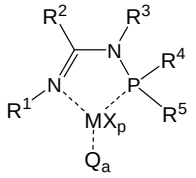
CLAIMS

1. A catalyst system comprising:

   i) an N^2-phosphinyl amidine metal salt complex having the formula:



   wherein:

   R^1 is a C_1 to C_{30} organyl group,

   R^2 is a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

   R^3 is hydrogen or a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

   R^4 and R^5 are each independently a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

   MX_p represents the metal salt where M is a transition metal, X is a monoanion, and p ranges from 2 to 6,

   Q is a neutral ligand, and

   a ranges from 0 to 6, and

   ii) a metal alkyl,

   wherein the inert functional groups are selected from the group consisting of halo groups, nitro groups, hydrocarboxy groups, sulfidyl groups, hydrocarbyl groups, or combinations thereof.

2. The catalyst system of claim 1, wherein

   R^1 is a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, or a C_6 to C_{20} substituted aryl group,

   R^2 is a C_6 to C_{20} phenyl group, a C_6 to C_{20} substituted phenyl group, a C_6 to C_{20} benzyl group, a C_6 to C_{20} substituted benzyl group, a C_6 to C_{20} ethylphenyl group, or a C_6 to C_{20} substituted ethylphenyl group,

   R^3 is hydrogen, a C_1 to C_{10} alkyl group, a C_1 to C_{15} cycloalkyl group, a C_1 to C_{15} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic

heterocyclic group, a C_6 to C_{15} aryl group, a C_6 to C_{15} substituted aryl group, a C_3 to C_{15} heteroaryl group, or a substituted C_3 to C_{15} heteroaryl group,

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group,

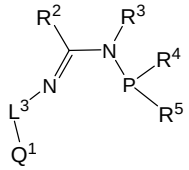
the metal salt comprises a Group 3-10 transition metal in a +2 or +3 oxidation state, and

the metal alkyl comprises an aluminoxane and

the aluminum of the aluminoxane to the metal of the metal complex molar ratio is at least 5:1.

3. The catalyst system of claim 1, wherein

R^1 comprises a metal complexing group and a linking group linking the metal complexing group to the N^1 nitrogen atom of a N^2-phosphinyl amidine group of the N^2-phosphinyl amidine compound having the formula



wherein Q^1 represents the metal complexing group and is a dialkyl aminyl group, a dicycloalkyl aminyl group, a di(substituted cycloalkyl) aminyl group, a N-(alkyl)-N-(cycloalkyl) aminyl group, a N-(alkyl)-N-(substituted cycloalkyl) aminyl group, a N-(cycloalkyl)-N-(substituted cycloalkyl) aminyl group, a diaryl aminyl group, a di(substituted aryl) aminyl group, an N-aryl-N-(substituted aryl) aminyl group, an N-alkyl-N-aryl aminyl group, an N-alkyl-N-(substituted aryl) aminyl group, a dialkyl phosphinyl group, a dicycloalkyl phosphinyl group, a di(substituted cycloalkyl) phosphinyl group), a N-(alkyl)-N-(cycloalkyl) phosphinyl group, a N-(alkyl)-N-(substituted cycloalkyl) phosphinyl group, a N-(cycloalkyl)-N-(substituted cycloalkyl) phosphinyl group, a diaryl phosphinyl group, a di(substituted aryl) phosphinyl group, a P-aryl-P-(substituted aryl) phosphinyl group, a P-alkyl-P-aryl phosphinyl group, a P-alkyl-P-(substituted aryl) phosphinyl group, an alkyl etheryl group, an aryl etheryl group, a substituted aryl etheryl group, an alkyl sulfidyl group, an aryl sulfidyl group, a substituted aryl sulfidyl group, a

furanyl group, a substituted furanyl group, a thienyl group, a substituted thienyl group, a tetrahydrofuranyl group, a substituted tetrahydrofuranyl group, a thiophanyl group, a substituted thiophanyl group, a pyridinyl group, a substituted pyridinyl group, a morphilinyl group, a substituted morphilinyl group, a pyranyl group, a substituted pyranyl group, a tetrahydropyranyl group, a substituted tetrahydropyranyl group, a quinolinyl group, a substituted quinolinyl group, a pyrrolyl group, a substituted pyrrolyl group, a pyrrolidinyl group, a substituted pyrrolidinyl group, a piperidinyl group, or a substituted piperidinyl group, and L^3 represents the linking group and is a bond or a C_1 to C_{10} organyl group,

R^2 is a C_6 to C_{20} phenyl group, a C_6 to C_{20} substituted phenyl group, a C_6 to C_{20} benzyl group, a C_6 to C_{20} substituted benzyl group, a C_6 to C_{20} ethylphenyl group, or a C_6 to C_{20} substituted ethylphenyl group,

R^3 is hydrogen, a C_1 to C_{10} alkyl group, a C_1 to C_{15} cycloalkyl group, a C_1 to C_{15} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{15} aryl group, a C_6 to C_{15} substituted aryl group, a C_3 to C_{15} heteroaryl group, or a substituted C_3 to C_{15} heteroaryl group,

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group,

the metal salt comprises a Group 3-10 transition metal in a +2 or +3 oxidation state, and

the metal alkyl comprises an aluminoxane and

the aluminum of the aluminoxane to the metal of the metal complex molar ratio is at least 5:1.

4. The catalyst system of claim 1, wherein

R^1 is a phenyl group or a substituted phenyl group,

R^2 is a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_7 to C_{20} aralkyl group, or a C_7 to C_{20} substituted aralkyl group,

R^3 is hydrogen, and

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, or a C_6 to C_{20} substituted aryl group,

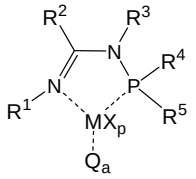
the metal salt is a chromium(III) carboxylate, a chromium(III) β-diketonate, or a chromium(III) halide,

the metal alkyl comprises an aluminoxane and the aluminoxane comprises methylaluminoxane (MAO), modified methylaluminoxane (MMAO), ethylaluminoxane, n-propylaluminoxane, iso-propylaluminoxane, n-butylaluminoxane, sec-butylaluminoxane, iso-butylaluminoxane, t-butyl aluminoxane, 1-pentylaluminoxane, 2-pentylaluminoxane, 3-pentylaluminoxane, iso-pentylaluminoxane, neopentylaluminoxane, or mixtures thereof, and

the aluminum of the aluminoxane to the metal of the metal complex molar ratio is at least 5:1.

5. A method of preparing a catalyst system, comprising forming a catalyst system mixture comprising:

i) an N^2-phosphinyl amidine metal salt complex having the formula:



wherein:

R^1 is a C_1 to C_{30} organyl group,

R^2 is a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^3 is hydrogen or a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^4 and R^5 are each independently a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

MX_p represents the metal salt where M is a transition metal, X is a monoanion, and p ranges from 2 to 6,

Q is a neutral ligand, and

a ranges from 0 to 6, and

ii) a metal alkyl,

wherein the inert functional groups are selected from the group consisting of halo groups, nitro groups, hydrocarboxy groups, sulfidyl groups, hydrocarbyl groups, or combinations thereof.

6. The method of claim 5, wherein

R^1 is a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, or a C_6 to C_{20} substituted aryl group,

R^2 is a C_6 to C_{20} phenyl group, a C_6 to C_{20} substituted phenyl group, a C_6 to C_{20} benzyl group, a C_6 to C_{20} substituted benzyl group, a C_6 to C_{20} ethylphenyl group, or a C_6 to C_{20} substituted ethylphenyl group,

R^3 is hydrogen, a C_1 to C_{10} alkyl group, a C_1 to C_{15} cycloalkyl group, a C_1 to C_{15} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{15} aryl group, a C_6 to C_{15} substituted aryl group, a C_3 to C_{15} heteroaryl group, or a substituted C_3 to C_{15} heteroaryl group,

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group,

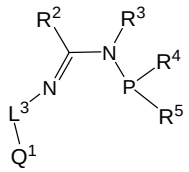
the metal salt comprises a Group 3-10 transition metal in a +2 or +3 oxidation state, and

the metal alkyl comprises an aluminoxane and

the metal of the metal alkyl to the metal of the metal of the N^2-phosphinyl amidine metal salt complex molar ratio is at least 5:1.

7. The method of claim 5, wherein

R^1 comprises a metal complexing group and a linking group linking the metal complexing group to the N^1 nitrogen atom of a N^2-phosphinyl amidine group of the N^2-phosphinyl amidine compound having the formula



wherein Q^1 represents the metal complexing group and is a dialkyl aminyl group, a dicycloalkyl aminyl group, a di(substituted cycloalkyl) aminyl group, a N-(alkyl)-N-(cycloalkyl) aminyl group, a N-(alkyl)-N-(substituted cycloalkyl) aminyl group, a N-(cycloalkyl)-N-(substituted cycloalkyl) aminyl group, a diaryl aminyl group, a di(substituted aryl) aminyl group, an N-aryl-N-(substituted aryl) aminyl group, an N-alkyl-N-aryl aminyl group, an N-alkyl-N-(substituted aryl) aminyl group, a dialkyl phosphinyl group, a dicycloalkyl phosphinyl group, a di(substituted cycloalkyl) phosphinyl group), a N-(alkyl)-N-(cycloalkyl) phosphinyl group, a N-(alkyl)-N-(substituted cycloalkyl) phosphinyl group, a N-(cycloalkyl)-N-(substituted cycloalkyl) phosphinyl group, a diaryl phosphinyl group, a di(substituted aryl) phosphinyl group, a P-aryl-P-(substituted aryl) phosphinyl group, a P-alkyl-P-aryl phosphinyl group, a P-alkyl-P-(substituted aryl) phosphinyl group, an alkyl etheryl group, an aryl etheryl group, a substituted aryl etheryl group, an alkyl sulfidyl group, an aryl sulfidyl group, a substituted aryl sulfidyl group, a furanyl group, a substituted furanyl group, a thienyl group, a substituted thienyl group, a tetrahydrofuranyl group, a substituted tetrahydrofuranyl group, a thiophanyl group, a substituted thiophanyl group, a pyridinyl group, a substituted pyridinyl group, a morphilinyl group, a substituted morphilinyl group, a pyranyl group, a substituted pyranyl group, a tetrahydropyranyl group, a substituted tetrahydropyranyl group, a quinolinyl group, a substituted quinolinyl group, a pyrrolyl group, a substituted pyrrolyl group, a pyrrolidinyl group, a substituted pyrrolidinyl group, a piperidinyl group, or a substituted piperidinyl group, and L^3 represents the linking group and is a bond or a C_1 to C_{10} organyl group,

R^2 is a C_6 to C_{20} phenyl group, a C_6 to C_{20} substituted phenyl group, a C_6 to C_{20} benzyl group, a C_6 to C_{20} substituted benzyl group, a C_6 to C_{20} ethylphenyl group, or a C_6 to C_{20} substituted ethylphenyl group,

R^3 is hydrogen, a C_1 to C_{10} alkyl group, a C_1 to C_{15} cycloalkyl group, a C_1 to C_{15} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{15} aryl group, a C_6 to C_{15} substituted aryl group, a C_3 to C_{15} heteroaryl group, or a substituted C_3 to C_{15} heteroaryl group,

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15}

substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group,

the metal salt comprises a Group 3-10 transition metal in a +2 or +3 oxidation state, and

the metal alkyl comprises an aluminoxane and

the metal of the metal alkyl to the metal of the of the N^2-phosphinyl amidine metal salt complex molar ratio is at least 5:1.

8. The method of claim 5, wherein

R^1 is a phenyl group or a substituted phenyl group,

R^2 is a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_7 to C_{20} aralkyl group, or a C_7 to C_{20} substituted aralkyl group,

R^3 is hydrogen, and

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, or a C_6 to C_{20} substituted aryl group,

the metal salt is a chromium(III) carboxylate, a chromium(III) β-diketonate, or a chromium(III) halide,

the metal alkyl comprises an aluminoxane and the aluminoxane comprises methylaluminoxane (MAO), modified methylaluminoxane (MMAO), ethylaluminoxane, n-propylaluminoxane, iso-propylaluminoxane, n-butylaluminoxane, sec-butylaluminoxane, iso-butylaluminoxane, t-butyl aluminoxane, 1-pentylaluminoxane, 2-pentylaluminoxane, 3-pentylaluminoxane, iso-pentylaluminoxane, neopentylaluminoxane, or mixtures thereof, and

the metal of the metal alkyl to the metal of the metal of the N^2-phosphinyl amidine metal salt complex molar ratio ranges from 100:1 to 2,500:1.

9. The method of claim 5, wherein the mixture further comprises a solvent.

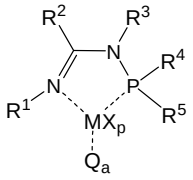
10. The method of claim 5, wherein the metal alkyl is an aluminoxane and the aluminoxane is thermally aged at a temperature of from 30 °C to 100 °C for at least 12 hours before contacting it with the metal complex.

11. The method of claim 5, wherein the catalyst system mixture is aged in the substantial absence of an olefin for at least 15 minutes.

12. An olefin oligomerization process comprising:

a) contacting an olefin and a catalyst system, the catalyst system comprising:

i) an N^2-phosphinyl amidine metal salt complex having the formula:



wherein:

R^1 is a C_1 to C_{30} organyl group,

R^2 is a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^3 is hydrogen or a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^4 and R^5 are each independently a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

MX_p represents the metal salt where M is a transition metal, X is a monoanion, and p ranges from 2 to 6,

Q is a neutral ligand, and

a ranges from 0 to 6, and

ii) a metal alkyl; and

b) forming an olefin oligomer product,

wherein the inert functional groups are selected from the group consisting of halo groups, nitro groups, hydrocarboxy groups, sulfidyl groups, hydrocarbyl groups, or combinations thereof.

13. The olefin oligomerization process of claim 12, wherein the olefin, the catalyst system, and hydrogen are contacted to form the olefin oligomer product.

14. The olefin oligomerization process of claim 12, wherein the olefin comprises ethylene.

15. The olefin oligomerization process of claim 12, wherein the olefin consists essentially of ethylene and a liquid product comprises at least 70 wt. % C_6 and C_8 olefins.

16. The olefin oligomerization process of claim 15, wherein the C_6 olefin product comprises at least 90 wt. % 1-hexene.

17. The olefin oligomerization process of claim 15, wherein the C_8 olefin product comprises at least 90 wt. % 1-octene.

18. The olefin oligomerization process of claim 12, wherein the olefin oligomer product is formed at reaction conditions capable of forming an olefin oligomer comprising a temperature ranging from 20 °C to 150 °C.

19. The olefin oligomerization process of claim 12, further comprising
forming a catalyst system mixture comprising the N^2-phosphinyl amidine metal salt complex and the aluminoxane and
contacting the catalyst system mixture with ethylene.

20. The olefin oligomerization process of claim 19, wherein the catalyst system mixture further comprises a first solvent.

21. The olefin oligomerization process of claim 20, wherein the first solvent is a C_6-C_{20} aromatic hydrocarbon, a C_1-C_{10} halogenated hydrocarbon, or a combination thereof.

22. The olefin oligomerization process of claim 19, wherein the catalyst system mixture is aged in the substantial absence of an olefin for at least 15 minutes.

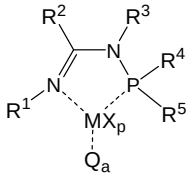
23. The olefin oligomerization process of claim 19, wherein the catalyst system mixture and olefin are contacted with a second solvent.

24. The olefin oligomerization process of claim 23, wherein the second solvent is a C_2-C_{20} aliphatic hydrocarbon, a C_6-C_{20} aromatic hydrocarbon, or a combination thereof.

25. The olefin oligomerization process of claim 12, comprising:

a) contacting an olefin comprising ethylene and a catalyst system, the catalyst system comprising:

i) the N^2-phosphinyl amidine metal salt complex having the formula:



wherein:

R^1 is a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, or a C_6 to C_{20} substituted aryl group,

R^2 is a C_6 to C_{20} phenyl group, a C_6 to C_{20} substituted phenyl group, a C_6 to C_{20} benzyl group, a C_6 to C_{20} substituted benzyl group, a C_6 to C_{20} ethylphenyl group, or a C_6 to C_{20} substituted ethylphenyl group,

R^3 is hydrogen, a C_1 to C_{10} alkyl group, a C_1 to C_{15} cycloalkyl group, a C_1 to C_{15} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{15} aryl group, a C_6 to C_{15} substituted aryl group, a C_3 to C_{15} heteroaryl group, or a substituted C_3 to C_{15} heteroaryl group,

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group,

MX_p represents the metal salt where M is a Group 3-10 transition metal in a +2 or +3 oxidation state, X is a monoanion, and p ranges from 2 to 3,

Q is a neutral ligand, and

a ranges from 0 to 6, and

ii) the metal alkyl comprising an aluminoxane; and

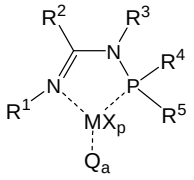
b) forming an olefin oligomer product comprising a liquid product comprising at least 70 wt. % C_6 and C_8 olefins;

wherein the metal of the metal alkyl to the metal of the metal of the N^2-phosphinyl amidine metal salt complex molar ratio is at least 5:1.

26. The olefin oligomerization process of claim 12, comprising:

a) contacting an olefin comprising ethylene and a catalyst system, the catalyst system comprising:

i) the N^2-phosphinyl amidine metal salt complex having the formula:



wherein:

R^1 is a phenyl group or a substituted phenyl group,

R^2 is a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_7 to C_{20} aralkyl group, or a C_7 to C_{20} substituted aralkyl group,

R^3 is hydrogen, and

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_6 to C_{20} aryl group, or a C_6 to C_{20} substituted aryl group,

MX_p represents the metal salt and the the metal salt is a chromium(III) carboxylate, a chromium(III) β-diketonate, or a chromium(III) halide,

Q is a neutral ligand, and

a ranges from 0 to 6, and

ii) the metal alkyl comprising an aluminoxane and the aluminoxane comprises methylaluminoxane (MAO), modified methylaluminoxane (MMAO), ethylaluminoxane, n-propylaluminoxane, iso-propylaluminoxane, n-butylaluminoxane, sec-butylaluminoxane, iso-butylaluminoxane, t-butyl

aluminoxane, 1-pentylaluminoxane, 2-pentylaluminoxane, 3-pentylaluminoxane, iso-pentylaluminoxane, neopentylaluminoxane, or mixtures thereof; and

b) forming an olefin oligomer product comprising a liquid product comprising at least 70 wt. % C_6 and C_8 olefins;

wherein the metal of the metal alkyl to the metal of the metal of the N^2-phosphinyl amidine metal salt complex molar ranges from 100:1 to 2,500:1.

27. The olefin oligomerization process of claim 26, wherein ethylene, the catalyst system, and hydrogen are contacted to form the olefin oligomer product.

28. The olefin oligomerization process of claim 26, wherein the C_6 olefin product comprises at least 90 wt. % 1-hexene.

29. The olefin oligomerization process of claim 26, wherein the C_8 olefin product comprises at least 90 wt. % 1-octene.

30. The olefin oligomerization process of claim 26, wherein the olefin oligomer productis formed at reaction conditions capable of forming an olefin oligomer comprising a temperature ranging from 20 °C to 150 °C.

31. The olefin oligomerization process of claim 26, further comprising
forming a catalyst system mixture comprising the N^2-phosphinyl amidine metal salt complex and the aluminoxane, and
contacting the catalyst system mixture with ethylene.

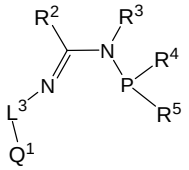
32. The olefin oligomerization process of claim 31, wherein the catalyst system mixture is aged in the substantial absence of ethylene for at least 15 minutes.

33. The olefin oligomerization process of claim 26, wherein
the metal salt is chromium(III) chloride,
the aluminoxane comprises modified methylaluminoxane (MMAO),
the olefin oligomer productis formed at reaction conditions capable of forming an olefin oligomer comprising a temperature ranging from 20 °C to 150 °C, an ethylene partial

pressure ranging from 50 psig to 4000 psig, and a hydrogen partial pressure ranging from 5 psig to 400 psig.

34. The olefin oligomerization process of claim 26, further comprising
forming a catalyst system mixture comprising the N^2-phosphinyl amidine metal salt complex and the aluminoxane,
aging the catalyst system mixture in the substantial absence of ethylene for at least 15 minutes, and contacting the catalyst system mixture with ethylene.

35. An N^2-phosphinyl amidine compound characterized by having the formula:



wherein:
Q1 represents the metal complexing group and is a dialkyl aminyl group, a dicycloalkyl aminyl group, a di(substituted cycloalkyl) aminyl group, a N-(alkyl)-N-(cycloalkyl) aminyl group, a N-(alkyl)-N-(substituted cycloalkyl) aminyl group, a N-(cycloalkyl)-N-(substituted cycloalkyl) aminyl group, a diaryl aminyl group, a di(substituted aryl) aminyl group, an N-aryl N-(substituted aryl) aminyl group, an N-alkyl N-aryl aminyl group, an N-alkyl N-(substituted aryl) aminyl group, a dialkyl phosphinyl group, a dicycloalkyl phosphinyl group, a di(substituted cycloalkyl) phosphinyl group), a N (alkyl)-N-(cycloalkyl) phosphinyl group, a N-(alkyl)-N-(substituted cycloalkyl) phosphinyl group, a N-(cycloalkyl)-N-(substituted cycloalkyl) phosphinyl group, a diaryl phosphinyl group, a di(substituted aryl) phosphinyl group, a P-aryl P-(substituted aryl) phosphinyl group, a P-alkyl P-aryl phosphinyl group, a P-alkyl P-(substituted aryl) phosphinyl group, an alkyl etheryl group, an aryl etheryl group, a substituted aryl etheryl group, an alkyl sulfidyl group, an aryl sulfidyl group, a substituted aryl sulfidyl group, a furanyl group, a substituted furanyl group, a thienyl group, a substituted thienyl group, a tetrahydrofuranyl group, a substituted tetrahydrofuranyl group, a thiophanyl group, a substituted thiophanyl group, a pyridinyl group, a substituted pyridinyl group, a morphilinyl group, a substituted morphilinyl group, a pyranyl group, a substituted pyranyl group, a tetrahydropyranyl group,

a substituted tetrahydropyranyl group, a quinolinyl group, a substituted quinolinyl group, a pyrrolyl group, a substituted pyrrolyl group, a pyrrolidinyl group, a substituted pyrrolidinyl group, a piperidinyl group, or a substituted piperidinyl group,

L^3 represents a linking group linking the metal complexing group to the N^1 nitrogen atom of a N^2-phosphinyl amidine group of the N^2-phosphinyl amidine compound and is a bond or a C_1 to C_{10} organyl group,

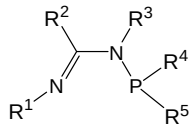
R^2 is a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^3 is hydrogen, a C_1 to C_{30} organyl group, or a C_1 to C_{30} organyl group consisting essentially of inert functional groups, and

R^4 and R^5 are each independently a C_1 to C_{30} organyl group consisting essentially of inert functional groups; and

wherein the inert functional groups are selected from the group consisting of halo groups, nitro groups, hydrocarboxy groups, sulfidyl groups, hydrocarbyl groups, or combinations thereof.

36. A method of preparing an N^2-phosphinyl amidine compound having the formula:



wherein:

R^1 is a C_1 to C_{30} organyl group,

R^2 is a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^3 is hydrogen, a C_1 to C_{30} organyl group ,or a C_1 to C_{30} organyl group consisting essentially of inert functional groups, and R^4 and R^5 are each independently a C_1 to C_{30} organyl group consisting essentially of inert functional groups; and

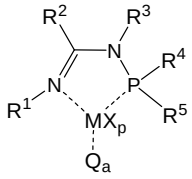
wherein the inert functional groups are selected from the group consisting of halo groups, nitro groups, hydrocarboxy groups, sulfidyl groups, hydrocarbyl groups, or combinations thereof,

the method comprising:

a) contacting a metal amide with a nitrile under conditions capable of forming a metal amidinate; and

b) contacting a phosphine halide with the metal amidinate under conditions capable of forming a compound comprising a N^2-phosphinyl amidine group.

37. A metal salt complex of an N^2-phosphinyl amidine compound having the formula:



wherein:

R^1 is a C_1 to C_{30} organyl group,

R^2 is a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^3 is hydrogen or a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^4 and R^5 are each independently a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

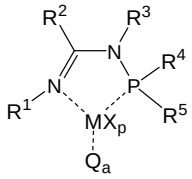
MX_p represents the metal salt where M is a transition metal, X is a monoanion, and p ranges from 2 to 6,

Q is a neutral ligand, and

a ranges from 0 to 6; and

wherein the inert functional groups are selected from the group consisting of halo groups, nitro groups, hydrocarboxy groups, sulfidyl groups, hydrocarbyl groups, or combinations thereof.

38. A method of preparing an N^2-phosphinyl amidine metal salt complex having the formula:



wherein:

R^1 is a C_1 to C_{30} organyl group,

R^2 is a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^3 is hydrogen or a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

R^4 and R^5 are each independently a C_1 to C_{30} organyl group consisting essentially of inert functional groups,

MX_p represents the metal salt where M is a transition metal, X is a monoanion, and p ranges from 2 to 6,

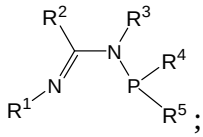
Q is a neutral ligand, and

a ranges from 0 to 6; and

wherein the inert functional groups are selected from the group consisting of halo groups, nitro groups, hydrocarboxy groups, sulfidyl groups, hydrocarbyl groups, or combinations thereof:

the method comprising:

a) contacting a transition metal salt with an N^2-phosphinyl amidine compound having the formula



; and

b) forming the N^2-phosphinyl amidine metal salt complex.

39. The N^2-phosphinyl amidine compound of claim 35, wherein R^2 is a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_7 to C_{20} aralkyl group, a C_7 to C_{20} substituted aralkyl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group.

40. The N^2-phosphinyl amidine compound of claim 35, wherein R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group.

41. The N^2-phosphinyl amidine compound of claim 35, wherein

R^2 is a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_7 to C_{20} aralkyl group, a C_7 to C_{20} substituted aralkyl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group,

R^3 is hydrogen, and

R^4 and R^5 are independently a C_1 to C_{15} alkyl group, a C_4 to C_{20} cycloalkyl group, a C_4 to C_{20} substituted cycloalkyl group, a C_3 to C_{15} aliphatic heterocyclic group, a C_3 to C_{15} substituted aliphatic heterocyclic group, a C_6 to C_{20} aryl group, a C_6 to C_{20} substituted aryl group, a C_3 to C_{20} heteroaryl group, or a C_3 to C_{20} substituted heteroaryl group.

42. The method of claim 36, wherein the metal amidinate of step a) is neutralized with a protic compound to form a non-metal amidine compound prior to step b).

43. The method of claim 36, wherein the metal amidinate of step a) is contacted with the phosphine halide without forming a non-metal amidine compound.

44. The method of claim 36, wherein the compound comprising the N^2-phosphinyl amidine group is isolated and optionally purified.

45. The metal salt complex of claim 37, wherein the metal salt comprises a Group 3-10 transition metal.

46. The metal salt complex of claim 37, wherein the metal of the metal salt is in a +2 or +3 oxidation state.

47. The metal salt complex of claim 37, wherein the metal salt comprises chromium.

48. The method of claim 38, wherein the transition metal salt and the N^2-phosphinyl amidine compound are contacted at a transition metal salt to N^2-phosphinyl amidine compound equivalent ratio of at least 0.9:1.