples of the phosphite include triphenyl phosphite, tri(p-cresyl) phosphite, tri(nonylphenyl) phosphite, tri-iso-octyl phosphite, diphenyl-iso-decyl phosphite, phenyl-di-iso-decyl phosphite, tri-iso-decyl phosphite, tristearyl phosphite, and trioleyl phosphite.

Given as examples of the acidic phosphite are di(2-ethylhexyl) hydrogenphosphite, dilauryl hydrogenphosphite, and dioleyl hydrogenphosphite.

The component (D) is incorporated in the traction drive fluid composition in the amount of 0.01 to 5.0% by weight, preferably 0.03 to 3% by weight, and particularly preferably 0.05 to 1% by weight.

The component (E) is an N-type friction modifier or an ester-type friction modifier.

Typical N-type friction modifiers are compounds containing -(CO)NH- (amide bond), -NH-, or -N< in the molecule.

The compound containing the amide bond is typified by compounds represented by the formula R_{11}- (CO)NH-R_{12}, wherein R_{11} represents a hydrocarbon group having 3 to 20 carbon atoms and R_{12} represents a hydrocarbon group having 2 to 20 carbon atoms. Preferred hydrocarbon groups are alkyl or alkenyl groups. Specific examples include ethyl hexyl amide, butyl hexyl amide, butyl decyl amide, ethyl hexadecyl amide, butyl eicosyl amide, and dihexadecyl amide. Of these, particularly preferred are butyl decyl amide, ethyl hexadecyl amide, and butyl eicosyl amide.

The compound containing an -NH- group is typified by compounds represented by the formula R_{13}-NH-R_{14}, wherein R_{13} and R_{14} individually represent a hydrocarbon group having 2 to 20 carbon atoms. Specific examples include ethyl hexyl amine, ethyl decyl amine, butyl decyl amine, ethyl hexadecyl amine, and butyl eicosyl amine. Of these, particularly preferred are ethyl decyl amine, butyl decyl amine, and butyl eicosyl amine.

The compound containing an -N< group is typified by compounds represented by the formula R_{15}-N(R_{16}-COOH)$_2$, wherein R_{15} and R_{16} individually represent a hydrocarbon group having 2 to 20 carbon atoms. A specific example is $C_{18}H_{37}$-N(C_8H_{16}-COOH)$_2$. This is a compound containing both a carboxyl group and the -N< bond.

The ester-type friction modifiers include an ester group, -COOH-, and include such compounds as methyl hexanoate, methyl undecanoate, methyl tetradecanoate, methyl octadecanoate, butyl eicosanoate, octadecyl acetate, and ditetradecyl succinate. Of these, methyl tetradecanoate and methyl octadecanoate are preferred.

The component (E) is incorporated in the traction drive fluid composition in the amount of 0.01-3.0% by weight, preferably 0.03-1% by weight, and particularly preferably 0.05-0.5% by weight. If this amount is too small, only slight improvement can be achieved in the anti-shudder characteristic (μ-V characteristic); if too large, the static friction coefficient is decreased and sliding of the wet clutch is produced due to the decrease in the transmission torque capacity.

Beside the above components, various additives may be incorporated in the traction drive fluid composition of the present invention. Such additives include anti-wear agents, ashless-type dispersants, metallic-type detergents, antioxidants, rust inhibitors, metal deactivators, viscosity index improvers, pour point depressants, metal deactivators, and anti-foaming agents.

Given as specific examples of these additives are: as the metallic-type detergents, alkaline earth metal sulfonates and alkaline earth metal phenates; as the ashless-type dispersants, alkenyl succinic acid imide, alkenyl succinic ester, and amides of long-chain fatty acid and polyamine (amino-amide type); as the wear preventives, zinc dialkyldithiophosphate; as the anioxidants, amine-type anioxidants and phenol-type anioxidants; as the rust inhibitors, alkenyl succinic ester and alkenyl succinic half ester; as the metal deactivators, benztriazole and thiadizole; as the viscosity index improvers, polymethacrylates and olefin copolymers; as the pour point depressants, polymethacrylates; and as the anti-foaming agents, silicon compounds and ester-type anti-foaming agents.

The combination of the component (A) and the component (B), which is a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product thereof, exhibits a synergistic effect of the two components and remarkably increases the traction coefficient of the composition particularly at high temperatures. This is very clearly demonstrated in Examples and Comparative Examples hereinafter, wherein it was shown that the traction coefficient for the compositions in Examples 1-6 using the combination of the components (A) and (B) is higher than that of Comparative Examples 1 and 2 using only the component (A), that of Comparative Example 3 using only the component (C), and that of Comparative Example 4 using the combination of the components (B) and (C).

This synergistic effect of high traction coefficient due to the combination of the components (A) and (B) cannot be seen in the above-mentioned Japanese Patent Application Laid-Open No. 1292/1993. Furthermore, because the synergistic effect of the present invention is brought about by the combination of the component (A) and the heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product thereof, this effect is different from that of Japanese Patent Application Laid-Open No. 230696/1989.

From the above description it can be understood that the composition of the components (A) and (B), or the composition further added with the component (C) which has a viscosity smaller than the component (A), provides a traction drive fluid composition having a high traction coefficient in a wide temperature range and exhibiting excellent low temperature fluidity.

Furthermore, if the components (D) and (E) are further added, friction characteristics of the composition required for traction drive devices are remarkably improved. This is manifested by Examples 7-20 wherein the compositions are significantly excellent in the overall characteristics such as transmission torque capacity, anti-shudder performance, and temperature-viscosity characteristics.

The traction drive fluid composition of the present invention thus having a high traction coefficient over a wide temperature range and exhibiting excellent friction characteristics is particularly useful for use in vehicles.

Other features of the invention will become apparent in the course of the following description of the exemplary embodiments which are given for illustration of the invention and are not intended to be limiting thereof.

EXAMPLES

Synthetic Example 1

1,200 g of α-methylstyrene, 400 g of water, and 800 g of $H_3PW_{12}O_{40}$ were placed in a 5 l reaction vessel made of glass equipped with a cooling tube and a thermometer, and reacted at 100°C for 3 hours. After the reaction, the reaction mixture was cooled to remove a water layer. The organic layer was dehydrated with anhydrous Na_2SO_4. After removal of the Na_2SO_4 by filtration, the organic layer was analyzed by gas chromatography to confirm that the conversion rate of α-methylstyrene was 89.5wt%, the yield of α-methylstyrene dimer was 86.4 wt%, and the selectivity was 96.5 wt%.

1,200 g the organic layer thus obtained was placed in a 10 l autoclave together with 5,000 g of cyclohexane and 120 g of N113™ (a hydrogenation catalyst, manufactured by Nikki Kagaku Co., Ltd.). After sealing the autoclave, the mixture was reacted at 180°C under a hydrogen pressure of 60 Kg/cm^2 (G) for 5 hours. The reaction mixture was cooled and the catalyst was removed by filtration. Hydrogenation products of α-methylstyrene and cyclohexane were removed by evaporation to obtain 1,250 g of a product. Gas chromatography analysis confirmed that this product was 2,4-dicyclohexyl-2-methylpentane (a compound with a structure of formula (A-2), hereinafter referred to as a component (a-1)) with a purity of 96.5 wt%.

Synthetic Example 2

2,300 g of dehydrated cumene, 40 g of metallic sodium, and 11 g of iso-propyl alcohol were placed in a 5 l reaction vessel made of glass equipped with a cooling tube and a thermometer. The mixture was reacted at 130°C while vigorously stirring and adding 650 of styrene dropwise for 3 hours, followed by further stirring for one hour. After termination of the stirring, the reaction mixture was cooled to separate an oil layer. After the addition of 200 g of ethanol, the oil layer was washed three times with 5 N aqueous solution of hydrochloric acid and 2 l of saturated brine, and dried with anhydrous Na_2SO_4. Unreacted cumene was evaporated by a rotary evaporator and the residue was distilled under reduced pressure to obtain 700 g of a fraction with a boiling point range of 115-125°C. 450 g this fraction was placed in a 10 l autoclave together with 4,500 g of cyclohexane and 45 g of N113™ (a hydrogenation catalyst, manufactured by Nikki Kagaku Co., Ltd.). After sealing the autoclave, the mixture was hydrogenated at 180°C under a hydrogen pressure of 60 Kg/cm^2 (G) for 5 hours. The reaction mixture was cooled and the catalyst was removed by filtration. Cyclohexane was evaporated by a rotary evaporator. Analysis of the residue confirmed that the product was 1,3-dicyclohexyl-3-methylbutane (a compound with a structure of formula (A-2), hereinafter referred to as a component (a-2)).

Synthetic Example 3

500 g of a cyclopentadiene fraction obtained from steam cracking of naphtha (consisting of 75.0 wt% of dicyclopentadiene, 5.4 wt% of olefins, and balance of which the major component is saturated hydrocarbons), 125 g of styrene monomer, and 775 g of xylene were reacted at 260°C in a nitrogen atmosphere at a pressure of 18 Kg/cm^2 (G) for 3 hours. After evaporating inert fractions in the raw materials, unreacted raw materials, and the solvent, initially under pressure and subsequently under reduced pressure at 252°C, and after retaining the mixture at this temperature under a reduced pressure of 50 Torr for one hour, a second stage polymerization was carried out while evaporating cyclopentadiene condensates, thus obtaining 401 g of a copolymer of cyclopentadiene and vinyl aromatic hydrocarbons as a residue. 3 wt% of N111™ (a hydrogenation catalyst, manufactured by Nikki Kagaku Co., Ltd.) was added and the mixture was hydrogenated at 220°C under a hydrogen pressure of 60 Kg/cm^2 (G) for 6 hours, to obatin 401 g of the target hydrogenated copolymer of cyclopentadiene and vinyl aromatic hydrocarbons. This copolymer is one of the examples of the component (B) and hereinafter referred to as a component (b). The copolymer had a softening point of 175°C and a weight average molecular weight of 1,300.

Synthetic Example 4

600 g of the same cyclopentadiene fraction as used in Synthetic Example 3 and 400 g of xylene used as a solvent were reacted at 260°C in a nitrogen atmosphere at a pressure of 18 Kg/cm^2 (G) for 3 hours. After evaporating inert fractions, unreacted raw materials, and the solvent, initially under pressure and subsequently under reduced pressure at 160°C, the mixture was retained at this temperature under a reduced pressure of 50 Torr for one hour, to obtain 56 g of the target cyclopentadiene condensate. To 56 g of this fraction, 3 wt% of N111™ (a hydrogenation catalyst, manufactured by Nikki Kagaku Co., Ltd.) was added and the mixture was hydrogenated at 180°C under a hydrogen pressure of

60 Kg/cm^2 (G) for 4 hours, to obatin 56 g of the target hydrogenated cyclopentadiene condensate. This product is structurally one of the examples of the compound (iii) of the component (C) and hereinafter referred to as a component (c-1). A GPC analysis confirmed that the product contained trimer, tetramer, pentamer, and hexamer of cyclopentadiene in the amount respectively of 41 wt%, 25 wt%, 19 wt%, and 7 wt%.

Synthetic Example 5

A hydrogenated cyclopentadiene condensate prepared in the same manner as in Synthetic Example 4 was distilled to obtain 48 wt% of an overhead fraction. A GPC analysis of this overhead fraction confirmed that the product contained trimer, tetramer, and pentamer of cyclopentadiene in the amount respectively of 85 wt%, 13 wt%, and 2 wt%. This product is structurally one of the examples of the compound (ii) of the component (C) and hereinafter referred to as a component (c-2).

Synthetic Example 6

1 kg of 2-ethylnaphthalene (manufactured by Aldrich Co.), 100 g of N113™ (a hydrogenation catalyst, manufactured by Nikki Kagaku Co., Ltd.), and 10 kg of cyclohexane were placed in a 20 l autoclave. After sealing the autoclave, the mixture was reacted at 200°C under a hydrogen pressure of 6.0 Mpa for 5 hours while stirring. The autoclave was opened, the catalyst was removed by filtration, and cyclohexane was evaporated to obtain 1.06 kg of 2-ethyldecaline. This compound is structurally one of the examples of the compound (iv) of the component (C) and hereinafter referred to as a component (c-3).

Examples 1-6, Comparative Examples 1-4

Traction drive fluid compositions with the formulation shown in Table 1 were prepared using the products prepared in Synthetic Examples 1-6.

TABLE 1

	Amount (wt%)						Viscosity (cSt)	
	a-1	a-2	b	c-1	c-2	c-3	40℃	100℃
Example 1	90	-	10	-	-	-	44.9	5.67
Example 2	95	-	5	-	-	-	32.3	4.13
Example 3	-	90	10	-	-	-	40.3	5.12
Example 4	45	-	5	-	50	-	19.1	3.74
Example 5	40	-	10	-	50	-	28.0	4.74
Example 6	63	-	7	-	-	30	27.4	4.31
Comparative Example 1	100	-	-	-	-	-	20.1	3.58
Comparative Example 2	-	100	-	-	-	-	16.5	3.21
Comparative Example 3	-	-	-	100	-	-	26.6	4.44
Comparative Example 4	-	-	10	90	-	-	73.3	8.00

a-1: 2,4-Dicyclohexyl-2-methylpentane

a-2: 1,3-Dicyclohexyl-3-methylbutane

b: Hydrogenated copolymer of cyclopentadiene and vinyl aromatic hydrocarbons

c-1: A mixture of cyclopentadiene oligomers containing 41 wt% of trimer, 25 wt% of tetramer, 19 wt% of pentamer, and 7 wt% of hexamer.

c-2: A mixture of cyclopentadiene oligomers containing 85 wt% of trimer, 13 wt% of tetramer, and 2 wt% of pentamer.

c-3: 2-Ethyldecaline

The traction coefficient was measured for the fluid compositions of Examples 1-6 and Comparative Examples 1-4 at temperatures of 30-120°C. The results are shown in Figures 1-3, wherein the temperature is plotted along the axis of abscissa and the traction coefficient is plotted along the axis of ordinate. It can be seen from these Figures that all results in Examples 1-6 are superior to those in Comparative Examples 1-4.

Examples 7-19

Traction drive fluid compositions were prepared according to the formulation shown in Tables 2-1 and 2-2, wherein, (A) is 2,4-dicyclohexyl-2-methylpenetane, (B) is hydrogenated copolymer of cyclopentadiene and vinyl aromatic hydrocarbons, (C1) is hydrogenated cyclopentadiene condensate (dimers and trimers), and (C2) is polyisobutylene with a weight average molecular weight of 300.

The transmission torque capacity, anti-shudder performance, viscosity, and traction coefficient of these compositions were measured by the following methods. The results are shown in Tables 2-1 and 2-2.

〈Transmission torque capacity〉

The transmission torque capacity was measured by SAE No. 2 test using two paper disks for automatic transmission, four steel plates for automatic transmission, at a rotation of motor of 3,000 rpm (dynamic cycle) or 0.7 rpm (static cycle), a pressure of 2.81 kg/cm^2, and an oil bath temperature of 120°C. The static friction coefficient at static cycle was measured after 500 cycle operation at dynamic cycle. The transmission torque capacity was deemed to be sufficient if the static friction coefficient was 0.120 or greater.

〈Anti-shudder performance〉

Friction coefficient at a rotation of 1 rpm (μ1) and a rotation of 50 rpm (μ50) were measured at a fluid temperature of 40°C and a pressure of 10 kg/cm^2 using a paper disk for automatic change gear and a steel plate for automatic change gear. The anti-shudder performance indicated by the ratio μ 1/μ50 was calculated. The value μ1/μ50 less than 1 indicates that no shudder occurrs.

〈Viscosity〉

The viscosity at -30°C was measured according to the Brookfield viscosity test method of ASTM D 2983.

〈Traction coefficient〉

A transmitted tangential stress was measured using a four-cylinder friction tester at a driving axial rotation of 2,000 rpm (4.19 m/s), a specific sliding of 5%, a transmitted tangential stress of 395 kg, and test fluid temperatures of 30°C and 120°C. The traction coefficient is expressed by the ratio of the transmitted tangential stress against the transmitted tangential stress.

TABLE 2-1

(Examples 7-13)								
Example		7	8	9	10	11	12	13
(A)		90	90	90	90	90	90	90
(B) Petroleum resin		10	10	10	10	10	10	10
(C)	(C1)*							
	(C2) Polyisobutylene							
(D)	Trioctyl phosphate	0.3	0.3					0.3
	2-Ethylhexyl phosphate			0.3	0.3			
	Di-2-ethylhexyl hydrogen phosphate					0.3	0.3	
(E)	Butyldecyl amide	0.1		0.05		0.05		0.1
	Buthyldecyl amine		0.1		0.1		0.05	
	Methyl myristate	0.1	0.1	0.1	0.1	0.1	0.1	
	Methyl stearate							0.1
Antioxidant		0.5						
Ashless-type dispersant		4.0						
Metal-type detergent		0.1						
Wear preventive		0.1						
Metal deactivator		0.05						
Transmission torque capacity, 500 cycle μs		0.132	0.122	0.125	0.122	0.125	0.130	0.129
Anti-shudder performance (μ1/μ50)		0.75	0.77	0.83	0.79	0.74	0.85	0.80
Viscosity, @ -30°C		192000	191000	192000	189000	191000	192000	192000
Traction coefficient	30°C	0.119	0.118	0.118	0.119	0.120	0.118	0.119
	120°C	0.100	0.099	0.100	0.100	0.099	0.098	0.100

* Hyrogenated heat copolymer of cyclopentadiene-styrene

Note for Tables 2-1 and 2-2

(1) Alkyldiphenylamine

(2) Alkenyl succinic acid imide

(3) Calcium sulfonate

(4) Benzyl sulfide

(5) Benztriazole

TABLE 2-2

(Examples 14-20)							
Example		14	15	16	17	18	19
(A)		90	72	50	45	45	40
(B) Petroleum resin		10	8	10	5	5	10
(C)	(C1)*		20	40	50		
	(C2) Polyisobutylene					50	50
(D)	Trioctyl phosphate		0.3			0.3	
	2-Ethylhexyl phosphate	0.3		0.3			0.3
	Di-2-ethylhexyl hydrogen phosphate				0.3		
(E)	Butyldecyl amide	0.05	0.05	0.05		0.05	0.05
	Buthyldecyl amine				0.05		
	Methyl myristate		0.1	0.1	0.1	0.1	0.1
	Methyl stearate	0.1					
Antioxidant (1) Ashless-type dispersant (2) Metal-type detergent (3) Wear preventive (4) Metal deactivator (5)							
Transmission torque capacity, 500 cycle μs		0.127	0.131	0.127	0.130	0.132	0.127
Anti-shudder performance (μ1/μ50)		0.79	0.82	0.80	0.86	0.82	0.81
Viscosity, @ -30°C		190000	44600	14400	8960	9520	15100
Traction coefficient	30°C	0.119	0.111	0.102	0.100	0.105	0.109
	120°C	0.101	0.088	0.078	0.072	0.073	0.085

* Hyrogenated heat copolymer of cyclopentadiene-styrene

Note for Tables 2-1 and 2-2

(1) Alkyldiphenylamine

(2) Alkenyl succinic acid imide

(3) Calcium sulfonate

(4) Benzyl sulfide

(5) Benztriazole

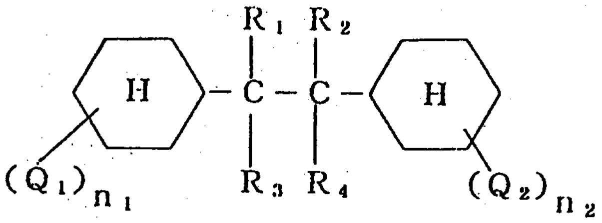
As shown in Tables 2-1 and 2-2, the compositions of Examples 7-14 possessed a high traction coefficient in a wide temperature range and exhibited excellent transmission torque capacity and anti-shudder performance, although the low-temperature fluidity of these compositions was rather small. On the other hand, as can be seen in the compositions of Examples 15-19, the addition of the component (C) as a low-viscosity component or a viscosity decreasing agent improved the temperature characteristics and resulted in traction drive fluid compositions with excellent low-temperature fluidity. Although the compositions of Examples 15-19 has a traction coefficient slightly smaller than that of the compositions in Examples 7-14, their temperature characteristics and low-temperature fluidity are more excellent. The former compositions are therefore suitable as a traction drive fluid for vehicles used under the condistions of a wide temperature range.

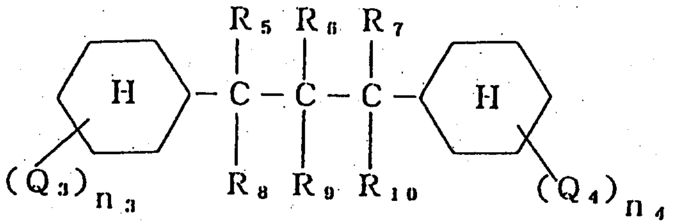
Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

Claims

1. A traction drive fluid composition comprising the following component (A) and Component (B) at a weight ratio (A)/(B) of 85/15 to 97/3:

   (A) at least one compound represented by one of the following formulas,





   wherein R_1 to R_{10} individually represent a hydrogen, a C_1-C_3 alkyl group, or a cyclohexyl group; Q_1 to Q_4 individually represent a C_1-C_3 alkyl group or a cyclohexyl group; and n1 to n4 individually represent an integer from 0 to 5, wherein when n1 to n4 are an integer from 2 to 5 a plurality of Q_1 to Q_4 may be the same or different, and

   (B) a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of the heat copolymer, the heat copolymer or the hydrogenated product thereof having a softening point of 40°C or higher or a weight average molecular weight of 250 or larger.

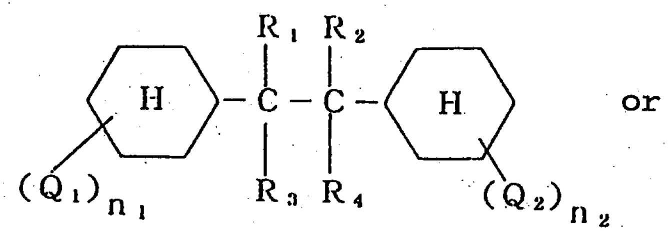
2. The traction drive fluid composition according to claim 1, further comprising at least one of the following compounds (i) to (iv) as a component (C):

   (i) a hydrogenated product of dicyclopentadiene or a dicyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;
   (ii) a hydrogenated product of tricyclopentadiene or a tricyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;
   (iii) a hydrogenated product of tetracyclopentadiene or a tetracyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups; and
   (iv) a decaline or a decaline derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;

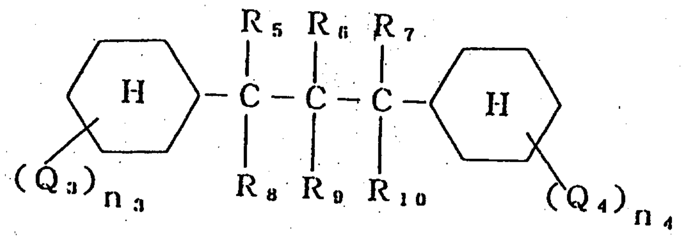
   wherein the component (C) has a lower viscosity than that of the component (A) at 40°C.

3. A traction drive fluid composition comprising the following component (A), component (B), and component (C):

   (A) at least one compound represented by one of the following formulas,



or



wherein R_1 to R_{10} individually represent a hydrogen, a C_1-C_3 alkyl group, or a cyclohexyl group; Q_1 to Q_4 individually represent a C_1-C_3 alkyl group or a cyclohexyl group; and n1 to n4 individually represent an integer from 0 to 5, wherein when n1 to n4 are an integer from 2 to 5 a plurality of Q_1 to Q_4 may be the same or different,

(B) a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of the heat copolymer, the heat copolymer or the hydrogenated product thereof having a softening point of 40°C or higher or a weight average molecular weight of 250 or larger, and

(C) at least one of the following compounds (i) to (iv):

(i) a hydrogenated product of dicyclopentadiene or a dicyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;

(ii) a hydrogenated product of tricyclopentadiene or a tricyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;

(iii) a hydrogenated product of tetracyclopentadiene or a tetracyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups; and

(iv) decaline or a decaline derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;

wherein the component (C) has a lower viscosity than that of the component (A) at 40°C and the weight ratio (A)/(B) is less than 85/15.

4. The traction drive fluid composition according to claim 1, wherein the component (A) is a hydrogenated product of an α-alkylstyrene dimer.

5. The traction drive fluid composition according to claim 1, wherein the C_1-C_3 alkyl group in the component (A) is a methyl, ethyl, n-propyl, i-propyl, or cyclohexyl group.

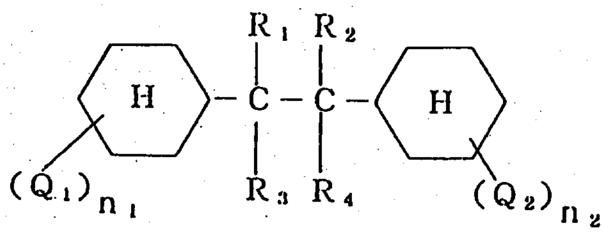
6. The traction drive fluid composition according to claim 1, wherein the component (B) is a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of thereof, having a softening point of 100°C to 200°C or a weight average molecular weight of 400 to 2,000.

7. The traction drive fluid composition according to claim 2 or claim 3, comprising the component (C) in the amount of 10-70% by weight.

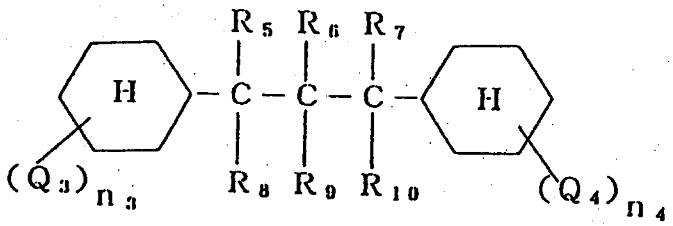
8. The traction drive fluid composition according to claim 2 or claim 3, wherein the cyclopentadiene oligomers (i) to (iii) contain 0 to 4 C_1-C_3 alkyl groups and the decaline compound (iv) contains 0 to 8 C_1-C_3 alkyl groups.

9. A traction drive fluid composition comprising the following component (A), component (B), component (D), and component (E):

(A) at least one compound represented by one of the following formulas,



or



wherein R_1 to R_{10} individually represent a hydrogen, a C_1-C_3 alkyl group, or a cyclohexyl group; Q_1 to Q_4 individually represent a C_1-C_3 alkyl group or a cyclohexyl group; and n1 to n4 individually represent an integer from 0 to 5, wherein when n1 to n4 are an integer from 2 to 5 a plurality of Q_1 to Q_4 may be the same or different,

(B) a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of the heat copolymer, the heat copolymer or the hydrogenated product thereof having a softening point of 40°C or higher or a weight average molecular weight of 250 or larger,

(D) at least one phosphorous compound, and

(E) a friction modifier.

wherein the weight ratio (A)/(B) is 85/15 to 97/3.

10. The traction drive fluid composition according to claim 9, further comprising at least one of the following compounds (i) to (v) as component (C):

(i) a hydrogenated product of dicyclopentadiene or a dicyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;

(ii) a hydrogenated product of tricyclopentadiene or a tricyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;

(iii) a hydrogenated product of tetracyclopentadiene or a tetracyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups;

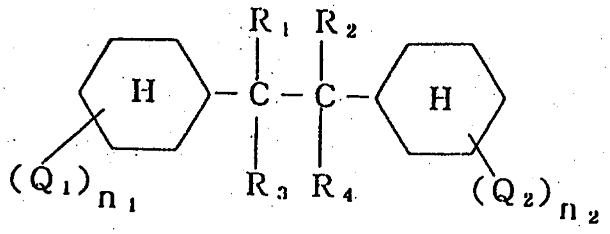
(iv) decaline or a decaline derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups; and

(v) a branched poly-α-olefin compound with a weight average molecular weight of 100-1,000,

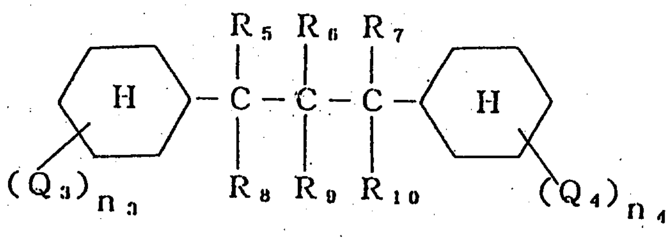
wherein the component (C) has a lower viscosity than that of the component (A) at 40°C.

11. A traction drive fluid composition comprising the following component (A), component (B), component (C), component (D), and component (E):

(A) at least one compound represented by one of the following formulas,



or



wherein R_1 to R_{10} individually represent a hydrogen, a C_1-C_3 alkyl group, or a cyclohexyl group; Q_1 to Q_4 individually represent a C_1-C_3 alkyl group or a cyclohexyl group; and n1 to n4 individually represent an integer from 0 to 5, wherein when n1 to n4 are an integer from 2 to 5 a plurality of Q_1 to Q_4 may be the same or different;

(B) a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of the heat copolymer, the heat copolymer or the hydrogenated product thereof having a softening point of 40°C or higher or a weight average molecular weight of 250 or larger;

(C) at least one of the following compounds (i) to (iv):

(i) a hydrogenated product of dicyclopentadiene or a dicyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups,

(ii) a hydrogenated product of tricyclopentadiene or a tricyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups,

(iii) a hydrogenated product of tetracyclopentadiene or a tetracyclopentadiene derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups,

(iv) a decaline or a decaline derivative with any optional hydrogen atoms being replaced by C_1-C_3 alkyl groups or cyclohexyl groups, and

(v) a branched poly-α-olefin compound with a weight average molecular weight of 100-1,000;

(D) at least one phosphorous compound; and

(E) a friction modifier.

wherein the component (C) has a viscosity lower than the viscosity of the component (A) at 40°C and the weight ratio (A)/(B) is less than 85/15.

12. The traction drive fluid composition according to claim 9, wherein the component (A) is a hydrogenated product of an α-alkylstyrene dimer.

13. The traction drive fluid composition according to claim 9, wherein the C_1-C_3 alkyl group in the component (A) is a methyl, ethyl, n-propyl, i-propyl, or cyclohexyl group.

14. The traction drive fluid composition according to claim 9, wherein the component (B) is a heat copolymer of a cyclopentadiene compound and a vinyl aromatic hydrocarbon compound or a hydrogenated product of thereof, having a softening point of 100°C to 200°C or a weight average molecular weight of 400 to 2,000.

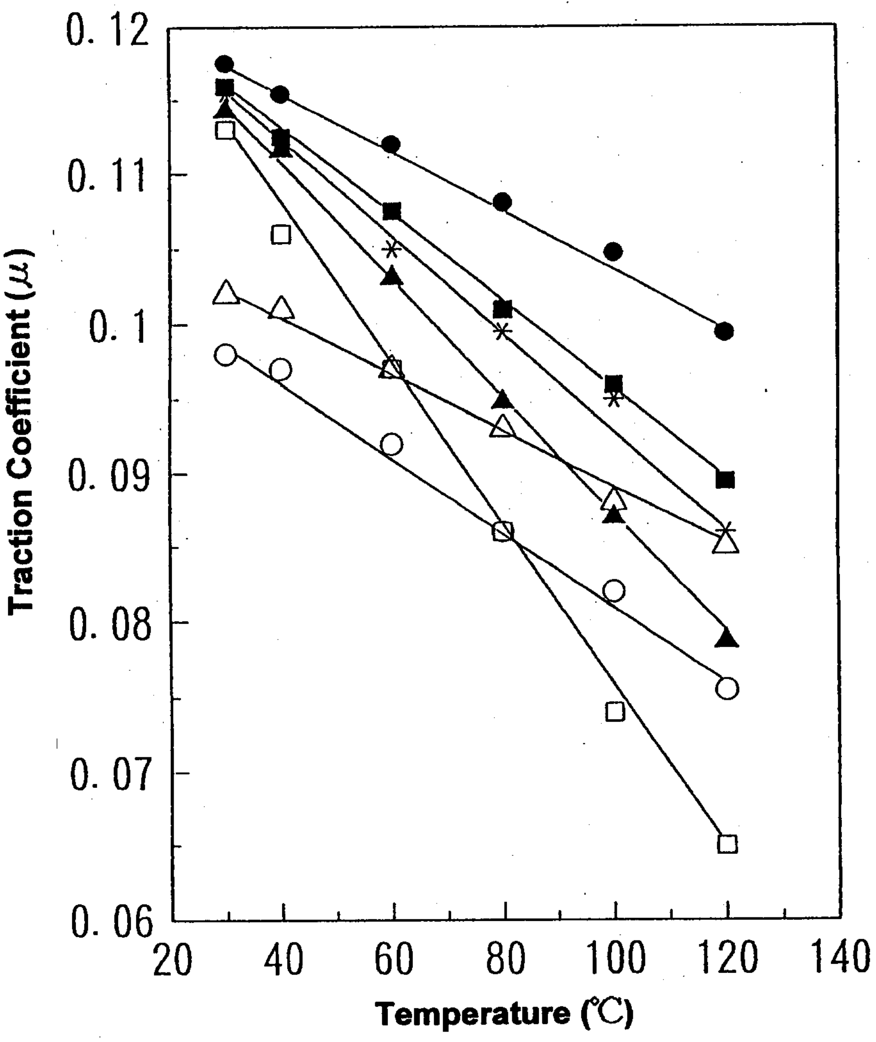
15. The traction drive fluid composition according to claim 10 or claim 11, comprising the component (C) in the amount of 10-70% by weight.

16. The traction drive fluid composition according to claim 10 or claim 11, wherein the cyclopentadiene oligomers (i) to (iii) contain 0 to 4 C_1-C_3 alkyl groups and the decaline compound (iv) contains 0 to 8 C_1-C_3 alkyl groups.

17. The traction drive fluid composition according to claim 10 or claim 11, wherein the branched poly-α-olefin compound (v) is polyisobutylene.

18. The traction drive fluid composition according to claim 9, wherein the component (D) is a phosphate, an acidic phosphate, a phosphite, or an acidic phosphite, and the component (E) is an N-type friction modifier or an ester-type friction modifier.

Figure 1



● Example 1
■ Example 2
▲ Example 3
∗ Comparative Example 1
□ Comparative Example 2
○ Comparative Example 3
△ Comparative Example 4

Figure 2

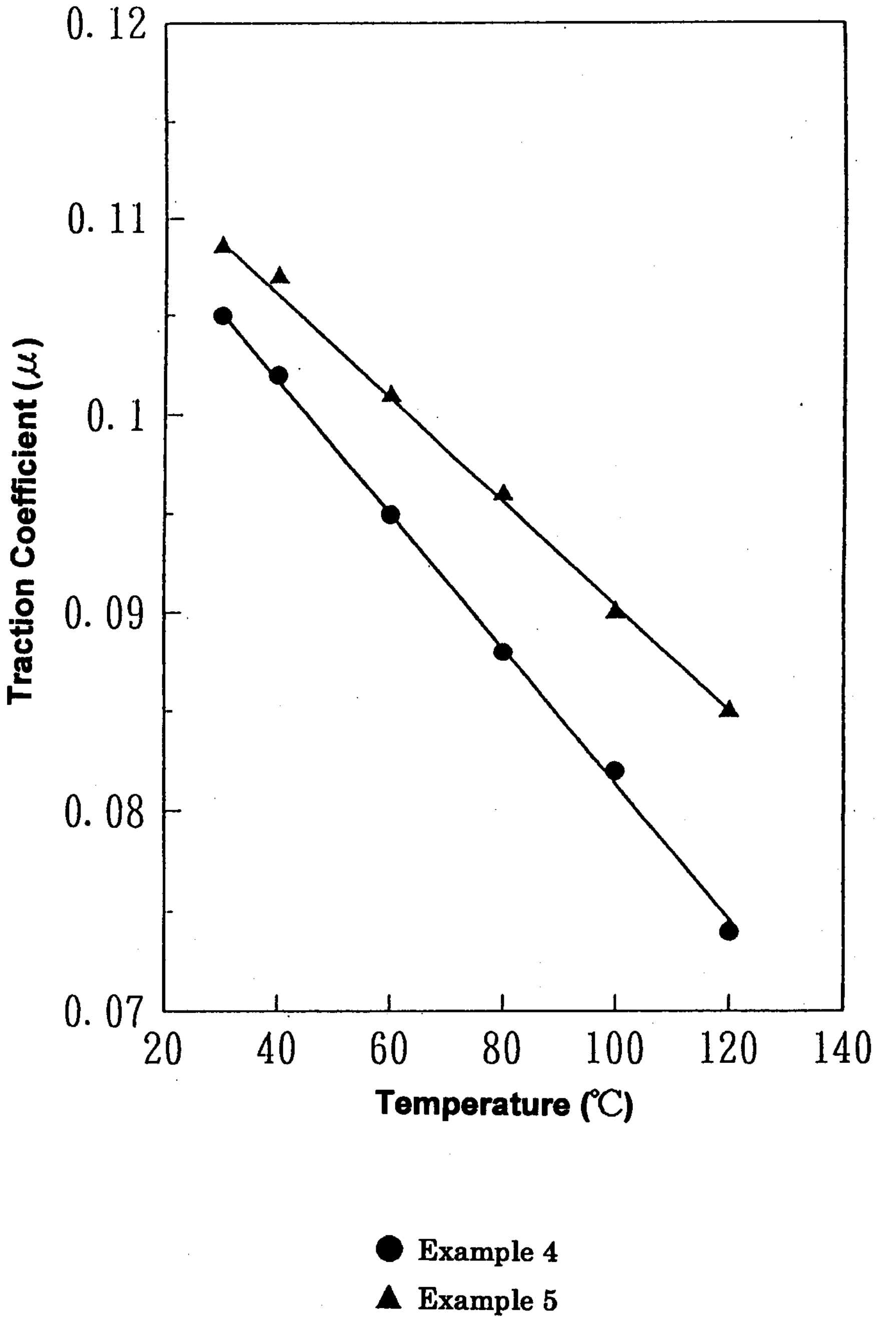
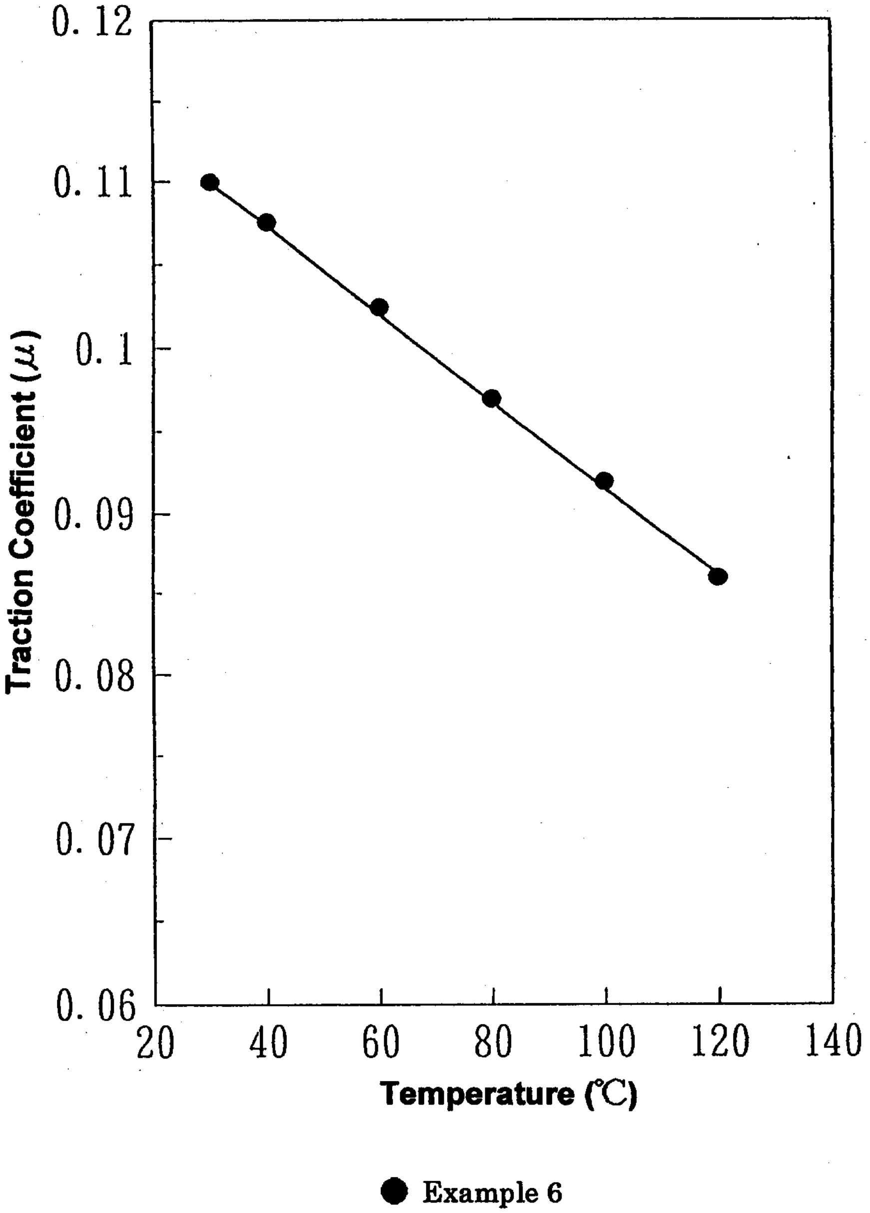

0. 12
0. 11
0. 1
0. 09
0. 08
0. 07
Traction Coefficient (μ)
20
40
60
80
100
120
140
Temperature (℃)
● Example 4
▲ Example 5

Figure 3


Traction Coefficient (μ)
0. 12
0. 11
0. 1
0. 09
0. 08
0. 07
0. 06
20
40
60
80
100
120
140
Temperature (℃)
● Example 6