CLAIMS

1. A process for producing a catalyst support-activator for olefin polymerization catalyst compositions in the absence or substantial absence of an aluminoxane or borate activator, said support-activator comprising an intercalated smectite clay having pillars comprising aluminum and optionally: (i) at least one rare earth or lanthanum group metal; or (ii) at least one rare earth or lanthanide group metal and gallium; said clay comprising at least one ion-exchanged metal ion selected from the group consisting of aluminum, barium, calcium, cerium, cesium, copper, chromium, gadolinium, gallium, germanium, hafnium, holmium, iron (II and III), lanthanum, lithium, magnesium, manganese, neodymium, potassium, praseodymium, rubidium, samarium, silver, selenium, sodium, strontium, tellurium, terbium, thallium, thorium, tin, titanium, uranium, ytterbium, yttrium, zinc and zirconium comprising steps:

(A) contacting an aqueous slurry comprising a smectite clay with an aqueous pillaring agent comprising aluminum and optionally: (i) at least one rare earth or lanthanide group metal; or (ii) at least one rare earth or lanthanide group metal and gallium; to form a solids-containing phase and an aqueous phase;

(B) separating the solids-containing phase from the aqueous phase formed in (A);

(C) contacting the separated solids obtained in (B) at least once with an aqueous Met_mX_n composition, comprising at least one Met_mX_n wherein Met_m is at least one metal ion selected from the group consisting of aluminum, barium, calcium, cerium, cesium, chromium, cobalt, copper, chromium, gadolinium, gallium, germanium, hafnium, holmium, iron (II and III), lanthanum, lithium, magnesium, manganese, neodymium, nickel, potassium, praseodymium, rubidium, samarium, silver, selenium, sodium, strontium, tellurium, terbium, thallium, thorium, tin, titanium, uranium, ytterbium, yttrium, zinc and zirconium, and X_n comprises at least one anionic species; and m and n = numerals that together satisfy the valence requirement for the combination of Met_m and X_n, to form a mixture comprising a solids-containing phase and an aqueous phase;

(D) separating the aqueous phase formed in (C) in order to form a new solids-containing phase;

(E) drying the separated, solids-containing phase from (D) in order to obtain dry solids and reducing said dry solids to a dry, particulate form; and

(F) calcining the dry, particulate from (E) to form a dry, pillared, solid catalyst support-activator in particulate form.

2. The process of claim 1, wherein X_n comprises at least one anionic species independently selected from the group consisting of a halide selected from the group consisting of chloride, iodide, fluoride and bromide; bromate; chlorate; perchlorate; sulfate; sulfamate; carbonate; hydrogen-carbonate; carbamate; nitrite; nitrate; oxalate; phosphate; selenate; sulfamate; azide;

alkoxide; amide, including NR_2 or $R[CON(R)]_a$, wherein R is independently H or a C_1-C_{20} unsubstituted or substituted hydrocarbyl group and a=1-4; and carboxylate, including $R[CO_2]_b$, wherein R is independently H or a C_1-C_{20} unsubstituted or substituted hydrocarbyl group and b=1-4; or wherein $MetX_n$ is selected from the group consisting of MgF_2, $MgCl_2$, LiCl, $Mg(OAc)_2$, $Mg(NO_3)_2$, $ZnCl_2$, NaCl, CsCl, $ZnSO_4$, KCl, $CaCl_2$, RbCl, LiCl, $CuCl_2$, $CuSO_4$, $FeCl_3$, $CoCl_2$, and mixtures thereof.

3. The process of any one of claims 1 to 2 wherein following separation of the solids-containing phase in (B), the solids-containing phase is extracted at least once with water until upon separation from the solids, the separated water is free or substantially free of: (i) residual anions originally present in the aqueous pillaring agent; or (ii) unconsumed pillaring agent or byproduct thereof; or (iii) both (i) and (ii).

4. The process of claim 1 wherein contacting with Met_mX_n is carried out from 2 to about 10 times, and wherein Met_mX_n used in more than one contacting step is the same or different as Met_mX_n used in a prior contacting step, and including a separating step as in (D) between one or more contacting step.

5. The process of any one of claims 1 to 4, wherein the pillaring agent is selected from the group consisting of a basic aluminum complex, a basic zirconium complex, a basic chromium complex and mixtures thereof.

6. The process of any one of claims 1 to 5 wherein following separation of the solids-containing phase in (D), the new solids-containing phase is extracted at least once with water, wherein water extraction is repeated until upon separation from the solids, the separated water is free or substantially free of: (i) residual anions originally present in the Met_mX_n composition; or (ii) unconsumed Met_mX_n composition or byproduct thereof; or (iii) both (i) and (ii).

7. A process to produce an olefin polymerization catalyst composition, said process comprising contacting:

(1) at least one organometal compound, and

(2) at least one organoaluminum compound, and

(3) at least one catalyst support-activator,

the catalyst composition having catalytic activity for the polymerization of at least one olefin in the absence or substantial absence of organoborates and aluminoxanes,

wherein:

the organometal compound has the following general formula:

$$(X^1)(X^2)(X^3)(X^4)M^1$$

wherein:

M^1 is selected from the group consisting of titanium, zirconium, or hafnium;

(X^1) is independently selected from the group consisting of cyclopentadienyls, indenyls, fluorenyls, substituted cyclopentadienyls, substituted indenyls, and substituted fluorenyls;

substituents on the substituted cyclopentadienyls, substituted indenyls, and substituted fluorenyls of (X^1) are selected from the group consisting of aliphatic groups, cyclic groups, combinations of aliphatic and cyclic groups, silyl groups, alkyl halide groups, halides, organometallic groups, phosphorus groups, nitrogen groups, silicon, phosphorus, boron, or germanium;

at least one substituent on (X^1) can be a bridging group which connects (X^1) and (X^2);

(X^3) and (X^4) are independently selected from the group consisting of halides, aliphatic groups, substituted aliphatic groups, cyclic groups, substituted cyclic groups, combinations of aliphatic groups and cyclic groups, combinations of substituted aliphatic groups and cyclic groups, combinations of aliphatic groups and substituted cyclic groups, combinations of substituted aliphatic groups and substituted cyclic groups, amido groups, substituted amido groups, phosphido groups, substituted phosphido groups, alkyloxide groups, substituted alkyloxide groups, aryloxide groups, substituted aryloxide groups, organometallic groups, and substituted organometallic groups; and (X^3) and (X^4) together may form a diene or polyene moiety or a metallocycle, or may be linked to form a ring;

(X^2) is selected from cyclopentadienyls, indenyls, fluorenyls, substituted cyclopentadienyls, substituted indenyls, substituted fluorenyls, halides, aliphatic groups, substituted aliphatic groups, cyclic groups, substituted cyclic groups, combinations of aliphatic groups and cyclic groups, combinations of substituted aliphatic groups and cyclic groups, combinations of aliphatic groups and substituted cyclic groups, combinations of substituted aliphatic groups and substituted cyclic groups, amido groups, substituted amido groups, phosphido groups, substituted phosphido groups, alkyloxide groups, substituted alkyloxide groups, aryloxide groups, substituted aryloxide groups, organometallic groups, and substituted organometallic groups;

substituents on (X^2) are selected from the group consisting of aliphatic groups, cyclic groups, combinations of aliphatic groups and cyclic groups, silyl groups, alkyl halide groups, halides, organometallic groups, phosphorus groups, nitrogen groups, silicon, phosphorus, boron, and germanium;

at least one substituent on (X^2) can be a bridging group which connects (X^1) and (X^2);

wherein the organoaluminum compound has the general formula:

$$Al(X^5)_n(X^6)_{3-n}$$

wherein:

(X^5) is a hydride or hydrocarbyl having from 1 to about 20 carbon atoms;

(X^6) is an anionic species independently selected from the group consisting of a halide selected from the group consisting of chloride, iodide, fluoride and bromide; bromate; chlorate; perchlorate; sulfate; sulfamate; carbonate; hydrogen-carbonate; carbamate; nitrite; nitrate; oxalate; phosphate; selenate; sulfamate; azide; alkoxide; amide, including NR_2 or $R[CON(R)]_a$, wherein R is independently H or a C_1-C_{20} unsubstituted or substituted hydrocarbyl group and a=1-4; and carboxylate, including $R[CO_2]_b$, wherein R is independently H or a C_1-C_{20} unsubstituted or substituted hydrocarbyl group and b=1-4; and

n is a number from 1 to 3 inclusive; and

wherein the catalyst support-activator is produced by a process comprising:

(A) contacting an aqueous slurry comprising a smectite clay with an aqueous pillaring agent comprising aluminum and optionally: (i) at least one rare earth or lanthanide group metal; or (ii) at least one rare earth or lanthanide group metal and gallium; to form a solids-containing phase and an aqueous phase;

(B) separating the solids-containing phase from the aqueous phase formed in (A);

(C) contacting the solids obtained in (B) at least once with an aqueous Met_mX_n composition, wherein Met_m is at least one metal ion selected from the group consisting of aluminum, barium, calcium, cerium, cesium, copper, chromium, gadolinium, gallium, germanium, hafnium, holmium, iron (II and III), lanthanum, lithium, magnesium, manganese, neodymium, potassium, praseodymium, rubidium, samarium, silver, selenium, sodium, strontium, tellurium, terbium, thallium, thorium, tin, titanium, uranium, ytterbium, yttrium, zinc and zirconium and X_n comprises at least one anionic species; and m and n = numerals that together satisfy the valence requirement for the combination of Met_m and X_n, in order to form a mixture comprising a solids-containing phase and an aqueous phase;

(D) separating the aqueous phase formed in (C) in order to form a new solids-containing phase;

(E) drying the separated, solids-containing phase from (D) in order to obtain dry solids and reducing said dry solids to a dry, particulate form; and

(F) calcining the dry, particulate from (E) and optionally removing entrapped air, to form a dry, solid catalyst support-activator in particulate form.

8. The process of claim 7, wherein X_n comprises at least one anionic species independently selected from the group consisting of a halide selected from the group consisting of chloride, iodide, fluoride and bromide; bromate; chlorate; perchlorate; sulfate; sulfamate; carbonate; hydrogen-carbonate; carbamate; nitrite; nitrate; oxalate; phosphate; selenate; sulfamate; azide; alkoxide; amide, including NR_2 or $R[CON(R)]_a$, wherein R is independently H or a C_1-C_{20} unsubstituted or substituted hydrocarbyl group and a=1-4; and carboxylate, including $R[CO_2]_b$, wherein R is independently H or a C_1-C_{20} unsubstituted or substituted hydrocarbyl group and b=1-4;

or wherein Met_mX_n is selected from the group consisting of MgF_2, $MgCl_2$, LiCl, $Mg(OAc)_2$, $Mg(NO_3)_2$, $ZnCl_2$, NaCl, CsCl, $ZnSO_4$, KCl, $CaCl_2$, RbCl, LiCl, $CuCl_2$, $CuSO_4$, $FeCl_3$, $CoCl_2$ and mixtures thereof.

9. The process of any one of claims 7 to 8 wherein following separation of the solids-containing phase in (B), the solids-containing phase is extracted at least once with water until upon separation from the solids, the separated water is free or substantially free of: (i) residual anions originally present in the aqueous pillaring agent; or (ii) unconsumed pillaring agent or byproduct thereof; or (iii) both (i) and (ii).

10. The process of claim 9 wherein free or substantially free is confirmed by a conductance value of less than 20,000 μS/cm or a negative $AgNO_3$ test result, or both.

11. The process of claim 10 wherein contacting with Met_mX_n is carried out from 2 to about 10 times, and wherein Met_mX_n used in more than one contacting step is the same or different as Met_mX_n used in a prior contacting step, and including a separating step as in (D) between one or more contacting step.

12. The process of any one of claims 7 to 11, wherein the pillaring agent is selected from the group consisting of a basic aluminum complex, a basic zirconium complex, a basic chromium complex and mixtures thereof.

13. The process of any one of claims 7 to 12 wherein following separation of the solids-containing phase in (D), the new solids-containing phase is extracted at least once with water, wherein water extraction is repeated until upon separation from the solids, the separated water is free or substantially free of: (i) residual anions originally present in the Met_mX_n composition; or (ii) unconsumed Met_mX_n composition or byproduct thereof; or (iii) both (i) and (ii).

14. An olefin polymerization catalyst composition produced by the process of any one of claims 7 to 13, comprising an organometal compound or procatalyst compound, an organoaluminum compound and a catalyst support-activator comprising an intercalated calcined smectite clay having pillars comprising aluminum and optionally: (i) at least one rare earth or lanthanide group metal; or (ii) at least one rare earth or lanthanide group metal and gallium; said clay comprising at least one ion-exchanged metal ion selected from the group consisting of aluminum, barium, calcium, cerium, cesium, copper, chromium, gadolinium, gallium, germanium, hafnium, holmium, iron (II and III), lanthanum, lithium, magnesium, manganese, neodymium, potassium, praseodymium, rubidium, samarium, silver, selenium, sodium, strontium, tellurium, terbium, thallium, thorium, tin, titanium,

uranium, ytterbium, yttrium, zinc and zirconium; said catalyst composition in the absence or substantial absence of an aluminoxane or borate activator.

15. The catalyst composition of claim 14 wherein the catalyst support-activator is characterized by a basal spacing (x) equal to or greater than about 9 angstroms and equal to or less than about 18 angstroms; or (y) wherein the catalyst support-activator comprises (i) or (ii) and is characterized by a basal spacing equal to or greater than about 18.5 angstroms and equal to or less than about 100 angstroms.