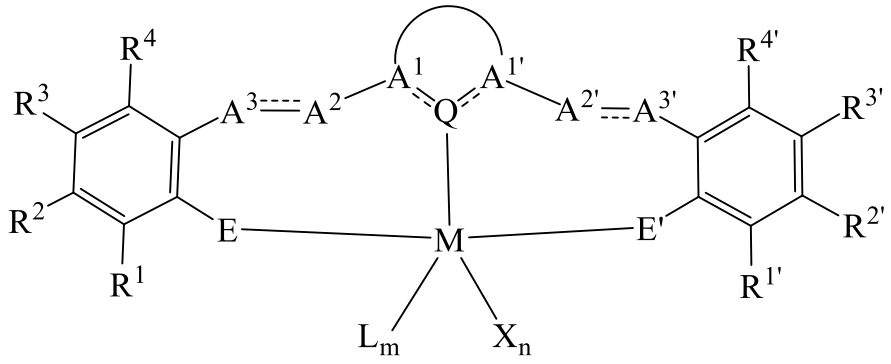
Claims

1. A polymerization process comprising contacting in a homogeneous phase ethylene and an optional comonomer selected from C_3 to C_{40} alpha olefins with a catalyst system comprising activator and catalyst compound represented by the Formula (**I**):



(**I**)

wherein:

M is a group 3, 4, 5, or 6 transition metal or a Lanthanide;

E and E' are each independently O, S, or NR^9 where R^9 is independently hydrogen, a C_1-C_{40} hydrocarbyl, a C_1-C_{40} substituted hydrocarbyl or a heteroatom-containing group;

Q is group 14, 15, or 16 atom that forms a dative bond to metal M;

$A^1QA^{1'}$ are part of a heterocyclic Lewis base containing 4 to 40 non-hydrogen atoms that links A^2 to $A^{2'}$ via a 3-atom bridge with Q being the central atom of the 3-atom bridge, A^1 and $A^{1'}$ are independently C, N, or $C(R^{22})$, where R^{22} is selected from hydrogen, C_1-C_{20} hydrocarbyl, C_1-C_{20} substituted hydrocarbyl;

A^3=A^2 is a divalent group containing 2 to 40 non-hydrogen atoms that links A^1 to the E-bonded aryl group via a 2-atom bridge;

$A^{2'}$=$A^{3'}$ is a divalent group containing 2 to 40 non-hydrogen atoms that links $A^{1'}$ to the E'-bonded aryl group via a 2-atom bridge;

L is a Lewis base;

X is an anionic ligand;

n is 1, 2 or 3;

m is 0, 1, or 2;

n+m is not greater than 4;

each of R^1, R^2, R^3, R^4, $R^{1'}$, $R^{2'}$, $R^{3'}$, and $R^{4'}$ is independently hydrogen, a C_1-C_{40} hydrocarbyl, a C_1-C_{40} substituted hydrocarbyl, a heteroatom or a heteroatom-containing group, and one or more of R^1 and R^2, R^2 and R^3, R^3 and R^4, $R^{1'}$ and $R^{2'}$, $R^{2'}$ and $R^{3'}$, $R^{3'}$ and $R^{4'}$ may be

joined to form one or more substituted hydrocarbyl rings, unsubstituted hydrocarbyl rings, substituted heterocyclic rings, or unsubstituted heterocyclic rings each having 5, 6, 7, or 8 ring atoms, and where substitutions on the ring can join to form additional rings;

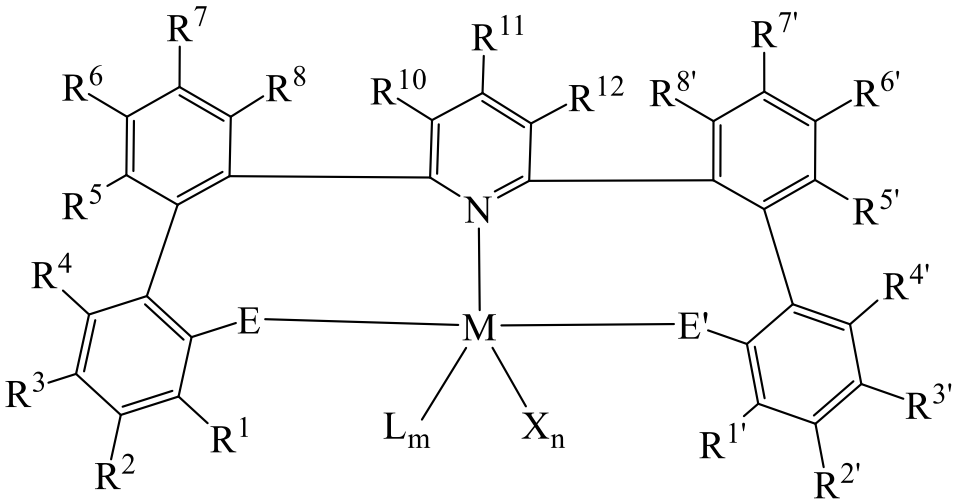
any two L groups may be joined together to form a bidentate Lewis base;

an X group may be joined to an L group to form a monoanionic bidentate group;

any two X groups may be joined together to form a dianionic ligand group;

and obtaining a polymer comprising greater than 35 mole% ethylene.

2. The process of claim 1 where the catalyst compound represented by the Formula (**II**):



(**II**)

wherein:

M is a group 3, 4, 5, or 6 transition metal or a Lanthanide;

E and E' are each independently O, S, or NR^9, where R^9 is independently hydrogen, a C_1-C_{40} hydrocarbyl, a C_1-C_{40} substituted hydrocarbyl, or a heteroatom-containing group;

each L is independently a Lewis base;

each X is independently an anionic ligand;

n is 1, 2 or 3;

m is 0, 1, or 2;

n+m is not greater than 4;

each of R^1, R^2, R^3, R^4, $R^{1'}$, $R^{2'}$, $R^{3'}$, and $R^{4'}$ is independently hydrogen, C_1-C_{40} hydrocarbyl, C_1-C_{40} substituted hydrocarbyl, a heteroatom or a heteroatom-containing group, or one or more of R^1 and R^2, R^2 and R^3, R^3 and R^4, $R^{1'}$ and $R^{2'}$, $R^{2'}$ and $R^{3'}$, $R^{3'}$ and $R^{4'}$ may be joined to form one or more substituted hydrocarbyl rings, unsubstituted hydrocarbyl rings, substituted heterocyclic rings, or unsubstituted heterocyclic rings each having 5, 6, 7, or 8 ring atoms, and where substitutions on the ring can join to form additional rings; any two L groups may be joined together to form a bidentate Lewis base;

an X group may be joined to an L group to form a monoanionic bidentate group;

any two X groups may be joined together to form a dianionic ligand group;

each of R^5, R^6, R^7, R^8, $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$, R^{10}, R^{11}, and R^{12} is independently hydrogen, a C_1-C_{40} hydrocarbyl, a C_1-C_{40} substituted hydrocarbyl, a heteroatom or a heteroatom-containing group, or one or more of R^5 and R^6, R^6 and R^7, R^7 and R^8, $R^{5'}$ and $R^{6'}$, $R^{6'}$ and $R^{7'}$, $R^{7'}$ and $R^{8'}$, R^{10} and R^{11}, or R^{11} and R^{12} may be joined to form one or more substituted hydrocarbyl rings, unsubstituted hydrocarbyl rings, substituted heterocyclic rings, or unsubstituted heterocyclic rings each having 5, 6, 7, or 8 ring atoms, and where substitutions on the ring can join to form additional rings.

3. The process of claim 1 or 2 wherein the M is Hf, Zr or Ti.

4. The process of claim 1, 2 or 3 wherein E and E' are each O.

5. The process of claim 1, 2, 3, or 4 wherein R^1 and $R^{1'}$ is independently a C_4-C_{40} tertiary hydrocarbyl group.

6. The process of claim 1, 2, 3, or 4 wherein R^1 and $R^{1'}$ is independently a C_4-C_{40} cyclic tertiary hydrocarbyl group.

7. The process of claim 1, 2, 3, or 4 wherein R^1 and $R^{1'}$ is independently a C_4-C_{40} polycyclic tertiary hydrocarbyl group.

8. The process any of claims 1 to 7 wherein each X is, independently, selected from the group consisting of substituted or unsubstituted hydrocarbyl radicals having from 1 to 20 carbon atoms, hydrides, amides, alkoxides, sulfides, phosphides, halides, and a combination thereof, (two X's may form a part of a fused ring or a ring system).

9. The process any of claims 1 to 8 wherein each L is, independently, selected from the group consisting of: ethers, thioethers, amines, phosphines, ethyl ether, tetrahydrofuran, dimethylsulfide, triethylamine, pyridine, alkenes, alkynes, allenes, and carbenes and a combinations thereof, optionally two or more L's may form a part of a fused ring or a ring system.

10. The process of claim 1, wherein M is Zr or Hf, Q is nitrogen, both A^1 and $A^{1'}$ are carbon, both E and $E^{'}$ are oxygen, and both R^1 and $R^{1'}$ are C_4-C_{20} cyclic tertiary alkyls.

11. The process of claim 1, wherein M is Zr or Hf, Q is nitrogen, both A^1 and $A^{1'}$ are carbon, both E and E' are oxygen, and both R^1 and $R^{1'}$ are adamantan-1-yl or substituted adamantan -1-yl.

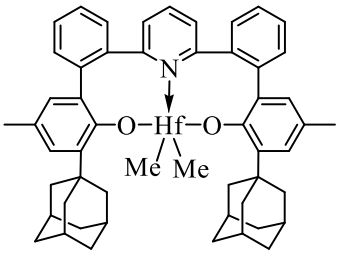
12. The process of claim 1, wherein M is Zr or Hf, Q is nitrogen, both A^1 and $A^{1'}$ are carbon, both E and E' are oxygen, and X is methyl or chloro, and n is 2.

13. The process of claim 1, wherein Q is nitrogen, A^1 and $A^{1'}$ are both carbon, both R^1 and $R^{1'}$ are hydrogen, both E and E' are NR^9, where R^9 is selected from a C_1-C_{40} hydrocarbyl, a C_1-C_{40} substituted hydrocarbyl, or a heteroatom-containing group.

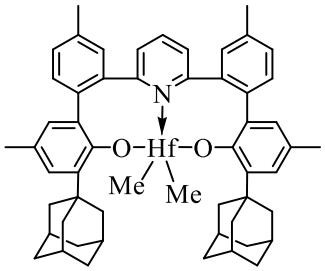
14. The process of claim 1, wherein Q is carbon, A^1 and $A^{1'}$ are both nitrogen, and both E and E' are oxygen.

15. The process of claim 1, wherein Q is carbon, A^1 is nitrogen, $A^{1'}$ is $C(R^{22})$, and both E and E' are oxygen, where R^{22} is selected from hydrogen, C_1-C_{20} hydrocarbyl, C_1-C_{20} substituted hydrocarbyl.

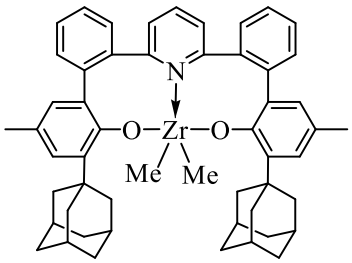
16. The process of claim 1 wherein the catalyst compound is represented by one or more of the following formulas:



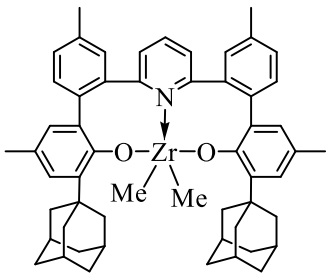
Complex 1



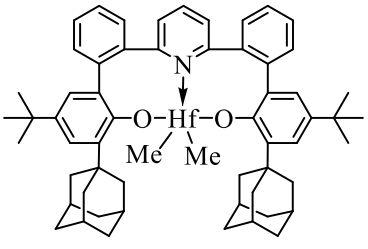
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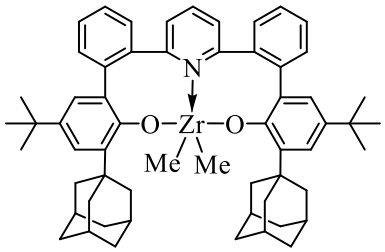
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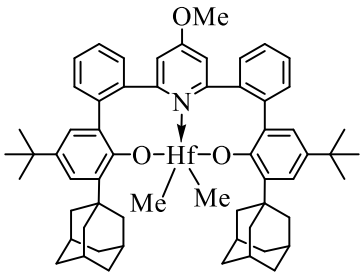
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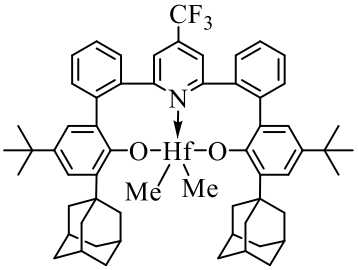
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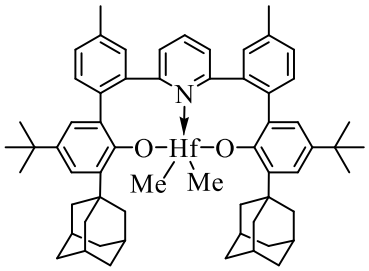
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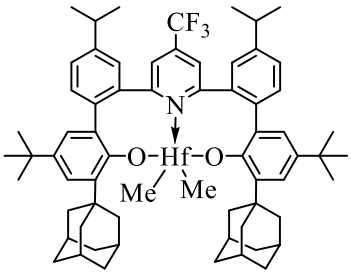
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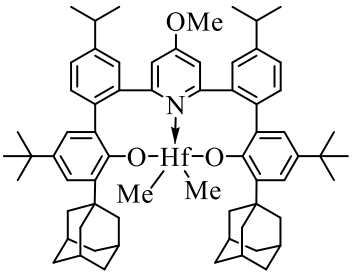
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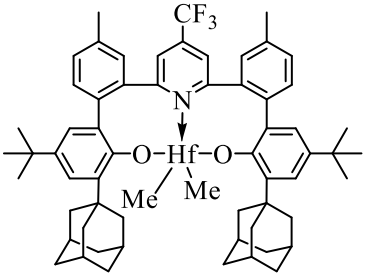
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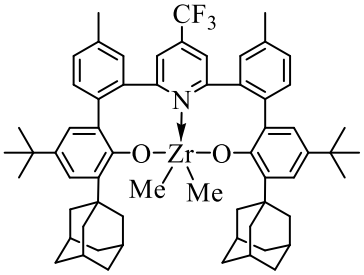
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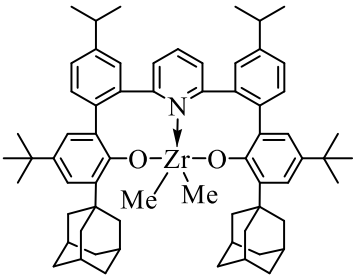
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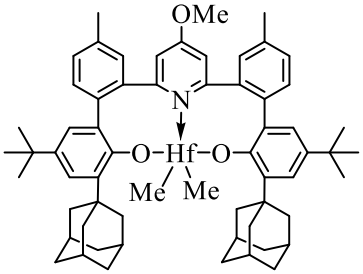
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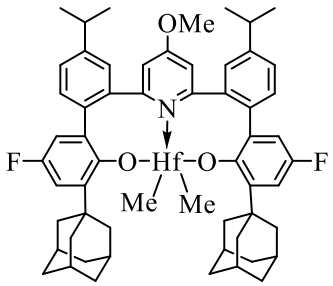
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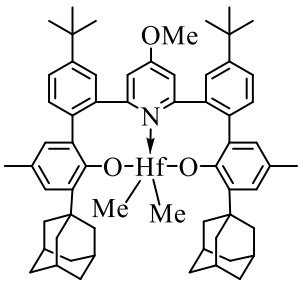
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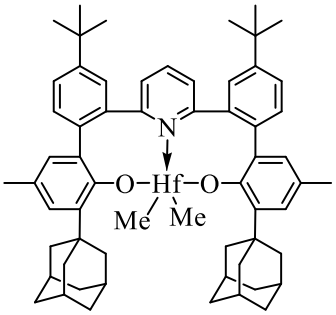
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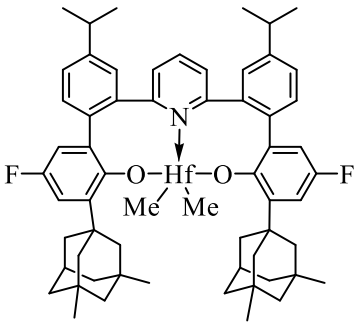
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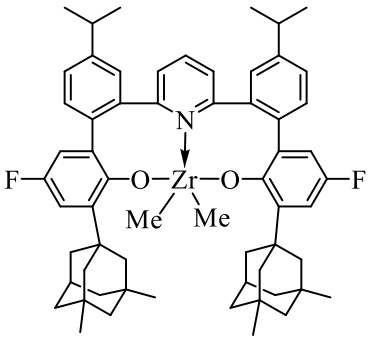
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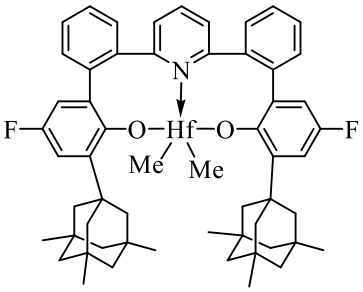
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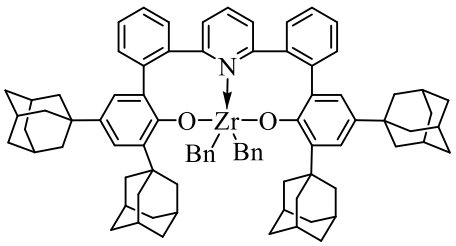
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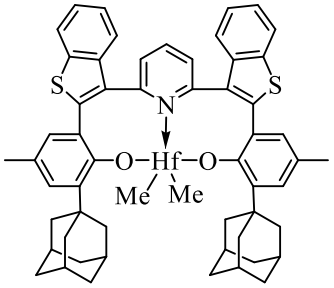
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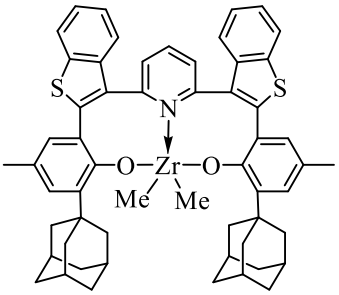
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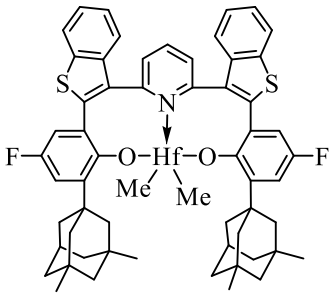
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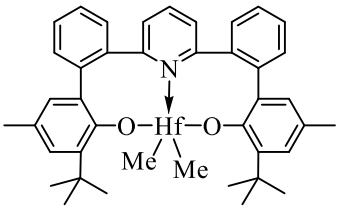
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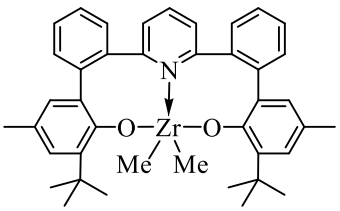
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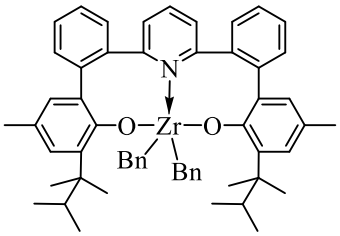
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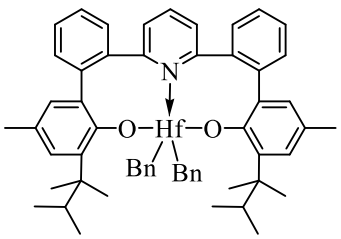
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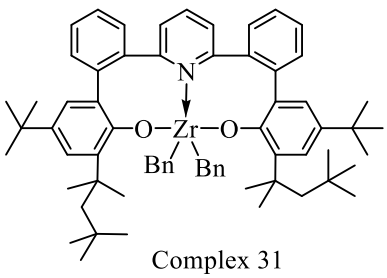
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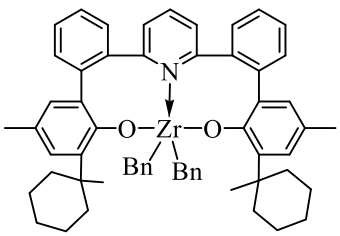
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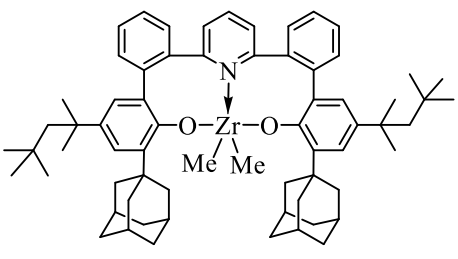
Complex 30



Complex 31



Complex 32



Complex 33

17. The process of any of claims 1 to 16 further comprising obtaining a polyethylene composition with at least 20 mol% ethylene content.

18. The process of any of claims 1 to 16 further comprising obtaining an ethylene copolymer wherein the copolymer has a composition of at least 20 mol% ethylene, and a shear thinning ratio that is greater than 30, and an I_{21}/I_2 greater than 10.

19. A copolymer produced by a polymerization process comprising contacting in a homogeneous phase ethylene and propylene with a catalyst system comprising an activator and group 4 bis(phenolate) catalyst compound, wherein the polymerization process takes place at a temperature of 90°C or higher in the absence of added hydrogen, to produce a polymer having:

(i) 65 to 80 mol% ethylene;

(ii) a shear thinning ratio (measured at 125°) of 70-150;

(iii) a phase angle (measured at 125°C) @ complex modulus G* = 500 kPa of less than 50^o;

(iv) a Mooney Large viscosity (measured at 125°C) of 80 to 120 mu; and

(v) a Mooney relaxation area (measured at 125°) of 550 to 3200 mu.sec.

20. A copolymer produced by a polymerization process comprising contacting in a homogeneous phase ethylene and propylene with a catalyst system comprising an activator and group 4 bis(phenolate) catalyst compound, wherein the polymerization process takes place at a temperature of 120°C or higher in the presence of added hydrogen, to produce a polymer having:

(i) 50 to 65 mol% ethylene;

(ii) a g'_{vis} of from 0.8 to 0.9;

(iii) a Mooney Large viscosity (measured at 125°C) of 35 to 40 mu;

(iv) a Mooney relaxation area (measured at 125°C) of 300-400 mu.sec.