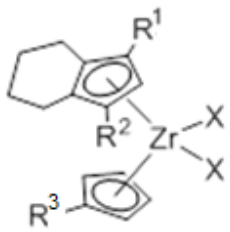
[0013a] In one aspect, the present disclosure refers to a polymerization catalyst having improved selectivity for ethylene enchainment, the polymerization catalyst comprising a zirconocene catalyst of Formula I:



(Formula I)

wherein R_1 is a C_1 to C_{20} alkyl, aryl or aralkyl group, wherein R_2 is an C_1 to C_{20} alkyl, aryl or aralkyl group, and wherein R_3 is a C_1 to C_{20} alkyl or a hydrogen, and wherein each X is independently a halide, C_1 to C_{20} alkyl, aralkyl group or hydrogen, and wherein R_3 is a C_1 alkyl or a linear C_3 alkyl.

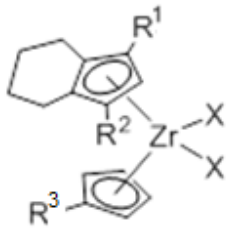
[0013b] In another aspect, the present disclosure refers to a bimodal polymerization catalyst system including the polymerization catalyst as disclosed herein and a non-metallocene olefin polymerization catalyst.

[0014] Further, the present disclosure provides bimodal polyethylene compositions including a high molecular weight polyethylene component and a low molecular weight polyethylene component having improved ethylene enchainment formed in a single reactor via a bimodal polymerization catalyst comprising a non-metallocene catalyst and a zirconocene catalyst of the Formula I, as described above.

[0014a] In another aspect, the present disclosure refers to a bimodal polyethylene composition having improved ethylene enchainment comprising a high molecular weight polyethylene component and a low molecular weight polyethylene component formed together in a single reactor via a bimodal polymerization catalyst system comprising:

a non-metallocene olefin polymerization catalyst; and

a zirconocene catalyst of the Formula I:



(Formula I)

wherein R_1 is a C_1 to C_{20} alkyl, aryl or aralkyl group, wherein R_2 is an C_1 to C_{20} alkyl, aryl or aralkyl group, and wherein R_3 is a C_1 to C_{20} alkyl or a hydrogen, and wherein each X is independently a halide, C_1 to C_{20} alkyl, aralkyl group or hydrogen, and wherein R_3 is a C_1 alkyl or a linear C_3 alkyl.

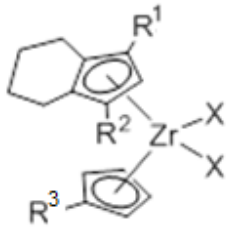
[0015] Furthermore, the present disclosure provides methods of producing polyethylene, the methods including polymerizing ethylene in a reactor in presence of a bimodal polymerization catalyst system to form the polyethylene, where the bimodal polymerization catalyst system includes a non-metallocene catalyst and a zirconocene catalyst of Formula I, as described above.

[0015a] In another aspect, the present disclosure refers to a method of producing a bimodal polyethylene having improved ethylene enchainment, the method comprising:

polymerizing ethylene in a reactor in presence of a bimodal polymerization catalyst system to form the bimodal polyethylene, wherein the bimodal polymerization catalyst comprises:

a non-metallocene catalyst; and

a zirconocene catalyst of Formula I:



(Formula I)

wherein R_1 is a C_1 to C_{20} alkyl, aryl or aralkyl group, wherein R_2 is an C_1 to C_{20} alkyl, aryl or aralkyl group, and wherein R_3 is a C_1 to C_{20} alkyl or a hydrogen, and wherein each X is independently a halide, C_1 to C_{20} alkyl, aralkyl or hydrogen, and wherein R_3 is a C_1 alkyl or a linear C_3 alkyl.

[0016] The above summary of the present disclosure is not intended to describe each disclosed example or every implementation of the present disclosure. The description that follows more particularly exemplifies illustrative examples. In several places throughout the application, guidance is provided through lists of examples, which examples can be used in various combinations. In each instance, the recited list serves only as a representative group and should not be interpreted as an exclusive list.

Detailed Description

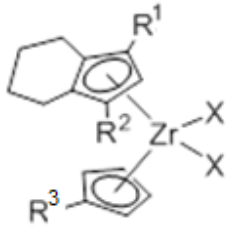
[0017] Polymerization catalysts with improved ethylene enchainment, bimodal polyethylene compositions formed via bimodal polymerization catalyst systems with improved ethylene enchainment, and methods of producing polyethylene employing bimodal polymerization catalyst systems with improved ethylene enchainment are described herein. Polymerization catalysts and bimodal polymerization catalyst systems include a new zirconocene catalyst of Formula I, as described herein. In general, the present techniques are directed to the new zirconocene catalyst of Formula I that improves polymerization economics and gives desirable polymer properties. For instance, the polymerization catalysts having including the new zirconocene of Formula I can be employed in a single reactor to form a polyethylene having desirable properties such as having improved ethylene enchainment (e.g., as evidenced by a lower butyl branching frequency).

[0018] Similarly, bimodal polymerization catalyst systems including the new zirconocene catalyst of Formula I can be employed in a single reactor to form bimodal polyethylene compositions having desirable properties such as a desirable (e.g., broad) molecular weight distribution and/or having improved ethylene enchainment. Further, in

Claims

What is claimed:

1. A polymerization catalyst having improved selectivity for ethylene enchainment, the polymerization catalyst comprising a zirconocene catalyst of Formula I:



(Formula I)

wherein R_1 is a C_1 to C_{20} alkyl, aryl or aralkyl group, wherein R_2 is an C_1 to C_{20} alkyl, aryl or aralkyl group, and wherein R_3 is a C_1 to C_{20} alkyl or a hydrogen, and wherein each X is independently a halide, C_1 to C_{20} alkyl, aralkyl group or hydrogen, and wherein R_3 is a C_1 alkyl or a linear C_3 alkyl.

2. The polymerization catalyst of claim 1, wherein R_2 is a C_1 alkyl.

3. The polymerization catalyst of claim 2, wherein R_1 is a C_1 alkyl.

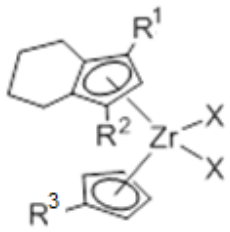
4. The polymerization catalyst of claim 2, wherein R_1 is a C_1 alkyl or a C_3 alkyl.

5. A bimodal polymerization catalyst system including the polymerization catalyst of claim 1 and a non-metallocene olefin polymerization catalyst.

6. A bimodal polyethylene composition having improved ethylene enchainment comprising a high molecular weight polyethylene component and a low molecular weight polyethylene component formed together in a single reactor via a bimodal polymerization catalyst system comprising:

a non-metallocene olefin polymerization catalyst; and

a zirconocene catalyst of the Formula I:



(Formula I)

wherein R_1 is a C_1 to C_{20} alkyl, aryl or aralkyl group, wherein R_2 is an C_1 to C_{20} alkyl, aryl or aralkyl group, and wherein R_3 is a C_1 to C_{20} alkyl or a hydrogen, and wherein each X is independently a halide, C_1 to C_{20} alkyl, aralkyl group or hydrogen, and wherein R_3 is a C_1 alkyl or a linear C_3 alkyl.

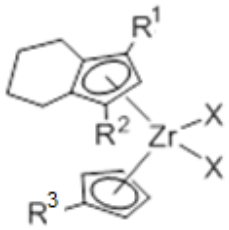
7. The bimodal polyethylene composition of claim 6, wherein the low molecular weight polyethylene has a butyl branching frequency of from 0.43 to 0.72.

8. A method of producing a bimodal polyethylene having improved ethylene enchainment, the method comprising:

polymerizing ethylene in a reactor in presence of a bimodal polymerization catalyst system to form the bimodal polyethylene, wherein the bimodal polymerization catalyst comprises:

a non-metallocene catalyst; and

a zirconocene catalyst of Formula I:



(Formula I)

wherein R_1 is a C_1 to C_{20} alkyl, aryl or aralkyl group, wherein R_2 is an C_1 to C_{20} alkyl, aryl or aralkyl group, and wherein R_3 is a C_1 to C_{20} alkyl or a hydrogen, and wherein each X is independently a halide, C_1 to C_{20} alkyl, aralkyl or hydrogen, and wherein R_3 is a C_1 alkyl or a linear C_3 alkyl.