CLAIMS

1. A process for forming an oligomer product comprising:

   a) introducing into a reaction zone

   i. ethylene;

   ii. a heteroatomic ligand metal salt complex comprising a heteroatomic ligand complexed to a first metal salt where the first metal salt is an iron salt, a cobalt salt, or a combination thereof;

   iii. a second metal salt wherein an equivalent molar ratio of the second metal salt to the heteroatomic ligand of the heteroatomic ligand metal salt complex is at least 0.5:1 and wherein the second metal salt has the formula MX_n, where M is iron, cobalt, or any combination thereof, X represents a monoanionic species, and n represents the number of monoanionic species and has a value of 1, 2, or 3;

   iv. an organoaluminum compound;

   v. optionally hydrogen; and

   vi. optionally an organic reaction medium; and

   b) forming an oligomer product in the reaction zone.

2. The process of claim 1, wherein the organo groups of the organoaluminum compound are substantially devoid of β,γ-branched organo groups and/or β,δ-branched organo groups.

3. The process of claim 1, wherein a C_4-C_{20} productivity of the process is at least 10% greater than the C_4-C_{20} productivity of an otherwise similar process wherein an equivalent molar ratio of the second metal salt to the heteroatomic ligand of the heteroatomic ligand metal salt complex is less than 0.1:1.

4. The process of claim 1, wherein the heteroatomic ligand of the heteroatomic ligand metal salt complex comprises 1) a bidentate metal salt complexing moiety, or 2) a tridentate metal salt complexing moiety, wherein the bidentate metal salt complexing moiety and the tridentate metal salt complexing moiety each independently comprise at least two metal salt complexing groups selected from the group consisting of an imine group and an aromatic nitrogen atom containing group.

5. The process of claim 1, wherein the heteroatomic ligand of the heteroatomic ligand metal salt complex is an α-diimine, a pyridine bisimine, a phenanthroline imine, or any combination thereof.

6. The process of claim 5, wherein the heteroatomic ligand of the heteroatomic ligand metal salt complex is the α-diimine and the α-diimine comprises i) an α-diimine group, ii) a first imine group consisting of a hydrocarbyl group or a substituted hydrocarbyl group attached to a first imine nitrogen atom of the α-diimine group, and iii) a second imine group comprising a first metal salt complexing group and a linking group linking the first metal salt complexing group to a second imine nitrogen atom of the α-diimine group.

7. The process of claim 6, wherein the α-diimine comprises i) an α-diimine group derived from acenaphthenequinone, phenanthrenequinone, or pyrenequinone, ii) a first imine group consisting of a 2,6-dihydrocarbylphenyl group attached to the first imine nitrogen atom of the α-diimine group, and iii) a second imine group comprising a diphenylphosphinyl first metal salt

complexing group or a di(substituted phenyl)phosphinyl first metal salt complexing group and a —CH_2CH_2— linking group linking the first metal salt complexing group to the second imine nitrogen atom of the α-diimine group.

8. The process of claim 5, wherein the heteroatomic ligand of the heteroatomic ligand metal salt complex is the pyridine bisimine and the pyridine bisimine comprises i) a 2,6-bis[(arylimine)hydrocarbyl]pyridine wherein the aryl groups can be the same or different, ii) a bis[(substituted arylimine)hydrocarbyl]pyridine wherein the substituted aryl groups can be the same or different, or iii) an [(arylimine)hydrocarbyl],[(substituted arylimine)hydrocarbyl]pyridine.

9. The process of claim 8, wherein the pyridine bisimine is selected from the group consisting of 2,6-bis[(phenylimine) methyl]pyridine, 2,6-bis[(2-methylphenylimine)methyl]pyridine, 2,6-bis[(2-ethylphenylimine)methylpyridine, 2,6-bis[(2-isopropylphenylimine)methyl]pyridine, 2,6-bis[(2,4-dimethylphenylimine)methyl]pyridine, 2,6-bis[(2,6-diethylphenylimine)methyl]pyridine, 2-[(2,4,6-trimethylphenylimine)methyl]-6-[(4-methylphenylimine)methyl)pyridine, 2-[(2,4,6-trimethylphenylimine)methyl]-6-[(3,5-dimethylphenylimine)methyl]pyridine, and 2-[(2,4,6-trimethylphenylimine)methyl]-6-[(4-t-butylphenylimine)methyl]pyridine.

10. The process of claim 5, wherein the heteroatomic ligand of the heteroatomic ligand metal salt complex is the phenanthroline imine and the phenanthroline imine comprises a 2-(hydrocarbylimine)-1,10-phenanthroline, a 2-[(hydrocarbylimine)hydrocarbyl]-1,10-phenanthroline, a 2-(arylimine)-1,10-phenanthroline, a 2-[(arylimine)hydrocarbyl]-1,10-phenanthroline, a 2-(substituted arylimine)-1,10-phenanthroline, or a 2-[(substituted arylimine)hydrocarbyl]-1,10-phenanthroline.

11. The process of claim 10, wherein the phenanthroline imine comprises a 2-(2,6-dialkylphenylimine)-1,10-phenanthroline, a 2-[(2,6-dialkylphenylimine)alkyl]-1,10-phenanthroline, a 2-[(2,6-dialkylphenylimine)phenyl]-1,10-phenanthroline, a 2-(2,4,6-trialkylphenylimine)-1,10-phenanthroline, a 2-[(2,4,6-trialkylphenylimine)alkyl]-1,10-phenanthroline, a 2-[(2,4,6-trialkylphenylimine)phenyl-1,10-phenanthroline, a 2-(2,6-dihalophenylimine)-1,10-phenanthroline, a 2-[(2,6-dihalophenylimine)alkyl]-1,10-phenanthroline, a 2-[(2,6-dihalophenylimine)phenyl]-1,10-phenanthroline, or any combination thereof.

12. The process of claim 1, wherein the organoaluminum compound comprises an aluminoxane.

13. The process of claim 12, wherein the aluminoxane comprises methylaluminoxane, a modified methylaluminoxane, 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.

14. The process of claim 1, where the first metal salt comprises an iron halide, an iron β-diketonate, an iron carboxylate, or any combination thereof and the second metal salt comprises an iron halide, an iron β-diketonate, an iron carboxylate, or any combination thereof and where the first metal salt and the second metal salt are the same or different.