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What is claimed is:

1. A method for selectively hydrogenating acetylene, the method comprising contacting a catalyst composition comprising a porous support, palladium, and at least one ionic liquid with a process gas comprising
 - ethylene, present in the process gas in an amount of at least 10 mol.%;
 - acetylene, present in the process gas in an amount of at least 1 ppm;
 - hydrogen, present in the process gas in amount of at least 5 mol.%; and
 - 0 ppm to 190 ppm carbon monoxide;wherein at least 90% of the acetylene present in the process gas is hydrogenated, and no more than 1 mol.% of the total of acetylene and ethylene present in the process gas is converted to ethane.
2. A method according to claim 1, wherein carbon monoxide is present in the process gas in an amount up to 150 ppm.
3. A method according to claim 1, wherein carbon monoxide is present in the process gas in an amount up to 85 ppm.
4. A method for selectively hydrogenating acetylene, the method comprising contacting a catalyst composition comprising a porous support, palladium, and at least one ionic liquid with a process gas comprising
 - ethylene, present in the process gas in an amount of at least 10 mol.%;
 - acetylene, present in the process gas in an amount of at least 1 ppm;
 - hydrogen, present in the process gas in amount of at least 5 mol.%; and
 - at least 600 ppm carbon monoxide;wherein at least 90% of the acetylene present in the process gas is hydrogenated, and no more than 1 mol.% of the total of acetylene and ethylene present in the process gas is converted to ethane.
5. A method according to claim 4, wherein carbon monoxide is present in the process gas in an amount within the range of 1000 ppm to 20,000 ppm.
6. A method according to any of claims 1-5, wherein the process gas is contacted with the catalyst at a gas hourly space velocity (GHSV) within the range of 2,000 h⁻¹ to 40,000 h⁻¹.

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7. A method according to any of claims 1-5, wherein the process gas is contacted with the catalyst at a GHSV within the range of 7,100 h⁻¹ to 40,000 h⁻¹.
8. A method according to any of claims 1-5, wherein the selective hydrogenation is conducted at a temperature within the range of 20 °C to 140 °C.
9. A method according to any of claims 1-5, wherein at least 95% of the acetylene present in the process gas is hydrogenated.
10. A method according to any of claims 1-5, wherein the amount of ethane in the product of the selective hydrogenation is no more than 0.5 mol.% greater than the amount of ethane in the process gas.
11. A method according to any of claims 1-5, wherein ethylene is present in the process gas in an amount of at least 20 mol.%.
12. A method according to any of claims 1-5, wherein acetylene is present in the process gas in an amount of at least 500 ppm.
13. A method according to any of claims 1-5, wherein hydrogen is present in the process gas in an amount in the range of 5 mol.% to 35 mol.%.
14. The method according to any of claims 1-5, wherein the process gas contains no more than 5 mol.% of carbon-containing components other than C₁ components (e.g., methane, carbon monoxide, and carbon dioxide), C₂ components (e.g., ethylene, ethane, and acetylene) and C₃ components (e.g., propane, propylene, methyl acetylene, and propadiene).
15. A method according to any of claims 1-5, wherein the catalyst composition comprises a porous support selected from alumina, silica, titania, and mixtures thereof, present in the catalyst composition in an amount within the range of 90 wt.% to 99.9 wt.%.
16. A method according to any of claims 1-5, wherein the catalyst composition comprises palladium in an amount of at least 0.02 wt.%.

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17. A method according to any of claims 1-5, wherein the catalyst composition comprises the at least one ionic liquid in a total amount up to 10 wt.%.

18. A method according to any of claims 1-5, wherein the at least one ionic liquid is selected from 1-butyl-3-methylimidazolium triflate, 1-ethyl-3-methylpyridinium ethylsulfate, 1-butyl-1-methylpyrrolidinium triflate, 1-butyl-2,3-dimethylimidazolium triflate, 1-butyl-3-methylimidazolium tricyanomethane, 1-butyl-3-methylimidazolium methylsulfate, 1-butyl-3-methylimidazolium octylsulfate, 1-butyl-3-methylimidazolium tetrafluoroborate, 1-ethyl-3-methylimidazolium ethylsulfate, 1-ethyl-3-methylimidazolium methylphosphonate, 1-ethyl-3-methylimidazolium triflate, 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide, 1-butyl-1-methylpyrrolidinium tetracyanoborate, 1-butyl-1-methylpyrrolidinium tris(pentafluoroethyl)trifluorophosphate, 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide, 1-butyl-3-methylimidazolium tricyanomethane, 1-ethyl-3-methylpyridinium bis(trifluoromethylsulfonyl)imide, 1-ethyl-3-methylimidazolium tetracyanoborate, 1-ethyl-3-methylimidazolium tris(pentafluoroethyl)trifluorophosphate, 1-methyl-3-octylimidazolium triflate, ethyldimethyl-(2-methoxyethyl)ammonium tris(pentafluoroethyl)trifluorophosphate, tributylmethylammonium dicyanamide, tricyclohexyltetradecylphosphonium tris(pentafluoroethyl)trifluorophosphate, and 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide.

19. The method according to any of claims 1-5, wherein the catalyst composition comprises:

- a porous support, present in the composition in an amount within the range of 90 wt.% to 99.9 wt.%;
- palladium, present in the composition in an amount within the range of 0.02 wt.% to 0.5 wt.% (e.g., within the range of 0.03 wt.% to 0.4 wt.%, or 0.04 wt.% to 0.3 wt.%), calculated on an elemental mass basis; and
- one or more ionic liquids, present in the composition in a combined amount up to 10 wt.%.

20. The method according to any of claims 1-5, wherein the catalyst composition comprises

- a porous support, present in the composition in an amount within the range of 90 wt.% to 99.9 wt.%;
- palladium, present in the composition in an amount within the range of at least 0.02 wt.%, calculated on an elemental mass basis; and

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one or more ionic liquids, present in the composition in a combined amount up to 10 wt.%,

wherein the hydrogenation catalyst has a BET surface area of no more than 10 m²/g and a pore volume of at least 0.05 mL/g.