CLAIMS

What is claimed is:

1. A lubricant composition comprising:

a lubricating oil basestock comprising a Group I basestock, a Group II basestock, a Group III basestock, or a mixture thereof;

a lubricant additive comprising one or more of an antioxidant, a corrosion inhibitor, an anti-wear additive, a friction modifier, a dispersant, a detergent, a defoaming agent, an extreme pressure additive, a pour point depressant, and a seal-swelling control agent; and

a comb copolymer viscosity modifier made by polymerization comprising at least the following monomers:

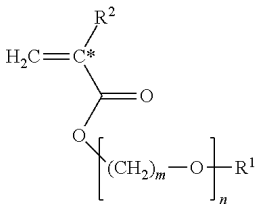
(a) a hydrogenated polybutadiene-based (alk)acrylate ester macromonomer;

(b) a C_3-C_8 alkyl (alk)acrylate ester monomer;

(c) a C_{12}-C_{24} alkyl (alk)acrylate ester monomer; and

(d)a C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer having the following structure (II):

(II)



in which R^2 represents hydrogen or C_1-C_2 alkyl, m is from 2 to 6, such that —$(CH_2)_m$— represents a linear, branched, and/or cyclic alkyl group between oxygens, n is from 1 to 10, and R^1 represents a C_6-C_{20} aryl, aralkyl, or alkaryl endcap,

wherein repeat units based on the C_{12}-C_{24} alkyl (alk)acrylate ester monomer comprise at least 21.0 wt % of repeat units of the comb copolymer viscosity modifier, and

wherein repeat units based on the C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer comprise at least 3.0 wt% and up to 20 wt% of the repeat units of the comb copolymer viscosity modifier.

2. The lubricant composition of claim 1, wherein:

the comb copolymer viscosity modifier comprises substantially no repeat units based on styrene monomer;

repeat units based on the C_{12}-C_{24} alkyl (alk)acrylate ester monomer comprise up to 35.0 wt% of repeat units of the comb copolymer viscosity modifier; and

repeat units based on the C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer comprise at least 4 wt% and up to 18 wt% of the repeat units of the comb copolymer viscosity modifier.

3. The lubricant composition of claim 1, wherein:

(i) repeat units based on the hydrogenated polybutadiene-based (alk)acrylate ester macromonomer comprise from 7.0 wt % to 18 wt % of the repeat units of the comb copolymer viscosity modifier;

(ii) repeat units based on the C_3-C_8 alkyl (alk)acrylate ester monomer comprise from 33 wt % to 64 wt % of the repeat units of the comb copolymer viscosity modifier.

4. The lubricant composition of claim 1, wherein R^2 represents hydrogen or methyl, m is from 2 to 4, n is from 1 to 6, and R^1 represents C_6-C_{11} aryl, aralkyl, or alkaryl.

5. The lubricant composition of claim 1, wherein R^2 is methyl, m is 2 or 3, n is from 1 to 6, and R^1 is phenyl.

6. The lubricant composition of claim 1, wherein:

(i) the C_3-C_8 alkyl (alk)acrylate ester monomer is a butyl acrylate and/or a butyl methacrylate;

(ii) the C_{12}-C_{24} alkyl (alk)acrylate ester monomer comprises a lauryl acrylate, a lauryl methacrylate, a myristyl acrylate, a myristyl methacrylate, a palmityl acrylate, a palmityl methacrylate, a heptadecanoyl acrylate, a heptadecanoyl methacrylate, or a combination thereof; or

(iii) both (i) and (ii).

7. The lubricant composition of claim 1, wherein the C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer comprises an ethylene glycol phenyl ether acrylate, an ethylene glycol phenyl ether methacrylate, an ethylene glycol benzyl ether acrylate, an ethylene glycol benzyl ether methacrylate, an oligo(ethylene glycol) phenyl ether acrylate, an oligo(ethylene glycol) phenyl ether methacrylate, an oligo(ethylene glycol) benzyl ether acrylate, an oligo(ethylene glycol)

benzyl ether methacrylate, an oligo(ethylene glycol) naphthyl ether acrylate, an oligo(ethylene glycol) naphthyl ether methacrylate, a propylene glycol phenyl ether acrylate, a propylene glycol phenyl ether methacrylate, an oligo(propylene glycol) phenyl ether acrylate, an oligo(propylene glycol) phenyl ether methacrylate, an oligo(propylene glycol) benzyl ether acrylate, an oligo(propylene glycol) benzyl ether methacrylate, an oligo(propylene glycol) naphthyl ether acrylate, an oligo(propylene glycol) naphthyl ether methacrylate, or a combination thereof.

8. The lubricant composition of claim 1, comprising from 0.5 mass% to 9.0 mass% of the comb copolymer viscosity modifier, based on the total mass of the lubricant composition.

9. The lubricant composition of claim 1, comprising from 75 mass% to 95 mass% of the lubricating oil basestock, based on the total mass of the lubricant composition.

10. The lubricant composition of claim 1, wherein the comb copolymer viscosity modifier exhibits a weight average molecular weight of less than or equal to 625,000 g/mol, as measured by gel permeation chromatography (GPC) at about 35°C. in tetrahydrofuran (THF) using polystyrene standards, and wherein the lubricant composition exhibits:

a non-linear model applied yield stress (APY) value of at most 0.55 Pa and/or a linear model soot rating of at least 20, when measured in the presence of an additional ~6 wt% carbon black; and

at least three of the following characteristics:

a high-temperature high-shear viscosity at approximately 150°C. (HTHS150) of at least 2.55 cPs;

a high-temperature high-shear viscosity at approximately 100°C. (HTHS100) of at most 5.56 cPs;

a high-temperature high-shear viscosity at approximately 80°C. (HTHS80) of at most 833 cPs;

a KV100 from 6.90 cSt to 8.50 cSt;

a kinematic viscosity at approximately 40° C. (KV40) of at most 35.0 cSt;

a kinematic viscosity at approximately 20°C. (KV20) of at most 80.5 cSt; and

a viscosity index of at least 175.

11. The lubricant composition of claim 1, wherein the lubricant composition exhibits:

a non-linear model applied yield stress (APY) value of at most 0.52 Pa and/or a linear model soot rating of at least 25, when measured in the presence of an additional ~6wt% carbon black; and

at least four of the following characteristics:

a high-temperature high-shear viscosity at approximately 150°C. (HTHS150) of at least 2.55 cPs;

a high-temperature high-shear viscosity at approximately 100°C. (HTHS100) of at most 5.52 cPs;

a high-temperature high-shear viscosity at approximately 80°C. (HTHS80) of at most 8.30 cPs;

a KV100 from 7.00 cSt to 8.30 cSt;

a kinematic viscosity at approximately 40°C. (KV40) of at most 34.5 cSt;

a kinematic viscosity at approximately 20°C. (KV20) of at most 80.0 cSt; and

a viscosity index (VI) of at least 185.

12. The lubricant composition of claim 1, wherein the comb copolymer viscosity modifier is made by polymerization of monomers consisting essentially of:

(a) the hydrogenated polybutadiene-based (alk)acrylate ester macromonomer;

(b) the C_3-C_8 alkyl (alk)acrylate ester monomer;

(c) the C_{12}-C_{24} alkyl (alk)acrylate ester monomer; and

(d) the C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer.

13. The lubricant composition of claim 1, wherein the comb copolymer viscosity modifier:

(i) is made by polymerization of monomers that comprise substantially no styrene nor styrenic monomers; and

(ii) comprises substantially no styrene-based nor styrenic-based repeat units.

14. The lubricant composition of claim 1, wherein the comb copolymer viscosity modifier is made by polymerization comprising monomers (a), (b), (c), (d), and (e) at least one additional

olefinic monomer, different from monomers (a), (b), (c), and (d) and which is not a C_6-C_{20} aryl, aralkyl, or alkaryl (alk)acrylate ester monomer.

15. A lubricant composition comprising:

a lubricating oil basestock comprising a Group I basestock, a Group II basestock, a Group III basestock, or a mixture thereof; and optionally a Group IV basestock;

a lubricant additive comprising one or more of an antioxidant, a corrosion inhibitor, an anti-wear additive, a friction modifier, a dispersant, a detergent, a defoaming agent, an extreme pressure additive, a pour point depressant, and a seal-swelling control agent; and

a comb copolymer viscosity modifier made by polymerization comprising at least the following monomers:

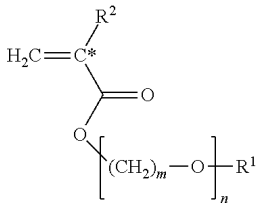
(a) a hydrogenated polybutadiene-based (alk)acrylate ester macromonomer;

(b) a C_3-C_8 alkyl (alk)acrylate ester monomer;

(c) a C_{12}-C_{24} alkyl (alk)acrylate ester monomer; and

(d) a C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer having the following structure (II):

(II)



in which R^2 represents hydrogen or C_1-C_2 alkyl, m is from 2 to 6, such that —$(CH_2)_m$— represents a linear, branched, and/or cyclic alkyl group between oxygens, n is from 1 to 10, and R^1 represents a C_6-C_{20} aryl, aralkyl, or alkaryl endcap,

wherein a sum of the C_{12}-C_{24} alkyl (alk)acrylate ester monomer repeat units plus the C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer repeat units collectively comprise at least 21.0 wt % of repeat units of the comb copolymer viscosity modifier, but where the C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer repeat units comprise only up to 20 wt% of the repeats units of the comb copolymer viscosity modifier .

16. A method of modifying a viscosity and a dispersancy of a lubricant composition comprising:

forming a viscosity and dispersancy modified mixture by combining a viscosity and dispersancy modifying amount of a comb copolymer viscosity modifier with one of the following lubricant composition components:

(1) a lubricating oil basestock comprising at least 75% by weight of one or more basestocks selected from the group consisting of Group I, Group II, and Group III basestocks;

(2) a concentrated lubricant additive package comprising a minor amount of a lubricating oil basestock and one or more of an antioxidant, a corrosion inhibitor, an anti-wear additive, a friction modifier, a dispersant, a detergent, a defoaming agent, an extreme pressure additive, a pour point depressant, and a seal-swelling control agent; or

(3) a lubricant composition comprising both (1) and (2),

the comb copolymer viscosity modifier being made by polymerization comprising at least the following monomers:

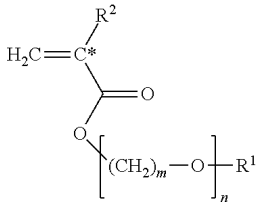
(a) a hydrogenated polybutadiene-based (alk)acrylate ester macromonomer;

(b) a C_3-C_8 alkyl (alk)acrylate ester monomer;

(c) a C_{12}-C_{24} alkyl (alk)acrylate ester monomer; and

(d) a C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer having the following structure (II):

(II)



in which R^2 represents hydrogen or C_1-C_2 alkyl, m is from 2 to 6, such that —$(CH_2)_m$— represents a linear, branched, and/or cyclic alkyl group between oxygens, n is from 1 to 10, and R^1 represents a C_6-C_{20} aryl, aralkyl, or alkaryl endcap,

wherein repeat units based on the C_{12}-C_{24} alkyl (alk)acrylate ester monomer comprise at least 21.0 wt % of repeat units of the comb copolymer viscosity modifier, and

wherein repeat units based on the C_6-C_{20} aryl-, aralkyl-, or alkaryl-endcapped C_2-C_6 oxyalkyl or C_2-C_6 oligo(alkylene glycol)-based (alk)acrylate ester monomer comprise from 3.0 wt% to 20 wt% of the repeat units of the comb copolymer viscosity modifier,

wherein the viscosity and dispersancy modified mixture exhibits:

(i) at least a 25% improvement, relative to the lubricant composition components (1), (2), or (3) without the comb copolymer viscosity modifier, with regard to soot dispersancy; wherein soot dispersancy is measured using a non-linear model applied yield stress (APY) value and/or a linear model soot rating, when measured in the presence of an additional ~6wt% carbon black; and

(ii) at least a 5% difference, relative to the lubricant composition components (1), (2), or (3) without the comb copolymer viscosity modifier, with regard to one or more of HTHS150, HTHS100, HTHS80, KV100, KV40, KV20, and VI.

17. The method of claim 16, wherein the viscosity and dispersancy modifying amount of the comb copolymer viscosity modifier is from 1.0 mass % to 8.0 mass%, based on the total mass of the viscosity modified mixture.

18. The method of claim 16, wherein the comb copolymer viscosity modifier is combined with (1) the lubricating oil basestock, or (3) the lubricant composition comprising (1) and (2) the concentrated lubricant additive package, and wherein the 25% improvement and 5% difference are thus relative to lubricant composition components (1) or (3).

19. The method of claim 16, wherein the viscosity and dispersancy modified mixture exhibits at least a 33% improvement with regard to a non-linear model applied yield stress measurement of soot dispersancy and at least a 5% difference with regard to four or more of the enumerated viscosity characteristics.

20. The method of claim 16, wherein the viscosity and dispersancy modified mixture exhibits at least a 33% improvement with regard to a linear model soot rating measurement of soot dispersancy and at least a 10% difference with regard to three or more of the enumerated viscosity characteristics.