Claims

1. A process for the oligomerization of ethylene, comprising the steps of:

   a) oligomerizing of ethylene in a reactor in the presence of solvent and catalyst;

   b) transferring reactor overhead effluent to an externally located cooling device and recycling condensed effluent into the reactor;

   c) transferring the reactor bottom effluent to a series of fractionation columns and, in the following order,

      i) optionally separating C6 fraction,

      ii) separating C6 fraction,

      iii) simultaneously separating C8 and C10 fractions and recycling thereof into the reactor, and

      iv) separating residues comprising ≥ C12 fractions, spent catalyst, polymer material and quench media, from the process,

      wherein the solvent is separated in any of the steps i)-iv) and/or in an additional step.

2. The process according to claim 1, wherein the catalyst comprises (1) a chromium compound, (2) a ligand of the general structure (A) R_1R_2P-$N(R_3)$-$P(R_4)$-$N(R_5)$-H or (B)

R_1R_2P-$N(R_3)$-$P(R_4)$-$N(R_5)$-PR_6R_7, wherein R_1, R_2, R_3, R_4, R_5, R_6 and R_7 are independently selected from halogen, amino, trimethylsilyl, C1-C10-alkyl, C_6-C_{20} aryl and substituted C_6-C_{20} aryl, and (3) an activator or co-catalyst.

3. The process according to claim 1 or 2, wherein the chromium compound is selected from the group consisting of $CrCl_3(THF)_3$, Cr(III) acetyl acetonate, Cr(III) octanoate, chromium hexacarbonyl, Cr(III)-2-ethyl hexanoate, benzene(tricarbonyl)-chromium, and Cr(III) chloride.

4. The process according to any of the preceding claims, wherein the activator or co-catalyst is selected from trimethyl aluminum, triethyl aluminum, triisopropyl aluminum, triisobutyl aluminum, ethylaluminiumsesquichloride, diethyl aluminum chloride, ethyl aluminum dichloride, methyl aluminoxane (MAO) or mixtures thereof.

5. The process according to any of the precedings claims, which is the trimerization of ethylene.

6. The process according to any of the preceding claims, wherein the reactor overhead transferred and recycled in step b) comprises unreacted ethylene or unreacted ethylene and butenes.

7. The process according to any of the preceding claims, wherein the cooling device is a condenser or a series of heat exchangers.

8. The process according to any of the preceding claims, wherein the reactor overhead effluent is cooled in the cooling device to a temperature of -30°C to +10°C, preferably -10°C to +5°C, more preferably -5°C to 0°C, and is then recycled into the reactor.

9. The process according to any of the preceding claims, wherein make-up ethylene is added to the condensed reactor overhead effluent to be recycled into the reactor.

10. The process according to any of the preceding claims, wherein the C8 and C10 fractions obtained in step iii) are recycled into the reactor at a temperature of about 10-20°C.

11. The process according to any of the preceding claims, wherein the residue obtained in step iv) is sent to incineration or is used as fuel in an adjacent plant.

12. The process according to any of the preceding claims, wherein the content of C4 in the reactor is from 5 to 30 weight percent, the content of C8 is from 1 to 2 weight percent, and/or the content of C10 in the reactor is from 5-10 weight percent, all weight percentages given based on the total weight of liquids contained in the reactor.

13. The process according to any of the preceding claims, wherein the total content of linear alpha-olefins in the liquid is from 30-75 wt.% based on the total weight of liquids contained in the reactor.

14. The process according to any of the preceding claims, wherein the reactor is a multi tubular reactor and/or a bubble column reactor.

CLAIMS

1. A process for the oligomerization of ethylene, comprising:
   a) oligomerizing ethylene in a reactor in the presence of solvent and catalyst;
   b) transferring reactor overhead effluent to an externally located cooling device and recycling condensed effluent into the reactor;
   c) transferring the reactor bottom effluent to a series of fractionation columns and, in the following order,
      i) optionally separating C4 fraction,
      ii) separating C6 fraction,
      iii) simultaneously separating C8 and C10 fractions and recycling thereof into the reactor, and
      iv) separating residues comprising ≥ C12 fractions, spent catalyst, polymer material and quench media, from the process,

   wherein the solvent is separated in any of the steps i)-iv) and/or in an additional step.

2. The process according to claim 1, wherein the catalyst comprises (1) a chromium compound, (2) a ligand of the general structure (A) R_1R_2P-$N(R_3)$-$P(R_4)$-$N(R_5)$-H or (B) R_1R_2P-$N(R_3)$-$P(R_4)$-$N(R_5)$-PR_6R_7, wherein R_1, R_2, R_3, R_4, R_5, R_6 and R_7 are independently selected from halogen, amino, trimethylsilyl, C_1-C_{10}-alkyl, C_6-C_{20} aryl and substituted C_6-C_{20} aryl, and (3) an activator or co-catalyst.

3. The process according to claim 1 or 2, wherein the chromium compound is selected from the group consisting of $CrCl_3(THF)_3$, Cr(III) acetyl acetonate, Cr(III) octanoate, chromium hexacarbonyl, Cr(III)-2-ethyl hexanoate, benzene(tricarbonyl)-chromium, and Cr(III) chloride.

4. The process according to any of the preceding claims, wherein the activator or co-catalyst is selected from trimethyl aluminum, triethyl aluminum, triisopropyl aluminum, triisobutyl aluminum, ethylaluminiumsesquichloride, diethyl aluminum chloride, ethyl aluminum dichloride, methyl aluminoxane (MAO) or mixtures thereof.

5. The process according to any of the precedings claims, which is the trimerization of ethylene.

6. The process according to any of the preceding claims, wherein the reactor overhead transferred and recycled in step b) comprises unreacted ethylene or unreacted ethylene and butenes.

7. The process according to any of the preceding claims, wherein the cooling device is a condenser or a series of heat exchangers.

8. The process according to any of the preceding claims, wherein the reactor overhead effluent is cooled in the cooling device to a temperature of -30°C to +10°C, preferably -10°C to +5°C, more preferably -5°C to 0°C, and is then recycled into the reactor.

9. The process according to any of the preceding claims, wherein make-up ethylene is added to the condensed reactor overhead effluent to be recycled into the reactor.

10. The process according to any of the preceding claims, wherein the C8 and C10 fractions obtained in step iii) are recycled into the reactor at a temperature of about 10-20°C.

11. The process according to any of the preceding claims, wherein the residue obtained in step iv) is sent to incineration or is used as fuel in an adjacent plant.

12. The process according to any of the preceding claims, wherein the content of C4 in the reactor is from 5 to 30 weight percent, the content of C8 is from 1 to 2 weight percent,

and/or the content of C10 in the reactor is from 5-10 weight percent, all weight percentages given based on the total weight of liquids contained in the reactor.

13. The process according to any of the preceding claims, wherein the total content of linear alpha-olefins in the liquid is from 30-75 wt.% based on the total weight of liquids contained in the reactor.

14. The process according to any of the preceding claims, wherein the reactor is a multi-tubular reactor and/or a bubble column reactor.