CLAIMS:

What is claimed is:

1. A process for regenerating an at least partially deactivated catalyst comprising a Group 10 element, an inorganic support, and a contaminant, wherein the Group 10 element has a concentration in the range from 0.06 wt% to 6 wt%, based on the weight of the inorganic support, and the process comprises:

(I) heating the at least partially deactivated catalyst using a heating gas mixture comprising H_2O at a concentration of greater than 5 mol%, based on the total moles in the heating gas mixture to produce a precursor catalyst;

(II) providing an oxidative gas comprising no greater than 5 mol% of H_2O, based on the total moles in the oxidative gas;

(III) contacting the precursor catalyst at an oxidizing temperature in a range from 620°C to 1,000°C with the oxidative gas for a duration of at least 30 seconds, preferably at least 1 minute, preferably at least 5 minutes, to produce an oxidized precursor catalyst; and

(IV) obtaining a regenerated catalyst from the oxidized precursor catalyst;

wherein the at least partially deactivated catalyst further comprises one or more elements having an atomic number of 57 to 71.

2. The process of claim 1, wherein the heating gas mixture is produced by combusting a fuel with an oxidizing gas.

3. The process of claim 2, wherein the fuel comprises at least one of H_2, CO, and a hydrocarbon, and the oxidizing gas comprises O_2.

4. The process of any one of the preceding claims, wherein the Group 10 element comprises Pt.

5. The process of any one of the preceding claims, wherein the inorganic support comprises at least 0.5 wt% of a Group 4 element, based on the weight of the inorganic support.

6. The process of claim 5, wherein the inorganic support comprises at least 0.5 wt% of Zr.

7. The process of claim 5 or claim 6, wherein at least a portion of the Group 4 element is in the form of ZrO_2.

8. The process of claim 1, wherein the at least partially deactivated catalyst comprises 0.01 wt%, 0.05 wt%, or 0.1 wt% to 1 wt%, 5 wt%, or 10 wt% of a total amount of the one or more elements having an atomic number of 57 to 71, based on the weight of the inorganic support.

9. The process of any one of the preceding claims, wherein the at least partially deactivated catalyst further comprises up to 10 wt% of a promoter, based on the weight of the inorganic support, and wherein the promoter comprises one or more of the following elements: Sn, Ga, Zn, Ge, In, Re, Ag, Au, Cu, a combination thereof, or a mixture thereof.

10. The process of any one of the preceding claims, wherein the at least partially deactivated catalyst further comprises up to 5 wt% of an alkali metal element, based on the weight of the inorganic support, and wherein the alkali metal element comprises at least one of: Li, Na, K, Rb, and Cs.

11. The process of any one of the preceding claims, wherein an active component of the regenerated catalyst that is capable of effecting one or more of dehydrogenation, dehydroaromatization, and dehydrocyclization of a hydrocarbon-containing feed comprising one or more of C_2-C_{16} linear or branched alkanes, or one or more of C_4-C_{16} cyclic alkanes, one or more C_8-C_{16} alkyl aromatics, or a mixture thereof comprises the Group 10 element.

12. The process of any one of the preceding claims, wherein step (II) comprises:

(IIa) providing the oxidative gas at a temperature below the oxidizing temperature; and

(IIb) pre-heating the oxidative gas to a temperature higher than the temperature of the precursor catalyst before the contacting in step (III).

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

(V) heating the oxidative gas, the precursor catalyst, or both, during step (III) by using a radiant/conductive heat source, a heat exchanger, or a combination thereof.

14. The process of any one of the preceding claims, wherein step (IV) comprises:

(IVa) contacting the oxidized precursor catalyst with a first stripping gas free of O_2 to produce a stripped oxidized precursor catalyst; and

(IVb) obtaining the regenerated catalyst from the stripped oxidized precursor catalyst.

15. The process of any one of the preceding claims, wherein step (IV) comprises:

(IVc) contacting the oxidized precursor catalyst or the stripped oxidized precursor catalyst with a H_2-containing atmosphere to produce a reduced catalyst; and

(IVd) obtaining the regenerated catalyst from the reduced catalyst.

16. The process of claim 15, wherein step (IVd) comprises:

(IVd-1) contacting the reduced catalyst with a second stripping gas to produce the regenerated catalyst.

17. The process of claim 15 or claim 16, wherein step (IVc) is carried out at a temperature of the oxidized precursor catalyst higher than a use temperature of the regenerated catalyst, and step (IVd) further comprises:

(IVd-2) cooling the reduced catalyst or the regenerated catalyst to the use temperature in a duration no greater than 10 minutes, no greater than 5 minutes, no greater than 1 minute, no greater than 30 seconds, no greater than 10 seconds, no greater than 5 seconds, no greater than 1 second, no greater than 0.5 seconds, no greater than 0.1 seconds, no greater than 0.01 seconds, or no greater than 0.001 seconds.

18. A dehydrogenation process using the regenerated catalyst produced by a process of any one of the preceding claims, the dehydrogenation process comprising:

(VI) contacting a hydrocarbon-containing feed with the regenerated catalyst to effect one or more of dehydrogenation, dehydroaromatization, and dehydrocyclization of at least a portion of the hydrocarbon-containing feed to produce the at least partially deactivated catalyst comprising the Group 10 element, the inorganic support, and the contaminant and an effluent comprising one or more upgraded hydrocarbons and molecular hydrogen, wherein the hydrocarbon 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; and

(VII) repeating steps (I) through (IV), wherein, in step (III) additional oxidized precursor catalyst is produced, and wherein, in step (IV), additional regenerated catalyst is obtained from the additional oxidized precursor catalyst; and

(VIII) contacting an additional quantity of the hydrocarbon-containing feed with at least a portion of the additional regenerated catalyst to produce additional at least partially deactivated catalyst and additional effluent.

19. The dehydrogenation process of claim 18, wherein a cycle time from the contacting the hydrocarbon-containing feed with the regenerated catalyst in step (VI) to the contacting the additional quantity of the hydrocarbon-containing feed with the additional regenerated catalyst in step (VIII) is ≤ 5 hours.

20. A process for upgrading a hydrocarbon, comprising:

(I) contacting a hydrocarbon-containing feed with a catalyst comprising a Group 10 element and an inorganic support to effect one or more of dehydrogenation, dehydroaromatization, and dehydrocyclization of at least a portion of the hydrocarbon-containing feed to produce an at least partially deactivated catalyst comprising the Group 10 element, the inorganic support, and a contaminant and an effluent comprising 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, or one or more of C_4-C_{16} cyclic alkanes, one or more C_8-C_{16} alkyl aromatics, or a mixture thereof;

the Group 10 element has a concentration in the range from 0.06 wt% to 6 wt%, based on the weight of the inorganic support;

the hydrocarbon-containing feed and the catalyst are contacted at a temperature in a range from 300°C to 900°C; and

the one or more upgraded hydrocarbons comprise at least one of a dehydrogenated hydrocarbon, a dehydroaromatized hydrocarbon, and a dehydrocyclized hydrocarbon;

(II) heating the at least partially deactivated catalyst using a heating gas mixture comprising H_2O at a concentration of greater than 5 mol%, based on the total moles in the heating gas mixture to produce a precursor catalyst;

(III) providing an oxidative gas comprising no greater than 2 mol% of H_2O, based on the total moles in the oxidative gas;

(IV) contacting the precursor catalyst at an oxidizing temperature in a range from 620°C to 1,000°C with the oxidative gas for a duration of at least 30 seconds, preferably at least 1 minute, preferably at least 5 minutes, to produce an oxidized precursor catalyst;

(V) obtaining a regenerated catalyst from the oxidized precursor catalyst; and

(VI) contacting an additional quantity of the hydrocarbon-containing feed with at least a portion of the regenerated catalyst to produce additional at least partially deactivated catalyst and additional effluent;

wherein the at least partially deactivated catalyst further comprises one or more elements having an atomic number of 57 to 71.

21. The process of claim 20, wherein the heating gas mixture is produced by combusting a fuel with an oxidizing gas.

22. The process of claim 21, wherein the fuel comprises at least one of H_2, CO, and a hydrocarbon, and the oxidizing gas comprises O_2.

23. The process of any one of claims 20 to 22, wherein:

the Group 10 element comprises Pt, and

the inorganic support comprises at least 0.5 wt% of a Group 4 element, based on the weight of the inorganic support.

24. The process of any one of claims 20 to 23, wherein the catalyst further comprises up to 10 wt% of a promoter, based on the weight of the inorganic support, and wherein the promoter comprises one or more of the following elements: Sn, Ga, Zn, Ge, In, Re, Ag, Au, Cu, a combination thereof, or a mixture thereof.

25. The process of any one of claims 20 to 24, wherein the catalyst further comprises up to 5 wt% of an alkali metal element, based on the weight of the inorganic support, and wherein the alkali metal element comprises at least one of: Li, Na, K, Rb, and Cs.

26. The process of any one of claims 20 to 25, wherein step (III) comprises:

(IIIa) providing the oxidative gas at a temperature below the oxidizing temperature; and

(IIIb) pre-heating the oxidative gas to a temperature higher than the temperature of the precursor catalyst before the contacting in step (IV).

27. The process of any one of claims 20 to 26, further comprising:

(VII) heating the oxidative gas, the precursor catalyst, or both, during step (IV) by using a radiant/conductive heat source, a heat exchanger, or a combination thereof.

28. The process of any one of claims 20 to 27, wherein a cycle time from the contacting the hydrocarbon-containing feed with the catalyst in step (I) to the contacting the additional quantity of the hydrocarbon-containing feed with the regenerated catalyst in step (VI) is ≤ 5 hours.