7,199,255 B2 does not mention or disclose any species of the second metal compound wherein the catalyst precursor contains a quinoline moiety.

WO 02/079207 A2 mentions, among other things, an amido ligand and its synthesis, and use of the amide ligand in a variety of metal complexes, and transition metals in particular. WO 02/079207 A2 also mentions that amido ligand transition metal complexes are expected to find utility as catalysts in numerous stoichiometric and catalytic transformations such as, by way of example and not limitation, hydroamination, olefin hydration, alkane oxidation, dioxygen activation and subsequent olefin epoxidation, dinitrogen activation/reduction/functionalization, olefin polymerization/copolymerization/living polymerization, catalytic C-E bond formation (where E is C, N, O, S, Si, H, and so forth), as well as Heck, Suzuki, and Sonagoshira coupling reactions. WO 02/079207 A2 does not mention or disclose any species of the amido ligand transition metal complex wherein the transition metal is a metal of Group 3, 4, 5, or 6 of the Periodic Table of the Elements.

Shen M., et al., *Synthesis and characterization of organoaluminum compounds containing quinolin-8-amine derivatives and their catalytic behaviour for ring-opening polymerization of ε-caprolactone*, Dalton Transactions, 2009: 9000-9009, mention certain organoaluminum compounds containing certain 2-substituted, N-substituted quinolin-8-amine derived ligands.

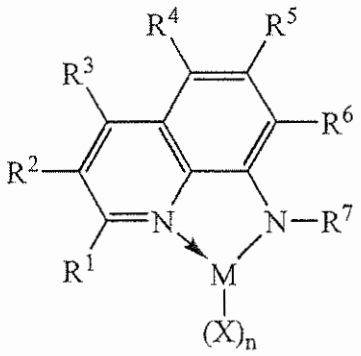
Chemical industry desires new processes and catalysts for polymerizing olefin monomers.

BRIEF SUMMARY ~~OF THE INVENTION~~

In a first aspect, there is provided a process for polymerizing an olefin monomer, the process comprising a step of

contacting together a catalytic amount of a catalyst comprising a mixture or reaction product of ingredients (a) and (b), wherein ingredient (a) comprises a metal-ligand complex and ingredient (b) comprises an activating co-catalyst; and an olefin monomer as ingredient (c);

the component (a) being one or more metal-ligand complexes of formula (I):



(I)

wherein:

M is a metal of Group 4 of the Periodic Table of the Elements, the metal being in a formal oxidation state of +3 or +4;

n is an integer of from 1 to 5;

Each X independently is a monodentate ligand that is neutral, monoanionic, or dianionic; or two X are taken together to form a bidentate ligand that is neutral, monoanionic, or dianionic;

X and n are chosen in such a way that the metal-ligand complex of formula (I) is, in aggregate, neutral;

Each of R^1 to R^6 independently is a hydrogen atom, $(C_1\text{-}C_{40})$hydrocarbyl, $(C_1\text{-}C_{40})$heterohydrocarbyl, $(C_1\text{-}C_{40})$hydrocarbyl-O-, or halogen atom;

R^7 independently is a $(C_1\text{-}C_{40})$hydrocarbyl or $(C_1\text{-}C_{40})$heterohydrocarbyl;

Or one X, when a monodentate ligand, is taken together with any one of R^1 to R^7 in such a way so that the metal-ligand complex of formula (I) contains a tridentate ligand;

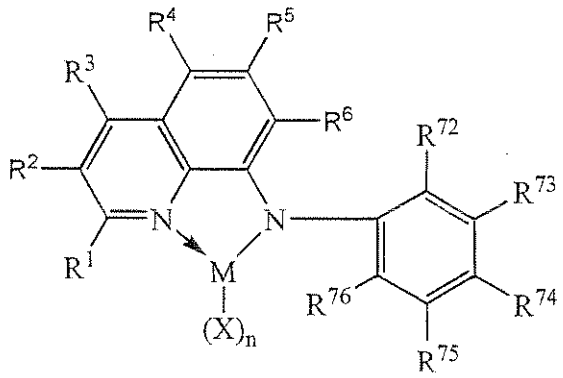
Each of the aforementioned hydrocarbyl and heterohydrocarbyl independently is unsubstituted or substituted with one or more substituents R^S; and

Each R^S independently is a halogen atom, polyfluoro, perfluoro, unsubstituted $(C_1$-$C_{18})$alkyl, F_3C-, FCH_2O-, F_2HCO-, F_3CO-, R_3Si-, RO-, RS-, RS(O)-, $RS(O)_2$-, R_2P-, R_2N-, R_2C=N-, NC-, RC(O)O-, ROC(O)-, RC(O)N(R)-, or $R_2NC(O)$-, wherein each R independently is an unsubstituted $(C_1$-$C_{18})$alkyl; and

the component (b) being one or more activating co-catalysts, or a reaction product thereof, wherein the ratio of total number of moles of the one or more metal-ligand complexes of formula (I) to total number of moles of the one or more activating co-catalysts is from 1:10,000 to 100:1;

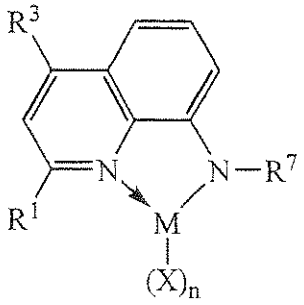
wherein the contacting step is performed under olefin polymerizing conditions and prepares a polyolefin, and

wherein the metal-ligand complex of formula (I) is a metal-ligand complex of formula (Ip), (Ia), (Ia-1), (Ia-1.1), or (Ia-1.2):



(Ip)

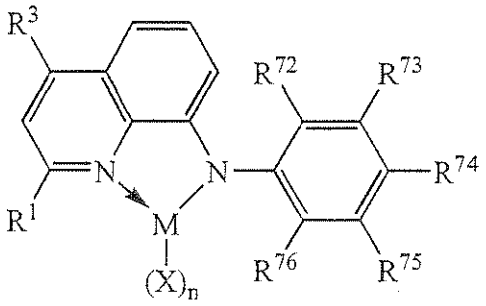
wherein at least one of R^{72} and R^{76} independently is a $(C_1$-$C_{40})$alkyl and each of the remainder of R^{72} to R^{76} independently is a hydrogen atom or R^S;



(Ia)

;

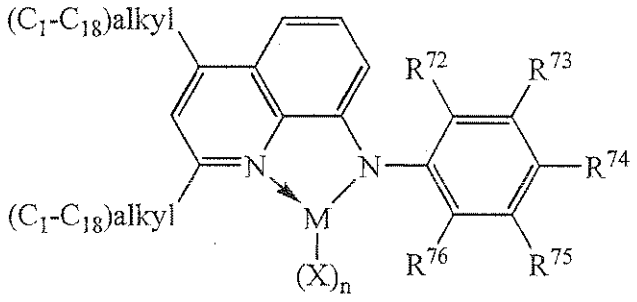
wherein in formula (Ia) each of R^1 and R^3 independently is a $(C_1$-$C_{40})$ hydrocarbyl or $(C_1$-$C_{40})$ heterohydrocarbyl;



(Ia-1)

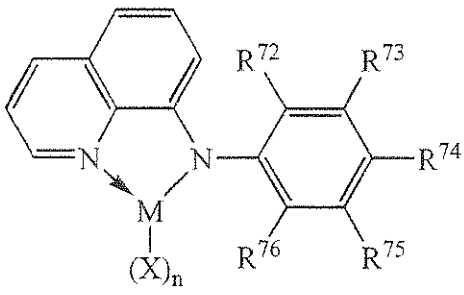
,

wherein in formula (Ia-1) each of R^{72} to R^{76} independently is a hydrogen atom, a $(C_1$-$C_{40})$ alkyl, or R^S, wherein R^S is as defined previously; and wherein in formula (Ia-1) each of R^1 and R^3 independently is a $(C_1$-$C_{40})$ hydrocarbyl or $(C_1$-$C_{40})$ heterohydrocarbyl; or



(Ia-1.1)

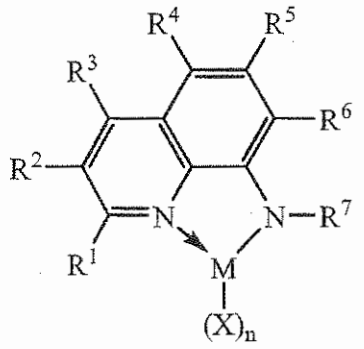
wherein in formula (Ia-1.1) each of R^{72} to R^{76} independently is a hydrogen atom, a $(C_1$-$C_{40})$ alkyl, or R^S, wherein R^S is as defined previously; or



(Ia-1.2)

wherein in formula (Ia-1.2) each of R^{72} to R^{76} independently is a hydrogen atom, a $(C_1$-$C_{40})$ alkyl, or R^S, wherein R^S is as defined previously.

In a first embodiment, the present disclosure~~invention~~ is a process for polymerizing an olefin monomer, the process comprising a step of contacting together a catalytic amount of a catalyst comprising a mixture or reaction product of ingredients (a) and (b), wherein ingredient (a) comprises a metal-ligand complex and ingredient (b) comprises an activating co-catalyst; and an olefin monomer as ingredient (c); the ingredient (a) being one or more metal-ligand complexes (also referred to herein as precatalysts) of formula (I):



(I)

wherein:

M is a metal of any one of Groups 3, 4, 5, and 6 of the Periodic Table of the Elements, the metal being in a formal oxidation state of +2, +3, +4, +5, or +6;

n is an integer of from 1 to 5;

Each X independently is a monodentate ligand that is neutral, monoanionic, or dianionic; or two X are taken together to form a bidentate ligand that is neutral, monoanionic, or dianionic;

X and n are chosen in such a way that the metal-ligand complex of formula (I) is, in aggregate, neutral;

Each of R^1 to R^6 independently is a hydrogen atom, $(C_1\text{-}C_{40})$hydrocarbyl, $(C_1\text{-}C_{40})$heterohydrocarbyl, $(C_1\text{-}C_{40})$hydrocarbyl-O-, or halogen atom;

R^7 independently is a $(C_1\text{-}C_{40})$hydrocarbyl or $(C_1\text{-}C_{40})$heterohydrocarbyl;

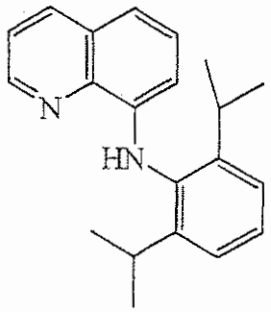
Or one X, when a monodentate ligand, is taken together with any one of R^1 to R^7 in such a way so that the metal-ligand complex of formula (I) contains a tridentate ligand (such that the tridentate ligand is bonded to M via the X, quinoline ring nitrogen atom, and nitrogen atom bearing R^7);

Each of the aforementioned hydrocarbyl (e.g., $(C_1\text{-}C_{40})$hydrocarbyl and $(C_1\text{-}C_{40})$hydrocarbyl of $(C_1\text{-}C_{40})$hydrocarbyl-O-) and heterohydrocarbyl independently is unsubstituted or substituted with one or more substituents R^S; and

Each R^S independently is a halogen atom, polyfluoro, perfluoro, unsubstituted $(C_1\text{-}C_{18})$alkyl, F_3C-, FCH_2O-, F_2HCO-, F_3CO-, R_3Si-, RO-, RS-, RS(O)-, $RS(O)_2$-, R_2P-, R_2N-, R_2C=N-, NC-, RC(O)O-, ROC(O)-, RC(O)N(R)-, or $R_2NC(O)$-, wherein each R independently is an unsubstituted $(C_1\text{-}C_{18})$alkyl; and

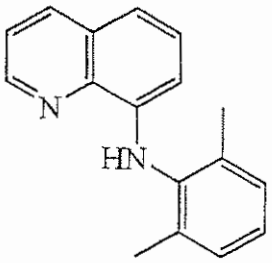
the ingredient (b) being one or more activating co-catalysts, or a reaction product thereof, wherein the ratio of total number of moles of the one or more metal-ligand complexes of formula (I) to total number of moles of the one or more activating co-catalysts is from 1:10,000 to 100:1; wherein the contacting step is performed under olefin polymerizing conditions (described later) and prepares a polyolefin.

In a second aspect, there is provided a ligand of any one of formulas (1) to (4):



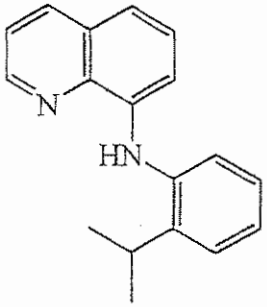
(1)

;



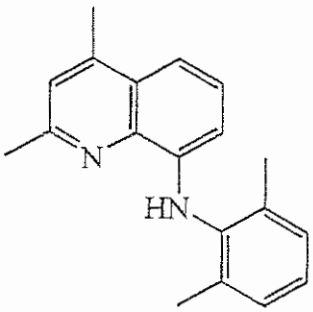
(2)

;



(3)

; and



(4)

;

or a Group 1 or 2 metal salt thereof.

In a third aspect, there is provided a metal complex comprising the ligand as defined above.

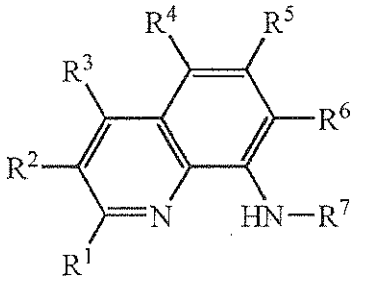
In a second embodiment the present disclosure~~invention~~ is the metal-ligand complex of formula (I).

In a fourth aspect, there is provided a catalyst comprising the metal complex as defined above.

In a third embodiment the present disclosure~~invention~~ is a catalyst comprising or prepared from the one or more metal-ligand complexes of formula (I) and one or more activating co-catalysts, or a reaction product thereof, wherein the ratio of total number of moles of the one or more metal-

ligand complexes of formula (I) to total number of moles of the one or more activating co-catalysts is from 1:10,000 to 100:1.

The disclosure~~invention~~ also contemplates a process for preparing the metal-ligand complex of formula (I) by reacting a ligand of formula (Q):



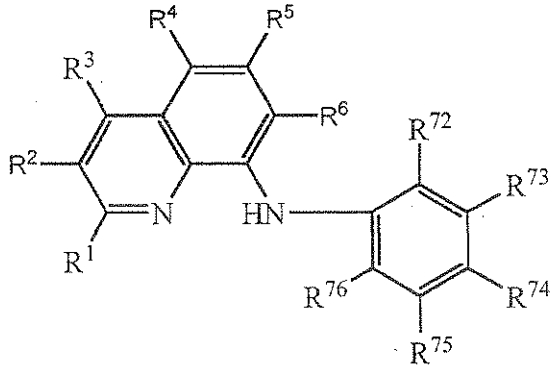
(Q)

or a Group 1 or 2 metal salt of the ligand of formula (Q), wherein the metal of the Group 1 or 2 metal salt is a cation of any one of the metals of Groups 1 and 2 of the Periodic Table of the Elements, with a source or sources of M and X (e.g., a salt of formula $M(X)_{n+1}$) in such a way so as to prepare the metal-ligand complex of formula (I), wherein the metal-ligand complex of formula (I), M, X, and R^1 to R^7 are as defined in the first embodiment.

The disclosure~~invention~~ also contemplates a process for preparing the ligand of formula (Q), and intermediates in the preparation thereof.

The ligand of formula (Q) is useful in the process of preparing the metal-ligand complex of formula (I), which in turn is useful in the process of preparing the disclosed~~invention~~ catalyst as described herein.

In another embodiment the present disclosure~~invention~~ is a ligand of formula (Qp):



(Qp)

or a Group 1 or 2 metal salt thereof, wherein the Group 1 or 2 metal of the Group 1 or 2 metal salt is a cation of any one of the metals of Groups 1 and 2 of the Periodic Table of the Elements;

Each of R^1 to R^6 independently is a hydrogen atom, $(C_1\text{-}C_{40})$hydrocarbyl, $(C_1\text{-}C_{40})$heterohydrocarbyl, $(C_1\text{-}C_{40})$hydrocarbyl-O-, or halogen atom;

At least one of R^{72} and R^{76} independently is a $(C_1\text{-}C_{40})$alkyl and each of the remainder of R^{72} to R^{76} independently is a hydrogen atom or R^S, wherein R^S is as defined previously;

Each of the aforementioned hydrocarbyl (e.g., $(C_1\text{-}C_{40})$hydrocarbyl) and heterohydrocarbyl independently is unsubstituted or substituted with one or more substituents R^S; and

Each R^S independently is a halogen atom, polyfluoro, perfluoro, unsubstituted $(C_1\text{-}C_{18})$alkyl, F_3C-, FCH_2O-, F_2HCO-, F_3CO-, R_3Si-, RO-, RS-, RS(O)-, $RS(O)_2$-, R_2P-, R_2N-, R_2C=N-, NC-, RC(O)O-, ROC(O)-, RC(O)N(R)-, or $R_2NC(O)$-, wherein each R independently is an unsubstituted $(C_1\text{-}C_{18})$alkyl.

The metal-ligand complex(es) of formula (I) and catalyst(s) prepared therefrom with the one or more activating co-catalysts are useful in the process of the first embodiment. As can be illustrated later, the disclosed~~invention~~ process is characterizable by one or more activities of the catalyst(s), one or more properties of the polyolefin prepared thereby, or a combination thereof.

Accordingly, the present disclosure~~invention~~ also contemplates novel polyolefins prepared by the process of the first embodiment. Examples of polyolefins that can be prepared by the disclosed~~invention~~ process are a polyethylene, poly(alpha-olefin), polystyrene, and poly(ethylene alpha-olefin) copolymer, including poly(ethylene alpha-olefin) block copolymer. The term "poly(ethylene alpha-olefin) block copolymer" is used interchangeably herein with the terms "olefin block copolymer," "OBC," "ethylene/α-olefin block interpolymer," and "ethylene/α-olefin block copolymer". The terms "alpha-olefin" and "α-olefin" are used interchangeably herein. The term "ethylene" means ethene, i.e., H_2C=CH_2.

The polyolefins prepared by the process of the first embodiment are useful in numerous applications such as, for example, synthetic lubricants, films, fibers, pipes, and elastic films for hygiene applications (e.g., for diaper covers); flexible molded goods for appliances, tools, consumer goods (e.g., toothbrush handles), sporting goods, building and construction components, automotive parts, and medical applications (e.g., medical devices); flexible gaskets and profiles for appliance (e.g., refrigerator door gaskets and profiles), building and construction, and automotive applications; adhesives for packaging (e.g., for use in manufacturing corrugated