

CLAIMS

1. A catalyst system comprising:
a heterogeneous procatalyst comprising a titanium species, an aluminum species, and a magnesium chloride component; and
an electron donor; and
a hydrogenation procatalyst having the formula $\text{Cp}_2\text{TiX}_n\text{TiCp}_2$ or Cp_2TiX_n
where:
each Cp is cyclopentadienyl substituted with at least one $(\text{C}_1\text{--}\text{C}_{10})$ alkyl;
each X is independently monoanionic or neutral, wherein each X is
independently $(\text{C}_1\text{--}\text{C}_{40})$ hydrocarbon, $(\text{C}_1\text{--}\text{C}_{40})$ heterohydrocarbon,
 $(\text{C}_1\text{--}\text{C}_{40})$ hydrocarbyl, $(\text{C}_1\text{--}\text{C}_{40})$ heterohydrocarbyl, or a halogen
atom; and
n is 1 or 2.
2. The catalyst system of claim 1, wherein the electron donor is a vanadium compound
chosen from VOX_3 or $\text{VO}(\text{OR}^3)_3$, where each X is independently a halogen atom or
 $(\text{C}_1\text{--}\text{C}_{40})$ heterohydrocarbyl anion; and each R^3 is independently $(\text{C}_1\text{--}\text{C}_{20})$ hydrocarbyl or
 $-\text{C}(\text{O})\text{R}^{11}$, where R^{11} is $(\text{C}_1\text{--}\text{C}_{30})$ hydrocarbyl.
3. The catalyst system of claim 1, wherein the heterogeneous procatalyst is an unsupported
bulk catalyst.
4. The catalyst system of any one of claims 1 to 3, wherein the heterogeneous procatalyst
comprises particles having an average particle size from 0.1 micron to 10 microns.
5. The catalyst system of any one of claims 1 to 4, wherein the heterogeneous procatalyst
comprises heterogeneous procatalyst particles with a non-controlled morphology.
6. The catalyst system of any one of claims 1 to 5, wherein the heterogeneous procatalyst
comprises heterogeneous procatalyst particles, wherein greater than or equal to 10% of the
particles have a particle size less than or equal to 1 micron
7. The catalyst system of any one of claims 1 to 6, further comprising an alkyl aluminum
cocatalyst having a structure $\text{Al}(\text{R}^2)_3$, where each R^2 is independently $(\text{C}_1\text{--}\text{C}_{20})$ alkyl or halogen
atom.

8. The catalyst system of any one of claims 1 to 8, further comprising an alkyl aluminum cocatalyst selected from the group consisting of trialkylaluminum compounds, dialkylaluminum chlorides, alkylaluminum dichlorides, alkylaluminum alkoxides, and alkylaluminoxanes.
9. A polymerization process comprising reacting (C₂–C₁₂) α -olefins in solution in the presence of a catalyst system, the catalyst system comprising:
- a heterogeneous procatalyst comprising a titanium species and a magnesium chloride component;
 - an electron donor; and
 - a hydrogenation procatalyst having the formula Cp₂TiX_nTiCp₂ or Cp₂TiX_n where:
 - each Cp is cyclopentadienyl substituted with at least one (C₁–C₁₀)alkyl;
 - each X is independently monoanionic or neutral, wherein each X is independently (C₁–C₄₀)hydrocarbon, (C₁–C₄₀)heterohydrocarbon, (C₁–C₄₀)hydrocarbyl, (C₁–C₄₀)heterohydrocarbyl, or a halogen atom; and
 - n is 1 or 2.
10. The polymerization process of claim 9, further comprising an alkylaluminum cocatalyst having a structure Al(R²)₃, where each R² is independently (C₁–C₂₀)alkyl or halogen atom.
11. The polymerization process of claim 10 or claim 11, further comprising trialkylaluminum, dialkylaluminum chloride, alkylaluminum dichloride, alkylaluminum alkoxide, or alkylaluminoxane.
12. The polymerization process of claim 9, wherein the electron donor is a vanadium compound chosen from VOX₃ or VO(OR³)₃, where each X is independently a halogen atom or (C₁–C₄₀)heterohydrocarbyl anion; and R³ is (C₁–C₂₀)hydrocarbyl or –C(O)R¹¹, where R¹¹ is (C₁–C₃₀)hydrocarbyl.
13. The polymerization process of any one of claims 9 to 12, wherein the heterogeneous procatalyst is a bulk catalyst.
14. The polymerization process of any one of claims 9 to 13, wherein the heterogeneous procatalyst comprises heterogeneous procatalyst particles, wherein greater than or equal to 10% of the particles have a particle size less than or equal to 1 micron.

15. The polymerization process of any one of claims 9 to 14, wherein the proheterogeneous catalyst comprises heterogeneous procatalyst particles with a non-controlled particle morphology.
16. The polymerization process of any one of claims 9 to 16, wherein the (C₂–C₁₂) α -olefins in solution are reacted in a reactor at a reaction temperature from 150 °C to 350 °C.