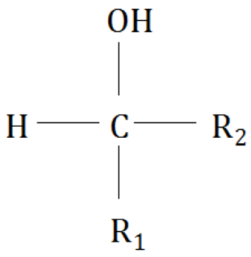
What is claimed is:

1. A viscosity index improver comprising a reaction product of

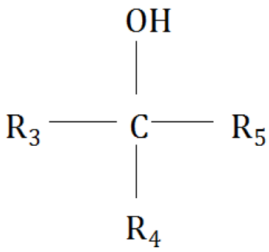
(i) an acylated copolymer obtainable by acylating, with an acylating agent, a copolymer of ethylene and one or more C_3-C_{10} alpha-olefins having a number average molecular weight of 20~~3~~,000 to 250,000 g/mol as measured by GPC, an ethylene content of the copolymer of ethylene and one or more C_3-C_{10} alpha-olefins is 10 mol% to 70 mol% and the C_3-C_{10} alpha-olefin content of the copolymer of ethylene and one or more C_3-C_{10} alpha-olefins includes at least 40 mol% of propylene when the one or more C_3-C_{10} alpha-olefins comprises propylene; and

(ii) a compound selected from one or more compounds of the formulae (I)-(II~~I~~V~~)~~):



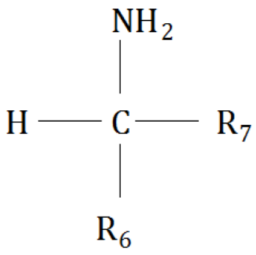
(I)

wherein R_1 is selected from a hydrogen and ~~-~~an optionally substituted linear or branched alkyl or alkenyl group; and R_2 is an optionally substituted linear or branched alkyl or alkenyl group, and a sum of a number of carbon atoms of R_1 and R_2 is from 7 to 31;



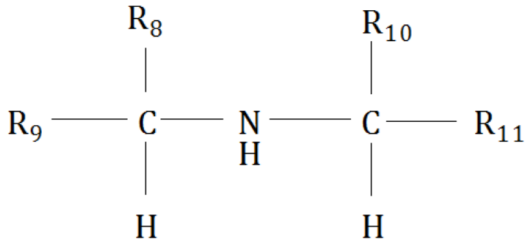
(II)

wherein R_3, R_4, and R_5 are independently selected from an optionally substituted linear or branched alkyl or alkenyl group, and a sum of a number of carbon atoms of R_3, R_4 and R_5 is from 7 to 31;



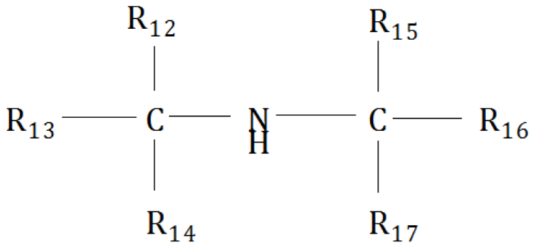
~~(III)~~

~~wherein R_6 is selected from a hydrogen and an optionally substituted linear or branched alkyl or alkenyl group, and R_7 is an optionally substituted linear or branched alkyl or alkenyl group, and a sum of a number of carbon atoms of R_6 and R_7 is from 7 to 31;~~



~~(IV)~~

~~wherein R_8, R_9 and R_{10} are independently selected from a hydrogen and an optionally substituted linear or branched alkyl or alkenyl group; and R_{11} is selected from an optionally substituted linear or branched alkyl or alkenyl group, and a sum of a number of carbon atoms of R_8, R_9, R_{10} and R_{11} is from 6 to 30; and~~



~~(V)~~

~~wherein R_{13}, R_{14}, R_{16}, and R_{17} are independently selected from an optionally substituted linear or branched alkyl or alkenyl group; R_{12} and R_{15} are independently selected from hydrogen and an optionally substituted linear or branched alkyl or alkenyl group, a sum of a number of carbon atoms of R_{12}, R_{13}, R_{14}, R_{15}, R_{16} and R_{17} is from 6 to 30, and only one of R_{12} and R_{15} can be hydrogen;~~ and

the alkyl or alkenyl groups of the compounds of the formulae (I)-(III~~V~~) are optionally substituted with one or more of halo groups, alkoxy groups, mercapto groups, nitro groups, nitroso groups, sulfoxy groups, pyridyl groups, furyl groups, thienyl groups, imidazolyl groups, and sulfur, and no more than two non-hydrocarbon substituents are present for every ten carbon atoms in the alkyl or alkenyl group.

2. The viscosity index improver of claim 1, wherein one or more of R_2~~,~~ and R_3~~, R_7, R_{11}, and R_{13}~~ is an alkyl group or an alkenyl group that provides branching at one or more of an alpha and a beta carbon atom of the compound (ii).

3. The viscosity index improver of claim 1, wherein one or more of R_2 and, R_3, R_7, R_{11}, and R_{13} is an alkyl group or an alkenyl group that provides branching at at least an alpha carbon atom of the compound (ii).

4. The viscosity index improver of claim 1, wherein one or more of R_2 and, R_3, R_7, R_{11}, and R_{13} is an alkyl group or an alkenyl group that provides branching at at least a beta carbon atom of the compound (ii).

5. The viscosity index improver of claim 1, wherein the compound (ii) is a compound of the formula (I), R_1 is hydrogen and R_2 is a branched alkyl group or branched alkenyl group.

6. The viscosity index improver of claim 1, wherein the compound (ii) is a compound of the formula (I) and R_1 is a linear or branched alkyl or alkenyl group.

7. The viscosity index improver of claim 1, wherein the compound (ii) is a compound of the formula (II) and at least one of R_3, R_4, and R_5 is a branched alkyl or a branched alkenyl group.

8. The viscosity index improver of claim 1, wherein the compound (ii) is a compound of the formula (III) and R_6 is a linear or branched alkyl or alkenyl group.

9. The viscosity index improver of claim 1, wherein the compound (ii) is a compound of the formula (IV), and R_9 and R_{11} are independently selected from a branched alkyl group and a branched alkenyl group.

10. The viscosity index improver of claim 1, wherein the compound (ii) is a compound of the formula (V) and at least one of R_{12}, R_{13}, and R_{14} is a branched alkyl group or branched alkenyl group, and at least one of R_{15}, R_{16}, and R_{17} is a branched alkyl group or branched alkenyl group.

811. The viscosity index improver of claim 4, wherein the at least one group that provides beta branching is a C_2-C_{17} alkyl or alkenyl group.

12. The viscosity index improver of claim 11, wherein the compound (ii) is a primary amine.

~~13. The viscosity index improver of claim 4, wherein the compound (ii) is a secondary amine and the at least one group that provides beta branching is a C_8-C_{18} alkyl or alkenyl group.~~

~~14~~9. The viscosity index improver of claim 1, wherein the compound (ii) is selected from 2-ethylhexanol, 2-butyloctanol, isomyristyl alcohol, 2-hexyldecanol, isostearyl alcohol, 2-octyldodecanol, 2-decyltetradecanol, 2-dodecylhexadecanol, and 2-tetradecyloctadecanol.

~~15. The viscosity index improver of claim 1, wherein the compound (ii) is selected from 2-ethyl-1-hexyl, 2-butyl-1-octylamine, 2-hexyl-1-decamine, 2-octyl-1-dodecylamine, 2-decyl-1-tetradecamine, 2-dodecyl-1-hexadecamine, and 2-tetradecyl-1-octadecamine.~~

~~16. The viscosity index improver of claim 1, wherein the compound (ii) is selected from dioctylamine, 2-ethyl-1-hexylamine and bis(2-ethyl-1-hexyl)amine.~~

10~~17~~. The viscosity index improver of claim 1, wherein the compound (ii) is selected from 2-hexyldecanol, 2-hexyloctanol, and 2-dodecylhexadecanol.

11~~18~~. The viscosity index improver of claim 1, wherein the compound (ii) is a compound of the Formulae (I) and (II) and one or more of R_2 and R_3 is a linear alkyl group or a linear alkenyl group attached to provide branching at a β carbon atom of the compound (ii).

~~19. The viscosity index improver of claim 1, wherein the compound (ii) is a compound of the Formulae (III)-(V) and one or more of R_7, R_{11}, and R_{13} is a linear alkyl group or a linear alkenyl group attached to provide branching at a β carbon atom of the compound (ii).~~

12~~20~~. The viscosity index improver of claim 1, wherein the acylating agent is an ethylenically unsaturated acylating agent having at least one carboxylic acid or carboxylic anhydride group.

13~~21~~. The viscosity index improver of claim 1, wherein the acylating agent is at least one selected from the group consisting of maleic acid, fumaric acid, itaconic acid, citraconic acid, cyclohex-4-ene-l,2-di-carboxylic acid, bicyclo[2.21]hept-5-ene-2,3-dicarboxylic acid, maleic anhydride, itaconic anhydride, citraconic anhydride, allylsuccinic anhydride, 4-methylcyclohex-4-ene- 1,2-dicarboxylic anhydride and bicyclo[2.2.1]hept-5-ene-2,3-dicarboxylic anhydride.

1422. The viscosity index improver of claim 1, wherein the acylating agent is maleic anhydride.

1523. The viscosity index improver of claim 1, wherein the ratio of moles of ~~amine and/or~~ alcohol per mole of carboxyl groups of the acylated polymer, is from 0.25:1 to 4:1 or from 0.5:1 to 2:1 or from 0.5:1 to 1:1, or more preferably from ~~about~~ 1:1.

1624. The viscosity index improver of claim 1, wherein the acylated copolymer has acyl groups present in an amount of 0.3 weight percent to less than 30 weight percent, based on a total weight of the acylated copolymer.

1725. The viscosity index improver of claim 1, wherein the acylated copolymer has acyl groups present in an amount of 0.5 wt.% to 5 wt.%, based on a total weight of the acylated copolymer.

1826. The viscosity index improver of claim 1, wherein the acylated copolymer has 0.1 to 0.8 acyl groups per 1000 number average molecular weight units of the ethylene/C_3-C_{10} alpha-olefin copolymers.

1927. The viscosity index improver of claim 1, the ethylene content of the copolymer of ethylene and one or more C_3-C_{10} alpha-olefins is greater than ~~from~~ 10 mol% to 70 mol% and the C_3-C_{10} alpha-olefin content of the copolymer of ethylene and one or more C_3-C_{10} alpha-olefins includes at least 40 mol% of propylene when the one or more C_3-C_{10} alpha-olefins comprises propylene.

2028. The viscosity index improver of claim 1, wherein the copolymer of ethylene and one or more C_3-C_{10} alpha-olefins has a polydispersity index of less than or equal to 4 and an average ethylene derived unit run length (n_{C2}) which is less than 2.6, as determined by ^{13}C NMR spectroscopy, the average ethylene derived unit run length n_{c2} is defined as the total number of ethylene-derived units in the copolymer divided by a number of runs of one or more sequential ethylene-derived units in the copolymer, and the average ethylene derived unit run length n_{c2} also satisfies the relationship shown by the expression below:

$$n_{C2} < \frac{(EEE + EEA + AEA)}{(AEA + 0.5EEA)}$$

wherein

$$EEE = (x_{C2})^3$$

$$EEA = 2(x_{C2})^2(1 - x_{C2})$$

$$AEA = x_{C2}(1 - x_{C2})^2$$

x_{C2} being a mole fraction of ethylene incorporated in the copolymer as measured by ^{1}H-NMR spectroscopy, E representing an ethylene unit, and A representing a C_3-C_{10} alpha olefin unit.

2129. The viscosity index improver of claim 2028, wherein less than 20% of unit triads in the copolymer are ethylene-ethylene-ethylene triads.

2230. A lubricating oil composition comprising:

greater than 50 wt.% of a base oil, based on the total weight of the lubricating oil composition, and

0.1 wt.% to 20 wt.%, based on the total weight of the lubricating oil composition, of a viscosity index improver as claimed in claim 1.

2331. The lubricating oil composition of claim 2230, wherein the lubricating oil composition is an engine oil composition.

2432. A method for improving thin film friction in an engine, comprising the step of lubricating the engine with the engine oil composition as claimed in claim 2331, wherein the thin film friction is determined by measuring traction coefficients using a mini-traction machine at 130°C with an applied load of 50N between an ANSI 52100 steel disk and an ANSI 52100 steel ball as oil was being pulled through the contact zone at an entrainment speed of 500 mm/s while maintaining a slide-to-roll ratio of 50% between the ball and disk during the measurements.

2533. A method for improving low temperature performance in an engine as determined according to the method of ASTM D5293, comprising the step of lubricating the engine with the engine oil composition as claimed in claim 2331.

26. The viscosity index improver of claim 1, wherein the ethylene content of the copolymer of ethylene and one or more C_3-C_{10} alpha-olefins is 30 to 70 wt.%.

27. The viscosity index improver of claim 1, wherein the acylated copolymer has a number average molecular weight of greater than 20,000 to 100,000 g/mol as measured by GPC and greater than 6 to 75 moles of acyl groups per mole of polymer chain.