

WHAT IS CLAIMED IS:

1. A method for producing an alkylene oxide polymer or copolymer, comprising combining (i) at least one aluminum compound containing at least one trisubstituted aluminum atom, wherein at least one of the substituents of at least one trisubstituted aluminum atom is hydrocarbyl, (ii) at least one starter, (iii) at least one alkylene oxide, (iv) from 0.00005 to 0.1 mole, per equivalent of starter, of at least one phosphazene-nitrogen base and optionally (v) at least one comonomer that is not an oxirane, and polymerizing the alkylene oxide(s) or copolymerizing the alkylene oxide(s) and the comonomer to form the alkylene oxide polymer or copolymer.

2. The method of claim 1 wherein an aluminum atom of the aluminum compound is substituted with one or two hydrocarbyl groups, and is substituted with one or two halogen, oxo, ether, hydride or phosphonate groups.

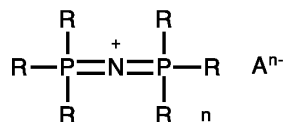
3. The method of claim 1 wherein the aluminum compound includes one or more of trimethyl aluminum, triethyl aluminum, triisopropyl aluminum, tri-n-propyl aluminum, triisobutyl aluminum, tri-n-butyl aluminum, tri-t-butylaluminum and trioctadecylaluminum.

4. The method of claim 1 wherein the aluminum compound includes one or more of dimethyl aluminum chloride, methyl aluminum dichloride, diethyl aluminum chloride, ethyl aluminum dichloride, diisobutyl aluminum chloride, isobutyl aluminum dichloride, methyl aluminum di[(2,6-di-t-butyl-4-methyl)phenoxy] (Al(BHT)₂Me), dimethyl 2,6-di-t-butyl-4-methylphenoxy (AlBHTMe₂) methyl aluminum di(2,6-diisopropyl)phenoxy, di methyl aluminum (2,6-diisopropyl)phenoxy methyl aluminum di [(2,6-diphenyl) phenoxy], dimethyl aluminum (2,6-diphenyl) phenoxy, methyl aluminum di[(2,4,6-trimethyl)phenoxy], dimethyl aluminum (2,4,6-trimethyl)phenoxy, tetraethylaluminane, tetramethylaluminane, diisobutyl aluminum hydride, isobutyl aluminum dihydride, dimethyl aluminum hydride, methyl aluminum dihydride, diethyl aluminum hydride, ethyl aluminum dihydride, diisopropyl aluminum hydride, isopropyl aluminum dihydride, diethyl aluminum ethoxide, ethyl aluminum diethoxide, dimethyl aluminum ethoxide, methyl aluminum diethoxide, dimethyl aluminum fluoride, methyl aluminum difluoride, diethyl aluminum fluoride, ethyl

aluminum difluoride, diisobutyl aluminum fluoride, isobutyl aluminum difluoride, dimethyl aluminum bromide, methyl aluminum dibromide, diethyl aluminum bromide, ethyl aluminum dibromide, diisobutyl aluminum bromide, isobutyl aluminum dibromide, dimethyl aluminum iodide, methyl aluminum diiodide, diethyl aluminum iodide, ethyl aluminum diiodide, diisobutyl aluminum iodide and isobutyl aluminum iodide.

5. The method of claim 1 wherein the aluminum compound includes one or more of bis(dimethylaluminum) methylphosphonate, bis(diethyl aluminum) methylphosphonate, bis(diethoxyaluminum) methylphosphonate, bis(di-n-propylaluminum) methyl phosphonate, bis(diisopropyl aluminum) methylphosphonate, bis (di-n-propoxylaluminum) methyl phosphonate, bis(diisopropoxylaluminum) methylphosphonate, bis(di-t-butylaluminum) methyl phosphonate, bis(di-t-butoxyaluminum) methyl phosphonate, bis(diphenylaluminum) methyl phosphonate, bis(diphenoxylaluminum) methyl phosphonate, bis(diisobutylaluminum) methylphosphonate and a tetraalkylaluminumoxane in which each alkyl group independently contains 1 to 6 carbon atoms.

6. The method of any preceding claim wherein the phosphorus-nitrogen bases is represented by the structure I:

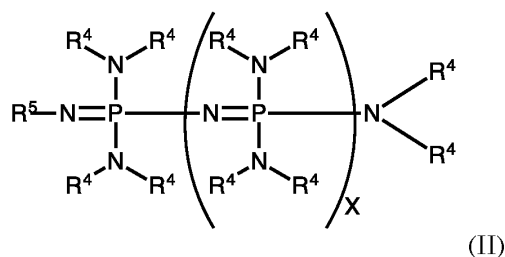


(I)

wherein each R is hydrocarbyl, NH₂ or -N=P-R₃, A is an anion, and n is the valence of the anion A, the phosphorus-nitrogen base having a molecular mass of up to 1000 g/mol.

7. The method of claim 6 wherein the phosphorus-nitrogen base is a fluoride, chloride, bromide, iodide, acetate, triflate, BF₄⁻ or PF₆⁻ salt of bis(triphenylphosphoranylidene)ammonium.

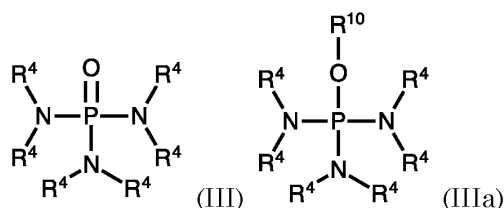
8. The method of any of claims 1-5 wherein the phosphorus-nitrogen base is represented by the structure II:



wherein R^5 and each R^4 are independently $-P[N(R^4)_2]_3$ or hydrocarbyl, provided that any two hydrocarbyl R^4 groups may form a divalent hydrocarbyl group that forms a ring that includes the nitrogen atom or atoms to which such R^4 groups are bonded, x is zero or a positive number and the phosphorus-nitrogen base has a molecular weight of up to 1000 g/mol.

9. The method of claim 8 wherein the phosphorus-nitrogen base is one or more of methylimino-tris(dimethylamino)phosphorane, ethylimino-tris(dimethylamino)phosphorane, t-butylimino-tris(dimethylamino)phosphorane, tert-octylimino-tris(dimethylamino)phosphorane, phosphazene base P2, phosphazene base P2-Et, phosphazene base P2-t-Bu, phosphazene base P2-tert-octyl, ethylimino-tris(pyrrolidino)phosphorane, t-butylimino-tris(pyrrolidino)phosphorane, tert-octylimino-tris(pyrrolidino)phosphorane, 2-ethylimino-2-diethylamino-1,3-dimethylperhydro-1,3-2-diazaphosphorine, 2-t-butylimino-2-diethylamino-1,3-dimethylperhydro-1,3-2-diazaphosphorine, 2-tert-octylimino-2-diethylamino-1,3-dimethylperhydro-1,3-2-diazaphosphorine, phosphazene base P4 (1-methyl-4,4,4-tris(dimethylamino)-2,2-bis[tris(dimethylamino)-phosphoranylidenamino]-2 λ^5 ,4 λ^5 -catenadi(phosphazene)), 1-ethyl-4,4,4-tris(dimethylamino)-2,2-bis[tris(dimethylamino)-phosphoranylidenamino]-2 λ^5 ,4 λ^5 -catenadi(phosphazene)) and 1-tert-Butyl-4,4,4-tris(dimethylamino)-2,2-bis[tris(dimethylamino)-phosphoranylidenamino]-2 λ^5 ,4 λ^5 -catenadi(phosphazene).

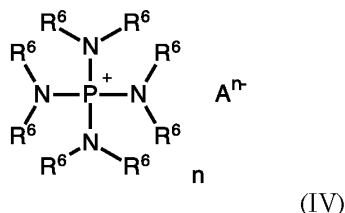
10. The method of any of claims 1-5 wherein the phosphorus-nitrogen base is represented by structure III or IIIa:



wherein each R^4 are independently $-PN(R^4)_3$, hydrocarbyl (more preferably alkyl or alkylene), provided that any two R^4 groups may form a divalent hydrocarbyl group that forms a ring that includes the nitrogen atom or atoms to which such R^4 groups are bonded, R^{10} is hydrocarbyl, and the phosphorus-nitrogen base has a molecular weight of up to 1000 g/mol.

11. The method of claim 10 wherein the phosphorus-nitrogen base is one or more of hexamethylphosphoramide (tris(dimethylaminophosphine oxide), hexaethylphosphoramide, hexa-*t*-butylphosphoramide and tris (N,N-tetramethylene) phosphoramide.

12. The method of any of claims 1-5 wherein the phosphorus-nitrogen base is represented by the structure IV:

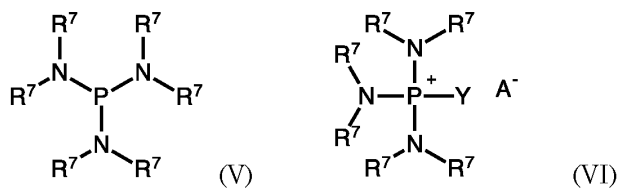


where A is an anion, and n is the valence of the anion A, and each R^6 is independently hydrocarbyl or $-N=P-(NR^6)_3$, provided further that any two R^6 groups may form a divalent hydrocarbyl group that forms a ring that includes the nitrogen atom or atoms to which such R^6 groups are bonded, and the phosphorus-nitrogen base having a molecular mass of up to 1000 g/mol.

13. The method of any claim 12 wherein the phosphorus-nitrogen bases is one or more 1,1,1,3,3,3-hexakis(dimethylamino)diphosphazanium fluoride, 1,1,1,3,3,3-hexakis(dimethylamino)diphosphazanium chloride, 1,1,1,3,3,3-hexakis(dimethylamino)diphosphazanium bromide, tetrakis[tris(dimethylamino)phosphoranylideneamino] phosphonium fluoride,

tetrakis[tris(dimethylamino)phosphoranylidenamino]phosphonium chloride and tetrakis[tris(dimethylamino)phosphoranylidenamino] phosphonium bromide.

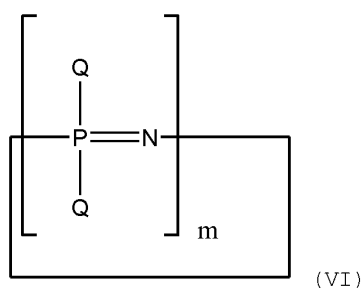
14. The method of any of claims 1-5 wherein the phosphorus-nitrogen bases is
5 a phosphine compound represented by structure V or structure VI:



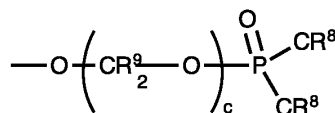
wherein each R^7 is independently hydrocarbyl, provided that any two R^7 groups may
form a divalent hydrocarbyl group that forms a ring that includes the nitrogen atom or
10 atoms to which such R^7 groups are bonded, Y is halogen, A is a monovalent anion and
the phosphorus-nitrogen base has a molecular weight of up to 1000 g/mol.

15. The method of claim 14 wherein the phosphine compound is one or more
of tris(dimethylamino)phosphine, tris(diethylamino)phosphine and tri(di-t-
15 butylamino)phosphine.

16. The method of any of claims 1-5 wherein the phosphorus-nitrogen base is
represented by the structure VI:



20 in which m is a number from 3 to 20, each Q is independently selected from
hydrocarbyl; $-N=P-R_3$ where each R is independently hydrocarbyl; aryloxy; alkoxy; and



wherein c is zero or a positive number which is preferably up to 4, each R⁹ is independently hydrocarbon, and each R⁸ is independently hydrocarbon.

17. The method of any preceding claim wherein the aluminum compound is
5 present in an amount sufficient to provide 100 to 2,500 parts by weight of aluminum per million parts by weight of the alkylene oxide polymer or copolymer.

18. The method of any preceding claim wherein the aluminum compound and
10 starter are combined at proportions that provide 0.00005 to 0.05 moles of aluminum per equivalent of starter.

19. The method of any preceding claim wherein the mole ratio of the aluminum compound to the phosphorus-nitrogen base is at least 1:3, and up to 5:1.

15 20. The method of any preceding claim wherein the starter contains one or more hydroxyl groups and has a hydroxyl equivalent weight of 30 to 6000 g/equivalent.

21. The method of any preceding claim wherein the starter contains 2 to 8
20 hydroxyl groups and has an equivalent weight of 30 to 250 g/equivalent.

22. The method of any preceding claim wherein the alkylene oxide is propylene oxide, ethylene oxide or a mixture of propylene oxide and ethylene oxide.

23. The method of any of claims 1-20 wherein the starter is a homopolymer of
25 propylene oxide and/or a random or block copolymer of propylene oxide that has a hydroxyl equivalent weight of at least 125 and up to 4000 g/equivalent and in which no more than 25% of the hydroxyl groups are primary.