

CLAIMS:

What is claimed is:

1. A process for upgrading a hydrocarbon, comprising:

(I) contacting a hydrocarbon-containing feed with fluidized catalyst particles
 5 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 C₂-C₁₆ linear or branched
 10 alkanes, one or more of C₄-C₁₆ cyclic alkanes, one or more of C₈-C₁₆ 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
 15 pressure is the total partial pressure of any C₂-C₁₆ alkanes and any C₈-C₁₆ 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:

20 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,
 25 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,

30 m, n, p, and q are independently a number that is in a range from 1 to 100, and
 a sum of $w/m + x/n + y/p + z/p \geq 1$, based on the weight of the support;

the one or more upgraded hydrocarbons comprise a dehydrogenated hydrocarbon, a dehydroaromatized hydrocarbon, a dehydrocyclized 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;

5 (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

10 (V) contacting an additional quantity of the hydrocarbon-containing feed with fluidized regenerated catalyst particles to produce additional conversion effluent comprising re-coked catalyst particles, additional one or more upgraded hydrocarbons, and additional molecular hydrogen.

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

(IVa) contacting at least a portion of the regenerated catalyst particles with a reducing gas 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).

20 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, preferably 600°C to 900°C, more preferably 620°C to 900°C, more preferably 650°C to 850°C, or more preferably from 670°C to 800°C; and

25 (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, preferably from 50 kPa-absolute to 500 kPa-absolute, or more preferably from 70 kPa-absolute to 300 kPa-absolute.

4. The process of claim 2 or claim 3, wherein at least a portion of the Group 8-10 element in the regenerated and reduced catalyst particles is in the elemental state.

30 5. The process of any of claims 1 to 4, 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 ≤ 70 minutes, preferably from 1 minute to 70 minutes, or more preferably from 5 minutes to 45 minutes.

6. The process of any of the preceding claims, 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%, preferably from 0.5 vol% to 30 vol%,
5 or more preferably from 1 vol% to 15 vol%, based on a total volume of any C₂-C₁₆ alkanes and any C₈-C₁₆ alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

7. The process of any of the preceding claims, 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%
10 to 50 vol%, preferably from 0.5 vol% to 30 vol%, or more preferably from 1 vol% to 15 vol%, based on a total volume of any C₂-C₁₆ alkanes and any C₈-C₁₆ alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

8. The process of any of claims 1 to 6, 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 C₂-C₁₆ alkanes and any
15 C₈-C₁₆ alkyl aromatic hydrocarbons in the hydrocarbon-containing feed.

9. The process of any of the preceding claims, 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
20 $\geq 75\%$, $\geq 80\%$, $\geq 85\%$, $\geq 90\%$, or $\geq 95\%$.

10. The process of any of claims 1 to 9, 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
25 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 $\geq 75\%$, $\geq 80\%$, $\geq 85\%$, $\geq 90\%$, or $\geq 95\%$.

11. The process of any of claims 1 to 10, wherein in step (I), at least one of the following is met:

30 (i) the hydrocarbon-containing feed and the catalyst particles are contacted at a temperature in a range from 600°C to 900°C, preferably from 600°C to 800°C, more preferably from 650°C to 750°C, or more preferably from 670°C to 720°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, preferably

from 50 kPa-absolute to 500 kPa-absolute, or more preferably 70 kPa-absolute to 300 kPa-absolute.

12. The process of any of the preceding claims, wherein in step (III), at least one of the following is met:

5 (i) the coked catalyst particles and oxidant are contacted at a temperature in a range from 600°C to 1,100°C, preferably from 650°C to 1,000°C, more preferably from 700°C to 900°C, or more preferably from 750°C to 850°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, preferably from 50 kPa-absolute to 500 kPa-absolute, or more preferably from 100 kPa-absolute to 300 kPa-absolute.

13. The process of any of the preceding claims, 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.

14. The process of any of the preceding claims, 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.

15. The process of any of the preceding claims, 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.

20 16. The process of any of the preceding claims, 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.

25 17. The process of any of the preceding claims, 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.

18. The process of any of the preceding claims, wherein at least one of the following is met:

30 (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, preferably from 0.5 seconds to 1 minute, or more preferably from 1 seconds to 30 seconds;

(ii) a weight ratio of the catalyst particles to a combined amount of any C₂-C₁₆ alkanes and any C₈-C₁₆ aromatic hydrocarbons is in a range from 1 to 150, preferably from 5 to 100, or more preferably from 10 to 80; 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} , preferably from 0.2 hr^{-1} to 64 hr^{-1} , or more preferably from 0.4 hr^{-1} to 32 hr^{-1} , based on the weight of any $\text{C}_2\text{-C}_{16}$ alkanes and any $\text{C}_8\text{-C}_{16}$ aromatic hydrocarbons in the hydrocarbon-containing feed.

5 19. The process of any of the preceding claims, wherein the catalyst particles are in the form of a dense turbulent fluidized bed when contacted with the hydrocarbon-containing feed.

20. The process of any of the preceding claims, wherein the conversion zone is disposed within a riser reactor or a down reactor.

21. The process of any of the preceding claims, 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 (II), 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).

22. The process of any of the preceding claims, further comprising:

15 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

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

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

24. The process of any of the preceding claims, 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 .

25. The process of any of the preceding claims, wherein the catalyst particles have a size and particle density that are consistent with a Geldart A definition.