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 about 1 ppm; and

hydrogen, present in the process gas in amount of at least 5 mol.%

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

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

wherein the process gas is contacted with the catalyst at a gas hourly space velocity (GHSV) based on total catalyst volume in one bed or multiple beds of at least 10,000 h^{-1} to 40,000 h^{-1};

wherein the hydrogenation catalyst has a BET surface area of no more than 10 m^2/g and a pore volume of at least 0.05 mL/g; and

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 the gas hourly space velocity is in the range of 15,000 h^{-1} to 40,000 h^{-1}.

3. A method according to claim 1, wherein the selective hydrogenation is conducted at a temperature within the range of 20 °C to 140 °C.

4. A method according to claim 1, wherein the selective hydrogenation is conducted at a temperature within the range of 40 °C to 100 °C.

5. A method according to claim 1, wherein carbon monoxide is present in the process gas in an amount up to 20,000 ppm.

6. A method according to claim 1, wherein carbon monoxide is present in the process gas in an amount in the range of 0 ppm to 190 ppm.

7. A method according to any of claims 1-6, wherein at least 95% of the acetylene present in the process gas is hydrogenated.

8. A method according to any of claims 1-6, 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.

9. A method according to any of claims 1-6, wherein ethylene is present in the process gas in an amount of at least 20 mol.%.

10. A method according to any of claims 1-6, wherein acetylene is present in the process gas in an amount of at least 500 ppm.

11. A method according to any of claims 1-6, wherein hydrogen is present in the process gas in an amount in the range of 5 mol.% to 35 mol.%.

12. The method according to any of claims 1-6, wherein the process gas contains no more than 5 mol.% of carbon-containing components other than C_1 components (e.g., methane, carbon monoxide, and carbon dioxide), C_2 components (e.g., ethylene, ethane, and acetylene) and C_3 components (e.g., propane, propylene, methyl acetylene, and propadiene).

13. A method according to any of claims 1-6, wherein the porous support is selected from alumina, silica, titania, and mixtures thereof.

14. A method according to any of claims 1-6, 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.

15. A method according to any of claims 1-6, wherein the hydrogenation 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.% to 0.5 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.%.