CLAIMS

What is claimed is:

1. A catalyst system comprising a product of the combination of ion-exchange layered silicate, a catalyst compound, and an aluminum compound represented by formula:

$Al(R')_{3-v}(R'')_v$

wherein each R', independently, is a C_1-C_{30} hydrocarbyl group;

each R'', independently, a C_4-C_{20} hydrocarbenyl group, having an end-vinyl group; and

v is from 0.1 to 3.

2. The catalyst system of claim 1, wherein R'' is butenyl, pentenyl, heptenyl, or octenyl.

3. The catalyst system of claim 1 or 2, wherein R'' is octenyl.

4. The catalyst system of claim 1, 2, or 3, wherein the aluminum compound contains less than 20 weight percent of dimer.

5. The catalyst system of any of claims 1 to 4, wherein the aluminum compound comprises diisobutyl(oct-7-en-1-yl)aluminum and / or isobutyldi(oct-7-en-1-yl)aluminum.

6. The catalyst system of any of claims 1 to 5, wherein the aluminum compound comprises tri(but-3-en-1-yl)aluminum, tri(pent-4-en-1-yl)aluminum, tri(oct-7-en-1-yl)aluminum, tri(non-8-en-1-yl)aluminum, tri(dec-9-en-1-yl)aluminum, isobutyl-di(oct-7-en-1-yl)-aluminum, isobutyl-di(dec-9-en-1-yl)-aluminum, isobutyl-di(non-8-en-1-yl)-aluminum, isobutyl-di(hept-6-en-1-yl)-aluminum, dimethyl(oct-7-en-1-yl)aluminum, diethyl(oct-7-en-1-yl)aluminum, dibutyl(oct-7-en-1-yl)aluminum, diisobutyl(oct-7-en-1-yl)aluminum, diisobutyl(non-8-en-1-yl)aluminum, diisobutyl(dec-8-en-1-yl)aluminum, diisobutyl(dodec-10-en-1-yl)aluminum, or a mixture thereof.

7. The catalyst system of any of claims 1 to 6, wherein the ion-exchange layered silicate is natural or synthetic montmorillonite, nontronite, beidellite, volkonskoite, laponite, hectorite, saponite, sauconite, stevensite, vermiculite, halloysite, aluminate oxides, bentonite, kaolinite, dickite, smectic clays, mica, magadiite, kenyaite, octosilicate, kanemite, makatite, attapulgite, sepiolite, zeolitic layered materials or a mixture thereof.

8. The catalyst system of any of claims 1 to 7, wherein R' is methyl, ethyl, propyl, isobutyl, or butyl.

9. The catalyst system of any of claims 1 to 8, wherein R' is isobutyl.

10. The catalyst system of any of claims 1 to 9, wherein v is about 2.

11. The catalyst system of any of claims 1 to 10, wherein the aluminum compound contains less than 1 weight percent of dimer.

12. The catalyst system of any of claims 1 to 11, wherein the catalyst compound is represented by the formula:

$$T_jL^AL^BL^C{}_iMDE$$

where, M is a group 3, 4, 5, or 6 transition metal atom, or a lanthanide metal atom, or actinide metal atom; L^A is a substituted or unsubstituted monocyclic or polycyclic arenyl pi-bonded to M; L^B is as defined for L^A or is J, a hetero-atom ancillary ligand bonded to M through the heteroatom; the L^A and L^B ligands may be covalently bridged together through a bridging group, T, containing a group 14, 15 or 16 element or boron wherein j is 0 or 1; $L^C{}_i$ is an optional neutral, non-oxidizing ligand having a dative bond to M; i equals 0, 1, 2 or 3; and, D and E are independently mono-anionic labile ligands, each having a sigma-bond to M, optionally bridged to each other or to L^A, L^B or L^C.

13. The catalyst system of any of claims 1 to 11, wherein the catalyst compound is one or more of:

rac-dimethylsilylbis[(2-methyl-4-phenyl)indenyl] zirconiumdimethyl;

rac-dimethylsilylbis[(2-methyl)indenyl] zirconiumdimethyl;

rac-dimethylsilyl-bis(indenyl)hafniumdimethyl;

rac-dimethylsilyl-bis(indenyl)hafniumdichloride;

rac-dimethylsilyl-bis(indenyl)zirconiumdimethyl;

rac-dimethylsilyl-bis(indenyl)zirconiumdichloride;

rac-dimethylsilyl-bis(2-methyl-4-phenyl-indenyl)hafniumdimethyl;

rac-dimethylsilyl-bis(2-methyl-4-phenyl-indenyl) hafniumdichloride;

rac-dimethylsilyl-bis(2-methyl-4-phenyl-indenyl) zirconiumdimethyl;
rac-dimethylsilyl-bis(2-methyl-4-phenyl-indenyl) zirconiumdichloride;
rac-dimethylsilyl-bis(2-methyl-benzindenyl)hafniumdimethyl;
rac-dimethylsilyl-bis(2-methyl-benzindenyl) hafniumdichloride;
rac-dimethylsilyl-bis(2-methyl-benzindenyl) zirconiumdimethyl;
rac-dimethylsilyl-bis(2-methyl-benzindenyl) zirconiumdichloride;
bis(1-methyl,4-butylcyclopentadienyl)zirconiumdichloride;
bis(1-methyl,4-butylcyclopentadienyl)zirconiumdimethyl;
bis(1-methyl,4-butylcyclopentadienyl)zirconiumdimethoxide;
bis(1-methyl,4-butylcyclopentadienyl)zirconiumdibenzyl;
bis(1-methyl,4-butylcyclopentadienyl)zirconiumdifluoride;
bis(1-methyl,4-butylcyclopentadienyl)zirconiumdiamide;
bis(1-methyl,4-ethylcyclopentadienyl)zirconiumdichloride;
bis(1-methyl,4-ethylcyclopentadienyl)zirconiumdimethyl;
bis(1-methyl,4-benzylcyclopentadienyl)zirconiumdichloride;
bis(1-methyl,4-benzylcyclopentadienyl)zirconiumdimethyl;
bis(1-methyl,3-butylcyclopentadienyl)zirconiumdichloride;
bis(1-methyl,3-butylcyclopentadienyl)zirconiumdimethyl;
bis(1-methyl,3-n-propylcyclopentadienyl)zirconiumdichloride;
bis(1-methyl,3-n-propylcyclopentadienyl)zirconiumdimethyl;
1,1'-bis(4-triethylsilylphenyl)methylene-(cyclopentadienyl)(2,7-di-*tert*-butyl-fluoren-9-yl)hafnium dimethyl;
dimethylsilylene(cyclopentadienyl)(2,7-di-*tert*-butyl-fluoren-9-yl)hafnium dimethyl;
dimethylsilylene(cyclopentadienyl)(3,6-di-*tert*-butyl-fluoren-9-yl)hafnium dimethyl;
diphenylmethylene(cyclopentadienyl)(2,7-di-*tert*-butyl-fluoren-9-yl)hafnium dimethyl;
diphenylmethylene(cyclopentadienyl)(3,6-di-*tert*-butyl-fluoren-9-yl)hafnium dimethyl;
isopropylidene(cyclopentadienyl)(2,7-di-*tert*-butyl-fluoren-9-yl)hafnium dimethyl;
isopropylidene(cyclopentadienyl)(3,6-di-*tert*-butyl-fluoren-9-yl)hafnium dimethyl;
dimethylsilylene(cyclopentadienyl)(2,7-dimethylfluoren-9-yl)hafnium dimethyl;
dimethylsilylene(cyclopentadienyl)(3,6-dimethylfluoren-9-yl)hafnium dimethyl;
diphenylmethylene(cyclopentadienyl)(2,7-dimethylfluoren-9-yl)hafnium dimethyl;
diphenylmethylene(cyclopentadienyl)(3,6-dimethylfluoren-9-yl)hafnium dimethyl;
dimethylsilylene(cyclopentadienyl)(fluoren-9-yl)hafnium dimethyl;

isopropylidene(cyclopentadienyl)(fluoren-9-yl)hafnium dimethyl; diphenylmethylene(cyclopentadienyl)(fluoren-9-yl)hafnium dimethyl; and 1,1'-bis(4-triethylsilylphenyl)methylene(cyclopentadienyl)(2,7-di-*tert*-butyl-fluoren-9-yl)hafnium dimethyl.

14. The catalyst system of any of claims 1 to 11, wherein the catalyst compound is $Me_2Si(2,3,4,5\text{-tetramethylCp})(Cp)ZrMe_2$; $(1,3\text{-Me-nBuCp})_2ZrCl_2$; and/or rac-$Me_2Si(H_4Ind)_2ZrCl_2$.

15. The catalyst system of any of claims 1 to 14, wherein the ion-exchange layered silicate is montmorillonite.

16. The catalyst system of any of claims 1 to 15 further comprising an activator.

17. The catalyst system of claim 16, wherein the activator comprises an alumoxane.

18. The catalyst system of claim 16, wherein the activator comprises a non-coordinating anion.

19. The catalyst system of claim 16, wherein the activator comprises one or more of: trimethylammonium tetrakis(perfluoronaphthyl)borate, N,N-dimethylanilinium tetrakis(perfluoronaphthyl)borate, N,N-diethylanilinium tetrakis(perfluoronaphthyl)borate, triphenylcarbenium tetrakis(perfluoronaphthyl)borate, trimethylammonium tetrakis(perfluorobiphenyl)borate, N,N-dimethylanilinium tetrakis(perfluorobiphenyl)borate, triphenylcarbenium tetrakis(perfluorobiphenyl)borate, N,N-dimethylanilinium tetrakis(3,5-bis(trifluoromethyl)phenyl)borate, triphenylcarbenium tetrakis(perfluoronaphthyl)borate, triphenylcarbenium tetrakis(perfluorobiphenyl)borate, triphenylcarbenium tetrakis(3,5-bis(trifluoromethyl)phenyl)borate, triphenylcarbenium tetrakis(perfluorophenyl)borate, $[Ph_3C^+][B(C_6F_5)_4^-]$, $[Me_3NH^+][B(C_6F_5)_4^-]$, 1-(4-(tris(pentafluorophenyl)borate)-2,3,5,6-tetrafluorophenyl)pyrrolidinium, tetrakis(pentafluorophenyl)borate, 4-(tris(pentafluorophenyl)borate)-2,3,5,6-tetrafluoropyridine, triphenylcarbenium tetraphenylborate, and triphenylcarbenium tetrakis-(2,3,4,6-tetrafluorophenyl)borate.

20. A polymerization process comprising contacting one or more alkene monomers with the catalyst system of any of claims 1 to 19.

21. The process of claim 20, wherein the monomer comprises ethylene and or propylene.

22. The process of claim 20 or 21, wherein the polymerization is conducted in gas phase or as a slurry.

23. A composition comprising a polymer and ion-exchange layered silicate with an aluminum alkylene or aluminum dialkylene appended thereto produced by contacting one or more alkene monomers with the catalyst system any of claims 1 to 19.