

TITLE

PROCESS OF COPRODUCING HFO-E/Z-1132
AND COMPOSITIONS THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority of U.S. Provisional Application 63/541,353 filed September 29, 2023, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] Hydrofluoroolefins (HFOs) having low ozone depletion potential (ODP) and low global warming potential (GWP) have been replacing saturated CFCs (chlorofluorocarbons), HCFCs (hydrochlorofluorocarbons), and HFCs (hydrofluorocarbons) in a variety of applications for several years because saturated hydrohalocarbons tend to have high GWP values. For example, HFC-32 (CH_2F_2), HFC-125 (C_2HF_5), and HFC-134a (CH_2FCF_3) have GWPs of 675, 3500 and 1430, respectively. As a result, low ODP and GWP materials continue to be of interest for use as refrigerants, solvents, foam expansion agents, cleaning agents, aerosol propellants, dielectrics, fire extinguishants, and power cycle working fluids.

[0003] The regulatory landscape is continuously evolving, taking into consideration properties beyond just ODP and GWP. More particularly, there is a need for refrigerant compositions that not only meet low ODP standards and have low global warming potentials, but that also exhibit low or no flammability, provide superior performance in a variety of applications and which meet the standards of evolving regulations.

[0004] There is a need in this art for new refrigerants that meet evolving regulations as well as provide heat transfer and refrigerant characteristics that meet or exceed the effectiveness of conventional refrigerants.

[0005] To meet these increasing demands, existing and new haloolefins continue to be developed, evaluated, and produced with more efficient processes. One such candidate is the E- and/or Z-isomers of HFO-1132 which are suitable as blending components given its environmentally friendly decomposition profile in atmosphere.

Current processing generally favors the production of the Z- isomer, which requires significant amounts to be isomerized to the E- isomer. Thus, the need for new processes to produce these new refrigerant candidate remains.

SUMMARY OF THE INVENTION

[0006] The present invention relates to processes for producing the E- and Z- isomers of 1,2-difluoroethylene (HFO-E/Z-1132), compositions thereof and methods of using said isomers.

[0007] Certain embodiments disclosed herein relate to an integrated process of making E- and Z-isomers of 1,2-difluoroethylene using a tetrafluoroethane starting material.

[0008] Certain embodiments disclosed herein relate to an integrated process which comprises converting 1,1,1,2-tetrafluoroethane (HFC-134a) to mainly E-1,2-difluoroethylene according to the reaction steps (1), (2), and (3).

(1): 1,1,1,2-tetrafluoroethane (HFC-134a) $\rightarrow$ 1,1,2-trifluoroethylene (HFO-1123) + HF

(2): HFO-1123 + H₂ $\rightarrow$ 1,1,1-trifluoroethane (HFC-143)

(3): HFC-143 $\rightarrow$ Z-1,2-difluoroethylene (HFO-Z-1132) + E-1,2-difluoroethylene (HFO-E-1132) + HF

(4): HFO-Z-1132 $\rightarrow$ HFO-E-1132

[0009] In other embodiments disclosed herein the process relates to an integrated process in which 1,1,2,2-tetrafluoroethane (HFC-134) is used as an alternative to HFC-134a, and is converted to mainly Z-1,2-difluoroethylene according to the following reaction steps,

(1a): 1,1,1,2-tetrafluoroethane (HFC-134) $\rightarrow$ 1,1,2-trifluoroethylene (HFO-1123) + HF

(2): HFO-1123 + H₂ $\rightarrow$ 1,1,1-trifluoroethane (HFC-143)

(3): HFC-143 $\rightarrow$ Z-1,2-difluoroethylene (HFO-Z-1132) + E-1,2-difluoroethylene (HFO-E-1132) + HF

(4): HFO-Z-1132 $\rightarrow$ HFO-E-1132

[0010] In certain embodiments disclosed herein, reactions (1), (2), (3), and (4) are part of an integrated process and each reaction is respectively conducted in a separate and discrete reactor.

[0011] In certain embodiments disclosed herein, reactions (1/1a) and (2) are respectively conducted in discrete reactors/reactor systems in close proximity to one another because 1,1,2-trifluoroethylene (HFO-1123) is highly unstable, in the absence or presence of air. HFO-1123 should be treated as tetrafluoroethylene, and therefore it is desired the system for producing HFO-1123 is in close proximity to the system for hydrogenating HFO-1123. This can be achieved by integrating the reactor system for each process at the same location with minimum transportation either by directly coupling the two process steps together or building the hydrogenation process system at the location where HFO-1123 is produced, optionally at a common plant facility.

[0012] One embodiment disclosed herein relates to a process wherein the dehydrofluorination of steps (1) or (1a) are conducted in the vapor phase, the hydrogenation of step (2) is conducted in the liquid or vapor phase, the dehydrofluorination of step (3) is conducted in the vapor or liquid phase, and the isomerization of HFO-Z-1132 is conducted in the presence of a catalyst or in the absence of a catalyst at temperatures above 600°C.

[0013] Another embodiment disclosed herein relates to a process wherein the dehydrofluorination of step (1) is conducted in the vapor phase, the hydrogenation of step (2) is conducted in the liquid phase, the dehydrofluorination of step (3) is conducted in the liquid phase, and the isomerization of HFO-Z-1132 is conducted in the presence of a catalyst at temperatures between 200°C and 400°C or in the absence of a catalyst above 600°C, preferably between 600°C and 800°C.

[0014] One embodiment disclosed herein relates to a process for making HFO-E/Z-1132 which comprises dehydrofluorination steps (1), (1a) and (3) and hydrogenation step (2) respectively conducted in the vapor phase, and the isomerization of HFO-Z-1132 is conducted in the presence or in the absence of a catalyst at temperatures above 600°C.

[0015] In certain embodiments disclosed herein the process relates to the dehydrofluorination of a HFC-134 feed or a HFC-134a feed, wherein (1) the HFC-

134 feed comprises in addition to HFC-134 at least two additional compounds selected from HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HC-161, or **(2)** the HFC-134a feed comprises in addition to HFC-134a at least two additional compound selected from HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a, wherein said dehydrofluorination is conducted in the gas phase at a temperature between 200°C and 500°C.

[0016] In certain embodiments disclosed herein, the process relates to hydrogenation of HFO-1123 wherein the reactor feed comprises at least two of the compounds selected from HFC-134, HFC-134a, HCFO-1122, CFO-1113, HFO-1132a, HFO-1141, which is conducted in the gas phase at a temperature between 50°C and 200°C, in the presence of a supported or unsupported catalyst.

[0017] In some embodiments, the process further comprises separating the E-isomer of HFO-1132 from the Z-isomer, for example by simple or fractional distillation or an extractive distillation of the HFO-E/Z-1132 produced by reaction **(3)**, to provide at least one first fraction which comprises HFO-E-1132 and is free of or substantially free of HFO-Z-1132 and a second fraction which comprises HFO-Z-1132 and small amounts of HFO-E-1132. For example, in one embodiment, the first fraction comprises greater than about 99 wt.% HFO-E-1132 and less than about 1 wt.% HFO-Z-1132, and the second fraction comprises greater than about 99 wt.% HFO-Z-1132 and less than about 1 wt.% HFO-E-1132.

[0018] Thus, the process produces at least one fraction or composition which comprises HFO-E-1132 and is free of or substantially free of HFO-Z-1132. The process further comprises collecting the at least one first fraction as a purified composition of HFO-E-1132, and optionally further purifying the HFO-E-1132 composition (e.g., by additional distillation or solvent scrubbing as described above) to remove or reduce the amount of additional compounds present therein, such as but not limited to acetylene, fluoroacetylene, HFC-152, HCO-1140, and/or HFO-1141. Thus, the process produces a treated and purified composition comprising HFO-E-1132 and which is free of or substantially free of HFO-Z-1132, HFO-1141 and HFC-152.

[0019] In some embodiments, the process further comprises contacting the at least one second fraction (which comprises more HFO-Z-1132 than HFO-E-1132) with hydrogen fluoride (HF) under conditions to convert the HFO-Z-1132 and HFO-E-1132 to HFC-143. The hydrofluorination of the HFO-E/Z-1132 mixture to produce HFC-143 is followed by dehydrofluorination of the HFC-143 under conditions to convert the HFC-143 to HFO-E/Z-1132 as disclosed herein with respect to reaction (3). The resulting HFO-E/Z-1132 is then recycled to the simple or fractional distillation or extractive distillation. Thus, in this manner, the second fraction rich in HFO-Z-1132 can be processed to make additional amounts of HFO-E-1132. In certain embodiments disclosed herein, the process relates to catalytic hydrogenation of the preceding HFO-1123 feed, wherein the catalyst comprises a metal selected from nickel, palladium, platinum, cobalt, rhodium, iridium, rhenium and ruthenium. The metal catalysts are preferably supported on carbon. The concentration of metal supported on carbon is typically within the range of about 0.1% to about 10% by weight based on metal and the support. The carbon support includes activated carbon and acid-washed carbons (e.g., carbons which have been treated with hydrochloric acid or hydrochloric acid followed by hydrofluoric acid). Suitable acid treatment of carbons is described in U.S. Patent No. 5,136,113. Vegetable-based carbons, such as coconut shell-based carbon, are preferred for the acid treatment.

[0020] In certain embodiments disclosed herein, relates to a hydrogenation process of an HFO-1123 feed also comprising at least two of the compounds selected from HFO-1123, HFC-134, HFC-134a, HCFO-1122, CFO-1113, HFO-1132a, and HFO-1141 which is conducted in the liquid phase at a temperature between 30°C and 150°C.

[0021] In certain embodiments disclosed herein, dehydrofluorination of HFC-143 wherein the reactor feed comprises HFC-143 and at least two compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), HFC-236fa, HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100

ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), 1-chloro-1,2-difluoroethylene (HCFO-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane (HFC-23), ethylene, and acetylene, and the dehydrofluorination is conducted in the gas phase at a temperature between 150°C and 400°C. in the presence of a catalyst selected from the group consisting of aluminum fluoride, fluorided alumina, a metal supported on a trivalent aluminum compound containing fluoride anion (e.g., aluminum fluoride and/or fluorided alumina), lanthanum fluoride, fluorided lanthanum oxide, metal supported on a trivalent lanthanum compound containing fluoride anion (e.g., lanthanum fluoride and/or fluorided lanthanum oxide), trivalent chromium compounds (e.g., Cr₂O₃), wherein the metal is selected from the group consisting of one or more of chromium, manganese, iron, cobalt, nickel, magnesium, and zinc; or a cobalt- or nickel-substituted chromium oxide.

[0022] In certain embodiments disclosed herein, conversion of HFC-143 and at least two of the compounds selected from the list 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), HFC-236fa, HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152), fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), 1-chloro-1,2-difluoroethylene (HCFO-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene in the liquid phase is conducted at a temperature between -20 °C and 150°C in the presence of a strong base in a polar solvent, and optionally a phase transfer catalysts selected from quaternary ammonium salts of the formula [NR₁R₂R₃R₄]X and phosphonium salts of the

formula [PR₁R₂R₃R₄]X wherein X = F, Cl, Br, I, OH, HCO₃, CO₃, HSO₄, or SO₄, and R₁, R₂, R₃, and R₄ are independently selected from the group consisting of alkyl group, an aryl group or an aralkyl group. Specific examples include tetramethylammonium chloride, tetramethylammonium bromide, benzyltriethylammonium chloride, methyltrioctylammonium chloride, tetra-n-butylammonium chloride, tetra-n-butylammonium bromide, tetra-n-butylammonium hydrogen sulfate, tetra-n-butylphosphonium chloride, tetraphenylphosphonium bromide, tetraphenylphosphonium chloride, triphenylmethylphosphonium bromide and triphenylmethylphosphonium chloride.

[0023] In certain embodiments disclosed herein, conversion of a HFC-143 feed comprising HFC-143 and at least two compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), HFC-236fa, HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), 1-chloro-1,2-difluoroethylene (HCFO-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), and ethylene and acetylene if present in the liquid phase is conducted under anhydrous conditions at a temperature between -20°C and 100°C in the presence of a strong base such as an alkaline metal or alkaline-earth metal alkoxide, an alkaline or alkaline-earth metal hydride, an organometallic lithium compound, or an alkaline or an alkaline-earth metal amide where the alkaline metal is a Group 1A metal of the Periodic Table excluding hydrogen and the alkaline-earth metal is a Group 2A metal of the Periodic Table excluding beryllium. Non-limiting examples of an alkaline metal or alkaline-earth metal alkoxide include lithium methoxide, sodium methoxide, sodium ethoxide, potassium tert-butoxide, sodium tert-butoxide sodium isopropoxide, or magnesium ethoxide. Non-limiting examples of

an alkyl lithium include n-butyl lithium and methyl lithium. Non-limiting examples of an alkaline or alkaline-earth metal hydride include lithium hydride, sodium hydride, or calcium hydride. Non-limiting examples of an alkaline or alkaline-earth metal amide include sodium amide, lithium diisopropylamide, and magnesium bis(diisopropylamide). Said conversion of HFC-143 composition is conducted in an aprotic organic solvent selected from an ether (e.g., diethyl ether, ethylene glycol dimethyl ether, diethylene glycol dimethyl ether, tetraethylene glycol dimethyl ether) or a cyclic ether (e.g., tetrahydrofuran, dioxane). The reaction with a strong base may be conducted with or without a catalyst such as a Crown ether or cryptand. Specific examples of crown ether include 1,4,7,10,13-Pentaoxacyclopentadecane (15-crown-5) and 1,4,7,10,13,16-Hexaoxacyclooctadecane (18-crown-6). A well-known example of a cryptand is 4,7,13,16,21,24-hexaoxa-1,10-diazabicyclo-(8.8.8) hexacosane also known as 2,2,2-cryptand.

[0024] One embodiment disclosed herein relates to a process wherein the dehydrofluorination of step (1) or step (1a) is conducted in the vapor phase, the hydrogenation of step (2) is conducted in the liquid phase and the dehydrofluorination of step (3) is conducted in the vapor phase, and the isomerization of at least a portion of HFO-Z-1132 is conducted at temperatures above 600°C, preferably between 600°C and 800°C.

[0025] One embodiment disclosed herein relates to a process wherein the dehydrofluorination of step (1) or (1a) is conducted in the vapor phase, the hydrogenation of step (2) is conducted in the vapor phase, the dehydrofluorination of step (3) is conducted in the liquid phase, and the isomerization of HFO-Z-1132 is conducted at temperatures above 600°C, preferably between 600°C and 800°C.

[0026] In another embodiment disclosed herein the dehydrofluorination of step (1) or (1a) is conducted simultaneously using a mixture of HFC-134 and HFC-134a in the vapor phase to provide HFO-1123.

[0027] Certain process embodiment disclosed herein isomerize at least a portion of HFO-Z-1132 to HFO-E-1132 at temperatures between 600°C and 800°C.

[0028] In dehydrofluorination processes disclosed herein the catalyst comprises one of chromium(III) oxide (Cr_2O_3), aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, chromium oxide/aluminum oxide mixtures,

chromium oxide supported on AlF_3 , chromium fluoride, cubic chromium fluoride, or a cobalt- or nickel-substituted chromium oxide.

[0029] In certain embodiments disclosed herein the process relates to dehydrofluorinating HFC-134a in the presence of catalyst which comprises one of chromium(III) oxide (Cr_2O_3), aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, chromium oxide/aluminum oxide mixtures, chromium oxide supported on AlF_3 , chromium fluoride and cubic chromium fluoride, preferably one of aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, or a cobalt- or nickel-substituted chromium oxide.

[0030] In certain embodiments disclosed herein the process relates to dehydrofluorinating 1,1,2-trifluoroethane (HFC-143) with a catalyst that may be the same as or different from the catalyst of Step (1) or (1a), and is selected one of chromium(III) oxide (Cr_2O_3), aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, chromium oxide/aluminum oxide mixtures, chromium oxide supported on AlF_3 , chromium fluoride and cubic chromium fluoride, preferably one of aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, or a cobalt- or nickel-substituted chromium oxide.

[0031] Certain process embodiments disclosed herein relate to the hydrogenation of 1,1,2-trifluoroethylene (HFO-1123) is conducted in the presence of a hydrogenation catalyst.

[0032] Certain process embodiments disclosed herein relate to the hydrogenation of 1,1,2-trifluoroethylene (HFO-1123) in the vapor phase at a H_2 /1123 molar ratio in the range of 0.2:1 to 10:1.

[0033] In liquid phase hydrogenation embodiments step (2), the solvents comprise alcohols (e.g., methanol, ethanol, propanol, n-butanol), ethers (e.g., diethyl ether, dibutyl ether, ethylene glycol dimethyl ether, and diethylene glycol dimethyl ether), cyclic ethers (e.g., tetrahydrofuran and dioxane), and polar aprotic solvents (e.g., dimethylsulfoxide, N,N-dimethylformamide, N-methylpyrrolidinone).

[0034] In certain liquid phase dehydrofluorinations of step (3) the solvents can be aqueous or non-aqueous, and the liquid phase optionally includes a phase transfer catalyst. Suitable solvents include, but are not limited to, ethers (e.g., diethyl ether,

dibutyl ether, ethylene glycol dimethyl ether, and diethylene glycol dimethyl ether) or cyclic ethers (e.g., tetrahydrofuran and dioxane).

[0035] Certain process embodiments disclosed herein hydrogenate 1,1,2-trifluoroethylene (HFO-1123) in the presence of a catalyst in the liquid phase which comprises, consists essentially of, or consists of Group VIII metal such as Ru, Rh, Ni, Pd, or Pt. The metal may be supported (e.g., Pd supported on alumina, aluminum fluoride, or carbon) or may be unsupported (e.g., Raney nickel). Carbon-supported metal catalysts are preferred, with Pd/C being particularly preferred. Concentrations of Pd on the carbon support may be in the range of 0.1 weight % to 10 weight %.

[0036] One embodiment disclosed herein relates to a process for thermally converting HFO-Z-1132 to HFO-E-1132 at temperature range from 600°C to about 800°C.

[0037] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,1,2-tetrafluoroethane (HFC-134a) and at least 1,1,2-trifluoroethylene (HFO-1123).

[0038] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2,2-tetrafluoroethane (HFC-134) and at least 1,1,2-trifluoroethylene (HFO-1123).

[0039] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethylene (HFO-1123) and at least 1,1,2-trifluoroethane (HFC-143).

[0040] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethane (HFC-143) and at least one of HFO-E-1132 and HFO-Z-1132. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

[0041] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of HFO-E-1132 and HFO-Z-1132 and optionally one or more of fluoroethylene (HFO-1141), vinyl chloride (HCC-1140), fluoroacetylene or acetylene, wherein each of HFO-1141, HCC-1140, fluoroacetylene and/or acetylene, if present, is contained in the composition in an

amount which is selected from one of <200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

[0042] In some embodiments, the composition comprising, consisting essentially of, or consisting of HFO-E-1132 and HFO-Z-1132 is preferably free of HFO-1141, HCC-1140, acetylene and/or fluoroacetylene. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

[0043] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of HFO-E-1132 and HFO-Z-1132, and optionally one or more of HFO-1141, HCC-1140, fluoroacetylene or acetylene, wherein each of HFO-1141, HCC-1140, fluoroacetylene and/or acetylene, if present, is contained in the composition in an amount selected from between one of ≤ 1 ppm, ≥ 0.1 ppm or ≥ 0.01 ppm and <200 ppm, <100 ppm, <50 ppm, or <10 ppm, and most preferably the composition is free of HFO-1141, HCC-1140, acetylene and/or fluoroacetylene. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

[0044] Certain embodiments disclosed herein relate to compositions selected from one of:

- a) HFC-134 and one or more additional compounds selected from HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161;
- b) HFC-134a and one or more additional compounds selected from HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a;
- c) HFC-143 and one or more additional compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), HFC-236fa, HFO-Z-1132, HFO-E-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133,

Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), 1-chloro-1,2-difluoroethylene (HCFO-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene, where the total amount of additional compounds is less than 1 weight % of the total composition;

- d) HFO-1123 and one or more additional compounds selected from 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), 1-chloro-2,2-difluoroethylene (HCFO-1122);
- e) HFO-E-1132 and one or more additional compounds selected from two or more of difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123) and fluoroethylene (HFO-1141), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-1-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), (i) optionally HFO-Z-1132, and (ii) optionally one or more of HFO-1141, HCC-1140, fluoroacetylene or acetylene, wherein each of HFO-1141, HCC-1140, fluoroacetylene and/or acetylene, if present, is contained in the composition in an amount which is selected from one of one of < 200 ppm,

<100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably in amounts ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, most preferably the composition is substantially or completely free of HFO-1141, HCC-1140, acetylene, or fluoroacetylene; or

- f) HFO-Z-1132 and one or more additional compounds selected from two or more of difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123) and fluoroethylene (HFO-1141), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and <100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-1-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122); (i) optionally HFO-E-1132; and/or (ii) optionally one or more of HFO-1141, HCC-1140, fluoroacetylene or acetylene, wherein each of HFO-1141, HCC-1140, fluoroacetylene and/or acetylene, if present, is contained in the composition in an amount which is selected from one of one of <200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, most preferably the composition is substantially or completely free of HFO-1141, HCC-1140, acetylene, or fluoroacetylene,

wherein the total amount of additional compounds in a)-f) is at most 1 weight % and, in any of a)-f), the amount 1,2-difluoroethane (HFC-152) is selected from one of <100 ppm, <50 ppm, <10 ppm, <5 ppm, <1 ppm or ≥ 0 and <1 ppm.

[0045] Certain embodiments disclosed herein relate to compositions selected from one of:

- a. HFC-134a and at least one additional compound selected from HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a;

- b. HFC-134 and at least one additional compound selected from HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a;
- c. HFO-1123 and at least one additional compound selected from CFO-1113, HFC-134a, HFC-134, HFO-1141, HFO-1132a, and HCFO-1122;
- d. HFC-143 and at least one additional compound selected from HFO-1123, CFO-1113, HFC-134a, HCFO-1131a, HCFC-142, HCFC-142a, HCFO-1122, HCFO-E/Z-1122a, and HCO-1140;
- e. HFO-E-1132 and at least one additional compound selected from HFO-Z-1132, HFO-1141, HFO-1123, acetylene, HFO-Z-1132, HFO-E-1131, HFC-125, HFC-32, HCFO-1131a, HCFO-Z-1122a, HCFO-E-1122a, HCFO-1122, and HCO-1140;
- f. HFO-E-1132, and at least one additional compound selected from HFO-Z-1132 (1) difluoromethane (HFC-32), (2) 1,1,1,2,2-pentafluoroethane (HFC-125), (3) E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), (4) Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), (5) 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), (6) 1-chloro-1,2,2-trifluoroethane (HCFC-133), (7) 1-chloro-1,1,2-trifluoroethane (HCFC-133b), (8) 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), (9) 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, (10) 1,1,2-trifluoroethane (HFC-143), (11) fluoromethane (HFC-41), (12) chlorodifluoromethane (HCFC-22), (13) ethylene, (14) 1-chloro-1,2-difluoroethane (HCFC-142a), (15) 1,1-difluoroethylene (HFO-1132a), vinyl chloride (HCO-1140), (16) 1-chloro-1-fluoroethene (HCFO-1131a), (17) E-1-chloro-2-fluoroethene (HCFO-E-1131), (18) Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and (19) 1-chloro-2,2-difluoroethylene (HCFO-1122), and acetylene and fluoroacetylene, if present;
- g. HFO-Z-1132 and at least one additional compound selected from HFO-E-1132, HFO-1141, HFO-1123, acetylene, HFC-134, HFO-E-1132, HFO-E-1131, HFO-Z-1131, HCFO-1131a, HCFO-Z-1122a, HCFO-E-1122a, HCFO-1122, or HCO-1140; or
- h. HFO-Z-1132 and at least one additional compound selected HFO-E-1132, (1) difluoromethane (HFC-32), (2) 1,1,1,2,2-pentafluoroethane (HFC-125), (3) E-

1-chloro-1,2-difluoroethylene (HCFO-E-1122a), (4) Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), (5) 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), (6) 1-chloro-1,1,2-trifluoroethane (HCFC-133), (7) 1-chloro-1,1,2-trifluoroethane (HCFC-133b), (8) 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), (9) 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, (10) 1,1,2-trifluoroethane (HFC-143), (11) fluoromethane (HFC-41), (12) chlorodifluoromethane (HCFC-22), (13) ethylene, (14) 1-chloro-1,2-difluoroethane (HCFC-142a), (15) 1,1-difluoroethylene (HFO-1132a), vinyl chloride (HCO-1140), (16) 1-chloro-1-fluoroethene (HCFO-E-1131a), (17) E-1-chloro-2-fluoroethene (HCFO-E-1131), (18) Z-1-chloro-1-fluoroethene (HCFO-Z-1131), and (19) 1-chloro-2,2-difluoroethylene (HCFO-1122),

wherein the total amount of additional compounds in "a"-"h" is at most 1 weight % and, in any of "a"-"h" the amount 1,2-difluoroethane (HFC-152) is selected from one of < 100 ppm, < 50 ppm, < 10 ppm, < 5 ppm, or 1 ppm or less.

[0046] Another embodiment disclosed herein relates to a composition comprising 1,1,2-trifluoroethylene (HFO-1123) and one or more compounds selected from 1,1,2,2-tetrafluoroethane (HFC-134), 1,1,1,2-tetrafluoroethane (HFC-134a), 1-chloro-1,2-difluoroethylene (HCFO-1122), 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1-difluoroethene (HFO-1132a), and fluoroethylene (HFO-1141).

[0047] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of trifluoroethylene (HFO-1123) and at least two compounds selected from 1,1,2,2-tetrafluoroethane (HFC-134), 1,1,1,2-tetrafluoroethane (HFC-134a), 1-chloro-1,2-difluoroethylene (HCFO-1122), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1,1-difluoroethene (HFO-1132a), and fluoroethylene (HFO-1141).

[0048] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethylene (HFO-1123) and at least three or more compounds selected from 1,1,2,2-tetrafluoroethane (HFC-134), 1,1,1,2-tetrafluoroethane (HFC-134a), 1-chloro-1,2-difluoroethylene (HCFO-1122), 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1-difluoroethene (HFO-1132a), and fluoroethylene (HFO-1141).

[0049] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethylene (HFO-1123) and one or more compounds selected from $\text{CFCl}=\text{CF}_2$, ethane, fluoroethane, CH_2FCF_3 , and CH_3CHF_2 .

[0050] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethane (HFC-143) and at least one additional compound selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,2-tetrafluoroethane (HFC-134), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), Z-1,2-difluoroethylene (HFO-Z-1132), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-2-fluoroethylene (HCFO-1131), 1-chloro-1-fluoroethane (HCFC-151a), chloroethane (HCC-160), 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), 1-chloro-1,2-difluoroethylene (HCFO-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene, wherein the total amount of additional compounds is less than 1 weight % of the total composition.

[0051] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethane (HFC-143) and at least two additional compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), Z-1,2-difluoroethylene (HFO-Z-1132), E-1,2-difluoroethylene (HFO-E-1132), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-2-fluoroethylene (HCFO-1131), 1-chloro-1-fluoroethane (HCFC-151a),

chloroethane (HCC-160), 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152), fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), 1-chloro-1,2-difluoroethylene (HCFO-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene, wherein the total amount of additional compounds is less than 1 weight % of the total composition.

[0052] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethane (HFC-143) and at least three additional compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), Z-1,2-difluoroethylene (HFO-Z-1132), E-1,2-difluoroethylene (HFO-E-1132), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), chloroethylene (HFO-1140, vinyl chloride), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-2-fluoroethylene (HCFO-1131), 1-chloro-1-fluoroethane (HCFC-151a), chloroethane (HCC-160), 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152), fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), vinyl chloride (HCO-1140), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene, wherein the total amount of additional compounds is at most 1 weight % and, the amount 1,2-difluoroethane (HFC-152) is selected from one of <100 ppm, 50 ppm or less, 10 ppm or less, 5 ppm or less, or 1 ppm or less.

[0053] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethane (HFC-143) and at least four additional compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-

tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), Z-1,2-difluoroethylene (HFO-Z-1132), E-1,2-difluoroethylene (HFO-E-1132), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-2-fluoroethylene (HCFO-1131), 1-chloro-1-fluoroethane (HCFC-151a), chloroethane (HCC-160), 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152), fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), chloroethylene (HCO-1140), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene, wherein the total amount of additional compounds is at most 1 weight % and, the amount 1,2-difluoroethane (HFC-152) is selected from one of <100 ppm, 50 ppm or less, 10 ppm or less, 5 ppm or less, or 1 ppm or less.

[0054] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethane (HFC-143) and at least five or more additional compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), Z-1,2-difluoroethylene (HFO-Z-1132), E-1,2-difluoroethylene (HFO-E-1132), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-2-fluoroethylene (HCFO-1131), 1-chloro-1-fluoroethane (HCFC-151a), chloroethane (HCC-160), and 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152), fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), chloroethylene (HCO-1140), dichlorofluoromethane (HCFC-21),

chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene, , wherein the total amount of additional compounds is at most 1 weight % and, the amount 1,2-difluoroethane (HFC-152) is selected from one of <100 ppm, 50 ppm or less, 10 ppm or less, 5 ppm or less, or 1 ppm or less.

[0055] In certain embodiments disclosed herein, the total amount of compounds in addition to HFO-E-1132 and HFO-Z-1132 is between >0 and ≤about 1.0 weight %, and all values and ranges therebetween. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

[0056] In certain embodiments disclosed herein the amount of each compound in addition to HFO-E-1132 and HFO-Z-1132 is independently between >0 and ≤about 0.1 weight % as measured by gas chromatography or between ≥0.0001 and <0.9 weight %, and all values and ranges therebetween. provided that the total amount of additional compounds is between >0 and <about weight 1%. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

[0057] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of 1,1,2-trifluoroethane (HFC-143) and at least two additional compound selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), Z-1,2-difluoroethylene (HFO-Z-1132), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-2-fluoroethylene (HCFO-1131), 1-chloro-1-fluoroethane (HCFC-151a), chloroethane (HCC-160), and 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), wherein the amount of the additional compounds is >0 and ≤about 3 weight %, preferably wherein the total amount of additional compounds is less than 1 weight % of the total composition.

[0058] Another embodiment disclosed herein relates to a composition comprising, consisting essentially of, or consisting of HFO-1123 and one or more compounds comprising HFC-134, HFC-134a, and HFC-143.

[0059] In another embodiment disclosed herein relate to a composition comprising, consisting essentially of, or consisting of E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132) and two or more of acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152), 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-1-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), wherein the total amount of additional compounds is at most 1 weight % and, the amount 1,2-difluoroethane (HFC-152) is selected from one of <100 ppm, 50 ppm or less, 10 ppm or less, 5 ppm or less, or 1 ppm or less. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

[0060] In another embodiment disclosed herein relate to a composition comprising, consisting essentially of, or consisting of E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132) and two or more of, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152), 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), -1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-1-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), wherein the amount of each of fluoroethylene (HFO-1141), vinyl chloride (HCO-1140), fluoroacetylene, and acetylene, if present, comprises one of <500 ppm, <400 ppm, <300 ppm, <200 ppm,

<100 ppm, <50 ppm, <10 ppm, or <5 ppm, and wherein the total amount of additional compounds is at most 1 weight % and, the amount 1,2-difluoroethane (HFC-152) is selected from one of <100 ppm, 50 ppm or less, 10 ppm or less, 5 ppm or less, or 1 ppm or less. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

[0061] In another embodiment disclosed herein relate to a composition comprising, consisting essentially of, or consisting of E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132) and two or more of acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152), 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-1-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), wherein the amount of each of fluoroethylene (HFO-1141), HFO-1140, fluoroacetylene or acetylene, if present, comprises one of <200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably ≤10 ppm, ≤5 ppm, ≤4 ppm, ≤3 ppm, ≤2 ppm, or ≤1 ppm. In some embodiments, the amount of HFO-Z-1132 is selected from one of <5000 ppm, <2000 ppm, <1000 ppm, <500 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, or <1 ppm.

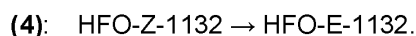
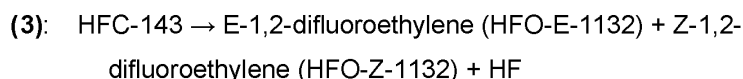
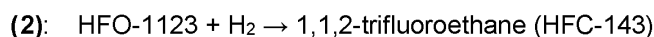
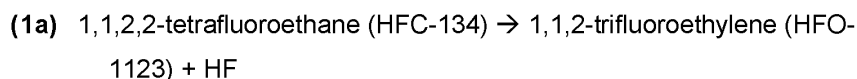
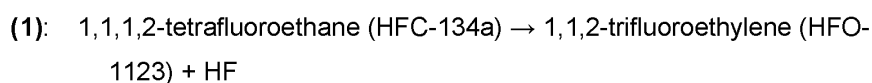
[0062] In one embodiment disclosed herein the HFO-E-1132 and/or the HFO-Z-1132 composition, is blended with other HFC, HFO and HCFO compounds for as refrigerants, solvents, foam expansion agents, cleaning agents, aerosol propellants, dielectrics, fire extinguishants, and power cycle working fluids.

[0063] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. In case of conflict, the present specification, including definitions, will control. Although methods and materials similar or

equivalent to those described herein can be used in the practice or testing of embodiments of the present invention, suitable methods and materials are described below. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

DETAILED DESCRIPTION OF THE INVENTION

[0064] The present invention relates to integrated processes for producing E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132) according to the following reaction steps:



[0065] The present invention relates to compositions from steps (1), (1a), (2), (3) and/or (4).

[0066] Before addressing details of embodiments described herein, some terms are defined or clarified as follows.

[0067] The term “compound” as used herein is meant to include all stereoisomers, geometric isomers, tautomers, and isotopes of the structures or chemical described. Compounds herein identified by name or structure as one particular tautomeric form are intended to include other tautomeric forms unless otherwise specified.

[0068] The term “hydrohaloalkane,” as used herein means a molecule containing hydrogen, carbon, fluorine and/or chlorine and/or bromine and/or iodine, with no carbon-carbon double bond (halo=fluoro, chloro, bromo, iodo). Examples are described throughout the instant specification.

[0069] The term “hydrohaloalkene” is intended to mean a chemical compound selected from the classes of hydrofluoroolefms (HFOs) and hydrochlorofluoroolefins (HCFOs) which include a double bond between adjacent carbon atoms and can contain 1 to 8 carbon atoms.

[0070] The term “isomerization process,” as used herein, means a process for changing geometry of a molecule, e.g., from the cis- orientation to the trans- orientation. In an isomerization process the relative ratios of Z and E isomers in a mixture is changed.

[0071] The term “scrubbing” is meant using solid or liquid media to selectively remove certain components to achieve desired production quality

[0072] In addition to the reactors disclosed herein, heat exchangers, effluent lines, units associated with mass transfer, contacting vessels (pre-mixers), distillation columns, and feed and material transfer lines associated with reactors, heat exchangers, vessels, columns, and units that are used in the processes of embodiments disclosed herein should be constructed of materials resistant to corrosion. Preferably, the reactors and components are made of an acid resistant alloy, e.g., nickel, a nickel-based alloys (e.g., Hastelloy®, available from Special Metals Corp.), nickel-chromium alloys commercially available under the trade name of Inconel® (hereafter “Inconel®”), or nickel-copper alloys marketed under the trade name Monel®. Alternatively, containers, piping, or reactors fabricated from less corrosive-resistant metals such as stainless steel or carbon steel may be lined with a fluoropolymer such as poly(tetrafluoroethylene). In addition to the reactors disclosed herein, preheaters and vaporizers, heat exchangers, feed and effluent lines, units associated with mass transfer, contacting vessels (pre-mixers), distillation columns, and valving associated with reactors, heat exchangers, vessels, columns, and units that are used in the processes of various embodiments disclosed herein should be constructed of materials resistant to corrosion.

[0073] As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or

apparatus. Further, unless expressly stated to the contrary, “or” refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B is true (or present).

[0074] The transitional phrase “consisting of” excludes any element, step, or ingredient not specified. If in the claim such would close the claim to the inclusion of materials other than those recited except for impurities ordinarily associated therewith. When the phrase “consists of” appears in a clause of the body of a claim, rather than immediately following the preamble, it limits only the element set forth in that clause; other elements are not excluded from the claim as a whole.

[0075] The transitional phrase “consisting essentially of” is used to define a composition, method that includes materials, steps, features, components, or elements, in addition to those literally disclosed provided that these additional included materials, steps, features, components, or elements do not materially affect the basic and novel characteristic(s) of the claimed invention, especially the mode of action to achieve the desired result of any of the processes of the present invention. The term ‘consisting essentially of’ occupies a middle ground between “comprising” and ‘consisting of.’

[0076] Where applicants have defined an invention or a portion thereof with an open-ended term such as “comprising,” it should be readily understood that (unless otherwise stated) the description should be interpreted to also include such an invention using the terms “consisting essentially of” or “consisting of.”

[0077] Also, use of “a” or “an” are employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

[0078] Where a range of numerical values is recited herein, unless otherwise stated, the range is intended to include the endpoints thereof, and all integers and fractions within the range. It is not intended that the scope of the invention be limited to the specific values recited when defining a range. Moreover, all ranges set forth herein are intended to include not only the particular ranges specifically described,

but also any combination of values therein, including the minimum and maximum values recited.

[0079] When an amount, concentration, or other value or parameter is given as either a range, preferred range or a list of upper preferable values and/or lower preferable values, this is to be understood as specifically disclosing all ranges formed from any pair of any upper range limit or preferred value and any lower range limit or preferred value, regardless of whether ranges are separately disclosed. Where a range of numerical values is recited herein, unless otherwise stated, the range is intended to include the endpoints thereof, and all integers and fractions within the range.

[0080] As used herein GC/FID peak area correlates to the amount of a compound present as a proportion of the total area of all detected peaks. FID area% can be converted to mol% using a response factor either calculated or measured

[0081] As used herein, the term “substantially free” means that less than about 0.0001 percent by weight is present (1 ppm).

[0082] As used herein the term “about” in certain embodiments can be quantified to mean $\pm 1\%$, $\pm 2\%$, $\pm 3\%$ up to and including $\pm 10\%$ of the stated value, and all whole numbers and fractions therebetween.

COMPOUND TABLE

[0083] By way of example, mention is made of the following compounds i:

TABLE 1

Name	Chemical Name	Formula
HC-170	ethane	CH ₃ CH ₃
HCO-1150	ethylene	CH ₂ =CH ₂
HCO-1140	vinyl chloride	CH ₂ =CHCl
	acetylene	CH $\equiv$ CH
HCFC-21	dichlorofluoromethane	CHCl ₂ F
HCFC-22	chlorodifluoromethane	CHClF ₂
HFC-23	trifluoromethane	CHF ₃
HCFC-31	dichlorofluoromethane	CH ₂ ClF
HFC-32	difluoromethane	CH ₂ F ₂
CFC-113	1,1,2-trichloro-1,2,2-trifluoroethane	CCl ₂ FCFCl ₂
CFC-114	1,1,2,2-tetrachloro-1,2-difluoroethane	CClF ₂ CClF ₂

Name	Chemical Name	Formula
CFC-114a	1,1,1,2-tetrachloro-2,2-difluoroethane	$\text{CF}_3\text{CCl}_2\text{F}$
HCFC-124	1-chloro-1,2,2,2-tetrafluoroethane	CHClFCHF_3
HFC-125	1,1,2,2,2-pentafluoroethane	CHF_2CF_3
HCFC-133	1-chloro-1,2,2-trifluoroethane	CHClFCHF_2
HCFC-133b	1-chloro-1,1,2-trifluoroethane	$\text{CClF}_2\text{CH}_2\text{F}$
HFC-134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3
HFC-134	1,1,2,2-tetrafluoroethane	CHF_2CHF_2
HCFC-141	1,2-dichloro-1-fluoroethane	$\text{CHClFCH}_2\text{Cl}$
HCFC-142	2-chloro-1,1-difluoroethane	$\text{CHF}_2\text{CH}_2\text{Cl}$
HCFC-142a	1-chloro-1,2-difluoroethane	$\text{CHClFCH}_2\text{F}$
HFC-143	1,1,2-trifluoroethane	CH_2FCHF_2
HFC-143a	1,1,1-trifluoroethane	CH_3CF_3
HCFC-151a	1-chloro-1-fluoroethane	CHClFCH_3
HFC-152	1,2-difluoroethane	$\text{CH}_2\text{FCH}_2\text{F}$
HFC-152a	1,1-difluoroethane	CHF_2CH_3
HCC-160	chloroethane	CH_2ClCH_3
HFC-161	fluoroethane	$\text{CH}_3\text{CH}_2\text{F}$
HFC-236fa	1,1,1,3,3,3-hexafluoropropane	$\text{CF}_3\text{CH}_2\text{CF}_3$
HFC-245cb	1,1,1,2,2-pentafluoropropane	$\text{CH}_3\text{CF}_2\text{CF}_3$
FC-C318	octafluorocyclobutane	$\text{cyclo-CF}_2\text{CF}_2\text{CF}_2\text{CF}_2$
CFO-1113	1-chloro-1,2,2-trifluoroethene	$\text{CClF}=\text{CF}_2$
FO-1114	tetrafluoroethene	$\text{CF}_2=\text{CF}_2$
HCFO-1122	1-chloro-2,2-difluoroethylene,	$\text{CHCl}=\text{CF}_2$
HCFO-1122a	E/Z-1-chloro-1,2-difluoroethylene,	$\text{E/Z-CClF}=\text{CHF}$
HFO-1123	1,1,2-trifluoroethylene	$\text{CF}_2=\text{CHF}$
HCFO-1131	E/Z-1-chloro-2-fluoroethylene,	$\text{E/Z-CHCl}=\text{CHF}$
HCFO-1131a	1-chloro-1-fluoroethylene,	$\text{CH}_2=\text{CClF}$
HFO-1132	E/Z-1,2-difluoroethylene,	$\text{E/Z-CHF}=\text{CHF}$
HFO-1132a	1,1-difluoroethylene	$\text{CF}_2=\text{CH}_2$
HFO-1141	fluoroethylene	$\text{CHF}=\text{CH}_2$
FO-1318my	E/Z-1,1,1,2,3,4,4,4-octafluoro-2-butene	$\text{E/Z-CF}_3\text{CF}=\text{CFCF}_3$

[0084] Some of the compounds present in the compositions of the present invention identified in Table 1 may exist as different configurational isomers or stereoisomers. The present invention is intended to include all single configurational isomers, single stereoisomers or any combination or mixture thereof. For instance, 1,2-difluoroethylene (HFO-1132) is meant to represent the cis-isomer (Z), trans-isomer (E), or any combination or mixture of both isomers in any ratio. Similarly, 1-chloro-1,2-difluoroethylene (HFO-1122a) exists as the Z-isomer, E-isomer, or any combination or mixture of both isomers in any ratio. Single isomers or multiple isomers of the same compound may be used in any proportion.

[0085] One embodiment disclosed herein relates to a process comprising, consisting essentially or, or consisting of converting a tetrahaloethane selected from the group consisting of $\text{CH}_2\text{FCX}_2\text{F}$ or CHXFCHXF wherein X is independently selected from the group consisting of F, Cl, Br, or I to a mixture of E-1,2-difluoroethylene and Z-1,2-difluoroethylene at a Z/E ratio of >1.1 .

[0086] Another embodiment disclosed herein relates to a process comprising, consisting essentially or, or consisting of converting at least one compound selected from the group consisting of $\text{CH}_2\text{FCCl}_2\text{F}$ or CHClFCHClF to a mixture of E-1,2-difluoroethylene and Z-1,2-difluoroethylene at a Z/E ratio of $>1.1:1$. The process comprises (i) dehydrochlorination of mixture of $\text{CH}_2\text{FCCl}_2\text{F}$ and/or CHClFCHClF to a mixture of E- and Z-HCFO-1122a, (ii) hydrogenation of the mixture of E- and Z-HCFO-1122a to a mixture comprising HCFC-142a, and (iii) dehydrochlorination of said mixture comprising HCFC-142a to a mixture of E-1,2-difluoroethylene and Z-1,2-difluoroethylene at a Z/E ratio of $>1.1:1$.

[0087] Another embodiment disclosed herein relates to a process comprising, consisting essentially or, or consisting of converting at least one compound selected from the group consisting of $\text{CH}_2\text{FCCl}_2\text{F}$ or CHClFCHClF to a mixture comprising HCFC-142a by contacting said mixture with hydrogen in a reaction zone in the vapor phase in the presence of a catalyst.

[0088] In one embodiment disclosed herein relates an integrated process comprising, consisting essentially or, or consisting of first converting one of (i) 1,1,1,2-tetrafluoroethane (HFC-134a) containing two or more of the following compounds selected from HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161, or (ii) 1,1,2,2-tetrafluoroethane HFC-134 containing two or more the following compounds selected from HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161 to 1,1,2-trifluoroethylene (HFO-1123), which is converted to 1,1,2-trifluoroethane and then dehydrofluorinated to a mixture of E-1,2-difluoroethylene and Z-1,2-difluoroethylene at an E/Z ratio of less than 1.

[0089] Certain embodiments disclosed herein relate to a process comprising, consisting essentially of, or consisting of converting 1,1,2-trifluoroethane to E-1,2-difluoroethylene, Z-1,2-difluoroethylene and mixtures thereof.

[0090] One embodiment disclosed herein relates to a process for heating a mixture of HFO-Z-1132 and HFO-E-1132 at temperature $\geq 600^{\circ}\text{C}$ to isomerize at least a portion of HFO-Z-1132 into HFO-E-1132.

[0091] In certain embodiments disclosed herein dehydrofluorination of HFC-134 or HFC-134a is conducted in the gas phase at a temperature between 200°C to 500°C , including but not limited to 200°C , 210°C , 220°C , 230°C , 240°C , 250°C , 260°C , 270°C , 280°C , 290°C , 300°C , 310°C , 320°C , 330°C , 340°C , 350°C , 360°C , 370°C , 380°C , 390°C , 400°C , 410°C , 420°C , 430°C , 440°C , 450°C , 460°C , 470°C , 480°C , 490°C , 500°C , and all values and ranges therebetween, including, but not limited to 200°C to 500°C , 250°C to 450°C , 300°C to 400°C , 250°C to 500°C , 250°C to 400°C , and 250°C to 350°C .

[0092] In certain embodiments disclosed herein hydrogenation of HFO-1123 is conducted in the gas phase at a temperature between 50°C to 200°C , including but not limited to 50°C , 60°C , 70°C , 80°C , 90°C , 100°C , 110°C , 120°C , 130°C , 140°C , 150°C , 160°C , 170°C , 180°C , 190°C or 200°C , and all values and ranges therebetween 50°C to 200°C , including, but not limited to 50°C to 200°C , 50°C to 175°C , 50°C to 150°C , 50°C to 125°C , 50°C to 100°C , 75°C to 200°C , 75°C to 175°C , 75°C to 150°C , 75°C to 125°C , 75°C to 100°C , 100°C to 200°C , 100°C to 175°C , or 100°C to 150°C .

[0093] In certain embodiments disclosed herein hydrogenation of HFO-1123 is conducted in the gas phase at a temperature between 50°C and 200°C , preferably with a $\text{H}_2/1123$ molar feed ratio of from about 0.2:1 to about 2:1, including but not limited to 0.2:1, 0.3:1, 0.4:1, 0.5:1, 1:1, 1.2:1, 1.4:1, 1.6:1, 1.8:1, and 2:1.

[0094] In certain embodiments disclosed herein hydrogenation of HFO-1123 is conducted in the gas phase, at a $\text{H}_2/1123$ mol ratio of between 0.2:1 and 2:1 at a temperature between 50°C and 200°C in the presence of a catalyst selected from a palladium catalyst, including but not limited to palladium supported on carbon, alumina, or chromia.

[0095] In certain embodiments disclosed herein hydrogenation of HFO-1123 is conducted in the liquid phase at a temperature between 30°C and 150°C, including but not limited to 30°C, 40°C, 50°C, 60°C, 70°C, 80°C, 90°C, 100°C, 110°C, 120°C, 130°C, 140°C or 150°C, between one of 30°C, 40°C, 50°C, 60°C, 70°C, 80°C, 90°C, 100°C, 110°C, 120°C, 130°C, or 140°C and 150°C, and all values and ranges therebetween 30°C and 150°C.

[0096] In certain embodiments disclosed herein dehydrofluorination of HFC-143 is conducted in the gas phase at a temperature between 150°C and 400°C, including but not limited to 150°C, 160°C, 170°C, 180°C, 190°C, 200°C, 210°C, 220°C, 230°C, 240°C, 250°C, 260°C, 270°C, 280°C, 290°C, 300°C, 310°C, 320°C, 330°C, 340°C, 350°C, 360°C, 370°C, 380°C, 390°C, or 400°C, or between 200°C and 350°C, 250°C and 300°C, 150°C and 350°C, 150°C and 300°C, 150°C and 250°C, 200°C and 400°C, 200°C and 300°C, and all values and ranges between 150°C and 400°C, in the presence of a catalyst selected from Cr₂O₃, fluorided Cr₂O₃, Al₂O₃, fluorided Al₂O₃, or AlF₃, chromium supported on alumina, fluorided alumina, or AlF₃, or cobalt- or nickel-substituted chromium oxide as disclosed in U.S. 7,217,678.

[0097] In certain embodiments disclosed herein conversion of HFC-143 to HFO-1123 in the liquid phase is conducted at a temperature between -55°C, -45°C, -35°C, -25°C, -15°C, 0°C, 5°C, 15°C, 25°C, 35°C, or 45°C and 50°C, in the presence of a strong base and solvent, including but not limited to and alkali metal hydroxide in water in the presence of a phase transfer catalyst.

[0098] In certain embodiments disclosed herein conversion of HFC-143 in the liquid phase is conducted at a temperature between -20°C and 150°C, including but not limited to -20°C, -10°C, 0°C, 10°C, 20°C, 30°C, 40°C, 50°C, 60°C, 70°C, 80°C, 90°C, 100°C, 110°C, 120°C, 130°C, 140°C, 150°C, between -20°C and 130°C, -20°C and 110°C, -20°C and 90°C, 0°C and 150°C, 0°C and 130°C, 0°C and 110°C, 0°C and 90°C, 20°C and 150°C, 20°C and 130°C, 20°C and 110°C, 20°C and 90°C and all values and ranges between -20°C and 150°, in the presence of a strong base and solvent including but not limited to alkali metal hydroxides in water in the presence of a phase transfer catalyst.

[0099] In certain embodiments disclosed herein dehydrofluorination of HFC-143 in the liquid phase is conducted at a temperature between -20°C and 150°C, by

reaction with an alkaline or alkaline-earth metal alkoxide, an alkaline or alkaline-earth metal hydride, an organometallic lithium compound, or an alkaline or an alkaline-earth metal amide, in the presence of an aprotic organic solvent comprising an acyclic or cyclic ether, optionally in the presence of a catalyst comprising a Crown ether or cryptand, wherein the alkaline metal or alkaline-earth metal alkoxide comprises lithium methoxide, sodium methoxide, sodium ethoxide, potassium tert-butoxide, sodium tert-butoxide, sodium isopropoxide, or magnesium ethoxide, the alkaline or alkaline-earth metal hydride comprises lithium hydride, sodium hydride, potassium hydride, or calcium hydride, the organometallic lithium compound comprises n-butyl lithium, methyl lithium, or isopropyl lithium, and the alkaline or an alkaline-earth metal amide comprises lithium dimethylamide, lithium diethylamide, lithium diisopropylamide, or magnesium bis(diisopropylamide) wherein the alkaline metal is a Group 1A metal of the Periodic Table excluding hydrogen and the alkaline-earth metal is a Group 2A metal of the Periodic Table excluding beryllium. Said liquid phase dehydrofluorination preferably in the presence of an aprotic organic solvent, wherein the solvent includes, but is not limited to, ethers such as tetrahydrofuran, ethylene glycol dimethyl ether, diethylene glycol dimethyl ether, tetrahydrofuran, and dioxane and polar aprotic solvents such as dimethylformamide (DMF), *N,N*-dimethylacetamide (DMAc), dimethyl sulfoxide (DMSO), *N*-methyl pyrrolidinone (NMP).

[0100] One embodiment disclosed herein relates to a process wherein the dehydrofluorination of step (1) is conducted in the vapor phase, the hydrogenation of step (2) is conducted in the liquid phase and the dehydrofluorination of step (3) is conducted in the vapor phase, and the isomerization of HFO-Z-1132 is conducted at temperatures above 600°C, preferable between 600°C and 800°C.

[0101] One embodiment disclosed herein relates to a process wherein the dehydrofluorination of step (1) or step (1a) is conducted in the vapor phase, the hydrogenation of step (2) is conducted in the vapor phase and the dehydrofluorination of step (3) is conducted in the liquid phase, and the isomerization of HFO-Z-1132 is conducted at temperatures above 600°C, preferable between 600°C and 800°C.

[0102] Certain process embodiments disclosed herein isomerize HFO-Z-1132 to HFO-E-1132 at temperatures between 600°C and 800°C.

[0103] In certain embodiments disclosed herein isomerization is conducted at temperature between 600°C and 800°C, including but not limited to 600°C, 610°C, 620°C, 630°C, 640°C, 650°C, 660°C, 670°C, 680°C, 690°C, 700°C, 710°C, 720°C, 730°C, 740°C, 750°C, 760°C, 770°C, 780°C, 790°C, or 800°C, and all values and ranges between 600°C and 800°C, 600°C to 690°C, 610°C to 690°C, 600°C to 680°C, 600°C to 670°C, 600°C to 660°C, 700°C to 800°C, 710°C to 790°C or 800°C, 720°C to 780°C, 790°C or 800°C, or 730°C to 750°C, 760°C, 770°C, 780°C, 790°C or 800°C.

[0104] In certain embodiments disclosed herein isomerization is conducted at in the presence of a catalyst selected from Cr₂O₃, fluorided Cr₂O₃, Al₂O₃, fluorided Al₂O₃, or AlF₃, chromium supported on alumina, fluorided alumina, or AlF₃, or cobalt- or nickel-substituted chromium oxide as disclosed in U.S. 7,217,678 at a temperature of between about 250°C and about 400°C.

[0105] Certain embodiments disclosed herein relate to recovering at least one of HFO-1123 and HFC-143, respectively, prior to hydrogenation and dehydrofluorination.

[0106] Certain embodiments disclosed herein relate to directly conveying and subjecting an HFO-1123 product mixture to hydrogenation.

[0107] Certain embodiments disclosed herein relate to subjecting an HFO-1123 product stream to mixture to hydrodefluorination.

[0108] Certain embodiments disclosed herein relate to recovering HFO-1123 prior to hydrogenation to HFC-143.

[0109] Certain embodiments disclosed herein relate to recovering HFC-143 prior to dehydrofluorination to HFO-Z-1132 and HFO-E-1132.

[0110] Certain embodiments disclosed herein relating to recovering at least one of HFO-1123 and HFC-143, respectively, prior to hydrogenation and dehydrofluorination, comprises separation using one or more distillation and/scrubbers.

[0111] In certain embodiments disclosed herein relating to recovering HFO-1123 prior to hydrogenation to HFC-143, comprise separation using one or more distillation and/scrubbers.

[0112] Certain embodiments disclosed herein relate to recovering HFC-143 prior to dehydrofluorination to HFO-Z-1132 and HFO-E-1132.

[0113] Certain embodiments disclosed herein relate to recovering to HFO-Z-1132 and HFO-E-1132, and optionally separating HFO-Z-1132 from HFO-E-1132, followed by isomerizing at least a portion of HFO-Z-1132 to HFO-E-1132 at temperatures between 600°C and 800°C.

[0114] In some embodiments, the process further comprises separating the E-isomer of HFO-1132 from the Z-isomer, for example by simple or fractional distillation or an extractive distillation of the HFO-E/Z-1132 produced by reaction (3), to provide at least one first fraction which comprises HFO-E-1132 and is free of or substantially free of HFO-Z-1132 and a second fraction which comprises HFO-Z-1132 and small amounts of HFO-E-1132. For example, in one embodiment, the first fraction comprises greater than about 99 wt.% HFO-E-1132 and less than about 1 wt.% HFO-Z-1132, and the second fraction comprises greater than about 99 wt.% HFO-Z-1132 and less than about 1 wt.% HFO-E-1132.

[0115] Thus, the process produces at least one fraction or composition which comprises HFO-E-1132 and is free of or substantially free of HFO-Z-1132. The process further comprises collecting the at least one first fraction as a purified composition of HFO-E-1132, and optionally further purifying the HFO-E-1132 composition (e.g., by additional distillation or solvent scrubbing as described above) to remove or reduce the amount of additional compounds present therein, such as but not limited to acetylene, fluoroacetylene, HFC-152, HCO-1140, and/or HFO-1141. Thus, the process produces a treated and purified composition comprising HFO-E-1132 and which is free of or substantially free of HFO-Z-1132, HFO-1141 and HFC-152.

[0116] In some embodiments, the process further comprises contacting the at least one second fraction (which comprises more HFO-Z-1132 than HFO-E-1132) with hydrogen fluoride (HF) under conditions to convert the HFO-Z-1132 and HFO-E-1132 to HFC-143. The hydrofluorination of the HFO-E/Z-1132 mixture to produce

HFC-143 is followed by dehydrofluorination of the HFC-143 under conditions to convert the HFC-143 to HFO-E/Z-1132 as disclosed herein with respect to reaction (3). The resulting HFO-E/Z-1132 is then recycled to the simple or fractional distillation or extractive distillation. Thus, in this manner, the second fraction rich in HFO-Z-1132 can be processed to make additional amounts of HFO-E-1132.

EXAMPLES

Examples 1 and 2

[0117] **Step 1:** 1,1,1,2-tetrafluoroethane (HFC-134a) $\rightarrow$ 1123 (~15 mol %)+ HF

[0118] **Step 1a:** 1,1,2,2-tetrafluoroethane (HFC-134) $\rightarrow$ 1123 (~10 mol %) + HF

PREPARATION OF DEHYDROFLUORINATION CATALYST

[0119] Catalysts suitable for dehydrofluorination of tetrafluoroethane isomers $\text{CF}_3\text{CH}_2\text{F}$ and CHF_2CHF_2 or mixtures thereof include chromium(III) oxide (Cr_2O_3), aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, chromium oxide/aluminum oxide mixtures, chromium oxide supported on AlF_3 , chromium fluoride, cubic chromium fluoride as disclosed in U.S. Patent No. 6,031,141 or cobalt- or nickel-substituted chromium oxide as disclosed in U.S. Patent No. 7,217,678, the disclosure of which are incorporated herein by reference in their entirety.

Example 1

[0120] A 15 inch (38 cm) by 3/8 inch (0.95 cm) outer diameter tubing fabricated from Hastelloy™ C is charged with 12-20 mesh gamma-alumina (8.0 g, about 13 cc). The catalyst is activated by heating in a nitrogen stream (50 sccm, $8.3 \times 10^{-7} \text{ m}^3/\text{s}$) for 20 minutes at 200°C, 20 minutes at 325°C, and 20 minutes at 400°C. The temperature is reduced to 300°C and the nitrogen flow reduced to 35 sccm ($5.8 \times 10^{-7} \text{ m}^3/\text{s}$). After 30 minutes, HF is co-fed to the tube at a flow rate of 12 sccm ($2.0 \times 10^{-7} \text{ m}^3/\text{s}$) for 30 minutes. The temperature is then raised to 325°C, 350°C, 375°C, 400°C, and 425°C in with 60-minute hold periods at each temperature. The nitrogen and HF flows are then adjusted to 25 sccm ($4.2 \times 10^{-7} \text{ m}^3/\text{s}$) and 20 sccm ($3.3 \times 10^{-7} \text{ m}^3/\text{s}$), respectively, and held for 20 minutes. The nitrogen and HF flows are then adjusted

to 15 sccm (2.5×10^{-7} m³/s) and 28 sccm (4.7×10^{-7} m³/s), respectively, and held for 20 minutes. The nitrogen and HF flows are then adjusted to 5 sccm (8.3×10^{-8} m³/s) and 36 sccm (6.0×10^{-7} m³/s), respectively, and held for 20 minutes. Finally, the nitrogen flow is curtailed, and HF is fed at 40 sccm (6.7×10^{-7} m³/s) for two hours at 425°C. Nitrogen is then fed to the reactor at 20 sccm (3.3×10^{-7} m³/s) and HF flow is turned off as the reactor cools to 375°C.

[0121] A mixture of nitrogen and 1,1,1,2-tetrafluoroethane (HFC-134a) and at least two of the compounds from HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, and CFC-114a are fed to the reactor at flow rates of 20 sccm (3.3×10^{-7} m³/s). The reactor effluent is primarily CH₂FCF₃ (85 mol %) and CF₂=CHF (15 mol %) as determined by GC-MS.

Example 2

[0122] A mixture of nitrogen (20 sccm, 3.3×10^{-7} m³/s) and 1,1,2,2-tetrafluoroethane (HFC-134) (20 sccm, 3.3×10^{-7} m³/s) and at least two of the compounds from the list of HFC-134a, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a are co-fed to the reactor containing the fluorided gamma alumina described above in **Example 1**. At 375°C, the reactor effluent is primarily CHF₂CHF₂ (90 mol %) and CF₂=CHF (10 mol %) as determined by GC-MS.

Examples 3-4

[0123] STEP 2: 1,1,2-trifluoroethylene + H₂ → 1,1,2-trifluoroethane (HFC-143)

Example 3: Preparation of 98% Chromium/2%

Palladium Hydrogenation Catalyst

[0124] A solution of 760.28 g Cr(NO₃)₃[9(H₂O)] (1.90 moles) and 10.1 g Pd(NO₃)₂[2(H₂O)] (0.038 mole) is prepared in 2000 mL of deionized water. The pH of the solution is adjusted to 8.5 by treatment with 7.4M aqueous ammonium hydroxide. The resulting slurry is stirred at room temperature overnight and then dried at 110-120°C in air for 48 hours. The dried solid is crushed to a powder and calcined in air at 400°C for 24 hours. The calcined powder is pressed into disks, broken up, and

sieved to provide a –10 to +20 mesh (1.68 to 0.84 mm) fraction used for catalyst evaluation.

Example 4: Hydrogenation of Trifluoroethene

[0125] A 15 mL portion (19 g) of the granulated Cr/Pd (98/2) catalyst is placed in a 5/8" (1.58 cm) diameter Inconel™ nickel alloy reactor tube heated in a fluidized sand bath. The catalyst is dried in a stream of nitrogen (20 cc/min) over the course of 1.5 h as the temperature is raised from 34°C to 150°C. The nitrogen flow is then replaced with hydrogen (20 cc). The catalyst is reduced for 3 h at 150°C and for 3 h at 200°C. The performance of the catalyst for hydrogenation of trifluoroethene and at least one or more of the compounds selected from 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), 1-chloro-2,2-difluoroethylene (HCFO-1122) is then tested at 75°C to 250°C at various ratios of H₂ to CHF=CF₂. At a H₂/CHF=CF₂ ratio of 1/1 and a reaction temperature of 175°C and a contact time of 15 seconds, the reactor effluent is primarily CHF₂CHF₂ (85 mol %) and CHF=CF₂ (15 mol %) with small amounts of C₂H₆ (0.2%), C₂H₂F₂ isomers (0.2%), CH₂FCF₃ (0.2%), and CH₃CHF₂ (0.5%) as determined by GC-MS.

Examples 5 and 6

[0126] Step 3: HFC-143 → Z-1,2-difluoroethene (Z-HFO-1132) + E-1,2-difluoroethene (HFO-E-1132) + HF

Example 5-Gas/Vapor Phase Dehydrofluorination

[0127] An Inconel® pipe (0.5-inch OD, 10-inch length, 0.35 in wall thickness) is filled with 2 cc of Cr₂O₃ catalyst. The reactor is heated to 375°C under a flow of nitrogen optionally with an oxygen containing gas. HFC-143 and at least two of the compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-

143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene is fed at 4.23 mL/hr via an ISCO pump via a vaporizer controlled at 20°C. The pressure of the reaction during the run is varied from 0 to 50 psig. The effluent of the reactor is analyzed online using an Agilent® 7890 GC/5971 MS. HFC-143 conversion is 53% with 90% 1132 selectivity. The Z-1132 to E-1132 ratio is about 4 to 1.

Example 6 Liquid Phase Dehydrofluorination

[0128] A mixture of CF_2HCFH_2 and at least two of the compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene (84 g, 1 mol) and potassium tert-butoxide (80 g, 1 mmol) in anhydrous DMF (200 ml) is stirred in a 400 mL autoclave at 0°C. Gas chromatography is used to monitor the reaction. After 3 hours, 43 g product $\text{CFH}=\text{CFCH}$ (conversion 70%, selectivity 96%) is collected in dry ice trap. The ratio of Z-1132 and E-1132 is about 9 to 1.

Example 7: Thermal Isomerization

[0129] **Step 4:** HFO-Z-1132 → HFO-E-1132

[0130] A mixture of HFO-Z-1132 and HFO-E-1132 having a E/Z molar ratio of 1/100 is passed into a Hastelloy™ C tube (0.5-inch OD, 10 inch length, 0.35 in wall thickness) resting in an electrically heated tube furnace. The heated zone is held at a temperature between 600°C and 800°C with a residence time sufficient to produce a mixture of HFO-Z-1132 and HFO-E-1132 in which the Z/E ratio mixture of HFO-Z-1132 and HFO-E-1132 is 1.2 to 1 to 3 to 1, including 1.2:1, 1.5:1, 1.6:1, 1.8:1, 1.9:1 20:1 to 3:1 and all values and ranges between 1: 1 and 3: 1.

Example 7A: Thermal Isomerization

[0131] **Step 4A:** HFO-E-1132 → HFO-Z-1132

[0132] An E isomer enriched mixture of HFO-Z-1132 and HFO-E-1132 having a mol ratio of 1/15 is passed into a Hastelloy™ C tube (0.5-inch OD, 10-inch length, 0.35 in wall thickness) resting in an electrically heated tube furnace. The heated zone is held at a temperature between 600°C and 800°C with a residence time sufficient to produce a mixture of HFO-Z-1132 and HFO-E-1132 in which the Z/E ratio is increased to 0.8 to 1, 0.9:1, 1:1, 1.2:1, 1.3 to 1, 1.4:1,

Example 8 Catalytic Isomerization

[0133] **Step 4:** HFO-Z-1132 → HFO-E-1132

[0134] An Hastelloy™ C tube resting in a Lindberg furnace (0.5-inch OD, 15-inch length, 0.34 in wall thickness) is filled with 12 cc of Cr₂O₃ catalyst. The catalyst is activated with anhydrous HF at 300°C. A mixture of HFO-Z-1132 and HFO-E-1132 having a E/Z molar ratio of 1:100, optionally in the presence of an oxygen containing gas, is passed into the tube at a flow rate of 20 cc/min (3.3(10)⁻⁷m³/sec) along with a nitrogen co-feed of 20 cc/min. At a reaction zone temperature of 350°C, a new mixture of HFO-Z-1132 and HFO-E-1132 in which the E/Z ratio varies from about 1:1.4 to about 1:3 is obtained.

Example 8A Catalytic Isomerization

[0135] **Step 4A:** HFO-E-1132 → HFO-Z-1132

[0136] An Hastelloy™ C tube resting in a Lindberg furnace (0.5-inch OD, 15-inch length, 0.34 in wall thickness) is filled with 12 cc of Cr₂O₃ catalyst. The catalyst is activated with anhydrous HF at 300°C. A mixture of HFO-Z-1132 and HFO-E-1132 having a mol ratio of 1/15, optionally in the presence of an oxygen containing gas, is passed into the tube at a flow rate of 20 cc/min (3.3(10)⁻⁷m³/sec) along with a nitrogen co-feed of 20 cc/min. At a reaction zone temperature of 350°C, a new mixture of HFO-Z-1132 and HFO-E-1132 in which the Z/E ratio is increased is obtained from 0.5:1 to about 2 :1 obtained.

[0137] In certain embodiments disclosed herein the amount of each compound in addition to HFO-E-1132 and HFO-Z-1132 is independently between >0 and ≤about 0.1 weight % as measured by gas chromatography or between ≥0.0001 and <0.9 weight %, and all values and ranges therebetween. provided that the total amount of additional compounds is between >0 and <about 1%by weight.

[0138] In certain embodiments disclosed herein the amount of each compound in addition to HFO-E-1132 and HFO-Z-1132 selected from HFO-1141, HFO-1123, acetylene, HCFO-E-1131, HFC-125, HFC-32, HCFO-1131a, HCFO-Z-1122a, HCFO-E-1122a, HCFO-1122, and HCO-1140 is independently between >0 and ≤about 0.1 weight % as measured by gas chromatography or between ≥0.0001 and <0.9 weight %, and all values and ranges therebetween. provided that the total amount of additional compounds is between >0 and <about 1%by weight.

CLAIM EMBODIMENTS

[0139] Embodiment 1. A process comprising,

- (a) converting a tetrafluoroethane feed selected from one of a 1,1,1,2-tetrafluoroethane (HFC-134a) feed or a 1,1,2,2-tetrafluoroethane (HFC-134) feed to a first product mixture comprising 1,1,2-trifluoroethylene (HFO-1123),
- (b) contacting the first product mixture comprising HFO-1123 and hydrogen to form a second product mixture comprising 1,1,1-trifluoroethane (HFC-143), and

- (c) converting the second product mixture comprising HFC-143 to a third product mixture comprising E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132).

[0140] Embodiment 2. The process of Embodiment 1, wherein the HFC-134 feed comprises (i) mainly HFC-134 and at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a, or (ii) mainly HFC-134a and at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161.

[0141] Embodiment 3: The process of Embodiment 1, wherein the HFC-134a feed comprises (i) mainly HFC-134a and the balance comprises at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a, or (ii) mainly HFC-134 and the balance comprises at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161.

[0142] Embodiment 4. The process of any of Embodiments 1 to 3, wherein the first product mixture comprises HFO-1123 and one or more additional compounds selected from the group consisting of 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), 1-chloro-2,2-difluoroethylene (HCFO-1122).

[0143] Embodiment 5. The process of any of Embodiments 1 to 4, preferably of Embodiment 4, wherein the second product mixture comprises HFC-143 and one of more additional compounds selected from the group consisting of 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-

1132, HFO-E-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), 1-chloro-1,2-difluoroethylene (HCFO-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene.

[0144] Embodiment 6. The process of any of Embodiments 1 to 5, preferably of Embodiment 5, wherein the third product mixture comprises one of:

- i. HFO-E-1132 and one or more additional compounds selected from the group consisting of HFO-Z-1132, acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), or
- ii. HFO-Z-1132 and one or more additional compounds selected from the group consisting of HFO-E-1132, acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1,1-

dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122).

[0145] Embodiment 7. The process of any of Embodiments 1 to 6, wherein at least a portion of the Z-1,2-difluoroethylene (HFO-Z-1132) in the third product mixture is isomerized to E-1,2-difluoroethylene (HFO-E-1132) to form an isomerized mixture having a greater E/Z ratio compared to the third product mixture.

[0146] Embodiment 8. The process of Embodiment 7, wherein a majority portion of the Z-1,2-difluoroethylene (HFO-Z-1132) in the third product mixture is isomerized to E-1,2-difluoroethylene (HFO-E-1132) to form an isomerized mixture having a greater E/Z ratio compared to the third product mixture.

[0147] Embodiment 9. The process of Embodiment 7 or Embodiment 8, wherein the isomerization is conducted at a temperature between 600°C and 800°C .

[0148] Embodiment 10. The process of any of Embodiments 7 to 9, wherein the isomerization is conducted in the presence of a catalyst.

[0149] Embodiment 11. The process of Embodiment 10, wherein the catalyst comprises a material selected from the group consisting of Cr_2O_3 , fluorided Cr_2O_3 , Al_2O_3 , fluorided Al_2O_3 , AlF_3 , chromium supported on alumina, and cobalt- or nickel-substituted chromium oxide.

[0150] Embodiment 12. The process of any of Embodiments 7 to 11, wherein one of the third product mixture or the isomerized mixture is substantially free of vinyl chloride (HCO-1140), acetylene, fluoroacetylene, and fluoroethylene (HFO-1141).

[0151] Embodiment 13. The process of any of Embodiments 7 to 12, wherein the amount of each of vinyl chloride (HCO-1140), acetylene, fluoroacetylene, and fluoroethylene (HFO-1141) in one of the third product mixture or the isomerized mixture is selected from one of < 200 ppm, < 100 ppm, < 50 ppm, < 10 ppm, or < 5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

[0152] Embodiment 14. The process of any of Embodiments 1 to 13, wherein the converting the 1,1,1,2-tetrafluoroethane (HFC-134a) feed or the 1,1,2,2-tetrafluoroethane (HFC-134) feed comprises dehydrofluorination, optionally in the presence of HF, to form the first 1,1,2-trifluoroethylene (HFO-1123) product mixture.

[0153] Embodiment 15. The process of Embodiment 14, wherein the dehydrofluorination is conducted in the gas phase at a temperature of between 200°C and 500°C.

[0154] Embodiment 16. The process of Embodiment 14 or Embodiment 15, wherein the dehydrofluorination is conducted in the presence of a catalyst.

[0155] Embodiment 17. The process of Embodiment 16, wherein the catalyst comprises a material selected from the group consisting of chromium(III) oxide (Cr_2O_3), aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, chromium oxide/aluminum oxide mixtures, chromium oxide supported on AlF_3 , chromium fluoride and cubic chromium fluoride, preferably one of aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), or fluorided alumina.

[0156] Embodiment 18. The process of any of Embodiments 1 to 17, wherein the contacting of HFO-1123 and hydrogen is conducted in a liquid phase or vapor phase and comprises hydrogenation of the first product mixture comprising 1,1,2-trifluoroethylene to the second product mixture comprising 1,1,1-trifluoroethane (HFC-143).

[0157] Embodiment 19. The process of Embodiment 18, wherein the contacting of HFO-1123 and hydrogen is conducted in the liquid phase.

[0158] Embodiment 20. The process of Embodiment 19, wherein the hydrogenation is conducted in the liquid phase at a temperature between 30°C and 150°C.

[0159] Embodiment 21. The process of Embodiment 18, wherein the contacting of the 1,1,2-trifluoroethylene (HFO-1123) and hydrogen is conducted in the vapor phase in the presence of a catalyst, optionally supported on carbon.

[0160] Embodiment 22. The process of Embodiment 21, wherein the hydrogenation is conducted in the vapor phase at a temperature between 50°C and 200°C.

[0161] Embodiment 23. The process of any of Embodiments 1 to 20, wherein the converting of the second product mixture comprising HFC-143 involves dehydrofluorination conducted in a liquid phase or vapor phase to form the third product mixture of Z-1,2-difluoroethylene (HFO-Z-1132) and E-1,2-difluoroethylene (HFO-E-1132).

[0162] Embodiment 24. The process of Embodiment 23, wherein dehydrofluorination of 1,1,2-trifluoroethane (HFC-143) in the second product mixture is conducted in the liquid phase at a temperature between -20°C and 150°C.

[0163] Embodiment 25. The process of Embodiment 24, wherein dehydrofluorination of 1,1,2-trifluoroethane (HFC-143) in the second product mixture is conducted at a temperature between -20°C and 100°C.

[0164] Embodiment 26. The process of Embodiment 23, wherein the dehydrofluorination of the second product mixture comprising HFC-143 is conducted in the liquid phase in the presence of a strong base, a polar solvent, and optionally in the presence of phase transfer catalyst.

[0165] Embodiment 27. The process of Embodiment 23, wherein the dehydrofluorination of the second product mixture comprising HFC-143 is conducted in the liquid phase in the presence of a strong base comprising an alkaline or alkaline earth metal alkoxide, where the alkali metal is a Group 1A metal excluding hydrogen and the alkaline earth metal is a Group 2A metal excluding beryllium, and in the presence of an organic solvent selected from an acyclic or cyclic ether, optionally in the presence of a catalyst comprising a Crown ether or cryptand.

[0166] Embodiment 28. The process of Embodiment 23, wherein dehydrofluorination of 1,1,2-trifluoroethane (HFC-143) in the second mixture is conducted in the vapor phase at a temperature between 150°C and 400°C.

[0167] Embodiment 29. The process of Embodiment 23, where dehydrofluorination of 1,1,2-trifluoroethane (HFC-143) is conducted in the gas phase in the presence of a catalyst which may be the same of different than catalyst used

for converting 1,1,1,2-tetrafluoroethane (HFC-134a) or 1,1,2,2-tetrafluoroethane (HFC-134).

[0168] Embodiment 30. The process of Embodiment 29, wherein the catalysts are the same.

[0169] Embodiment 31. The process of Embodiment 29, wherein the catalyst for converting HFC-143 is different from the catalyst for converting HFC-134a/HFC-134.

[0170] Embodiment 32. The process of Embodiment 29, wherein catalyst for converting HFC-143 comprises a material selected from the group consisting of chromium(III) oxide (Cr_2O_3), aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, chromium oxide/aluminum oxide mixtures, chromium oxide supported on AlF_3 , chromium fluoride and cubic chromium fluoride, preferably one of aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina.

[0171] Embodiment 33. A composition formed by the method of any of Embodiments 1-32.

[0172] Embodiment 34. A composition comprising HFO-1123 and at least one additional compound, preferably at least two additional compounds, selected from the group consisting of CFO-1113, HFO-1132a, and HFO-1141.

[0173] Embodiment 35. A composition comprising HFC-143 and at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFO-1123, HFC-134a, HFC-152a, HFC-236fa, HFO-E-1132, HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, HCO-1140, HCFC-133b, HCFC-133a, HCFO-Z-1131, HCFO-E-1131, HCFC-151a, HCC-160, and CFC-113.

[0174] Embodiment 36. An HFO-E/Z-1132 composition comprising at least one compound selected from fluoroacetylene, HFO-1141, HCO-1140, or acetylene, each compound, if present, is contained in the composition in an amount selected from one of <200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

[0175] Embodiment 37. An HFO-E-1132 composition comprising at least one compound selected from fluoroacetylene, HFO-1141, HCO-1140, or acetylene, each

compound, if present, is contained in the composition in an amount selected from one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

[0176] Embodiment 38. An HFO-Z-1132 composition comprising at least one compound selected from fluoroacetylene, HFO-1141, HCO-1140, or acetylene, each compound, if present, is contained in the composition in an amount selected from one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

[0177] Embodiment 39. A composition comprising one of:

HFC-134 which comprises one or more additional compounds selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161, or

HFC-134a which comprises one or more additional compounds selected from the group consisting of HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161.

[0178] Embodiment 40. A composition comprising one of:

- (i) HFO-1123 which comprises one or more additional compounds selected from the group consisting of 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), and 1-chloro-2,2-difluoroethylene (HCFO-1122);
- (ii) HFC-143 which comprises one or more additional compounds selected from the group consisting of 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-

chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), E/Z-1-chloro-1,2-difluoroethylene (HCFO-E/Z-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene;

(iii) HFO-E-1132 which comprises (i) two or more additional compounds selected from HFO-Z-1132, acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), and (ii) optionally fluoroethylene (HFO-1141), HFO-1140, fluoroacetylene or acetylene, each in an amount which is selected from one of one of < 200 ppm, < 100 ppm, < 50 ppm, < 10 ppm, or < 5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, if present; or

(iv) HFO-Z-1132 which comprises (i) one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFO-E-1132, acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a),

vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), and (ii) optionally fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene, each in an amount which is selected from one of one of <200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, if present.

[0179] Embodiment 41. The composition of Embodiment 40 comprising (iii), wherein the amount of each of fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene is selected from one of <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

[0180] Embodiment 42. The composition of Embodiment 40 comprising (iv), wherein the amount of each of fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene is selected from one of <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

[0181] Embodiment 43. The composition of Embodiment 40, wherein composition (iii) is an isomerized composition and the amount of each of fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene is selected from one of <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

[0182] Embodiment 44. The composition of Embodiment 40, wherein composition (iv) is an isomerized composition and the amount of each of fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene is selected from one of <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

[0183] Embodiment 45. A process comprising blending the composition of any of Embodiments 41-44 with other HFC, HFO, and HCFO compounds.

[0184] Embodiment 46. A process comprising blending comprising blending the composition of any of Embodiments 41 to 44 with one or more other HFC, HFO and HCFO compounds, and using the blended composition as one of a refrigerant, solvents foam expansion agent, cleaning agent, aerosol propellant, dielectric, fire

extinguishant, and power cycle working fluid, wherein the HFC and HFO compounds are selected from the group consisting of HFO-E-1234ze, HFO-1234yf, HFC-152a, HFC-134a, HFC-134, HFO-Z--1234ze, HCFO-E-1233zd, and HFC-227ea

[0185] Embodiment 47. A process comprising,

- (a) converting a tetrafluoroethane feed selected from one of a 1,1,1,2-tetrafluoroethane (HFC-134a) feed or a 1,1,2,2-tetrafluoroethane (HFC-134) feed, to a first product mixture comprising 1,1,2-trifluoroethylene (HFO-1123),
- (b) contacting the first product mixture comprising HFO-1123 and hydrogen to form a second product mixture comprising 1,1,1-trifluoroethane (HFC-143), and
- (c) converting the second product mixture comprising HFC-143 to a third product by dehydrofluorinating the HFC-143 in the second mixture in the gas phase at a temperature of between 150°C and 400°C to form a mixture of E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132).

[0186] Embodiment 48. The process of Embodiment 47, wherein:

- (a) the tetrafluoroethane comprises one of (i) an HFC-134 feed which comprises mainly HFC-134 and one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, CHFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, and CFC-114a, or mainly HFC-134a and one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFC-134, HCFC-124, CHFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161, or (ii) an HFC-134a feed which comprises mainly HFC-134a and the balance comprises one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFC-134, HCFC-124, CHFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, and CFC-114a, or mainly HFC-134a and the balance comprises one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a,

HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161,

- (b) the first product mixture comprises HFO-1123 and one or more additional compounds selected from the group consisting of 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), and 1-chloro-2,2-difluoroethylene (HCFO-1122), and
- (c) the second product mixture comprises HFC-143 and one or more additional compounds selected from the group consisting of 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), E/Z-1-chloro-1,2-difluoroethylene (HCFO-E/Z-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene.

[0187] Embodiment 49. The process of any of Embodiments 47 or 48 wherein the dehydrofluorination is conducted in the presence of a catalyst.

[0188] Embodiment 50. A process comprising:

hydrogenating HFO-1123 to form a product mixture comprising 1,1,1-trifluoroethane (HFC-143),

dehydrofluorinating the HFC-143 in the gas phase at a temperature of between 150°C and 400°C to form a mixture of E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132), and

optionally isomerizing at least one of HFO-E-1132 and HFO-Z-1132 to increase yield.

[0189] Embodiment 51. The process of Embodiment 50, wherein the isomerization is of HFO-Z-1132 to HFO-E-1132 to increase yield of HFO-E-1132.

[0190] Embodiment 52. The process of Embodiment 50 or Embodiment 51, wherein the isomerization conducted in the presence or absence of a catalyst.

OTHER “INVENTIVE” EMBODIMENTS (OE)

- OE1.** A composition comprising HFC-134 and one, two, three or four or more additional compounds selected from HFC-134a, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161.
- OE2.** A composition comprising HFC-134a and one, two, three or four or more additional compounds selected from HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161.
- OE3.** A composition comprising HFC-143 and one, two, three or four or more additional compounds selected from 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene.

- OE4.** A composition comprising HFO-1123 and one, two, three or four or more additional compounds selected from 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), 1-chloro-2,2-difluoroethylene (HCFO-1122).
- OE5.** A composition comprising HFO-E-1132 and (i) one, two, three or four or more additional compounds selected from two or more of difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-1-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), and optionally (i) HFO-Z-1132, and if present (iii) fluoroethylene (HFO-1141), vinyl chloride (HCO-1140), acetylene or fluoroacetylene, each in an amount which is selected from one of one of < 200 ppm, < 100 ppm, < 50 ppm, < 10 ppm, or < 5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, and wherein the total amount of additional compounds is less than 1 weight percent of the total composition after purification.
- OE6.** A composition comprising HFO-Z-1132 and (i) one, two, three or four or more additional compounds selected from two or more of difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane

(HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-1-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), and optionally (ii) HFO-E-1132 and/or (iii) optionally fluoroethylene (HFO-1141), vinyl chloride (HCO-1140), acetylene or fluoroacetylene, each in an amount which is selected from one of one of <200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably in an amount of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, if present, and more preferably the composition is free of HFO-1141, HCO-1140, acetylene, or fluoroacetylene, and wherein the total amount of additional compounds is less than 1 weight percent of the total composition after purification.

- OE7.** A process comprising dehydrofluorinating an HFC-134a composition containing one or more additional members selected from HFC-134, HCFC-124, HCFO-1122, CFC-114, CFC-114a, 40, 1140, HFC-125, HFC-32, HCC-40, and HFC-143a.
- OE8.** A process comprising dehydrofluorinating an HFC-134 composition containing one or more additional members selected from HFC-134, HCFC-124, HCFO-1122, CFC-114, CFC-114a, and HFC-143a.
- OE9.** A process comprising hydrogenating an HFO-1123 composition containing one or more additional members selected from CFO-1113, HFC-134a, HFC-134, HFO-1141, HFO-1132a, and HCFO-1122.
- OE10.** A process comprising dehydrofluorinating an HFC-143 composition containing one or more additional members selected from HFO-1123, CFO-1113, HFC-134a, HFC-134, HCFO-1131a, HCFC-142, HCFC-142a, HCFO-1122, HCFO-1122a, and HCO-1140.
- OE11.** A process comprising increasing the yield of HFO-E-1132 comprising isomerizing an HFO-1132 composition containing HFO-Z-1132 and one or more additional members selected from HFO-1141, HFO-1123, acetylene, HFO-Z-1132, HCFO-E1131, HFC-125, HFC-32, HCFO-1131a, HCFO-Z-1122a, HCFO-E-1122a, HCFO-1122, and HCO-1140.

- OE12.** An HFO-E/Z-1132 composition containing fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene, each in an amount is selected from one of one of <200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.
- OE13.** An HFO-E-1132 composition containing fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene, each in an amount is selected from one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.
- OE14.** An HFO-Z-1132 composition containing fluoroethylene (HFO-1141), vinyl chloride (HCO-1140), fluoroacetylene or acetylene, each in an amount selected from one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, if present.
- OE15.** A process comprising hydrogenating HFO-1123 to form a product mixture comprising 1,1,1-trifluoroethane (HFC-143), dehydrofluorinating 1,1,2-trifluoroethane (HFC-143) in the gas phase at a temperature of between 150°C and 400°C to form a mixture of E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132), and optionally isomerizing one of 1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132) to increase yield.
- OE16.** The process of OE15 wherein isomerization conducted in the presence or absence of a catalyst.

[0191] Although certain aspects, embodiments and principals have been described above, it is understood that this description is made only way of example and not as limitation of the scope of the invention or appended claims. The foregoing various aspects, embodiments and principals can be used alone and in combinations with each other.

CLAIMS

What is claimed is:

1. A process comprising,
 - (a) converting a tetrafluoroethane feed selected from one of a 1,1,1,2-tetrafluoroethane (HFC-134a) feed or a 1,1,2,2-tetrafluoroethane (HFC-134) feed to a first product mixture comprising 1,1,2-trifluoroethylene (HFO-1123),
 - (b) contacting the first product mixture comprising HFO-1123 and hydrogen to form a second product mixture comprising 1,1,1-trifluoroethane (HFC-143), and
 - (c) converting the second product mixture comprising HFC-143 to a third product mixture comprising E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132).
2. The process of claim 1, wherein the HFC-134 feed comprises (i) mainly HFC-134 and at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a, or (ii) mainly HFC-134a and at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161.
3. The process of claim 1, wherein the HFC-134a feed comprises (i) mainly HFC-134a and the balance comprises at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114 and CFC-114a, or (ii) mainly HFC-134 and the balance comprises at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161.

4. The process of any of claims 1 to 3, wherein the first product mixture comprises HFO-1123 and one or more additional compounds selected from the group consisting of 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), 1-chloro-2,2-difluoroethylene (HCFO-1122).
5. The process of any of claims 1 to 4, preferably of claim 4, wherein the second product mixture comprises HFC-143 and one of more additional compounds selected from the group consisting of 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-1132, HFO-E-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), 1-chloro-1,2-difluoroethylene (HCFO-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene.
6. The process of any of claims 1 to 5, preferably of claim 5, wherein the third product mixture comprises one of:
 - i. HFO-E-1132 and one or more additional compounds selected from the group consisting of HFO-Z-1132, acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount

- between ≥ 0 and <100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), or
- ii. HFO-Z-1132 and one or more additional compounds selected from the group consisting of HFO-E-1132, acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and <100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122).
7. The process of any of claims 1 to 6, wherein at least a portion of the Z-1,2-difluoroethylene (HFO-Z-1132) in the third product mixture is isomerized to E-1,2-difluoroethylene (HFO-E-1132) to form an isomerized mixture having a greater E/Z ratio compared to the third product mixture.
8. The process of claim 7, wherein a majority portion of the Z-1,2-difluoroethylene (HFO-Z-1132) in the third product mixture is isomerized to E-1,2-difluoroethylene (HFO-E-1132) to form an isomerized mixture having a greater E/Z ratio compared to the third product mixture.
9. The process of claim 7 or claim 8, wherein the isomerization is conducted at a temperature between 600°C and 800°C .
10. The process of any of claims 7 to 9, wherein the isomerization is conducted in the presence of a catalyst.

11. The process of claim 10, wherein the catalyst comprises a material selected from the group consisting of Cr_2O_3 , fluorided Cr_2O_3 , Al_2O_3 , fluorided Al_2O_3 , AlF_3 , chromium supported on alumina, and cobalt- or nickel-substituted chromium oxide.
12. The process of any of claims 7 to 11, wherein one of the third product mixture or the isomerized mixture is substantially free of vinyl chloride (HCO-1140), acetylene, fluoroacetylene, and fluoroethylene (HFO-1141).
13. The process of any of claims 7 to 12, wherein the amount of each of vinyl chloride (HCO-1140), acetylene, fluoroacetylene, and fluoroethylene (HFO-1141), is present, in one of the third product mixture or the isomerized mixture is selected from one of <200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.
14. The process of any of claims 1 to 13, wherein the converting the 1,1,1,2-tetrafluoroethane (HFC-134a) feed or the 1,1,2,2-tetrafluoroethane (HFC-134) feed comprises dehydrofluorination, optionally in the presence of HF, to form the first 1,1,2-trifluoroethylene (HFO-1123) product mixture.
15. The process of claim 14, wherein the dehydrofluorination is conducted in the gas phase at a temperature of between 200°C and 500°C.
16. The process of claim 14 or claim 15, wherein the dehydrofluorination is conducted in the presence of a catalyst.
17. The process of claim 16, wherein the catalyst comprises a material selected from the group consisting of chromium (III) oxide (Cr_2O_3), aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, chromium oxide/aluminum oxide mixtures, chromium oxide supported on AlF_3 , chromium fluoride and cubic chromium fluoride, preferably one of aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), or fluorided alumina.
18. The process of any of claims 1 to 17, wherein the contacting of HFO-1123 and hydrogen is conducted in a liquid phase or vapor phase and comprises hydrogenation of the first product mixture comprising 1,1,2-trifluoroethylene to the second product mixture comprising 1,1,1-trifluoroethane (HFC-143).

19. The process of claim 18, wherein the contacting of HFO-1123 and hydrogen is conducted in the liquid phase.
20. The process of claim 19, wherein the hydrogenation is conducted in the liquid phase at a temperature between 30°C and 150°C.
21. The process of claim 18, wherein the contacting of the 1,1,2-trifluoroethylene (HFO-1123) and hydrogen is conducted in the vapor phase in the presence of a catalyst, optionally supported on carbon.
22. The process of claim 21, wherein the hydrogenation is conducted in the vapor phase at a temperature between 50°C and 200°C.
23. The process of any of claims 1 to 20, wherein the converting of the second product mixture comprising HFC-143 involves dehydrofluorination conducted in a liquid phase or vapor phase to form the third product mixture of Z-1,2-difluoroethylene (HFO-Z-1132) and E-1,2-difluoroethylene (HFO-E-1132).
24. The process of claim 23, wherein dehydrofluorination of 1,1,2-trifluoroethane (HFC-143) in the second product mixture is conducted in the liquid phase at a temperature between -20°C and 150°C.
25. The process of claim 24, wherein dehydrofluorination of 1,1,2-trifluoroethane (HFC-143) in the second product mixture is conducted at a temperature between -20°C and 100°C.
26. The process of claim 23, wherein the dehydrofluorination of the second product mixture comprising HFC-143 is conducted in the liquid phase in the presence of a strong base, a polar solvent, and optionally in the presence of phase transfer catalyst.
27. The process of claim 23, wherein the dehydrofluorination of the second product mixture comprising HFC-143 is conducted in the liquid phase in the presence of a strong base comprising an alkaline or alkaline earth metal alkoxide, where the alkali metal is a Group 1A metal excluding hydrogen and the alkaline earth metal is a Group 2A metal excluding beryllium, and in the presence of an organic solvent selected from an acyclic or cyclic ether, optionally in the presence of a catalyst comprising a Crown ether or cryptand.

28. The process of claim 23, wherein dehydrofluorination of 1,1,2-trifluoroethane (HFC-143) in the second mixture is conducted in the vapor phase at a temperature between 150°C and 400°C.
29. The process of claim 23, where dehydrofluorination of 1,1,2-trifluoroethane (HFC-143) is conducted in the gas phase in the presence of a catalyst which may be the same or different than catalyst used for converting 1,1,1,2-tetrafluoroethane (HFC-134a) or 1,1,2,2-tetrafluoroethane (HFC-134).
30. The process of claim 29, wherein the catalysts are the same.
31. The process of claim 29, wherein the catalyst for converting HFC-143 is different from the catalyst for converting HFC-134a/HFC-134.
32. The process of claim 29, wherein catalyst for converting HFC-143 comprises a material selected from the group consisting of chromium (III) oxide (Cr_2O_3), aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina, chromium oxide/aluminum oxide mixtures, chromium oxide supported on AlF_3 , chromium fluoride and cubic chromium fluoride, preferably one of aluminum oxide (alumina, Al_2O_3), aluminum fluoride (AlF_3), fluorided alumina.
33. A composition formed by the method of any of claims 1-32.
34. A composition comprising HFO-1123 and at least one additional compound, preferably at least two additional compounds, selected from the group consisting of CFO-1113, HFO-1132a, and HFO-1141.
35. A composition comprising HFC-143 and at least one additional compound, preferably at least two additional compounds, selected from the group consisting of HFO-1123, HFC-134a, HFC-152a, HFC-236fa, HFO-E-1132, HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, HCO-1140, HCFC-133b, HCFC-133a, HCFO-Z-1131, HCFO-E-1131, HCFC-151a, HCC-160, and CFC-113.
36. An HFO-E/Z-1132 composition comprising at least one compound selected from fluoroacetylene, HFO-1141, HCO-1140, or acetylene, each compound, if present, is contained in the composition in an amount selected from one of

<200 ppm, <100 ppm, <50 ppm, <10 ppm, or <5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

37. An HFO-E-1132 composition comprising at least one compound selected from fluoroacetylene, HFO-1141, HCO-1140, or acetylene, each compound, if present, is contained in the composition in an amount selected from one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.
38. An HFO-Z-1132 composition comprising at least one compound selected from fluoroacetylene, HFO-1141, HCO-1140, or acetylene, each compound, if present, is contained in the composition in an amount selected from one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.
39. A composition comprising one of:
 - (i) HFC-134 which comprises one or more additional compounds selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161, or
 - (ii) HFC-134a which comprises one or more additional compounds selected from the group consisting of HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161.
40. A composition comprising one of:
 - (i) HFO-1123 which comprises one or more additional compounds selected from the group consisting of 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), and 1-chloro-2,2-difluoroethylene (HCFO-1122);
 - (ii) HFC-143 which comprises one or more additional compounds selected from the group consisting of 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-

133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), E/Z-1-chloro-1,2-difluoroethylene (HCFO-E/Z-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene;

- (iii) HFO-E-1132 which comprises (i) two or more additional compounds selected from the group consisting of HFO-Z-1132, acetylene, fluoroacetylene, difluoromethane (HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), and (ii) optionally fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene, each in an amount which is selected from one of one of < 200 ppm, < 100 ppm, < 50 ppm, < 10 ppm, or < 5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, if present; or
- (iv) HFO-Z-1132 which comprises (i) one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFO-E-1132, acetylene, fluoroacetylene, difluoromethane

(HFC-32), 1,1,1,2,2-pentafluoroethane (HFC-125), E-1-chloro-1,2-difluoroethylene (HCFO-E-1122a), Z-1-chloro-1,2-difluoroethylene (HCFO-Z-1122a), 1,1,2-trifluoroethylene (HFO-1123), fluoroethylene (HFO-1141), 1-chloro-1,1,2-trifluoroethane (HCFC-133b), 1-chloro-1,2,2-trifluoroethane (HCFC-133), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, 1,1,2-trifluoroethane (HFC-143), fluoromethane (HFC-41), chlorodifluoromethane (HCFC-22), ethylene, 1-chloro-1,2-difluoroethane (HCFC-142a), 1,1-difluoroethylene (HFO-1132a), vinyl chloride (1140), 1-chloro-1-fluoroethene (HCFO-1131a), E-1-chloro-2-fluoroethene (HCFO-E-1131), Z-1-chloro-2-fluoroethene (HCFO-Z-1131), and 1-chloro-2,2-difluoroethylene (HCFO-1122), and (ii) optionally fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene, each in an amount which is selected from one of one of < 200 ppm, < 100 ppm, < 50 ppm, < 10 ppm, or < 5 ppm, preferably ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm, if present.

41. The composition of claim 40 comprising (iii), wherein the amount of each of fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene is selected from one of < 100 ppm, < 50 ppm, < 10 ppm, or < 5 ppm, preferably one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.
42. The composition of claim 40 comprising (iv), wherein the amount of each of fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene is selected from one of < 100 ppm, < 50 ppm, < 10 ppm, or < 5 ppm, preferably one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.
43. The composition of claim 40, wherein composition (iii) is an isomerized composition and the amount of each of fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene is selected from one of < 100 ppm, < 50 ppm, < 10 ppm, or < 5 ppm, preferably one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.
44. The composition of claim 40, wherein composition (iv) is an isomerized composition and the amount of each of fluoroethylene (HFO-1141), HCO-1140, fluoroacetylene or acetylene is selected from one of < 100 ppm, < 50

ppm, <10 ppm, or <5 ppm, preferably one of ≤ 10 ppm, ≤ 5 ppm, ≤ 4 ppm, ≤ 3 ppm, ≤ 2 ppm, or ≤ 1 ppm.

45. A process comprising blending the composition of any of claims 41-44 with other HFC, HFO, and HCFO compounds.
46. A process comprising blending comprising blending the composition of any of claims 41 to 44 with one or more other HFC, HFO and HCFO compounds, and using the blended composition as one of a refrigerant, solvents foam expansion agent, cleaning agent, aerosol propellant, dielectric, fire extinguishant, and power cycle working fluid, wherein the HFC and HFO compounds are selected from the group consisting of HFO-E-1234ze, HFO-1234yf, HFC-152a, HFC-134a, HFC-134, HFO-Z--1234ze, HCFO-E-1233zd, and HFC-227ea
47. A process comprising,
 - (a) converting a tetrafluoroethane feed selected from one of a 1,1,1,2-tetrafluoroethane (HFC-134a) feed or a 1,1,2,2-tetrafluoroethane (HFC-134) feed, to a first product mixture comprising 1,1,2-trifluoroethylene (HFO-1123),
 - (b) contacting the first product mixture comprising HFO-1123 and hydrogen to form a second product mixture comprising 1,1,1-trifluoroethane (HFC-143), and
 - (c) converting the second product mixture comprising HFC-143 to a third product by dehydrofluorinating the HFC-143 in the second mixture in the gas phase at a temperature of between 150°C and 400°C to form a mixture of E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132).
48. The process of claim 47, wherein:
 - (a) the tetrafluoroethane comprises one of (i) an HFC-134 feed which comprises mainly HFC-134 and one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, CHFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, and CFC-114a, or mainly

HFC-134a and one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161, or (ii) an HFC-134a feed which comprises mainly HFC-134a and the balance comprises one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFC-134, HCFC-124, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, and CFC-114a, or mainly HFC-134a and the balance comprises one or more additional compounds, preferably two or more additional compounds, selected from the group consisting of HFC-134a, HCFC-124, HCFC-124a, HCFO-1122, HFC-143a, HCFC-31, HFC-32, HFC-125, CFC-114, CFC-114a, FCO-1114, HFC-152a, FCO-1318my, HFC-245cb, FC-C318, and HFC-161,

- (b) the first product mixture comprises HFO-1123 and one or more additional compounds selected from the group consisting of 1-chloro-1,2,2-trifluoroethene (CFO-1113), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,2,2-tetrafluoroethane (HFC-134), fluoroethylene (HFO-1141), 1,1-difluoroethylene (HFO-1132a), and 1-chloro-2,2-difluoroethylene (HCFO-1122), and
- (c) the second product mixture comprises HFC-143 and one or more additional compounds selected from the group consisting of 1,1,2-trifluoroethylene (HFO-1123), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1-difluoroethane (HFC-152a), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), HFO-Z-1132, HCFO-E-1122a, HCFO-Z-1122a, vinyl chloride (HCO-1140), HCFC-133b, HCFC-133, Z-1-chloro-2-fluoroethylene (HCFO-Z-1131), E-1-chloro-2-fluoroethylene (HCFO-E-1131), HCFC-151a, HCC-160, CFC-113, 1,1-difluoroethylene (HFO-1132a), 1,1,1-trifluoromethane (HFC-143a), 1-chloro-1,2,2-trifluoroethylene (CFO-1113), 1-chloro-1-fluoroethylene (HCFO-1131a), 1,2-difluoroethane (HFC-152) in an amount between ≥ 0 and < 100 ppm, fluoroethane (HFC-161), 1,2-dichloro-1-fluoroethane (HCFC-141), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), 1-chloro-2,2-difluoroethane (HCFC-142), 1-chloro-1,2-

difluoroethane (HCFC-142a), 1-chloro-2,2-difluoroethylene (HCFO-1122), E/Z-1-chloro-1,2-difluoroethylene (HCFO-E/Z-1122a), fluoroethylene (HFO-1141), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), trifluoromethane, (HFC-23), ethylene, and acetylene.

49. The process of any of claims 47 or 48 wherein the dehydrofluorination is conducted in the presence of a catalyst.
50. A process comprising:
 - hydrogenating HFO-1123 to form a product mixture comprising 1,1,1-trifluoroethane (HFC-143),
 - dehydrofluorinating the HFC-143 in the gas phase at a temperature of between 150°C and 400°C to form a mixture of E-1,2-difluoroethylene (HFO-E-1132) and Z-1,2-difluoroethylene (HFO-Z-1132), and
 - optionally isomerizing at least one of HFO-E-1132 and HFO-Z-1132 to increase yield.
51. The process of claim 50, wherein the isomerization is of HFO-Z-1132 to HFO-E-1132 to increase yield of HFO-E-1132.
52. The process of claim 50 or claim 51, wherein the isomerization conducted in the presence or absence of a catalyst.