CLAIMS

1. A process of conducting hydrogen mediated saline hydride initiated polymerizations which features feeding one or more vinyl aromatic monomer to a reaction medium containing a soluble saline hydride catalyst under an atmosphere comprising molecular hydrogen.

2. A process of conducting hydrogen mediated saline hydride initiated polymerizations which features feeding one or more vinyl aromatic monomer to a reaction medium containing a soluble saline hydride LOXSH catalyst formed from (i) molecular hydrogen; (ii) an organolithium compound and/or an organomagnesium compound; (iii) optionally a polytertiaryamine compound; (iv) a polarizing complexing agent selected from a tertiary aminoalcohol compound; a tertiary amino ether-alcohol, an ether-alcohol or combinations thereof; (v) optionally an alkali metal or metal alloy and/or a solid saline hydride and/or a saline metal amide; (vi) optionally an aromatic hydrocarbon having at least one C-H covalent bond pK_a within the range of 2.75 pK_a units above that of the pK_a of toluene to -4.30 pK_a units below the pK_a of toluene; and (vii) a hydrocarbon solvent with a pK_a greater than H_2; wherein the aromatic hydrocarbon and hydrocarbon solvent may be the same or different.

3. The process of claims 1 or 2, wherein the vinyl aromatic monomer is styrene; *o*- *m*-, and *p*-, isomers of methyl styrene; *p*-isopropylstyrene; 2,4-diethylstyrene; *o*-ethylstyrene; 3,5-di-isobutylstyrene; 2,6-dimethylstyrene; 2-ethyl-4-methylstyrene.

4. The process of claims 1 or 2, wherein the vinyl aromatic monomer is 1) a styrenic monomer; or 2) a styrenic monomer and styrene; or 3) is styrene.

5. The process of claims 1 or 2 wherein the reaction medium is a hydrocarbon solvent with a pK_a greater than that of H_2.

6. The process of claims 1 or 2 wherein the partial pressure of molecular hydrogen is maintained at pressures between 0.5 Bar to 19.0 Bar.

7. The process of claim 1 or 2 wherein the temperature of the process is maintained in the range of 20°C to 130°C.

8. The process of claim 1 or 2 wherein the molar ratio of the total charge of monomer to soluble saline hydride catalyst initially formed is 10:1 to 1000:1.

9. The process of claim 1 or 2, wherein the saline hydride catalyst is a LOXSH catalyst.

10. The process of claim 2 wherein the monomer is styrene; the saline hydride LOXSH catalyst is a LOXLiH catalyst formed from molecular hydrogen, an organolithium compound, optionally TMEDA, *N*,*N*-dimethylethanolamine in a hydrocarbon solvent reaction medium comprising one or more of ethylbenzene, cyclohexane and methylcyclohexane; the polymerization temperature is maintained between 20°C and less than 100°C; the partial pressure of molecular hydrogen is maintained between 0.5 Bar to 6.0 Bar; and the molar ratio of the total charge of monomer to soluble saline hydride catalyst initially formed is 10:1 to 600:1.

11. The process of claim 10, wherein the LOXLIH catalyst have the chemical formulas $[DMEA^{-}]_xLi_yH_z$, wherein said catalyst is formed from the process of contacting: (i) y equivalents of an organolithium compound; (ii) optionally TMEDA compound; (iii) x equivalents of dimethylamionethanol; (iv) optionally ethylbenzene; (v) a hydrocarbon solvent with a pKa greater than H_2; wherein the aromatic hydrocarbon and hydrocarbon solvent may be the same or different; and (vi) molecular hydrogen, wherein the amount of hydride formed z is given by the equation z = y – x and x, y and z are positive real numbers whole or fractional greater than zero; wherein said formula can further comprise *N*,*N*,*N'*,*N'*-tetramethylethylenediamine (TMEDA) ligand complex i.e. $[DMEA^{-}]_xLi_yH_z$ XTMEDA in a molar ratio X moles TMEDA per mole of catalyst $[DMEA^{-}]_xLi_yH_z$ wherein X = 0.0001 to 8.0.

12. The process of claim 2 wherein the monomer is styrene; the saline hydride LOXSH catalyst is a bimetallic $LOXMgH_2$ catalyst formed from molecular hydrogen, an organolithium compound and an organomagnesium compound, optionally TMEDA, *N*,*N*-dimethylethanolamine in a hydrocarbon solvent reaction medium comprising one or more of ethylbenzene, cyclohexane and methylcyclohexane; the polymerization temperature is maintained between 20°C and 90°C; the partial pressure of molecular hydrogen is maintained between 0.5 Bar to 6.0 Bar; and the molar ratio of the total charge of monomer to soluble saline hydride catalyst initially formed is 10:1 to 600:1.

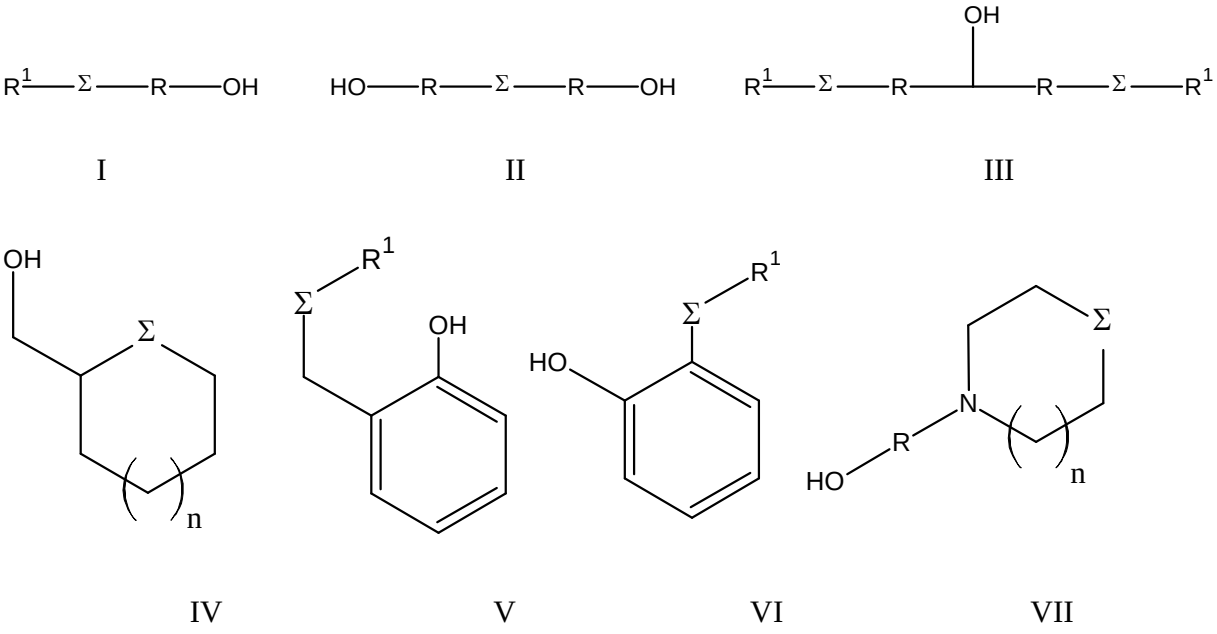
13. The process of claims 2, 10 or 12 wherein the soluble LOXSH catalyst contains the polytertiaryamine (PTA) compound and is formed using an alkali metal or metal alloy and/or a

solid saline hydride and/or a saline metal amide wherein the molar ratio of the PTA to the total alkali metal and alkali earth metal charged in forming LOXSH catalyst is 1:10,000 to 8:1.

14. The process of claims 2, 10 or 12 wherein the organolithium compound is *n*-butyllithium, *sec*-butyllithium, *t*-butyllithium, allyllithium, vinyllithium, phenyllithium, 1-hexyl-1-phenyllithium, 1-hexyl-1,1-diphenyllithium, cyclohexyllithium, or poly(styryl)lithium compounds which can be added or generated *in situ*.

15. The process of claim 2 or 12 wherein the organomagnesium compounds is butylethylmagnesium (BEM), di-*n*-butylmagnesium (DBM), *n*-butyl-*n*-octylmagnesium, di-*n*-octylmagnesium, di-cyclohexylmagnesium, or poly(styryl)magnesium compounds which can be added or generated *in situ*.

16. The process of claim 2 wherein the polarizing complexing agent is at least one of the structures:



wherein R is independently an organic group capable of forming bonds with one or more tertiary amines and one hydroxyl, R^1 is independently an organic group which may also be further substituted by other tertiary amines, Σ can include: i) O or NR^1 for I, II, III, IV, V and VI; ii) and VII can include O or NR^1 or CH_2; and the index value n is independently a whole number equal to or greater than 0.

17. The process of claim 2 wherein the polarizing complexing agent is at least one aminoalcohol selected from: dimethylaminoethanol, diethylaminoethanol, *N*-methyl-diethanolamine, 3-dimethylamino-1-propanol, 2-[2-(dimethylamino)ethoxy]ethanol, 1-(2-hydroxyethyl)piperidine, 1-(2-hydroxyethyl)morpholine, 1-(2-hydroxyethyl)pyrolidine, or 1-methyl-2-pyrolidinemethanol.

18. The process of claim 2 wherein the polytertiary amine (PTA) compoundis present in a molar ratio of total alkali and alkali earth metal to PTA from 10,000 to 1.0 to 1.0 to 8.0.

19. The process of claim 2 wherein the polytertiary amine (PTA) compoundis at least one of *N,N,N',N'*-tetramethylethylenediamine (TMEDA), *N,N,N',N'',N''*-pentamethyldiethylenetriamine (PMDETA), sparteine, isosparteine, and 1,4-methylpiperazine.

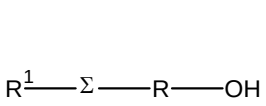
20. The process of claim 2 wherein the aromatic hydrocarbon is at least one of benzene, toluene, mesitylene, ethylbenzene, *n*-propylbenzene, *n*-butylbenzene, *iso*-butylbenzene, amylbenzene, 1.2-darylethanes, 1,3-diarylpropanes, cumene, *t*-butylbenzene, 1-alkyl naphthalene, 2-alkylnaphthalene, a styrene dimer or low molecular weight styrene oligomer distribution.

21. The process of claim 2, wherein the catalyst has the empirical chemical formula: a) $[PCA^-]_4Li_6H_2$; b) $[PCA^-]_4Li_8H_4$; c) $[PCA^-]_2Li_6H_4$; d) $[PCA^-]_4Li_{12}H_8$; e) $[PCA^-]_5Li_{15}H_{10}$; f) $[PCA^-]_5Li_{12}H_7$; g) $[PCA^-]_2Li_5H_3$; h) $[PCA^-]_4Li_4MgH_2$; i) $[PCA^-]_4Li_4Mg_2H_4$; j) $[PCA^-]_2Li_4MgH_4$; k) $[PCA^-]_4Li_6Mg_3H_8$; l) $[PCA^-]_5Li_9Mg_3H_{10}$; m) $[PCA^-]_5Li_6Mg_3H_7$; n) $[PCA^-]_2Li_3MgH_3$; o) $[PCA^-]_4Li_5KH_2$; p) $[PCA^-]_4Li_7KH_4$; and q) $[PCA^-]_2Li_5KH_4$, wherein $[PCA^-]$ independently denotes the alkoxide of the corresponding polarizing complexing agent reagent alcohol having given up one proton to a more basic species and wherein said empirical chemical formula can optionally further comprise a PTA ligand complex in a molar ratio of total alkali and alkali earth metal to PTA from 10,000 to 1.0 to 1.0 to 8.0.

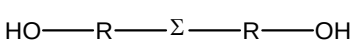
22. The process of claim 21, wherein [PCA$^-$] is independently [DMEA$^-$], [DMAEOE$^-$] or [MEOE$^-$].

23. A hydrocarbon soluble catalyst or reagent composition formed from (i) an organolithium compound optionally with an organomagnesium compound; (ii) an optional polytertiaryamine promotor compound; (iii) a polarizing complexing agent selected from a tertiary amino alcohol, a tertiary amino ether-alcohol an ether-alcohol or combinations thereof; (iv) optionally an aromatic hydrocarbon having at least one C-H covalent bond pK_a within the range of 2.75 pK_a units above that of the pK_a of toluene to -4.30 pK_a units below the pK_a of toluene; (v) an optional solid alkali or alkaline earth metal hydride or an alkali metal or alkali metal alloy or a alkali or alkaline earth amide; (vi) a hydrocarbon solvent having a pK_a greater than H_2, wherein the aromatic hydrocarbon and hydrocarbon solvent may be the same or different; and (vii) molecular hydrogen.

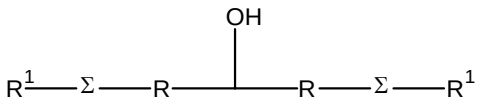
24. The hydrocarbon soluble catalyst or reagent composition of Claim 23 wherein the polarizing complexing agent is at least one of the structures:



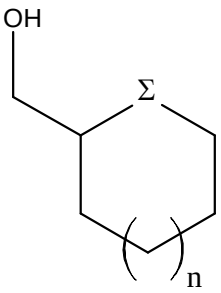
I

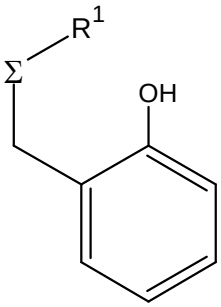


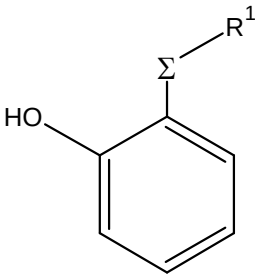
II

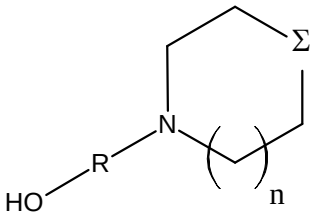


III









IV V VI VII

wherein R is an organic group capable of forming bonds with one or more tertiary amines and one hydroxyl, R^1 is independently an organic group which may also be further substituted by other tertiary amines, Σ can include: i) O or NR^1 for I, II, III, IV, V and VI; and ii) O or NR^1 or CH_2 for VII; and the index value n is independently a whole number equal to or greater than 0.

25. The hydrocarbon soluble catalyst or reagent composition of Claim 23 formed from reagents comprising a solid alkali hydride, an alkali metal and/or an alkali metal alloy and/or a saline metal amide wherein the ratio of polarizing complexing agent to total alkali metal is in the range of range of from 1:1.05 to 1:6; and the molar ratio of organolithium compound to alkali metal is from 10,000:1 to 1:2.

26. A hydrocarbon soluble catalyst or reagent composition of Claim 23 wherein the catalyst is a monometallic lithium hydride LOXLiH catalyst, wherein the ratio of polarizing complexing agent to lithium is in the range from 1:1.05 to 1:6.

27. The hydrocarbon soluble catalyst or reagent composition of Claim 23 wherein the catalyst is a monometallic lithium hydride LOXLiH catalyst having the chemical formulas $[DMEA^-]_xLi_yH_z$; wherein z = y – x and x, y and z are positive real numbers, whole or fractional,

greater than zero, and optionally wherein said formula can further comprise *N,N,N',N'*-tetramethylethylenediamine (TMEDA) ligand complex in a molar ratio of total lithium to TMEDA from 10,000 to 1.0 to 1.0 to 8.0.

28. The hydrocarbon soluble catalyst or reagent composition of claim 27, wherein the_lithium hydride LOXLiH catalyst has one or more of the chemical formulas:

$[DMEA^-]Li_2H$; $[DMEA^-]_2Li_3H$; $[DMEA^-]Li_3H_2$; $[DMEA^-]Li_4H_3$; $[DMEA^-]_2Li_4H_2$; $[DMEA^-]_3Li_4H$; $[DMEA^-]Li_5H_4$; $[DMEA^-]_2Li_5H_3$; $[DMEA^-]_3Li_5H_2$; $[DMEA^-]_4Li_5H$; $[DMEA^-]Li_6H_5$; $[DMEA^-]_2Li_6H_4$; $[DMEA^-]_3Li_6H_3$; $[DMEA^-]_4Li_6H_2$; $[DMEA^-]_5Li_6H$; $[DMEA^-]Li_7H_6$; $[DMEA^-]_2Li_7H_5$; $[DMEA^-]_3Li_7H_4$; $[DMEA^-]_4Li_7H_3$; $[DMEA^-]_5Li_7H_2$; $[DMEA^-]_6Li_7H$; $[DMEA^-]Li_8H_7$; $[DMEA^-]_2Li_8H_6$; $[DMEA^-]_3Li_8H_5$; $[DMEA^-]_4Li_8H_4$; $[DMEA^-]_5Li_8H_3$; $[DMEA^-]_6Li_8H_2$; $[DMEA^-]_7Li_8H$; $[DMEA^-]Li_9H_8$; $[DMEA^-]_2Li_9H_7$; $[DMEA^-]_3Li_9H_6$; $[DMEA^-]_4Li_9H_5$; $[DMEA^-]_5Li_9H_4$; $[DMEA^-]_6Li_9H_3$; $[DMEA^-]_7Li_9H_2$; $[DMEA^-]_8Li_9H$; $[DMEA^-]Li_{10}H_9$; $[DMEA^-]_2Li_{10}H_8$; $[DMEA^-]_3Li_{10}H_7$; $[DMEA^-]_4Li_{10}H_6$; $[DMEA^-]_5Li_{10}H_5$; $[DMEA^-]_6Li_{10}H_4$; $[DMEA^-]_7Li_{10}H_3$; $[DMEA^-]_8Li_{10}H_2$; $[DMEA^-]_9Li_{10}H$; $[DMEA^-]Li_{11}H_{10}$; $[DMEA^-]_2Li_{11}H_9$; $[DMEA^-]_3Li_{11}H_8$; $[DMEA^-]_4Li_{11}H_7$; $[DMEA^-]_5Li_{11}H_6$; $[DMEA^-]_6Li_{11}H_5$; $[DMEA^-]_7Li_{11}H_4$; $[DMEA^-]_8Li_{11}H_3$; $[DMEA^-]_9Li_{11}H_2$; $[DMEA^-]_9Li_{11}H$; $[DMEA^-]Li_{12}H_{11}$; $[DMEA^-]_2Li_{12}H_{10}$; $[DMEA^-]_3Li_{12}H_9$; $[DMEA^-]_4Li_{12}H_8$; $[DMEA^-]_5Li_{12}H_7$; $[DMEA^-]_6Li_{12}H_6$; $[DMEA^-]_7Li_{12}H_5$; $[DMEA^-]_8Li_{12}H_4$; $[DMEA^-]_9Li_{12}H_3$; $[DMEA^-]_{10}Li_{12}H_2$; $[DMEA^-]_{11}Li_{12}H$; $[DMEA^-]Li_{13}H_{12}$; $[DMEA^-]_2Li_{13}H_{11}$; $[DMEA^-]_3Li_{13}H_{10}$; $[DMEA^-]_4Li_{13}H_9$; $[DMEA^-]_5Li_{13}H_7$; $[DMEA^-]_6Li_{13}H_7$; $[DMEA^-]_7Li_{13}H_6$; $[DMEA^-]_8Li_{13}H_5$; $[DMEA^-]_9Li_{13}H_4$; $[DMEA^-]_{10}Li_{13}H_3$; $[DMEA^-]_{11}Li_{13}H_2$; $[DMEA^-]_{12}Li_{13}H$; $[DMEA^-]Li_{14}H_{13}$; $[DMEA^-]_2Li_{14}H_{12}$; $[DMEA^-]_3Li_{14}H_{11}$; $[DMEA^-]_4Li_{14}H_{10}$; $[DMEA^-]_5Li_{14}H_9$; $[DMEA^-]_6Li_{14}H_8$; $[DMEA^-]_7Li_{14}H_7$; $[DMEA^-]_8Li_{14}H_6$; $[DMEA^-]_9Li_{14}H_5$; $[DMEA^-]_{10}Li_{14}H_4$; $[DMEA^-]_{11}Li_{14}H_3$; $[DMEA^-]_{12}Li_{14}H_2$; $[DMEA^-]_{13}Li_{14}H$; $[DMEA^-]Li_{15}H_{14}$; $[DMEA^-]_2Li_{15}H_{13}$; $[DMEA^-]_3Li_{15}H_{12}$; $DMEA^-]_4Li_{15}H_{11}$; $[DMEA^-]_5Li_{15}H_{10}$; $[DMEA^-]_6Li_{15}H_9$; $[DMEA^-]_7Li_{15}H_8$; $[DMEA^-]_8Li_{15}H_7$; $[DMEA^-]_9Li_{15}H_6$; $[DMEA^-]_{10}Li_{15}H_5$; $[DMEA^-]_{11}Li_{15}H_4$; $[DMEA^-]_{12}Li_{15}H_3$;$[DMEA^-]_{13}Li_{15}H_2$; $[DMEA^-]_{14}Li_{15}H$.

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29. The hydrocarbon soluble catalyst or reagent composition of claim 27, wherein the lithium hydride LOXLiH catalyst has the chemical formulas $[DMEA^{-}]_xLi_yH_z$, wherein said catalyst is formed from the process of contacting: (i) y equivalents of an organolithium compound; (ii) an optional amount of TMEDA; (iii) x equivalents of dimethylaminoethanol; (iv) optionally ethylbenzene; in (v) a hydrocarbon solvent having a pK_a greater than H_2, wherein the aromatic hydrocarbon can be ethylbenzene or different and (vi) molecular hydrogen, wherein the amount of hydride formed z is given by the equation z = y – x and z, y and z are positive real numbers whole or fractional greater than zero.

30. The hydrocarbon soluble catalyst or reagent composition of claim 27, wherein the monometallic lithium hydride LOXLiH catalyst has the chemical formulas $[DMEA^{-}]_xLi_yH_z$, wherein said catalyst is formed from the process of:

a) forming a well-mixed and reacted solution or suspension comprised of y equivalents (i), optionally (ii), x equivalents of (iii), and optionally (iv) in (v) under an inert atmosphere to form a precursor “ate” complex which is then converted to $[DMEA^{-}]_xLi_yH_z$ by replacing or otherwise displacing the inert atmosphere with hydrogen; or

b) forming a well-mixed and reacted solution or suspension comprised of a portion of x equivalents of (i) with optionally (ii), x equivalents of (iii), and optionally (iv) in (vi) in an external reactor, transferring said solution to the hydride forming reactor under hydrogen and then charging the balance of z or y-x equivalents (i); or

c) forming a well-mixed and reacted solution or suspension comprised of optionally (ii), x equivalents of (iii), and optionally (iv) in (v) under a hydrogen atmosphere; then feeding y equivalents of (i) all at once or in large proportion increments; or

d) forming a well-mixed and reacted solution or suspension comprised of optionally (ii), x equivalents of (iii), and optionally (iv) in (v) under a hydrogen atmosphere then feeding y equivalents of (i) continuously or in increments over a period greater than 3 minutes; or

e) forming a well-mixed and reacted solution or suspension comprised of x equivalents of (iii), and optionally (iv) in (v) under a hydrogen atmosphere then feeding y equivalents of (i) continuously or in increments over a period greater than 3 minutes followed by the addition of desired amount of (ii); or

f) forming a well-mixed and reacted solution or suspension comprised of x equivalents of (iii), and optionally (iv) in a portion of (v) under a hydrogen atmosphere then feeding y equivalents of (i) previously further diluted with (iv) and/or a portion of (v) continuously or in increments over a period greater than 3 minutes followed by the addition of desired amount of (ii); or

g) forming a well-mixed and reacted solution or suspension comprised of x equivalents of (i), and optionally (iv) in a portion of (v) under a hydrogen atmosphere then feeding x equivalents of (iii) previously further diluted with (iv) and/or a portion of (v) all at once, or continuously or in increments over time until the entire charge of (iii) is complete then feeding z or y - x equivalents of (i) followed by the addition of desired amount of (ii); or

h) forming a well-mixed and reacted solution comprising: (a) 3 equivalents of (i) is further dissolved in a solvent comprising ethylbenzene 1 to 10 times the weight of a 2.0 M solution of (i); (b) feeding (a) over a period of 15 to 25 minutes to 2 equivalents of (iii) dissolved in 24 to 28 parts by weight of (iv) and/or (v) free of (ii) stirred at just sufficient for hydrogen mass transfer to the condensed phase at 35°C to 40°C under a hydrogen atmosphere of 16 to 21 PSIG; (c) optionally adding (ii); (d) increasing the hydrogen pressure to 40 to 50 PSIG and then increasing the mixing for more sufficient hydrogen mass transfer; (e) warming the solution formed in (b) to 65 to 85 °C; (f) further increasing the hydrogen pressure to 75 PSIG; and (g) aging the catalyst for a period of 1 hour to greater than 5 hours.

31. The hydrocarbon soluble catalyst or reagent composition of Claim 23 wherein the catalyst is a bimetallic lithium magnesium hydride $LOXMgH_2$ catalyst, wherein the ratio of polarizing complexing agent to total-metal-equivalents, where lithium provides one equivalent and magnesium provides 2 equivalents, is in the range from 1:1.05 to 1:6.

32. The hydrocarbon soluble catalyst or reagent composition of claim 23, wherein the catalyst has the empirical formula: a) $[PCA^-]_4Li_6H_2$; b) $[PCA^-]_4Li_8H_4$; c) $[PCA^-]_2Li_6H_4$; d) $[PCA^-]_4Li_{12}H_8$; e) $[PCA^-]_5Li_{15}H_{10}$; f) $[PCA^-]_5Li_{12}H_7$; g) $[PCA^-]_2Li_5H_3$; h) $[PCA^-]_4Li_4MgH_2$; i) $[PCA^-]_4Li_4Mg_2H_4$; j) $[PCA^-]_2Li_4MgH_4$; k) $[PCA^-]_4Li_6Mg_3H_8$; l) $[PCA^-]_5Li_9Mg_3H_{10}$; m) $[PCA^-]_5Li_6Mg_3H_7$; n) $[PCA^-]_2Li_3MgH_3$; o) $[PCA^-]_4Li_5KH_2$; p) $[PCA^-]_4Li_7KH_4$; and q) $[PCA^-]_2Li_5KH_4$, wherein $[PCA^-]$ independently denotes the alkoxide of the corresponding polarizing complexing agent reagent alcohol having giving up one proton to a more basic species and wherein said empirical formula can optionally further comprise a PTA ligand complex in a molar ratio of total alkali and alkali earth metal to PTA from 10,000 to 1.0 to 1.0 to 8.0.

33. The hydrocarbon soluble catalyst or reagent composition of claim 32, wherein $[PCA^-]$ is independently $[DMEA^-]$, $[DMAEOE^-]$ or $[MEOE^-]$.

34. The hydrocarbon soluble catalyst or reagent composition of claim 23 further formed from reagents comprising a solid alkali hydride, an alkali metal and/or an alkali metal alloy and/or a saline metal amide wherein the ratio of polarizing complexing agent to total alkali metal is in the range of range of from 1:1.05 to 1:6; and the molar ratio of organolithium compound to alkali metal is from 10,000:1 to 1:2.

35. The hydrocarbon soluble monometallic catalyst or reagent composition of claim 23 formed from molecular hydrogen and either:

a) a polarizing complexing agent reacted to form a lithium alkoxide and an organolithium compound wherein the molar ratio of polarizing complexing agent to total alkali metal is in the range of from 1:1.05 to 1:6; or

b) a polarizing complexing agent and an organolithium compound wherein the molar ratio of polarizing complexing agent to lithium is in the range of from 1:1.05 to 1:6; or

c) a polarizing complexing agent; at least one of a solid lithium hydride and/or lithium metal and/or a lithium amide; and an organolithium compound wherein the molar ratio of polarizing complexing agent to total lithium is in the range of range of from 1:1.05 to 1:6.

36. The hydrocarbon soluble bimetallic catalyst or reagent composition of claim 23 formed from molecular hydrogen and either:

a) a polarizing complexing agent reacted to form at least one alkali or alkaline earth metal alkoxide and an organolithium compound and/or an organomagnesium compound wherein the molar ratio of polarizing complexing agent to total alkali metal is in the range of from 1:1.05 to 1:6; or

b) a polarizing complexing agent reacted to form a lithium and/or magnesium alkoxide; an organolithium compound and/or an organomagnesium compound; wherein the molar ratio of polarizing complexing agent to total-metal-equivalents is in the range of from 1:1.05 to 1:6, where lithium provides one equivalent and magnesium provides 2 equivalents; or

c) a polarizing complexing agent; an organolithium compound; and an organomagnesium compound; wherein the molar ratio of polarizing complexing agent to total-metal-equivalents is in the range of from 1:1.05 to 1:6, where lithium provides one equivalent and magnesium provides 2 equivalents; or

d) a polarizing complexing agent; at least one of solid lithium hydride, metallic lithium, solid magnesium hydride, a lithium amide, a magnesium diamide; at least one of an organolithium compound and/or an organomagnesium compound; wherein the molar ratio of polarizing complexing agent to total-metal-equivalents is in the range of from 1:1.05 to 1:6, where lithium provides one equivalent and magnesium provides 2 equivalents; or

e) a polarizing complexing agent; at least one of solid lithium hydride and/or metallic lithium; and organomagnesium compound; wherein the molar ratio of polarizing complexing agent to total-metal-equivalents is in the range of from 1:1.05 to 1:6, where lithium provides one equivalent and magnesium provides 2 equivalents; or

f) a polarizing complexing agent; solid magnesium hydride; and an organolithium compound; wherein the molar ratio of polarizing complexing agent to total-metal-equivalents is in the range of from 1:1.05 to 1:6, where lithium provides one equivalent and magnesium provides 2 equivalents;

and wherein the molar ratio of lithium to magnesium in the catalyst composition is from 10,000:1 to 1:6.

37. A process for forming the LOXSH catalyst of Claim 23 wherein (i) an organolithium compound with or without an organomagnesium compound; (ii) an optional polytertiaryamine promotor compound; (iii) a polarizing complexing agent selected from a tertiary amino alcohol, a tertiary amino ether-alcohol an ether-alcohol or combinations thereof; (iv) optionally an aromatic hydrocarbon having at least one C-H covalent bond pK_a within the range of 2.75 pK_a units above that of the pK_a of toluene to -4.30 pK_a units below the pK_a of toluene; (v) an optional solid alkali or alkaline earth metal hydride or an alkali metal or alkali metal alloy or a alkali or alkaline earth

amide; (vi) a hydrocarbon solvent having a pK_a greater than H_2, wherein the aromatic hydrocarbon and hydrocarbon solvent may be the same or different; and (vii) molecular hydrogen are contacted or otherwise combined.

38. The process of Claim 37 wherein (i); (ii); (iii); optionally (iv); optionally (v) and (vi) are contacted or otherwise combined by:

a) forming a well-mixed and reacted solution or suspension comprised of (i), optionally (ii), (iii), optionally (iv) and optionally (v) in (vi) under an inert atmosphere and then converted to LOXSH by: 1) feeding a portion of the monomer to the thus formed “ate” complex; and then 2) replacing or otherwise displacing the inert atmosphere with H_2; or

b) forming a well-mixed and reacted solution or suspension comprised of (i), optionally (ii), (iii), optionally (iv) and optionally (v) in (vi) under an inert atmosphere to form a precursor “ate” complex which is then converted to LOXSH by replacing or otherwise displacing the inert atmosphere with hydrogen; or

c) forming a well-mixed and reacted solution or suspension comprised of a portion of (i) with optionally (ii), (iii), the desired amount of (iv) and optionally (v) in (vi) in an external reactor, transferring said solution to the polymerization reactor under hydrogen and then charging the balance of (i); or

d) forming a well-mixed and reacted solution or suspension comprised of optionally (ii), (iii), optionally (iv) and optionally (v) in (vi) under a hydrogen atmosphere; feeding a portion of the monomer then feeding (i) all at once; or

e) forming a well-mixed and reacted solution or suspension comprised of optionally (ii), (iii), optionally (iv) and optionally (v) in (vi) under a hydrogen atmosphere then feeding (i) over a period greater than 3 minutes then optionally or when necessary feeding monomer; or

f) forming a well-mixed and reacted solution or suspension comprised of (iii), optionally (iv) and optionally (v) in (vi) under a hydrogen atmosphere then feeding (i) over a period greater than 3 minutes followed by the addition of desired amount of (ii) then optionally or when necessary feeding monomer.

39. The process of Claim 37 for forming the hydrocarbon soluble catalyst or reagent composition wherein the hydrogen partial pressure used in forming the catalyst is in the range of from 0.1 bar to 300 bar.

40. The process of Claim 37 for forming the hydrocarbon soluble catalyst or reagent composition wherein the temperature used in forming the catalyst is in the range of from -96°C to 130°C.

41. The process of Claim 37 for forming the hydrocarbon soluble catalyst or reagent composition wherein the molar equivalent charge ratios of the polarizing complexing agent to the organolithium compound and/or an organomagnesium used in forming the catalyst is in the range of from 1:1.05 to 1:6 moles of polarizing complexing agent per mole of metal-alkyl equivalents where lithium provides one equivalent and magnesium provides 2 equivalents.

42. The process of Claim 37 for forming the hydrocarbon soluble catalyst or reagent composition wherein the molar ratios of the PTA to total metal is from 10,000 to 1.0 to 1.0 to 8.0.

43. The process of Claim 37 for forming the hydrocarbon soluble catalyst or reagent composition wherein:

a) the polarizing complexing agent is first contacted with an alkali alkoxide forming reagent thereby forming a reaction mixture wherein the stoichiometric molar equivalent ratio of polarizing complexing agent to alkoxide forming reagent is from 1:1 to less than 1:1;

b) wherein said alkoxide forming reagent is at least one of a) a solid alkali hydride; b) an alkali metal; c) an alkali metal alloy; d) and alkali amide; e) magnesium amide; f) organolithium compound; g) organomagnesium compound;

c) wherein the organolithium and/or organomagnesium compound is further added;

d) wherein the ratio of polarizing complexing agent to total alkali metal is in the range of from 1:1.05 to 1:6;

e) wherein either the molar ratio of lithium to non-lithium alkali metal is in the range of range of from 1:2 to 10,000:1 or the alkali metal of the catalyst composition is exclusively lithium;

f) and wherein the formed reaction product is further reduced with hydrogen to form the hydrocarbon soluble saline hydride catalyst or reagent.

44. The process of Claim 37 for forming the hydrocarbon soluble catalyst or reagent composition wherein:

a) the polarizing complexing agent is first contacted with at least one alkoxide forming reagent of: a) solid lithium hydride; b) lithium metal; c) magnesium hydride; d) lithium amide; e) magnesium amide; f) organolithium compound; g) organomagnesium compound

thereby forming a reaction mixture wherein the stoichiometric molar equivalent ratio of polarizing complexing agent to alkoxide forming reagent is from 1:1 to less than 1:1 where lithium provides one equivalent and magnesium provides 2 equivalents;

b) wherein the organolithium compound and/or organomagnesium compound is further added;

c) wherein the ratio of polarizing complexing agent to total metal equivalents is in the range of from 1:1.05 to 1:6 where lithium provides one equivalent and magnesium provides 2 equivalents;

d) wherein either the molar ratio of lithium to magnesium is in the range of from 10,000:1 to 1.0:6.0 or wherein the catalyst is comprised sole of lithium metal;

e) and wherein the formed reaction product is further reduced with hydrogen to form the hydrocarbon soluble saline hydride catalyst or reagent.

45. A process of any of claims 37, 41, 43 or 44 for forming the hydrocarbon soluble catalyst or reagent composition wherein the process further comprises feeding styrenic monomer to form a poly(styryl)magnesium and/or a poly(styryl)lithium and/or an anionic poly(styryl) compound prior to reduction by contacting with molecular hydrogen to form the soluble saline hydride wherein the molar ratio of styrenic monomer to total metal is from 1:10 to 20:1.

46. The process of any of claims 37, 41, 43 or 44 for forming the hydrocarbon soluble catalyst or reagent composition wherein the process further comprises feeding styrenic monomer to form a transient 1-phenyl-hexylmagnesium compound and/or poly(styryl)magnesium compound which

is further reduced by molecular hydrogen to the soluble saline hydride wherein the molar ratio of styrenic monomer to magnesium is from 1:5 to 20:1.

47. The process of any of claims 45 or 46 where the styrenic monomer is styrene.

48. A catalyst or reagent composition formed from: (i) molecular hydrogen; (ii) an organolithium compound and/or an organomagnesium compound; (iii) optionally a polytertiaryamine compound; (iv) a polarizing complexing agent selected from a tertiary aminoalcohol compound; a tertiary amino ether-alcohol, an ether-alcohol or combinations thereof; (v) optionally an alkali metal or metal alloy and/or a solid saline hydride (vi) optionally an aromatic hydrocarbon having at least one C-H covalent bond pK_a within the range of 2.75 pK_a units above that of the pK_a of toluene to -4.30 pK_a units below the pK_a of toluene; (vii) a vinylaromatic monomer; and in (viii) a hydrocarbon solvent with a pK_a greater than H_2; wherein the aromatic hydrocarbon and hydrocarbon solvent may be the same or different.

49. A catalyst or reagent composition of claims 23 or 49 formed wherein the molecular hydrogen is isotopically enriched with: a) deuterium; or b) tritium to form a deuteride or tritride.

50. A catalyst or reagent composition of claims 50 wherein the hydride, deuteride or tritride formed is a polyhydride, polydeuteride or a polytritide.

51. A process for forming a brominated polystyrene composition comprising: conducting hydrogen mediated saline hydride initiated polymerizations which features feeding styrene to a

reaction medium containing a soluble saline hydride LOXSH catalyst formed from (i) molecular hydrogen; (ii) an organolithium compound and/or an organomagnesium compound; (iii) optionally a polytertiaryamine compound; (iv) a polarizing complexing agent selected from a tertiary aminoalcohol compound; a tertiary amino ether-alcohol, an ether-alcohol or combinations thereof; (v) optionally an alkali metal or metal alloy and/or a solid saline hydride and/or a saline metal amide; (vi) optionally an aromatic hydrocarbon having at least one C-H covalent bond pK_a within the range of 2.75 pK_a units above that of the pK_a of toluene to -4.30 pK_a units below the pK_a of toluene; and in (vii) a hydrocarbon solvent with a pK_a greater than H_2; wherein the aromatic hydrocarbon and hydrocarbon solvent may be the same or different; quenching the polymerization reaction mixture; washing to remove catalyst components; stripping solvent and dimer; and then brominating.