CLAIMS

1. A method of selectively hydrogenating highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition comprising:

contacting the highly unsaturated hydrocarbons and hydrogen in a reaction zone with a catalyst comprising palladium and an organophosphorus compound under conditions suitable for hydrogenating at least a portion of the highly unsaturated hydrocarbons to unsaturated hydrocarbons to produce the unsaturated hydrocarbon enriched composition.

2. The method of claim **1** wherein the highly unsaturated hydrocarbons comprise acetylene, methylacetylene, propadiene, butadiene, or combinations thereof.

3. The method of claim **2** wherein the unsaturated hydrocarbon enriched composition comprises less than about 5 ppm of highly unsaturated hydrocarbons.

4. The method of claim **1** wherein the contacting occurs at a temperature less than about the boiling point of the organophosphorus compound.

5. The method of claim **4**, further comprising increasing the temperature to equal to or greater than about the boiling point of the organophosphorus compound.

6. The method of claim **1** wherein the contacting occurs at a temperature of from about 5° C. to about 300° C.

7. The method of claim **1** wherein the contacting occurs at a temperature of about 80° F. to about 160° F. and the unsaturated hydrocarbon enriched composition comprises less than about 20 ppm highly unsaturated hydrocarbons.

8. The method of claim **1** wherein the contacting occurs in an operating window of from about 35° F. to about 120° F.

9. The method of claim **1** wherein the contacting occurs in an operating window increased by greater than about 10% in comparison to an otherwise similar method performed with a catalyst lacking the organophosphorus compound.

10. The method of claim **1** wherein a selectivity for hydrogenation of the highly unsaturated hydrocarbons to the unsaturated hydrocarbons is improved in comparison to an otherwise similar method performed with a catalyst lacking the organophosphorus compound.

11. The method of claim **1** wherein the contacting produces from about 1 wt. % to about 25 wt. % less C4+ material than an otherwise similar composition prepared with a catalyst lacking the organophosphorus compound.

12. The method of claim **1** wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a backend acetylene removal unit, a frontend deethanizer unit, a frontend depropanizer unit, or a raw gas unit.

13. The method of claim **12** wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a backend acetylene removal unit; the highly unsaturated hydrocarbons comprise acetylene; and a mole ratio of hydrogen to acetylene being fed to the reaction zone is in the range of from about 0.1 to about 10.

14. The method of claim **12** wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a frontend deethanizer unit, a frontend depropanizer unit, or a raw gas unit; the highly unsaturated hydrocarbons comprise acetylene; and a mole ratio of hydrogen to acetylene being fed to the reaction zone is in the range of from about 10 to about 3000.

15. The method of claim **12** wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a frontend depropanizer unit or a raw gas unit; the highly unsaturated hydrocarbons comprise methylacetylene; and a mole ratio of hydrogen to methylacetylene being fed to the reaction zone is in the range of from about 3 to about 3000.

16. The method of claim **12** wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a frontend depropanizer unit or a raw gas unit; the highly unsaturated hydrocarbons comprise propadiene; and a mole ratio of hydrogen to propadiene being fed to the reaction zone is in the range of from about 3 to about 3000.

17. The method of claim **1** wherein the organophosphorus compound is represented by the general formula $(R)_x(OR')_yP{=}O$, wherein x and y are integers ranging from 0 to 3 and x plus y equals 3, wherein each R is hydrogen, a hydrocarbyl group, or combinations thereof; and

wherein each R' is a hydrocarbyl group; or

wherein the organophosphorus compound is a product of an organophosphorus compound precursor represented by the general formula of $(R)_x(OR')_yP$, wherein x and y are integers ranging from 0 to 3 and x plus y equals 3, wherein each R is hydrogen, a hydrocarbyl group, or combinations thereof; and wherein each R' is a hydrocarbyl group.

18. The method of claim **17** wherein the organophosphorus compound comprises a phosphine oxide, phosphinate, phosphonate, phosphate, or combinations thereof; or wherein the organophosphorus compound precursor comprises a phosphite, a phosphonite, a phosphinite, a phosphine, an organic phosphine, or combinations thereof.

19. The method of claim **1** wherein the catalyst further comprises one or more selectivity enhancers selected from the group consisting of Group 1B metals, Group 1B metal compounds, silver compounds, fluorine, fluoride compounds, sulfur, sulfur compounds, alkali metal, alkali metal compounds, alkaline earth metals, alkaline earth metal compounds, iodine, iodide compounds, and combinations thereof.

20. The method of claim **1** wherein the catalyst is supported and the support has a surface area of from about 2 m^2/g to about 100 m^2/g, and greater than about 90 wt. % of the palladium is concentrated near a periphery of the support.

21. The method of claim **1** wherein the catalyst is prepared by a method comprising:

contacting a support with a palladium-containing compound to form a palladium supported composition;

contacting the palladium supported composition with an organophosphorus compound to form a catalyst precursor; and

reducing the catalyst precursor to form the catalyst.

CLAIMS

1. A method of selectively hydrogenating highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition comprising:

contacting the highly unsaturated hydrocarbons and hydrogen in a reaction zone with a catalyst comprising palladium deposited on an inorganic support and an organophosphorus compound under conditions suitable for hydrogenating at least a portion of the highly unsaturated hydrocarbons to unsaturated hydrocarbons to produce the unsaturated hydrocarbon enriched composition;

wherein the catalyst has an operating window of from about 35° F (1.666667°C) to about 120° F (48.88889°C); and

wherein the contacting occurs at a temperature of from about 5° C to about 300° C

2. The method of claim 1 wherein the highly unsaturated hydrocarbons comprise acetylene, methylacetylene, propadiene, butadiene, or combinations thereof.

3. The method of claim 2 wherein the unsaturated hydrocarbon enriched composition comprises less than about 5 ppm of highly unsaturated hydrocarbons.

4. The method of claim 1 wherein the contacting occurs at a temperature less than about the boiling point of the organophosphorus compound.

5. The method of claim 4, further comprising increasing the temperature to equal to or greater than about the boiling point of the organophosphorus compound.

6. The method of claim 1 wherein the catalyst has a clean up temperature of from about 80° F (26.66667°C) to about 160° F (71.11111°C) and the unsaturated hydrocarbon enriched composition comprises less than about 20 ppm highly unsaturated hydrocarbons.

7. The method of claim 1 wherein the catalyst has an operating window increased by greater than about 10% in comparison to an otherwise similar method performed with a catalyst lacking the organophosphorus compound.

8. The method of claim 1 wherein a selectivity for hydrogenation of the highly unsaturated hydrocarbons to the unsaturated hydrocarbons is improved in comparison to an otherwise similar method performed with a catalyst lacking the organophosphorus compound.

9. The method of claim 1 wherein contacting the highly unsaturated hydrocarbons and hydrogen in a reaction zone with the catalyst described in claim 1 produces an unsaturated hydrocarbon composition comprising from about 1 wt. % to about 25 wt. % less C4+ material than an otherwise similar unsaturated hydrocarbon composition prepared with the catalyst described in claim 1 but lacking the organophosphorus compound.

10. The method of claim 1 wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a backend acetylene removal unit, a frontend deethanizer unit, a frontend depropanizer unit, or a raw gas unit.

11. The method of claim 10 wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a backend acetylene removal unit;

the highly unsaturated hydrocarbons comprise acetylene; and

a mole ratio of hydrogen to acetylene being fed to the reaction zone is in the range of from about 0.1 to about 10.

12. The method of claim 10wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a frontend deethanizer unit, a frontend depropanizer unit, or a raw gas unit;

the highly unsaturated hydrocarbons comprise acetylene; and

a mole ratio of hydrogen to acetylene being fed to the reaction zone is in the range of from about 10 to about 3000.

13. The method of claim 10wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a frontend depropanizer unit or a raw gas unit;

the highly unsaturated hydrocarbons comprise methylacetylene; and

a mole ratio of hydrogen to methylacetylene being fed to the reaction zone is in the range of from about 3 to about 3000.

14. The method of claim 10 wherein the selective hydrogenation of the highly unsaturated hydrocarbons to an unsaturated hydrocarbon enriched composition is performed in a frontend depropanizer unit or a raw gas unit;

the highly unsaturated hydrocarbons comprise propadiene; and

a mole ratio of hydrogen to propadiene being fed to the reaction zone is in the range of from about 3 to about 3000.

15. The method of claim 1 wherein the organophosphorus compound is represented by the general formula $(R)_x(OR')_yP=O$, wherein x and y are integers ranging from 0 to 3 and x plus y equals 3, wherein each R is hydrogen, a hydrocarbyl group, or combinations thereof; and

wherein each R' is a hydrocarbyl group; or wherein the organophosphorus compound is a product of an organophosphorus compound precursor represented by the general formula of $(R)_x(OR')_yP$, wherein x and y are integers ranging from 0 to 3 and x plus y equals 3, wherein each R is hydrogen, a hydrocarbyl group, or combinations thereof; and

wherein each R' is a hydrocarbyl group.

16. The method of claim 15 wherein the organophosphorus compound comprises a phosphine oxide, phosphinate, phosphonate, phosphate, or combinations thereof; or

wherein the organophosphorus compound precursor comprises a phosphite, a phosphonite, a phosphinite, a phosphine, an organic phosphine, or combinations thereof.

17. The method of claim 1 wherein the catalyst further comprises one or more selectivity enhancers selected from the group consisting of Group 1B metals, Group 1B metal compounds, silver compounds, fluorine, fluoride compounds, sulfur, sulfur compounds, alkali metal, alkali metal compounds, alkaline earth metals, alkaline earth metal compounds, iodine, iodide compounds, and combinations thereof.

18. The method of claim 1 wherein the catalyst is supported and the support has a surface area of from about 2 m^2/g to about 100 m^2/g, and greater than about 90 wt. % of the palladium is concentrated near a periphery of the support.

19. The method of claim 1 wherein the catalyst is prepared by a method comprising:

contacting a support with a palladium-containing compound to form a palladium supported composition; contacting the palladium supported composition with an organophosphorus compound to form a catalyst precursor; and reducing the catalyst precursor to form the catalyst.