CLAIMS

What is claimed is:

1. A polymerization process, comprising:

supplying a feed containing ethylene and at least one alpha-olefin having 3 to 12 carbon atoms in a solvent to a reactor, where the feed is supplied at a temperature in the range of about -80°C to about -30°C; and

contacting the feed with a catalyst in the reactor to form a reaction mixture containing an ethylene-alpha-olefin polymer,

wherein the solvent is provided at a solvent feed rate such that the polymer concentration in the reaction mixture is greater than 5 wt% based on the weight of the reaction mixture.

2. The process of claim 1, wherein the feed temperature is less than or equal to -40°C.

3. The process of claim 1 or 2, wherein the polymer concentration is greater than 7 wt% based on the weight of the reaction mixture.

4. The process of any one of claims 1-3, wherein the catalyst is supplied at a catalyst feed rate such that the catalyst efficiency is greater than 400.

5. The process of any one of claims 1-4, wherein the catalyst comprises a transition metal of Groups 4 to 6 in the Periodic Table of Elements.

6. The process of any one of claims 1-5, wherein the process is carried out in the presence of a chain transfer agent in an amount of from 100 to 500 ppm based on the weight of the ethylene.

7. The process of any one of claims 1-6, wherein the solvent comprises at least one of alicyclic and acyclic hydrocarbons having 5 to 10 carbon atoms, aromatic hydrocarbons, aromatic hydrocarbons, and halogenated hydrocarbons.

8. The process of any one of claims 1-6, wherein the solvent is n-hexane, isohexane, or mixture of hexane isomers.

9. The process of any one of claims 1-8, wherein the ethylene-alpha-olefin polymer has a Mooney viscosity (ML 1+4, 125°C) as measured by ASTM-D 1646 of from 10 to 100.

10. The process of claim 9, wherein the ethylene-alpha-olefin polymer has a MLRA of from 50 to 1000, where MLRA is the area under the Mooney Relaxation Curve measured according to ASTM-D 1646 (1+4 @ 125°C).

11. The process of claim 9 or 10, wherein the ethylene-alpha-olefin polymer has a cMLRA of less than 2000, where cMLRA is MLRA corrected for Mooney viscosity and

~~MLRA is the area under the Mooney Relaxation Curve measured according to ASTM-D~~ 1646 (1+4 @ 125°C).

12. The process of any one of claims 1-11, wherein the ethylene-alpha-olefin polymer comprises 10 wt% to 90 wt% of ethylene-derived units and 90 wt% to 10 wt% of the at least one alpha-olefin-derived units based on the total weight of the polymer.

13. The process of claim 12, wherein the polymer further comprises about 0.1 wt% to about 15 wt% of the diene-derived units based on the total weight of the polymer.

14. The process of any one of claims 1-13, wherein the feed comprises ethylene, propylene, and ethylidene norbornene.

15. A process for improving the energy utilization of a polymerization process, wherein the polymerization process comprises supplying at a first feed temperature a feed containing ethylene and at least one alpha-olefin having 3 to 12 carbon atoms in a solvent to a reactor, where the solvent is supplied at a first solvent feed rate; supplying a catalyst at a first catalyst feed rate to the reactor; and contacting the feed with the catalyst to form a reaction mixture containing an ethylene-alpha-olefin polymer; and

wherein the process to improve the energy utilization comprises:

decreasing the first feed temperature to a second feed temperature;

decreasing the first solvent feed rate to a second solvent feed rate; and

decreasing the first catalyst feed rate to a second catalyst feed rate.

16. The process of claim 15, wherein the second feed temperature is at least 1°C less than the first feed temperature.

17. The process of claim 15 or 16, wherein the second feed temperature is -40°C or less but greater than -80°C.

18. The process of any one of claims 15-17, wherein decreasing the first solvent feed rate to the second solvent feed rate increases the polymer concentration in the reaction mixture by at least 1 wt%.

19. The process of any one of claims 15-18, wherein decreasing the first solvent feed rate to the second solvent feed rate obtains the polymer concentration in the reaction mixture of greater than 7 wt%.

20. The process of any one of claims 15-19, wherein decreasing the first solvent feed rate to the second solvent feed rate follows to equation:

~~$M_{s2} \times (T_r - T_{f2}) \geq M_{s1} \times (T_r - T_{f1})$~~

wherein M_{s1} represents the first solvent feed rate and M_{s2} represents the second solvent feed rate, T_r represents the reactor temperature, T_{f1} represents the first feed temperature and T_{f2} represents the second feed temperature.

21. The process of any one of claims 15-19, wherein decreasing the first catalyst feed rate to the second catalyst feed rate increases the catalyst efficiency by at least 10%.

22. The process of any one of claims 15-19, wherein decreasing the first catalyst feed rate to the second catalyst feed rate obtains the catalyst efficiency of greater than 400.

23. The process of any one of claims 15-22, comprising supplying a chain transfer agent at a first chain transfer agent rate to the reactor and increasing the first chain transfer agent feed rate to a second chain transfer agent feed rate.

24. The process of claim 23, wherein decreasing the first chain transfer agent feed rate to the second chain transfer agent feed rate obtains the amount of the chain transfer agent in the reactor of from 100 ppm to 500 ppm by the weight of the ethylene.

25. A polymerization process, comprising:

supplying at a first feed temperature of greater than -80°C and less than -30°C a feed containing ethylene, at least one alpha-olefin having 3 to 12 carbon atoms and a diene in a solvent to a reactor, where the solvent is supplied at a first solvent feed rate;

supplying a catalyst at a first catalyst feed rate to the reactor; and

contacting the feed with the catalyst to form a reaction mixture containing an ethylene-alpha-olefin-diene polymer,

wherein the process further comprises:

decreasing the first feed temperature to a second feed temperature, and the second feed temperature is at least 5°C less than the first feed temperature;

decreasing the first solvent feed rate to a second solvent feed rate to obtain the polymer concentration in the reaction mixture of greater than 7 wt%; and

decreasing the first catalyst feed rate to a second catalyst feed rate to increase the catalyst efficiency by at least 10%.

CLAIMS:

What is claimed is:

1. A polymerization process, comprising:

supplying a feed containing ethylene and at least one alpha-olefin having 3 to 12 carbon atoms in a solvent to a reactor, where the feed is supplied at a temperature in the range of about -80°C to about -30°C; and

contacting the feed with a catalyst in the reactor to form a reaction mixture containing an ethylene-alpha-olefin polymer,

wherein the solvent is provided at a solvent feed rate such that the polymer concentration in the reaction mixture is greater than 5 wt % based on the weight of the reaction mixture;

wherein the catalyst is supplied at a catalyst feed rate such that the catalyst efficiency is greater than 400.

2. The process of claim 1, wherein the feed temperature is less than or equal to -40°C.

3. The process of claim 1, wherein the polymer concentration is greater than 7 wt % based on the weight of the reaction mixture.

4. The process of claim 1, wherein the catalyst comprises a transition metal of Groups 4 to 6 in the Periodic Table of Elements.

5. The process of claim 1, wherein the process is carried out in the presence of a chain transfer agent in an amount of from 100 to 500 ppm based on the weight of the ethylene.

6. The process of claim 1, wherein the solvent comprises at least one of alicyclic and acyclic hydrocarbons having 5 to 10 carbon atoms, aromatic hydrocarbons, aromatic hydrocarbons, and halogenated hydrocarbons.

7. The process of claim 1, wherein the solvent is n-hexane, isohexane, or mixture of hexane isomers.

8. The process of claim 1, wherein the ethylene-alpha-olefin polymer has a Mooney viscosity (ML 1+4, 125°C) as measured by ASTM-D 1646 of from 10 to 100.

9. The process of claim 8, wherein the ethylene-alpha-olefin polymer has a MLRA of from 50 to 1000, where MLRA is the area under the Mooney Relaxation Curve measured according to ASTM-D 1646 (1+4 @ 125°C).

10. The process of claim 8, wherein the ethylene-alpha-olefin polymer has a cMLRA of less than 2000, where cMLRA is MLRA corrected for Mooney viscosity and MLRA is the area under the Mooney Relaxation Curve measured according to ASTM-D 1646 (1+4 @ 125°C).

11. The process of claim 1, wherein the ethylene-alpha-olefin polymer comprises 10 wt % to 90 wt % of ethylene-derived units and 90 wt % to 10 wt % of the at least one alpha-olefin-derived units based on the total weight of the polymer.

12. The process of claim 11, wherein the polymer further comprises about 0.1 wt % to about 15 wt % of the diene-derived units based on the total weight of the polymer.

13. The process of claim 1, wherein the feed comprises ethylene, propylene, and ethylidene norbornene.

14. A process for improving the energy utilization of a polymerization process, wherein the polymerization process comprises supplying at a first feed temperature a feed containing ethylene and at least one alpha-olefin having 3 to 12 carbon atoms in a solvent to a reactor, where the solvent is supplied at a first solvent feed rate; supplying a catalyst at a first catalyst feed rate to the reactor; and contacting the feed with the catalyst to form a reaction mixture containing an ethylene-alpha-olefin polymer; and

wherein the process to improve the energy utilization comprises:

decreasing the first feed temperature to a second feed temperature;
decreasing the first solvent feed rate to a second solvent feed rate; and
decreasing the first catalyst feed rate to a second catalyst feed rate.

15. The process of claim 14, wherein the second feed temperature is at least 1°C less than the first feed temperature.

16. The process of claim 14, wherein the second feed temperature is -40°C or less but greater than -80°C.

17. The process of claim 14, wherein decreasing the first solvent feed rate to the second solvent feed rate increases the polymer concentration in the reaction mixture by at least 1 wt %.

18. The process of claim 14, wherein decreasing the first solvent feed rate to the second solvent feed rate obtains the polymer concentration in the reaction mixture of greater than 7 wt %.

19. The process of claim 14, wherein decreasing the first solvent feed rate to the second solvent feed rate follows to equation:

$$M_{s2} \times (T_r - T_{f2}) \geq M_{s1} \times (T_r - T_{f1})$$

wherein M_{s1} represents the first solvent feed rate and M_{s2} represents the second solvent feed rate, T_r represents the reactor temperature, T_{f1} represents the first feed temperature and T_{f2} represents the second feed temperature.

20. The process of claim 14, wherein decreasing the first catalyst feed rate to the second catalyst feed rate increases the catalyst efficiency by at least 10%.

21. The process of claim 14, wherein decreasing the first catalyst feed rate to the second catalyst feed rate obtains the catalyst efficiency of greater than 400.

22. The process of claim 14 comprising supplying a chain transfer agent at a first chain transfer agent rate to the reactor and increasing the first chain transfer agent feed rate to a second chain transfer agent feed rate.

23. The process of claim 22, wherein the second chain transfer agent feed rate introduces chain transfer agent to the reactor in an amount of from 100 ppm to 500 ppm by the weight of the ethylene.

24. A polymerization process, comprising:

supplying at a first feed temperature of greater than -80°C and less than -30°C a feed containing ethylene, at least one alpha-olefin having 3 to 12 carbon atoms and a diene in a solvent to a reactor, where the solvent is supplied at a first solvent feed rate;

supplying a catalyst at a first catalyst feed rate to the reactor; and

contacting the feed with the catalyst to form a reaction mixture containing an ethylene-alpha-olefin-diene polymer,

wherein the process further comprises:

decreasing the first feed temperature to a second feed temperature, and the second feed temperature is at least 5°C less than the first feed temperature;

decreasing the first solvent feed rate to a second solvent feed rate to obtain the polymer concentration in the reaction mixture of greater than 7 wt %; and

decreasing the first catalyst feed rate to a second catalyst feed rate to increase the catalyst efficiency by at least 10%.