or hexene 2 or hexene-3 to hexene-1. For both of these systems there is a need to reduce the cycle to cycle deactivation thus maintaining higher activity over the complete catalyst life cycle.

SUMMARY OF THE DISCLOSURE

[0024] ~~In one aspect, e~~Embodiments disclosed herein relate to a process for the double-bond isomerization of olefins, the process including: contacting a fluid stream comprising olefins with a fixed bed comprising an activated basic metal oxide isomerization catalyst comprising a structure stabilizing agent, to convert at least a portion of the olefin to its isomer. In an aspect, there is provided a process for the double-bond isomerization of olefins, the process comprising: contacting a fluid stream comprising olefins with a fixed bed comprising an activated basic metal oxide isomerization catalyst, to convert at least a portion of the olefin to its isomer; wherein the isomerization catalyst is prepared from an admixture of a basic metal oxide and colloidal silica as a structure stabilizing agent.

[0025] ~~In another aspect, e~~Embodiments disclosed herein relate to a process for the double-bond isomerization of olefins, the process including: contacting a fluid stream comprising olefins with a fixed bed comprising an activated basic metal oxide isomerization catalyst having an effective diameter in the range of 0.25 mm to 4.0 mm to convert at least a portion of the olefin to its isomer.

[0026] ~~In another aspect, e~~Embodiments disclosed herein relate to a process for the production of propylene, including: fractionating a hydrocarbon stream comprising n-butenes, isobutene, and paraffins into at least two fractions including a light C_4 fraction comprising isobutene and a heavy C_4 fraction comprising n-butenes and paraffins; feeding ethylene and the heavy C_4 fraction to a fixed bed reactor comprising a metathesis catalyst and an activated basic metal oxide isomerization catalyst comprising a structure stabilizing agent, contacting the heavy C_4 fraction with the activated basic metal oxide isomerization catalyst to convert at least a portion of the 1-butene to 2-butene; and contacting ethylene and at least a portion of the 2-butene with a metathesis catalyst to form a metathesis product comprising propylene, paraffins, any unreacted ethylene, and any unreacted 1-butene and 2-butene. In another aspect, there is provided a process for the production of propylene, comprising: fractionating a hydrocarbon stream comprising n-butenes, isobutene, and paraffins into at least two fractions including a light C_4 fraction comprising isobutene

and a heavy C_4 fraction comprising n-butenes and paraffins; feeding ethylene and the heavy C_4 fraction to a fixed bed reactor comprising an activated basic metal oxide isomerization catalyst and a metathesis catalyst, wherein the isomerization catalyst is prepared from an admixture of a basic metal oxide and colloidal silica as a structure stabilizing agent; contacting the heavy C_4 fraction with the activated basic metal oxide isomerization catalyst to convert at least a portion of the 1-butene to 2-butene; andcontacting ethylene and at least a portion of the 2-butene with the metathesis catalyst to form a metathesis product comprising propylene, paraffins, any unreacted ethylene, and any unreacted 1-butene and 2-butene.

[0027] ~~In another aspect, e~~Embodiments disclosed herein relate to a process for the production of propylene, including: fractionating a hydrocarbon stream comprising n-butenes, isobutene, and paraffins into at least two fractions including a light C_4 fraction comprising isobutene and a heavy C_4 fraction comprising n-butenes and paraffins; feeding ethylene and the heavy C_4 fraction to a fixed bed reactor comprising a metathesis catalyst and activated basic metal oxide isomerization catalyst wherein the isomerization catalyst has an effective diameter between 0.25 and

4.0 mm and does not contain a stabilizing agent; contacting the heavy C_4 fraction with the activated basic metal oxide isomerization catalyst to convert at least a portion of the 1-butene to 2-butene; and contacting the ethylene and at least a portion of the 2-butene with a metathesis catalyst to form a metathesis product comprising propylene, paraffins, any unreacted ethylene, and any unreacted 1-butene and 2-butene.

[0028] Other ~~aspects~~ embodiments and advantages will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0029] Figure 1 is a graphical representation of changes in BET surface area of MgO tablets containing a structure stabilizing agent, as a function of thermal aging.

[0030] Figures 2A and 2B are graphical representations of changes in BET surface area and pore structure of MgO tablets of different sizes, after severe thermal aging at 650°C (2A = 5 mm, 2B = 3 mm catalyst effective diameters).

[0031] Figure 3 is a simplified process flow diagram of a process for isomerization and metathesis using catalysts according to embodiments disclosed herein.

[0032] Figure 4 is a graphical illustration of catalyst activity over time for catalysts according to embodiments disclosed herein as compared to typical magnesium oxide catalysts when used in the presence of ethylene.

[0033] Figures 5 is a graphical illustration of the comparison of 1-butene conversion over cumulative age for different particle size MgO catalysts in metathesis service for propylene for both initial and 5th cycles.

DETAILED DESCRIPTION

[0034] In one aspect, embodiments disclosed herein relate to the improvement in the stability of the isomerization catalyst surface area over multiple regenerations by the addition of a structure stabilizing agent. In another aspect, embodiments disclosed herein relate to the improvement in the stability of the isomerization catalyst surface area over multiple regenerations by the reduction of the effective diameter of the isomerization catalyst without the addition of a stabilizing agent.

[0035] In further aspects, embodiments disclosed herein relate generally to the processing of a C_3 to C_6 hydrocarbon cut from a cracking process, such as steam or fluid catalytic cracking, primarily for conversion of C_4 olefins to propylene via metathesis. More specifically, embodiments disclosed herein relate to a catalyst for the metathesis of

CLAIMS

What is claimed:

1. A process for the double-bond isomerization of olefins, the process comprising:

   contacting a fluid stream comprising olefins with a fixed bed comprising an activated basic metal oxide isomerization catalyst, to convert at least a portion of the olefin to its isomer;

   wherein the isomerization catalyst is prepared from an admixture of a basic metal oxide and colloidal silica as a structure stabilizing agent.

2. The process of claim 1, wherein the basic metal oxide isomerization catalyst comprises at least one of magnesium oxide, calcium oxide, strontium oxide, barium oxide, lithium oxide, and combinations thereof.

3. The process of claim 1, wherein the basic metal oxide isomerization catalyst comprises magnesium oxide.

4. The process of claim 1, wherein the catalyst comprises 0.04 weight% to 40 weight% of the structure stabilizing agent.

5. The process of claim 1, wherein the catalyst has an effective diameter in the range from 0.25 mm to 5.0 mm.

6. The process of claim 1, wherein the catalyst has an effective diameter in the range from 0.5 mm to 3.2 mm.

7. The process of claim 1, wherein an initial activity of the basic metal oxide isomerization catalyst is a 2-butene to 1-butene product ratio of at least 3.0, as measured by conversion of pure 1-butene to 2-butene in the presence of at least an equimolar amount of ethylene at a temperature of 600°F and a pressure of 2.76 MPaG (400 psig).

8. A process for the production of propylene, comprising:

   fractionating a hydrocarbon stream comprising n-butenes, isobutene, and paraffins into at least two fractions including a light C_4 fraction comprising isobutene and a heavy C_4 fraction comprising n-butenes and paraffins;

   feeding ethylene and the heavy C_4 fraction to a fixed bed reactor comprising an activated basic metal oxide isomerization catalyst and a metathesis catalyst, wherein the isomerization catalyst is prepared from an admixture of a basic metal oxide and colloidal silica as a structure stabilizing agent;

   contacting the heavy C_4 fraction with the activated basic metal oxide isomerization catalyst to convert at least a portion of the 1-butene to 2-butene; and

contacting ethylene and at least a portion of the 2-butene with the metathesis catalyst to form a metathesis product comprising propylene, paraffins, any unreacted ethylene, and any unreacted 1-butene and 2-butene.

9. The process of claim 8, further comprising fractionating the metathesis product to recover an ethylene fraction, a propylene fraction, and a C_4 fraction.
10. The process of claim 9, further comprising recycling at least a portion of the C_4 fraction to the fractionating a hydrocarbon stream.
11. The process of claim 9, further comprising recycling at least a portion of the ethylene fraction to the fixed bed reactor.
12. The process of claim 8, further comprising maintaining a ratio of ethylene to n-butene fed to the fixed bed reactor in a range from 0.5 to 2.5.
13. The process of claim 12, wherein the ratio of ethylene to n-butene fed is at least 1.0.
14. The process of claim 8, wherein the metathesis catalyst is admixed with the isomerization catalyst.
15. The process of claim 8, wherein the fixed bed reactor comprises a bed of the metathesis catalyst and a bed of the isomerization catalyst.
16. The process of claim 8, wherein the hydrocarbon stream further comprises butadiene, the process further comprising hydrogenating at least a portion of the butadiene prior to the fractionating.
17. The process of claim 8, wherein the basic metal oxide isomerization catalyst comprises at least one of magnesium oxide, calcium oxide, strontium oxide, barium oxide, lithium oxide, and combinations thereof.
18. The process of claim 8, wherein the basic metal oxide isomerization catalyst comprises magnesium oxide.
19. The process of claim 8, wherein the catalyst comprises 0.04 weight% to 40 weight% of the structure stabilizing agent.
20. The process of claim 8, wherein the catalyst has an effective diameter in the range from 0.25 mm to 5.0 mm.
21. The process of claim 8, wherein the catalyst has an effective diameter in the range from 0.5 mm to 3.2 mm.

CLAIMS

What is claimed:

1. A process for the double-bond isomerization of olefins, the process comprising:

   contacting a fluid stream comprising olefins with a fixed bed comprising an activated basic metal oxide isomerization catalyst comprising a structure stabilizing agent, to convert at least a portion of the olefin to its isomer.

2. The process of claim 1, wherein the basic metal oxide isomerization catalyst comprises at least one of magnesium oxide, calcium oxide, strontium oxide, barium oxide, lithium oxide, and combinations thereof.

3. The process of claim 1, wherein the basic metal oxide isomerization catalyst comprises magnesium oxide.

4. The process of claim 1, wherein the structure stabilizing agent comprises at least one of elements Al, Si, Ti, Cr, Mn, Fe, Y, Zr, Mo, and combinations thereof.

5. The process of claim 1, wherein the catalyst comprises 0.04 weight% to 40 weight% of the structure stabilizing agent.

6. The process of claim 1, wherein the structure stabilizing agent is in the form of a binder comprising at least one of silica, alumina, and natural clays.

7. The process of claim 1, wherein the structure stabilizing agent comprises at least one of a compound and a mixture.

8. The process of claim 1, wherein the catalyst has an effective diameter in the range from about 0.25 mm to about 5.0 mm.

9. The process of claim 1, wherein the catalyst has an effective diameter in the range from about 0.5 mm to about 3.2 mm.

10. The process of claim 1, wherein the catalyst is in the form of a tablet or an extrudate.

11. The process of claim 1, wherein an initial activity of the basic metal oxide isomerization catalyst is a 2-butene to 1-butene product ratio of at least 3.0, as measured by conversion of pure 1-butene to 2-butene in the presence of at least an equimolar amount of ethylene at a temperature of 600°F and a pressure of 400 psig.

12. A process for the double-bond isomerization of olefins, the process comprising:

    contacting a fluid stream comprising olefins with a fixed bed comprising an activated basic metal oxide isomerization catalyst having an effective diameter in the range of 0.25 mm to 4.0 mm to convert at least a portion of the olefin to its isomer.

13. The process of claim 12, wherein the basic metal oxide isomerization catalyst comprises at least one of magnesium oxide, calcium oxide, strontium oxide, barium oxide, lithium oxide, and combinations thereof.
14. The process of claim 12, wherein the basic metal oxide isomerization catalyst comprises magnesium oxide.
15. The process of claim 12, wherein the effective diameter of the catalyst is in the range from about 0.5 mm to about 3.2 mm.
16. The process of claim 12 wherein the catalyst is in the form of a tablet or an extrudate.
17. A process for the production of propylene, comprising:

fractionating a hydrocarbon stream comprising n-butenes, isobutene, and paraffins into at least two fractions including a light C_4 fraction comprising isobutene and a heavy C_4 fraction comprising n-butenes and paraffins;

feeding ethylene and the heavy C_4 fraction to a fixed bed reactor comprising a metathesis catalyst and an activated basic metal oxide isomerization catalyst comprising a structure stabilizing agent,

contacting the heavy C_4 fraction with the activated basic metal oxide isomerization catalyst to convert at least a portion of the 1-butene to 2-butene; and

contacting ethylene and at least a portion of the 2-butene with a metathesis catalyst to form a metathesis product comprising propylene, paraffins, any unreacted ethylene, and any unreacted 1-butene and 2-butene.

18. The process of claim 17, further comprising fractionating the metathesis product to recover an ethylene fraction, a propylene fraction, and a C_4 fraction.
19. The process of claim 17, further comprising recycling at least a portion of the C_4 fraction to the fractionating a hydrocarbon stream.
20. The process of claim 17, further comprising recycling at least a portion of the ethylene fraction to the fixed bed reactor.
21. The process of claim 17, further comprising maintaining a ratio of ethylene to n-butene fed to the fixed bed reactor in a range from about 0.5 to about 2.5.
22. The process of claim 21, wherein the ratio of ethylene to n-butene fed is at least 1.0.
23. The process of claim 17, wherein the metathesis catalyst is admixed with the isomerization catalyst.
24. The process of claim 17, wherein the fixed bed reactor comprises a bed of the metathesis catalyst and a bed of the isomerization catalyst.

25. The process of claim 17, wherein the hydrocarbon stream further comprises butadiene, the process further comprising hydrogenating at least a portion of the butadiene prior to the fractionating.
26. The process of claim 17, wherein the basic metal oxide isomerization catalyst comprises at least one of magnesium oxide, calcium oxide, strontium oxide, barium oxide, lithium oxide, and combinations thereof.
27. The process of claim 17, wherein the basic metal oxide isomerization catalyst comprises magnesium oxide.
28. The process of claim 17, wherein the structure stabilizing agent comprises at least one of elements Si, Al, Zr, Mn, Cr, Fe, Y and combinations thereof.
29. The process of claim 17, wherein the catalyst comprises 0.04 weight% to 40 weight% of the structure stabilizing agent.
30. The process of claim 17, wherein the structure stabilizing agent is in the form of a binder comprising at least one of silica, alumina, and natural clay.
31. The process of claim 17, wherein the catalyst has an effective diameter in the range from about 0.25 mm to about 5.0 mm.
32. The process of claim 17, wherein the catalyst has an effective diameter in the range from about 0.5 mm to about 3.2 mm.
33. A process for the production of propylene, comprising:

fractionating a hydrocarbon stream comprising n-butenes, isobutene, and paraffins into at least two fractions including a light C_4 fraction comprising isobutene and a heavy C_4 fraction comprising n-butenes and paraffins;

feeding ethylene and the heavy C_4 fraction to a fixed bed reactor comprising a metathesis catalyst and activated basic metal oxide isomerization catalyst wherein the isomerization catalyst has an effective diameter between 0.25 and 4.0 mm and does not contain a stabilizing agent;

contacting the heavy C_4 fraction with the activated basic metal oxide isomerization catalyst to convert at least a portion of the 1-butene to 2-butene; and

contacting the ethylene and at least a portion of the 2-butene with a metathesis catalyst to form a metathesis product comprising propylene, paraffins, any unreacted ethylene, and any unreacted 1-butene and 2-butene.

34. The process of claim 33, further comprising fractionating the metathesis product to recover an ethylene fraction, a propylene fraction, and a C_4 fraction.

35. The process of claim 343 further comprising recycling at least a portion of the C_4 fraction to the fractionating a hydrocarbon stream.
36. The process of claim 33, further comprising recycling at least a portion of the ethylene fraction to the fixed bed reactor.
37. The process of claim 33, further comprising maintaining a ratio of ethylene to n-butene fed to the fixed bed reactor in a range from about 0.5 to about 2.5.
38. The process of claim 37, wherein the ratio of ethylene to n-butene fed is at least 1.0.
39. The process of claim 33, wherein the metathesis catalyst is admixed with the isomerization catalyst.
40. The process of claim 33, wherein the fixed bed reactor comprises a bed of the metathesis catalyst and a bed of the isomerization catalyst.
41. The process of claim 33, wherein the hydrocarbon stream further comprises butadiene, the process further comprising hydrogenating at least a portion of the butadiene prior to the fractionating.
42. The process of claim 33, wherein the basic metal oxide isomerization catalyst comprises at least one of magnesium oxide, calcium oxide, strontium oxide, barium oxide, lithium oxide, and combinations thereof.
43. The process of claim 33, wherein the basic metal oxide isomerization catalyst comprises magnesium oxide.
44. The process of claim 33, wherein the catalyst has an effective diameter in the range from about 1.0 mm to about 3.5 mm.
45. The process of claim 33, wherein the catalyst has an effective diameter in the range from about 1.5 mm to about 3.2 mm.
46. The process of claim 33 wherein the catalyst is in the form of a tablet or extrudate.