found that employing a hydrogen separating membrane offers an attractive solution to this problem.

It is thus an object of the present invention to provide a new process for separating hydrogen from a gaseous feed stream in a polymerisation process which enables effective removal such that a hydrogen-lean gaseous stream may be generated which can be recycled back to the reactor. In particular, a process with high separation efficiency is desirable. A process which can easily be incorporated into existing technologies and plant set-ups is looked-for. Ideally, the process will be more-straightforward and cost effective than those already known in the art. Preferably, more than one of these factors is achieved.

Summary

Thus, the disclosure provides a process for separating hydrogen from a gaseous feed stream in a polymerisation process, comprising the steps:

i. polymerising an olefin monomer and optionally at least one olefin comonomer in the presence of a solvent, optionally in the presence of hydrogen, so as to form a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;

ii. separating said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;

iii. feeding said unreacted monomer(s), solvent and hydrogen to a separator so as to form said gaseous feed stream;

iv. contacting said gaseous feed stream with a hydrogen separating membrane so as to form a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream.

In one aspect, the present disclosure provides a process for separating hydrogen from a gaseous feed stream in a polymerisation process, comprising the steps:

i. polymerising an olefin monomer and optionally at least one olefin comonomer, in the presence of a solvent, optionally in the presence of hydrogen, to form a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;

ii. separating said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;

iii. feeding said unreacted monomer(s), solvent and hydrogen to a separator to form said gaseous feed stream;

iv. contacting said gaseous feed stream with a single hydrogen separating membrane to form a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream, wherein a separation efficiency of step iv. is at least 75%.

In a further example, the disclosure provides a process as hereinbefore defined, wherein said polymerisation process is a solution polymerisation process.

The disclosure provides the use of a hydrogen separating membrane for the separation of hydrogen in a process as hereinbefore defined.

The disclosure provides apparatus arranged to perform the process as hereinbefore defined comprising:

a) At least one reactor configured to receive an olefin monomer, solvent and optionally at least one olefin comonomer, and optionally hydrogen, via at least one first inlet so as to produce a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;

b) A first separator in fluid communication with said reactor configured to receive said polymerisation reaction mixture via at least one second inlet so as to separate said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;

c) A second separator in fluid communication with said first separator configured to receive said unreacted monomer(s), solvent and hydrogen via at least one third inlet so as to produce a gaseous feed stream; and

d) A membrane contactor in fluid communication with said second separator configured to receive said gaseous feed stream via at least one fourth inlet so as to produce a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream.

In another aspect, the present disclosure provides an apparatus arranged to perform the process as described herein comprising:

a) at least one reactor configured to receive an olefin monomer and optionally at least one olefin comonomer, solvent and optionally hydrogen via at least one first inlet to produce a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;

b) a first separator in fluid communication with said reactor configured to receive said polymerisation reaction mixture via at least one second inlet to separate said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;

c) a second separator in fluid communication with said first separator configured to receive said unreacted monomer(s), solvent and hydrogen via at least one third inlet to produce a gaseous feed stream; and

d) a single membrane contactor in fluid communication with said second separator configured to receive said gaseous feed stream via at least one fourth inlet to produce a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream, wherein a separation efficiency is at least 75%.

The disclosure provides a process for controlling the molecular weight of a polyolefin polymer comprising the comprising the steps:

i. polymerising an olefin monomer and optionally at least one olefin comonomer in the presence of a solvent, optionally in the presence of hydrogen, so as to form a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;

ii. separating said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;

iii. feeding said unreacted monomer(s), solvent and hydrogen to a separator so as to form said gaseous feed stream;

iv. contacting said gaseous feed stream with a hydrogen separating membrane so as to form a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream.

v. recycling the hydrogen-lean gaseous stream from step iv to step i.

In another aspect, the present disclosure provides a process for controlling molecular weight of a polyolefin polymer comprising the comprising the steps:

i. polymerising an olefin monomer and optionally at least one olefin comonomer in the presence of a solvent, optionally in the presence of hydrogen, to form a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;

ii. separating said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;

iii. feeding said unreacted monomer(s), solvent and hydrogen to a separator to form said gaseous feed stream;

iv. contacting said gaseous feed stream with a single hydrogen separating membrane to form a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream, wherein a separation efficiency of step iv. is at least 75%; and

v. recycling the hydrogen-lean gaseous stream from step iv to step i.

Claims

1. A process for separating hydrogen from a gaseous feed stream in a polymerisation process, comprising the steps:
    i. polymerising an olefin monomer and optionally at least one olefin comonomer, in the presence of a solvent, optionally in the presence of hydrogen, to form a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;
    ii. separating said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;
    iii. feeding said unreacted monomer(s), solvent and hydrogen to a separator to form said gaseous feed stream;
    iv. contacting said gaseous feed stream with a single hydrogen separating membrane to form a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream, wherein a separation efficiency of step iv. is at least 75%.
2. The process as claimed in claim 1, wherein said polymerisation process is a solution polymerisation process.
3. The process as claimed in claim 1 or 2, further comprising
    v. recycling the hydrogen-lean gaseous stream from step iv to step i.
4. The process as claimed in any of claims 1 to 3, wherein said polyolefin is polyethylene.
5. The process as claimed in claim 4, wherein said polyethylene is a polyethylene homopolymer or a polyethylene copolymer of ethylene and at least one alpha-olefin comonomer.
6. The process as claimed in claim 5, wherein the at least one alpha-olefin comonomer comprises a C3-C8 alpha-olefin comonomer.
7. The process as claimed in any of claims 1 to 6, wherein step i. is carried out in the presence of a polymerisation catalyst.
8. The process as claimed in claim 7, wherein the polymerisation catalyst is a metallocene catalyst.
9. The process as claimed in any of claims 1 to 8, wherein the separation efficiency of step iv. is at least 80%.
10. The process as claimed in any of claims 1 to 9, wherein the separation efficiency of step iv. is at least 90%.

11. The process as claimed in any of claims 1 to 10, wherein said membrane is a polymeric or inorganic membrane.
12. An apparatus arranged to perform the process as defined in any of claims 1 to 11 comprising:
    a) at least one reactor configured to receive an olefin monomer and optionally at least one olefin comonomer, solvent and optionally hydrogen via at least one first inlet to produce a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;
    b) a first separator in fluid communication with said reactor configured to receive said polymerisation reaction mixture via at least one second inlet to separate said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;
    c) a second separator in fluid communication with said first separator configured to receive said unreacted monomer(s), solvent and hydrogen via at least one third inlet to produce a gaseous feed stream; and
    d) a single membrane contactor in fluid communication with said second separator configured to receive said gaseous feed stream via at least one fourth inlet to produce a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream, wherein a separation efficiency is at least 75%.

13. A process for controlling molecular weight of a polyolefin polymer comprising the comprising the steps:
    i. polymerising an olefin monomer and optionally at least one olefin comonomer in the presence of a solvent, optionally in the presence of hydrogen, to form a polymerisation reaction mixture comprising a polyolefin polymer, unreacted monomer(s), solvent and hydrogen;
    ii. separating said polyolefin polymer from said unreacted monomer(s), solvent and hydrogen;
    iii. feeding said unreacted monomer(s), solvent and hydrogen to a separator to form said gaseous feed stream;
    iv. contacting said gaseous feed stream with a single hydrogen separating membrane to form a hydrogen-rich gaseous stream and a hydrogen-lean gaseous stream, wherein a separation efficiency of step iv. is at least 75%; and

v. recycling the hydrogen-lean gaseous stream from step iv to step i.