CLAIMS:

What is claimed is:

1. A process for upgrading a hydrocarbon, comprising:

(I) contacting a hydrocarbon-containing feed with fluidized catalyst particles comprising a Group 8-10 element disposed on a support within a conversion zone to effect one or more of dehydrogenation, dehydroaromatization, and dehydrocyclization of at least a portion of the hydrocarbon-containing feed to produce a conversion effluent comprising coked catalyst particles, one or more upgraded hydrocarbons, and molecular hydrogen, wherein:

the hydrocarbon-containing feed comprises one or more of C_2-C_{16} linear or branched alkanes, one or more of C_4-C_{16} cyclic alkanes, one or more of C_8-C_{16} alkyl aromatic hydrocarbons, or a mixture thereof;

the hydrocarbon-containing feed and catalyst particles are contacted at a temperature in a range from 300°C to 900°C, for a time period in a range from 0.1 seconds to 2 minutes, under a hydrocarbon partial pressure of at least 20 kPa-absolute, wherein the hydrocarbon partial pressure is the total partial pressure of any C_2-C_{16} alkanes and any C_8-C_{16} alkyl aromatic hydrocarbons in the hydrocarbon-containing feed;

the hydrocarbon-containing feed and the catalyst particles are contacted with one another in the presence of steam at an amount in a range from 0.1 vol% to 50 vol%, based on a total volume of any C_2-C_{16} alkanes and any C_8-C_{16} alkyl aromatic hydrocarbons in the hydrocarbon-containing feed;

the catalyst particles comprise from 0.05 wt% to 6 wt% of the Group 8-10 element based on the weight of the support; and

the support comprises:

at least one of: w wt% of a Group 2 element, x wt% of a Group 4 element, y wt% of a Group 12 element, and z wt% of an element having an atomic number of 21, 39, or 57-71, based on the weight of the support, wherein w, x, y, and z are independently in a range from 0 to 100, wherein:

any Group 2 element is associated with a wt% m based on the weight of the support,

any Group 4 element is associated with a wt% n based on the weight of the support,

any group 12 element is associated with a wt% p based on the weight of the support, and

any element having an atomic number of 21, 39, or 57-71 is associated with a wt% q based on the weight of the support,

m, n, p, and q are independently a number that is in a range from 1 to 100, and

a sum of w/m + x/n + y/p + z/p is ≥ 1, based on the weight of the support;

the one or more upgraded hydrocarbons comprise a dehydrogenated hydrocarbon, a dehydroaromatized hydrocarbon, a dehydroxylated hydrocarbon, or a mixture thereof;

(II) obtaining from the conversion effluent a first gaseous stream rich in the one or more upgraded hydrocarbons and the molecular hydrogen and a first particle stream rich in the coked catalyst particles;

(III) contacting at least a portion of the coked catalyst particles in the first particle stream with an oxidant in a combustion zone to effect combustion of at least a portion of the coke to produce a combustion effluent comprising regenerated catalyst particles lean in coke and a combustion gas;

(IV) obtaining from the combustion effluent a second gaseous stream rich in the combustion gas and a second particle stream rich in the regenerated catalyst particles; and

(V) contacting an additional quantity of the hydrocarbon-containing feed with fluidized regenerated and reduced catalyst particles to produce additional conversion effluent comprising re-coked catalyst particles, additional one or more upgraded hydrocarbons, and additional molecular hydrogen, wherein a cycle time from the contacting the hydrocarbon-containing feed with the catalyst particles in step (I) to the contacting the additional quantity of the hydrocarbon-containing feed with the fluidized regenerated and reduced catalyst particles in step (V) is ≤ 60 minutes.

2. The process of claim 1, further comprising, after step (IV) and before step (V), the following step:

(IVa) contacting at least a portion of the regenerated catalyst particles with a reducing gas for a period of time in a range from 1 second to less than 30 minutes to produce regenerated and reduced catalyst particles, wherein the additional quantity of the hydrocarbon-containing feed is contacted with fluidized regenerated and reduced catalyst particles in step (V).

3. The process of claim 2, wherein in step (IVa), at least one of the following is met:

(i) the regenerated catalyst particles and reducing gas are contacted at a temperature in a range from 450°C to 900°C; and

(ii) the regenerated catalyst particles and reducing gas are contacted under a reducing gas partial pressure in a range from 20 kPa-absolute to 1,000 kPa-absolute.

4. The process of claim 3, wherein the regenerated catalyst particles and reducing gas are contacted at a temperature in a range from 600°C to 900°C.

5. The process of claim 3, wherein the regenerated catalyst particles and reducing gas are contacted at a temperature in a range from 620°C to 850°C.

6. The process of claim 3, wherein the regenerated catalyst particles and reducing gas are contacted at a temperature in a range from 650°C to 850°C.

7. The process of claim 3, wherein the regenerated catalyst particles and reducing gas are contacted at a temperature in a range from 670°C to 800°C.

8. The process of any one of claims 3 to 7, wherein the regenerated catalyst particles and reducing gas are contacted under a reducing gas partial pressure in a range from 50 kPa-absolute to 500 kPa-absolute.

9. The process of any one of claims 3 to 7, wherein the regenerated catalyst particles and reducing gas are contacted under a reducing gas partial pressure in a range from 70 kPa-absolute to 300 kPa-absolute.

10. The process of any one of claims 2 to 9, wherein at least a portion of the Group 8-10 element in the regenerated and reduced catalyst particles is in the elemental state.

11. The process of any one of claims 1 to 10, wherein a cycle time from the contacting the hydrocarbon-containing feed with the catalyst particles in step (I) to the contacting the additional quantity of the hydrocarbon-containing feed with the regenerated and reduced catalyst particles in step (V) is $\leq$ 70 minutes.

12. The process of any one of claims 1 to 10, wherein a cycle time from the contacting the hydrocarbon-containing feed with the catalyst particles in step (I) to the contacting the additional quantity of the hydrocarbon-containing feed with the regenerated and reduced catalyst particles in step (V) is from 1 minute to 70 minutes.

13. The process of any one of claims 1 to 10, wherein a cycle time from the contacting the hydrocarbon-containing feed with the catalyst particles in step (I) to the contacting the additional quantity of the hydrocarbon-containing feed with the regenerated and reduced catalyst particles in step (V) is from 5 minutes to 45 minutes.

14. The process of any one of claims 1 to 13, wherein in step (I), the hydrocarbon-containing feed and the catalyst particles are contacted with one another in the presence of steam at an amount in a range from 0.5 vol% to 30 vol%, based on a total volume of any C_2-C_{16} alkanes and any C_8-C_{16} alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

15. The process of any one of claims 1 to 13, wherein in step (I), the hydrocarbon-containing feed and the catalyst particles are contacted with one another in the presence of steam at an amount in a range from 1 vol% to 15 vol%, based on a total volume of any C_2-C_{16} alkanes and any C_8-C_{16} alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

16. The process of any one of claims 1 to 15, wherein the support comprises the Group 2 element, and wherein in step (I), the hydrocarbon-containing feed and the catalyst particles are contacted with one another in the presence of steam at an amount in a range from 0.1 vol% to 50 vol%, based on a total volume of any C_2-C_{16} alkanes and any C_8-C_{16} alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

17. The process of any one of claims 1 to 15, wherein the support comprises the Group 2 element, and wherein in step (I), the hydrocarbon-containing feed and the catalyst particles are contacted with one another in the presence of steam at an amount in a range from 0.5 vol% to 30 vol%, based on a total volume of any C_2-C_{16} alkanes and any C_8-C_{16} alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

18. The process of any one of claims 1 to 15, wherein the support comprises the Group 2 element, and wherein in step (I), the hydrocarbon-containing feed and the catalyst particles are contacted with one another in the presence of steam at an amount in a range from 1 vol% to 15 vol%, based on a total volume of any C_2-C_{16} alkanes and any C_8-C_{16} alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

19. The process of any one of claims 1 to 18, wherein the hydrocarbon-containing feed and the catalyst particles are contacted with one another in the absence of any steam or in the presence of less than 0.1 vol% of steam based on a total volume of any C_2-C_{16} alkanes and any C_8-C_{16} alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

20. The process of any one of claims 1 to 19, wherein the hydrocarbon-containing feed comprises propane, wherein the upgraded hydrocarbon comprises propylene, and wherein contacting the hydrocarbon-containing feed with the catalyst particles in step (I) has a propylene yield of at least 52 %, or at least 62 %, or at least 72 % at a propylene selectivity of ≥ 75%, ≥ 80%, ≥ 85%, ≥ 90%, or ≥ 95%.

21. The process of any one of claims 1 to 20, wherein the hydrocarbon-containing feed comprises ≥ 70 vol% of propane, based on a total volume of the hydrocarbon-containing feed, wherein the hydrocarbon-containing feed and catalyst particles are contacted under a propane partial pressure of at least 40 kPa-absolute, and wherein contacting the hydrocarbon-containing feed with the catalyst particles in step (I) has a propylene yield of at least 52 %, or at least 62 %, or at least 72 % at a propylene selectivity of ≥ 75%, ≥ 80%, ≥ 85%, ≥ 90%, or ≥ 95%.

22. The process of any one of claims 1 to 21, wherein in step (I), at least one of the following is met:

(i) the hydrocarbon-containing feed and the catalyst particles are contacted at a temperature in a range from 600°C to 900°C; and

(ii), the hydrocarbon-containing feed and the catalyst particles are contacted under a hydrocarbon partial pressure in a range from 20 kPa-absolute to 1,000 kPa-absolute.

23. The process of claim 22, wherein the hydrocarbon-containing feed and the catalyst particles are contacted at a temperature in a range from 600°C to 800°C.

24. The process of claim 22, wherein the hydrocarbon-containing feed and the catalyst particles are contacted at a temperature in a range from 650°C to 750°C.

25. The process of claim 22, wherein the hydrocarbon-containing feed and the catalyst particles are contacted at a temperature in a range from 670°C to 720°C.

26. The process of any one of claims 22 to 25, wherein the hydrocarbon-containing feed and the catalyst particles are contacted under a hydrocarbon partial pressure in a range from 50 kPa-absolute to 500 kPa-absolute.

27. The process of any one of claims 22 to 25, wherein the hydrocarbon-containing feed and the catalyst particles are contacted under a hydrocarbon partial pressure in a range from 70 kPa-absolute to 300 kPa-absolute.

28. The process of any one of claims 1 to 27, wherein in step (III), at least one of the following is met:

(i) the coked catalyst particles and oxidant are contacted at a temperature in a range from 600°C to 1,100°C; and

(ii) the coked catalyst particles and oxidant are contacted under an oxidant partial pressure in a range from 20 kPa-absolute to 1,000 kPa-absolute.

29. The process of claim 28, wherein the coked catalyst particles and oxidant are contacted at a temperature in a range from 650°C to 1,000°C.

30. The process of claim 28, wherein the coked catalyst particles and oxidant are contacted at a temperature in a range from 700°C to 900°C.

31. The process of claim 28, wherein the coked catalyst particles and oxidant are contacted at a temperature in a range from 750°C to 850°C.

32. The process of any one of claims 28 to 31, wherein the coked catalyst particles and oxidant are contacted under an oxidant partial pressure in a range from 50 kPa-absolute to 500 kPa-absolute.

33. The process of any one of claims 28 to 31, wherein the coked catalyst particles and oxidant are contacted under an oxidant partial pressure in a range from 100 kPa-absolute to 300 kPa-absolute.

34. The process of any one of claims 1 to 33, wherein the catalyst particles further comprise a promoter, and wherein the promoter comprises Sn, Ga, Zn, Ge, In, Re, Ag, Au, Cu, a combination thereof, or a mixture thereof.

35. The process of any one of claims 1 to 34, wherein the catalyst particles further comprise an alkali metal element selected from Li, Na, K, Rb, Cs, and combinations and mixtures thereof disposed on the support, the catalyst particles comprise up to 5 wt% of the alkali metal element based on the total weight of the support.

36. The process of claim 1, wherein m, n, p, and q are each equal to 1, 15, or 30, or wherein m = 1, n = 15, p = 15, and q = 1.

37. The process of claim 1, wherein a molar ratio of a combined amount of any Group 2 element, any Group 4 element, any Group 12 element, and any element having an atomic number of 21, 39, or 57-71 to the Group 8-10 element is at least 0.18, at least 0.19, at least 0.24, or at least 0.29.

38. The process of any one of claims 1 to 37, wherein the support further comprises at least one compound comprising at least one metal element or metalloid element selected from Groups 5, 6, 7, 11, 13, 14, 15, and 16.

39. The process of any one of claims 1 to 38, wherein at least one of the following is met:

(i) the hydrocarbon-containing feed and catalyst particles are contacted in step (I) for a time period in a range from 0.1 seconds to 1.5 minutes;

(ii) a weight ratio of the catalyst particles to a combined amount of any C_2-C_{16} alkanes and any C_8-C_{16} aromatic hydrocarbons is in a range from 1 to 150; and

(iii) the hydrocarbon-containing feed contacts the catalyst in step (I) at a weight hourly space velocity in a range from 0.1 hr^{-1} to 100 hr^{-1}, based on the weight of any C_2-C_{16} alkanes and any C_8-C_{16} aromatic hydrocarbons in the hydrocarbon-containing feed.

40. The process of claim 39, wherein the hydrocarbon-containing feed and catalyst particles are contacted in step (I) for a time period in a range from 0.5 seconds to 1 minute.

41. The process of claim 39, wherein the hydrocarbon-containing feed and catalyst particles are contacted in step (I) for a time period in a range from 1 seconds to 30 seconds;

42. The process of any one of claims 39 to 41, wherein the weight ratio of the catalyst particles to a combined amount of any C_2-C_{16} alkanes and any C_8-C_{16} aromatic hydrocarbons is in a range from 5 to 100.

43. The process of any one of claims 39 to 41, wherein the weight ratio of the catalyst particles to a combined amount of any C_2-C_{16} alkanes and any C_8-C_{16} aromatic hydrocarbons is in a range from 10 to 80.

44. The process of any one of claims 39 to 43, wherein the hydrocarbon-containing feed contacts the catalyst in step (I) at a weight hourly space velocity in a range from 0.2 hr^{-1} to 64 hr^{-1}, based on the weight of any C_2-C_{16} alkanes and any C_8-C_{16} aromatic hydrocarbons in the hydrocarbon-containing feed.

45. The process of any one of claims 39 to 43, wherein the hydrocarbon-containing feed contacts the catalyst in step (I) at a weight hourly space velocity in a range from 0.4 hr^{-1} to 32 hr^{-1}, based on the weight of any C_2-C_{16} alkanes and any C_8-C_{16} aromatic hydrocarbons in the hydrocarbon-containing feed.

46. The process of any one of claims 1 to 45, wherein the catalyst particles are in the form of a dense turbulent fluidized bed when contacted with the hydrocarbon-containing feed.

47. The process of any one of claims 1 to 46, wherein the conversion zone is disposed within a riser reactor or a down reactor.

48. The process of any one of claims 1 to 47, wherein a first portion of the coked catalyst particles in first particle stream rich in the coked catalyst particles is contacted with the oxidant in the combustion zone in step (III), and wherein a second portion of the coked catalyst particles in the first particle stream rich in the coked catalyst particles is contacted with the additional quantity of the hydrocarbon-containing feed in step (V).

49. The process of any one of claims 1 to 48, further comprising:

removing a portion of the catalyst particles from the conversion zone during contact of the hydrocarbon-containing feed with the fluidized catalyst particles during step (I);

heating the portion of the catalyst particles removed from the conversion zone to produce heated catalyst particles; and

feeding the heated catalyst particles into the conversion zone to contact the hydrocarbon-containing feed.

50. The process of any one of claims 1 to 49, further comprising supplying heat to the catalyst particles within the conversion zone during contact of the catalyst particles with the hydrocarbon-containing feed.

51. The process of any one of claims 1 to 50, wherein the catalyst particles have a particle density in a range from 0.5 g/cm^3 to 3 g/cm^3, 0.7 g/cm^3 to 2 g/cm^3, or 0.8 g/cm^3 to 1.4 g/cm^3.

52. The process of any one of claims 1 to 51, wherein the catalyst particles have a size and particle density that are consistent with a Geldart A definition.

53. The process of claim 1, wherein the support comprises ≥ 3 wt% of a Group 2 element.

54. The process of claim 1, wherein the support comprises calcined hydrotalcite.

55. The process of claim 2, wherein, in step (IVa), the temperature range is from 620°C to 900°C and the time period is from 1 second to 10 minutes to produce the regenerated and reduced catalyst particles.

56. The process of claim 2, wherein:

the support comprises ≥ 3 wt% of a Group 2 element,

in step (IVa), the temperature range is from 620°C to 900°C and the time period is from 1 second to 5 minutes to produce the regenerated and reduced catalyst particles, and

in step (V), the cycle time is ≤ 45 minutes.

57. The process of claim 2, wherein:

the support comprises ≥ 11 wt% of a Group 2 element,

in step (IVa), the temperature range is from 650°C to 900°C and the time period is from 1 second to 5 minutes to produce the regenerated and reduced catalyst particles, and

in step (V), the cycle time is up to ≤ 45 minutes.