Claims

1. A process for polymerizing propylene in the presence of a polymerization catalyst comprising

(I) a solid catalyst component comprising a magnesium halide, a titanium halide and an internal electron donor; and

(II) a cocatalyst comprising an aluminium alkyl and optionally an external electron donor, said process comprising the steps of:

(A) continuously polymerizing propylene, optionally together with ethylene, in a first polymerization stage by introducing streams of propylene, hydrogen and optionally ethylene into the first polymerization stage at a temperature of from 60 to 100 °C and a pressure of from 10 to 100 bar to produce a first polymer of propylene and a first fluid reaction mixture wherein the first polymer has a melt flow rate MFR_2 of from 0.3 to 5.0 g/10 min;

(B) withdrawing from the first polymerization stage a stream comprising the first polymer of propylene and passing it into a second polymerization stage;

(C) continuously polymerizing propylene in the presence of said first polymer of propylene in the second polymerization stage at a temperature of from 65 to 100 °C and a pressure of from 10 to 100 bar by introducing streams of propylene, hydrogen, and ethylene, to produce a first polymer mixture of said first polymer of propylene and a second copolymer of propylene, said first polymer mixture comprising from 30 to 60 % by weight of said first polymer and from 40 to 70 % by weight of said second copolymer wherein the first polymer mixture has a melt flow rate MFR_2 of 0.05 to 1.0 g/10 min and a content of ethylene units of from 2 to 12 % by mole and wherein the melt flow rate MFR_2 of said first polymer mixture is smaller than the melt flow rate MFR_2 of said first polymer and the content of ethylene units in said first polymer mixture is greater than the content of ethylene units in said first polymer;

(D) withdrawing a stream comprising the first polymer mixture from the second polymerization stage and passing it into a third polymerization stage;

(E) continuously polymerizing propylene and ethylene in the presence of the first polymer mixture in the third polymerization stage at a temperature of from 65 to 100 °C, a molar ratio of ethylene to propylene of from 100 to 350 mol/kmol

and a pressure of from 10 to 100 bar by introducing streams of propylene, hydrogen, and the comonomer, to produce a second copolymer mixture comprising the first polymer mixture and a third copolymer of propylene wherein the second copolymer mixture has a melt flow rate MFR_2 of 0.05 to 1.0 g/10 min and a content of ethylene units of from 4.5 to 15 % by mole; wherein the second copolymer mixture comprises from 75 to 98 % by weight of said first polymer mixture and from 2 to 25 % by weight of said third copolymer and wherein the melt flow rate MFR_2 of the second copolymer mixture is smaller than the melt flow rate MFR_2

of said first polymer mixture and the ratio of the content of the ethylene units in the first polymer mixture to the content of the ethylene units in the second copolymer mixture, both expressed in mol-%, is within the range of from 0.50 to 0.96;
(F) withdrawing a stream comprising the second copolymer mixture from the third polymerization stage and optionally mixing the second copolymer mixture with additives; and
(G) extruding the second polymer mixture into pellets.

2. The process according to claim 1 wherein the first polymer is a propylene ethylene copolymer and wherein the first polymer contains from 0.1 to 6 mol-% of units derived from ethylene.

3. The process according to claim 2 wherein the first polymer mixture is a mixture of copolymers of propylene and ethylene and wherein the first copolymer mixture has a content of ethylene of from 2 to 12 mol-%.

4. The process according to any one of the preceding claims wherein the first polymerization stage is conducted in a loop reactor as a slurry polymerization step.

5. The process according to claim 4 wherein the loop reactor is operated at a temperature within the range of from 60 to 75 °C.

6. The process according to any one of the preceding claims wherein the second and third polymerization stages are conducted in gas phase reactors.

7. The process according to claim 6 wherein the gas phase reactors are operated at a temperature within the range of from 65 to 85 °C.

8. The process according to any one of the claims 6 and 7 wherein the first polymerization stage is conducted in a loop reactor as a slurry polymerization step and the slurry stream comprising the first polymer and the first fluid reaction mixture withdrawn from the loop reactor is passed into the gas phase reactor of the second polymerization stage.

9. The process according to any one of the preceding claims wherein the ratio of the melt index MFR_2 of the first copolymer mixture to the melt index MFR_2 of the first copolymer, $MFR_{2,b1}/MFR_{2,1}$, has a value of not higher than 0.8, preferably not higher than 0.7 and in more preferably not higher than 0.6.

10. The process according to any one of claims 3 to 9 wherein the ratio of the ethylene content of the first copolymer to the ethylene content of the first copolymer mixture, both

expressed in mol-%, C_1/C_{b1}, is not higher than 0.98, more preferably not higher than 0.9 and especially preferably not higher than 0.85.

11. The process according to any one of the preceding claims wherein the ratio of the melt index MFR_2 of the second polymer mixture to the melt index MFR_2 of the first polymer mixture , $MFR_{2,b2}/MFR_{2,b1}$, has a value of not higher than 0.95, and preferably not higher than 0.90.

12. The process according to any one of claims 3 to 11 wherein the ratio of the content of ethylene units in the first copolymer mixture to the content of the ethylene units in the second copolymer mixture, both expressed in % by mole, is within the range of 0.55 to 0.95, preferably from 0.6 to 0.9.

13. The process according to any one of the preceding claims wherein the solid component of the polymerization catalyst comprises a transition metal component comprising magnesium, titanium and halogen, and a polymeric component comprising polymer of a vinyl compound of the formula $CH_2=CH-CHR_6R_7$, wherein R_6 and R_7 together form a 5- or 6-membered saturated, unsaturated or aromatic ring or independently represent an alkyl group comprising 1 to 4 carbon atoms.

14. The process according to claim 13 wherein the vinyl compound of the formula $CH_2=CH-CHR_6R_7$ is vinyl cyclohexane or 3-methyl-1-butene.

15. The process according to any one of the preceding claims wherein the content of ethylene units in the third copolymer is from 10 to 40 % by mole and a content of propylene units of from 60 to 90 % by mole.

16. A process for producing pipes comprising the steps of:
- polymerizing propylene in the process according to any one of claims 1 to 15; and
- extruding the polymer to a pipe.