

ALKYL PHENOL BASED POLYETHER DERIVED COMPOUNDS AS DEPOSIT CONTROL ADDITIVES

TECHNICAL FIELD

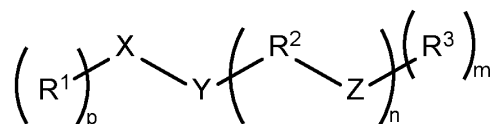
[0001] This disclosure relates to lubricant additive compositions and lubricating oil compositions containing the same. More particularly, the composition(s) improve oxidative stability and/or deposit control in an engine environment.

BACKGROUND

[0002] While all engines put stress on lubricating oils, some engines run continuously at near full load and high temperature conditions which place greater thermal stress on the lubricants. Under such conditions, engines are particularly susceptible to oxidation and deposit formation which can lead to degradation of engine performance. Moreover, some of these engines require lubricating oils to be within a specified viscosity range necessitating the use of components such as thickeners.

SUMMARY

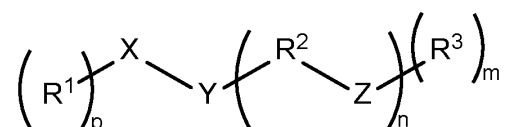
[0003] In one aspect, there is provided a gaseous-fueled engine lubricating oil composition comprising: a major amount of base oil; and a lubricant additive having the following structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; Z is

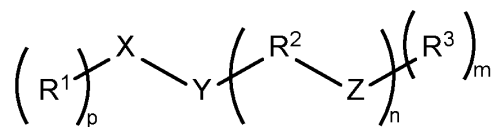
nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3.

[0004] In another aspect, there is provided a lubricating oil composition for a low-speed or medium-speed diesel engine, the composition comprising: a major amount of base oil; and a lubricant additive having the following structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; Z is nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3.

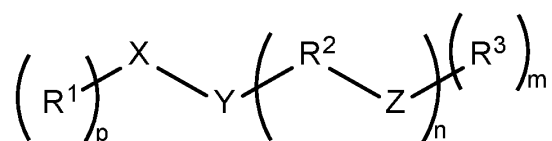
[0005] In yet another aspect, there is provided a method of thickening a lubricating oil composition in a gaseous-fueled, low-speed, or medium-speed engine, the method comprising adding to said engine a lubricating oil composition comprising: a major amount of base oil; and a lubricant additive having the following structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; Z is

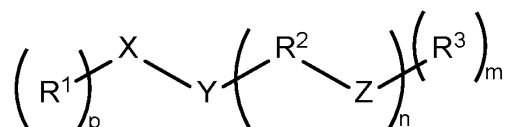
nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3.

[0006] In still yet another aspect, there is provided a method of improving piston cleanliness or oxidation inhibition in an engine, the method comprising lubricating the engine with a lubricating oil composition comprising: a of base oil; and a lubricant additive having the following structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; Z is nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3.

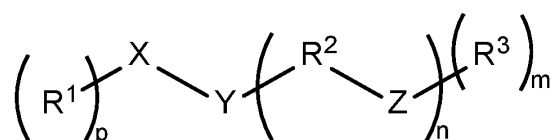
[0007] In still yet another further aspect, there is provided a method of removing existing deposits in an internal combustion engine, the method comprising lubricating the engine with a composition comprising: a base oil; and an additive having the following structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; Z is

nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3.

[0008] In yet still another further aspect, there is provided a method of removing existing deposits from the crankcase, rocker cover, camshaft region, timing gear cover, cylinder head, combustion chamber, piston rings and/or ring grooves in an internal combustion engine, the method comprising lubricating or rapid cleaning the engine with a composition comprising: a base oil; and an additive having the following structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; Z is nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3.

DETAILED DESCRIPTION

[0009] It is understood that when combinations, subsets, groups, etc. of elements are disclosed (e.g., combinations of components in a composition, or combinations of steps in a method), that while specific reference of each of the various individual and collective combinations and permutations of these elements may not be explicitly disclosed, each is specifically contemplated and described herein.

[0010] The present disclosure relates to lubricant additive compositions with enhanced oxidative stability, thickening ability, and/or deposit control capability (i.e., preventing deposit formation and/or removal of existing deposits), lubricating oil compositions containing the lubricant additive, and methods of using the composition(s).

[0011] When used during regular maintenance such as scheduled oil change recommend by OEM, the lubricating oil composition works primarily (not necessarily exclusively) to prevent deposit formation. When used on as needed basis such as a rapid cleaning service, the lubricating oil composition works primarily (not necessarily exclusively) to remove existing deposits.

[0012] The compositions disclosed herein are particularly suitable for engines operating under sustained high load conditions such as gaseous-fueled engines, dual-fuel engines, and low-speed or medium-speed engines. The engine may be a two-stroke engine or four-stroke engine. The engine may also include any number of combustion chambers, pistons, and associated cylinders (e.g., 1-24). For example, in certain embodiments, the engine may be a large-scale industrial reciprocating engine having 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 16, 18, 20, 24 or more pistons reciprocating in cylinders. In certain embodiments, the piston may be an aluminum piston or a steel piston (e.g., steel or any of a variety of steel alloys, such as 42CrMo4V or 38MnVS6).

[0013] The gaseous-fueled engine may be a stationary natural gas engine, a stationary biogas engine, a stationary landfill gas engine, a stationary unconventional gaseous-fueled engine, or a dual-fuel engine. Dual-fuel engines can operate using a mixture of two different fuels. Frequently, diesel and natural gas fuels are used together within dual fuel engines. Beyond natural gas and diesel, some dual-fuel engines can also use varying mixtures of biodiesel, landfill gas, bio-gas and other fuels.

[0014] The fuel which is used to operate the gaseous-fueled engine may include carbon-based gaseous fuels (e.g., natural gas, biogas, landfill gas, wood gas, methane, propane, butane, etc.) and non-carbon based gaseous fuels (e.g. ammonia, hydrogen).

[0015] Diesel engines may generally be classified as low-speed, medium-speed or high-speed engines. Herein, a “low-speed” engine means a compression-ignition internal combustion engine that is driven at a rotational speed that is less than 500 revolutions per minute (rpm), such as marine crosshead diesel engines; a “medium-speed” engine means a compression-ignition internal combustion engine that is driven at a rotational speed of 500 to 1800 rpm, such as locomotive (“railroad”) diesel engines, marine trunk piston diesel engines, or land-based stationary power diesel engines; and a “high-speed” engine means a compression-ignition internal combustion engine that is driven at a rotational speed that is higher than 1800 rpm, such as diesel engines for highway vehicles.

[0016] In some embodiments, the lubricating oil composition disclosed herein may be utilized in controlling deposits in engines operating under high sustained load conditions, such as a Brake Mean Effective Pressure (BMEP) of at least 10 bar (1.0 MPa), of at least 12 bar (1.2 MPa), of at least 14 bar (1.4 MPa), of at least 16 bar (1.6 MPa), of at least 18 bar (1.8 MPa), of at least 20 bar (2.0 MPa), e.g., at least 22 bar (2.2 MPa), at least 24 bar (2.4 MPa), at least 26 bar (2.6 MPa), 10 to 30 bar (1.0 to 3.0 MPa), 20 to 30 bar (2.0 to 3.0 MPa), 22 to 30 bar (2.2 to 3.0 MPa), 22 to 28 bar (2.2 to 2.8 MPa), or 24 to 30 bar (2.4 to 3.0 MPa).

[0017] The lubricant additive disclosed herein and compositions containing the same can be used in a number of lubricant applications such as a railroad engine oil (RREO), marine system oil (SO), marine cylinder lubricant (MCL), trunk piston engine oil (TPEO), natural gas engine oil (NGEO), or dual-fuel (DF) engine oil.

[0018] In some embodiments, the lubricating oil composition disclosed herein has a total base number (TBN) of 2 to 200 mgKOH/g such as 2 to 175, 2 to 150, 2 to 100, 5 to 200, 5 to 175, 5 to 150, 5 to 100, 10 to 200, 10 to 175, 10 to 150, 10 to 100, 50 to 200, 50 to 175, 50 to 150, and 50 to 100.

[0019] In some embodiments, the lubricating oil composition disclosed herein is suitable for use as a marine cylinder lubricant used to lubricate a low-speed crosshead engine. Marine cylinder lubricants are typically made to the SAE 30, SAE 40,

SAE 50, or SAE 60 monograde specification in order to provide a sufficiently thick lubricant film at the high temperatures on the cylinder liner wall. Typically, marine diesel cylinder lubricants have a TBN of up to 200 mg KOH/g, or ranging from 2 to 200 mg KOH/g (e.g., from 2 to 200 mg KOH/g, from 5 to 200 mg KOH/g, from 10 to 200 mg KOH/g, from 15 to 150 mg KOH/g, from 15 to 60 mg KOH/g, from 20 to 200 mg KOH/g, from 20 to 150 mg KOH/g from 20 to 120 mg KOH/g, from 20 to 80 mg KOH/g, from 30 to 200 mg KOH/g, or from 30 to 150 mg KOH/g, or from 30 to 120 mg KOH/g, from 30 to 100 mg KOH/g, from 30 to 80 mg KOH/g, from 60 to 200 mg KOH/g, from 60 to 150 mg KOH/g, from 60 to 120 mg KOH/g, from 60 to 100 mg KOH/g, from 60 to 80 mg KOH/g, from 80 to 200 mg KOH/g, from 80 to 150 mg KOH/g, from 80 to 150 mg 120 KOH/g, from 120 to 200 mg KOH/g, or from 120 to 150 mg KOH/g).

[0020] In some embodiments, the lubricating oil composition disclosed herein is suitable for use as a marine system oil used to lubricate the crankcase of a low-speed crosshead engine. Marine system oil lubricants are typically made to the SAE 20, SAE 30, or SAE 40 monograde specification. The viscosity for the marine system oil is set at relatively low level(s) in part because a system oil can increase in viscosity during use and the engine designers have set viscosity increase limits to prevent operational problems. Typically, marine system oil lubricants have a TBN of up to 12 mg KOH/g or ranging from 2 to 12 mg KOH/g (e.g., from 3 to 12 mg KOH/g, from 5 to 12 mg KOH/g, from 5 to 10 mg KOH/g, or from 5 to 9 mg KOH/g).

[0021] In some embodiments, the lubricating oil composition disclosed herein is suitable for use as a marine trunk piston engine oil (TPEO). Marine TPEO lubricants are typically made to the SAE 30 or SAE 40 monograde specification. Typically, marine TPEO lubricants have a TBN of up to 60 mg KOH/g or ranging from 2 to 60 mg KOH/g (e.g., from 5 to 60 mg KOH/g, 10 to 30 mg KOH/g, from 15 to 60 mg KOH/g, from 15 to 40 mg KOH/g, from 20 to 60 mg KOH/g, 20 to 40 mg KOH/g, from 30 to 60 mg KOH/g, or from 30 to 55 mg KOH/g).

[0022] In some embodiments, the lubricating oil composition disclosed herein is suitable for use as a gaseous-fueled engine oil, such as a natural gas fueled engine

oil. Gaseous-fueled engine oils typically have a TBN up to 10 mg KOH/g or ranging from 2 to 10 mg KOH/g (e.g., from 2 to 9 mg KOH/g, or 2 to 8 mg KOH/g).

[0023] In some embodiments, the lubricating oil composition disclosed herein is suitable for use as a medium speed engine oil, such as a locomotive (railroad) engine oil. Locomotive engine oil lubricants typically have a TBN up to 20 mg KOH/g, up to 15 mg KOH/g, up to 10 mg KOH/g, or ranging from 4 to 20 mg KOH/g, from 4 to 15 mg KOH/g, 4 to 10 mg KOH/g, or 5 to 9 mg KOH/g.

[0024] In some embodiments, the lubricating oil composition disclosed herein may be used during rapid cleaning service to remove accumulated deposits, sludge, and other gunk from an internal combustion engine. A rapid cleaning service can remove sludge, heavy deposits, and/or other insoluble material that may have been built up over time. The cleaning process may be comprised of using the lubricant in the engine sump or crankcase and circulating the lubricating oil without starting the engine. An additional step would include circulating the lubricating oil and allowing it to soak under a static condition for 15 minutes, 30 minutes, 1 hour, 1.5 hours, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7, hours, 8 hours, 9 hours, 10 hours, 11 hours, 12 hours, 16 hours, 20 hours, 24 hours, 2 days, 3 days, 4 days, 5 days, 6 days, or a week. Another cleaning step could include starting and operating the engine at any running condition appropriate for the engine design and fuel for 15 minutes, 30 minutes, 1 hour, 1.5 hours, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7, hours, 8 hours, 9 hours, 10 hours, 11 hours, 12 hours, 16 hours, 20 hours, 24 hours, 2 days, 3 days, 4 days, 5 days, 6 days, or a week. In some embodiments, the lubricating oil composition disclosed herein may be used for removing existing deposits from the crankcase, rocker cover, camshaft region, timing gear cover, cylinder head, combustion chamber, piston rings and/or ring grooves in an internal combustion engine.

[0025] When used during a rapid cleaning service, the lubricating oil composition can require the lubricant additive at a higher concentration than is typically used during regular maintenance. This lubricating oil with higher amounts of the deposit cleaning lubricant additive is used to lubricate and clean the engine. The

resulting mixed product (concentrated lubricating oil and deposits) can then be flushed. The flushing step typically occurs after completion of the cleaning step.

[0026] In some embodiments, the cleaning step of the rapid cleaning service involves lubricating the engine with the lubricating oil composition for 15 minutes, 30 minutes, 1 hour, 1.5 hours, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7, hours, 8 hours, 9 hours, 10 hours, 11 hours, 12 hours, 16 hours, 20 hours, 24 hours, 2 days, 3 days, 4 days, 5 days, 6 days, or a week. The exact amount of time can vary depending on a number of factors such as, but not limited, the size of engine, the amount of deposits in the engine, desired level of cleanliness, and so forth.

[0027] In some embodiments, the flushing takes place after 5 minutes, after 15 minutes, after 30 minutes, after 45 minutes, after 1 hour, after 2 hours, after three 3, after 4 hours, after 5 hours, after 6 hours, after 8 hours, after 12 hours, after 16 hours, after 24 hours, after 2 days, after 3 days, after 4 days, after 1 week, after 2 weeks, after 3 weeks, after 4 weeks, after 6 weeks, after 8 weeks from the cleaning step. In some embodiments, the flushing step can occur up to a period equivalent to about 25% of the OEM recommended oil change interval period.

[0028] In some embodiments, the lubricating oil composition disclosed herein may contain low levels of sulfated ash, as determined by ASTM D874. The compositions may have a sulfated ash content of less than 1.5 wt. % (e.g., less than 0.6 wt. % or even less than 0.06 wt. %), based on the total weight of the composition. The compositions may have a sulfated ash content from 0.01 to 1.0 wt.%, from 0.1 to 1.0 wt.%, from 0.3 to 0.8 wt.%, from 0.4 to 1.0 wt.%, from 0.5 to 0.9 wt.%, or from 0.5 to 1.0 wt.%. In some embodiments the lubricating oil composition may be ashless.

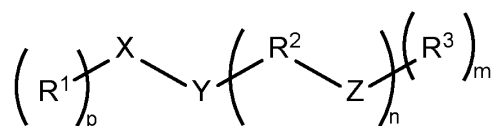
[0029] The lubricating oil composition disclosed herein may provide advantaged deposit control performance in any of a number of mechanical components of an engine. The mechanical component may be a piston, a piston ring, piston ring grooves, a crankcase, a rocker cover, a camshaft region, a timing gear cover, a cylinder head, a combustion chamber, a cylinder liner, a cylinder, a cam, a tappet, a lifter, a gear, a valve, a valve guide, or a bearing including a journal, a roller, a tapered,

a needle, or a ball bearing. In some cases, the mechanical component may comprise steel.

[0030] The term “on an actives basis” refers to additive material that is not diluent oil or solvent. All concentrations should be considered on an actives basis unless stated otherwise.

Lubricant Additive

[0031] The lubricant additive composition of the present disclosure can be represented by the following generalized chemical Structure I:



Structure I

wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is independently nitrogen, oxygen, and/or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, (e.g., $-NH_2$, $-OH$, etc.) wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3. In some embodiments, X is a cyclic or acyclic alkyl group. In some preferred embodiments, X is aryl moiety. In some embodiments, Y may include one or more hydrogens. In some preferred embodiments, Z is nitrogen. In some preferred embodiments, Z is oxygen. In some preferred embodiments, Z is oxygen or nitrogen or both. Each R^1 is independently a moiety that includes 10 to 400 carbon atoms, such as 10 to 390, 10 to 380, 10 to 370, 10 to 360, 10 to 350, 10 to 340, 10 to 330, 10 to 320, 10 to 310, 10 to 300, 10 to 290, 10 to 280, 10 to 270, 10 to 260, 10 to 250, 10 to 240, 10 to 230, 10 to 220, 10 to 210, 10 to 200, 10 to 190, 10 to 180, 10 to 170, 10 to 160, 10 to 150, 10 to 140, 10 to 130, 10 to 120, 10 to 110, 10 to 100, 10 to 90, 10 to 80, 10 to 70, 10 to 60, 10 to 50, 10 to 40, 10 to 30, 10 to 20, 20 to 400, 20 to 390, 20 to 380,

20 to 370, 20 to 360, 20 to 350, 20 to 340, 20 to 330, 20 to 320, 20 to 310, 20 to 300, 20 to 290, 20 to 280, 20 to 270, 20 to 260, 20 to 250, 20 to 240, 20 to 230, 20 to 220, 20 to 210, 20 to 200, 20 to 190, 20 to 180, 20 to 170, 20 to 160, 20 to 150, 20 to 140, 20 to 130, 20 to 120, 20 to 110, 20 to 100, 20 to 90, 20 to 80, 20 to 70, 20 to 60, 20 to 50, 20 to 40, 20 to 30, 30 to 400, 30 to 390, 30 to 380, 30 to 370, 30 to 360, 30 to 350, 30 to 340, 30 to 330, 30 to 320, 30 to 310, 30 to 300, 30 to 290, 30 to 280, 30 to 270, 30 to 260, 30 to 250, 30 to 240, 30 to 230, 30 to 220, 30 to 210, 30 to 200, 30 to 190, 30 to 180, 30 to 170, 30 to 160, 30 to 150, 30 to 140, 30 to 130, 30 to 120, 30 to 110, 30 to 100, 30 to 90, 30 to 80, 30 to 70, 30 to 60, 30 to 50, 30 to 40, 40 to 400, 40 to 390, 40 to 380, 40 to 370, 40 to 360, 40 to 350, 40 to 340, 40 to 330, 40 to 320, 40 to 310, 40 to 300, 40 to 290, 40 to 280, 40 to 270, 40 to 260, 40 to 250, 40 to 240, 40 to 230, 40 to 220, 40 to 210, 40 to 200, 40 to 190, 40 to 180, 40 to 170, 40 to 160, 40 to 150, 40 to 140, 40 to 130, 40 to 120, 40 to 110, 40 to 100, 40 to 90, 40 to 80, 40 to 70, 40 to 60, 40 to 50, 50 to 400, 50 to 390, 50 to 380, 50 to 370, 50 to 360, 50 to 350, 50 to 340, 50 to 330, 50 to 320, 50 to 310, 50 to 300, 50 to 290, 50 to 280, 50 to 270, 50 to 260, 50 to 250, 50 to 240, 50 to 230, 50 to 220, 50 to 210, 50 to 200, 50 to 190, 50 to 180, 50 to 170, 50 to 160, 50 to 150, 50 to 140, 50 to 130, 50 to 120, 50 to 110, 50 to 100, 50 to 90, 50 to 80, 50 to 70, 50 to 60, 60 to 400, 60 to 390, 60 to 380, 60 to 370, 60 to 360, 60 to 350, 60 to 340, 60 to 330, 60 to 320, 60 to 310, 60 to 300, 60 to 290, 60 to 280, 60 to 270, 60 to 260, 60 to 250, 60 to 240, 60 to 230, 60 to 220, 60 to 210, 60 to 200, 60 to 190, 60 to 180, 60 to 170, 60 to 160, 60 to 150, 60 to 140, 60 to 130, 60 to 120, 60 to 110, 60 to 100, 60 to 90, 60 to 80, 60 to 70, 70 to 400, 70 to 390, 70 to 380, 70 to 370, 70 to 360, 70 to 350, 70 to 340, 70 to 330, 70 to 320, 70 to 310, 70 to 300, 70 to 290, 70 to 280, 70 to 270, 70 to 260, 70 to 250, 70 to 240, 70 to 230, 70 to 220, 70 to 210, 70 to 200, 70 to 190, 70 to 180, 70 to 170, 70 to 160, 70 to 150, 70 to 140, 70 to 130, 70 to 120, 70 to 110, 70 to 100, 70 to 90, 70 to 80, 80 to 400, 80 to 390, 80 to 380, 80 to 370, 80 to 360, 80 to 350, 80 to 340, 80 to 330, 80 to 320, 80 to 310, 80 to 300, 80 to 290, 80 to 280, 80 to 270, 80 to 260, 80 to 250, 80 to 240, 80 to 230, 80 to 220, 80 to 210, 80 to 200, 80 to 190, 80 to 180, 80 to 170, 80 to 160, 80 to 150,

80 to 140, 80 to 130, 80 to 120, 80 to 110, 80 to 100, 80 to 90, 90 to 400, 90 to 390, 90 to 380, 90 to 370, 90 to 360, 90 to 350, 90 to 340, 90 to 330, 90 to 320, 90 to 310, 90 to 300, 90 to 290, 90 to 280, 90 to 270, 90 to 260, 90 to 250, 90 to 240, 90 to 230, 90 to 220, 90 to 210, 90 to 200, 90 to 190, 90 to 180, 90 to 170, 90 to 160, 90 to 150, 90 to 140, 90 to 130, 90 to 120, 90 to 110, 90 to 100, 100 to 400, 100 to 390, 100 to 380, 100 to 370, 100 to 360, 100 to 350, 100 to 340, 100 to 330, 100 to 320, 100 to 310, 100 to 300, 100 to 290, 100 to 280, 100 to 270, 100 to 260, 100 to 250, 100 to 240, 100 to 230, 100 to 220, 100 to 210, 100 to 200, 100 to 190, 100 to 180, 100 to 170, 100 to 160, 100 to 150, 100 to 140, 100 to 130, 100 to 120, 100 to 110, 110 to 400, 110 to 390, 110 to 380, 110 to 370, 110 to 360, 110 to 350, 110 to 340, 110 to 330, 110 to 320, 110 to 310, 110 to 300, 110 to 290, 110 to 280, 110 to 270, 110 to 260, 110 to 250, 110 to 240, 110 to 230, 110 to 220, 110 to 210, 110 to 200, 110 to 190, 110 to 180, 110 to 170, 110 to 160, 110 to 150, 110 to 140, 110 to 130, 110 to 120, 120 to 400, 120 to 390, 120 to 380, 120 to 370, 120 to 360, 120 to 350, 120 to 340, 120 to 330, 120 to 320, 120 to 310, 120 to 300, 120 to 290, 120 to 280, 120 to 270, 120 to 260, 120 to 250, 120 to 240, 120 to 230, 120 to 220, 120 to 210, 120 to 200, 120 to 190, 120 to 180, 120 to 170, 120 to 160, 120 to 150, 120 to 140, 120 to 130, 130 to 400, 130 to 390, 130 to 380, 130 to 370, 130 to 360, 130 to 350, 130 to 340, 130 to 330, 130 to 320, 130 to 310, 130 to 300, 130 to 290, 130 to 280, 130 to 270, 130 to 260, 130 to 250, 130 to 240, 130 to 230, 130 to 220, 130 to 210, 130 to 200, 130 to 190, 130 to 180, 130 to 170, 130 to 160, 130 to 150, 130 to 140, 140 to 400, 140 to 390, 140 to 380, 140 to 370, 140 to 360, 140 to 350, 140 to 340, 140 to 330, 140 to 320, 140 to 310, 140 to 300, 140 to 290, 140 to 280, 140 to 270, 140 to 260, 140 to 250, 140 to 240, 140 to 230, 140 to 220, 140 to 210, 140 to 200, 140 to 190, 140 to 180, 140 to 170, 140 to 160, 140 to 150, 150 to 400, 150 to 390, 150 to 380, 150 to 370, 150 to 360, 150 to 350, 150 to 340, 150 to 330, 150 to 320, 150 to 310, 150 to 300, 150 to 290, 150 to 280, 150 to 270, 150 to 260, 150 to 250, 150 to 240, 150 to 230, 150 to 220, 150 to 210, 150 to 200, 150 to 190, 150 to 180, 150 to 170, 150 to 160, 160 to 400, 160 to 390, 160 to 380, 160 to 370, 160 to 360, 160 to 350, 160 to 340, 160 to 330, 160 to 320, 160 to 310, 160 to 300, 160 to 290, 160 to 280, 160 to 270,

160 to 260, 160 to 250, 160 to 240, 160 to 230, 160 to 220, 160 to 210, 160 to 200, 160 to 190, 160 to 180, 160 to 170, 170 to 400, 170 to 390, 170 to 380, 170 to 370, 170 to 360, 170 to 350, 170 to 340, 170 to 330, 170 to 320, 170 to 310, 170 to 300, 170 to 290, 170 to 280, 170 to 270, 170 to 260, 170 to 250, 170 to 240, 170 to 230, 170 to 220, 170 to 210, 170 to 200, 170 to 190, 170 to 180, 180 to 400, 180 to 390, 180 to 380, 180 to 370, 180 to 360, 180 to 350, 180 to 340, 180 to 330, 180 to 320, 180 to 310, 180 to 300, 180 to 290, 180 to 280, 180 to 270, 180 to 260, 180 to 250, 180 to 240, 180 to 230, 180 to 220, 180 to 210, 180 to 200, 180 to 190, 190 to 400, 190 to 390, 190 to 380, 190 to 370, 190 to 360, 190 to 350, 190 to 340, 190 to 330, 190 to 320, 190 to 310, 190 to 300, 190 to 290, 190 to 280, 190 to 270, 190 to 260, 190 to 250, 190 to 240, 190 to 230, 190 to 220, 190 to 210, 190 to 200, 200 to 400, 200 to 390, 200 to 380, 200 to 370, 200 to 360, 200 to 350, 200 to 340, 200 to 330, 200 to 320, 200 to 310, 200 to 300, 200 to 290, 200 to 280, 200 to 270, 200 to 260, 200 to 250, 200 to 240, 200 to 230, 200 to 220, 200 to 210, 210 to 400, 210 to 390, 210 to 380, 210 to 370, 210 to 360, 210 to 350, 210 to 340, 210 to 330, 210 to 320, 210 to 310, 210 to 300, 210 to 290, 210 to 280, 210 to 270, 210 to 260, 210 to 250, 210 to 240, 210 to 230, 210 to 220, 220 to 400, 220 to 390, 220 to 380, 220 to 370, 220 to 360, 220 to 350, 220 to 340, 220 to 330, 220 to 320, 220 to 310, 220 to 300, 220 to 290, 220 to 280, 220 to 270, 220 to 260, 220 to 250, 220 to 240, 220 to 230, 230 to 400, 230 to 390, 230 to 380, 230 to 370, 230 to 360, 230 to 350, 230 to 340, 230 to 330, 230 to 320, 230 to 310, 230 to 300, 230 to 290, 230 to 280, 230 to 270, 230 to 260, 230 to 250, 230 to 240, 240 to 400, 240 to 390, 240 to 380, 240 to 370, 240 to 360, 240 to 350, 240 to 340, 240 to 330, 240 to 320, 240 to 310, 240 to 300, 240 to 290, 240 to 280, 240 to 270, 240 to 260, 240 to 250, 250 to 400, 250 to 390, 250 to 380, 250 to 370, 250 to 360, 250 to 350, 250 to 340, 250 to 330, 250 to 320, 250 to 310, 250 to 300, 250 to 290, 250 to 280, 250 to 270, 250 to 260, 260 to 400, 260 to 390, 260 to 380, 260 to 370, 260 to 360, 260 to 350, 260 to 340, 260 to 330, 260 to 320, 260 to 310, 260 to 300, 260 to 290, 260 to 280, 260 to 270, 270 to 400, 270 to 390, 270 to 380, 270 to 370, 270 to 360, 270 to 350, 270 to 340, 270 to 330, 270 to 320, 270 to 310, 270 to 300, 270 to 290, 270 to 280, 280 to 400, 280 to 390, 280 to 380, 280 to 370, 280 to

360, 280 to 350, 280 to 340, 280 to 330, 280 to 320, 280 to 310, 280 to 300, 280 to 290, 290 to 400, 290 to 390, 290 to 380, 290 to 370, 290 to 360, 290 to 350, 290 to 340, 290 to 330, 290 to 320, 290 to 310, 290 to 300, 300 to 400, 300 to 390, 300 to 380, 300 to 370, 300 to 360, 300 to 350, 300 to 340, 300 to 330, 300 to 320, 300 to 310, 310 to 400, 310 to 390, 310 to 380, 310 to 370, 310 to 360, 310 to 350, 310 to 340, 310 to 330, 310 to 320, 320 to 400, 320 to 390, 320 to 380, 320 to 370, 320 to 360, 320 to 350, 320 to 340, 320 to 330, 330 to 400, 330 to 390, 330 to 380, 330 to 370, 330 to 360, 330 to 350, 330 to 340, 340 to 400, 340 to 390, 340 to 380, 340 to 370, 340 to 360, 340 to 350, 350 to 400, 350 to 390, 350 to 380, 350 to 370, 350 to 360, 360 to 400, 360 to 390, 360 to 380, 360 to 370, 370 to 400, 370 to 390, 370 to 380, 380 to 400, 380 to 390, or 390 to 400 carbon atoms.

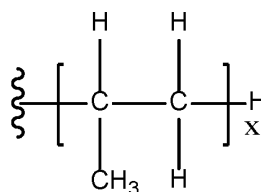
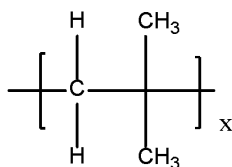
[0032] R¹ may include, for example, saturated and unsaturated hydrocarbon groups, linear and branched alkyl groups, and polyalkyl groups (e.g., polyisobutenyl group or "PIB", polyethylene, polypropylene, etc.). The polyalkyl groups may be the obtained from a polymerization reaction using olefin monomers (e.g., isobutylene).

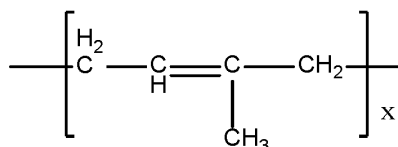
[0033] In some preferred embodiments, R¹ is a polyisobutenyl group. In some preferred embodiments, the polyisobutenyl group has an average molecular weight of about 350 to about 5000. In some preferred embodiments, the polyisobutenyl group has an average molecular weight of about 150 to about 1250, such as about 200 to about 1200, about 300 to about 1100, about 400 to about 1000, about 500 to about 900, and about 600 to about 800. In some preferred embodiments, the polyisobutenyl group has an average molecular weight of about 250 to about 1000, such as about 300 to about 900, about 400 to about 800, and about 500 to about 700.

[0034] In some preferred embodiments, the polyisobutenyl group has an average molecular weight of about 500 to about 4000, such as about 600 to about 5000, about 700 to about 5000, about 800 to about 5000, about 900 to about 5000, about 1000 to about 5000, about 500 to about 4000, such as about 600 to about 4000, about 700 to about 4000, about 800 to about 4000, about 900 to about 4000, about 1000 to about 4000, about 1100 to about 4000, about 1200 to about 4000, about 1300

to about 4000, about 1400 to about 4000, about 1500 to about 4000, about 1600 to about 4000, about 1700 to about 4000, about 1800 to about 4000, about 1900 to about 4000, about 2000 to about 4000, about 2100 to about 4000, about 2200 to about 4000, about 2300 to about 4000, about 2400 to about 4000, about 2500 to about 4000, about 2600 to about 4000, about 2700 to about 4000, about 2800 to about 4000, about 2900 to about 4000, about 3000 to about 4000, about 500 to about 3500, such as about 600 to about 3500, about 700 to about 3500, about 800 to about 3500, about 900 to about 3500, about 1000 to about 3500, about 1100 to about 3500, about 1200 to about 3500, about 1300 to about 3500, about 1400 to about 3500, about 1500 to about 3500, about 1600 to about 3500, about 1700 to about 3500, about 1800 to about 3500, about 1900 to about 3500, about 2000 to about 3500, about 2100 to about 3500, about 2200 to about 3500, about 2300 to about 3500, about 2400 to about 3500, about 2500 to about 3500, about 2600 to about 3500, about 2700 to about 3500, about 2800 to about 3500, about 2900 to about 3500, about 3000 to about 3500, about 500 to about 3000, such as about 600 to about 3000, about 700 to about 3000, about 800 to about 3000, about 900 to about 3000, about 1000 to about 3000, about 1100 to about 3000, about 1200 to about 3000, about 1300 to about 3000, about 1400 to about 3000, about 1500 to about 3000, about 1600 to about 3000, about 1700 to about 3000, about 1800 to about 3000, about 1900 to about 3000, about 2000 to about 3000, about 2100 to about 3000, about 2200 to about 3000, about 2300 to about 3000, about 2400 to about 3000, and about 2500 to about 3000.

[0035] Specific examples of R¹ include the following:

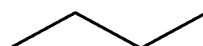
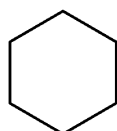
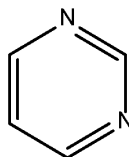
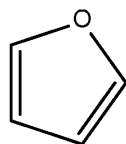
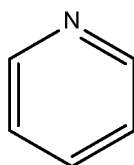
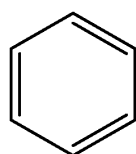


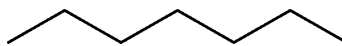
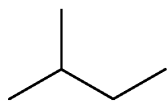


wherein x is an integer such that the total number of carbons is from 10 to 400 as described herein.

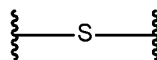
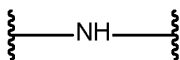
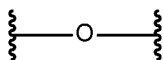
[0036] X is a moiety that includes 1 to 10 carbon atoms, such as 1 to 9, 1 to 8, 1 to 7, 1 to 6, 1 to 5, 1 to 4, 1 to 3, 1 to 2, 2 to 10, 2 to 9, 2 to 8, 2 to 7, 2 to 6, 2 to 5, 2 to 4, 2 to 3, 3 to 10, 3 to 9, 3 to 8, 3 to 7, 3 to 6, 3 to 5, 3 to 4, 4 to 10, 4 to 9, 4 to 8, 4 to 7, 4 to 6, 4 to 5, 5 to 10, 5 to 9, 5 to 8, 5 to 7, 5 to 6, 6 to 10, 6 to 9, 6 to 8, 6 to 7, 7 to 10, 7 to 9, 7 to 8, 8 to 10, 8 to 9, or 9 to 10 carbon atoms.

[0037] Specific examples of X include the following:





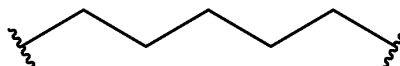
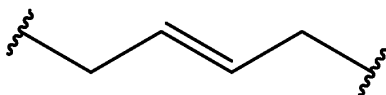
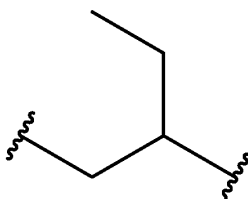
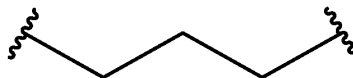
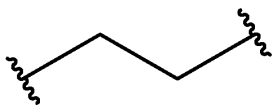
[0038] Specific examples of Y include the following:



[0039] Each R^2 is independently a moiety that includes 1 to 9 carbon atoms, such as from 1 to 5, 1 to 4, 1 to 3, 1 to 2, 2 to 6, 2 to 5, 2 to 4, 2 to 3, 3 to 6, 3 to 5, 3 to 4, 4 to 6, 4 to 5, or 5 to 6 carbon atoms.

[0040] Suitable examples of R^2 include, for example, saturated and unsaturated hydrocarbon groups, and linear and branched alkyl groups.

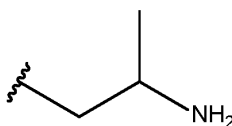
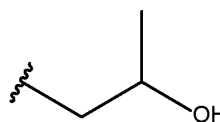
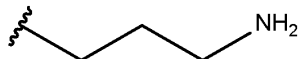
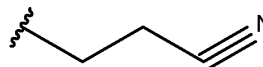
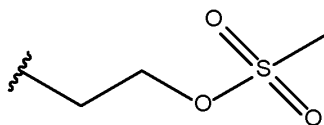
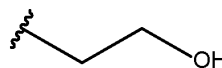
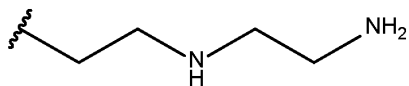
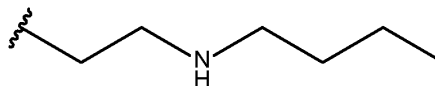
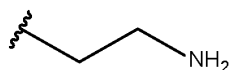
[0041] Specific examples of R^2 include the following:



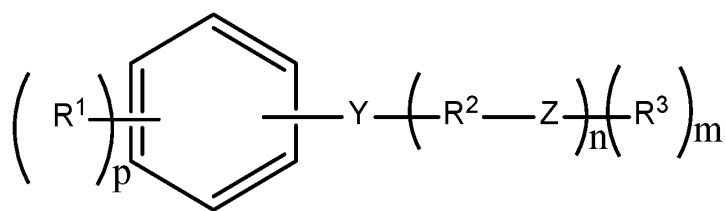
[0042] Z is nitrogen, oxygen, or sulfur atom.

[0043] Each R³ is independently a hydrogen atom or a moiety that includes 1 to 9 carbon atoms, such as from 1 to 5, 1 to 4, 1 to 3, 1 to 2, 2 to 6, 2 to 5, 2 to 4, 2 to 3, 3 to 6, 3 to 5, 3 to 4, 4 to 6, 4 to 5, or 5 to 6 carbon atoms. Each R³ moiety includes one or more nitrogen, oxygen, or sulfur functionalization.

[0044] Specific examples of R^3 include the following:



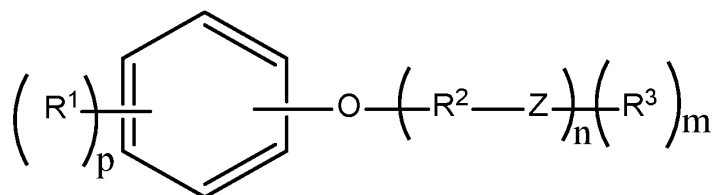
[0045] In some embodiments, the lubricant additive may have the following generalized Structure 2:



Structure 2

wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is independently nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization (e.g., $-\text{NH}_2$, $-\text{OH}$, etc.), wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3. In some preferred embodiments, Z is nitrogen. In some preferred embodiments, Z is oxygen. In some preferred embodiments, Z is oxygen or nitrogen or both. In some embodiments, Y may include one or more hydrogens.

[0046] In some embodiments, the lubricant additive may have the following generalized Structure 3:



Structure 3

wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is independently nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20 and m is 1 to 3.

[0047] Referring to the generalized structures disclosed herein, R¹ may have 10 to 400 carbon such as 10 to 380 carbons, 10 to 360 carbons, 10 to 340 carbons, 10 to 320 carbons, 10 to 300 carbons, 10 to 280 carbons, 10 to 260 carbons, 10 to 240 carbons, 10 to 220 carbons, 10 to 200 carbons, 10 to 180 carbons, 10 to 160 carbons, 10 to 140 carbons, 10 to 120 carbons, 10 to 100 carbons, 10 to 80 carbons, 10 to 60 carbons, 10 to 40 carbons, 10 to 20 carbons, 50 to 400 carbons, 50 to 380 carbons, 50 to 360 carbons, 50 to 340 carbons, 50 to 320 carbons, 50 to 300 carbons, 50 to 280 carbons, 50 to 260 carbons, 50 to 240 carbons, 50 to 220 carbons, 50 to 200 carbons, 50 to 180 carbons, 50 to 160 carbons, 50 to 140 carbons, 50 to 120 carbons, 50 to 100 carbons, 50 to 80 carbons, 50 to 60 carbon, 100 to 400 carbons, 100 to 380 carbons, 100 to 360 carbons, 100 to 340 carbons, 100 to 320 carbons, 100 to 300 carbons, 100 to 280 carbons, 100 to 260 carbons, 100 to 240 carbons, 100 to 220 carbons, 100 to 200 carbons, 100 to 180 carbons, 100 to 160 carbons, 100 to 140 carbons, 100 to 120 carbons, 150 carbons to 400 carbons, 150 to 380 carbons, 150 to 360 carbons, 150 to 340 carbons, 150 to 320 carbons, 150 to 300 carbons, 150 to 280 carbons, 150 to 260 carbons, 150 to 240 carbons, 150 to 220 carbons, 150 to 200 carbons, 150 to 180 carbons, 150 to 160 carbons, 200 to 400 carbons, 200 to 380 carbons, 200 to 360 carbons, 200 to 340 carbons, 200 to 320 carbons, 200 to 300 carbons, 200 to 280 carbons, 200 to 260 carbons, 200 to 240 carbons, 200 to 220 carbons, 250 to 400 carbons, 250 to 380 carbons, 250 to 360 carbons, 250 to 340 carbons, 250 to 320 carbons, 250 to 300 carbons, 250 to 280 carbons, 250 to 260 carbons, 300 to 400 carbons, 300 to 380 carbons, 300 to 360 carbons, 300 to 340 carbons, 300 to 320 carbons, 350 to 400 carbons, 350 to 380 carbons, or 350 to 360 carbons.

[0048] Referring to the generalized structures disclosed herein. X may have 1 to 10 carbons, such as from 1 to 9 carbons, 1 to 8 carbons, 1 to 7 carbons, 1 to 6 carbons, 1 to 5 carbons, 1 to 4 carbons, 1 to 3 carbons, 1 to 2 carbons, 2 to 10 carbons, 2 to 9 carbons, 2 to 8 carbons, 2 to 7 carbons, 2 to 6 carbons, 2 to 5 carbons, 2 to 4 carbons, 2 to 3 carbons, 3 to 10 carbons, 3 to 9 carbons, 3 to 8 carbons, 3 to 7 carbons, 3 to 6 carbons, 3 to 5 carbons, 3 to 4 carbons, 4 to 10 carbons, 4 to 9 carbons, 4 to 8 carbons,

4 to 7 carbons, 4 to 6 carbons, 4 to 5 carbons, 5 to 10 carbons, 5 to 9 carbons, 5 to 8 carbons, 5 to 7 carbons, 5 to 6 carbons, 6 to 10 carbons, 6 to 9 carbons, 6 to 8 carbons, 6 to 7 carbons, 7 to 10 carbons, 7 to 9 carbons, 7 to 8 carbons, 8 to 10 carbons, 8 to 9 carbons, or 9 to 10 carbons.

[0049] Referring to the generalized structures disclosed herein, Y may have 1 to 9 carbons, such as 1 to 8 carbons, 1 to 7 carbons, 1 to 6 carbons, 1 to 5 carbons, 1 to 4 carbons, 1 to 3 carbons, 1 to 2 carbons, 2 to 9 carbons, 2 to 8 carbons, 2 to 7 carbons, 2 to 6 carbons, 2 to 5 carbons, 2 to 4 carbons, 2 to 3 carbons, 3 to 9 carbons, 3 to 8 carbons, 3 to 7 carbons, 3 to 6 carbons, 3 to 5 carbons, 3 to 4 carbons, 4 to 9 carbons, 4 to 8 carbons, 4 to 7 carbons, 4 to 6 carbons, 4 to 5 carbons, 5 to 9 carbons, 5 to 8 carbons, 5 to 7 carbons, 5 to 6 carbons, 6 to 9 carbons, 6 to 8 carbons, 6 to 7 carbons, 7 to 9 carbons, 7 to 8 carbons, or 8 to 9 carbons.

[0050] Referring to the generalized structures disclosed herein, R¹ may have 1 to 9 carbons, such as 1 to 8 carbons, 1 to 7 carbons, 1 to 6 carbons, 1 to 5 carbons, 1 to 4 carbons, 1 to 3 carbons, 1 to 2 carbons, 2 to 9 carbons, 2 to 8 carbons, 2 to 7 carbons, 2 to 6 carbons, 2 to 5 carbons, 2 to 4 carbons, 2 to 3 carbons, 3 to 9 carbons, 3 to 8 carbons, 3 to 7 carbons, 3 to 6 carbons, 3 to 5 carbons, 3 to 4 carbons, 4 to 9 carbons, 4 to 8 carbons, 4 to 7 carbons, 4 to 6 carbons, 4 to 5 carbons, 5 to 9 carbons, 5 to 8 carbons, 5 to 7 carbons, 5 to 6 carbons, 6 to 9 carbons, 6 to 8 carbons, 6 to 7 carbons, 7 to 9 carbons, 7 to 8 carbons, or 8 to 9 carbons.

[0051] Referring to the generalized structures disclosed herein, p is 1 to 3, such as from 1, to 2, or 2 to 3.

[0052] Referring to the generalized structures disclosed herein, n is 1 to 20, such as from 1 to 19, 1 to 18, 1 to 17, 1 to 16, 1 to 15, 1 to 14, 1 to 13, 1 to 12, 1 to 11, 1 to 10, 1 to 9, 1 to 8, 1 to 7, 1 to 6, 1 to 5, 1 to 4, 1 to 3, 1 to 2, 2 to 20, 2 to 19, 2 to 18, 2 to 17, 2 to 16, 2 to 15, 2 to 14, 2 to 13, 2 to 12, 2 to 11, 2 to 10, 2 to 9, 2 to 8, 2 to 7, 2 to 6, 2 to 5, 2 to 4, 2 to 3, 3 to 20, 3 to 19, 3 to 18, 3 to 17, 3 to 16, 3 to 15, 3 to 14, 3 to 13, 3 to 12, 3 to 11, 3 to 10, 3 to 9, 3 to 8, 3 to 7, 3 to 6, 3 to 5, 3 to 4, 4 to 20, 4 to 19, 4 to 18, 4 to 17, 4 to 16, 4 to 15, 4 to 14, 4 to 13, 4 to 12, 4 to 11, 4 to 10, 4 to 9, 4

to 8, 4 to 7, 4 to 6, 4 to 5, 5 to 20, 5 to 19, 5 to 18, 5 to 17, 5 to 16, 5 to 15, 5 to 14, 5 to 13, 5 to 12, 5 to 11, 5 to 10, 5 to 9, 5 to 8, 5 to 7, 5 to 6, 6 to 20, 6 to 19, 6 to 18, 6 to 17, 6 to 16, 6 to 15, 6 to 14, 6 to 13, 6 to 12, 6 to 11, 6 to 10, 6 to 9, 6 to 8, 6 to 7, 7 to 20, 7 to 19, 7 to 18, 7 to 17, 7 to 16, 7 to 15, 7 to 14, 7 to 13, 7 to 12, 7 to 11, 7 to 10, 7 to 9, 7 to 8, 8 to 20, 8 to 19, 8 to 18, 8 to 17, 8 to 16, 8 to 15, 8 to 14, 8 to 13, 8 to 12, 8 to 11, 8 to 10, 8 to 9, 9 to 20, 9 to 19, 9 to 18, 9 to 17, 9 to 16, 9 to 15, 9 to 14, 9 to 13, 9 to 12, 9 to 11, 9 to 10, 10 to 20, 10 to 19, 10 to 18, 10 to 17, 10 to 16, 10 to 15, 10 to 14, 10 to 13, 10 to 12, 10 to 11, 11 to 20, 11 to 19, 11 to 18, 11 to 17, 11 to 16, 11 to 15, 11 to 14, 11 to 13, 11 to 12, 12 to 20, 12 to 19, 12 to 18, 12 to 17, 12 to 16, 12 to 15, 12 to 14, 12 to 13, 13 to 20, 13 to 19, 13 to 18, 13 to 17, 13 to 16, 13 to 15, 13 to 14, 14 to 20, 14 to 19, 14 to 18, 14 to 17, 14 to 16, 14 to 15, 15 to 20, 15 to 19, 15 to 18, 15 to 17, 15 to 16, 16 to 20, 16 to 19, 16 to 18, 16 to 17, 17 to 20, 17 to 19, 17 to 18, 18 to 20, 18 to 19, or 19 to 20.

[0053] Referring to the generalized structures disclosed herein, m is 1 to 3, such as from 1, to 2, or 2 to 3.

[0054] When formulated in engine oil (i.e., lubricating oil composition) or used during rapid cleaning service, the lubricant additive composition is usually present in concentrations ranging from about 0.1 to about 50.0 wt. % based on total weight of the lubricating oil composition (can be the mixed product), such as about 1 wt. % to about 50 wt. %, about 5 wt. % to about 50 wt. %, about 10 wt. % to about 50 wt. %, about 15 wt. % to about 50 wt. %, about 20 wt. % to about 50 wt. %, about 25 wt. % to about 50 wt. %, about 30 wt. % to about 50 wt. %, about 35 wt. % to about 50 wt. %, about 40 wt. % to about 50 wt. %, about 45 wt. % to about 50 wt. %, about 0.1 wt. % to about 45 wt. %, about 1 wt. % to about 45 wt. %, about 5 wt. % to about 45 wt. %, about 10 wt. % to about 45 wt. %, about 15 wt. % to about 45 wt. %, about 20 wt. % to about 45 wt. %, about 25 wt. % to about 45 wt. %, about 30 wt. % to about 45 wt. %, about 35 wt. % to about 45 wt. %, about 40 wt. % to about 45 wt. %, about 0.1 wt. % to about 40 wt. %, about 1 wt. % to about 40 wt. %, about 5 wt. % to about 40 wt. %, about 10 wt. % to about 40 wt. %, about 15 wt. % to about 40 wt. %, about 20 wt.

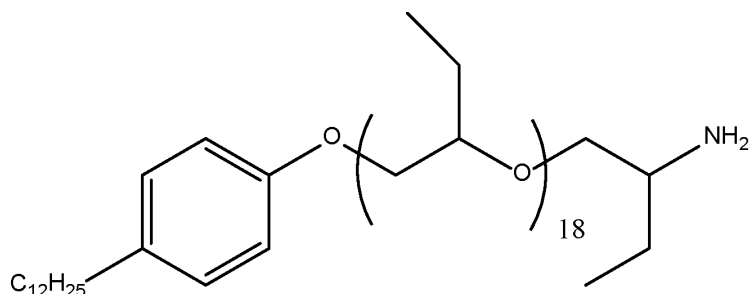
% to about 40 wt. %, about 25 wt. % to about 40 wt. %, about 30 wt. % to about 40 wt. %, about 35 wt. % to about 40 wt. %, about 0.1 wt. % to about 35 wt. %, about 1 wt. % to about 35 wt. %, about 5 wt. % to about 35 wt. %, about 10 wt. % to about 35 wt. %, about 15 wt. % to about 35 wt. %, about 20 wt. % to about 35 wt. %, about 25 wt. % to about 35 wt. %, about 30 wt. % to about 35 wt. %, about 0.1 wt. % to about 30 wt. %, about 1 wt. % to about 30 wt. %, about 5 wt. % to about 30 wt. %, about 10 wt. % to about 30 wt. %, about 15 wt. % to about 30 wt. %, about 20 wt. % to about 30 wt. %, about 25 wt. % to about 30 wt. %, about 0.1 wt. % to about 25 wt. %, about 1 wt. % to about 25 wt. %, about 5 wt. % to about 25 wt. %, about 10 wt. % to about 25 wt. %, about 15 wt. % to about 25 wt. %, and about 20 wt. % to about 25 wt. %, about 0.1 wt. % to about 20.0 wt. %, about 0.1 wt. % to about 19.0 wt. %, about 0.1 wt. % to about 18.0 wt. %, about 0.1 wt. % to about 17.0 wt. %, about 0.1 wt. % to about 16.0 wt. %, about 0.1 wt. % to about 15.0 wt. %, about 0.1 wt. % to about 14.0 wt. %, about 0.1 wt. % to about 13.0 wt. %, about 0.1 wt. % to about 12.0 wt. %, about 0.1 wt. % to about 11.0 wt. %, about 0.1 wt. % to about 10.0 wt. %, %, about 0.1 wt. % to about 9.0 wt. %, about 0.1 wt. % to about 8.0 wt. %, about 0.1 wt. % to about 7.0 wt. %, about 0.1 wt. % to about 6.0 wt. %, about 0.1 wt. % to about 5.0 wt. %, about 0.1 wt. % to about 4.0 wt. %, about 0.1 wt. % to about 3.0 wt. %, about 0.1 wt. % to about 2.0 wt. %, about 0.1 wt. % to about 1.0 wt. %, about 1.0 wt. % to about 20.0 wt. %, about 1.0 wt. % to about 19.0 wt. %, about 1.0 wt. % to about 18.0 wt. %, about 1.0 wt. % to about 17.0 wt. %, about 1.0 wt. % to about 16.0 wt. %, about 1.0 wt. % to about 15.0 wt. %, about 1.0 wt. % to about 14.0 wt. %, about 1.0 wt. % to about 13.0 wt. %, about 1.0 wt. % to about 12.0 wt. %, about 1.0 wt. % to about 11.0 wt. %, about 1.0 wt. % to about 10.0 wt. %, about 1.0 wt. % to about 9.0 wt. %, about 1.0 wt. % to about 8.0 wt. %, about 1.0 wt. % to about 7.0 wt. %, about 1.0 wt. % to about 6.0 wt. %, about 1.0 wt. % to about 5.0 wt. %, about 1.0 wt. % to about 4.0 wt. %, about 1.0 wt. % to about 3.0 wt. %, about 1.0 wt. % to about 2.0 wt. %, about 1.0 wt. % to about 1.0 wt. %, about 2.0 wt. % to about 20.0 wt. %, about 2.0 wt. % to about 19.0 wt. %, about 2.0 wt. % to about 18.0 wt. %, about 2.0 wt. % to about 17.0 wt. %, about 2.0 wt. % to about 16.0 wt. %, about 2.0 wt. % to about 15.0 wt. %, about

2.0 wt. % to about 14.0 wt. %, about 2.0 wt. % to about 13.0 wt. %, about 2.0 wt. % to about 12.0 wt. %, about 2.0 wt. % to about 11.0 wt. %, about 2.0 wt. % to about 10.0 wt. %, about 2.0 wt. % to about 9.0 wt. %, about 2.0 wt. % to about 8.0 wt. %, about 2.0 wt. % to about 7.0 wt. %, about 2.0 wt. % to about 6.0 wt. %, about 2.0 wt. % to about 5.0 wt. %, about 2.0 wt. % to about 4.0 wt. %, about 2.0 wt. % to about 3.0 wt. %, about 3.0 wt. % to about 20.0 wt. %, about 3.0 wt. % to about 19.0 wt. %, about 3.0 wt. % to about 18.0 wt. %, about 3.0 wt. % to about 17.0 wt. %, about 3.0 wt. % to about 16.0 wt. %, about 3.0 wt. % to about 15.0 wt. %, about 3.0 wt. % to about 14.0 wt. %, about 3.0 wt. % to about 13.0 wt. %, about 3.0 wt. % to about 12.0 wt. %, about 3.0 wt. % to about 11.0 wt. %, about 3.0 wt. % to about 10.0 wt. %, about 3.0 wt. % to about 9.0 wt. %, about 3.0 wt. % to about 8.0 wt. %, about 3.0 wt. % to about 7.0 wt. %, about 3.0 wt. % to about 6.0 wt. %, about 3.0 wt. % to about 5.0 wt. %, about 3.0 wt. % to about 4.0 wt. %, about 4.0 wt. % to about 20.0 wt. %, about 5.0 wt. % to about 20.0 wt. %, about 5.0 wt. % to about 19.0 wt. %, about 5.0 wt. % to about 18.0 wt. %, about 5.0 wt. % to about 17.0 wt. %, about 5.0 wt. % to about 16.0 wt. %, about 5.0 wt. % to about 15.0 wt. %, about 5.0 wt. % to about 14.0 wt. %, about 5.0 wt. % to about 13.0 wt. %, about 5.0 wt. % to about 12.0 wt. %, about 5.0 wt. % to about 11.0 wt. %, about 5.0 wt. % to about 10.0 wt. %, about 5.0 wt. % to about 9.0 wt. %, about 5.0 wt. % to about 8.0 wt. %, about 5.0 wt. % to about 7.0 wt. %, about 5.0 wt. % to about 6.0 wt. %, about 6.0 wt. % to about 20.0 wt. %, about 6.0 wt. % to about 19.0 wt. %, about 6.0 wt. % to about 18.0 wt. %, about 6.0 wt. % to about 17.0 wt. %, about 6.0 wt. % to about 16.0 wt. %, about 6.0 wt. % to about 15.0 wt. %, about 6.0 wt. % to about 14.0 wt. %, about 6.0 wt. % to about 13.0 wt. %, about 6.0 wt. % to about 12.0 wt. %, about 6.0 wt. % to about 11.0 wt. %, about 6.0 wt. % to about 10.0 wt. %, about 6.0 wt. % to about 9.0 wt. %, about 6.0 wt. % to about 8.0 wt. %, about 6.0 wt. % to about 7.0 wt. %, about 7.0 wt. % to about 20.0 wt. %, about 7.0 wt. % to about 19.0 wt. %, about 7.0 wt. % to about 18.0 wt. %, about 7.0 wt. % to about 17.0 wt. %, about 7.0 wt. % to about 16.0 wt. %, about 7.0 wt. % to about 15.0 wt. %, about 7.0 wt. % to about 14.0 wt. %, about 7.0 wt. % to about 13.0 wt. %, about 7.0 wt. % to about 12.0 wt. %, about 7.0 wt. % to about 11.0

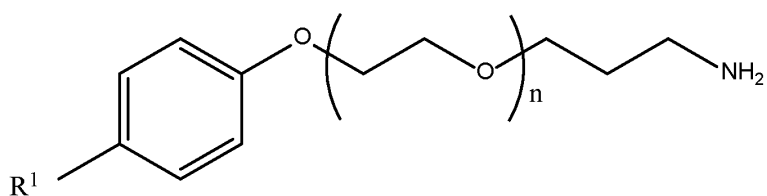
[illegible]

about 15.0 wt. % to about 20.0 wt. %, about 15.0 wt. % to about 19.0 wt. %, about 15.0 wt. % to about 18.0 wt. %, about 15.0 wt. % to about 17.0 wt. %, about 15.0 wt. % to about 16.0 wt. %, about 16.0 wt. % to about 20.0 wt. %, about 16.0 wt. % to about 19.0 wt. %, about 16.0 wt. % to about 18.0 wt. %, about 16.0 wt. % to about 17.0 wt. %, about 17.0 wt. % to about 20.0 wt. %, about 17.0 wt. % to about 19.0 wt. %, about 17.0 wt. % to about 18.0 wt. %, about 18.0 wt. % to about 20.0 wt. %, about 18.0 wt. % to about 19.0 wt. %, or about 19.0 wt. % to about 20.0 wt. %.

[0055] Specific non-limiting examples of the lubricant additive composition include the following (R¹ defined above):

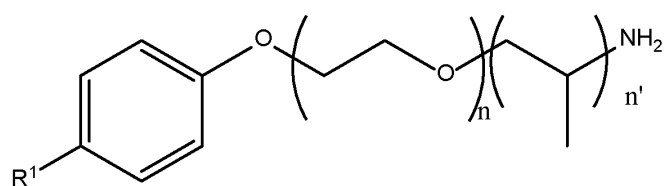


Compound 1

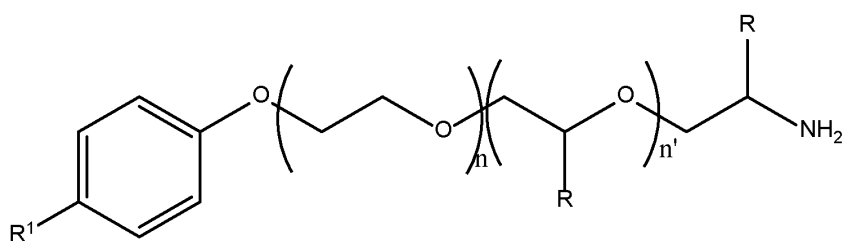


Compound 2

n = 1 to 6



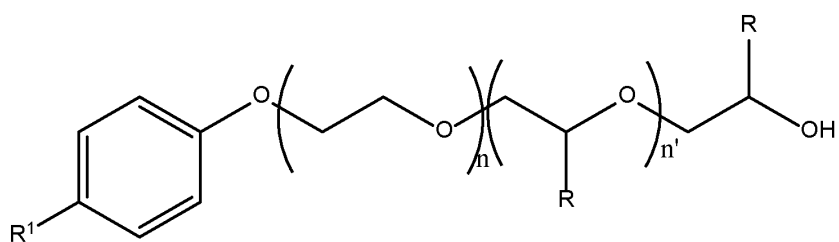
Compound 3

 $n = 0 \text{ to } 3$ $n' = 0 \text{ to } 3$ $n + n' \geq 1$ 

Compound 4

 $n = 0 \text{ to } 3$ $n' = 0 \text{ to } 3$ $n + n' \geq 1$

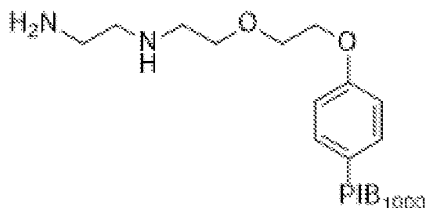
R = H methyl ethyl



Compound 5

 $n = 0 \text{ to } 3$ $n' = 0 \text{ to } 3$ $n + n' \geq 1$

R = H methyl ethyl



Compound 6

Synthesis

[0056] The lubricant additive composition or derivative or analogs thereof may be synthesized by any compatible method.

[0057] Other derivatization reactions may also be contemplated such between any of the lubricant additive compounds and a suitable reagent such as ethylene oxide, propylene oxide, butylene oxide, vinyl oxirane, diglycidyl ether, acrylonitrile, ammonia, and the like.

Base Oil

[0058] The lubricating oil composition of the present invention includes one or more base oils. These include, for example, Group I, II, III, IV, or V base oils, and biobased base oils. Examples of suitable biobased base oils are described in US Patent Pub No. 20230167378, which is hereby incorporated by reference.

[0059] Base stocks may be manufactured using a variety of different processes including, but not limited to, distillation, solvent refining, hydrogen processing, oligomerization, esterification, and rerefining. Rerefined stock shall be substantially free from materials introduced through manufacturing, contamination, or previous use. The base oil of the lubricating oil compositions of this invention may be any natural or synthetic lubricating base oil. Suitable hydrocarbon synthetic oils include, but are not limited to, oils prepared from the polymerization of ethylene or from the polymerization of 1-olefins to provide polymers such as polyalphaolefin or PAO oils,

or from hydrocarbon synthesis procedures using carbon monoxide and hydrogen gases such as in a Fischer-Tropsch process.

[0060] Moreover, the one or more base oils may include base oils from the same group (e.g., Group II Chevron Neutral Oil 600R®, Group II Chevron Neutral Oil 220R® and Group II Chevron Neutral Oil 100R®). The amount of base oil(s) is about 40 wt. % or greater (“a major amount”) based on the total weight of the lubricating oil composition, such as from about 45 wt. % or greater, 50 wt. % or greater, 55 wt. % or greater, 60 wt. % or greater, and so forth.

[0061] Groups I, II, III, IV and V are broad categories of base oil stocks developed and defined by the American Petroleum Institute (API Publication 1509—Appendix E) to create guidelines for lubricant base oils. Group I base stocks contain less than 90% saturates and/or greater than 0.03% sulfur and have a viscosity index greater than or equal to 80 and less than 120. Group II base stocks contain greater than or equal to 90% saturates and less than or equal to 0.03% sulfur and have a viscosity index greater than or equal to 80 and less than 120. Group III base stocks contain greater than or equal to 90% saturates and less than or equal to 0.03% sulfur and have a viscosity index greater than or equal to 120. Group IV base stocks are polyalphaolefins. Group V base stocks include all other base stocks not included in Groups I, II, III or IV. Table 1 summarizes properties of each of these five groups.

Table 1

Base Oil Properties

Group ⁽¹⁾	Saturates ⁽²⁾	Sulfur ⁽³⁾	Viscosity Index ⁽⁴⁾
Group I	< 90% and/or	> 0.03%	80 to < 120
Group II	≥ 90%	≤ 0.03%	80 to < 120
Group III	≥ 90%	≤ 0.03%	≥ 120
Group IV	Polyalphaolefins (PAOs)		
Group V	All other base stocks not included in Groups I, II, III, or IV		

(1) Group I-III are mineral oil base stocks

(2) ASTM D2007

(3) ASTM D2622, ASTM D3120, ASTM D4294 or ASTM D4927

(4) ASTM D2270

Lubricating Oil Composition

[0062] The lubricating oil composition of this disclosure can be identified by viscosity standards of the Society of Automotive Engineers (SAE) for engine oils (i.e., the SAE J300 standard). The SAE J300 viscosity grades are summarized in Table 2.

Table 2

SAE Viscosity Grade	Low Temp (°C) Cranking Viscosity ⁽¹⁾ , mPa*s Max	Low Temp (°C) Pumping Viscosity ⁽²⁾ , mPa*s Max with No Yield Stress	Low Shear Rate Kinematic Viscosity ⁽³⁾ (mm ² /s) at 100°C Min	Low Shear Rate Kinematic Viscosity ⁽³⁾ (mm ² /s) at 100°C Max	High Shear Rate Viscosity ⁽⁴⁾ , (mPa*s) at 150°C Min
0W	6200 at -35	60000 at -40	3.8	-	-
5W	6600 at -30	60000 at -35	3.8	-	-
10W	7000 at -25	60000 at -30	4.1	-	-
15W	7000 at -20	60000 at -25	5.6	-	-
20W	9500 at -15	60000 at -20	5.6	-	-
25W	13000 at -10	60000 at -15	9.3	-	-
8	-	-	4.0	<6.1	1.7
12	-	-	5.0	<7.1	2.0
16	-	-	6.1	<8.2	2.3
20	-	-	6.9	<9.3	2.6
30	-	-	9.3	<12.5	2.9
40	-	-	12.5	<16.3	3.5 ⁽⁵⁾
40	-	-	12.5	<16.3	3.7 ⁽⁶⁾
50	-	-	16.3	<21.9	3.7
60	-	-	21.9	<26.1	3.7

- (1) ASTM D5293
- (2) ASTM D4684
- (3) ASTM D445
- (4) ASTM D4683, ASTM D4741, ASTM D5481 or CEC L-36-90
- (5) For 0W-40, 5W-40 and 10W-40 grades
- (6) For 15W-40, 20W-40, 25W-40 and 40 grades

[0063] The lubricating oil composition of this disclosure may be a monograde engine oil, e.g., a SAE 20, SAE 30, SAE 40, SAE 50 or SAE 60 viscosity grade engine oil.

[0064] The lubricating oil composition of this disclosure may be a multi-grade engine oil, e.g., an engine oil with a SAE viscosity grade of 15W-X, 20W-X or 25W-X, where X may be selected from 30, 40, 50, or 60.

Additional Additives

[0065] The lubricating oil compositions of the present disclosure may contain one or more performance additives that can impart or improve any desirable property of the lubricating oil composition. Any additive known to those of skill in the art may be used in the lubricating oil composition disclosed herein. Some suitable additives have been described by R. M. Mortier et al. "Chemistry and Technology of Lubricants," 3rd Edition, Springer (2010) and L. R. Rudnik "Lubricant Additives: Chemistry and Applications," Second Edition, CRC Press (2009).

[0066] In general, the concentration of each of the additives in the lubricating oil composition, when used, may range from 0.001 to 60 wt. % (e.g., 0.01 to 50 wt. %, or 0.05 to 40 wt. %) of the lubricating oil composition. Further, the total amount of additives in the lubricating oil composition may range from 0.001 to 70 wt. % (e.g., 0.01 to 50 wt. % or 0.1 to 40 wt. %) of the lubricating oil composition.

[0067] The present lubricating oil composition may additionally contain one or more of the other commonly used lubricating oil performance additives including antioxidants, anti-wear agent, metal detergents, dispersants, friction modifiers, corrosion inhibitors, demulsifiers, viscosity modifiers, pour point depressants, foam inhibitors, and others.

Antioxidants

[0068] Antioxidants retard the oxidative degradation of base oils during service. Such degradation may result in deposits on metal surfaces, the presence of sludge, or a viscosity increase in the lubricant. Useful antioxidants include hindered phenols, aromatic amines, and sulfurized alkylphenols and alkali and alkaline earth metal salts thereof.

[0069] The hindered phenol antioxidant may contain a secondary butyl and/or a tertiary butyl group as a sterically hindering group. The phenol group may be further substituted with a hydrocarbyl group and/or a bridging group linking to a second aromatic group. Examples of suitable hindered phenol antioxidants include 2,6-di-tert-butylphenol, 4-methyl-2,6-di-tert-butylphenol, 2,2'-methylenebis(6-tert-butyl-4-methylphenol), 4,4'-bis(2,6-di-tert-butylphenol) and 4,4'-methylenebis(2,6-di-tert-butylphenol). The hindered phenol antioxidant may be an ester or an addition product derived from 2,6-di-tert-butylphenol and an alkyl acrylate, wherein the alkyl group may contain from 1 to 18 carbon atoms.

[0070] Suitable aromatic amine antioxidants include diarylamines such as alkylated diphenylamines (e.g., dioctyl diphenylamine, dinonyl diphenylamine), phenyl-alpha-naphthalene and alkylated phenyl-alpha-naphthalenes.

Anti-Wear Agents

[0071] Anti-wear agents reduce wear of metal parts. Examples of anti-wear agents include phosphorus-containing anti-wear/extreme pressure agents such as metal thiophosphates, phosphoric acid esters and salts thereof, phosphorus-containing carboxylic acids, esters, ethers, and amides; and phosphites. The anti-wear agent may be a zinc dialkyldithiophosphate. Non-phosphorus-containing anti-wear agents include borate esters (including borated epoxides), dithiocarbamate compounds, molybdenum-containing compounds, and sulfurized olefins.

Metal Detergents

[0072] A typical detergent is an anionic material that contains a long chain hydrophobic portion of the molecule and a smaller anionic or oleophobic hydrophilic portion of the molecule. The anionic portion of the detergent is typically derived from an organic acid such as a sulfur acid, carboxylic acid, phosphorous acid, phenol, or mixtures thereof. The counterion is typically an alkaline earth or alkali metal.

[0073] In some embodiments, the lubricating oil composition provided herein comprises at least a neutral or overbased metal detergent as an additive, or additive components. In certain embodiments, the metal detergents in lubricating oil compositions acts as a neutralizer of acidic products within the oil. In certain embodiments, the metal detergent prevents the formation of deposits on the surface of an engine. Depending on the nature of the acid used, the detergent may have additional functions, for example, antioxidant properties. In certain aspects, lubricating oil compositions contain metal detergents comprising either overbased detergents or mixtures of neutral and overbased detergents. The term "overbased" is intended to define additives which contain a metal content in excess of that required by the stoichiometry of the particular metal and the particular organic acid used. The excess metal exists in the form of particles of inorganic base (e.g., a hydroxide or carbonate) surrounded by a sheath of metal salt. The sheath serves to maintain the particles in dispersion in a liquid oleaginous vehicle. The amount of excess metal is commonly expressed as the ratio of total equivalence of excess metal to equivalence of organic acid and is typically in a range of 0.1 to 30.

[0074] Overbased detergents may be further characterized as low overbased, medium overbased, or high overbased. Low overbased detergents may be, for example, an overbased salt having a TBN below 100. In one embodiment, the TBN of a low overbased salt may be from about 5 to about 50. In another embodiment, the TBN of a low overbased salt may be from about 10 to about 30. In yet another embodiment, the TBN of a low overbased salt may be from about 15 to about 20.

[0075] Medium overbased detergents, may be, for example, an overbased salt having a TBN from about 100 to about 250. In one embodiment, the TBN of a medium

overbased salt may be from about 100 to about 200. In another embodiment, the TBN of a medium overbased salt may be from about 125 to about 175.

[0076] High overbased detergents may be, for example, an overbased salt having a TBN above 250. In one embodiment, the TBN of a high overbased salt may be from about 250 to about 550.

[0077] Some examples of suitable metal detergents include sulfurized or unsulfurized alkyl or alkenyl phenates, alkyl or alkenyl aromatic sulfonates, borated sulfonates, sulfurized or unsulfurized metal salts of multi-hydroxy alkyl or alkenyl aromatic compounds, alkyl or alkenyl hydroxy aromatic sulfonates, sulfurized or unsulfurized alkyl or alkenyl naphthenates, metal salts of alkanoic acids, metal salts of an alkyl or alkenyl multiacid, and chemical and physical mixtures thereof. Other examples of suitable metal detergents include metal sulfonates, phenates, salicylates (i.e. carboxylates, hydroxybenzoates), phosphonates, thiophosphonates and combinations thereof. The metal can be any metal suitable for making sulfonate, phenate, salicylate or phosphonate detergents. Non-limiting examples of suitable metals include alkali metals, alkaline metals and transition metals. In some embodiments, the metal is Ca, Mg, Ba, K, Na, Li or the like. An exemplary metal detergent which may be employed in the lubricating oil compositions includes overbased sulfurized calcium phenate.

Ashless Dispersants

[0078] A dispersant is an additive whose primary function is to hold solid and liquid contaminations in suspension, thereby passivating them and reducing engine deposits at the same time as reducing sludge depositions. For example, a dispersant maintains in suspension oil-insoluble substances that result from oxidation during use of the lubricant, thus preventing sludge flocculation and precipitation or deposition on metal parts of the engine.

[0079] Dispersants are usually "ashless", being non-metallic organic materials that form substantially no ash on combustion, in contrast to metal-containing, and hence ash-forming materials. They comprise a long hydrocarbon chain with a polar

head, the polarity being derived from inclusion of at least one nitrogen, oxygen or phosphorus atom. The hydrocarbon is an oleophilic group that confers oil-solubility, having, for example, 40 to 500 carbon atoms. Thus, ashless dispersants may comprise an oil-soluble polymeric backbone.

[0080] A preferred class of olefin polymers is constituted by polybutylenes, specifically polyisobutylenes (PIB) or poly-n-butylenes, such as may be prepared by polymerization of a C4 refinery stream.

[0081] Dispersants include, for example, derivatives of long chain hydrocarbon-substituted carboxylic acids, examples being derivatives of high molecular weight hydrocarbyl-substituted succinic acid. A noteworthy group of dispersants is constituted by hydrocarbon-substituted succinimides, made, for example, by reacting the above acids (or derivatives) with a nitrogen-containing compound, advantageously a polyalkylene polyamine, such as a polyethylene polyamine. Typical commercially available polyisobutylene-based succinimide dispersants contain polyisobutylene polymers having a number average molecular weight ranging from 900 to 2500, functionalized by maleic anhydride, and derivatized with polyamines having a molecular weight of from 100 to 350.

[0082] Other suitable dispersants include succinic esters and ester-amides, Mannich bases, polyisobutylene succinic acid (PIBSA), and other related components.

[0083] Succinic esters are formed by the condensation reaction between hydrocarbon-substituted succinic anhydrides and alcohols or polyols. For example, the condensation product of a hydrocarbon-substituted succinic anhydride and pentaerythritol is a useful dispersant.

[0084] Succinic ester-amides are formed by condensation reaction between hydrocarbon-substituted succinic anhydrides and alkanol amines. For example, suitable alkanol amines include ethoxylated polyalkylpolyamines, propoxylated polyalkylpolyamines and polyalkenylpolyamines such as polyethylene polyamines. One example is propoxylated hexamethylenediamine.

[0085] Mannich bases are made from the reaction of an alkylphenols, formaldehyde, and a polyalkylene polyamines. Molecular weights of the alkylphenol may range from 800 to 2500.

[0086] Nitrogen-containing dispersants may be post-treated by conventional methods to improve their properties by reaction with any of a variety of agents. Among these are boron compounds (e.g., boric acid) and cyclic carbonates (e.g., ethylene carbonate).

Friction Modifiers

[0087] A friction modifier is any material or materials that can alter the coefficient of friction of a surface lubricated by any lubricant or fluid containing such material(s). Friction modifiers include alkoxylated fatty amines, borated fatty epoxides, fatty phosphites, fatty epoxides, fatty amines, borated alkoxylated fatty amines, metal salts of fatty acids, fatty acid amides, glycerol esters, borated glycerol esters and fatty imidazolines. As used herein, the term "fatty" means a hydrocarbon chain having 10 to 22 carbon atoms, typically a straight hydrocarbon chain.

[0088] Other known friction modifiers comprise oil-soluble organo-molybdenum compounds. Such organo-molybdenum friction modifiers also provide antioxidant and anti-wear credits to a lubricating oil composition. Suitable oil-soluble organo-molybdenum compounds have a molybdenum-sulfur core. As examples, there may be mentioned dithiocarbamates, dithiophosphates, dithiophosphinates, xanthates, thioxanthates, sulfides, and mixtures thereof. The molybdenum compound may be dinuclear or trinuclear.

Corrosion Inhibitors

[0089] Corrosion inhibitors protect lubricated metal surfaces against chemical attack by water or other contaminants. Suitable corrosion inhibitors include polyoxyalkylene polyols and esters thereof, polyoxyalkylene phenols, thiadiazoles and anionic alkyl sulfonic acids.

Viscosity Modifiers

[0090] Viscosity modifiers provide lubricants with high and low temperature operability. These additives increase the viscosity of the oil composition at elevated temperatures which increases film thickness, while having limited effect on viscosity at low temperatures.

[0091] Suitable viscosity improvers include high molecular weight hydrocarbons, polyesters and viscosity index improver dispersants that function as both a viscosity index improver and a dispersant. Typical molecular weights of these polymers are in a range of 1000 to 1,000,000 (e.g., 2000 to 500,000 or 25,000 to 100,000).

[0092] Examples of suitable viscosity improvers are polymers and copolymers of methacrylate, butadiene, olefins, or alkylated styrenes. Polyisobutylene is a commonly used viscosity modifier. Another suitable viscosity modifier is polymethacrylate (copolymers of various chain length alkyl methacrylates, for example), some formulations of which also serve as pour point depressants. Other suitable viscosity modifiers include copolymers of ethylene and propylene, hydrogenated block copolymers of styrene and isoprene, and polyacrylates (copolymers of various chain length acrylates, for example). Specific examples include styrene-isoprene or styrene-butadiene based polymers of 50,000 to 200,000 molecular weight.

Pour Point Depressants

[0093] Pour point depressants lower the minimum temperature at which a fluid will flow or can be poured. Suitable pour point depressants include C8 to C18 dialkyl fumarate/vinyl acetate copolymers, polyalkylmethacrylates and the like.

Foam Inhibitors

[0094] Foam inhibitors retard the formation of stable foams. Examples of suitable foam inhibitors include polysiloxanes, polyacrylates, and the like.

Thickener

[0095] A thickener can increase the viscosity of a lubricating oil composition in order to achieve a desired viscosity grade. Any suitable thickener such as

polyisobutylene (PIB) may be used. PIB is a commercially available material from several manufacturers. Polyisobutylene is typically a viscous oil-miscible liquid having a number average molecular weight of 800 to 5000 (e.g., 1000 to 2500) and a kinematic viscosity at 100° C. of 200 to 5000 mm²/s (e.g., 200 to 1000 mm²/s). The amount of PIB added to the lubricating oil composition will normally be from 1 to 20 wt. % (e.g., 2 to 15 wt. % or 4 to 12 wt. %) of the finished oil.

EXAMPLES

[0096] The following non-limiting examples are illustrative of the present invention. Brief descriptions of how the examples were prepared and the test methods used in evaluation of the inventive lubricants are provided.

Black Sludge Deposit Test

[0097] This test was used to evaluate the ability of lubricants to cope with instable-unburned asphaltenes in residual fuel oil. The test measures the tendency of lubricants to cause deposits on a test strip, by applying oxidative thermal strain on a mixture of heavy fuel oil and lubricant.

[0098] During this test, a sample of lubricating oil composition is mixed with a specific amount of residual fuel to form test mixtures. The test mixture is injected as a thin film over a metal test strip for a period of time (12 hours) and temperature (200 °C). Next, the test strip is cooled, washed, dried, and then weighed. In this manner, the weight of the deposit (in mg) is measured and recorded as the change in weight of the test strip.

DSC Oxidation Test

[0099] The DSC test was used to evaluate thin film oxidation stability of test oils, in accordance with ASTM D-6186. Heat flow to and from test oil in a sample cup is compared against a reference cup during the test.

[0100] The Oxidation Onset Temperature is the temperature at which the oxidation of the test oil starts. The Oxidation Induction Time (OIT) is the time at which the oxidation of the test oil starts. A higher oxidation induction time indicates better performance. The oxidation reaction is exothermic as shown by the heat flow. The Oxidation Induction Time evaluates the thin film oxidation stability of the test oil.

Oxidation Deposit Test (ODT)

[0101] Lubricating oil samples were formulated and tested for oxidation performance via the Oxidation Deposit Test. ODT is a deposit bench test that generates deposits by splashing heated oil onto a heated metal plate for a specified interval and duration. The test is described in greater detail in US Pat. No. 8,549,897, which is hereby incorporated by reference.

TEOST MHT4 TEST

[0102] TEOST MHT4 or ASTM D-7097 is designed to predict the deposit-forming tendencies of engine oils in the piston ring belt and upper piston crown area. This test determines the mass of deposit formed on a specially constructed test rod exposed to repetitive passage of 8.5 g of engine oil over the rod in a thin film under oxidative and catalytic conditions at 285 °C.

[0103] Deposit-forming tendencies of an engine oil under oxidative conditions was determined by circulating an oil-catalyst mixture comprising a small sample (8.4 g) of the oil and a very small (0.1 g) amount of an organo-metallic catalyst. This mixture was circulated for 24 hours in the TEOST MHT instrument over a special wire-wound depositor rod heated by electrical current to a controlled temperature of 285 °C at the hottest location on the rod. The rod was weighed before and after the test. Deposit that fell off the depositor rod into the oil was filtered and weighed. Total deposit is sum of the weight of deposits on depositor rod and on the filter.

Base Oil Components

[0104] The base oil components used in the formulations of the examples include the following:

- a) 600N: ExxonMobil CORE® 600N Group I lubricating oil with K_v @100°C of 12.4 cSt;
- b) 2500BS ExxonMobil CORE® 2500BS Group I lubricating oil with K_v @100°C of 30.6 cSt;
- c) 600R: Chevron RLOP® 600R Group II lubricating oil with K_v @100°C of 11.9 cSt;
- d) 220R: Chevron RLOP® 220R Group II lubricating oil with K_v @100°C of 6.45 cSt;
- e) 100R: Chevron RLOP® 100R Group II lubricating oil with K_v @100°C of 4.2 cSt;
- f) 150N: ExxonMobil CORE® 150N Group I lubricating oil with K_v @100°C of 5.3 cSt;
- g) PIB-1: 2300 MW polyisobutylene;
- h) PIB-2: 1000 MW polyisobutylene

Example 1 and Comparative Example A

[0105] The Oxidation Onset Temperature is the temperature at which the oxidation of the test oil starts. The Oxidation Induction Time (OIT) is the time at which the oxidation of the test oil starts. A higher oxidation induction time indicates better performance. The oxidation reaction is exothermic as shown by the heat flow. The Oxidation Induction Time evaluates the thin film oxidation stability of the test oil.

Example 1 and Comparative Example A were formulated to provide marine cylinder lubricating (MCL) oils with the following finished oil specifications: 40 BN, SAE 50 viscosity grade (K_v @100 °C of 18.5 mm²/s). The following baseline components were used in Comparative Example A and Example 1:

- a) 8.5 wt.% of an oil concentrate of a 410BN high overbased calcium sulfonate detergent (38.7 wt.% diluent oil)
- b) 2.6 wt.% of an oil concentrate of a 95BN low overbased calcium sulfurized phenate detergent derived from C20-24 isomerized alpha olefin (20.0 wt.% diluent oil)
- c) 0.2 wt.% of an oil concentrate of a bissuccinimide dispersant derived from 1000MW PIB (30.0 wt.% of diluent oil)
- d) 1.0 wt.% aminic antioxidant
- e) 0.1 wt.% foam inhibitor

[0106] The formulation of Example 1 was identical to Comparative Example A. However, Example 1 further contained 6.0 wt.% of Compound 1.

[0107] Each of the finished oil lubricants were evaluated for deposit performance using the Black Sludge Deposit test. The results are set forth in Table 3 below.

Table 3

	Comparative Example A	Example 1
Compound 1	-	6.0
Baseoil 600R	79.85	75.69
Thickener PIB-1	7.75	5.91
Deposits, mg	9.80	0.0

[0108] The results set forth in Table 3 show that the marine cylinder lubricating oil composition containing lubricant additive Compound 1 exhibited less black sludge

deposit formation as compared to Comparative Example A. In addition to improved deposit control performance, the marine diesel cylinder lubricating oil composition of Example 1 achieved the desired viscosity using less PIB-1 thickener (2300MW PIB) and less of the heavy 600R baseoil than the comparative example, demonstrating the thickening capability of lubricant additive Compound 1.

Example 2 and Comparative Example B

[0109] Example 2 and Comparative Example B were formulated to provide marine trunk piston engine oils (TPEO) with the following specifications: 12 BN, SAE 40 viscosity grade (K_v @100 °C of 14.5 mm²/s).

The following baseline components were used in Example 2 and Comparative Example B:

- a) 0.85 wt.% of an oil concentrate of a 420BN high overbased calcium hydroxybenzoate detergent derived from C20-24 isomerized alpha olefin (33.0 wt.% diluent oil)
- b) 4.0 wt.% of an oil concentrate of a 180BN medium overbased calcium hydroxybenzoate detergent derived from C20-24 isomerized alpha olefin (20.0 wt.% diluent oil)
- c) 5.0 wt.% of an oil concentrate of an ethylene carbonate post-treated bissuccinimide dispersant derived from 2300MW PIB (43.0 wt.% diluent oil)
- d) 0.5 wt.% aminic antioxidant
- e) 0.7 wt.% zinc dithiophosphate from primary C8 alcohols
- f) 0.1 wt.% foam inhibitor

[0110] The formulation of Example 2 was identical to Comparative Example B. However, Example 2 further contained 3.0 wt.% of Compound 1.

[0111] Each of the finished oil lubricants were evaluated for deposit performance using the Black Sludge Deposit test. The results are set forth in Table 4 below.

Table 4

	Comparative Example B	Example 2
Compound 1	-	3.0
Baseoil 150N	4.8	9.63
Baseoil 600N	84.1	76.22
Deposits, mg	47.0	0.0

[0112] The results set forth in Table 4 show that the marine trunk piston engine lubricating oil composition containing lubricating additive Compound 1 exhibited surprisingly better deposit performance over Comparative Example B, as Example 2 exhibited less black sludge deposit formation as compared to Comparative Example B. In addition to improved deposit control performance, the marine trunk piston engine lubricating oil composition of Example 2 achieved the desired viscosity without the use of conventional thickeners (i.e. brightstock, PIB), and less use of heavy 600N baseoil, demonstrating the thickening capability of lubricant additive Compound 1.

Example 3 and Comparative Example C

[0113] Example 3 and Comparative Example C were formulated to provide marine trunk piston engine oils (TPEO) with the following specifications: 12 BN, SAE 40 viscosity grade (K_v @100 °C of 14.5 mm²/s).

[0114] The following baseline components were used in Example 3 and Comparative Example C:

- a) 0.85 wt.% of an oil concentrate of a 420BN high overbased calcium hydroxybenzoate detergent derived from C20-24 isomerized alpha olefin (33.0 wt.% diluent oil)
- b) 4.0 wt.% of an oil concentrate of a 180BN medium overbased calcium hydroxybenzoate detergent derived from C20-24 isomerized alpha olefin (20.0 wt.% diluent oil)
- c) 5.0 wt.% of an oil concentrate of an ethylene carbonate post-treated bissuccinimide dispersant derived from 2300MW PIB (43.0 wt.% diluent oil)
- d) 0.5 wt.% aminic antioxidant
- e) 0.7 wt.% zinc dithiophosphate from primary C8 alcohols
- f) 0.1 wt.% foam inhibitor

[0115] The formulation of Example 3 was identical to Comparative Example C. However, Example 3 further contained 3.0 wt.% of Compound 6. Each of the finished oil lubricants were evaluated for deposit performance using the Black Sludge Deposit test. The results are set forth in Table 5 below.

Table 5

	Comparative Example C	Example 3
Compound 6	-	3.0
Baseoil 150N	7.15	9.63
Baseoil 600N	81.7	76.22
Deposits, mg	47.0	0.0

[0116] The results set forth in Table 5 show that the marine trunk piston engine lubricating oil composition containing lubricating additive Compound 6 exhibited surprisingly better deposit performance over Comparative Example C, as Example 3 exhibited less black sludge deposit formation as compared to Comparative Example C. In addition to improved deposit control performance, the marine trunk piston engine lubricating oil composition of Example 3 achieved the desired viscosity without the use of conventional thickeners (i.e. brightstock, PIB), and less use of heavy 600N baseoil, demonstrating the thickening capability of lubricant additive Compound 6.

Example 4 and Comparative Example D

[0117] Example 4 and Comparative Example D were formulated to provide marine cylinder lubricating (MCL) oils with the following finished oil specifications: 40 BN, SAE 50 viscosity grade (K_v @100 °C of 18.5 mm²/s).

[0118] The following baseline components were used in Comparative Example D and Example 4:

- a) 8.5 wt.% of an oil concentrate of a 410BN high overbased calcium sulfonate detergent (38.7 wt.% diluent oil)
- b) 2.6 wt.% of an oil concentrate of a 95BN low overbased calcium sulfurized phenate detergent derived from C20-24 isomerized alpha olefin (20.0 wt.% diluent oil)
- c) 0.2 wt.% of an oil concentrate of a bissuccinimide dispersant derived from 1000MW PIB (30.0 wt.% of diluent oil)
- d) 1.0 wt.% aminic antioxidant
- e) 0.1 wt.% foam inhibitor

[0119] The formulation of Example 4 was identical to Comparative Example D. However, Example 4 further contained 6.0 wt.% of Compound 6.

[0120] Each of the finished oil lubricants were evaluated for deposit performance using the Black Sludge Deposit test. The results are set forth in Table 6 below.

Table 6

	Comparative Example D	Example 4
Compound 6	-	6.0
Baseoil 600R	78.85	75.3
Thickener PIB-1	8.75	6.3
Deposits, mg	9.80	4.4

[0121] The results set forth in Table 6 show that the marine cylinder lubricating oil composition containing lubricant additive Compound 6 exhibited less black sludge deposit formation as compared to Comparative Example D. In addition to improved deposit control performance, the marine diesel cylinder lubricating oil composition of Example 4 achieved the desired viscosity using less PIB-1 thickener (2300MW PIB) and heavy baseoil 600R than the comparative example, demonstrating the thickening capability of lubricant additive Compound 6.

Example 5 and Comparative Example E

[0122] Example 5 and Comparative Example E were formulated to provide natural gas engine oil (NGEO) compositions with the following specifications: SAE 40 viscosity grade, sulfated ash 0.43 percent.

[0123] The following baseline components were used in Example 5 and Comparative Example E:

- a) 1.0 wt.% of an oil concentrate of a high overbased calcium sulfurized phenate detergent (30.0 wt.% diluent oil)
- b) 0.5 wt.% of an oil concentrate of a low overbased calcium sulfonate detergent (50.0 wt.% diluent oil)
- c) 2.3 wt.% of an ethylene carbonate post treated bissuccinimide dispersant derived from 1000MW PIB
- d) 0.75 wt.% antioxidant
- e) 0.38 wt.% zinc dithiophosphate
- f) 1.05 wt.% diluent oil

[0124] The formulation of Example 5 was identical to Comparative Example E. However, Example 5 further contained 4.0 wt.% of Compound 6.

[0125] Each of the finished oil lubricants were evaluated for oxidation performance using the ODT test. The results are set forth in Table 7 below.

Table 7

	Comparative Example E	Example 5
Compound 6	-	4.0
Baseoil 600N	94.0	90.0
Deposits, mg	52.4	22.6

[0126] The results set forth in Table 7 show that the natural gas engine lubricating oil composition containing lubricant additive Compound 6 exhibited less deposit formation as compared to Comparative Example E.

Example 6 and Comparative Example F

[0127] Example 6 and Comparative Example F were formulated to provide natural gas engine oil (NGEO) compositions with the following specifications: SAE 40 viscosity grade, sulfated ash 0.49 percent.

[0128] The following baseline components were used in Example 6 and Comparative Example F:

- a) 2.3 wt.% of an oil concentrate of a low overbased calcium sulfurized phenate detergent (48.0 wt.% diluent oil)
- b) 0.5 wt.% of an oil concentrate of a medium overbased calcium hydroxybenzoate detergent derived from C20-24 isomerized alpha olefin (20.0 wt.% diluent oil)
- c) 0.5 wt.% of an oil concentrate of a low overbased calcium sulfonate detergent (50.0 wt.% diluent oil)
- d) 1.5 wt.% of an ethylene carbonate post treated bissuccinimide dispersant derived from 2300MW PIB
- e) 2.0 wt.% antioxidant
- f) 0.1 wt.% corrosion inhibitor
- g) 0.38 wt.% zinc dithiophosphate
- h) 0.5 wt.% diluent oil

[0129] The formulation of Example 6 was identical to Comparative Example F. However, Example 6 further contained 4.0 wt.% of Compound 6.

[0130] Each of the finished oil lubricants were evaluated for oxidation performance using the ODT test. The results are set forth in Table 8 below.

Table 8

	Comparative Example F	Example 6
Compound 6	-	4.0
Baseoil 600R	92.0	88.2
Deposits, mg	58.5	23.7

[0131] The results set forth in Table 8 show that the natural gas engine lubricating oil composition containing lubricant additive Compound 6 exhibited less deposit formation as compared to Comparative Example F.

[0132] For the sake of brevity, only certain ranges are explicitly disclosed herein. However, ranges from any lower limit may be combined with any upper limit to recite a range not explicitly recited, as well as, ranges from any lower limit may be combined with any other lower limit to recite a range not explicitly recited, in the same way, ranges from any upper limit may be combined with any other upper limit to recite a range not explicitly recited. Additionally, within a range includes every point or individual value between its end points even though not explicitly recited. Thus, every point or individual value may serve as its own lower or upper limit combined with any other point or individual value or any other lower or upper limit, to recite a range not explicitly recited.

[0133] Likewise, the term “comprising” is considered synonymous with the term “including.” Likewise whenever a composition, an element or a group of elements is preceded with the transitional phrase “comprising,” it is understood that we also contemplate the same composition or group of elements with transitional phrases “consisting essentially of,” “consisting of,” “selected from the group of consisting of,”

or "is" preceding the recitation of the composition, element, or elements and vice versa.

[0134] The terms "a" and "the" as used herein are understood to encompass the plural as well as the singular.

[0135] Various terms have been defined above. To the extent a term used in a claim is not defined above, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Furthermore, all patents, test procedures, and other documents cited in this application are fully incorporated by reference to the extent such disclosure is not inconsistent with this application and for all jurisdictions in which such incorporation is permitted.

[0136] The foregoing description of the disclosure illustrates and describes the present disclosure. Additionally, the disclosure shows and describes only the preferred embodiments but, as mentioned above, it is to be understood that the disclosure is capable of use in various other combinations, modifications, and environments and is capable of changes or modifications within the scope of the concept as expressed herein, commensurate with the above teachings and/or the skill or knowledge of the relevant art. While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

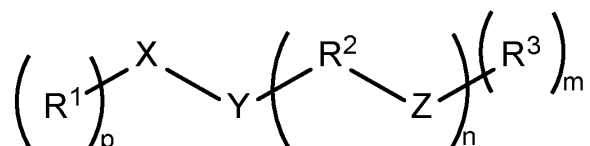
[0137] It is understood that when combinations, subsets, groups, etc. of elements are disclosed (e.g., combinations of components in a composition, or combinations of steps in a method), that while specific reference of each of the various individual and collective combinations and permutations of these elements may not be explicitly disclosed, each is specifically contemplated and described herein.

[0138] The embodiments described hereinabove are further intended to explain best modes known of practicing it and to enable others skilled in the art to utilize the disclosure in such, or other, embodiments and with the various modifications required

by the particular applications or uses. Accordingly, the description is not intended to limit it to the form disclosed herein. Also, it is intended that the appended claims be construed to include alternative embodiments.

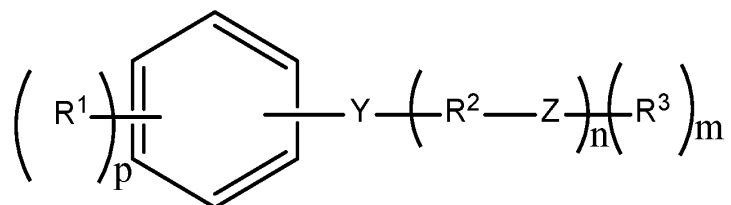
CLAIMS

1. A gaseous-fueled engine lubricating oil composition comprising:
a major amount of base oil; and
a lubricant additive having the following structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

2. The gaseous-fueled engine lubricating oil composition of claim 1, wherein the lubricant additive is present in about 0.1 to about 50 wt. % based on total weight of the lubricating oil composition.
3. The gaseous-fueled engine lubricating oil composition of claim 1, wherein R^1 is a polyisobutenyl group.
4. The gaseous-fueled engine lubricating oil composition of claim 1, wherein the lubricant additive has the following generalized structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 6 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

5. The gaseous-fueled engine lubricating oil composition of claim 1, wherein the gaseous-fueled engine lubricating oil composition has a total base number of 2 to 10 mg KOH/g.

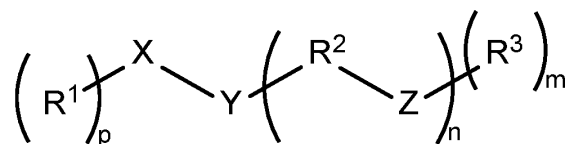
6. The gaseous-fueled engine lubricating composition of claim 1, wherein the gaseous-fueled engine lubricating oil composition is a SAE 20, SAE 30, SAE 40, SAE 50 or SAE 60 viscosity grade engine oil.

7. The gaseous-fueled engine lubricating oil composition of claim 1, wherein the gaseous-fueled engine lubricating oil composition is a SAE 15W – X, 20W – X, or 25W – X viscosity grade engine oil wherein X is 30, 40, 50 or 60.

8. A lubricating oil composition for a low-speed or medium-speed diesel engine, the composition comprising:

a major amount of base oil; and

a lubricant additive having the following structure:



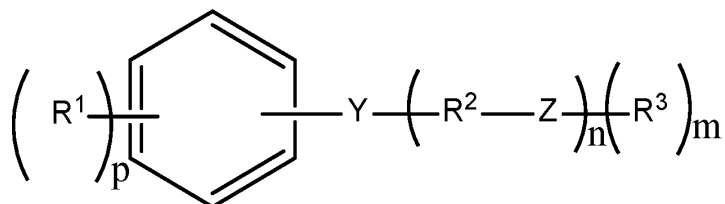
wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and R^3 is a hydrocarbyl group having 1 to 6 carbons with

one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

9. The lubricating oil composition of claim 8, wherein the lubricant additive is present in about 0.1 to about 50 wt. % based on total weight of the lubricating oil composition.

10. The lubricating oil composition of claim 8, wherein R¹ is a polyisobutenyl group.

11. The lubricating oil composition of claim 8, wherein the lubricant additive has the following generalized structure:



wherein each R¹ is independently a hydrocarbyl group having 10 to 400 carbons; Y is nitrogen, oxygen, or sulfur; each R² is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and each R³ is independently a hydrogen or hydrocarbyl group having 1 to 6 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

12. The lubricating oil composition of claim 8, wherein the lubricating oil composition has a total base number of 5 to 200 mg KOH/g.

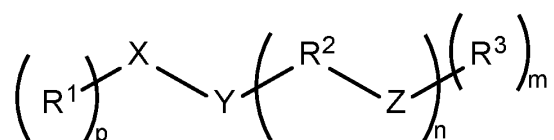
13. The lubricating composition of claim 8, wherein the lubricating oil composition is a marine diesel engine monograde composition meeting the viscosity specifications for a SAE 20, SAE 30, SAE 40, SAE 50, or SAE 60 viscosity grade engine oil.

14. The lubricating oil composition of claim 8, wherein the lubricating oil composition is a SAE 15W – X, 20W – X, or 25W – X viscosity grade engine oil wherein X is 30, 40, 50 or 60.

15. A method of thickening a lubricating oil composition in a gaseous-fueled, low-speed, or medium-speed engine, the method comprising adding to said engine a lubricating oil composition comprising:

a major amount of base oil; and

a lubricant additive having the following structure:

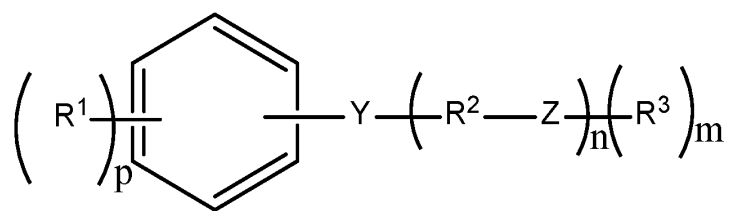


wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and R^3 is a hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

16. The method of claim 15, wherein the lubricant additive is present in about 0.1 to about 50 wt. % based on total weight of the lubricating oil composition.

17. The method of claim 15, wherein R^1 is a polyisobutenyl group.

18. The method of claim 15, wherein the lubricant additive has the following generalized structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 6 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

19. The method of claim 15, wherein the lubricating oil composition has a total base number of 5 to 200 mg KOH/g.

20. The method of claim 15, wherein the lubricating oil composition is a SAE 20, SAE 30, SAE 40, SAE 50, or SAE 60 viscosity grade engine oil.

21. The method of claim 15, wherein the lubricating oil composition is a SAE 15W – X, 20W – X, or 25W – X viscosity grade engine oil wherein X is 30, 40, 50, or 60.

22. The method of claim 15, wherein the engine is a stationary natural gas engine, a stationary biogas engine, a stationary landfill gas engine, a stationary unconventional natural gas fueled engine, or a dual-fuel engine.

23. The method of claim 15, wherein the engine is a low-speed diesel engine, or medium-speed diesel engine.

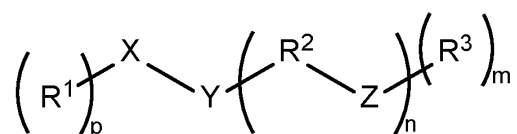
24. The method of claim 23, wherein the low-speed diesel engine is a marine crosshead diesel engine.

25. The method of claim 23, wherein the medium-speed diesel engine is a locomotive diesel engine, a marine trunk piston diesel engine or a land-based stationary power diesel engine.

26. A method of improving piston cleanliness or oxidation inhibition in an engine, the method comprising lubricating the engine with a lubricating oil composition comprising:

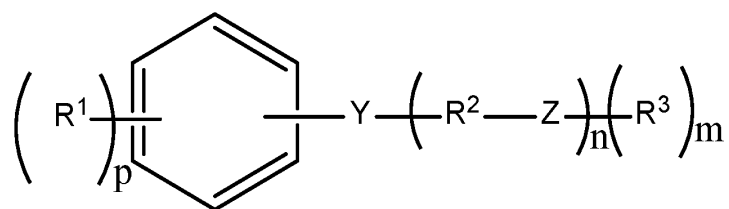
a major amount of base oil; and

a lubricant additive having the following structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and R^3 is a hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

27. The method of claim 26, wherein the lubricant additive has the following generalized structure:



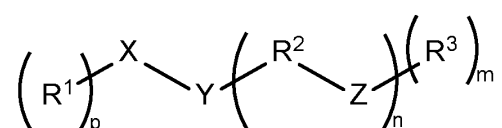
wherein R^1 is an hydrocarbyl group having 10 to 400 carbons, Y is nitrogen, oxygen, or sulfur, each R^2 is independently a hydrocarbyl group having 1 to 9 carbons, each Z is

nitrogen, oxygen, or sulfur, and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

28. A method of removing existing deposits in an internal combustion engine, the method comprising lubricating the engine with a composition comprising:

a base oil; and

an additive having the following structure:

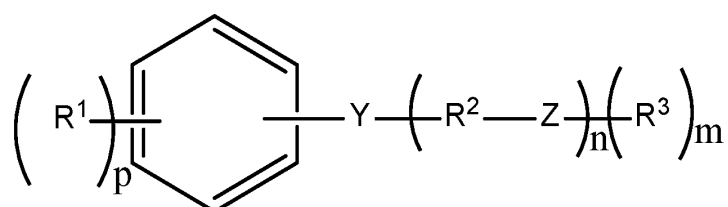


wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and R^3 is a hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 0 to 3.

29. The method of claim 28, wherein the additive is present in about 0.1 to about 50 wt. % based on total weight of the composition.

30. The method of claim 28, wherein R^1 is a polyisobutenyl group.

31. The method of claim 28, wherein the additive has the following generalized structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 0 to 3.

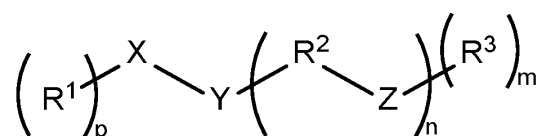
32. The method of claim 28, wherein R^1 is independently a hydrocarbyl group having 75 to 400 carbons.

33. The method of claim 30, wherein the polyisobutenyl group has an average molecular weight of 800 to 5000.

34. A method of removing existing deposits from the crankcase, rocker cover, camshaft region, timing gear cover, cylinder head, combustion chamber, piston rings and/or grooves in an internal combustion engine, the method comprising lubricating the engine with a composition comprising:

a base oil; and

an additive having the following structure:

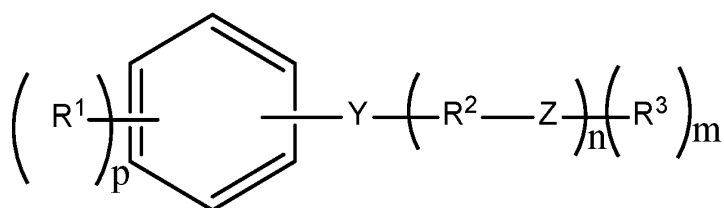


wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; X is an alkyl, aryl, or heteroaromatic group having 1 to 10 carbons; Y is nitrogen, oxygen, or sulfur; R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and R^3 is a hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

35. The method of claim 34, wherein the additive is present in about 0.1 to about 50 wt. % based on total weight of the composition.

36. The method of claim 34, wherein R^1 is a polyisobutenyl group.

37. The method of claim 34, wherein the additive has the following generalized structure:



wherein each R^1 is independently a hydrocarbyl group having 10 to 400 carbons; Y is nitrogen, oxygen, or sulfur; each R^2 is independently a hydrocarbyl group having 1 to 9 carbons; each Z is nitrogen, oxygen, or sulfur; and each R^3 is independently a hydrogen or hydrocarbyl group having 1 to 9 carbons with one or more nitrogen, oxygen, or sulfur functionalization, wherein p is 1 to 3, n is 1 to 20, and m is 1 to 3.

38. The method of claim 34, wherein R^1 is independently a hydrocarbyl group having 75 to 400 carbons.

39. The method of claim 36, wherein the polyisobutenyl group has an average molecular weight of 800 to 5000.