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Berry et al.(10) **Pub. No.: US 2009/0088353 A1**(43) **Pub. Date: Apr. 2, 2009**(54) **LUBRICATING GREASE COMPOSITION
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508/545(57) **ABSTRACT**

A grease composition is prepared from an isomerized base oil having consecutive numbers of carbon atoms and less than 10 wt % naphthenic carbon by n-d-M and a kinematic viscosity at 100° C. equal to or greater than 10 mm²/s. The grease composition in one embodiment, exhibits improved service life, i.e., capable of performing for longer period of time of at least 50% at high temperatures/speeds and in an oxidizing environment as compared to greases containing Group II or POA base oils in the prior art.

LUBRICATING GREASE COMPOSITION AND PREPARATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit under 35 USC 119 of Provisional Application 60/975,728 filed Sep. 27, 2007. This application claims priority to and benefits from the foregoing, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The invention relates generally to lubricating grease compositions having improved service life.

BACKGROUND

[0003] Lubrication of moving parts with grease is necessary to for efficient motion of these parts. In embodiments such as wheel bearings, a necessary property of the lubricating grease is extended life, i.e., the grease must protect the bearings for long periods of time under severe conditions. One measure of this performance in wheel bearing applications is ASTM D3527-02 Life Performance test, which employs severe conditions of 25 lbs force (111N) thrust load, 1000 rpm, and 160° C. spindle temperature to induce grease deterioration and failure. The test is performed in a 20/4 hour on/off cycle until the grease breaks down, causing measured drive motor torque to increase past an established end point. The number of hours to failure is the test result.

[0004] Grease compositions in the prior art typically employ a Group I, II, III, a synthetic PAO (for poly α -olefin) or mixtures thereof as a base oil stock. The groups are broad categories of base stocks developed by the American Petroleum Institute (API) for the purpose of creating guidelines for base oils. Recent reforming processes have formed a new class of oil, e.g., Fischer Tropsch base oil (FTBO), wherein the oil, fraction, or feed originates from or is produced at some stage by a Fischer-Tropsch process. The feedstock for a Fischer-Tropsch process may come from a wide variety of hydrocarbonaceous resources, including biomass, natural gas, coal, shale oil, petroleum, municipal waste, derivatives of these, and combinations thereof Crude product prepared from the Fischer-Tropsch process comprises a mixture of various solid, liquid, and gaseous hydrocarbons, which can be refined into products such as diesel oil, naphtha, wax, and other liquid petroleum or specialty products. Fischer-Tropsch synthesis products can be obtained by known processes such as, for example, the commercial SASOL® Slurry Phase Fischer-Tropsch technology, the commercial SHELL® Middle Distillate Synthesis (SMDS) Process, or by the non-commercial EXXON® Advanced Gas Conversion (AGC-21) process. Details of these processes and others are described in, for example, WO-9934917, WO-9920720 and WO-05107935, EP-776959, EP-668342; U.S. Pat. Nos. 4,943,672, 5,059,299, 5,733,839, and RE39073; US Published Application No. 2005/0227866, US 2006/0289337, US2006/0201851, US2006/0016721, US2006/0016724, US2006/0076267, US2006/020185, US2006/013210, US2005/0241990, US2005/0077208, US2005/0139513, US2005/0139514, US2005/0133409, US2005/0133407, US2005/0261147, US2005/0261146, US2005/0261145, US2004/0159582, U.S. Pat. No. 7,018,525, U.S. Pat. No. 7,083,713, U.S. application Ser. Nos. 11/400,570, 11/535,165 and 11/613,936, which are incorporated herein by refer-

ence. The Fischer-Tropsch synthesis product usually comprises hydrocarbons having 1 to 100, or even more than 100 carbon atoms, and typically includes paraffins, olefins and oxygenated products.

[0005] EP1630221A1 discloses a grease composition comprising a base oil prepared from a Fischer-Tropsch product wherein the weight ratio of compounds having at least 60 or more carbon atoms and compounds having at least 30 carbon atoms is at least 0.2 in the Fischer-Tropsch product, and with at least 30% of the compounds having at least 30 carbon atoms, for the grease composition to have an enhanced exhibited oxidational stability while allowing more soap thickeners to be used. The Fischer-Tropsch base oil used in the grease of EP1630221A1 is produced from a process in which dewaxing is a separate step from hydroisomerizing.

[0006] There is a need for an improved lubricating grease composition employing hydrocarbon resources such as Fischer Tropsch base oils. In one embodiment, the invention relates to a grease composition having extended service life compared to the grease compositions of the prior art, the composition is made from Fischer-Tropsch base oils produced from processes having a combined hydroisomerization dewaxing step.

SUMMARY OF THE INVENTION

[0007] In one embodiment, there is provided a grease composition comprising (i) a lubricating base oil; (ii) from 2 to 50 wt % of a thickener selected from a simple soap, a complex soap, polyurea, diurea, triurea, fluorocarbon resin, and mixtures thereof; and (iii) 0-30 wt % of at least an additive selected from the group of preservatives, colorants, anti-weld agents, extreme pressure agents, flame retardants, rust inhibitors, corrosion inhibitors, oil bleed inhibitors, metal deactivators, viscosity modifiers, pour point depressants, and mixtures thereof; the lubricating base oil comprises at least 50 wt. % of a Fischer-Tropsch base oil having a total weight percent of molecules with cycloparaffinic functionality of greater than 10, and a ratio of weight percent molecules with monocycloparaffinic functionality to weight percent molecules with multicycloparaffinic functionality of greater than 15. In one embodiment, the Fischer-Tropsch base oil is a Fischer-Tropsch derived base oil. In a second embodiment, the Fischer-Tropsch base oil is a base oil made from a waxy feed.

[0008] In another embodiment, a method to make a grease composition is provided. The method comprises blending a composition comprising a lubricating base oil with: 2 to 50 wt % of a thickener selected from a simple soap, a complex soap, polyurea, diurea, triurea, fluorocarbon resin, and mixtures thereof; and 0-10 wt % of at least an additive selected from the group of preservatives, colorants, anti-weld agents, extreme pressure agents, flame retardants, rust inhibitors, corrosion inhibitors, oil bleed inhibitors, metal deactivators, viscosity modifiers, pour point depressants, and mixtures thereof; the lubricating base oil comprises at least 50 wt. % of a Fischer-Tropsch base oil having a total weight percent of molecules with cycloparaffinic functionality of greater than 10, and a ratio of weight percent molecules with monocycloparaffinic functionality to weight percent molecules with multicycloparaffinic functionality of greater than 15.

[0009] In a third embodiment, there is provided an article having components lubricated by composition comprising (i) a lubricating base oil; (ii) from 2 to 30 wt % of a thickener selected from a simple soap, a complex soap, polyurea, diurea, triurea, fluorocarbon resin, and mixtures thereof; and

(iii) 0-10 wt % of at least an additive selected from the group of preservatives, colorants, anti-weld agents, extreme pressure agents, flame retardants, rust inhibitors, corrosion inhibitors, oil bleed inhibitors, metal deactivators, viscosity modifiers, pour point depressants, and mixtures thereof; the lubricating base oil comprises at least 50 wt. % of a Fischer-Tropsch base oil having a total weight percent of molecules with cycloparaffinic functionality of greater than 10, and a ratio of weight percent molecules with monocycloparaffinic functionality to weight percent molecules with multicycloparaffinic functionality of greater than 15.

DETAILED DESCRIPTION

[0010] The following terms will be used throughout the specification and will have the following meanings unless otherwise indicated.

[0011] "Fischer-Tropsch derived" means that the product, fraction, or feed originates from or is produced at some stage by a Fischer-Tropsch process. As used herein, "Fischer-Tropsch base oil" may be used interchangeably with "FT base oil," "FTBO," "GTL base oil" (GTL: gas-to-liquid), or "Fischer-Tropsch derived base oil."

[0012] As used herein, "isomerized base oil" refers to a base oil made by isomerization of a waxy feed, which may be derived from a Fischer-Tropsch process or a mineral oil.

[0013] As used herein, a "waxy feed" comprises at least 40 wt % n-paraffins. In one embodiment, the waxy feed comprises greater than 50 wt % n-paraffins. In another embodiment, greater than 75 wt % n-paraffins. In one embodiment, the waxy feed also has very low levels of nitrogen and sulphur, e.g., less than 25 ppm total combined nitrogen and sulfur, or in other embodiments less than 20 ppm. Examples of waxy feeds include slack waxes, deoiled slack waxes, refined foots oils, waxy lubricant raffinates, n-paraffin waxes, NAO waxes, waxes produced in chemical plant processes, deoiled petroleum derived waxes, microcrystalline waxes, Fischer-Tropsch waxes, and mixtures thereof. In one embodiment, the waxy feeds have a pour point of greater than 50° C. In another embodiment, greater than 60° C.

[0014] "Kinematic viscosity" is a measurement in mm²/s of the resistance to flow of a fluid under gravity, determined by ASTM D445-06.

[0015] "Viscosity index" (VI) is an empirical, unit-less number indicating the effect of temperature change on the kinematic viscosity of the oil. The higher the VI of an oil, the lower its tendency to change viscosity with temperature. Viscosity index is measured according to ASTM D 2270-04.

[0016] Cold-cranking simulator apparent viscosity (CCS VIS) is a measurement in millipascal seconds, mPa.s to measure the viscometric properties of lubricating base oils under low temperature and high shear. CCS VIS is determined by ASTM D 5293-04.

[0017] The boiling range distribution of base oil, by wt %, is determined by simulated distillation (SIMDIS) according to ASTM D 6352-04, "Boiling Range Distribution of Petroleum Distillates in Boiling Range from 174 to 700° C. by Gas Chromatography."

[0018] "Noack volatility" is defined as the mass of oil, expressed in weight %, which is lost when the oil is heated at 250° C. with a constant flow of air drawn through it for 60 min., measured according to ASTM D5800-05, Procedure B.

[0019] Brookfield viscosity is used to determine the internal fluid-friction of a lubricant during cold temperature operation, which can be measured by ASTM D 2983-04.

[0020] "Pour point" is a measurement of the temperature at which a sample of base oil will begin to flow under certain carefully controlled conditions, which can be determined as described in ASTM D 5950-02.

[0021] "Auto ignition temperature" is the temperature at which a fluid will ignite spontaneously in contact with air, which can be determined according to ASTM 659-78.

[0022] "Ln" refers to natural logarithm with base "e."

[0023] "Traction coefficient" is an indicator of intrinsic lubricant properties, expressed as the dimensionless ratio of the friction force F and the normal force N, where friction is the mechanical force which resists movement or hinders movement between sliding or rolling surfaces. Traction coefficient can be measured with an MTM Traction Measurement System from PCS Instruments, Ltd., configured with a polished 19 mm diameter ball (SAE AISI 52100 steel) angled at 220 to a flat 46 mm diameter polished disk (SAE AISI 52100 steel). The steel ball and disk are independently measured at an average rolling speed of 3 meters per second, a slide to roll ratio of 40 percent, and a load of 20 Newtons. The roll ratio is defined as the difference in sliding speed between the ball and disk divided by the mean speed of the ball and disk, i.e. roll ratio = (Speed1 - Speed2) / ((Speed1 + Speed2) - 2).

[0024] As used herein, "consecutive numbers of carbon atoms" means that the base oil has a distribution of hydrocarbon molecules over a range of carbon numbers, with every number of carbon numbers in-between. For example, the base oil may have hydrocarbon molecules ranging from C22 to C36 or from C30 to C60 with every carbon number in-between. The hydrocarbon molecules of the base oil differ from each other by consecutive numbers of carbon atoms, as a consequence of the waxy feed also having consecutive numbers of carbon atoms. For example, in the Fischer-Tropsch hydrocarbon synthesis reaction, the source of carbon atoms is CO and the hydrocarbon molecules are built up one carbon atom at a time. Petroleum-derived waxy feeds have consecutive numbers of carbon atoms. In contrast to an oil based on poly-alpha-olefin ("PAO"), the molecules of an isomerized base oil have a more linear structure, comprising a relatively long backbone with short branches. The classic textbook description of a PAO is a star-shaped molecule, and in particular tridecane, which is illustrated as three decane molecules attached at a central point. While a star-shaped molecule is theoretical, nevertheless PAO molecules have fewer and longer branches than the hydrocarbon molecules that make up the isomerized base oil disclosed herein.

[0025] "Molecules with cycloparaffinic functionality" mean any molecule that is, or contains as one or more substituents, a monocyclic or a fused multicyclic saturated hydrocarbon group.

[0026] "Molecules with monocycloparaffinic functionality" mean any molecule that is a monocyclic saturated hydrocarbon group of three to seven ring carbons or any molecule that is substituted with a single monocyclic saturated hydrocarbon group of three to seven ring carbons.

[0027] "Molecules with multicycloparaffinic functionality" mean any molecule that is a fused multicyclic saturated hydrocarbon ring group of two or more fused rings, any molecule that is substituted with one or more fused multicyclic saturated hydrocarbon ring groups of two or more fused rings, or any molecule that is substituted with more than one monocyclic saturated hydrocarbon group of three to seven ring carbons.

[0028] Molecules with cycloparaffinic functionality, molecules with monocycloparaffinic functionality, and molecules with multicycloparaffinic functionality are reported as weight percent and are determined by a combination of Field Ionization Mass Spectroscopy (FIMS), HPLC-UV for aromatics, and Proton NMR for olefins, further fully described herein.

[0029] Oxidator BN measures the response of a lubricating oil in a simulated application. High values, or long times to adsorb one liter of oxygen, indicate good stability. Oxidator BN can be measured via a Dornite-type oxygen absorption apparatus (R. W. Dornite "Oxidation of White Oils," Industrial and Engineering Chemistry, Vol. 28, page 26, 1936), under 1 atmosphere of pure oxygen at 340° F., time to absorb 1000 ml of O₂ by 100 g. of oil is reported. In the Oxidator BN test, 0.8 ml of catalyst is used per 100 grams of oil. The catalyst is a mixture of soluble metal-naphthenates simulating the average metal analysis of used crankcase oil. The additive package is 80 millimoles of zinc bispolypolypropylenephenyldithiophosphate per 100 grams of oil.

[0030] Molecular characterizations can be performed by methods known in the art, including Field Ionization Mass Spectroscopy (FIMS) and n-d-M analysis (ASTM D 3238-95 (Re-approved 2005) with normalization). In FIMS, the base oil is characterized as alkanes and molecules with different numbers of unsaturations. The molecules with different numbers of unsaturations may be comprised of cycloparaffins, olefins, and aromatics. If aromatics are present in significant amount, they would be identified as 4-unsaturations. When olefins are present in significant amounts, they would be identified as 1-unsaturations. The total of the 1-unsaturations, 2-unsaturations, 3-unsaturations, 4-unsaturations, 5-unsaturations, and 6-unsaturations from the FIMS analysis, minus the wt % olefins by proton NMR, and minus the wt % aromatics by HPLC-UV is the total weight percent of molecules with cycloparaffinic functionality. If the aromatics content was not measured, it was assumed to be less than 0.1 wt % and not included in the calculation for total weight percent of molecules with cycloparaffinic functionality. The total weight percent of molecules with cycloparaffinic functionality is the sum of the weight percent of molecules with monocycloparaffinic functionality and the weight percent of molecules with multicycloparaffinic functionality.

[0031] Molecular weights are determined by ASTM D2503-92 (Reapproved 2002). The method uses thermoelectric measurement of vapour pressure (VPO). In circumstances where there is insufficient sample volume, an alternative method of ASTM D2502-94 may be used; and where this has been used it is indicated.

[0032] Density is determined by ASTM D4052-96 (Reapproved 2002). The sample is introduced into an oscillating sample tube and the change in oscillating frequency caused by the change in the mass of the tube is used in conjunction with calibration data to determine the density of the sample.

[0033] Weight percent olefins can be determined by proton-NMR according to the steps specified herein. In most tests, the olefins are conventional olefins, i.e. a distributed mixture of those olefin types having hydrogens attached to the double bond carbons such as: alpha, vinylidene, cis, trans, and trisubstituted, with a detectable allylic to olefin integral ratio between 1 and 2.5. When this ratio exceeds 3, it indicates a higher percentage of tri or tetra substituted olefins being present, thus other assumptions known in the analytical art can be made to calculate the number of double bonds in the

sample. The steps are as follows: A) Prepare a solution of 5-10% of the test hydrocarbon in deuteriochloroform. B) Acquire a normal proton spectrum of at least 12 ppm spectral width and accurately reference the chemical shift (ppm) axis, with the instrument having sufficient gain range to acquire a signal without overloading the receiver/ADC, e.g., when a 30 degree pulse is applied, the instrument having a minimum signal digitization dynamic range of 65,000. In one embodiment, the instrument has a dynamic range of at least 260,000. C) Measure the integral intensities between: 6.0-4.5 ppm (olefin); 2.2-1.9 ppm (allylic); and 1.9-0.5 ppm (saturate). D) Using the molecular weight of the test substance determined by ASTM D 2503-92 (Reapproved 2002), calculate: 1. The average molecular formula of the saturated hydrocarbons; 2. The average molecular formula of the olefins; 3. The total integral intensity(=sum of all integral intensities); 4. The integral intensity per sample hydrogen(=total integral/number of hydrogens in formula); 5. The number of olefin hydrogens(=olefin integral/integral per hydrogen); 6. The number of double bonds(=olefin hydrogen times hydrogens in olefin formula/2); and 7. The wt % olefins by proton NMR=100 times the number of double bonds times the number of hydrogens in a typical olefin molecule divided by the number of hydrogens in a typical test substance molecule. In this test, the wt % olefins by proton NMR calculation procedure, D, works particularly well when the percent olefins result is low, less than 15 wt %.

[0034] Weight percent aromatics in one embodiment can be measured by HPLC-UV. In one embodiment, the test is conducted using a Hewlett Packard 1050 Series Quaternary Gradient High Performance Liquid Chromatography (HPLC) system, coupled with a HP 1050 Diode-Array UV-Vis detector interfaced to an HP Chem-station. Identification of the individual aromatic classes in the highly saturated base oil can be made on the basis of the UV spectral pattern and the elution time. The amino column used for this analysis differentiates aromatic molecules largely on the basis of their ring-number (or double-bond number). Thus, the single ring aromatic containing molecules elute first, followed by the polycyclic aromatics in order of increasing double bond number per molecule. For aromatics with similar double bond character, those with only alkyl substitution on the ring elute sooner than those with naphthenic substitution. Unequivocal identification of the various base oil aromatic hydrocarbons from their UV absorbance spectra can be accomplished recognizing that their peak electronic transitions are all red-shifted relative to the pure model compound analogs to a degree dependent on the amount of alkyl and naphthenic substitution on the ring system. Quantification of the eluting aromatic compounds can be made by integrating chromatograms made from wavelengths optimized for each general class of compounds over the appropriate retention time window for that aromatic. Retention time window limits for each aromatic class can be determined by manually evaluating the individual absorbance spectra of eluting compounds at different times and assigning them to the appropriate aromatic class based on their qualitative similarity to model compound absorption spectra.

[0035] Weight percent aromatic carbon ("Ca"), weight percent naphthenic carbon ("Cn") and weight percent paraffinic carbon ("Cp") in one embodiment can be measured by ASTM D3238-95 (Reapproved 2005) with normalization. ASTM D3238-95 (Reapproved 2005) is the Standard Test Method for Calculation of Carbon Distribution and Structural Group

Analysis of Petroleum Oils by the n-d-M Method. This method is for "olefin free" feedstocks which are assumed in this application to mean that that olefin content is 2 wt % or less. The normalization process consists of the following: A) If the Ca value is less than zero, Ca is set to zero, and Cn and Cp are increased proportionally so that the sum is 100%. B) If the Cn value is less than zero, Cn is set to zero, and Ca and Cp are increased proportionally so that the sum is 100%; and C) If both Cn and Ca are less than zero, Cn and Ca are set to zero, and Cp is set to 100%.

[0036] HPLC-UV Calibration. In one embodiment, HPLC-UV can be used for identifying classes of aromatic compounds even at very low levels, e.g., multi-ring aromatics typically absorb 10 to 200 times more strongly than single-ring aromatics. Alkyl-substitution affects absorption by 20%. Integration limits for the co-eluting 1-ring and 2-ring aromatics at 272 nm can be made by the perpendicular drop method. Wavelength dependent response factors for each general aromatic class can be first determined by constructing Beer's Law plots from pure model compound mixtures based on the nearest spectral peak absorbances to the substituted aromatic analogs. Weight percent concentrations of aromatics can be calculated by assuming that the average molecular weight for each aromatic class was approximately equal to the average molecular weight for the whole base oil sample.

[0037] NMR analysis. In one embodiment, the weight percent of all molecules with at least one aromatic function in the purified mono-aromatic standard can be confirmed via long-duration carbon 13 NMR analysis. The NMR results can be translated from % aromatic carbon to % aromatic molecules (to be consistent with HPLC-UV and D 2007) knowing that 95-99% of the aromatics in highly saturated base oils are single-ring aromatics. In another test to accurately measure low levels of all molecules with at least one aromatic function by NMR, the standard D 5292-99 (Reapproved 2004) method can be modified to give a minimum carbon sensitivity of 500:1 (by ASTM standard practice E 386) with a 15-hour duration run on a 400-500 MHz NMR with a 10-12 mm Nalorac probe. Acorn PC integration software can be used to define the shape of the baseline and consistently integrate.

[0038] Extent of branching refers to the number of alkyl branches in hydrocarbons. Branching and branching position can be determined using carbon-13 (^{13}C) NMR according to the following nine-step process. 1) Identify the CH branch centers and the CH_3 branch termination points using the DEPT Pulse sequence (Doddrell, D. T.; D. T. Pegg; M. R. Bendall, *Journal of Magnetic Resonance* 1982, 48, 323ff.). 2) Verify the absence of carbons initiating multiple branches (quaternary carbons) using the APT pulse sequence (Patt, S. L.; J. N. Shoolery, *Journal of Magnetic Resonance* 1982, 46, 535ff.). 3) Assign the various branch carbon resonances to specific branch positions and lengths using tabulated and calculated values known in the art (Lindeman, L. P., *Journal of Qualitative Analytical Chemistry* 43, 1971 1245ff; Netzel, D. A., et.al., *Fuel*, 60, 1981, 307ff). 4) Estimate relative branching density at different carbon positions by comparing the integrated intensity of the specific carbon of the methyl/alkyl group to the intensity of a single carbon (which is equal to total integral/number of carbons per molecule in the mixture). For the 2-methyl branch, where both the terminal and the branch methyl occur at the same resonance position, the intensity is divided by two before estimating the branching density. If the 4-methyl branch fraction is calculated and tabulated, its contribution to the 4+methyls is subtracted to

avoid double counting. 5) Calculate the average carbon number. The average carbon number is determined by dividing the molecular weight of the sample by 14 (the formula weight of CH_2). 6) The number of branches per molecule is the sum of the branches found in step 4. 7) The number of alkyl branches per 100 carbon atoms is calculated from the number of branches per molecule (step 6) times 100/average carbon number. 8) Estimate Branching Index (BI) by ^1H NMR Analysis, which is presented as percentage of methyl hydrogen (chemical shift range 0.6-1.05 ppm) among total hydrogen as estimated by NMR in the liquid hydrocarbon composition. 9) Estimate Branching proximity (BP) by ^{13}C NMR, which is presented as percentage of recurring methylene carbons—which are four or more carbons away from the end group or a branch (represented by a NMR signal at 29.9 ppm) among total carbons as estimated by NMR in the liquid hydrocarbon composition. The measurements can be performed using any Fourier Transform NMR spectrometer, e.g., one having a magnet of 7.0 T or greater. After verification by Mass Spectrometry, UV or an NMR survey that aromatic carbons are absent, the spectral width for the ^{13}C NMR studies can be limited to the saturated carbon region, 0-80 ppm vs. TMS (tetramethylsilane). Solutions of 25-50 wt. % in chloroform- d_1 are excited by 30 degrees pulses followed by a 1.3 sec acquisition time. In order to minimize non-uniform intensity data, the broadband proton inverse-gated decoupling is used during a 6 sec delay prior to the excitation pulse and on during acquisition. Samples are doped with 0.03 to 0.05 M Cr (acac) $_3$ (tris (acetylacetonato)-chromium (III)) as a relaxation agent to ensure full intensities are observed. The DEPT and APT sequences can be carried out according to literature descriptions with minor deviations described in the Varian or Bruker operating manuals. DEPT is Distortionless Enhancement by Polarization Transfer. The DEPT 45 sequence gives a signal all carbons bonded to protons. DEPT 90 shows CH carbons only. DEPT 135 shows CH and CH_3 up and CH_2 180 degrees out of phase (down). APT is attached proton test, known in the art. It allows all carbons to be seen, but if CH and CH_3 are up, then quaternaries and CH_2 are down. The branching properties of the sample can be determined by ^{13}C NMR using the assumption in the calculations that the entire sample was iso-paraffinic. The unsaturates content may be measured using Field Ionization Mass Spectroscopy (FIMS).

[0039] In one embodiment, the grease composition comprises a number of components, including optional additives, in a matrix of base oil.

[0040] Base Oil Matrix Component: In one embodiment, the base oil or blends thereof comprises at least an isomerized base oil which the product itself, its fraction, or feed originates from or is produced at some stage by isomerization of a waxy feed from a Fischer-Tropsch process ("Fischer-Tropsch derived base oils"). In another embodiment, the base oil comprises at least an isomerized base oil made from a substantially paraffinic wax feed ("waxy feed"). In a third embodiment, the base oil consists essentially of at least an isomerized base oil.

[0041] Fischer-Tropsch derived base oils are disclosed in a number of patent publications, including for example U.S. Pat. Nos. 6,080,301, 6,090,989, and 6,165,949, and US Patent Publication No. US2004/0079678A1, US20050133409, US20060289337. Fischer-Tropsch process is a catalyzed chemical reaction in which carbon monoxide and hydrogen are converted into liquid hydrocarbons of various forms

including a light reaction product and a waxy reaction product, with both being substantially paraffinic.

[0042] In one embodiment the isomerized base oil has consecutive numbers of carbon atoms and has less than 10 wt % naphthenic carbon by n-d-M. By “consecutive numbers of carbon atoms” we mean that the hydrocarbon molecules of the base oil differ from each other by consecutive numbers of carbon atoms, as a consequence of the waxy feed also having sequential numbers of carbon atoms. For example, in the Fischer-Tropsch hydrocarbon synthesis reaction the source of carbon atoms is CO and the hydrocarbon molecules are built up one carbon atom at a time. Petroleum-derived waxy feeds also have sequential numbers of carbon numbers. In contrast to an oil based on PAO, the molecules of the base oil have a more linear structure, comprising a relatively long backbone with short branches. The classic textbook description of a PAO is a star-shaped molecule, and in particular tridecane, which is illustrated as three decane molecules attached at a central point. While a star-shaped molecules is theoretical, nevertheless PAO molecules have fewer and longer branches than the hydrocarbon molecules that make up the base oil used in this disclosure.

[0043] In one embodiment the isomerized base oil has consecutive numbers of carbon atoms and has less than 25 wt % naphthenic carbon by n-d-M with normalization. In another embodiment, the amount of naphthenic carbon is less than 10 wt. %. In yet another embodiment the isomerized base oil made from a waxy feed has a kinematic viscosity at 100° C. between 1.5 and 3.5 mm²/s.

[0044] In one embodiment, the isomerized base oil is made by a process in which the hydroisomerization dewaxing is at conditions sufficient for the base oil to have: a) a wt. % of all molecules with at least one aromatic function less than 0.30; b) a wt. % of all molecules with at least one cycloparaffin function greater than 10; c) a ratio of wt. % of molecules containing monocycloparaffins to wt. % of molecules containing multicycloparaffins greater than 20; and d) a viscosity index greater than $28 \times \ln(\text{Kinematic viscosity at } 100^\circ \text{ C.}) + 80$.

[0045] In another embodiment, the isomerized base oil is made from a process in which the highly paraffinic wax is hydroisomerized using a shape selective intermediate pore size molecular sieve comprising a noble metal hydrogenation component, and under conditions of 600° F. to 750° F. In the process, the conditions for hydroisomerization are controlled such that the conversion of the compounds boiling above 700° F. in the wax feed to compounds boiling below 700° F. is maintained between 10 wt % and 50 wt %. The resulting FT base oil has a kinematic viscosity of between 1.0 and 3.5 mm²/s at 100° C. and a Noack volatility of less than 50 wt. %. The base oil comprises greater than 3 wt. % molecules with cycloparaffinic functionality and less than 0.30 weight percent aromatics. In one embodiment, the FT base oil has a Noack volatility less than the Noack volatility calculated by the following equation: $160 - 40(\text{Kinematic Viscosity at } 100^\circ \text{ C.})$.

[0046] In one embodiment, the isomerized base oil is made from a process in which the highly paraffinic wax is hydroisomerized under conditions for the base oil to have a kinematic viscosity at 100° C. of 3.6 to 4.2 mm²/s, a viscosity index of greater than 130, a wt % Noack volatility less than 12, a pour point of less than -9° C. In another embodiment, the base oil comprises greater than 10 wt. % and less than 70 wt. % total molecules with cycloparaffinic functionality, and

a ratio of wt. % molecules with monocycloparaffinic functionality to wt. % molecules with multicycloparaffinic functionality greater than 15.

[0047] In one embodiment the isomerized base oil has a Noack volatility less than an amount calculated by the following equation: $1000 \times (\text{Kinematic Viscosity at } 100^\circ \text{ C.})^{-2.7}$. In another embodiment, the isomerized base oil has a Noack volatility less than an amount calculated by the following equation: $900 \times (\text{Kinematic Viscosity at } 100^\circ \text{ C.})^{-2.8}$. In a third embodiment, the isomerized base oil has a Kinematic Viscosity at 100° C. of >1.808 mm²/s and a Noack volatility less than an amount calculated by the following equation: $1.286 + 20(\text{kv}100)^{-1.5} + 551.8 e^{-\text{kv}100}$, where kv100 is the kinematic viscosity at 100° C. In a fourth embodiment, the isomerized base oil has a kinematic viscosity at 100° C. of less than 4.0 mm²/s, and a wt % Noack volatility between 0 and 100. In a fifth embodiment, the isomerized base oil has a kinematic viscosity between 1.5 and 4.0 mm²/s and a Noack volatility less than the Noack volatility calculated by the following equation: $160 - 40(\text{Kinematic Viscosity at } 100^\circ \text{ C.})$.

[0048] In one embodiment, the isomerized base oil has a kinematic viscosity at 100° C. in the range of 2.4 and 3.8 mm²/s and a Noack volatility less than an amount defined by the equation: $900 \times (\text{Kinematic Viscosity at } 100^\circ \text{ C.})^{-2.8} - 15$. For kinematic viscosities in the range of 2.4 and 3.8 mm²/s, the equation: $900 \times (\text{Kinematic Viscosity at } 100^\circ \text{ C.})^{-2.8} - 15$ provides a lower Noack volatility than the equation: $160 - 40(\text{Kinematic Viscosity at } 100^\circ \text{ C.})$.

[0049] In one embodiment, the isomerized base oil is made from a process in which the highly paraffinic wax is hydroisomerized under conditions for the base oil to have a kinematic viscosity at 100° C. of 3.6 to 4.2 mm²/s, a viscosity index of greater than 130, a wt % Noack volatility less than 12, a pour point of less than -9° C.

[0050] In one embodiment, the isomerized base oil has an aniline point, in degrees F, greater than 200 and less than or equal to an amount defined by the equation: $36 \times \ln(\text{Kinematic Viscosity at } 100^\circ \text{ C., in mm}^2/\text{s}) + 200$.

[0051] In one embodiment, the isomerized base oil has an auto-ignition temperature (AIT) greater than the AIT defined by the equation: $\text{AIT in } ^\circ \text{C.} = 1.6 \times (\text{Kinematic Viscosity at } 40^\circ \text{ C., in mm}^2/\text{s}) + 300$. In a second embodiment, the base oil as an AIT of greater than 329° C. and a viscosity index greater than $28 \times \ln(\text{Kinematic Viscosity at } 100^\circ \text{ C., in mm}^2/\text{s}) + 100$.

[0052] In yet another embodiment, the isomerized base oil has a relatively low traction coefficient, specifically, its traction coefficient is less than an amount calculated by the equation: $\text{traction coefficient} = 0.009 \times \ln(\text{kinematic viscosity in mm}^2/\text{s}) - 0.001$, wherein the kinematic viscosity in the equation is the kinematic viscosity during the traction coefficient measurement and is between 2 and 50 mm²/s. In one embodiment, the isomerized base oil has a traction coefficient of less than 0.023 when measured at a kinematic viscosity of 15 mm²/s and at a slide to roll ratio of 40%. In another embodiment the isomerized base oil has a traction coefficient of less than 0.017 when measured at a kinematic viscosity of 15 mm²/s and at a slide to roll ratio of 40%. In another embodiment the isomerized base oil has a viscosity index greater than 150 and a traction coefficient less than 0.015 when measured at a kinematic viscosity of 15 mm²/s and at a slide to roll ratio of 40%.

[0053] In some embodiments, the isomerized base oil having low traction coefficients also display a higher kinematic viscosity and higher boiling points. In one embodiment, the

base oil has a traction coefficient less than 0.015, and a 50 wt % boiling point greater than 565° C. (1050° F.). In another embodiment, the base oil has a traction coefficient less than 0.011 and a 50 wt % boiling point by ASTM D 6352-04 greater than 582° C. (1080° F.).

[0054] In some embodiments, the isomerized base oil having low traction coefficients also display unique branching properties by NMR, including a branching index less than or equal to 23.4, a branching proximity greater than or equal to 22.0, and a Free Carbon Index between 9 and 30. In one embodiment, the base oil has at least 4 wt % naphthenic carbon, in another embodiment, at least 5 wt % naphthenic carbon by n-d-M analysis by ASTM D 3238-95 (Reapproved 2005) with normalization.

[0055] In one embodiment, the isomerized base oil is produced in a process wherein the intermediate oil isomerate comprises paraffinic hydrocarbon components, and in which the extent of branching is less than 7 alkyl branches per 100 carbons, and wherein the base oil comprises paraffinic hydrocarbon components in which the extent of branching is less than 8 alkyl branches per 100 carbons and less than 20 wt % of the alkyl branches are at the 2 position. In one embodiment, the FT base oil has a pour point of less than -8° C.; a kinematic viscosity at 100° C. of at least 3.2 mm²/s; and a Viscosity Index greater than a viscosity index calculated by the equation of $=22 \times \ln(\text{Kinematic Viscosity at } 100^\circ \text{ C.}) + 132$.

[0056] In one embodiment, the isomerized base oil has an average molecular weight between 600 and 1100, and an average degree of branching in the molecules between 6.5 and 10 alkyl branches per 100 carbon atoms.

[0057] In one embodiment, the isomerized base oil is obtained from a process in which the highly paraffinic wax is hydroisomerized at a hydrogen to feed ratio from 712.4 to 3562 liter H₂/liter oil, for the base oil to have a total weight percent (wt. %) of molecules with cycloparaffinic functionality of greater than 10, and a ratio of wt. % molecules with monocycloparaffinic functionality to wt. % molecules with multicycloparaffinic functionality of greater than 15. In another embodiment, the base oil has a viscosity index greater than an amount defined by the equation: $28 \times \ln(\text{Kinematic viscosity at } 100^\circ \text{ C.}) + 95$. In a third embodiment, the base oil comprises a wt. % aromatics less than 0.30; a wt. % of molecules with cycloparaffinic functionality greater than 10; a ratio of wt. % of molecules with monocycloparaffinic functionality to wt. % of molecules with multicycloparaffinic functionality greater than 20; and a viscosity index greater than $28 \times \ln(\text{Kinematic Viscosity at } 100^\circ \text{ C.}) + 110$. In a fourth embodiment, the base oil further has a kinematic viscosity at 100° C. greater than 6 mm²/s. In a fifth embodiment, the base oil has a wt. % aromatics less than 0.05 and a viscosity index greater than $28 \times \ln(\text{Kinematic Viscosity at } 100^\circ \text{ C.}) + 95$. In a sixth embodiment, the base oil has a wt. % aromatics less than 0.30, a wt. % molecules with cycloparaffinic functionality greater than the kinematic viscosity at 100° C., in mm²/s, multiplied by three, and a ratio of molecules with monocycloparaffinic functionality to molecules with multicycloparaffinic functionality greater than 15.

[0058] In yet another embodiment, the isomerized base oil contains between 2-10% naphthenic carbon as measured by n-d-M, with the lower viscosity base oil generally having a lower naphthenic carbon distribution. In one embodiment, the base oil has a kinematic viscosity of 1.5-3.0 mm²/s at 100° C. and 2-3% naphthenic carbon. In another embodiment, a kinematic viscosity of 1.8-3.5 mm²/s at 100° C. and 2.5-4% naph-

thenic carbon. In a third embodiment, a kinematic viscosity of 3-6 mm²/s at 100° C. and 2.7-5% naphthenic carbon. In a fourth embodiment, a kinematic viscosity of 10-30 mm²/s at 100° C. and greater than 5.2% naphthenic carbon.

[0059] In one embodiment, the isomerized base oil has an average molecular weight greater than 475; a viscosity index greater than 140, and a wt. % olefins less than 10. The base oil improves the air release and low foaming characteristics of the mixture when incorporated into the power transmission fluid composition.

[0060] In one embodiment, the isomerized base oil is a white oil as disclosed in U.S. Pat. No. 7,214,307 and US Patent Publication US20060016724, having a kinematic viscosity at 100° C. between about 1.5-36 mm²/s, a viscosity index greater than an amount calculated by the equation: $\text{Viscosity Index} = 28 \times \ln(\text{the Kinematic Viscosity at } 100^\circ \text{ C.}) + 105$, less than 18 wt. % molecules with cycloparaffinic functionality, a pour point less than 0° C., and a Saybolt color by ASTM D 156-02 of +20 or greater. In another embodiment, the isomerized base oil has between 5-18 wt. % molecules with cycloparaffinic functionality, less than 1.2 wt. % molecules with multicycloparaffinic functionality, a pour point less than 0° C., and a Saybolt color of +20 or greater. In yet a third embodiment, the isomerized base oil has less than 1.2 wt. % molecules with multicycloparaffin functionality.

[0061] In one embodiment, the isomerized base oil is produced from a process wherein the waxy feed is hydroisomerization dewaxed over a highly selective and active wax hydroisomerization catalyst which has: 1) a 1-D 10-ring molecular sieve having channels with a minimum crystallographic free diameter of not less than 3.9 Angstrom and a maximum crystallographic free diameter of not more than 6.0 Angstrom, and no channels with a maximum crystallographic free diameter greater than 6.0 Angstrom; 2) a noble metal hydrogenation component; and 3) a refractory oxide support. Additionally, the waxy feed has: 1) a T90 boiling point greater than 490° C.; 2) greater than 40 wt. % n-paraffins; and 3) less than 25 ppm total combined nitrogen and sulphur.

[0062] In one embodiment, the isomerized base oil has at least one of the following properties: a kinematic viscosity at 100° C. between 10 mm²/s and 20 mm²/s; a kinematic viscosity at 40° C. between 50 mm²/s and 120 mm²/s; a viscosity index between 140 and 170; cold cranking simulator viscosity in the range of 10,000-20,000 at -25° C., greater than 5,000 at -20° C., greater than 3,000 at -15° C., and greater than 1,500 at -10° C.; a spread between pour point and cloud point of greater than 20; cloud point of greater than 5° C.; molecular weight of 600-800; density in the range of 0.825 to 0.830; refractive index of 1.450 to 1.650; paraffinic carbon in the range of 90-95%; naphthenic carbon in the range of 5-10%; oxidator BN of 30 to 50 hours; bromine index of 10 to 25; surface tension of 25-40 dynes/cm; TGA Noack in wt. % of 0.70 to 14 as measured by ASTM D5800-05 Procedure B; and a ratio of wt. % molecules with monocycloparaffinic functionality to wt. % molecules with multicycloparaffinic functionality in the range of 2 to 25. In another embodiment, the isomerized base oil has an oxidator BN of 30 to 70 hours.

[0063] In one embodiment, the grease composition employs a base oil that consists of at least one of the isomerized base oils described above. In another embodiment, the composition consists essentially of at least a Fischer-Tropsch base oil. In yet another embodiment, the composition employs at least a Fischer-Tropsch base oil and optionally 5 to 95 wt. % of at least another type of oil, e.g., lubricant base oils

selected from Group I, II, III, IV, and V lubricant base oils as defined in the API Interchange Guidelines, and mixtures thereof. Examples include conventionally used mineral oils, synthetic hydrocarbon oils or synthetic ester oils, or mixtures thereof depending on the application. Mineral lubricating oil base stocks can be any conventionally refined base stocks derived from paraffinic, naphthenic and mixed base crudes. Synthetic lubricating oils that can be used include esters of glycols and complex esters. Other synthetic oils that can be used include synthetic hydrocarbons such as polyalphaolefins; alkyl benzenes, e.g., alkylate bottoms from the alkylation of benzene with tetrapropylene, or the copolymers of ethylene and propylene; silicone oils, e.g., ethyl phenyl polysiloxanes, methyl polysiloxanes, etc., polyglycol oils, e.g., those obtained by condensing butyl alcohol with propylene oxide; etc. Other suitable synthetic oils include the polyphenyl ethers, e.g., those having from 3 to 7 ether linkages and 4 to 8 phenyl groups. Other suitable synthetic oils include polyisobutenes, and alkylated aromatics such as alkylated naphthalenes.

[0064] Additional Components: In one embodiment, the grease composition further comprises at least a thickener component selected from the group including but not limited to lithium soaps (simple or complex), aluminum soaps (simple or complex), calcium soaps (simple or complex), sodium soaps (simple or complex), barium soaps (simple or complex), polyureas and polyurea complexes, triureas, diureas, fluorocarbon resin powder, graphite, silica, fumed silica, hydrocarbon nanotubes, asphaltics, and combinations thereof, in an amount ranging from 2 to 30 wt. % of the total weight of the grease composition. In one embodiment, the thickener is an alkyldiurea compound having an average molecular weight in the range of from 600 to 700, wherein in the range of from 25 to 60 mole % of the total alkyl groups is an unsaturated component, and the total amine value of the primary amine constituting the raw material is in the range of from 250 to 350.

[0065] In one embodiment, the thickener is a perfluorocarbon resins selected from the group of polytetrafluoroethylene (PTFE), tetrafluoroethylene-perfluoroalkylvinyl ether copolymer (PEA), tetrafluoroethylene-hexafluoropropylene copolymer (FEP) and combinations thereof. In one example, the thickener is polytetrafluoroethylene (PTFE) due to its excellent stability at high temperatures and resistance to chemicals.

[0066] In one embodiment, the thickener is a lithium complex soap containing at least two lithium components. Examples include a lithium soap of at least one, hydroxy fatty acid, e.g., C12 to C29. In another embodiment, the lithium component is selected from a lithium compound of (i) a C2 to C12 aliphatic or cycloaliphatic dicarboxylic acid (or C1 to C10, e.g., C1 to C4, alkyl ester thereof); or (ii) of a C3 to C24 hydroxy carboxylic acid (or C1 to C10, such as C1 to C4, alkyl ester thereof) which has the hydroxy group separated from the carboxyl group by six or less carbon atoms; or a mixture thereof. In yet another embodiment, the lithium component is a lithium salt of boric acid. In one embodiment, the amount of lithium complex thickeners ranges from 5 to 20 wt. % of the total grease composition.

[0067] In one embodiment, the thickener is a complex basic aluminum soap. By "complex basic aluminum soaps" is meant that the aluminum soap molecule contains at least one hydroxy anion for each aluminum cation, and at least two dissimilar anions substantially hydrocarbonaceous in charac-

ter. By "substantially hydrocarbonaceous anions" is meant those anions which are composed mainly of hydrogen and carbon, and include such anions which contain, in addition, minor amounts of substituents such as oxygen, nitrogen, etc. Examples of thickeners for use in the grease composition include aluminum laurate, aluminum soap oleate, aluminum stearate, aluminum benzoate stearate, aluminum benzoate oleate, aluminum benzoate 12-hydroxy stearate, aluminum toluate stearate, aluminum benzoate naphthenate, aluminum benzoate hydrogenated rosin, aluminum benzoate sulfonate, aluminum azelate stearate, aluminum phosphate benzoate stearate, aluminum benzoate hydroxy stearate, etc. For additional information on aluminum complex greases, see H. W. Kruschwitz, "The Development of Formulations for Aluminum Complex Thickener Systems," pp. 51-59, NLGI Spokesman (May 1976), the disclosure of which is incorporated herein by reference.

[0068] In one embodiment, the thickener is a mixture a ≥ 80 wt. % diureas and 0.10 to 20 wt. % polyureas, wherein the diureas and polyureas are formed by reaction of (a) an alkylamine or alkenylamine; (b) an alkylenediamine, polyoxyalkylenediamine, or cycloalkylenediamine; (c) a cycloalkylamine; and (d) an aryl-containing-diisocyanate or alkyl-diisocyanate. In another embodiment, the thickener is a mixture of diureas and polyureas, and wherein the diureas and polyureas are formed by the reaction of oleylamine, ethylenediamine, cyclohexylamine, and toluene diisocyanate.

[0069] In one embodiment, the thickener is a mixture comprising as the thickener constituents, (a) one or more urea-type compounds; (b) one or more fatty acid metal salts; and (c) at least one type of amide compound selected from the group comprised of aliphatic amides and aliphatic bisamides shown by the general formulae (1) and (2) $R_1CONHR_2NHCOR_1$ (2), wherein R_1 denotes a saturated or unsaturated alkyl group having from 15 to 17 carbon atoms and R_2 denotes a methylene group or an ethylene group.

[0070] In one embodiment, the grease composition further comprises at least an antioxidant in the range of 0.1 to 10 wt. %. In one embodiment, from 0.3 to 3.5 wt. % of at least an antioxidant. In a third embodiment, from 0.5 to 2 wt. % antioxidant. Examples of antioxidants include at least an organic compound containing nitrogen and mixtures thereof, such as organic amines, sulfides, hydroxy sulfides, phenols, etc., alone or in combination with metals like zinc, tin, or barium, etc. Examples include phenyl-alpha-naphthyl amine and derivatives, bis(alkylphenyl)amine, N,N diphenyl-p-phenylenediamine, 2,2,4 trimethyldihydroquinoline oligomer, bis(4 isopropylaminophenyl)-ether, N-acyl-p-aminophenol, N-acylphenothiazines, N of ethylenediamine tetraacetic acid, alkylphenol-formaldehyde-amine polycondensates, and alkylated diphenyl amines where the alkyl group(s) contain (s) from 1 to 12 carbon atoms; unsubstituted phenothiazine; substituted and unsubstituted quinolines where the substituents are alkyl groups of 1 to 10 carbon atoms; and mixtures thereof.

[0071] In another embodiment, the grease composition further comprises a polyhydroxylated compound to improve the low shear stability of the grease. In one embodiment, the polyhydroxylated compound is a polyhydroxylated ester. In another embodiment, the polyhydroxylated compound is pentaerythritol monooleate. As known in the art, the improvement in low shear stability is demonstrated by a lower percent softening measured using the Shell Roll Test (ASTM D1831-

00 (Reapproved 2006)). In one embodiment, the grease composition softens less than 10% in the Shell Roll Test.

[0072] In yet another embodiment, the grease composition further comprises preservatives including but not limited to fungicides and antibacterial agents; colorants; shear stability additives; anti-wear/anti-weld and/or extreme-pressure agents including but not limited to carbamates, esters, molybdenum complexes, alkali-metal borates, antimony dithiocarbamates having 1 to 50 carbon in the alkyl group, dihydrocarbyl polysulfide, phosphorus compounds, boron compounds, zinc dialky-1-dithiophosphate (primary alkyl, secondary alkyl, and aryl type), diphenyl sulfide, methyl trichlorostearate, chlorinated naphthalene, fluoroalkylpolysiloxane, lead naphthenate, neutralized phosphates, dithiophosphates, sulfur-free phosphates, and mixtures thereof; flame retardants such as calcium oxide; oiliness agents; ferrous/rust inhibitors such as polyoxyethylene lauryl ether, polyoxyethylene higher alcohol ether, polyoxyethylene nonyl phenyl ether, polyoxyethylene octyl phenyl ether, polyoxyethylene octyl stearyl ether, polyoxyethylene oleyl ether, polyoxyethylene sorbitol monostearate, polyoxyethylene sorbitol mono-oleate, stearic acid and other fatty acids, dicarboxylic acids, metal soaps, fatty acid amine salts, metal salts of heavy sulfonic acid, partial carboxylic acid ester of polyhydric alcohol, phosphoric ester, polyethylene glycol mono-oleate, borated esters, amines, ethers, alcohols metal sulfonate salts, alkyl and aryl succinic acids, alkyl and aryl succinate esters, amides, and other related derivatives; corrosion inhibitors such as alkali metal nitrite, e.g. sodium nitrite; oil bleed inhibitors such as polybutne; foam inhibitors such as alkyl methacrylate polymers and dimethyl silicone polymers; metal deactivators such as disalicylidene propylenediamine, triazole derivatives, thiadiazole derivatives, mercaptobenzimidazoles; complex organic nitrogen, and amines; friction modifiers; thermal conductive additives; electroconductive agents; elastomeric compatibilizers; viscosity modifiers such as polymethacrylate type polymers, ethylene-propylene copolymers, styrene-isoprene copolymers, hydrated styrene-isoprene copolymers, polyisobutylene, and dispersant type viscosity modifiers; pour point depressants such as polymethyl methacrylate; multifunctional additives such as sulfurized oxymolybdenum dithiocarbamate, sulfurized oxymolybdenum organo phosphorodithioate, oxymolybdenum monoglyceride, oxymolybdenum diethylate amide, amine-molybdenum complex compound, and sulfur-containing molybdenum complex compound; and the like, can be added to the grease composition, in an amount sufficient to provide the desired effects. In one embodiment, the rust inhibitor comprises a metallic salt of a polybasic acid, a polyvalent alcohol in which a part of a hydroxyl group is blocked, and at least one compound selected from an organic sulfonate and a fatty.

[0073] In one embodiment, the grease composition comprises greater than 4.0 wt % of calcium oxide having a LOI value of less than 3.0. LOI is "Loss on Ignition" parameter measured according to ASTM C25-06. LOI is used to measure the loss of flame retardant activity due to recarbonation.

[0074] In another embodiment and further to order to attain extreme pressure properties, anti-wear qualities, and/or friction reduction properties, as well as any elastomeric compatibility which may be required, the grease composition further comprises from 0.1 to 15 wt. % an nano-particle additive or mixture thereof. In one embodiment, the nano-particle additive is selected from the group of: a carbonate of a Group 1a

alkali metal; a carbonate of a Group 2a alkaline earth metal, a sulfate of a Group 1a alkali metal or a Group 2a alkaline earth metal; a phosphate of a Group 1a alkali metal or Group 2a alkaline earth metal; a carboxylate of a Group 1a alkali metal; a carbonate of a Group 2a alkaline earth metal, or mixtures thereof, having an average particle size of less than 100 nanometers.

[0075] In yet another embodiment, the grease composition further comprises 0.1 to 7 wt. % of at least one of an oil-soluble organic molybdenum complex, an oil-soluble organic zinc compound of dithiocarbamic acid, an oil-soluble organic zinc compound of dithiophosphoric acid, an inorganic sulphur compound, and mixtures thereof. In a second embodiment, the grease composition further comprises 0.1 to 10 wt. % of at least one or more metal salts of a fatty acid wherein the metal is selected from the group consisting of aluminum, magnesium, zinc, calcium and mixtures thereof. In a third embodiment, the grease composition further comprises at least an oil-soluble amine salt of a phosphorus compound, e.g., phosphate and/or monthiophosphate. In one example, the grease composition further comprises 0.25 to 10 wt. % of at least one of dibutylthiophosphate and dibutylphosphate salts, such as an oleylamine salt of a mixture of dibutylthiophosphate and dibutylphosphate. In a fourth embodiment, the grease composition further comprises 0.25 to 10 wt. % of an olefin or a sulfurized olefin, e.g., polybutene or sulfurized polybutene.

[0076] In one embodiment, the grease composition further comprises an inorganic filler selected from the group consisting of metal oxides, metal nitrides, metal carbides, clay minerals, diamond, and mixtures thereof. In one embodiment, the inorganic filler has an average particle size of less than 2 μ m.

[0077] In one embodiment for use as a thermally conductive grease, the grease composition further comprises at least a thermally conductive additive in an amount of is 0.1-10 wt. %. Examples include but are not limited to aluminum nitride, silica, alumina, metal silicon, boron nitride, zinc oxide, and mixtures thereof. In a second embodiment, the thermally conductive grease further comprises an electroconductive filler, e.g., graphite, carbon black, carbon nanotubes, metal powder, and mixtures thereof, in an amount of 0.1-10 wt. %.

[0078] In one embodiment wherein the grease composition is employed in a solid stick grease form, i.e., by admixing the grease composition within a resin with the resin comprising 20 to 80 by weight of the total weight of the stick grease. In one embodiment, the resin is a thermosetting plasticizer selected from the group consisting of branched phthalate, linear phthalate, branched adipate, mixed dibasic acid polyester, trimellitate, polyester glutarate, polyester adipate, citrate, polymeric plasticizer, sebacates, adipic acid polyesters, dioctyl adipate, a soybean-based plasticizer, and combinations thereof. In another embodiment, the resin is selected from the group of ultra molecular polyolefin powder having a mean molecular weight of 1×10^6 to 5×10^6 . In yet another embodiment, the resin comprises 5-95 wt. % of at least one of a polyamide and a polyacetal for the solid stick grease to have excellent heat resistance properties.

[0079] Method for Making: In one embodiment, the grease composition is prepared by mixing the base oil matrix with the thickener and/or components of thickeners, optional components and/or additives in a vessel, such as a grease making kettle, an-inline mixing chamber, or a contactor kettle. The mixture is then agitated with heating from 25° C. to 250° C. depending on the thickener(s) used. In yet another embodi-

ment and after mixing, the mixture of the base oil, thickener, and optional components/additives is sheared for a time sufficient to reduce substantially all of the thickener particles to below 500 microns in size. Any suitable shearing device may be employed such as static mixers, mechanical systems having counter rotating paddles, gaulin homogenizers, Charlotte mills, Morehouse mills, cone and stator mills, roll mills and the like. Shearing can be done at whatever temperature the mixture has been heated to. In one embodiment, the shearing is at a temperature of less than 65° C.

[0080] After mixing and/or optional shearing, the base oil/thickener mixture is further processed to form a grease. In one embodiment, the mixture is heated to a temperature of 125 to 175° C., then subsequently milled to form a homogeneous grease. In one embodiment, milling is conducted at temperatures ranging from 10° C. to 175° C. In a yet another embodiment, additional standard grease manufacturing procedures such as filtering and de-airating the grease may be employed.

[0081] Properties: The grease composition in one embodiment is characterized as having low noise characteristics. In one embodiment, the grease with low noise characteristics exhibits a peak average value of less than 15 microns/second when tested using a modified bearing vibration level tester (an anderometer) to test for grease noise, i.e., using a BeQuiet grease noise tester manufactured by the SKF Group of Sweden. Other grease noise testers can also be used, including but not limited to GRW noise testing instruments from GRW Gebr. Reinfurt GmbH & Co KG and the FAG-series instruments from the Schaeffler Group. In another embodiment, a grease composition comprising at least 90 wt. % FTBO oil having a kinematic viscosity at 100° C. of 8 mm²/s exhibits a peak average value of less than 12 microns/second when tested using BeQuiet grease noise tester. In yet another embodiment, the grease composition exhibits a value of less than 10 microns/second.

[0082] The grease composition also displays a high resistance to high temperature and operates effectively in oxidative or chemically aggressive environments. In one embodiment and when measured using pressure differential scanning calorimetry (PDSC) under oxygen at 20 MPa, the grease shows a flat thermogram and stability up to 250° C. In another embodiment, the composition shows stability up to 300° C. PDSC can be measured using either ASTM D5483-05 or ASTM D6186-98 (R 2003).

[0083] In one embodiment, the grease exhibits low shear rate and excellent heat resistance. Shear stability is the ability of a grease to resist a change in consistency during mechanical working. Under high rates of shear, grease structures tend to change in consistency. Greases with poor low shear stability will quickly break down, resulting in a thinning of the grease. A grease with good low shear stability, therefore, will not soften excessively under prolonged low shear stress. A large difference between the prolonged worked penetration (Full Scale, P100,000 by ASTM D217-02) and the worked penetration (½ Scale, P60 by ASTM D1403-02) of a grease indicates poor low shear stability. In one embodiment, the grease composition displays less than 15% difference between prolonged worked penetration and worked penetration. In a second embodiment, the difference is less than 10%. In a third embodiment, of less than 5%.

[0084] The heat resistance of a grease is often measured by its Dropping Point, such that good heat resistance is associated with a high Dropping point. The Dropping Point test is described in ASTM D2265-06. In one embodiment, the

grease composition has a Dropping Point of at least 215° C. In a second embodiment, the Dropping Point is at least 220° C. In a third embodiment, at least 240° C.

[0085] In one embodiment, the grease composition further exhibits excellent low temperature properties as characterized by a maximum torque of 6.74 N-m (as measured using ASTM D4693-03 at 3 min). In yet another embodiment, the grease composition has a maximum torque of 10 N-m at -40° C. In a third embodiment, the grease composition displays a maximum torque of 12 N-m at -40° C.

[0086] In one embodiment, the grease composition exhibits excellent bearing life, i.e., capable of performing for longer period of time of at least 50% at high temperatures/speeds and in an oxidizing environment as compared to greases containing Group II or PAO base oils in the prior art. In one embodiment simulating the high temperature stability of the grease in an automotive wheel bearing and in a modified automotive front wheel hub-spindle-bearings assembly (ASTM D3527-02 Life Performance test), the grease composition has a bearing life of at least 150 hours. In a second embodiment with additives such as antioxidant, extreme-pressure, etc. added to the grease, the composition has a bearing life of at least 200 hours.

[0087] In one embodiment with additives such as polybutene, the grease composition has a bearing life of at least 600 hours when tested for use with ball bearings operating under light loads at high speeds and elevated temperatures (ASTM D3336-97). When tested without the addition of additives such as polybutene, the composition still exhibits an extended life of at nearly 400 hours.

[0088] In yet another embodiment, the grease composition exhibits excellent extreme pressure properties as measured using ASTM D2596-97(Reapproved 2002), with a highest LWL (LWL: Load-Wear Index) of 73.05 Kg and a LNSL (LNSL: Last Non-Seizure Load) of 126 Kg. This compares with an LWI of 66.15 Kg and an LNSL of 126 Kg for greases compositions tested using Group II base oil as the matrix; and an LWI of 63.33 Kg and an LNSL of 126 Kg for greases compositions tested using PAO oils as the matrix.

[0089] In one embodiment, the grease composition exhibits excellent low temperature torque properties as measured according to ASTM D4693-03, standard test for grease-lubricated wheel bearings. The test determines the extent to which a test grease retards the rotation of a specially-manufactured, spring-loaded, automotive-type wheel bearing assembly when subjected to low temperatures. Torque values, calculated from restraining-force determinations, are a measure of the viscous resistance of the grease. In one embodiment, the grease has a bearing life of at least 100 hours. In another embodiment, a bearing life of at least 200 hours. In a third embodiment, a bearing life of at least 300 hours. In a fourth embodiment, at least 400 hours

[0090] Applications: In one embodiment, the grease composition is used in auto wheel bearings. In a second embodiment, the composition is used as a grease for parts and applications such as constant velocity joints, constant velocity gears, variable velocity gears, iron-making equipment, high-speed bearings, and the like. In a third embodiment, for rolling bearings of electric component parts of a car such as an alternator, an electromagnetic clutch for a car air conditioner, an intermediate pulley, an electromotive fan motor, a fan clutch and electric auxiliaries. In yet another embodiment, the grease composition can be tailored for the specific end-use applications, i.e., low temperature to high temperature ranges

by the selection of an isomerized base oil having the appropriate traction coefficient/BN oxidator.

[0091] In one embodiment wherein the grease composition is employed in a solid stick grease form, the solid stick grease is used between two metal surfaces in sliding and rolling-sliding contact such as steel wheel-rail systems including mass transit and freight systems.

[0092] In another embodiment wherein the grease is employed in a semi solid-like form, the composition further contains a liquid crystalline compound for use as lubrication grease for machine components, such as precision equipment, mobile telephone and hard disk drive of computer.

[0093] In yet another embodiment wherein the grease composition is used in electroconductive applications wherein the grease further comprises an electroconductive filler material, the grease is used for roll bearing of electric motor, automobile electrical parts, an alternator/an intermediate pulley (engine accessories), or an electromagnetic clutch for a car air conditioner.

[0094] The following Examples are given as non-limitative illustration of aspects of the present invention.

EXAMPLES.

[0095] Unless specified otherwise, the components in the examples are as follows:

[0096] Polybutene is commercially available from a number of sources, having a density of 7.48 and a kinematic viscosity of 630 mm²/s @100° C.

[0097] FT base oils are from Chevron Corporation of San Ramon, Calif. The properties of the FTBO base oils used in the examples are shown in Table 2.

[0098] PAO: is a mixture of two highly branched isoparaffinic polyalphaolefin (to get the desired viscosity) from Chevron Corporation of San Ramon, Calif. The first PAO has a kinematic viscosity of 39.72 mm²/s @100° C. (405.30 mm²/s @40° C.) and the second PAO has a kinematic viscosity of 7.771 mm²/s @100° C. (46.55 mm²/s @40° C.).

[0099] Group II is a commercially available mineral oil with a density of 7.2910 and kinematic viscosity of 12.15 mm²/s @100° C. (112.6 mm²/s @40° C.).

[0100] Bright stock base oil is commercially available from various sources, having a density of 7.467 and kinematic viscosity of 30.09 mm²/s @100° C. (461 mm²/s @40° C.).

Example 1

[0101] A base oil blend comprising 85 wt. % of FTBO-1 and 15 wt. % of FTBO-2 Fischer-Tropsch derived base oils is used as the base oil matrix for the grease composition. In addition to the base oil matrix which constitutes 50-85 wt. % of the final composition, the grease composition also comprises a polyurea thickener comprising a diisocyanate and an alkylamine in an approximate 1:2 (±0.5) to 1:3 ratio (±0.5), and 1.5 to 20 wt. % of one or more corrosion inhibitors and anti-oxidants known in the art, and optional carrier oil.

Example 2

[0102] A base oil blend comprising 70-90 wt. % mixture of FTBO-2 Fischer-Tropsch derived base oil with 2-30 wt. % of polybutene is provided as the base oil matrix. In addition to the base oil matrix, the grease composition further comprises 5-30 wt. % of a polyurea thickener comprising MDI, TDI or other diisocyanate and an alkyl amine in an approximate 1:1 (±0) to 1:3 ratio, 0.5-10 wt. % of one or more oxidation

inhibitors known in the art, 1.5 to 20 wt. % of at least a corrosion inhibitor known in the art, and optional carrier oil.

[0103] Examples 1 and 2 can be prepared as follows: A large stainless steel mixing bowl is charged with base oil (or mixtures thereof depending on the example) and heated close to 160° F. The mixer is started at a moderate rate setting, and calculated amounts of thickener additives are added and let melt first if necessary (approximately 5 to 10 minutes). The mixture is then heated slowly to not more than 400° F., preferably in the range of 250-390° F. for 30-60 minutes then slowly cooled, other additives incorporated at appropriate temperatures if needed upon cool-down, then tested.

[0104] For testing, ASTM 3336-E2006 can be used to evaluate performance in ball bearings operating under light loads at high speeds and elevated temperatures, specifically at a temperature of 350° F. (177° C.), 10,000 RPM, a radial load of 5 lbs., an axial load of 5 lbs., a bearing type of MRC 204S17 ABEC 3, with 20 hr. time running at 4 hr. time off.

[0105] A grease composition according to Example 1 was prepared and run 3 times, with the tests running normally for 360-391 hours at 355° F., after which the bearing temperature rose to 385° F. (criteria for grease failure). Temperature continued rising until a torque shutdown occurred, at which point the bearing failed between 392-398 hours.

[0106] A grease composition according to Example 2 grease with polybutene was prepared and tested 3 times. The tests ran normally for 600-640 hours at 355° F., after which the bearing temperature continued rising to 375-380° F. Temperature continued rising to 450-500° F. until a torque shutdown occurred. The bearing failed between 631 to 744 hours.

Examples 3-6

[0107] In these examples, the base oil is first measured and then blended in a large stainless steel mixing bowl. The oil is next heated to close to 160° F. Between 0.25-3 wt. % of a surfactant or surfactant blend is added and the mixture is stirred for 5 minutes. Between 3-15 wt % 12-Hydroxystearic can be added next. Mixture is allowed to cool gradually, then 0.5-10 wt % lithium hydroxide mono hydrate can be slowly added until well blended. The mixture is next heated slowly to 390-400° F. Temperature is held constant for 20 minutes, then mixture is allowed to cool off gradually to 180-250° F. before milling. In some examples where viscosity modifiers are used, the additives can be added last after milling, then the mixture is allowed to cool off to 180° F. Additives or additive packages used in this example may include 0.5-10 wt % extreme pressure agent(s), 0.1-5 wt % of at least a water resistance agent, 1-10 wt % of at least a viscosity modifier, 0.1-2 wt % of at least a rust inhibitor, 0-5 wt % of at least an antioxidant.

[0108] Examples 3 and 5 employ base oils commonly used in the prior art, i.e., a mixture of Group II and bright stock base oils for Example 3 and PAO base oils for Example 5. Example 4 employs FTBO-1 and Example 6 employs FTBO-3 as the base oil.

Examples 7-10

[0109] Examples 3-6 are duplicated, except no additives are used beyond the thickener system, with Example 7 employs the same base oil as in Example 3, Example 8 employs the FT base oil of medium viscosity grade in

Example 4, Example 10 employs the FT base oil of heavy viscosity grade in Example 5, and Example 9 employs the PAO mixture of Example 5.

Examples 11-12

[0110] In order to formulate the grease compositions in these examples, 1 kg. of the base oil is first measured and then blended in a large stainless steel mixing bowl. 5 to 17 wt. % of 12-hydroxy stearic acid, 1-6 wt. % of an additive such as Synative FA, 0.3 to 8 wt % of an additive such as an overbased calcium sulfonate extreme pressure additive, and 0.25-3 wt % of an additive such as nonyl phenol 4 mole ethoxylate can be added next. The mixture is next stirred and heated to approximately 220° F. The heating continued while 0.5-7% LiOH monohydrate is added slowly. The heating of the mixture continues to approximately 360° F. and held at that temperature for 20 minutes. The mixture is next cooled slowly with the addition of another 0.40-0.70 kg. of the base oil. Temperature is held constant for 10-30 minutes, then mixture is allowed to cool off gradually to approximately 240° F. In the next step, about 0.25-2.0 wt % of at least a metal passivants, 1.0-6 wt % of at least an extreme pressure agent, 0.1-2.0 wt % of at least a rust inhibitor, 0-1 wt % of a tackifier, and 0.1-5 wt % of at least an antioxidant are incorporated before milling.

[0111] A grease composition according to Example 11 grease was prepared employing a base oil commonly used in the prior art, i.e., PAO base oil and without polybutene as a viscosity modifier. A grease composition according to Example 12 grease was prepared employing a medium viscosity grade FT base oil, FTBO-1.

Examples 13-14

[0112] Examples 11-12 were duplicated, except performance additives beyond a thickener system, e.g., LiOH monohydrate or a similar thickener, was incorporated, with Example 13 employing the PAO in Example 11, and Example 14 employing the medium viscosity FT base oil FTBO-1 of Example 12.

Examples 15-17

[0113] In order to formulate the grease compositions in these examples, 1.5 kg. of the base oil is first measured, blended, and heated to 220° F. While blending, 2-8 wt % of

tallowalkylamine is added. Approximately 0.1-1.0 wt. % of a sulfinate detergent and H₂O are added next. The mixture is mixed for 15 minutes at approximately 160° F. In the next step, 2-10 wt % of MDI is added and the mixture is continuously mixed for an additional 30 minutes. The mixture is heated up slowly in stages to approximately 370° F. and held steady for 30 minutes. The mixture is next cooled slowly with the addition of another 0.53 kg. of the base oil. The mixture is allowed to cool off gradually to 240° F. before milling. Once milled, mixture is heated again to approx 170° F. and 0.1-2 wt % of at least a rust inhibitor, 0.1-5 wt % of at least an antioxidant, and 2-15 wt % of at least an extreme pressure agent are incorporated.

[0114] A grease composition according to Examples 15 and 16 employing base oils commonly used in the prior art were prepared with Example 15 incorporating a Group II base oil and Example 16 employing a PAO with a viscosity of about 4 mm²/s at 100° C. Example 17 employs a light viscosity grade FT base oil, FTBO-4.

Examples 18-20

[0115] Examples 15-17 were duplicated, except that the only additive used was the thickener system as in previous examples, Example 18 was made employing the Group II base oil used in Example 15, Example 19 employing the light viscosity FT base oil FTBO-4 of Example 17, and Example 20 employing the PAO base oil of Example 16.

[0116] A number of tests were conducted on the grease samples from the experiments with the test results reported in Table 1. Both additized and unadditized FTBO greases show superior performance for auto wheel bearing life (test D3527-02) and in extreme pressure testing (ASTM D2596-R2002) when compared to conventional Group II or PAO-based oil of similar viscosity (viscosity comparison at 100° C.). Additionally, low temperature torque properties of the FTBO grease show improvement over those made with Group II base oil or PAO based formulas. Additionally, grease compositions comprising FT base oils show excellent improvement in low temperature torque (ASTM D4693-03 at 3 min) vs. Group II based grease of the prior art. Finally, extreme pressure properties (ASTM D2596-R2002) of greases comprising FT base oil showed improvement with LWI/LNSL results of 73.05 Kg/160 Kg versus lower values of 66.15 Kg/126 Kg for Group II grease and 63.33 Kg/126 Kg for PAO based grease.

TABLE 1

GREASE	Vis, 40° C.	Vis, 100° C.	VI	LWI, Kg	LNSL, Kg	WP	Torque, 3 min, 40° C., N-m	bearing life (hrs)
Ex. 3 - Group II, additives	—	—	—	66.15	126	400	14.88	120
Ex. 4 - FTBO H, additives	—	—	—	70	160	315	—	—
Ex. 5 - PAO, additives	—	—	—	63.33	126	400	2.48	160
Ex. 6 - FTBO M/H, add.	—	—	—	73.05	160	400	6.57	199
Ex. 7 - Group II, no add.	131.5	13.23	94	22.89	32	160	10.22	40
Ex. 8 - FTBO H, no add.	—	—	—	27.98	40	200	—	—
Ex. 9 - PAO, no additive	94.83	13.31	140	22.74	40	160	1.17	40
Ex. 10 - FTBO M/H, no add.	—	—	—	23.56	40	200	9.28	200
Ex. 11 - PAO, no additives	405.3	39.72	147	24.3	50	160	6.56	20
Ex. 12 - FTBO M/H, no add.	367.6	35.01	138	23.73	40	200	10.23	120.5
Ex. 13 - PAO, additives	—	—	—	68.88	126	400	3.29	40.2
Ex. 14 - FTBO M/H, add.	—	—	—	68.11	100	500	4.76	140.0
Ex. 15 - Group II, additives	—	—	—	58.33	63	500	0.87	140
Ex. 16 - PAO, additives	—	—	—	61.31	80	500	0.64	120
Ex. 17 - FTBO L, additives	—	—	—	60.89	80	500	0.72	356
Ex. 18 - Group II, no add.	—	—	—	29.20	50	126	1.18	220

TABLE 1-continued

GREASE	Vis, 40° C.	Vis, 100° C.	VI	LWI, Kg	LNSL, Kg	WP	Torque, 3 min, 40° C., N-m	bearing life (hrs)
Ex. 19 - FTBO L, no add.	—	—	—	28.67	50	126	1.01	380
Ex. 20 - PAO, no add.	—	—	—	24.06	50	100	1.07	200

TABLE 2

Properties	FTBO-1 M/H	FTBO-2 M	FTBO-3 H	FTBO-4 L
Kinematic Visc. @40° C., mm ² /s	86.72	42.19	106.4	17.20
Kinematic Visc. @100° C., mm ² /s	13.14	7.901	16.01	4.101
Viscosity Index	152	161	161	145
Cold Crank Viscosity @ -40° C., cP		36,130		2,579
Cold Crank Viscosity @ -35° C., cP		13,547		1,561
Cold Crank Viscosity @ -30° C., cP		5,802	46,991	905
Cold Crank Viscosity @ -25° C., cP	16,528	2,896	18,905	
Pour Point, ° C.	-4	-14	-10	-20
Pour Point, ° C. n-d-m	18	2	15	-11
Molecular Weight, gm/mol (VPO)	724	575	743	428
Density, gm/ml	0.8326	0.8261	0.8330	0.8137
Refractive Index	1.4642	1.4608	1.4641	1.4541
Paraffinic Carbon, %	93.86	93.94	92.98	
Naphthenic Carbon, %	6.14	6.06	7.02	
Aromatic Carbon, %	0.00	0.00	0.00	
Oxidator BN, hrs	33.52	37.72	45.32	
Noack, wt. %	0.86	1.63	0.95	12.45
SIMDIST TBP (WT %), F				
TBP @0.5	906	838	915	332
TBP @5.0	953	877	963	725
TBP @10	974	890	988	756
TBP @20	995	907	1011	778
TBP @30	1007	920	1040	795
TBP @40	1020	930	1057	810
TBP @50	1036	939	1074	824
TBP @60	1048	948	1092	836
TBP @70	1061	959	1113	849
TBP @80	1078	973	1141	861
TBP @90	1106	987	1181	876
TBP @95	1140	998	1213	886
TBP @99.5	1228	1029	1290	905

[0117] For the purposes of this specification and appended claims, unless otherwise indicated, all numbers expressing quantities, percentages or proportions, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained and/or the precision of an instrument for measuring the value. Furthermore, all ranges disclosed herein are inclusive of the end-points and are independently combinable. In general, unless otherwise indicated, singular elements may be in the plural and vice versa with no loss of generality. As used herein, the term “include” and its grammatical variants are intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that can be substituted or added to the listed items.

[0118] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. The patentable scope is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims. All citations referred herein are expressly incorporated herein by reference.

1. A lubricating grease composition comprising (i) a lubricating base oil; (ii) from 2 to 30 wt % of a thickener selected from a simple soap, a complex soap, polyurea, diurea, triurea, fluorocarbon resin, and mixtures thereof; and (iii) 0-10 wt % of at least an additive selected from the group of preservatives, colorants, anti-weld agents, extreme pressure agents,

flame retardants, rust inhibitors, corrosion inhibitors, oil bleed inhibitors, metal deactivators, viscosity modifiers, pour point depressants, and mixtures thereof;

wherein the lubricating base oil comprises at least 50 wt. % of an isomerized base oil having consecutive numbers of carbon atoms and less than 10 wt % naphthenic carbon by n-d-M, and a kinematic viscosity at 100° C. equal to or greater than 10 mm²/s.

2. The lubricating grease composition of claim 1, wherein the grease has a bearing life of at least 150 hours as determined by ASTM D3527-02.

3. The lubricating grease composition of claim 1, wherein the grease has a maximum torque of 10 N-m at -40° C. as determined by ASTM D4693-03 at 3 minutes.

4. The lubricating grease composition of claim 1, wherein the grease has a bearing life of at least 600 hours as determined by ASTM 3336-97.

5. The lubricating grease composition of claim 1, wherein the grease has a dropping point of at least 215° C. as determined by ASTM D2265-06.

6. The lubricating grease composition of claim 1, wherein the grease exhibits a peak average value of less than 12 microns/second as determined by a BeQuiet grease noise tester.

7. The lubricating grease composition of claim 1, wherein the grease displays a difference of less than 15% difference between a prolonged worked penetration as determined by ASTM D217-02 at Full Scale, P100,000, and a worked penetration as determined by ASTM D1403-02 at 1/2 Scale, P60.

8. The lubricating grease composition of claim 1, wherein the thickener is selected from the group consisting of lithium soaps, calcium soaps, sodium soaps, aluminium soaps, barium soaps, polyureas, triureas, diureas, fluorocarbon resin powder, and combinations thereof, in an amount ranging from 2 to 30 wt. % of the total weight of the grease composition.

9. The lubricating grease composition of claim 8, wherein the thickener is a lithium complex soap.

10. The lubricating grease composition of claim 1, wherein the at least additive is an antioxidant selected from the group of organic amines, sulfides, hydroxy sulfides, and alone or in combination with at least a metal, and mixtures thereof.

11. The lubricating grease composition of claim 10, wherein the at least additive is an antioxidant selected from the group of alkylated diphenyl amine, phenothiazine, substituted and unsubstituted quinoline, and mixtures thereof.

12. The lubricating grease composition of claim 1, further comprising at least a thermosetting resin.

13. The lubricating grease composition of claim 12, in the form of a solid stick grease.

14. The lubricating grease composition of claim 1, wherein the isomerized base oil is a Fischer-Tropsch derived base oil made from a waxy feed.

15. The lubricating grease composition of claim 1, wherein the isomerized base oil has an average molecular weight between 600 and 1100, and an average degree of branching in the molecules between 6.5 and 10 alkyl branches per 100 carbon atoms.

16. The lubricating grease composition of claim 1, wherein the isomerized base oil has a wt % Noack volatility between 0 and 100.

17. The lubricating grease composition of claim 16, wherein the isomerized base oil has a Noack volatility that is less than an amount defined by: $900 \times (\text{Kinematic Viscosity at } 100^\circ \text{ C.})^{-2.8} - 15$.

18. The lubricating grease composition of claim 1, wherein the isomerized base oil has an auto-ignition temperature (AIT) greater than an amount defined by: $1.6 \times (\text{Kinematic Viscosity at } 40^\circ \text{ C., in mm}^2/\text{s}) + 300$.

19. The lubricating grease composition of claim 1, wherein the isomerized base oil has an auto-ignition temperature (AIT) greater than 329° C.

20. The lubricating grease composition of claim 1, wherein the isomerized base oil has a viscosity index greater than $28 \times \text{Ln}(\text{Kinematic Viscosity at } 100^\circ \text{ C., in mm}^2/\text{s}) + 300$.

21. The lubricating grease composition of claim 1, wherein the isomerized base oil has a ratio of weight percent molecules with monocycloparaffinic functionality to weight percent molecules with multicycloparaffinic functionality of greater than 15.

22. The lubricating grease composition of claim 1, wherein the isomerized base oil has a total weight percent of molecules with cycloparaffinic functionality of greater than 10, and a ratio of weight percent molecules with monocycloparaffinic functionality to weight percent molecules with multicycloparaffinic functionality of greater than 15.

23. The lubricating grease composition of claim 1, wherein the isomerized base oil has a viscosity index greater than an amount defined by: $28 \times \text{Ln}(\text{Kinematic viscosity at } 100^\circ \text{ C.}) + 95$.

24. The lubricating grease composition of claim 1, wherein the isomerized base oil is made from a process in which the highly paraffinic wax is hydroisomerized using a shape selective intermediate pore size molecular sieve comprising a noble metal hydrogenation component, and under conditions of about 600° F. to 750° F. and wherein the isomerized base oil has a Noack volatility of less than 50 weight %.

25. The lubricating grease composition of claim 1, wherein the isomerized base oil comprises greater than 3 weight % molecules with cycloparaffinic functionality and less than 0.30 weight percent aromatics.

26. The lubricating grease composition of claim 1, wherein the isomerized base oil has a Noack volatility less than an amount defined by: $160 - 40(\text{Kinematic Viscosity at } 100^\circ \text{ C.})$.

27. The lubricating grease composition of claim 1, wherein the isomerized base oil comprises greater than 10 wt. % and less than 70 wt. % total molecules with cycloparaffinic functionality

28. The lubricating grease composition of claim 1, wherein the isomerized base oil has a traction coefficient of less than 0.023 when measured at a kinematic viscosity of 15 mm²/s and at a slide to roll ratio of 40%.

29. The lubricating grease composition of claim 1, wherein the isomerized base oil has a viscosity index greater than 150 and a traction coefficient less than 0.015 when measured at a kinematic viscosity of 15 mm²/s and at a slide to roll ratio of 40 percent.

30. The lubricating grease composition of claim 1, wherein the isomerized base oil comprises paraffinic hydrocarbon components having less than 8 alkyl branches per 100 carbons and less than 20 wt % of the alkyl branches are at the 2 position.

31. The lubricating grease composition of claim 1, wherein the isomerized base oil has a pour point of less than -8° C.; a kinematic viscosity at 100° C. of at least 10 mm²/s; and a

Viscosity Index greater than an amount defined by: $22 \times \text{Ln}$ (Kinematic Viscosity at 100° C.)+132.

32. A method for making a grease composition, the method comprising blending a composition comprising a lubricating base oil with: 2 to 30 wt % of a thickener selected from a simple soap, a complex soap, polyurea, diurea, triurea, fluorocarbon resin, and mixtures thereof; and 0-10 wt % of at least an additive selected from the group of preservatives, colorants, anti-weld agents, extreme pressure agents, flame retardants, rust inhibitors, corrosion inhibitors, oil bleed inhibitors, metal deactivators, viscosity modifiers, pour point depressants, and mixtures thereof; the lubricating base oil

comprises at least 50 wt. % of an isomerized base oil having a total weight percent of molecules with cycloparaffinic functionality of greater than 10, and a ratio of weight percent molecules with monocycloparaffinic functionality to weight percent molecules with multicycloparaffinic functionality of greater than 15.

33. A bearing sealed with the grease composition of claim 1.

34. An article having components lubricated by the grease composition of claim 1.

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