CLAIMS

1. A process comprising:

   a) contacting (i) ethylene, (ii) a catalyst system comprising an α-diimine iron salt complex, a pyridine bisimine iron salt complex, or a pyridine bisimine and an iron salt, (iii) hydrogen, and (iv) optionally an organic reaction medium; and

   b) forming an oligomer product wherein the oligomer product is formed in the presence of ethylene and hydrogen at a ratio in the range of 0.4 g hydrogen /kg ethylene to 5 g hydrogen /kg ethylene, and wherein 1) the oligomer product has a Schulz-Flory K value from 0.4 to 0.8 and 2) the oligomer product comprises (a) less than 1 wt.% compounds having greater than 70 carbon atoms, (b) less than 1 wt.% compounds having a weight average molecular weight greater than 1000 g/mol, or (c) any combination thereof wherein the weight percentage is based on the total weight of the oligomer product.

2. The process of claim 1, wherein each carbon number fraction from C_4 to C_{18} of the oligomer product has a paraffin content equal to or less than 2 times the paraffin content of a corresponding carbon number fraction of the oligomer product produced in the absence of hydrogen based on the total weight of the carbon number fraction of the oligomer product.

3. The process of claim 1, wherein the catalyst system comprises the α-diimine iron salt complex, and wherein the α-diimine of the α-diimine iron salt complex comprises i) an α-diimine group, ii) a first imine group consisting of a hydrocarbyl group or substituted hydrocarbyl group attached to a first imine nitrogen atom of the α-diimine group, and iii) a

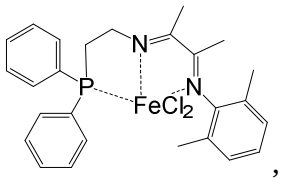
second imine group comprising an iron salt complexing group and a linking group linking the iron salt complexing group to a second imine nitrogen atom of the α-diimine group.

4. The process of claim 1, wherein the catalyst system comprises the α-diimine iron salt complex, and wherein the α-diimine of the α-diimine iron salt complex comprises i) an α-diimine group derived from an aromatic diacyl compound, ii) a first imine group consisting of an aryl group or substituted aryl group, and iii) a second imine group comprising a diarylphosphinyl iron salt complexing group and a $–CH_2CH_2-$ linking group linking the iron salt complexing group to a second imine nitrogen atom.

5. The process of claim 1, wherein the catalyst system comprises the α-diimine iron salt complex, and wherein the α-diimine of the α-diimine iron salt complex comprises i) an α-diimine group derived from acenaphthenequinone, phenanthrenequinone, or pyrenequinone, ii) a first imine group consisting of a 2,6-dihydrocarbylphenyl group, and iii) a second imine group comprising a diphenylphosphinyl iron salt complexing group or a di(substituted phenyl)phosphinyl iron complexing group and a $-CH_2CH_2-$ linking group linking the iron salt complexing group to a second imine nitrogen atom.

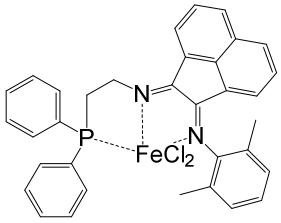
6. The process of claim 1, wherein the catalyst system comprises the α-diimine iron salt complex, and wherein the iron salt of the α-diimine iron salt complex comprises an iron halide, an iron acetylacetonate, an iron carboxylate, or any combination thereof.

7. The process of claim 1, wherein the catalyst system comprises the α-diimine iron salt complex, and wherein the α-diimine iron salt complex has a structure selected from the group consisting of



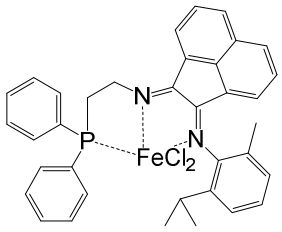
,

ADIFe I



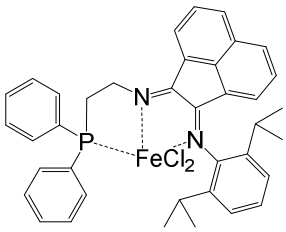
,

ADIFe II



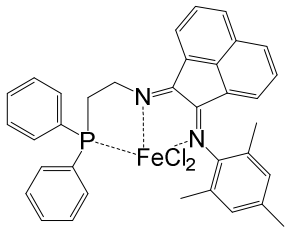
,

ADIFe III



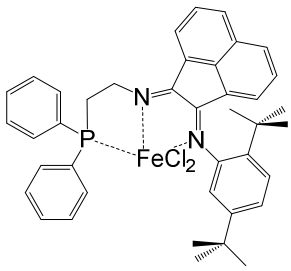
,

ADIFe IV



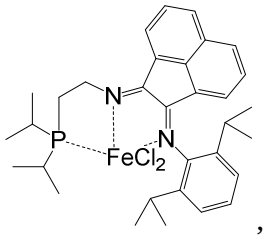
,

ADIFe V



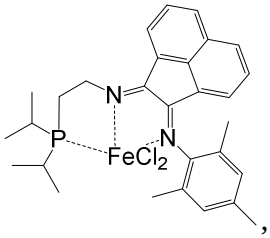
,

ADIFe VI



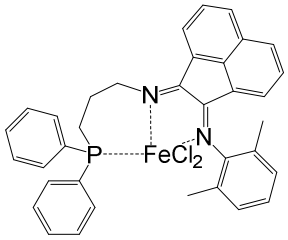
,

ADIFe VII



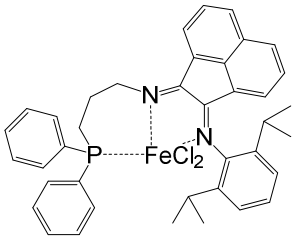
,

ADIFe VIII



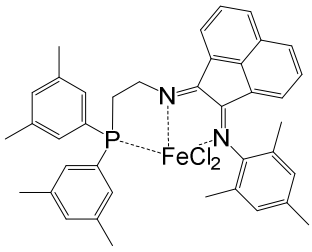
,

ADIFe IX



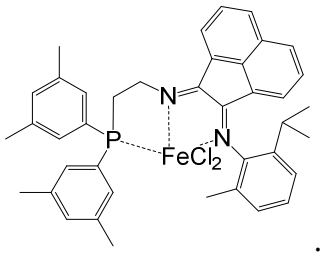
,

ADIFe X



, and

ADIFe XII



ADIFe XIII

8. The process of claim 1, wherein the catalyst system comprises the pyridine bisimine iron salt complex or the pyridine bisimine and the iron salt, and wherein the pyridine bisimine or the pyridine bisimine of the pyridine bisimine iron salt complex 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 1, wherein the catalyst system comprises the pyridine bisimine iron salt complex or the pyridine bisimine and the iron salt, and wherein the pyridine bisimine or the pyridine bisimine of the pyridine bisimine iron salt complex 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)methyl]pyridine, 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 1, wherein the catalyst system further comprises an organoaluminum compound.

11. The process of claim 10, wherein the organoaluminum compound comprises an aluminoxane.

12. The process of claim 1, wherein the oligomer product comprises a C_6 oligomer product having a 1-hexene content of at least 98.5 wt. %.

13. The process of claim 1, wherein the oligomer product comprises a C_8 olefin oligomer product having a 1-octene content of at least 98 wt. %.

14. The process of claim 1, wherein the oligomer product comprises a C_{10} oligomer product having a 1-decene content of at least 97.5 wt. %.

15. The process of claim 1, wherein the oligomer product comprises a C_{12} oligomer product having a 1-dodecene content of at least 96.5 wt. %.

16. A process comprising:

a) contacting (i) ethylene, (ii) a catalyst system comprising an α-diimine iron salt complex, a pyridine bisimine iron salt complex, or a pyridine bisimine and an iron salt, (iii) hydrogen, and (iv) optionally an organic reaction medium; and

b) forming an oligomer product wherein the oligomer product is formed in the presence of ethylene and hydrogen at a ratio in the range of 0.4 g hydrogen /kg ethylene to 5 g hydrogen /kg ethylene, and wherein 1) the oligomer product has a Schulz-Flory K value from 0.4 to 0.8, and 2) each carbon number fraction from C_4 to C_{18} of the oligomer product has a paraffin content equal to or less than 2 times the paraffin content of a corresponding carbon number fraction of the oligomer product produced in the absence of hydrogen based on the total weight of the carbon number fraction of the oligomer product.

17. The process of claim 16, wherein the oligomer product comprises (a) less than 1 wt.% compounds having greater than 70 carbon atoms, (b) less than 1 wt.% compounds having a weight average molecular weight greater than 1000 g/mole, or (c) any combination thereof wherein the weight percentage is based on the total weight of the oligomer product.

18. A process comprising:

a) contacting (i) ethylene, (ii) a catalyst system comprising an α-diimine iron salt complex, a pyridine bisimine iron salt complex, or a pyridine bisimine and an iron salt, (iii) hydrogen, and (iv) optionally an organic reaction medium; and

b) forming an oligomer product wherein the oligomer product is formed in the presence of ethylene and hydrogen at a ratio in the range of 0.4 g hydrogen /kg ethylene to 5 g hydrogen /kg ethylene, and wherein the oligomer product has a Schulz-Flory K value of from 0.4 to 0.8 and a Schulz-Flory K value that is within ± 5 % of an oligomer product produced in the absence of hydrogen.

19. The process of claim 18, wherein each carbon number fraction from C_4 to C_{18} of the oligomer product has a paraffin content of equal to or less than 2 times the paraffin content of a corresponding carbon number fraction of the oligomer product produced in the absence of hydrogen based on the total weight of the carbon number fraction of the oligomer product.

20. The process of claim 18, wherein the oligomer product comprises (a) less than 1 wt.% compounds having greater than 70 carbon atoms, (b) less than 1 wt.% compounds having a weight average molecular weight greater than 1000 g/mole, or (c) any combination thereof wherein the weight percentage is based on the total weight of the oligomer product.

21. The process of claim 18, wherein the catalyst system further comprises an aluminoxane and wherein b) further comprises forming the oligomer product at i) a temperature in a range of 0° C to 200° C, ii) an ethylene partial pressure in a range of 50 psi (344 KPa) to 5,000 psi (34.5 MPa), iii) an iron of the iron salt concentration, an iron of the pyridine bisimine iron salt complex concentration or an iron of the α-diimine iron salt complex concentration in a range of $1x10^{-6}$ mmol Fe/kg to $1x10^{-1}$ mmol Fe/kg, iv) an Al:Fe molar ratio in the range of 100:1 to

5,000:1, and v) optionally an ethylene to organic reaction medium mass ratio in a range of 0.8:1 to 4.5:1.

22. The process of claim 16, wherein the catalyst system further comprises an aluminoxane and wherein b) further comprises forming the oligomer product at i) a temperature in a range of 0° C to 200° C, ii) an ethylene partial pressure in a range of 50 psi (344 KPa) to 5,000 psi (34.5 MPa), iii) an iron of the iron salt concentration, an iron of the pyridine bisimine iron salt complex concentration or an iron of the α-diimine iron salt complex concentration in a range of $1x10^{-6}$ mmol Fe/kg to $1x10^{-1}$ mmol Fe/kg, iv) an Al:Fe molar ratio in the range of 100:1 to 5,000:1, and v) optionally an ethylene to organic reaction medium mass ratio in a range of 0.8:1 to 4.5:1.

23. The process of claim 1, wherein the catalyst system further comprises an aluminoxane and wherein b) further comprises forming the oligomer product at i) a temperature in a range of 0° C to 200° C, ii) an ethylene partial pressure in a range of 50 psi (344 KPa) to 5,000 psi (34.5 MPa), iii) an iron of the iron salt concentration, an iron of the pyridine bisimine iron salt complex concentration or an iron of the α-diimine iron salt complex concentration in a range of $1x10^{-6}$ mmol Fe/kg to $1x10^{-1}$ mmol Fe/kg, iv) an Al:Fe molar ratio in the range of 100:1 to 5,000:1, and v) optionally an ethylene to organic reaction medium mass ratio in a range of 0.8:1 to 4.5:1.