CLAIMS:

What is claimed is:

1. A lubricant composition comprising an oil and at least one long chain branched ethylene copolymer having;
    a. a Mw/Mn from ~~about~~ 2.0 to ~~about~~ 6.5;
    b. a Mw(LS) from ~~about~~ 30,000 to ~~about~~ 300,000 g/mol;
    c. a branching index (g'_{vis}) of from ~~about~~ 0.5 to ~~about~~ 0.97; and
    d. an ethylene content of ~~about~~ 40 wt% to ~~about~~ 75 wt%.
2. The composition of claim 1, wherein the long chain branched ethylene copolymer has one or more of:
    (a) a Mw(LS)/Mn(DRI) from ~~about~~ 2.0 to ~~about~~ 6.5;
    (b) a Mw(LS) from ~~about~~ 30,000 to ~~about~~ 300,000 g/mol;
    (c) a g'_{vis} of from ~~about~~ 0.5 to ~~about~~ 0.97;
    (d) an ethylene content of ~~about~~ 40 wt% to ~~about~~ 75 wt%; and
    (e) a shear stability index (30 cycles) of from ~~about~~ 1% to ~~about~~ 60%.
3. The composition of claim 1, where the ethylene copolymer comprises a blend of a first copolymer and a second copolymer, wherein at least one of the first copolymer and second copolymer is a long chain branched ethylene copolymer and the second copolymer has an ethylene content less than the ethylene content of the first copolymer.
4. The composition of claim 1 or 2, where the long chain branched ethylene copolymer is an ethylene/propylene copolymer
5. The composition of claim 1 or 2, wherein the lubricant composition has an aluminum content of 1 ppm or less.
6. The composition of claim 1 or 2, wherein the copolymer has an ethylene content of ~~about~~ 43 wt% to ~~about~~ 73 wt%.
7. The composition of claim 1 or 2 wherein the long chain branched ethylene copolymer has a shear thinning ratio greater than 0.8572*EXP(2E-05*w) where w is the Mw(LS) from light scattering GPC-3D.
8. The composition of claim 1 or 2, which has a kinematic viscosity at 100ºC of from ~~about~~ 3 cSt to ~~about 30~~ cSt.

9. The composition of claim 1 or 2, which has a kinematic viscosity at 100ºC of from ~~about~~ 10 cSt to ~~about~~ 15 cSt.
10. The composition of claim 1 or 2 has a shear stability index (30 cycles) of from ~~about~~ 10% to ~~about~~ 50%.
11. The composition of claim 1 or 2, which has a shear stability index (30 cycles) of from ~~about~~ 15% to ~~about~~ 40%.
12. The composition of claim 1 or 2, which has a thickening efficiency of from ~~about~~ 1 to ~~about~~ 4.
13. The composition of claim 1 or 2 has a thickening efficiency of from ~~about~~ 1.5 to ~~about~~ 3.5.
14. The composition of claim 1 or 2, wherein the long chain branched ethylene copolymer has a g'_{vis} of from ~~about~~ 0.55 to ~~about~~ 0.85.
15. The composition of claim 1 or 2, which comprises ~~about~~ 0.01 wt% to ~~about~~ 12 wt% of the long chain branched ethylene copolymer.
16. The composition of claim 1 or 2, which comprises ~~about~~ 0.01 wt% to ~~about~~ 3 wt% of the copolymer.
17. The composition of claim 1 or 2, wherein the oil comprises a hydrocarbon, polyalphaolefin, alkyl esters of dicarboxylic acids, polyglycols, alcohols, polybutenes, alkylbenzenes, organic esters of phosphoric acids, polysilicone oils, or combinations thereof.
18. The lubricant composition according to claim 1 or 2 further comprising at least one of a dispersant, a detergent, an antioxidant, an oiliness improver, a pour point depressant, a friction modifier, a wear modifier, an extreme pressure additive, a defoamer, a deemulsifier, or a corrosion inhibitor.
19. The composition of claim 1 or 2, which has a high temperature, high shear (HTHS) viscosity of ~~about~~ 4.0 cP or less.
20. The composition of claim 1 or 2, which has a shear stability index of ~~about~~ 60 or less.
21. The composition of claim 1, where the ethylene copolymer is made in a polymerization process using at least one metallocene catalyst.
22. The composition of claim 1 or 2 wherin the copolymer has a SSI (%) 30 cycle per ASTM D6278 less than 0.0003x-2.125 where x is Mw(LS) from GPC-3D;
23. A method of making a lubricant composition comprising blending an oil with long chain branched ethylene copolymer, wherein the copolymer has one or more of:

(a) a Mw(LS)/Mn(DRI) from ~~about~~ 2.0 to ~~about~~ 6.5;

(b) a Mw(LS) from ~~about~~ 30,000 to ~~about~~ 300,000 g/mol;

(c) a g'_{vis} of from ~~about~~ 0.5 to ~~about~~ 0.97;

(d) an ethylene content of ~~about~~ 40 wt% to ~~about~~ 75 wt%;

(e) a shear stability index (30 cycles) of from ~~about~~ 1% to ~~about~~ 60%.

24. A method of lubricating an engine comprising supplying to the engine a lubricating oil composition comprising an oil and a long chain branched ethylene copolymer; wherein the long chain branched ethylene copolymer has one or more of the following: a) a Mw/Mn from ~~about~~ 2.0 to ~~about~~ 6.5; b) a Mw(LS) from ~~about~~ 30,000 to ~~about~~ 300,000 g/mol; c) a branching index (g'_{vis}) of from ~~about~~ 0.5 to ~~about~~ 0.97; d) an ethylene content of ~~about~~ 40 wt% to ~~about~~ 75 wt%, and (e) a shear stability index (30 cycles) of from ~~about~~ 1% to ~~about~~ 60%.

25. A polymerization process for producing a long chain branched ethylene propylene copolymer, wherein the process comprises: (i) contacting at a temperature greater than 50°C, ethylene and propylene with a catalyst system capable of producing long chain branched ethylene propylene copolymers having vinyl chain ends, and wherein the catalyst system comprises a metallocene catalyst compound and an activator; (ii) converting at least 50% of the ethylene and propylene to a polyolefin; and (iii) obtaining a long chain branched ethylene propylene copolymer having from ~~about~~ 40% to less than 80% ethylene content by weight as determined by FTIR (ASTM D3900), wherein the copolymer has (a) a g'_{vis} of from ~~about~~ 0.5 to ~~about~~ 0.97, (b) a Mw(LS)/Mn(DRI) from ~~about~~ 2.0 to ~~about~~ 6.5 (c) a Mw(LS) from ~~about~~ 30,000 to ~~about~~ 300,000 g/mol.

~~26. The process of claim 25 wherein the copolymer produced has a branching index (g'_{vis}) less than -0.0003x +0.88, and greater than -0.0054x + 1.08 where x is the percent total monomer conversion.~~

~~27. The process of claim 25 wherein the copolymer produced has an "average sequence length for methylene sequences six and longer" is less than 0.1869z – 0.30, and greater than 0.1869z - 1.9 where z is the mol% of ethylene as measured by ^{13}C NMR.~~

~~28. The process of claim 25 wherein the copolymer produced has a "percentage of methylene sequence length of 6 or greater" less than 1.3z - 35.5 and greater than 1.3z - 50 where z is the mol% of ethylene as measured by ^{13}C NMR.~~

29. The process of claim 25 wherein the copolymer produced has an r_1r_2 less than 2.0 and greater than 0.45.

30. The process of claim 25 wherein the copolymer produced exhibits no polymer crystallinity.

31. The process of claim 25 wherein the copolymer produced exhibits a Tm of less than 50°Cas measured by DSC.

32. The process of claim 25 wherein the copolymer produced has a polymer crystallinity wherein the heat of fusion(J/g) as measured by DSC is less than 2.8y – 134 where y is the wt% of ethylene as measured by FTIR.

33. The process of claim 25 wherein the copolymer produced has a polymer crystallinity wherein the heat of fusion(J/g) as measured by DSC is less than 1.47y – 64 where y is the wt% of ethylene as measured by FTIR.

34. The process of claim 25 wherein copolymer has an ethylene content of about 45 wt% to about 70 wt%.

35. The process of claim 25 wherein copolymer has an ethylene content of about 45 wt% to less than 50 wt%.

36. The process of claim 25 wherein the Mw(LS)/Mn(DRI) is from about 2.5 to about 6.0

37. The process of claim 25 wherein the process is a solution process.

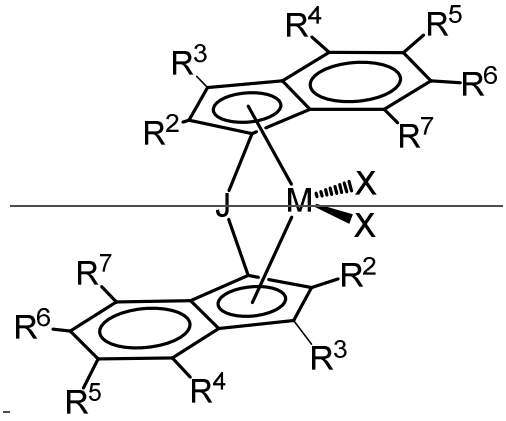
38. The process of claim 25 wherein the process is a continuous process.

39. The process of claim 25 wherein the monomer feed excludes dienes.

40. The process of claim 25 wherein the monomer feed excludes polyenes.

41. The process of claim 25 wherein the feed excludes aluminum vinyl transfer agents.

42. The process of claim 25 wherein the metallocene catalyst compound is represented by the formula:



where: (1) J is a divalent bridging group comprising C, Si, or both; (2) M is a group 4 transition metal; (3) each X is independently a univalent anionic ligand, or two Xs are joined and bound to the metal atom to form a metallocycle ring, or two Xs are joined to form a chelating ligand, a diene ligand, or an alkylidene ligand; and (4) each R^2, R^3, R^4, R^5, R^6, and R^7 is independently hydrogen, C_1-C_{50} substituted or unsubstituted hydrocarbyl, provided that any one or more of the pairs R^4 and R^5, R^5 and R^6, and R^6 and R^7 may optionally be bonded together to form a saturated or partially saturated cyclic or fused ring structure.

43. The process of claim 42 wherein each R^4 and R^7 are selected from the group of C_1—C_3 alkyl, each R^2 is hydrogen or C_1—C_3 alkyl, each R^3 are hydrogen, and each R^5 and R^6 are hydrogen or C_1—C_3 alkyl, and optionally each R^5 and R^6 are joined together to form a 5-membered partially unsaturated ring.

44. The process of claim 43 wherein each R^4 and R^7 is selected from the group of C_1—C_3 alkyl, each R^2 and R^3 is hydrogen, and each R^5 and R^6 are joined together to form a 5-membered partially unsaturated ring.

45. The process of claim 44 where each R^4 and R^7 is methyl.

46. The process of claim 42 wherein J is selected from cyclopentamethylenesilylene, cyclotetramethylenesilylene, cyclotrimethylenesilylene, cyclopropandiyl, cyclobutandiyl, cyclopentandiyl, cyclohexandiyl, dimethylsilylene, diethylsilylene, isopropylene, and ethylene.

47. The process of claim 25 or 42 wherein the metallocene comprises cyclotetramethylenesilylene-bis(4,8-dimethyl-1,5,6,7-tetrahydro-*s*-indacen-1-yl)hafnium dimethyl.

48.26. A long chain branched ethylene propylene copolymer having from about 40% to less than 80% ethylene content by weight as determined by FTIR (ASTM D3900), wherein the polymer has a g'_{vis} of from about 0.5 to about 0.97; a Mw(LS)/Mn(DRI) from about 2.5 to about 6.5; a Mw(LS) from about 30,000 to about 300,000 g/mol; and two or more additional properties selected from:

(a) a branching index (g'_{vis}) less than -0.0003x +0.88, and greater than -0.0054x + 1.08, where x is the percent total monomer conversion.

(b) a r_1r_2 less than 2.0 and greater than 0.45;

(c) an "average sequence length for methylene sequences six and longer" less than 0.1869z – 0.30, and greater than 0.1869z - 1.9, where z is the mol% of ethylene as measured by ^{13}C NMR;

(d) a percentage of methylene sequence length of 6 or greater less than 1.3z - 35.5, and greater than 1.3z – 50, where z is the mol% of ethylene as measured by ^{13}C NMR;

(e) exhibiting no polymer crystallinity, or a polymer crystallinity wherein the heat of fusion(J/g) as measured by DSC is less than 2.8y – 134, where y is the wt% of ethylene as measured by FTIR;

(f) exhibiting no polymer crystallinity, or a polymer crystallinity wherein the heat of fusion(J/g) as measured by DSC is less than 1.47y – 64, where y is the wt% of ethylene as measured by FTIR;

(g) exhibiting a Tm of less than 50°C as measured by DSC; and

(h) a shear thinning ratio of greater than 0.8572*EXP(2E-05*w) where w is the Mw(LS) from light scattering GPC-3D and the shear thinning ratio is defined as the complex viscosity at a frequency of 0.1 rad/s divided by the complex viscosity at a frequency of 100 rad/s.

~~49. The copolymer of claim 48, which has an ethylene content of about 45 wt% to about 70 wt%.~~

~~50. The copolymer of claim 48 wherein copolymer has an ethylene content of about 45 wt% to about 50 wt%.~~

~~51. The copolymer of claim 48 wherein the copolymer excludes dienes.~~

~~52. The copolymer of claim 48 wherein the copolymer excludes polyenes.~~

~~53. The copolymer of claim 48 wherein the copolymer excludes aluminum vinyl transfer agents or remnants from aluminum vinyl transfer agents.~~

~~54. The copolymer of claim 48 wherein the SSI (%) 30 cycle per ASTM D6278 is less than 0.0003x-2.125 where x is Mw(LS) from GPC-3D~~