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(54) ABSORPTION POWER CYCLE SYSTEM

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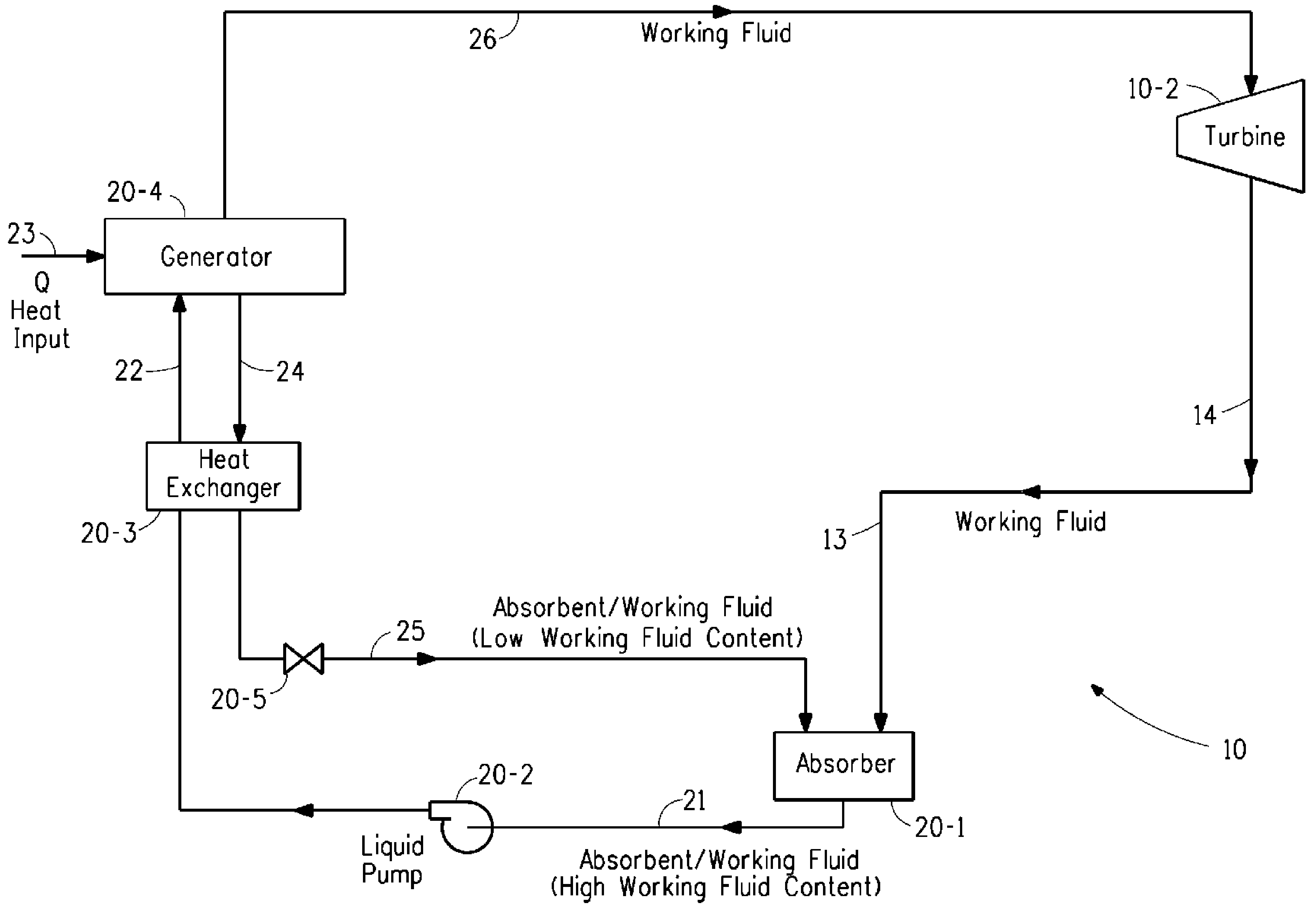
(57) **ABSTRACT**

An absorption power cycle system utilizes the working fluid from an absorption circuit to produce mechanical work. Such a system is useful in a wide range of absorption cycle applications.



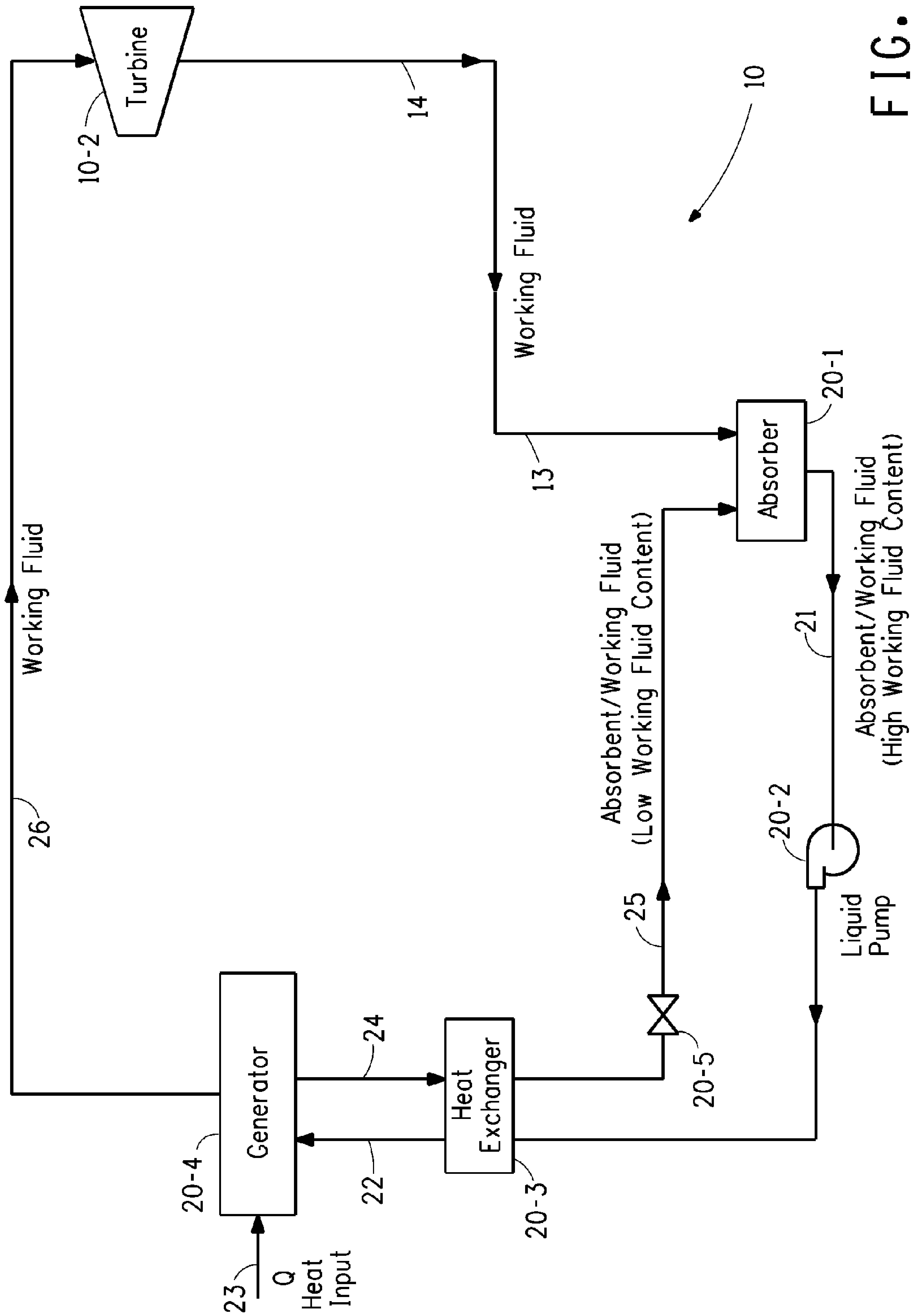

Turbine
10-2
14
Working Fluid
10
Absorber
20-1
13
Absorbent/Working Fluid
(Low Working Fluid Content)
25
20-5
Absorbent/Working Fluid
(High Working Fluid Content)
21
20-2
Liquid
Pump
Working Fluid
26
Generator
20-4
24
Heat
Exchanger
22
20-3
23
Q
Heat
Input

FIG. 1

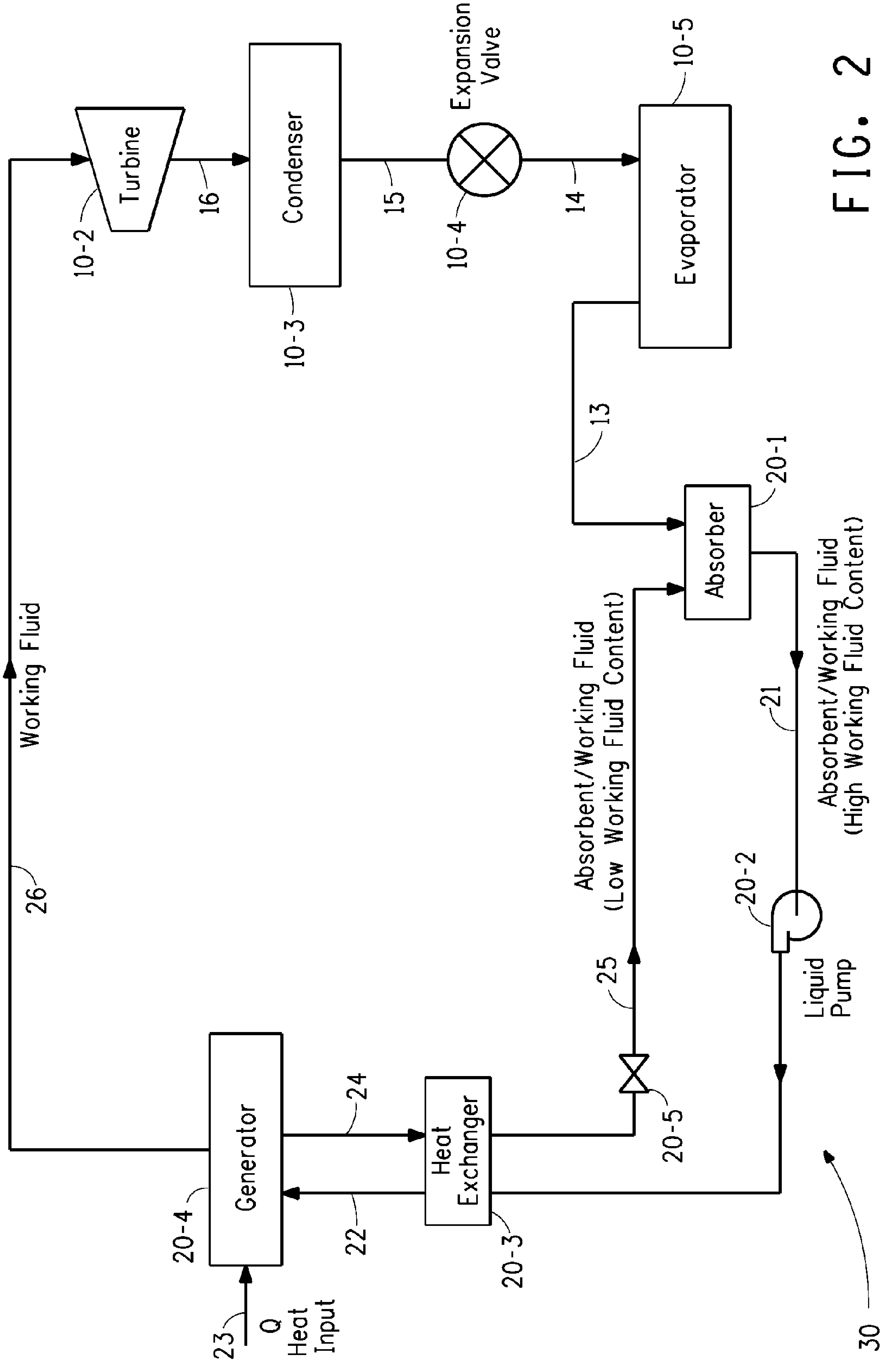

Turbine
10-2
16
Condenser
10-3
15
Expansion Valve
10-4
14
Evaporator
10-5
13
Absorber
20-1
Absorbent/Working Fluid (High Working Fluid Content)
21
20-2
Liquid Pump
Absorbent/Working Fluid (Low Working Fluid Content)
25
20-5
Heat Exchanger
20-3
24
22
Generator
20-4
Q Heat Input
23
Working Fluid
26
30

FIG. 2

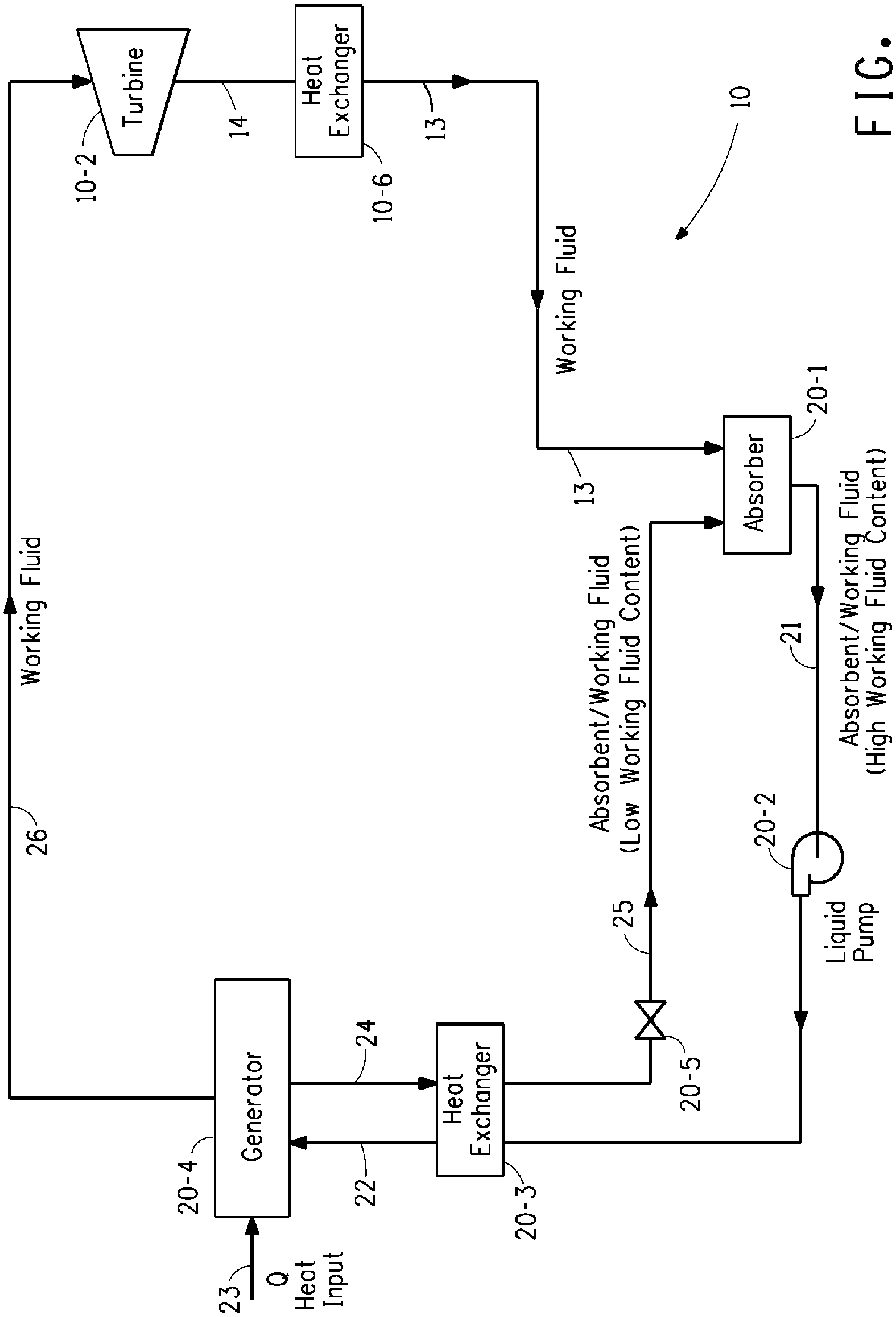

10
10-2
Turbine
14
Heat Exchanger
10-6
13
Working Fluid
13
Absorber
20-1
Absorbent/Working Fluid (Low Working Fluid Content)
Absorbent/Working Fluid (High Working Fluid Content)
21
25
20-2
Liquid Pump
20-5
Working Fluid
26
Generator
20-4
24
Heat Exchanger
20-3
22
23
Q Heat Input

FIG. 3

ABSORPTION POWER CYCLE SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of U.S. Provisional Patent Application No. 61/139,180, filed Dec. 19, 2008.

BACKGROUND

[0002] 1. Field of the Disclosure

[0003] The present disclosure relates to an absorption power cycle system which uses the working fluid from an absorption circuit to produce mechanical work. Such a system is useful in a wide range of absorption cycle applications.

[0004] 2. Description of Related Art

[0005] Absorption cycle systems are known in the fields of refrigeration, air conditioning and power generation. In a typical absorption cycle system, a working fluid is absorbed into an absorbent mixture and then is released out of the absorbent mixture. The absorber is part of an absorption circuit, which includes a liquid pump, a heat exchanger, an expansion or pressure reduction device and a generator, where the working fluid is released from the absorbent mixture before it enters a condenser and an evaporator to generate cooling or a turbine to generate mechanical power. The absorption circuit generates high pressure vapor through the use of, primarily, heat supplied to the generator and minimal mechanical power supplied to the liquid pump. The power generated by the turbine of an absorption cycle can be used to drive various types of equipment including equipment for the generation of electrical power.

SUMMARY OF THE INVENTION

[0006] It is an object of the present invention to provide an absorption cycle system which drives a device which produces mechanical work, such as a turbine or expander. The working fluid used could be or could contain hydrofluoroolefins or hydrochlorofluoroolefins with negligible ozone depletion potentials and low global warming potentials. The absorbent used in the absorption circuit could be or could contain an ionic compound including ionic liquids with melting points below 100° C. or even below ambient temperatures. One advantage of the use of ionic liquids as absorbents is their negligible volatility that allows almost pure working fluid to be released from the generator and supplied to the turbine without the need for any further rectification.

[0007] Therefore, in accordance with the present invention, there is provided an absorption power cycle system comprising an absorber for absorbing a working fluid into an absorbent, thereby forming an absorbent and working fluid mixture; a first heat exchanger disposed in fluid communication with the absorber for receiving and pre-heating the absorbent and working fluid mixture from the absorber, a liquid pump for pumping the absorbent and working fluid mixture from the absorber to the first heat exchanger; a generator disposed in fluid communication with the first heat exchanger for receiving the pre-heated mixture from the first heat exchanger and transferring additional heat into the pre-heated mixture, thereby releasing high pressure vapor of the working fluid; and a device for producing mechanical work from the high pressure working fluid disposed in fluid communication with the generator; wherein the absorbent comprises an ionic liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention may be better understood with reference to the following Figure, wherein:

[0009] FIG. **1** is a schematic diagram of an absorption power cycle system according to one embodiment of the present invention.

[0010] FIG. **2** is a schematic diagram of an absorption power cycle system that includes simultaneous cooling according to another embodiment of the present invention.

[0011] FIG. **3** is a schematic diagram of an absorption power cycle system that simultaneously provides cooling according to another embodiment of the present invention. It differs from the embodiment in FIG. **2** in that it does not involve condensation and evaporation of the working fluid.

DETAILED DESCRIPTION OF THE INVENTION

[0012] A schematic diagram of an absorption system according to the present invention is shown generally at 10 in FIG. **1**. The system includes an absorber circuit shown at 20-1 in FIG. **1** for mixing a working fluid with an absorbent, thereby forming an absorbent and working fluid mixture, and for circulating the absorbent and working fluid mixture therethrough. The system also includes a first heat exchanger 20-3 disposed in fluid communication with the absorber circuit, a generator 20-4 disposed in fluid communication with the first heat exchanger, and a device 10-2 for producing mechanical work disposed in fluid communication with the generator.

[0013] The absorber 20-1 has an inlet for delivering the working fluid vapor, where it is combined with a mixture of working fluid and an absorbent with a low working fluid-content delivered via line 25 to form an absorbent/working fluid mixture with a high working fluid-content. The absorbent may be or may contain an ionic compound. The absorption of the working fluid into the absorbent also, in general, generates heat (heat of absorption). Cooling water moves through the tube bundles (not shown) of the absorber to remove this heat of absorption from the system. The high working fluid-content mixture collects at the bottom of the absorber, so that the absorption cycle can begin again.

[0014] The high working fluid-content absorbent/working fluid mixture exits from the absorber through an outlet line 21 and is sent to the liquid pump, 20-2, which pumps the mixture to the first heat exchanger 20-3. The first heat exchanger pre-heats the mixture before it enters the generator. The first heat exchanger may be, as an example, a shell and tube type heat exchanger, or a plate and frame type heat exchanger. After exiting the first heat exchanger, the mixture flows into the generator through a line 22. The generator is supplied with heat from any suitable external source. If desired, a second, higher temperature generator may be used to improve process efficiency. In one embodiment, within the generator is a bundle of tubes (not shown) which carry hot water or other heat transfer fluid, steam, or combustion gases, which are supplied to the generator via a line 23. The hot water or other heat transfer fluid, steam or combustion gases transfer heat into the high working fluid-content absorbent/working fluid mixture. The heat causes the said mixture to release working fluid vapor, which exits from the generator through a line 26 leaving a low working fluid-content mixture behind. The working fluid exiting the generator is now a higher pressure vapor. In some instances, there is only trace working fluid left in the liquid mixture exiting the generator via a line 24. In other instances some non-negligible amount of working fluid remains in the absorbent/working fluid mixture exiting the generator, said amount ranging from about 1 weight percent to about 80 weight percent. In any case, the amount of working fluid in the mixture exiting the generator via line 24 is lower than in the mixture that exited the absorber via line 21. The exact amount of working fluid remaining in the mixture exiting the generator will depend on many factors including the solubility of the working fluid in the absorbent.

[0015] The low working fluid-content absorbent/working fluid mixture flows via line 24 back to the first heat exchanger where it is cooled by the high working fluid-content absorbent/working fluid mixture which has been pumped out of the absorber. The low working fluid-content absorbent/working fluid mixture flows from the first heat exchanger through an expansion or pressure reduction device 20-5 to the absorber via a line 25 and collects in the bottom of the absorber where it started the absorption circuit cycle, and the cycle through the absorber, pump, first heat exchanger and generator repeats.

[0016] As noted above, the working fluid, which is a high pressure vapor, exits the generator 20-4 via line 26. The high pressure working fluid vapor flows to a device for producing mechanical work, such as a turbine 10-2 as shown in FIG. **1**. In the turbine, the high pressure working fluid is used to drive a shaft or otherwise produce mechanical work. The working fluid exits from the turbine as a low pressure vapor, and enters the absorber, and the overall working fluid cycle repeats.

[0017] The present invention allows for various configurations for optimizing energy management, in general, thereby increasing cycle energy efficiency, and heat recovery, in particular, from the high-temperature, high-pressure working fluid which can be used in a device for producing mechanical work. While a turbine is shown in FIG. **1**, FIG. **2**, and FIG. **3** and described above (and in the description of other embodiments below), it is understood that various configurations of the device for producing mechanical work are within the scope of the present invention.

[0018] In an alternate embodiment, the absorption cycle of the present invention may be used to produce both mechanical work and heating or cooling. A schematic diagram of an absorption power system including simultaneous cooling according to another embodiment of the present invention is shown generally at 30 in FIG. **2**. In this case, the system includes a condenser 10-3, an expansion device (shown as an expansion valve 10-4 in FIG. **2**, but may be a capillary tube or other as generally known in the art) and an evaporator 10-5, in that order, between the turbine 10-2 and the absorber 20-1. The high pressure vapor working fluid from the generator 20-4 first flows to the turbine 10-2 through line 26, thus generating power. The vapor working fluid flows to the condenser 10-3, wherein cooling water (contained in, for instance, a coil of tubing (not shown) located within the condenser) causes the vapor working fluid to form liquid working fluid. The liquid working fluid flows from the condenser to an expansion valve 10-4 through line 16, where some vaporization would take place and the combined vapor and liquid working fluid then flows through line 14 to the evaporator 10-5, where it becomes fully vaporized working fluid, thereby producing cooling, so that no liquid remains. The vapor working fluid from the evaporator moves through line 13 to the absorber and the cycle then repeats as in the first embodiment described above herein.

[0019] The hot water or other heat transfer fluid, steam, or combustion gases supplied to the generator in order to release working fluid vapor from the absorbent/working fluid mixture may be supplied by any number of sources, including water heated with waste heat from a combustion engine (combustion gases), water heated with geothermal heat and solar heated water, among others. Additionally, some source of heat (for example, heat from a body to be cooled such as a building) is required to evaporate the working fluid in the evaporator of the alternative embodiment described for the absorption power cycle including simultaneous cooling.

[0020] Cooling water is used in the absorber and in the condenser in the embodiments as described above. For sake of simplicity, the cooling water streams through the absorber and condenser are not shown. In one embodiment, the cooling water will flow into the absorber, where it warms due to the heat of absorption released upon the working fluid absorbing into the absorbent. From the absorber, the cooling water flows to a cooling tower, not shown, and is pumped back to the absorber.

[0021] In one embodiment, disclosed herein is a process for producing mechanical work comprising forming an absorbent/working fluid mixture in an absorber, heating the absorbent/working fluid mixture to release working fluid vapor, and sending the working fluid vapor to a device for producing mechanical work, and reforming the heated absorbent/working fluid mixture. By reforming is meant re-diluting the concentrated absorbent/working fluid mixtures through the absorption of working fluid vapor to restore the ability of the mixture to transfer working fluid to the generator.

[0022] In another embodiment, said process for producing mechanical work, further comprises (after producing mechanical work and before reforming the heated absorbent/working fluid mixture) condensing said working fluid in a condenser; partially vaporizing said working fluid in an expansion device; and fully vaporizing said working fluid in an evaporator thereby producing cooling.

[0023] In yet another embodiment, the cycle of FIG. **2** can be used for simultaneous generation of mechanical power and heating. A heating cycle would function just as the cooling cycle of FIG. **2** described above herein, with the heating step taking place in the condenser 10-3. Heating is provided by the heat released by the working fluid upon condensation in the condenser and absorption in the absorber. In this embodiment, the evaporator extracts heat from sources external to the cycle (and not shown in FIG. **2**) such as ambient air, natural bodies of water including water in the bottom of a lake or pond or the relatively stable temperature ground below the earth's surface. The heating function of the cycle is thus similar to that of a heat pump. In this embodiment, said process for producing mechanical work, further comprises (after producing mechanical work and before reforming the heated absorbent/working fluid mixture) condensing said working fluid in a condenser thereby producing heat; partially vaporizing said working fluid in an expansion device; and fully vaporizing said working fluid in an evaporator.

[0024] In yet another embodiment, shown in FIG. **3**, simultaneous mechanical power and cooling are generated without a condenser. In this embodiment, the working fluid is expanded through the turbine or other expander producing mechanical work and being cooled to a temperature below the ambient temperature without condensation. Then the cold working fluid vapor passes through a second heat exchanger (shown as 10-6 in FIG. **3**) absorbing heat from a stream to be cooled (such as a heat transfer fluid, including water, among others, not shown in FIG. **3**). In this embodiment, said process for producing mechanical work, further comprises (after producing mechanical work and before reforming the heated absorbent/working fluid mixture) absorbing heat from a stream to be cooled in a second heat exchanger, thus producing cooling of the stream to be cooled.

Working Fluid/Absorbent Pairs

[0025] Working Fluids

[0026] The present invention provides working fluid/absorbent pair compositions for use in absorption power cycles with or without simultaneous generation of cooling or heating. In one embodiment, water is used as a working fluid in this invention. In another embodiment, the working fluid may be a hydrofluorocarbon, a hydrochlorofluorocarbon, a chlorofluorocarbon, a fluorocarbon, nitrogen (N_2), oxygen (O_2), carbon dioxide (O_2), ammonia (NH_3), argon (Ar), hydrogen (H_2), a non-fluorinated hydrocarbon, or methanol, or mixtures thereof, meaning mixtures of any of the foregoing working fluids in this paragraph. The non-fluorinated hydrocarbons are selected from the group consisting of C_1 to C_7 straight-chain, branched or cyclic alkanes and C_1 to C_7 straight-chain, branched or cyclic alkenes, is within the scope of this invention as well.

[0027] Hydrofluorocarbon and fluorocarbon working fluids of the present invention may be selected from the group consisting of:

[0028] (iii) fluoroolefins of the formula E- or Z-$R^1CH=CHR^2$, wherein R^1 and R^2 are, independently, C_1 to C_6 perfluoroalkyl groups;

[0029] (ii) cyclic fluoroolefins of the formula cyclo-$[CX=CY(CZW)_n—]$, wherein X, Y, Z, and W, independently, are H or F, and n is an integer from 2 to 5; and

[0030] (iii) fluoroolefins selected from the group consisting of: tetrafluoroethylene ($CF_2=CF_2$); hexafluoropropene ($CF_3CF=CF_2$); 1,2,3,3,3-pentafluoro-1-propene ($CHF=CFCF_3$), 1,1,3,3,3-pentafluoro-1-propene ($CF_2=CHCF_3$), 1,1,2,3,3-pentafluoro-1-propene ($CF_2=CFCHF_2$), 1,2,3,3-tetrafluoro-1-propene ($CHF=CFCHF_2$), 2,3,3,3-tetrafluoro-1-propene ($CH_2=CFCF_3$), 1,3,3,3-tetrafluoro-1-propene ($CHF=CHCF_3$), 1,1,2,3-tetrafluoro-1-propene ($CF_2=CFCH_2F$), 1,1,3,3-tetrafluoro-1-propene ($CF_2=CHCHF_2$), 1,2,3,3-tetrafluoro-1-propene ($CHF=CFCHF_2$), 3,3,3-trifluoro-1-propene ($CH_2=CHCF_3$), 2,3,3-trifluoro-1-propene ($CHF_2CF=CH_2$); 1,1,2-trifluoro-1-propene ($CH_3CF=CF_2$); 1,2,3-trifluoro-1-propene ($CH_2FCF=CF_2$); 1,1,3-trifluoro-1-propene ($CH_2FCH=CF_2$); 1,3,3-trifluoro-1-propene ($CHF_2CH=CHF$); 1,1,1,2,3,4,4,4-octafluoro-2-butene ($CF_3CF=CFCF_3$); 1,1,2,3,3,4,4,4-octafluoro-1-butene ($CF_3CF_2CF=CF_2$); 1,1,1,2,4,4,4-heptafluoro-2-butene ($CF_3CF=CHCF_3$); 1,2,3,3,4,4,4-heptafluoro-1-butene ($CHF=CFCF_2CF_3$); 1,1,1,2,3,4,4-heptafluoro-2-butene ($CHF_2CF=CFCF_3$); 1,3,3,3-tetrafluoro-2-(trifluoromethyl)-1-propene ($(CF_3)_2C=CHF$); 1,1,3,3,4,4,4-heptafluoro-1-butene ($CF_2=CHCF_2CF_3$); 1,1,2,3,4,4,4-heptafluoro-1-butene ($CF_2=CFCHFCF_3$); 1,1,2,3,3,4,4-heptafluoro-1-butene ($CF_2=CFCF_2CHF_2$); 2,3,3,4,4,4-hexafluoro-1-butene ($CF_3CF_2CF=CH_2$); 1,3,3,4,4,4-hexafluoro-1-butene ($CHF=CHCF_2CF_3$); 1,2,3,4,4,4-hexafluoro-1-butene ($CHF=CFCHFCF_3$); 1,2,3,3,4,4-hexafluoro-1-butene ($CHF=CFCF_2CHF_2$); 1,1,2,3,4,4-hexafluoro-2-butene ($CHF_2CF=CFCHF_2$); 1,1,1,2,3,4-hexafluoro-2-butene ($CH_2FCF=CFCF_3$); 1,1,1,2,4,4-hexafluoro-2-butene ($CHF_2CH=CFCF_3$); 1,1,1,3,4,4-hexafluoro-2-butene ($CF_3CH=CFCHF_2$); 1,1,2,3,3,4-hexafluoro-1-butene ($CF_2=CFCF_2CH_2F$); 1,1,2,3,4,4-hexafluoro-1-butene ($CF_2=CFCHFCHF_2$); 3,3,3-trifluoro-2-(trifluoromethyl)-1-propene ($CH_2=C(CF_3)_2$); 1,1,1,2,4-pentafluoro-2-butene ($CH_2FCH=CFCF_3$); 1,1,1,3,4-pentafluoro-2-butene ($CF_3CH=CFCH_2F$); 3,3,4,4,4-pentafluoro-1-butene ($CF_3CF_2CH=CH_2$); 1,1,1,4,4-pentafluoro-2-butene ($CHF_2CH=CHCF_3$); 1,1,1,2,3-pentafluoro-2-butene ($CH_3CF=CFCF_3$); 2,3,3,4,4-pentafluoro-1-butene ($CH_2=CFCF_2CHF_2$); 1,1,2,4,4-pentafluoro-2-butene ($CHF_2CF=CHCHF_2$); 1,1,2,3,3-pentafluoro-1-butene ($CH_3CF_2CF=CF_2$); 1,1,2,3,4-pentafluoro-2-butene ($CH_2FCF=CFCHF_2$); 1,1,3,3,3-pentafluoro-2-methyl-1-propene ($CF_2=C(CF_3)(CH_3)$); 2-(difluoromethyl)-3,3,3-trifluoro-1-propene ($CH_2=C(CHF_2)(CF_3)$); 2,3,4,4,4-pentafluoro-1-butene ($CH_2=CFCHFCF_3$); 1,2,4,4,4-pentafluoro-1-butene ($CHF=CFCH_2CF_3$); 1,3,4,4,4-pentafluoro-1-butene ($CHF=CHCHFCF_3$); 1,3,3,4,4-pentafluoro-1-butene ($CHF=CHCF_2CHF_2$); 1,2,3,4,4-pentafluoro-1-butene ($CHF=CFCHFCHF_2$); 3,3,4,4-tetrafluoro-1-butene ($CH_2=CHCF_2CHF_2$); 1,1-difluoro-2-(difluoromethyl)-1-propene ($CF_2=C(CHF_2)(CH_3)$); 1,3,3,3-tetrafluoro-2-methyl-1-propene ($CHF=C(CF_3)(CH_3)$); 3,3-difluoro-2-(difluoromethyl)-1-propene ($CH_2=C(CHF_2)_2$); 1,1,1,2-tetrafluoro-2-butene ($CF_3CF=CHCH_3$); 1,1,1,3-tetrafluoro-2-butene ($CH_3CF=CHCF_3$); 1,1,1,2,3,4,4,5,5,5-decafluoro-2-pentene ($CF_3CF=CFCF_2CF_3$); 1,1,2,3,3,4,4,5,5,5-decafluoro-1-pentene ($CF_2=CFCF_2CF_2CF_3$); 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)-2-butene ($(CF_3)_2C=CHCF_3$); 1,1,1,2,4,4,5,5,5-nonafluoro-2-pentene ($CF_3CF=CHCF_2CF_3$); 1,1,1,3,4,4,5,5,5-nonafluoro-2-pentene ($CF_3CH=CFCF_2CF_3$); 1,2,3,3,4,4,5,5,5-nonafluoro-1-pentene ($CHF=CFCF_2CF_2CF_3$); 1,1,3,3,4,4,5,5,5-nonafluoro-1-pentene ($CF_2=CHCF_2CF_2CF_3$); 1,1,2,3,3,4,4,5,5-nonafluoro-1-pentene ($CF_2=CFCF_2CF_2CHF_2$); 1,1,2,3,4,4,5,5,5-nonafluoro-2-pentene ($CHF_2CF=CFCF_2CF_3$); 1,1,1,2,3,4,4,5,5-nonafluoro-2-pentene ($CF_3CF=CFCF_2CHF_2$); 1,1,1,2,3,4,5,5,5-nonafluoro-2-pentene ($CF_3CF=CFCHFCF_3$); 1,2,3,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene ($CHF=CFCF(CF_3)_2$); 1,1,2,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene ($CF_2=CFCH(CF_3)_2$); 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)-2-butene ($CF_3CH=C(CF_3)_2$); 1,1,3,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene ($CF_2=CHCF(CF_3)_2$); 2,3,3,4,4,5,5,5-octafluoro-1-pentene ($CH_2=CFCF_2CF_2CF_3$); 1,2,3,3,4,4,5,5-octafluoro-1-pentene ($CHF=CFCF_2CF_2CHF_2$); 3,3,4,4,4-pentafluoro-2-(trifluoromethyl)-1-butene ($CH_2=C(CF_3)CF_2CF_3$); 1,1,4,4,4-pentafluoro-3-(trifluoromethyl)-1-butene ($CF_2=CHCH(CF_3)_2$); 1,3,4,4,4-pentafluoro-3-(trifluoromethyl)-1-butene ($CHF=CHCF(CF_3)_2$); 1,1,4,4,4-pentafluoro-2-(trifluoromethyl)-1-butene ($CF_2=C(CF_3)CH_2CF_3$); 3,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene ((CF_3)

${}_2CFCH=CH_2)$; 3,3,4,4,5,5,5-heptafluoro-1-pentene $(CF_3CF_2CF_2CH=CH_2)$; 2,3,3,4,4,5,5-heptafluoro-1-pentene $(CH_2=CFCF_2CF_2CHF_2)$; 1,1,3,3,5,5,5-heptafluoro-1-butene $(CF_2=CHCF_2CH_2CF_3)$; 1,1,1,2,4,4,4-heptafluoro-3-methyl-2-butene $(CF_3CF=C(CF_3)(CH_3))$; 2,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene $(CH_2=CFCH(CF_3)_2)$; 1,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene $(CHF=CHCH(CF_3)_2)$; 1,1,1,4-tetrafluoro-2-(trifluoromethyl)-2-butene $(CH_2FCH=C(CF_3)_2)$; 1,1,1,3-tetrafluoro-2-(trifluoromethyl)-2-butene $(CH_3CF=C(CF_3)_2)$; 1,1,1-trifluoro-2-(trifluoromethyl)-2-butene $((CF_3)_2C=CHCH_3)$; 3,4,4,5,5,5-hexafluoro-2-pentene $(CF_3CF_2CF=CHCH_3)$; 1,1,1,4,4,4-hexafluoro-2-methyl-2-butene $(CF_3C(CH_3)=CHCF_3)$; 3,3,4,5,5,5-hexafluoro-1-pentene $(CH_2=CHCF_2CHFCF_3)$; 4,4,4-trifluoro-2-(trifluoromethyl)-1-butene $(CH_2=C(CF_3)CH_2CF_3)$; 1,1,2,3,3,4,4,5,5,6,6,6-dodecafluoro-1-hexene $(CF_3(CF_2)_3CF=CF_2)$; 1,1,1,2,2,3,4,5,5,6,6,6-dodecafluoro-3-hexene $(CF_3CF_2CF=CFCF_2CF_3)$; 1,1,1,4,4,4-hexafluoro-2,3-bis(trifluoromethyl)-2-butene $((CF_3)_2C=C(CF_3)_2)$; 1,1,1,2,3,4,5,5,5-nonafluoro-4-(trifluoromethyl)-2-pentene $((CF_3)_2CFCF=CFCF_3)$; 1,1,1,4,4,5,5,5-octafluoro-2-(trifluoromethyl)-2-pentene $((CF_3)_2C=CHC_2F_5)$; 1,1,1,3,4,5,5,5-octafluoro-4-(trifluoromethyl)-2-pentene $((CF_3)_2CFCF=CHCF_3)$; 3,3,4,4,5,5,6,6,6-nonafluoro-1-hexene $(CF_3CF_2CF_2CF_2CH=CH_2)$; 4,4,4-trifluoro-3,3-bis(trifluoromethyl)-1-butene $(CH_2=CHC(CF_3)_3)$; 1,1,1,4,4,4-hexafluoro-3-methyl-2-(trifluoromethyl)-2-butene $((CF_3)_2C=C(CH_3)(CF_3))$; 2,3,3,5,5,5-hexafluoro-4-(trifluoromethyl)-1-pentene $(CH_2=CFCF_2CH(CF_3)_2)$; 1,1,1,2,4,4,5,5,5-nonafluoro-3-methyl-2-pentene $(CF_3CF=C(CH_3)CF_2CF_3)$; 1,1,1,5,5,5-hexafluoro-4-(trifluoromethyl)-2-pentene $(CF_3CH=CHCH(CF_3)_2)$; 3,4,4,5,5,6,6,6-octafluoro-2-hexene $(CF_3CF_2CF_2CF=CHCH_3)$; 3,3,4,4,5,5,6,6-octafluoro1-hexene $(CH_2=CHCF_2CF_2CF_2CHF_2)$; 1,1,1,4,4-pentafluoro-2-(trifluoromethyl)-2-pentene $((CF_3)_2C=CHCF_2CH_3)$; 4,4,5,5,5-pentafluoro-2-(trifluoromethyl)-1-pentene $(CH_2=C(CF_3)CH_2C_2F_5)$; 3,3,4,4,5,5,5-heptafluoro-2-methyl-1-pentene $(CF_3CF_2CF_2C(CH_3)=CH_2)$; 4,4,5,5,6,6,6-heptafluoro-2-hexene $(CF_3CF_2CF_2CH=CHCH_3)$; 4,4,5,5,6,6,6-heptafluoro-1-hexene $(CH_2=CHCH_2CF_2C_2F_5)$; 1,1,1,2,2,3,4-heptafluoro-3-hexene $(CF_3CF_2CF=CFC_2H_5)$; 4,5,5,5-tetrafluoro-4-(trifluoromethyl)-1-pentene $(CH_2=CHCH_2CF(CF_3)_2)$; 1,1,1,2,5,5,5-heptafluoro-4-methyl-2-pentene $(CF_3CF=CHCH(CF_3)(CH_3))$; 1,1,1,3-tetrafluoro-2-(trifluoromethyl)-2-pentene $((CF_3)_2C=CFC_2H_5)$; 1,1,1,2,3,4,4,5,5,6,6,7,7,7-tetradecafluoro-2-heptene $(CF_3CF=CFCF_2CF_2C_2F_5)$; 1,1,1,2,2,3,4,5,5,6,6,7,7,7-tetradecafluoro-3-heptene $(CF_3CF_2CF=CFCF_2C_2F_5)$; 1,1,1,3,4,4,5,5,6,6,7,7,7-tridecafluoro-2-heptene $(CF_3CH=CFCF_2CF_2C_2F_5)$; 1,1,1,2,4,4,5,5,6,6,7,7,7-tridecafluoro-2-heptene $(CF_3CF=CHCF_2CF_2C_2F_5)$; 1,1,1,2,2,4,5,5,6,6,7,7,7-tridecafluoro-3-heptene $(CF_3CF_2CH=CFCF_2C_2F_5)$; and 1,1,1,2,2,3,5,5,6,6,7,7,7-tridecafluoro-3-heptene $(CF_3CF_2CF=CHCF_2C_2F_5)$.

[0031] In some embodiments, these fluoroolefins are compounds, which comprise carbon atoms, fluorine atoms and optionally hydrogen or chlorine atoms, and at least one double bond. In one embodiment, the fluoroolefins used in the compositions of the present invention comprise compounds with 2 to 12 carbon atoms. In another embodiment the fluoroolefins comprise compounds with 3 to 10 carbon atoms, and in yet another embodiment the fluoroolefins comprise compounds with 3 to 7 carbon atoms. Representative fluoroolefins include but are not limited to all compounds as listed in Table 1, Table 2, and Table 3.

[0032] In one embodiment of the present invention the working fluid is selected from fluoroolefins having the formula E- or Z-$R^1CH=CHR^2$ (Formula (I)), wherein R^1 and R^2 are, independently, C_1 to C_6 perfluoroalkyl groups. Examples of R^1 and R^2 groups include, but are not limited to, CF_3, C_2F_5, $CF_2CF_2CF_3$, $CF(CF_3)_2$, $CF_2CF_2CF_2CF_3$, $CF(CF_3)CF_2CF_3$, $CF_2CF(CF_3)_2$, $C(CF_3)_3$, $CF_2CF_2CF_2CF_2CF_3$, $CF_2CF_2CF(CF_3)_2$, $C(CF_3)_2C_2F_5$, $CF_2CF_2CF_2CF_2CF_2CF_3$, $CF(CF_3)CF_2CF_2C_2F_5$, and $C(CF_3)_2CF_2C_2F_5$. In one embodiment the fluoroolefins of Formula (I) have at least 4 carbon atoms in the molecule. In another embodiment, the working fluid is selected from fluoroolefins of Formula (I) having at least 5 carbon atoms in the molecule. In yet another embodiment, the working fluid is selected from fluoroolefins of Formula (I) having at least 6 carbon atoms in the molecule. Exemplary, non-limiting Formula (I) compounds are presented in Table 1.

TABLE 1

Code	Structure	Chemical Name
F11E	$CF_3CH=CHCF_3$	1,1,1,4,4,4-hexafluorobut-2-ene
F12E	$CF_3CH=CHC_2F_5$	1,1,1,4,4,5,5,5-octafluoropent-2-ene
F13E	$CF_3CH=CHCF_2C_2F_5$	1,1,1,4,4,5,5,6,6,6-decafluorohex-2-ene
F13iE	$CF_3CH=CHCF(CF_3)_2$	1,1,1,4,5,5,5-heptafluoro-4-(trifluoromethyl)pent-2-ene
F22E	$C_2F_5CH=CHC_2F_5$	1,1,1,2,2,5,5,6,6,6-decafluorohex-3-ene
F14E	$CF_3CH=CH(CF_2)_3CF_3$	1,1,1,4,4,5,5,6,6,7,7,7-dodecafluorohept-2-ene
F14iE	$CF_3CH=CHCF_2CF{-}(CF_3)_2$	1,1,1,4,4,5,6,6,6-nonafluoro-5-(trifluoromethyl)hex-2-ene
F14sE	$CF_3CH=CHCF(CF_3){-}C_2F_5$	1,1,1,4,5,5,6,6,6-nonfluoro-4-(trifluoromethyl)hex-2-ene
F14tE	$CF_3CH=CHC(CF_3)_3$	1,1,1,5,5,5-hexafluoro-4,4-bis(trifluoromethyl)pent-2-ene
F23E	$C_2F_5CH=CHCF_2C_2F_5$	1,1,1,2,2,5,5,6,6,7,7,7-dodecafluorohept-3-ene
F23iE	$C_2F_5CH=CHCF(CF_3)_2$	1,1,1,2,2,5,6,6,6-nonafluoro-5-(trifluoromethyl)hex-3-ene
F15E	$CF_3CH=CH(CF_2)_4CF_3$	1,1,1,4,4,5,5,6,6,7,7,8,8,8-tetradecafluorooct-2-ene
F15iE	$CF_3CH=CH{-}CF_2CF_2CF(CF_3)_2$	1,1,1,4,4,5,5,6,7,7,7-undecafluoro-6-(trifluoromethyl)hept-2-ene
F15tE	$CF_3CH=CH{-}C(CF_3)_2C_2F_5$	1,1,1,5,5,6,6,6-octafluoro-4,4-bis(trifluoromethyl)hex-2-ene
F24E	$C_2F_5CH=CH(CF_2)_3CF_3$	1,1,1,2,2,5,5,6,6,7,7,8,8,8-tetradecafluorooct-3-ene
F24iE	$C_2F_5CH=CHCF_2CF{-}(CF_3)_2$	1,1,1,2,2,5,5,6,7,7,7-undecafluoro-6-(trifluoromethyl)hept-3-ene
F24sE	$C_2F_5CH=CHCF(CF_3){-}C_2F_5$	1,1,1,2,2,5,6,6,7,7,7-undecafluoro-5-(trifluoromethyl)hept-3-ene
F24tE	$C_2F_5CH=CHC(CF_3)_3$	1,1,1,2,2,6,6,6-octafluoro-5,5-bis(trifluoromethyl)hex-3-ene

TABLE 1-continued

Code	Structure	Chemical Name
F33E	$C_2F_5CF_2CH{=}CH{-}CF_2C_2F_5$	1,1,1,2,2,3,3,6,6,7,7,8,8,8-tetradecafluorooct-4-ene
F3i3iE	$(CF_3)_2CFCH{=}CH{-}CF(CF_3)_2$	1,1,1,2,5,6,6,6-octafluoro-2,5-bis(trifluoromethyl)hex-3-ene
F33iE	$C_2F_5CF_2CH{=}CH{-}CF(CF_3)_2$	1,1,1,2,5,5,6,6,7,7,7-undecafluoro-2-(trifluoromethyl)hept-3-ene
F16E	$CF_3CH{=}CH(CF_2)_5CF_3$	1,1,1,4,4,5,5,6,6,7,7,8,8,9,9,9-hexadecafluoronon-2-ene
F16sE	$CF_3CH{=}CHCF(CF_3)(CF_2)_2C_2F_5$	1,1,1,4,5,5,6,6,7,7,8,8,8-tridecafluoro-4-(trifluoromethyl)hept-2-ene
F16tE	$CF_3CH{=}CHC(CF_3)_2CF_2C_2F_5$	1,1,1,6,6,6-octafluoro-4,4-bis(trifluoromethyl)hept-2-ene
F25E	$C_2F_5CH{=}CH(CF_2)_4CF_3$	1,1,1,2,2,5,5,6,6,7,7,8,8,9,9,9-hexadecafluoronon-3-ene
F25iE	$C_2F_5CH{=}CH{-}CF_2CF_2CF(CF_3)_2$	1,1,1,2,2,5,5,6,6,7,8,8,8-tridecafluoro-7-(trifluoromethyl)oct-3-ene
F25tE	$C_2F_5CH{=}CH{-}C(CF_3)_2C_2F_5$	1,1,1,2,2,6,6,7,7,7-decafluoro-5,5-bis(trifluoromethyl)hept-3-ene
F34E	$C_2F_5CF_2CH{=}CH{-}(CF_2)_3CF_3$	1,1,1,2,2,3,3,6,6,7,7,8,8,9,9,9-hexadecafluoronon-4-ene
F34iE	$C_2F_5CF_2CH{=}CH{-}CF_2CF(CF_3)_2$	1,1,1,2,2,3,3,6,6,7,8,8,8-tridecafluoro-7-(trifluoromethyl)oct-4-ene
F34sE	$C_2F_5CF_2CH{=}CH{-}CF(CF_3)C_2F_5$	1,1,1,2,2,3,3,6,7,7,8,8,8-tridecafluoro-6-(trifluoromethyl)oct-4-ene
F34tE	$C_2F_5CF_2CH{=}CH{-}C(CF_3)_3$	1,1,1,5,5,6,6,7,7,7-decafluoro-2,2-bis(trifluoromethyl)hept-3-ene
F3i4E	$(CF_3)_2CFCH{=}CH{-}(CF_2)_3CF_3$	1,1,1,2,5,5,6,6,7,7,8,8,8-tridecafluoro-2(trifluoromethyl)oct-3-ene
F3i4iE	$(CF_3)_2CFCH{=}CH{-}CF_2CF(CF_3)_2$	1,1,1,2,5,5,6,7,7,7-decafluoro-2,6-bis(trifluoromethyl)hept-3-ene
F3i4sE	$(CF_3)_2CFCH{=}CH{-}CF(CF_3)C_2F_5$	1,1,1,2,5,6,6,7,7,7-decafluoro-2,5-bis(trifluoromethyl)hept-3-ene
F3i4tE	$(CF_3)_2CFCH{=}CH{-}C(CF_3)_3$	1,1,1,2,6,6,6-heptafluoro-2,5,5-tris(trifluoromethyl)hex-3-ene
F26E	$C_2F_5CH{=}CH(CF_2)_5CF_3$	1,1,1,2,2,5,5,6,6,7,7,8,8,9,9,10,10,10-octadecafluorodec-3-ene
F26sE	$C_2F_5CH{=}CHCF(CF_3)(CF_2)_2C_2F_5$	1,1,1,2,2,5,6,6,7,7,8,8,9,9,9-pentadecafluoro-5-(trifluoromethyl)non-3-ene
F26tE	$C_2F_5CH{=}CHC(CF_3)_2CF_2C_2F_5$	1,1,1,2,2,6,6,7,7,8,8,8-dodecafluoro-5,5-bis(trifluoromethyl)oct-3-ene
F35E	$C_2F_5CF_2CH{=}CH{-}(CF_2)_4CF_3$	1,1,1,2,2,3,3,6,6,7,7,8,8,9,9,10,10,10-octadecafluorodec-4-ene
F35iE	$C_2F_5CF_2CH{=}CH{-}CF_2CF_2CF(CF_3)_2$	1,1,1,2,2,3,3,6,6,7,7,8,9,9,9-pentadecafluoro-8-(trifluoromethyl)non-4-ene
F35tE	$C_2F_5CF_2CH{=}CH{-}C(CF_3)_2C_2F_5$	1,1,1,2,2,3,3,7,7,8,8,8-dodecafluoro-6,6-bis(trifluoromethyl)oct-4-ene
F3i5E	$(CF_3)_2CFCH{=}CH{-}(CF_2)_4CF_3$	1,1,1,2,5,5,6,6,7,7,8,8,9,9,9-pentadecafluoro-2-(trifluoromethyl)non-3-ene
F3i5iE	$(CF_3)_2CFCH{=}CH{-}CF_2CF_2CF(CF_3)_2$	1,1,1,2,5,5,6,6,7,8,8,8-dodecafluoro-2,7-bis(trifluoromethyl)oct-3-ene
F3i5tE	$(CF_3)_2CFCH{=}CH{-}C(CF_3)_2C_2F_5$	1,1,1,2,6,6,7,7,7-nonafluoro-2,5,5-tris(trifluoromethyl)hept-3-ene
F44E	$CF_3(CF_2)_3CH{=}CH{-}(CF_2)_3CF_3$	1,1,1,2,2,3,3,4,4,7,7,8,8,9,9,10,10,10-octadecafluorodec-5-ene
F44iE	$CF_3(CF_2)_3CH{=}CH{-}CF_2CF(CF_3)_2$	1,1,1,2,3,3,6,6,7,7,8,8,9,9,9-pentadecafluoro-2-(trifluoromethyl)non-4-ene
F44sE	$CF_3(CF_2)_3CH{=}CH{-}CF(CF_3)C_2F_5$	1,1,1,2,2,3,6,6,7,7,8,8,9,9,9-pentadecafluoro-3-(trifluoromethyl)non-4-ene
F44tE	$CF_3(CF_2)_3CH{=}CH{-}C(CF_3)_3$	1,1,1,5,5,6,6,7,7,8,8,8-dodecafluoro-2,2,-bis(trifluoromethyl)oct-3-ene
F4i4iE	$(CF_3)_2CFCF_2CH{=}CH{-}CF_2CF(CF_3)_2$	1,1,1,2,3,3,6,6,7,8,8,8-dodecafluoro-2,7-bis(trifluoromethyl)oct-4-ene
F4i4sE	$(CF_3)_2CFCF_2CH{=}CH{-}CF(CF_3)C_2F_5$	1,1,1,2,3,3,6,7,7,8,8,8-dodecafluoro-2,6-bis(trifluoromethyl)oct-4-ene
F4i4tE	$(CF_3)_2CFCF_2CH{=}CH{-}C(CF_3)_3$	1,1,1,5,5,6,7,7,7-nonafluoro-2,2,6-tris(trifluoromethyl)hept-3-ene
F4s4sE	$C_2F_5CF(CF_3)CH{=}CH{-}CF(CF_3)C_2F_5$	1,1,1,2,2,3,6,7,7,8,8,8-dodecafluoro-3,6-bis(trifluoromethyl)oct-4-ene
F4s4tE	$C_2F_5CF(CF_3)CH{=}CH{-}C(CF_3)_3$	1,1,1,5,6,6,7,7,7-nonafluoro-2,2,5-tris(trifluoromethyl)hept-3-ene
F4t4tE	$(CF_3)_3CCH{=}CH{-}C(CF_3)_3$	1,1,1,6,6,6-hexafluoro-2,2,5,5-tetrakis(trifluoromethyl)hex-3-ene

[0033] Compounds of Formula (I) may be prepared by contacting a perfluoroalkyl iodide of the formula R^{11} with a perfluoroalkyltrihydroolefin of the formula $R^2CH{=}CH_2$ to form a trihydroiodoperfluoroalkane of the formula $R^1CH_2CHIR^2$. This trihydroiodoperfluoroalkane can then be dehydroiodinated to form $R^1CH{=}CHR^2$. Alternatively, the olefin $R^1CH{=}CHR^2$ may be prepared by dehydroiodination of a trihydroiodoperfluoroalkane of the formula $R^1CHICH_2R^2$ formed in turn by reacting a perfluoroalkyl iodide of the formula R^2I with a perfluoroalkyltrihydroolefin of the formula $R^1CH{=}CH_2$.

[0034] The contacting of a perfluoroalkyl iodide with a perfluoroalkyltrihydroolefin may take place in batch mode by combining the reactants in a suitable reaction vessel capable of operating under the autogenous pressure of the reactants and products at reaction temperature. Suitable reaction vessels include fabricated from stainless steels, in particular of the austenitic type, and the well-known high nickel alloys such as Monel® nickel-copper alloys, Hastelloy® nickel based alloys and Inconel® nickel-chromium alloys.

[0035] Alternatively, the reaction may be conducted in semi-batch mode in which the perfluoroalkyltrihydroolefin reactant is added to the perfluoroalkyl iodide reactant by means of a suitable addition apparatus such as a pump at the reaction temperature.

[0036] The ratio of perfluoroalkyl iodide to perfluoroalkyltrihydroolefin should be between about 1:1 to about 4:1, preferably from about 1.5:1 to 2.5:1. Ratios less than 1.5:1 tend to result in large amounts of the 2:1 adduct as reported by Jeanneaux, et. al. in *Journal of Fluorine Chemistry*, Vol. 4, pages 261-270 (1974).

[0037] Preferred temperatures for contacting of said perfluoroalkyl iodide with said perfluoroalkyltrihydroolefin are preferably within the range of about 150° C. to 300° C., preferably from about 170° C. to about 250° C., and most preferably from about 180° C. to about 230° C.

[0038] Suitable contact times for the reaction of the perfluoroalkyl iodide with the perfluoroalkyltrihydroolefin are from about 0.5 hour to 18 hours, preferably from about 4 to about 12 hours.

[0039] The trihydroiodoperfluoroalkane prepared by reaction of the perfluoroalkyl iodide with the perfluoroalkyltrihydroolefin may be used directly in the dehydroiodination step or may preferably be recovered and purified by distillation prior to the dehydroiodination step.

[0040] The dehydroiodination step is carried out by contacting the trihydroiodoperfluoroalkane with a basic substance. Suitable basic substances include alkali metal hydroxides (e.g., sodium hydroxide or potassium hydroxide), alkali metal oxide (for example, sodium oxide), alkaline earth metal hydroxides (e.g., calcium hydroxide), alkaline earth metal oxides (e.g., calcium oxide), alkali metal alkoxides (e.g., sodium methoxide or sodium ethoxide), aqueous ammonia, sodium amide, or mixtures of basic substances such as soda lime. Preferred basic substances are sodium hydroxide and potassium hydroxide.

[0041] Said contacting of the trihydroiodoperfluoroalkane with a basic substance may take place in the liquid phase preferably in the presence of a solvent capable of dissolving at least a portion of both reactants. Solvents suitable for the dehydroiodination step include one or more polar organic solvents such as alcohols (e.g., methanol, ethanol, n-propanol, isopropanol, n-butanol, isobutanol, and tertiary butanol), nitriles (e.g., acetonitrile, propionitrile, butyronitrile, benzonitrile, or adiponitrile), dimethyl sulfoxide, N,N-dimethylformamide, N,N-dimethylacetamide, or sulfolane. The choice of solvent may depend on the boiling point product and the ease of separation of traces of the solvent from the product during purification. Typically, ethanol or isopropanol are good solvents for the reaction.

[0042] Typically, the dehydroiodination reaction may be carried out by addition of one of the reactants (either the basic substance or the trihydroiodoperfluoroalkane) to the other reactant in a suitable reaction vessel. Said reaction may be fabricated from glass, ceramic, or metal and is preferably agitated with an impeller or stirring mechanism.

[0043] Temperatures suitable for the dehydroiodination reaction are from about 10° C. to about 100° C., preferably from about 20° C. to about 70° C. The dehydroiodination reaction may be carried out at ambient pressure or at reduced or elevated pressure. Of note are dehydroiodination reactions in which the compound of Formula (I) is distilled out of the reaction vessel as it is formed.

[0044] Alternatively, the dehydroiodination reaction may be conducted by contacting an aqueous solution of said basic substance with a solution of the trihydroiodoperfluoroalkane in one or more organic solvents of lower polarity such as an alkane (e.g., hexane, heptane, or octane), aromatic hydrocarbon (e.g., toluene), halogenated hydrocarbon (e.g., methylene chloride, chloroform, carbon tetrachloride, or perchloroethylene), or ether (e.g., diethyl ether, methyl tert-butyl ether, tetrahydrofuran, 2-methyl tetrahydrofuran, dioxane, dimethoxyethane, diglyme, or tetraglyme) in the presence of a phase transfer catalyst. Suitable phase transfer catalysts include quaternary ammonium halides (e.g., tetrabutylammonium bromide, tetrabutylammonium hydrosulfate, triethylbenzylammonium chloride, dodecyltrimethylammonium chloride, and tricaprylylmethylammonium chloride), quaternary phosphonium halides (e.g., triphenylmethylphosphonium bromide and tetraphenylphosphonium chloride), or cyclic polyether compounds known in the art as crown ethers (e.g., 18-crown-6 and 15-crown-5).

[0045] Alternatively, the dehydroiodination reaction may be conducted in the absence of solvent by adding the trihydroiodoperfluoroalkane to a solid or liquid basic substance.

[0046] Suitable reaction times for the dehydroiodination reactions are from about 15 minutes to about six hours or more depending on the solubility of the reactants. Typically the dehydroiodination reaction is rapid and requires about 30 minutes to about three hours for completion. The compound of Formula (I) may be recovered from the dehydroiodination reaction mixture by phase separation after addition of water, by distillation, or by a combination thereof.

[0047] In another embodiment of the present invention, the working fluid is selected from fluoroolefins comprising cyclic fluoroolefins (cyclo-[$CX{=}CY(CZW)_n$—] (Formula (II)), wherein X, Y, Z, and W are independently selected from H and F, and n is an integer from 2 to 5). In one embodiment the fluoroolefins of Formula (II), have at least about 3 carbon atoms in the molecule. In another embodiment, the fluoroolefins of Formula (II) have at least about 4 carbon atoms in the molecule. In another embodiment, the fluoroolefins of Formula (II) have at least about 5 carbon atoms in the molecule. In yet another embodiment, the fluoroolefins of Formula (II) have at least about 6 carbon atoms in the molecule. Representative cyclic fluoroolefins of Formula (II) are listed in Table 2.

TABLE 2

Cyclic fluoroolefins	Structure	Chemical name
HFO-C1316cc	cyclo-$CF_2CF_2CF{=}CF$—	1,2,3,3,4,4-hexafluorocyclobutene
HFO-C1334cc	cyclo-$CF_2CF_2CH{=}CH$—	3,3,4,4-tetrafluorocyclobutene
HFO-C1436	cyclo-$CF_2CF_2CF_2CH{=}CH$—	3,3,4,4,5,5,-hexafluorocyclopentene
HFO-C1418y	cyclo-$CF_2CF{=}CFCF_2CF_2$—	1,2,3,3,4,4,5,5-octafluorocyclopentene
HFO-C151-10y	cyclo-$CF_2CF{=}CFCF_2CF_2CF_2$—	1,2,3,3,4,4,5,5,6,6-decafluorocyclohexene

[0048] The working fluid of the present invention may comprise a single compound of Formula (I) or Formula (II), for example, one of the compounds in Table 1 or Table 2, or may comprise a combination of compounds of Formula (I) or Formula (II).

[0049] In another embodiment, the working fluid is selected from fluoroolefins comprising those compounds listed in Table 3.

TABLE 3

Name	Structure	Chemical name
HFO-1225ye	$CF_3CF{=}CHF$	1,2,3,3,3-pentafluoro-1-propene
HFO-1225zc	$CF_3CH{=}CF_2$	1,1,3,3,3-pentafluoro-1-propene
HFO-1225yc	$CHF_2CF{=}CF_2$	1,1,2,3,3-pentafluoro-1-propene
HFO-1234ye	$CHF_2CF{=}CHF$	1,2,3,3-tetrafluoro-1-propene

TABLE 3-continued

Name	Structure	Chemical name
HFO-1234yf	$CF_3CF{=}CH_2$	2,3,3,3-tetrafluoro-1-propene
HFO-1234ze	$CF_3CH{=}CHF$	1,3,3,3-tetrafluoro-1-propene
HFO-1234yc	$CH_2FCF{=}CF_2$	1,1,2,3-tetrafluoro-1-propene
HFO-1234zc	$CHF_2CH{=}CF_2$	1,1,3,3-tetrafluoro-1-propene
HFO-1243yf	$CHF_2CF{=}CH_2$	2,3,3-trifluoro-1-propene
HFO-1243zf	$CF_3CH{=}CH_2$	3,3,3-trifluoro-1-propene
HFO-1243yc	$CH_3CF{=}CF_2$	1,1,2-trifluoro-1-propene
HFO-1243zc	$CH_2FCH{=}CF_2$	1,1,3-trifluoro-1-propene
HFO-1243ye	$CH_2FCF{=}CHF$	1,2,3-trifluoro-1-propene
HFO-1243ze	$CHF_2CH{=}CHF$	1,3,3-trifluoro-1-propene
HCFO-1233xf	$CF_3CCl{=}CH_2$	2-chloro-3,3,3-trifluoro-1-propene
HCFO-1233zd	$CF_3CH{=}CHCl$	1-chloro-3,3,3-trifluoro-1-propene
HFO-1318my	$CF_3CF{=}CFCF_3$	1,1,1,2,3,4,4,4-octafluoro-2-butene
HFO-1318cy	$CF_3CF_2CF{=}CF_2$	1,1,2,3,3,4,4,4-octafluoro-1-butene
HFO-1327my	$CF_3CF{=}CHCF_3$	1,1,1,2,4,4,4-heptafluoro-2-butene
HFO-1327ye	$CHF{=}CFCF_2CF_3$	1,2,3,3,4,4,4-heptafluoro-1-butene
HFO-1327py	$CHF_2CF{=}CFCF_3$	1,1,1,2,3,4,4-heptafluoro-2-butene
HFO-1327et	$(CF_3)_2C{=}CHF$	1,3,3,3-tetrafluoro-2-(trifluoromethyl)-1-propene
HFO-1327cz	$CF_2{=}CHCF_2CF_3$	1,1,3,3,4,4,4-heptafluoro-1-butene
HFO-1327cye	$CF_2{=}CFCHFCF_3$	1,1,2,3,4,4,4-heptafluoro-1-butene
HFO-1327cyc	$CF_2{=}CFCF_2CHF_2$	1,1,2,3,3,4,4-heptafluoro-1-butene
HFO-1336yf	$CF_3CF_2CF{=}CH_2$	2,3,3,4,4,4-hexafluoro-1-butene
HFO-1336ze	$CHF{=}CHCF_2CF_3$	1,3,3,4,4,4-hexafluoro-1-butene
HFO-1336eye	$CHF{=}CFCHFCF_3$	1,2,3,4,4,4-hexafluoro-1-butene
HFO-1336eyc	$CHF{=}CFCF_2CHF_2$	1,2,3,3,4,4-hexafluoro-1-butene
HFO-1336pyy	$CHF_2CF{=}CFCHF_2$	1,1,2,3,4,4-hexafluoro-2-butene
HFO-1336qy	$CH_2FCF{=}CFCF_3$	1,1,1,2,3,4-hexafluoro-2-butene
HFO-1336pz	$CHF_2CH{=}CFCF_3$	1,1,1,2,4,4-hexafluoro-2-butene
HFO-1336mzy	$CF_3CH{=}CFCHF_2$	1,1,1,3,4,4-hexafluoro-2-butene
HFO-1336qc	$CF_2{=}CFCF_2CH_2F$	1,1,2,3,3,4-hexafluoro-1-butene
HFO-1336pe	$CF_2{=}CFCHFCHF_2$	1,1,2,3,4,4-hexafluoro-1-butene
HFO-1336ft	$CH_2{=}C(CF_3)_2$	3,3,3-trifluoro-2-(trifluoromethyl)-1-propene
HFO-1345qz	$CH_2FCH{=}CFCF_3$	1,1,1,2,4-pentafluoro-2-butene
HFO-1345mzy	$CF_3CH{=}CFCH_2F$	1,1,1,3,4-pentafluoro-2-butene
HFO-1345fz	$CF_3CF_2CH{=}CH_2$	3,3,4,4,4-pentafluoro-1-butene
HFO-1345mzz	$CHF_2CH{=}CHCF_3$	1,1,1,4,4-pentafluoro-2-butene
HFO-1345sy	$CH_3CF{=}CFCF_3$	1,1,1,2,3-pentafluoro-2-butene
HFO-1345fyc	$CH_2{=}CFCF_2CHF_2$	2,3,3,4,4-pentafluoro-1-butene
HFO-1345pyz	$CHF_2CF{=}CHCHF_2$	1,1,2,4,4-pentafluoro-2-butene
HFO-1345cyc	$CH_3CF_2CF{=}CF_2$	1,1,2,3,3-pentafluoro-1-butene
HFO-1345pyy	$CH_2FCF{=}CFCHF_2$	1,1,2,3,4-pentafluoro-2-butene
HFO-1345eyc	$CH_2FCF_2CF{=}CHF$	1,2,3,3,4-pentafluoro-1-butene
HFO-1345ctm	$CF_2{=}C(CF_3)(CH_3)$	1,1,3,3,3-pentafluoro-2-methyl-1-propene
HFO-1345ftp	$CH_2{=}C(CHF_2)(CF_3)$	2-(difluoromethyl)-3,3,3-trifluoro-1-propene
HFO-1345fye	$CH_2{=}CFCHFCF_3$	2,3,4,4,4-pentafluoro-1-butene
HFO-1345eyf	$CHF{=}CFCH_2CF_3$	1,2,4,4,4-pentafluoro-1-butene
HFO-1345eze	$CHF{=}CHCHFCF_3$	1,3,4,4,4-pentafluoro-1-butene
HFO-1345ezc	$CHF{=}CHCF_2CHF_2$	1,3,3,4,4-pentafluoro-1-butene
HFO-1345eye	$CHF{=}CFCHFCHF_2$	1,2,3,4,4-pentafluoro-1-butene
HFO-1354fzc	$CH_2{=}CHCF_2CHF_2$	3,3,4,4-tetrafluoro-1-butene
HFO-1354ctp	$CF_2{=}C(CHF_2)(CH_3)$	1,1,3,3-tetrafluoro-2-methyl-1-propene
HFO-1354etm	$CHF{=}C(CF_3)(CH_3)$	1,3,3,3-tetrafluoro-2-methyl-1-propene
HFO-1354tfp	$CH_2{=}C(CHF_2)_2$	2-(difluoromethyl)-3,3-difluoro-1-propene
HFO-1354my	$CF_3CF{=}CHCH_3$	1,1,1,2-tetrafluoro-2-butene
HFO-1354mzy	$CH_3CF{=}CHCF_3$	1,1,1,3-tetrafluoro-2-butene
HFO-141-10myy	$CF_3CF{=}CFCF_2CF_3$	1,1,1,2,3,4,4,5,5,5-decafluoro-2-pentene
HFO-141-10cy	$CF_2{=}CFCF_2CF_2CF_3$	1,1,2,3,3,4,4,5,5,5-decafluoro-1-pentene
HFO-1429mzt	$(CF_3)_2C{=}CHCF_3$	1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)-2-butene
HFO-1429myz	$CF_3CF{=}CHCF_2CF_3$	1,1,1,2,4,4,5,5,5-nonafluoro-2-pentene
HFO-1429mzy	$CF_3CH{=}CFCF_2CF_3$	1,1,1,3,4,4,5,5,5-nonafluoro-2-pentene
HFO-1429eyc	$CHF{=}CFCF_2CF_2CF_3$	1,2,3,3,4,4,5,5,5-nonafluoro-1-pentene
HFO-1429czc	$CF_2{=}CHCF_2CF_2CF_3$	1,1,3,3,4,4,5,5,5-nonafluoro-1-pentene
HFO-1429cycc	$CF_2{=}CFCF_2CF_2CHF_2$	1,1,2,3,3,4,4,5,5-nonafluoro-1-pentene
HFO-1429pyy	$CHF_2CF{=}CFCF_2CF_3$	1,1,2,3,4,4,5,5,5-nonafluoro-2-pentene
HFO-1429myyc	$CF_3CF{=}CFCF_2CHF_2$	1,1,1,2,3,4,4,5,5-nonafluoro-2-pentene
HFO-1429myye	$CF_3CF{=}CFCHFCF_3$	1,1,1,2,3,4,5,5,5-nonafluoro-2-pentene
HFO-1429eyym	$CHF{=}CFCF(CF_3)_2$	1,2,3,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene
HFO-1429cyzm	$CF_2{=}CFCH(CF_3)_2$	1,1,2,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene
HFO-1429mzt	$CF_3CH{=}C(CF_3)_2$	1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)-2-butene
HFO-1429czym	$CF_2{=}CHCF(CF_3)_2$	1,1,3,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene
HFO-1438fy	$CH_2{=}CFCF_2CF_2CF_3$	2,3,3,4,4,5,5,5-octafluoro-1-pentene
HFO-1438eycc	$CHF{=}CFCF_2CF_2CHF_2$	1,2,3,3,4,4,5,5-octafluoro-1-pentene
HFO-1438ftmc	$CH_2{=}C(CF_3)CF_2CF_3$	3,3,4,4,4-pentafluoro-2-(trifluoromethyl)-1-butene
HFO-1438czzm	$CF_2{=}CHCH(CF_3)_2$	1,1,4,4,4-pentafluoro-3-(trifluoromethyl)-1-butene

TABLE 3-continued

Name	Structure	Chemical name
HFO-1438ezym	$CHF{=}CHCF(CF_3)_2$	1,3,4,4,4-pentafluoro-3-(trifluoromethyl)-1-butene
HFO-1438ctmf	$CF_2{=}C(CF_3)CH_2CF_3$	1,1,4,4,4-pentafluoro-2-(trifluoromethyl)-1-butene
HFO-1447fzy	$(CF_3)_2CFCH{=}CH_2$	3,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene
HFO-1447fz	$CF_3CF_2CF_2CH{=}CH_2$	3,3,4,4,5,5,5-heptafluoro-1-pentene
HFO-1447fycc	$CH_2{=}CFCF_2CF_2CHF_2$	2,3,3,4,4,5,5-heptafluoro-1-pentene
HFO-1447czcf	$CF_2{=}CHCF_2CH_2CF_3$	1,1,3,3,5,5,5-heptafluoro-1-pentene
HFO-1447mytm	$CF_3CF{=}C(CF_3)(CH_3)$	1,1,1,2,4,4,4-heptafluoro-3-methyl-2-butene
HFO-1447fyz	$CH_2{=}CFCH(CF_3)_2$	2,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene
HFO-1447ezz	$CHF{=}CHCH(CF_3)_2$	1,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene
HFO-1447qzt	$CH_2FCH{=}C(CF_3)_2$	1,4,4,4-tetrafluoro-2-(trifluoromethyl)-2-butene
HFO-1447syt	$CH_3CF{=}C(CF_3)_2$	2,4,4,4-tetrafluoro-2-(trifluoromethyl)-2-butene
HFO-1456szt	$(CF_3)_2C{=}CHCH_3$	3-(trifluoromethyl)-4,4,4-trifluoro-2-butene
HFO-1456szy	$CF_3CF_2CF{=}CHCH_3$	3,4,4,5,5,5-hexafluoro-2-pentene
HFO-1456mstz	$CF_3C(CH_3){=}CHCF_3$	1,1,1,4,4,4-hexafluoro-2-methyl-2-butene
HFO-1456fzce	$CH_2{=}CHCF_2CHFCF_3$	3,3,4,5,5,5-hexafluoro-1-pentene
HFO-1456ftmf	$CH_2{=}C(CF_3)CH_2CF_3$	4,4,4-trifluoro-2-(trifluoromethyl)-1-butene
HFO-151-12c	$CF_3(CF_2)_3CF{=}CF_2$	1,1,2,3,3,4,4,5,5,6,6,6-dodecafluoro-1-hexene (or perfluoro-1-hexene)
HFO-151-12mcy	$CF_3CF_2CF{=}CFCF_2CF_3$	1,1,1,2,2,3,4,5,5,6,6,6-dodecafluoro-3-hexene (or perfluoro-3-hexene)
HFO-151-12mmtt	$(CF_3)_2C{=}C(CF_3)_2$	1,1,1,4,4,4-hexafluoro-2,3-bis(trifluoromethyl)-2-butene
HFO-151-12mmzz	$(CF_3)_2CFCF{=}CFCF_3$	1,1,1,2,3,4,5,5,5-nonafluoro-4-(trifluoromethyl)-2-pentene
HFO-152-11mmtz	$(CF_3)_2C{=}CHC_2F_5$	1,1,1,4,4,5,5,5-octafluoro-2-(trifluoromethyl)-2-pentene
HFO-152-11mmyyz	$(CF_3)_2CFCF{=}CHCF_3$	1,1,1,3,4,5,5,5-octafluoro-4-(trifluoromethyl)-2-pentene
PFBE (or HFO-1549fz)	$CF_3CF_2CF_2CF_2CH{=}CH_2$	3,3,4,4,5,5,6,6,6-nonafluoro-1-hexene (or perfluorobutylethylene)
HFO-1549fztmm	$CH_2{=}CHC(CF_3)_3$	4,4,4-trifluoro-3,3-bis(trifluoromethyl)-1-butene
HFO-1549mmtts	$(CF_3)_2C{=}C(CH_3)(CF_3)$	1,1,1,4,4,4-hexafluoro-3-methyl-2-(trifluoromethyl)-2-butene
HFO-1549fycz	$CH_2{=}CFCF_2CH(CF_3)_2$	2,3,3,5,5,5-hexafluoro-4-(trifluoromethyl)-1-pentene
HFO-1549myts	$CF_3CF{=}C(CH_3)CF_2CF_3$	1,1,1,2,4,4,5,5,5-nonafluoro-3-methyl-2-pentene
HFO-1549mzzz	$CF_3CH{=}CHCH(CF_3)_2$	1,1,1,5,5,5-hexafluoro-4-(trifluoromethyl)-2-pentene
HFO-1558szy	$CF_3CF_2CF_2CF{=}CHCH_3$	3,4,4,5,5,6,6,6-octafluoro-2-hexene
HFO-1558fzccc	$CH_2{=}CHCF_2CF_2CF_2CHF_2$	3,3,4,4,5,5,6,6-octafluoro-2-hexene
HFO-1558mmtzc	$(CF_3)_2C{=}CHCF_2CH_3$	1,1,1,4,4-pentafluoro-2-(trifluoromethyl)-2-pentene
HFO-1558ftmf	$CH_2{=}C(CF_3)CH_2C_2F_5$	4,4,5,5,5-pentafluoro-2-(trifluoromethyl)-1-pentene
HFO-1567fts	$CF_3CF_2CF_2C(CH_3){=}CH_2$	3,3,4,4,5,5,5-heptafluoro-2-methyl-1-pentene
HFO-1567szz	$CF_3CF_2CF_2CH{=}CHCH_3$	4,4,5,5,6,6,6-heptafluoro-2-hexene
HFO-1567fzfc	$CH_2{=}CHCH_2CF_2C_2F_5$	4,4,5,5,6,6,6-heptafluoro-1-hexene
HFO-1567sfyy	$CF_3CF_2CF{=}CFC_2H_5$	1,1,1,2,2,3,4-heptafluoro-3-hexene
HFO-1567fzfy	$CH_2{=}CHCH_2CF(CF_3)_2$	4,5,5,5-tetrafluoro-4-(trifluoromethyl)-1-pentene
HFO-1567myzzm	$CF_3CF{=}CHCH(CF_3)(CH_3)$	1,1,1,2,5,5,5-heptafluoro-4-methyl-2-pentene
HFO-1567mmtyf	$(CF_3)_2C{=}CFC_2H_5$	1,1,1,3-tetrafluoro-2-(trifluoromethyl)-2-pentene
HFO-161-14myy	$CF_3CF{=}CFCF_2CF_2C_2F_5$	1,1,1,2,3,4,4,5,5,6,6,7,7,7-tetradecafluoro-2-heptene
HFO-161-14mcyy	$CF_3CF_2CF{=}CFCF_2C_2F_5$	1,1,1,2,2,3,4,5,5,6,6,7,7,7-tetradecafluoro-2-heptene
HFO-162-13mzy	$CF_3CH{=}CFCF_2CF_2C_2F_5$	1,1,1,3,4,4,5,5,6,6,7,7,7-tridecafluoro-2-heptene
HFC162-13myz	$CF_3CF{=}CHCF_2CF_2C_2F_5$	1,1,1,2,4,4,5,5,6,6,7,7,7-tridecafluoro-2-heptene
HFO-162-13mczy	$CF_3CF_2CH{=}CFCF_2C_2F_5$	1,1,1,2,2,4,5,5,6,6,7,7,7-tridecafluoro-3-heptene
HFO-162-13mcyz	$CF_3CF_2CF{=}CHCF_2C_2F_5$	1,1,1,2,2,3,5,5,6,6,7,7,7-tridecafluoro-3-heptene
PEVE	$CF_2{=}CFOCF_2CF_3$	pentafluoroethyl trifluorovinyl ether
PMVE	$CF_2{=}CFOCF_3$	trifluoromethyl trifluorovinyl ether

[0050] The compounds listed in Table 2 and Table 3 are available commercially or may be prepared by processes known in the art or as described herein.

[0051] 1,1,1,4,4-pentafluoro-2-butene may be prepared from 1,1,1,2,4,4-hexafluorobutane ($CHF_2CH_2CHFCF_3$) by dehydrofluorination over solid KOH in the vapor phase at room temperature. The synthesis of 1,1,1,2,4,4-hexafluorobutane is described in U.S. Pat. No. 6,066,768. 1,1,1,4,4,4-hexafluoro-2-butene may be prepared from 1,1,1,4,4,4-hexafluoro-2-iodobutane ($CF_3CHICH_2CF_3$) by reaction with KOH using a phase transfer catalyst at about 60° C. The synthesis of 1,1,1,4,4,4-hexafluoro-2-iodobutane may be carried out by reaction of perfluoromethyl iodide (CF_3I) and 3,3,3-trifluoropropene ($CF_3CH{=}CH_2$) at about 200° C. under autogenous pressure for about 8 hours.

[0052] 3,4,4,5,5,5-hexafluoro-2-pentene may be prepared by dehydrofluorination of 1,1,1,2,2,3,3-heptafluoropentane ($CF_3CF_2CF_2CH_2CH_3$) using solid KOH or over a carbon catalyst at 200-300° C. 1,1,1,2,2,3,3-heptafluoropentane may be prepared by hydrogenation of 3,3,4,4,5,5,5-heptafluoro-1-pentene ($CF_3CF_2CF_2CH{=}CH_2$).

[0053] 1,1,1,2,3,4-hexafluoro-2-butene may be prepared by dehydrofluorination of 1,1,1,2,3,3,4-heptafluorobutane ($CH_2FCF_2CHFCF_3$) using solid KOH.

[0054] 1,1,1,2,4,4-hexafluoro-2-butene may be prepared by dehydrofluorination of 1,1,1,2,2,4,4-heptafluorobutane ($CHF_2CH_2CF_2CF_3$) using solid KOH.

[0055] 1,1,1,3,4,4-hexafluoro2-butene may be prepared by dehydrofluorination of 1,1,1,3,3,4,4-heptafluorobutane ($CF_3CH_2CF_2CHF_2$) using solid KOH.

[0056] 1,1,1,2,4-pentafluoro-2-butene may be prepared by dehydrofluorination of 1,1,1,2,2,3-hexafluorobutane ($CH_2FCH_2CF_2CF_3$) using solid KOH.

[0057] 1,1,1,3,4-pentafluoro-2-butene may be prepared by dehydrofluorination of 1,1,1,3,3,4-hexafluorobutane ($CF_3CH_2CF_2CH_2F$) using solid KOH.

[0058] 1,1,1,3-tetrafluoro-2-butene may be prepared by reacting 1,1,1,3,3-pentafluorobutane ($CF_3CH_2CF_2CH_3$) with aqueous KOH at 120° C.

[0059] 1,1,1,4,4,5,5,5-octafluoro-2-pentene may be prepared from $(CF_3CHICH_2CF_2CF_3)$ by reaction with KOH using a phase transfer catalyst at about 60° C. The synthesis of 4-iodo-1,1,1,2,2,5,5,5-octafluoropentane may be carried out by reaction of perfluoroethyliodide (CF_3CF_2I) and 3,3,3-trifluoropropene at about 200° C. under autogenous pressure for about 8 hours.

[0060] 1,1,1,2,2,5,5,6,6,6-decafluoro-3-hexene may be prepared from 1,1,1,2,2,5,5,6,6,6-decafluoro-3-iodohexane $(CF_3CF_2CHICH_2CF_2CF_3)$ by reaction with KOH using a phase transfer catalyst at about 60° C. The synthesis of 1,1,1,2,2,5,5,6,6,6-decafluoro-3-iodohexane may be carried out by reaction of perfluoroethyliodide (CF_3CF_2I) and 3,3,4,4,4-pentafluoro-1-butene $(CF_3CF_2CH{=}CH_2)$ at about 200° C. under autogenous pressure for about 8 hours.

[0061] 1,1,1,4,5,5,5-heptafluoro-4-(trifluoromethyl)-2-pentene may be prepared by the dehydrofluorination of 1,1,1,2,5,5,5-heptafluoro-4-iodo-2-(trifluoromethyl)-pentane $(CF_3CHICH_2CF(CF_3)_2)$ with KOH in isopropanol. $CF_3CHICH_2CF(CF_3)_2$ is made from reaction of $(CF_3)_2CFI$ with $CF_3CH{=}CH_2$ at high temperature, such as about 200° C.

[0062] 1,1,1,4,4,5,5,6,6,6-decafluoro-2-hexene may be prepared by the reaction of 1,1,1,4,4,4-hexafluoro-2-butene $(CF_3CH{=}CHCF_3)$ with tetrafluoroethylene $(CF_2{=}CF_2)$ and antimony pentafluoride (SbF_5).

[0063] 2,3,3,4,4-pentafluoro-1-butene may be prepared by dehydrofluorination of 1,1,2,2,3,3-hexafluorobutane over fluorided alumina at elevated temperature.

[0064] 2,3,3,4,4,5,5,5-ocatafluoro-1-pentene may be prepared by dehydrofluorination of 2,2,3,3,4,4,5,5,5-nonafluoropentane over solid KOH.

[0065] 1,2,3,3,4,4,5,5-octafluoro-1-pentene may be prepared by dehydrofluorination of 2,2,3,3,4,4,5,5,5-nonafluoropentane over fluorided alumina at elevated temperature.

[0066] Many of the compounds of Formula 1, Formula 2, Table 1, Table 2 and Table 3 exist as different configurational isomers or stereoisomers. When the specific isomer is not designated, the present invention is intended to include all single configurational isomers, single stereoisomers, or any combination thereof. For instance, F11E is meant to represent the E-isomer, Z-isomer, or any combination or mixture of both isomers in any ratio. As another example, HFO-1225ye is meant to represent the E-isomer, Z-isomer, or any combination or mixture of both isomers in any ratio.

[0067] Additionally, the working fluid may be any of the single fluoroolefins of Formula (I), Formula (II), Table 1, Table 2 and Table 3, or may be any combination of the different fluoroolefins from Formula (I), Formula (II), Table 1, Table 2 and Table 3.

[0068] In some embodiments, the working fluid may be any combination of a single fluoroolefin or multiple fluoroolefins selected from Formula (I), Formula (II), Table 1, Table 2 and Table 3 with at least one additional refrigerant selected from hydrofluorocarbons, fluoroethers, hydrocarbons, CF_3I, ammonia (NH_3), carbon dioxide (CO_2), nitrous oxide (N_2O), and mixtures thereof, meaning mixtures of any of the foregoing compounds.

[0069] Hydrofluorocarbon working fluids may additionally include compounds having any combination of hydrogen and fluorine with carbon and include compounds with carbon-carbon double. Examples of hydrofluorocarbon working fluids useful for the invention include but are not limited to trifluoromethane (HFC-23), difluoromethane (HFC-32), fluoromethane (HFC-41), pentafluoroethane (HFC-125), 1,1,2,2-tetrafluoroethane (HFC-134), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,1-trifluoroethane (HFC-143a), 1,1-difluoroethane (HFC-152a), fluoroethane (HFC-161), 1,1,1,3,3-pentafluoropropane (HFC-245fa), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), 1,1,1,2,3,3,3-heptafluoropropane (HFC-227ea), 1,1,1,3,3-pentafluorobutane (HFC-365mfc), 1,1,1,2,3,4,4,5,5,5-decafluoropentane (HFC-43-10mee), 1,1,1,2,2,3,4,5,5,6,6,7,7,7-tetradecafluoroheptane (HFC-63-14mcee), cis- or trans-1,2-difluoroethene (HFO-1132), 2,3,3,3-tetrafluoropropene (HFO-1234yf), 1,3,3,3-tetrafluoropropene (HFO-1234ze), cis- or trans-1,2,3,3-tetrafluoropropene (HFO-1234ye), 3,3,3-trifluoropropene (HFO-1243zf), cis- or trans-1,2,3,3,3-pentafluoropropene (HFO-1225ye), 1,1,1,3,3-pentafluoropropene (HFO-1225zc), cis- or trans-1,1,1,2,4,4,4-heptafluoro-2-butene (HFO-1327my), cis- or trans-1,1,1,4,4,4-hexafluoro-2-butene (HFO-1336mzz), 3,4,4,4-tetrafluoro-3-trifluoromethyl-1-butene $((CF_3)_2CFCH{=}CH_2$, HFO-1447fzy), cis- or trans-1,1,1,4,4,5,5,5-octafluoro-2-pentene $(CF_3CF_2CH{=}CHCF_3$, HFO-1438mzz), cis- or trans-1,1,1,2,2,4,5,5,6,6,7,7,7-tridecafluoro-3-heptene (HFO-162-13mczy) and cis- or trans-1,1,1,2,2,3,5,5,6,6,7,7,7-tridecafluoro-3-heptene (HFO-162-13mcyz), and mixtures thereof. In one embodiment of the invention, the hydrofluorocarbon working fluids are selected from the group consisting of difluoromethane (HFC-32), pentafluoroethane (HFC-125), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,1-trifluoroethane (HFC-143a), 1,1-difluoroethane (HFC-152a), 2,3,3,3-tetrafluoropropene (HFO-1234yf), 1,3,3,3-tetrafluoropropene (HFO-1234ze), and mixtures thereof.

[0070] Chlorofluorocarbon working fluids may include compounds having any combination of chlorine and fluorine with carbon and include compounds with carbon-carbon double bonds with normal boiling points below 0° C. Representative chlorofluorocarbon working fluids useful for the invention include but are not limited to dichlorodifluoromethane (CFC-12), fluorotrichloromethane (CFC-11), 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), 1,2-dichloro-1,1,2,2-tetrafluoroethane (CFC-114) and mixtures thereof.

[0071] Hydrochlorofluorocarbon working fluids may include compounds with any combination of hydrogen, chlorine and fluorine with carbon and include compounds with carbon-carbon double bonds with normal boiling points below 0° C. Representative hydrochlorofluorocarbon working fluids useful for the invention include but are not limited to chlorodifluoromethane (HCFC-22), 2-chloro-3,3,3-trifluoropropene (HCFO-1233xf, $CF_3CCl{=}CH_2$), cis- or trans-1-chloro-3,3,3-trifluoropropene (HCFO-1233zd, $CF_3CH{=}CHCl$), and mixtures thereof.

[0072] Fluorocarbon working fluids may include compounds with any combination of fluorine and carbon and include compounds with carbon-carbon double bonds, as well as cyclic compounds. Examples of fluorocarbon working fluids useful for the invention include but are not limited to perfluoromethane (FC-14), perfluoroethane (FC-116), perfluoropropane (FC-218, perfluorocyclobutane (FC-C318), octafluoro-2-butene (FO-1318my), and mixtures thereof.

[0073] Non-fluorinated hydrocarbon working fluids useful for the invention may include but are not limited to methane, ethane, ethylene, propane, cyclopropane, propylene, n-butane, butane, isobutane, cyclobutane, n-pentane, isopentane, n-hexane, cyclohexane, n-heptane, and mixtures thereof.

[0074] In one embodiment, a working fluid as used herein may also be selected from the group consisting water, and mixtures of water with other water soluble compounds, such as alcohols, including methanol, ethanol, 1-propanol, 2-propanol, and butanols, and mixtures thereof. The other compounds may also include HFC-32, HFC-125, HFC-134, HFC-134a, HFC-143a, HFC-152a, HFC-161, HCFC-22, FC-14, FC-116, CFC-12, NH_3, CO_2, N_2, O_2, H_2, Ar, methane, ethane, propane, cyclopropane, propylene, butane, butene, and isobutane.

[0075] Mixtures of working fluids are also useful for achieving proper boiling temperature or pressure appropriate for absorption equipment. In particular, mixtures that form azeotropes, azeotrope-like mixtures, or constant boiling mixtures are sometimes preferred because minimal to no fractionation of the mixture will occur if the working fluid leaks from the absorption cooling system.

[0076] In another embodiment, the hydrofluorocarbon working fluids may comprise mixtures or blends of hydrofluorocarbons with other compounds such as hydrofluorocarbons, hydrochlorofluorocarbons, hydrocarbons or other compounds. Such working fluid blends include the following compositions:

[0077] HFO-1447fzy with at least one compound selected from the group consisting of cis- or trans-HFO-1438mzz, cis- or trans-HFO1336mzz, HCFO-1233xf, and cis- or trans-HCFO-1233zd;

[0078] cis-HFO-1438mzz with at least one compound selected from the group consisting of trans-HFO-1438mzz, cis- or trans-HFO1336mzz, HCFO-1233xf, and cis- or trans-HCFO-1233zd;

[0079] trans-HFO-1438mzz with at least one compound selected from the group consisting of cis- or trans-HFO1336mzz, HCFO-1233xf, cis- or trans-HCFO-1233zd, and isopentane;

[0080] cis-HFO-1336mzz with at least one compound selected from the group consisting of trans-HFO-1336mzz, HCFO-1233xf, cis- or trans-HCFO-1233zd, isopentane, n-pentane, cyclopentane, methyl formate, 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123), and trans-1,2-dichloroethylene;

[0081] trans-HFO-1336mzz with at least one compound selected from the group consisting of HCFO-1233xf, and cis- or trans-HCFO-1233zd;

[0082] HCFO-1233xf with at least one compound selected from the group consisting of cis- and trans-HCFO-1233zd.

[0083] In another embodiment, working fluids that are mixtures may be azeotrope or azeotrope-like compositions such as the following:

[0084] about 51 weight percent to about 70 weight percent cis-HFO-1336mzz and about 49 weight percent to about 30 weight percent isopentane;

[0085] about 62 weight percent to about 78 weight percent cis-HFO-1336mzz and about 38 weight percent to about 22 weight percent n-pentane;

[0086] about 75 weight percent to about 88 weight percent cis-HFO-1336mzz and about 25 weight percent to about 12 weight percent cyclopentane;

[0087] about 25 weight percent to about 35 weight percent cis-HFO-1336mzz and about 75 weight percent to about 65 weight percent HCFC-123;

[0088] about 67 weight percent to about 87 weight percent cis-HFO-1336mzz and about 33 weight percent to about 13 weight percent trans-1,2-dichloroethylene; and

[0089] about 61 weight percent to about 78 weight percent trans-HFO-1438mzz and about 39 weight percent to about 22 weight percent isopentane.

Absorbents

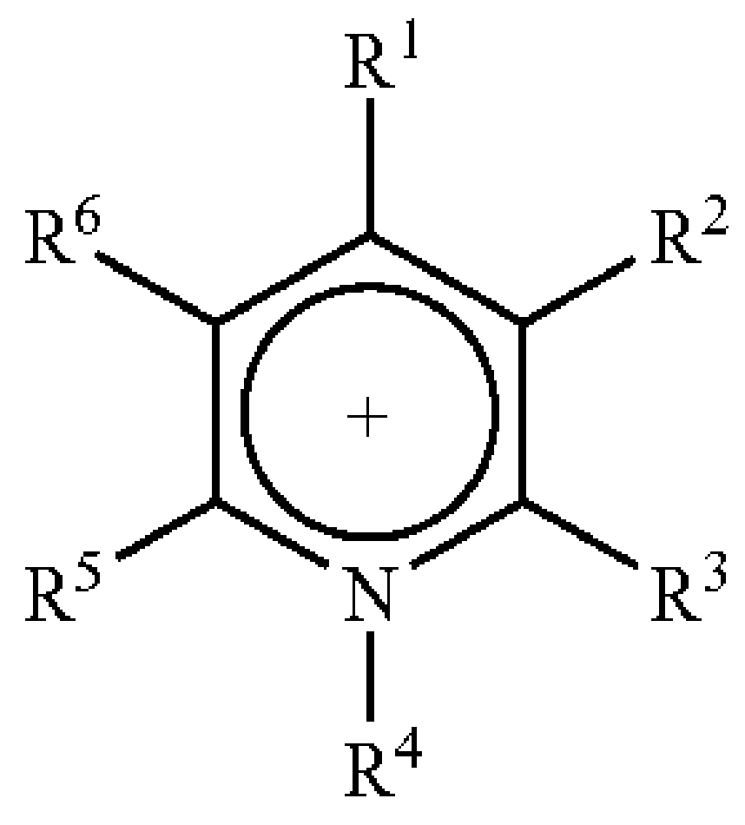
[0090] In a preferred embodiment of the absorption cycle of this invention, the absorbent used is an ionic compound, which can in principle be any ionic liquid that absorbs the selected working fluid (e.g. ammonia or CO_2, HFO-1336mzz or HFO-1234yf or HCFO-1233zd or HCFO-1233xf or mixtures thereof). A suitable ionic liquid that absorbs working fluid is an ionic liquid with which at least to some extent working fluid is miscible. The energy efficiency of the absorption power cycle will, generally, increase with increased absorptivity of the ionic liquid for the working fluid (i.e., the working fluid has high miscibility therewith or the working fluid is soluble therein to a large extent).

[0091] Many ionic liquids are formed by reacting a nitrogen-containing heterocyclic ring, preferably a heteroaromatic ring, with an alkylating agent (for example, an alkyl halide) to form a quaternary ammonium salt, and performing ion exchange or other suitable reactions with various Lewis acids or their conjugate bases to form the ionic compound. Examples of suitable heteroaromatic rings include substituted pyridines, imidazole, substituted imidazole, pyrrole and substituted pyrroles. These rings can be alkylated with virtually any straight, branched or cyclic C_{1-20} alkyl group, but preferably, the alkyl groups are C_{1-16} groups. Various triarylphosphines, thioethers and cyclic and non-cyclic quaternary ammonium salts may also been used for this purpose. Counterions that may be used include chloroaluminate, bromoaluminate, gallium chloride, tetrafluoroborate, tetrachloroborate, hexafluorophosphate, nitrate, trifluoromethane sulfonate, methylsulfonate, p-toluenesulfonate, hexafluoroantimonate, hexafluoroarsenate, tetrachloroaluminate, tetrabromoaluminate, perchlorate, hydroxide anion, copper dichloride anion, iron trichloride anion, zinc trichloride anion, as well as various lanthanum, potassium, lithium, nickel, cobalt, manganese, and other metal-containing anions.

[0092] Ionic liquids may also be synthesized by salt metathesis, by an acid-base neutralization reaction or by quaternizing a selected nitrogen-containing compound; or they may be obtained commercially from several companies such as Merck (Darmstadt, Germany) or BASF (Mount Olive, N.J.).

[0093] Representative examples of ionic liquids useful herein are included among those that are described in sources such as *J. Chem. Tech. Biotechnol.*, 68:351-356 (1997); *Chem. Ind.*, 68:249-263 (1996); *J. Phys. Condensed Matter,* 5: (supp 34B):B99-B106 (1993); *Chemical and Engineering News*, Mar. 30, 1998, 32-37*; J. Mater. Chem.*, 8:2627-2636 (1998); *Chem. Rev.*, 99:2071-2084 (1999); and WO 05/113,702 (and references therein cited). In one embodiment, a library, i.e. a combinatorial library, of ionic compounds may be prepared, for example, by preparing various alkyl derivatives of a quaternary ammonium cation, and varying the associated anions. The acidity of the ionic compounds can be adjusted by varying the molar equivalents and type and combinations of Lewis acids.

[0094] Ionic liquids that are suitable for use as absorbents include those having cations selected from the following, and mixtures thereof: Lithium, Sodium, Potassium, Cesium, and the following Formulae: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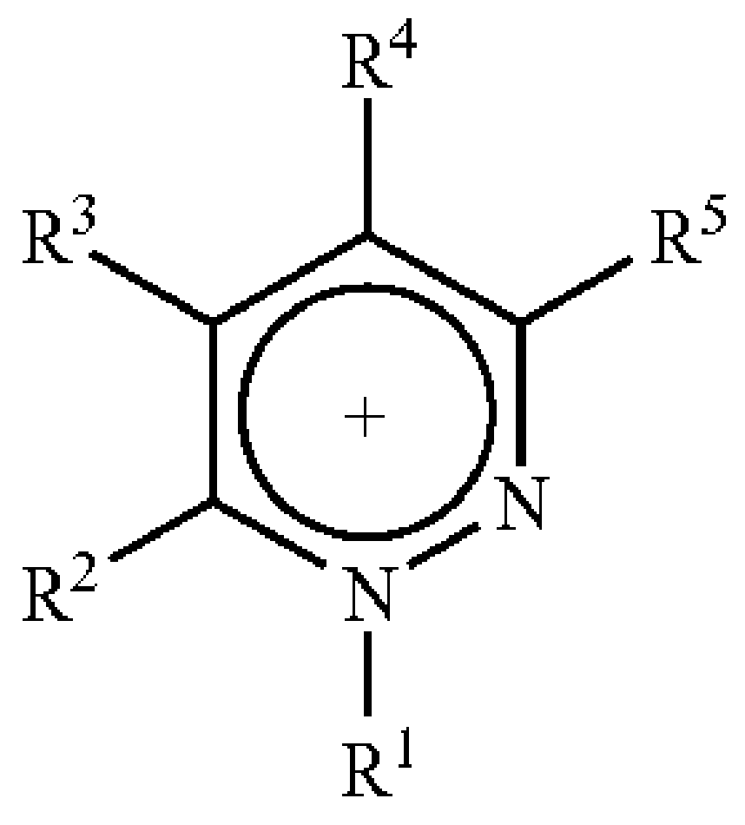
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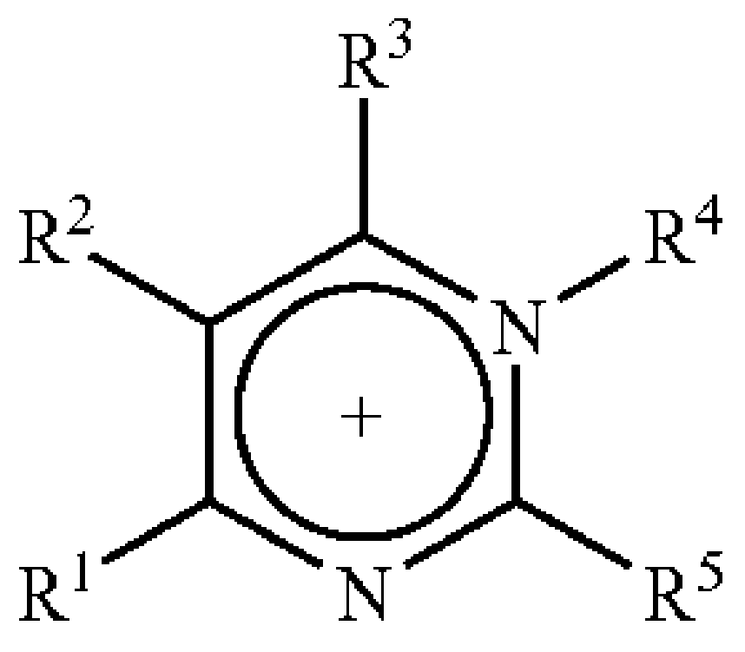
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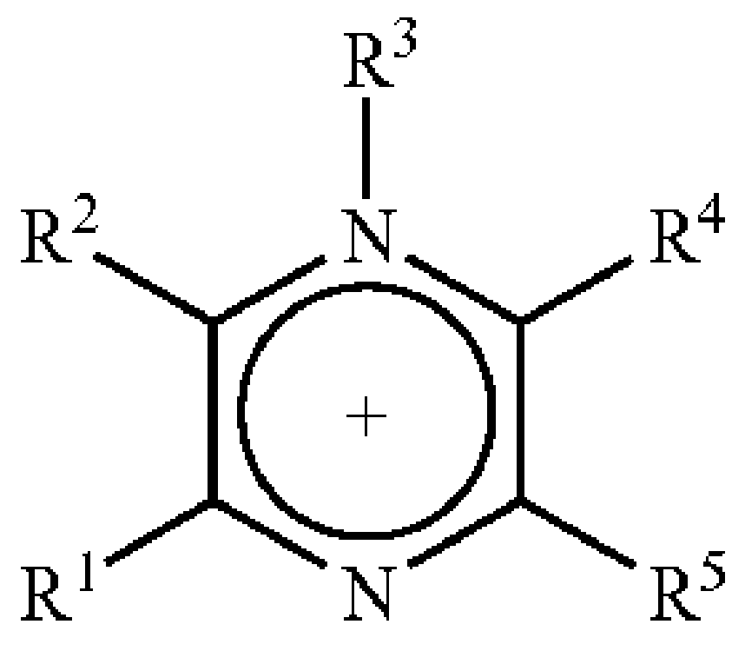
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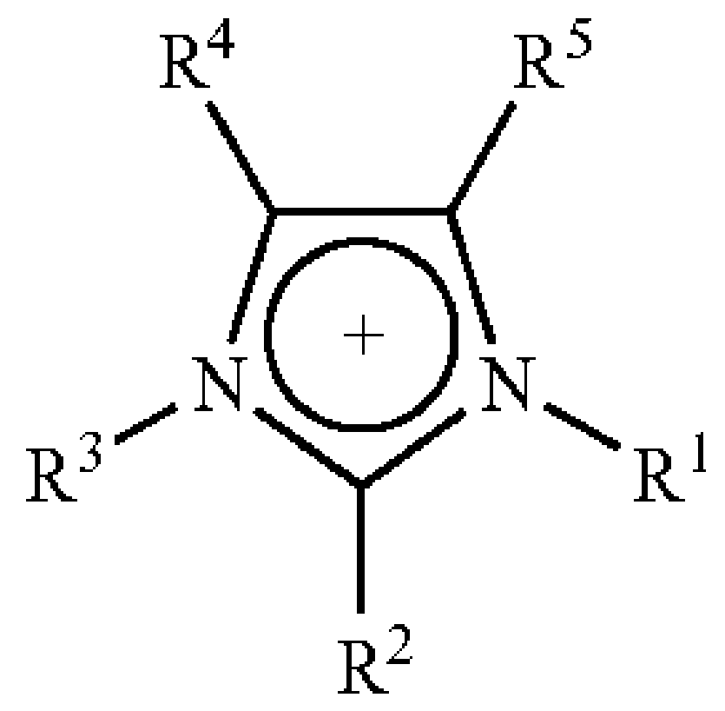
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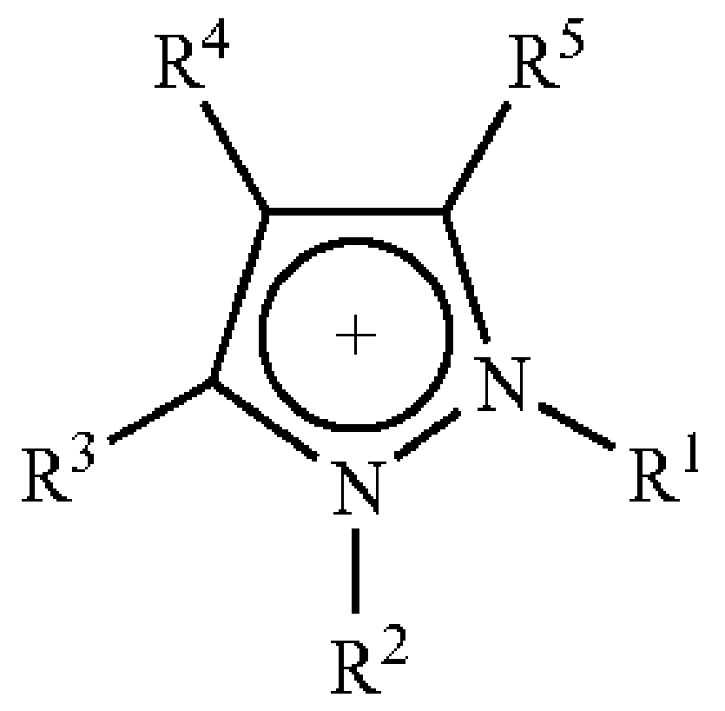
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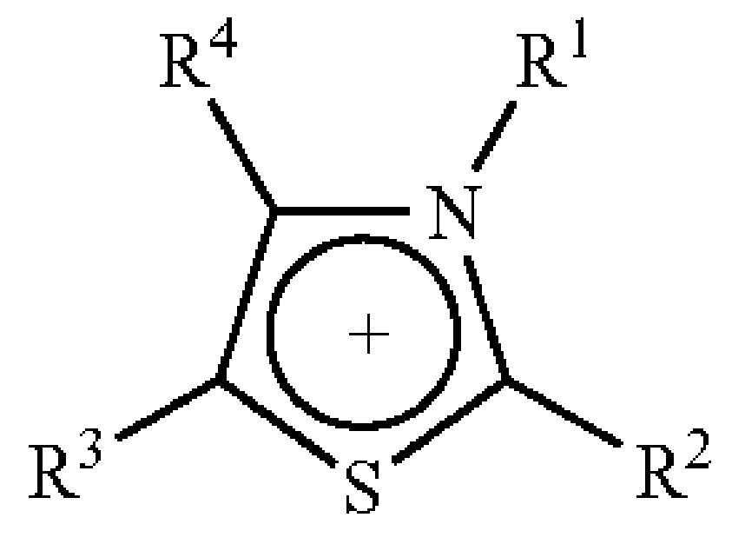
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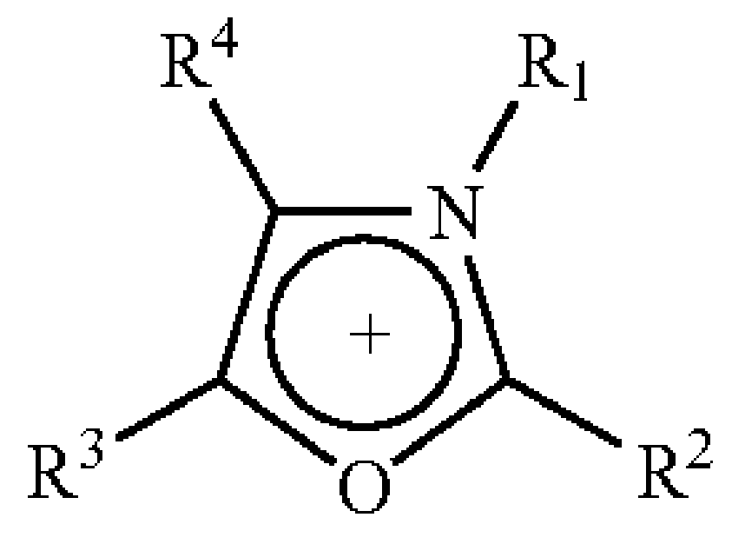
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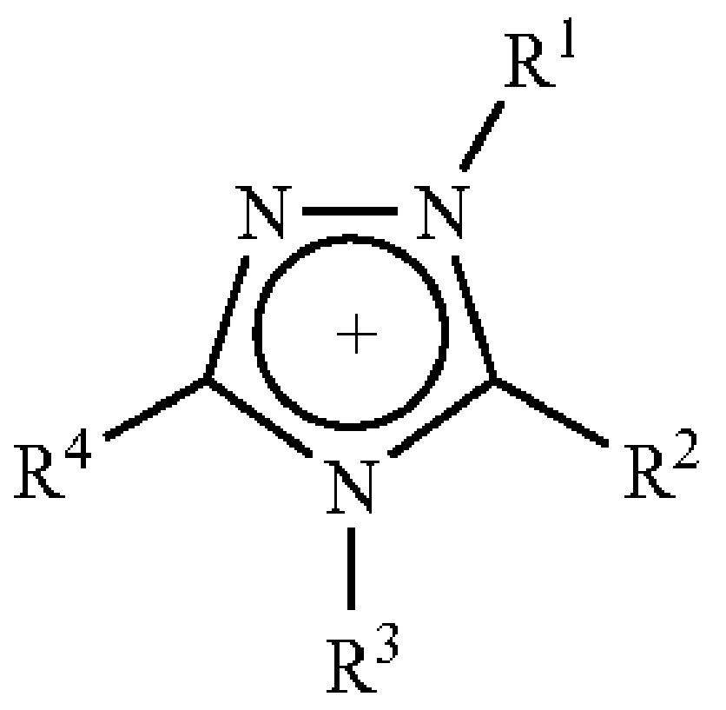
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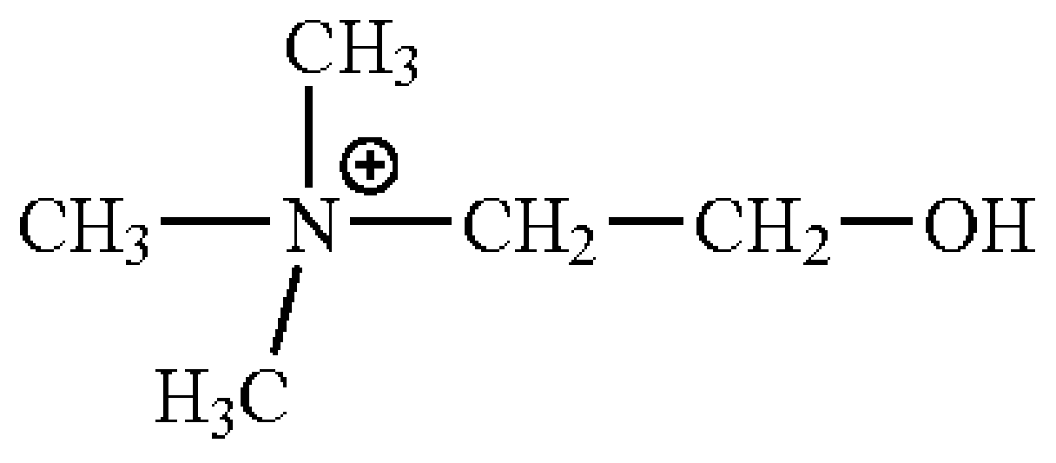
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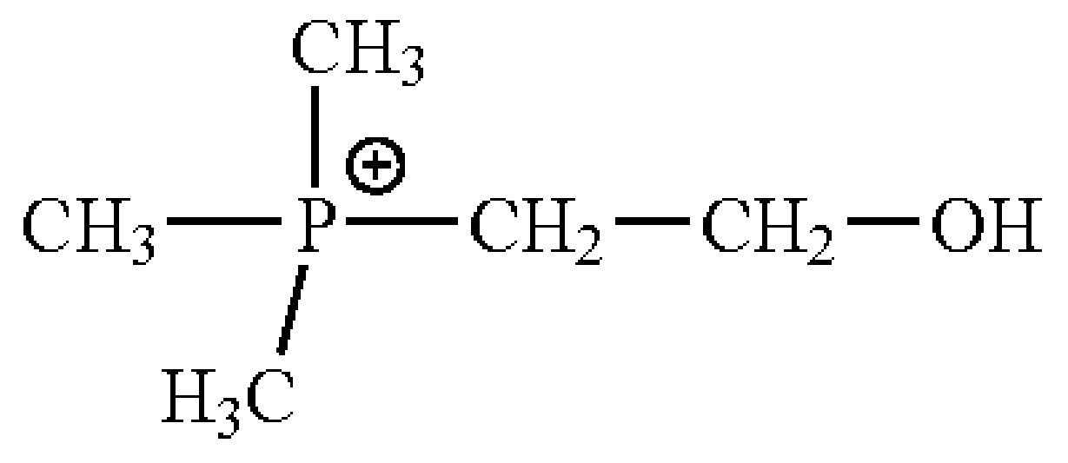
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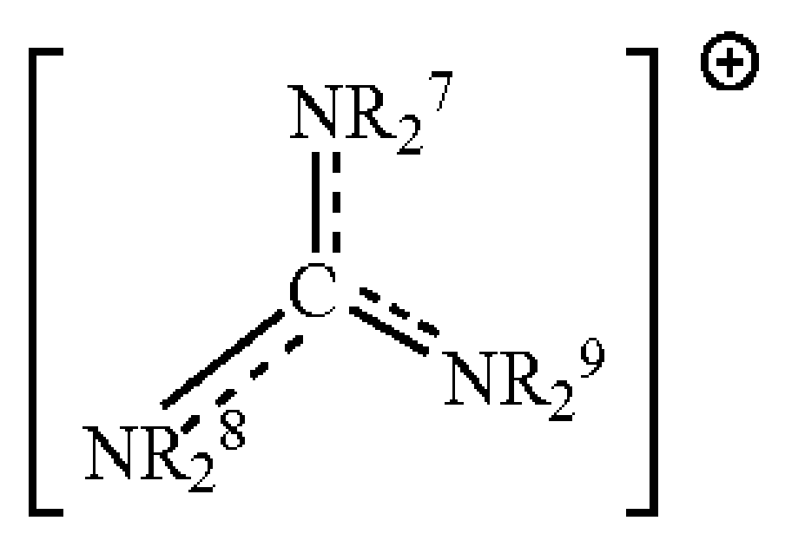
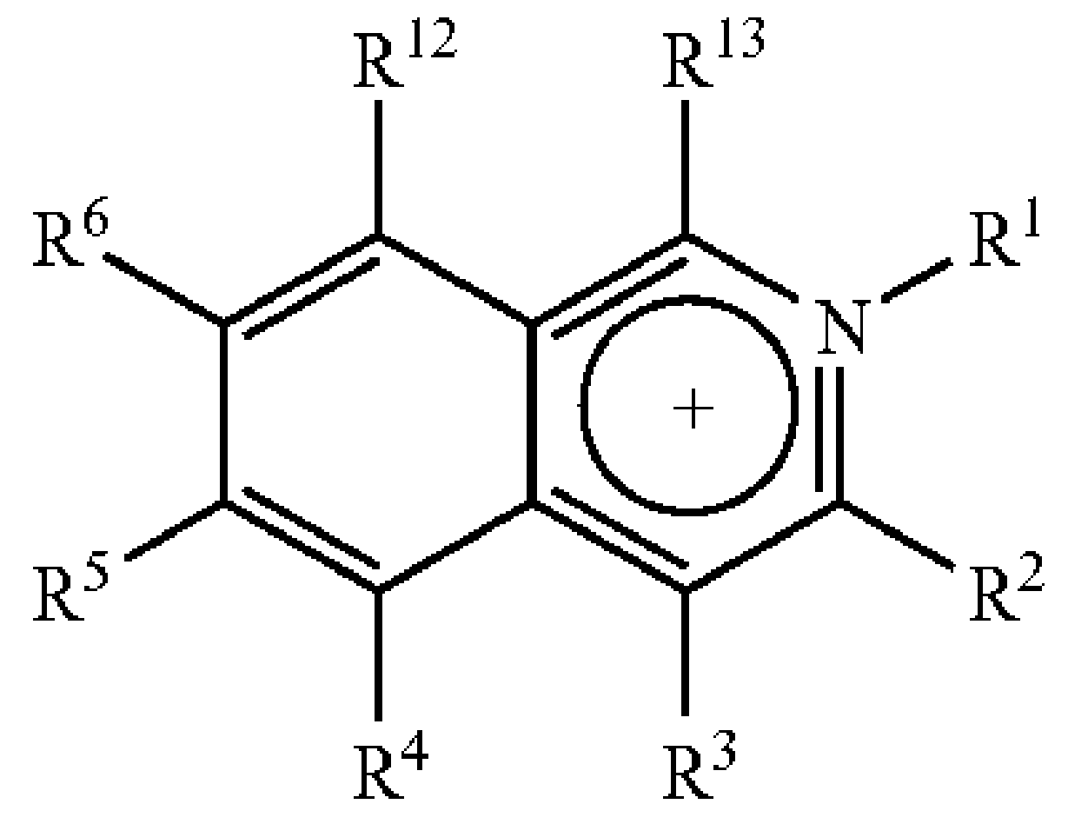
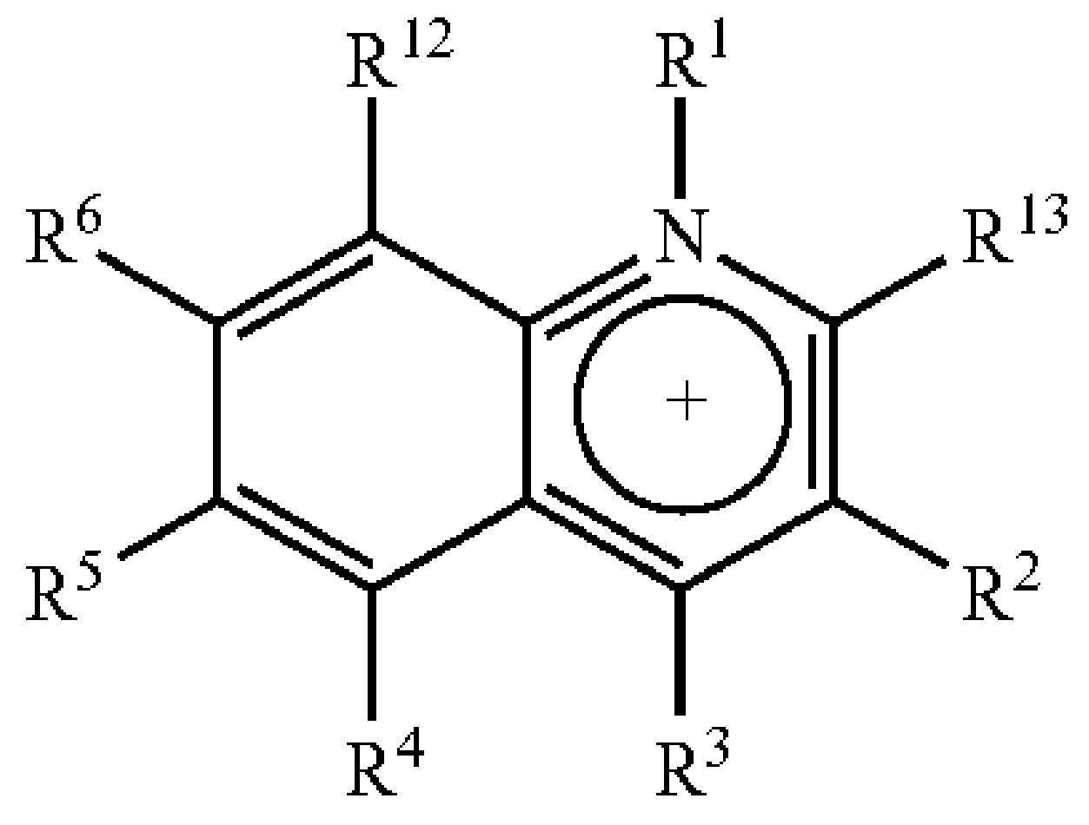
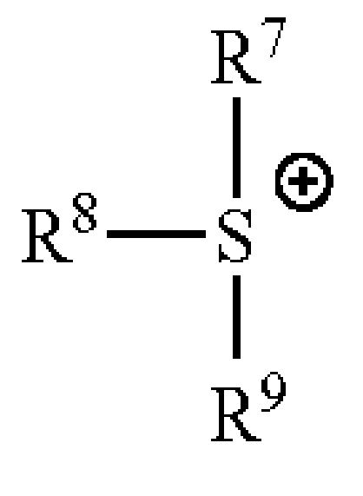
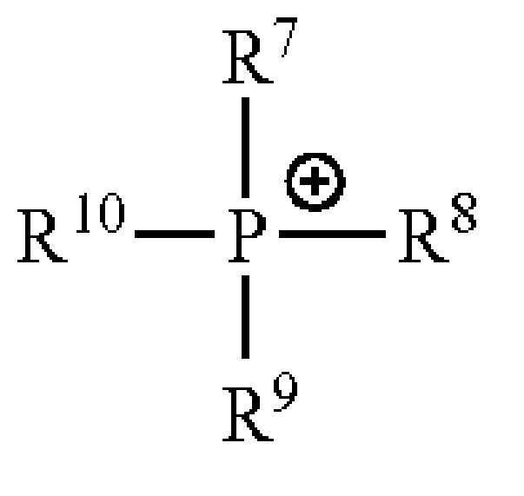

Guanidinium


Isoquinolinium

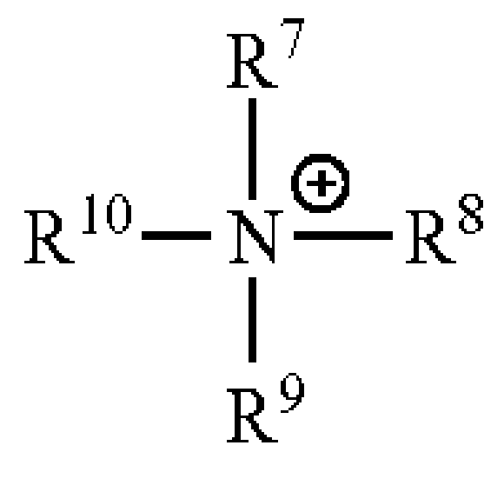

Quinolinium


$R^8-\overset{R^7}{\underset{R^9}{S^{\oplus}}}$

Sulfonium


$R^{10}-\overset{R^7}{\underset{R^9}{P^{\oplus}}}-R^8$ and

Phosphonium


$R^{10}-\overset{R^7}{\underset{R^9}{N^{\oplus}}}-R^8$

Ammonium

[0095] wherein R^1, R^2, R^3, R^4, R^5, R^6, R^{12} and R^{13} are independently selected from the group consisting of:

[0096] (i) H

[0097] (ii) halogen

[0098] (iii) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;

[0099] (iv) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene comprising one to three heteroatoms selected from the group consisting of O, N, Si and S, and optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;

[0100] (v) C_6 to C_{20} unsubstituted aryl, or C_3 to C_{25} unsubstituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and

[0101] (vi) C_6 to C_{25} substituted aryl, or C_3 to C_{25} substituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and wherein said substituted aryl or substituted heteroaryl has one to three substituents independently selected from the group consisting of:

[0102] (1) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F I, OH, NH_2 and SH,

[0103] (2) OH,

[0104] (3) NH_2, and

[0105] (4) SH;

[0106] R^7, R^8, R^9, and R^{10} are independently selected from the group consisting of:

[0107] (i) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;

[0108] (ii) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene comprising one to three heteroatoms selected from the group consisting of O, N, Si and S, and optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;

[0109] (iii) C_6 to C_{25} unsubstituted aryl, or C_3 to C_{25} unsubstituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and

[0110] (iv) C_6 to C_{25} substituted aryl, or C_3 to C_{25} substituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and wherein said substituted aryl or substituted heteroaryl has one to three substituents independently selected from the group consisting of:

[0111] (1) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH,

[0112] (2) OH,

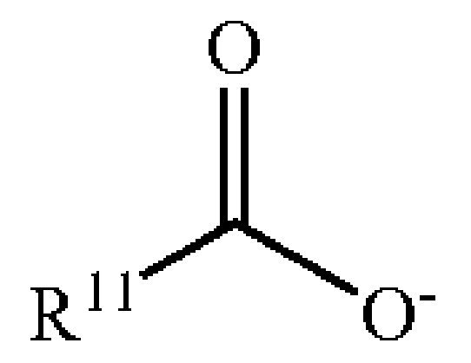
[0113] (3) NH_2, and

[0114] (4) SH; and

[0115] wherein optionally at least two of R^1, R^2, R^3, R^4, R^5, $R^{6,}$ R^7, R^8, R^9, and R^{10} can together form a cyclic or bicyclic alkanyl or alkenyl group.

[0116] Ionic liquids suitable for use as absorbents include those having anions selected from the following, and mixtures thereof: $[CH_3CO_2]^-$, $[HSO_4]$, $[CH_3OSO_3]^-$, $[C_2H_5OSO_3]^-$, $[AlCl_4]^-$, $[CO_3]^{2-}$, $[HCO_3]^-$, $[NO_2]^-$, $[NO_3]^-$, $[SO_4]^{2-}$, $[PO_3]^{3-}$, $[HPO_3]^{2-}$, $[H_2PO_3]^{1-}$, $[PO_4]^{3-}$,

$[HPO_4]^{2-}$, $[H_2PO_4]^-$, $[HSO_3]^-$, $[CuCl_2]^-$, Cl^-, Br^-, I^-, SCN^-; $BR^1R^2R^3R^4$, $BOR^1OR^2OR^3OR^4$, carborates (1-carbadodecaborate(1-)), optionally substituted with alkyl or substituted alkyl, carboranes (dicarbadodecaborate(1-)) optionally substituted with alkylamine, substituted alkylamine, alkyl or substituted alkyl, and preferably any fluorinated anion. Fluorinated anions useful herein include $[BF_4]^-$, $[PF_6]^-$, $[SbF_6]^-$, $[CF_3SO_3]^-$, $[HCF_2CF_2SO_3]^-$, $[CF_3HFCCF_2SO_3]^-$, $[HCClFCF_2SO_3]$, $[(CF_3SO_2)_2N]$, $[(CF_3CF_2SO_2)_2N]^-$, $[(CF_3SO_2)_3C]^-$, $[CF_3CO_2]^-$, $[CF_3OCFHCF_2SO_3]^-$, $[CF_3CF_2OCFHCF_2SO_3]^-$, $[CF_3CFHOCF_2CF_2SO_3]^-$, $[CF_2HCF_2OCF_2CF_2SO_3]^-$, $[CF_2ICF_2OCF_2CF_2SO_3]$, $[CF_3CF_2OCF_2CF_2SO_3]$, $[(CF_2HCF_2SO_2)_2N]$, $[(CF_3CFHCF_2SO_2)_2N]^-$; and F. Other suitable anions include those of the Formula:



[0117] wherein R^{11} is selected from the group consisting of:

[0118] (i) —CH_3, —C_2H_5, or C_3 to C_{10} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;

[0119] (ii) —CH_3, —C_2H_5, or C_3 to C_{10} straight-chain, branched or cyclic alkane or alkene comprising one to three heteroatoms selected from the group consisting of O, N, Si and S, and optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;

[0120] (iii) C_6 to C_{10} unsubstituted aryl, or C_3 to C_{10} unsubstituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and

[0121] (iv) C_6 to C_{10} substituted aryl, or C_3 to C_{10}substituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and wherein said substituted aryl or substituted heteroaryl has one to three substituents independently selected from the group consisting of:

[0122] (1) —CH_3, —C_2H_5, or C_3 to C_{10} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F I, OH, NH_2 and SH,

[0123] (2) OH,

[0124] (3) NH_2, and

[0125] (4) SH.

[0126] In another embodiment, ionic liquids suitable for use herein may have a cation selected from the group consisting of pyridinium, pyridazinium, pyrimidinium, pyrazinium, imidazolium, pyrazolium, thiazolium, oxazolium, triazolium, phosphonium, ammonium, benzyltrimethylammonium, cesium, choline, dimethylimidazolium, guanidinium, lithium, phosphonium choline (hydroxyethyl trimethylphosphonium), potassium, sodium, tetramethylammonium, tetramethylphosphonium, and anions selected from the group consisting of, aminoacetate (glycine), ascorbate, benzoate, catecholate, citrate, dimethylphosphate, formate, fumarate, gallate, glycolate, glyoxylate, iminodiacetate, isobutyrate, kojate (5-hydroxy-2-hydroxymethyl-4-pyrone ion), lactate, levulinate, oxalate, pivalate, propionate, pyruvate, salicylate, succinamate, succinate, tiglate ($CH_3CH{=}C(CH_3)COO^-$); , tetrafluoroborate, tetrafluoroethanesulfonate, and tropolonate (2-hydroxy-2,4,6-cycloheptatrien-1-one ion), $[CH_3CO_2]^-$, $[HSO_4]^-$, $[CH_3OSO_3]^-$, $[C_2H_5OSO_3]^-$, $[AlCl_4]^-$, $[CO_3]^{2-}$, $[HCO_3]^-$, $[NO_2]^-$, $[NO_3]^-$, $[SO_4]^{2-}$, $[PO_4]^-$, $[HPO_4]^{2-}$, $[H_2PO_4]^-$, $[HSO_3]^-$, $[CuCl_2]^-$, Cl^-, Br^-, SCN^-, $[BF_4]^-$, $[PF_6]^-$, $[SbF_6]^-$, $[CF_3SO_3]^-$, $[HCF_2CF_2SO_3]^-$, $[CF_3HFCCF_2SO_3]^-$, $[HCClFCF_2SO_3]^-$, $[(CF_3SO_2)_2N]^-$, $[(CF_3CF_2SO_2)_2N]^-$, $[(CF_3SO_2)_3C]^-$, $[CF_3CO_2]^-$, $[CF_3OCFHCF_2SO_3]^-$, $[CF_3CF_2OCFHCF_2SO_3]^-$, $[CF_3CFHOCF_2CF_2SO_3]^-$, $[CF_2HCF_2OCF_2CF_2SO_3]^-$, $[CF_2ICF_2OCF_2CF_2SO_3]^-$, $[CF_3CF_2OCF_2CF_2SO_3]^-$, $[(CF_2HCF_2SO_2)_2N]^-$, $[(CF_3CFHCF_2SO_2)_2N]^-$, F^-, and any fluorinated anion.

[0127] The working fluid will preferably be miscible with or soluble in an ionic liquid as used herein over the temperature range of the operation of the absorption system, particularly from that of the absorber to that of the generator. As a consequence, over the absorption system temperature range, a variety of different levels of the relative content of the working fluid and absorbent in an absorption cycle are suitable, and the concentration of either working fluid or an ionic liquid in a composition formed therefrom may be in the range of from about 1% to about 99% by weight of the combined weight of the ionic liquid and working fluid therein.

[0128] In various embodiments of this invention, an ionic liquid formed by selecting any of the individual cations described or disclosed herein, and by selecting any of the individual anions described or disclosed herein with which to pair the cation, may be used as an absorbent in an absorption power cycle. Correspondingly, in yet other embodiments, a subgroup of ionic liquids formed by selecting (i) a subgroup of any size of cations, taken from the total group of cations described and disclosed herein in all the various different combinations of the individual members of that total group, and (ii) a subgroup of any size of anions, taken from the total group of anions described and disclosed herein in all the various different combinations of the individual members of that total group, may be used as an absorbent. In forming an ionic liquid, or a subgroup of ionic liquids, by making selections as aforesaid, the ionic liquid or subgroup will be used in the absence of the members of the group of cations and/or anions that are omitted from the total group thereof to make the selection, and, if desirable, the selection may thus be made in terms of the members of the total group that are omitted from use rather than the members of the group that are included for use.

[0129] An absorbent as used in an absorption power cycle is desirably a compound that has high solubility for a working fluid (e.g., ammonia) and also a very high boiling point relative to the working fluid.

[0130] The absorbent used in the present invention could (but does not have to) contain or consist essentially of an ionic liquid, that is, it could contain or consist essentially of a non-ionic compound. Suitable non-ionic compound absorbents include, but are not limited to ethers, esters, amides and ketones.

[0131] Mixtures of ionic liquids or non-ionic compounds or mixtures of non-ionic compounds and ionic liquids may also be used herein as the absorbent, and such mixtures may be desirable, for example, for achieving proper absorption behavior.

[0132] Additives, such as lubricants, crystallization inhibitors, corrosion inhibitors, stabilizers, dyes, and other appropriate materials may be added to the working fluid/absorbent pair compositions useful for the invention for a variety of purposes provided they do not have an undesirable influence on the extent to which the working fluid is soluble in an ionic liquid absorbent. The working fluid/absorbent pair compositions of the invention may be prepared by any convenient method, including mixing or combining the desired amounts of each component in an appropriate container using, for example, known types of stirrers having rotating mixing elements.

[0133] Crystallization inhibitors include those compounds as described in co-pending PCT Patent Application No. PCT/US09/63599, filed Nov. 6, 2009, and co-pending U.S. Provisional Patent Application Ser. Nos. 61/165,089, 61/165,093, 61/165,147, 61/165,155, 61/165,160, 61/165,161, 61/165,166, and 61/165,173, all of which were filed on Mar. 31, 2009.

What is claimed is:

1. An absorption power cycle system, comprising:

(a) an absorber for absorbing a working fluid into an absorbent, thereby forming an absorbent and working fluid mixture;

(b) a first heat exchanger disposed in fluid communication with the absorber for receiving and pre-heating the absorbent and working fluid mixture from the absorber,

(c) a liquid pump for pumping the absorbent and working fluid mixture from the absorber to the first heat exchanger;

(d) a generator disposed in fluid communication with the first heat exchanger for receiving the pre-heated mixture from the first heat exchanger and transferring additional heat into the pre-heated mixture, thereby releasing high pressure vapor of the working fluid; and

(e) a device for producing mechanical work disposed in fluid communication with the generator for producing mechanical work from the high pressure working fluid;

wherein the absorbent comprises an ionic liquid.

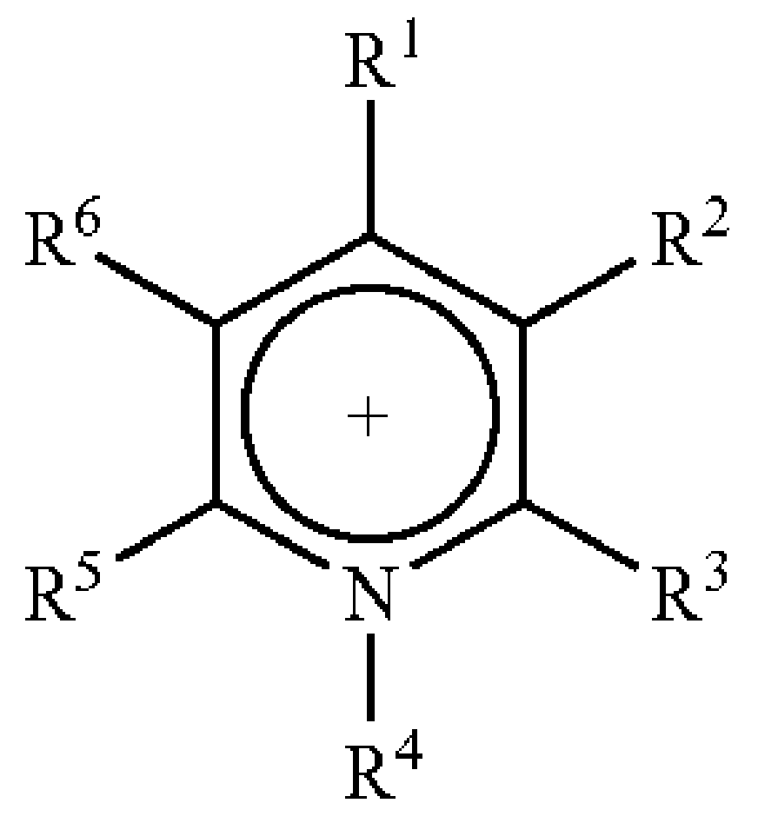
2. The absorption power cycle system of claim 1, further comprising:

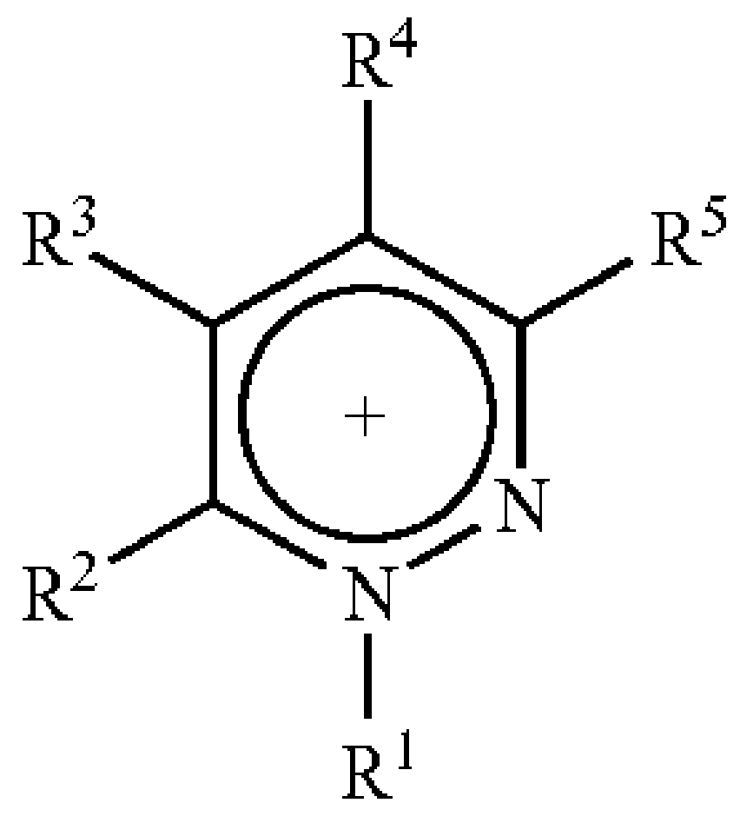
(a) a condenser to condense the high pressure working fluid exiting the device for producing mechanical work;

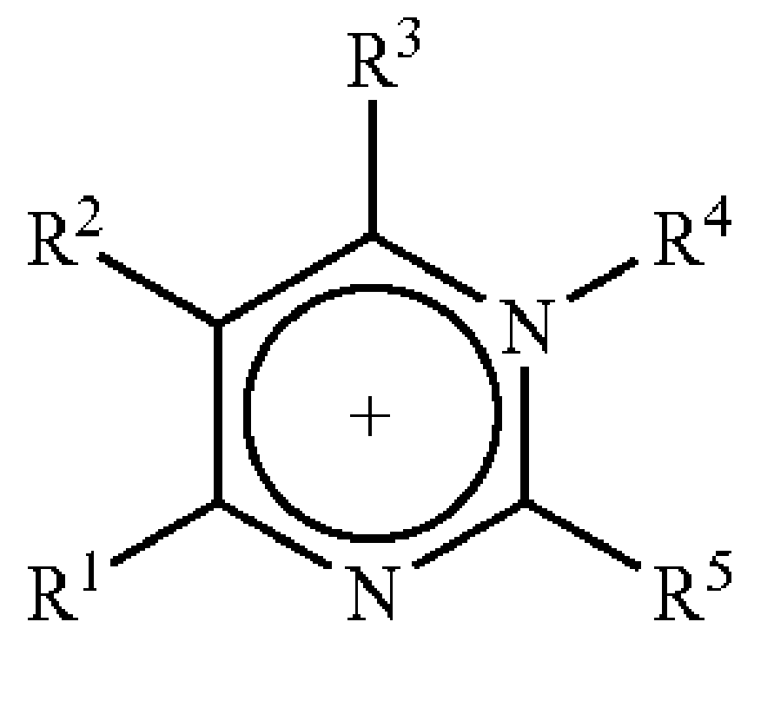
(b) an expansion device to reduce the pressure and partially vaporize the working fluid; and

(c) an evaporator to fully evaporate the working fluid, thus producing cooling.

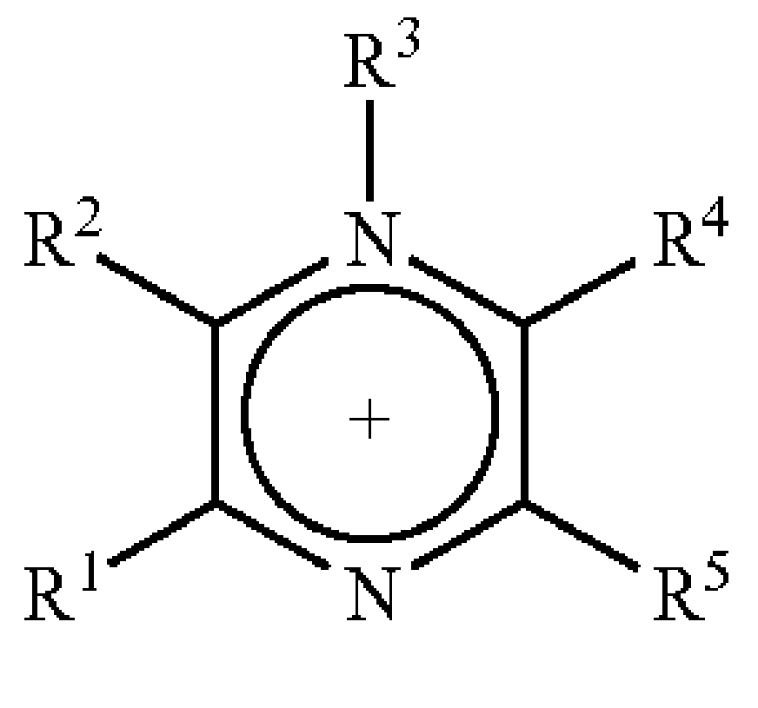
3. The absorption power cycle system of claim 1, wherein the ionic liquid comprises a cation and an anion, wherein the cation is selected from the group consisting of lithium, sodium, potassium, cesium, and the following Formulae:

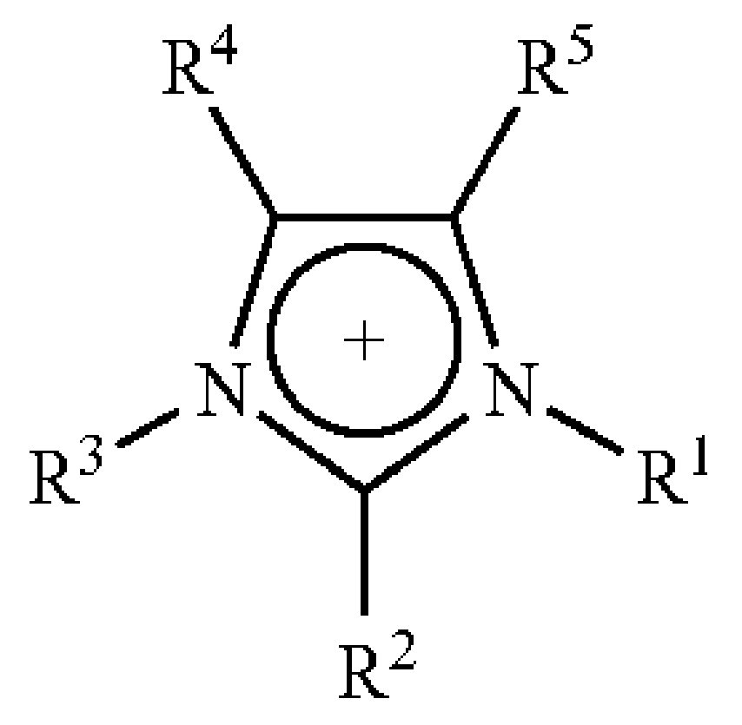

Pyridinium

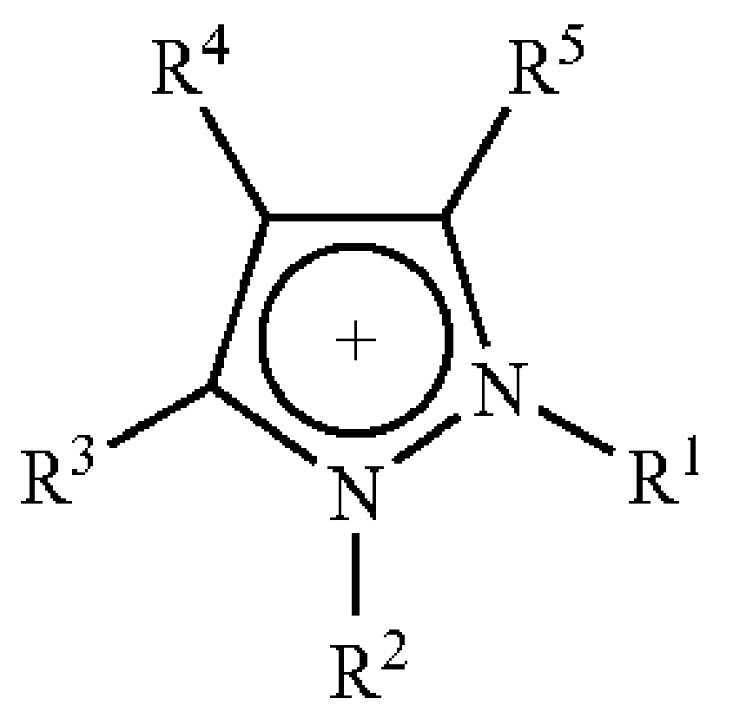

Pyridazinium

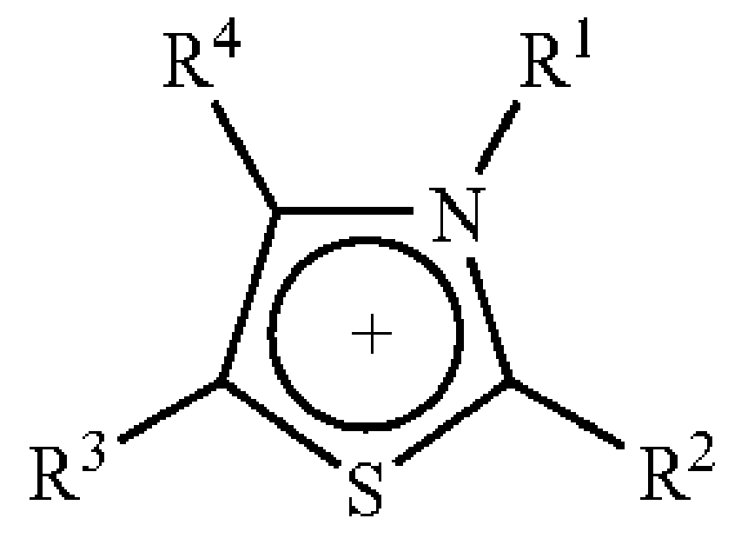

Pyrimidinium

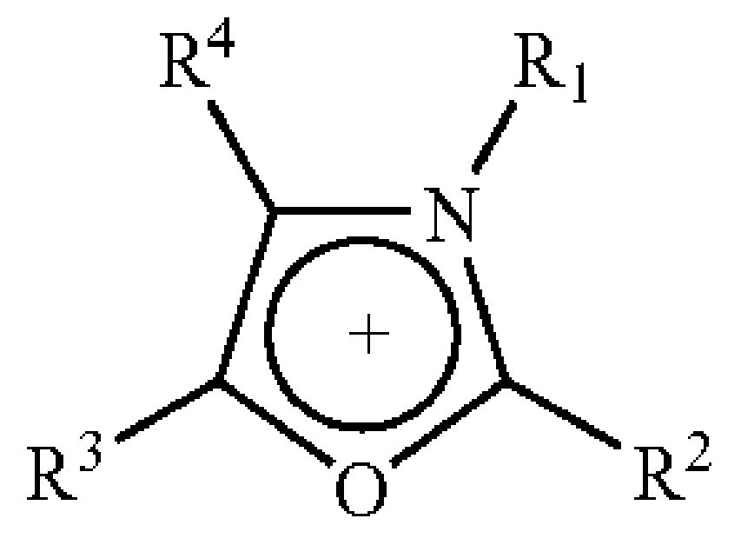
-continued

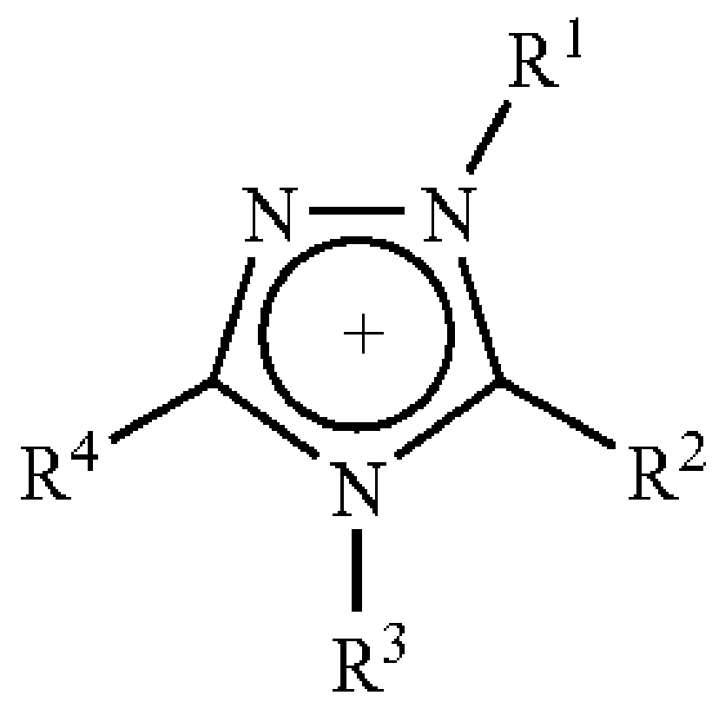

Pyrazinium

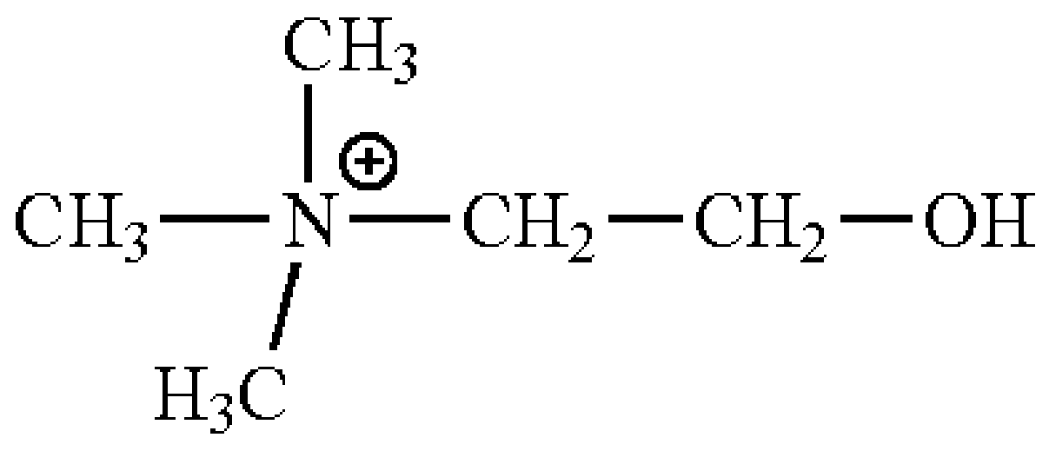

Imidazolium


Pyrazolium

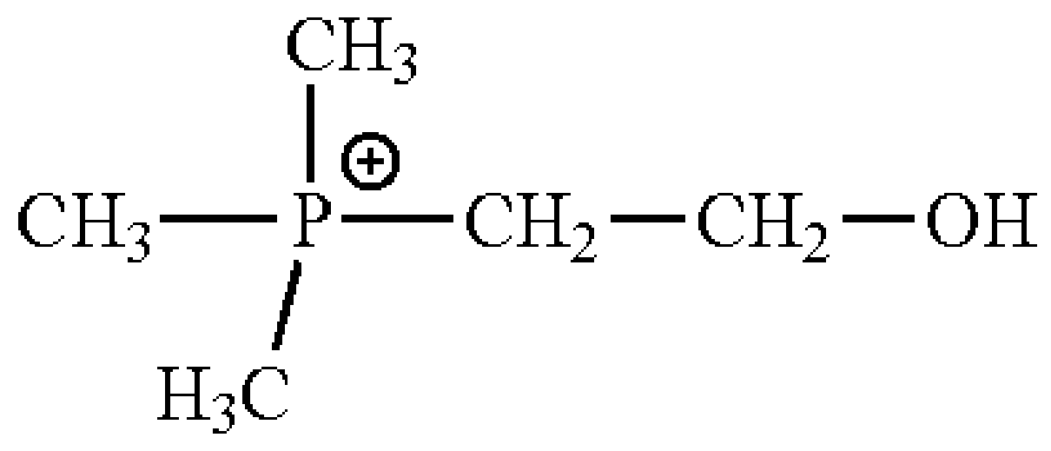

Thiazolium


Oxazolium

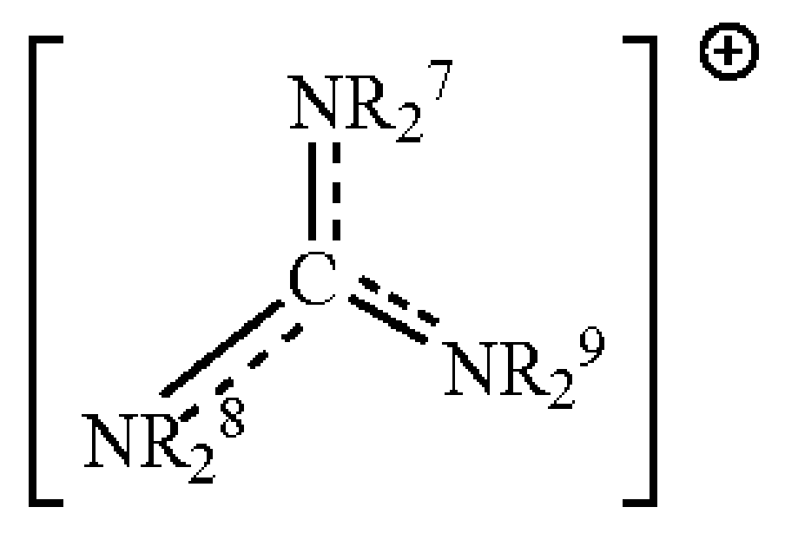

Triazolium

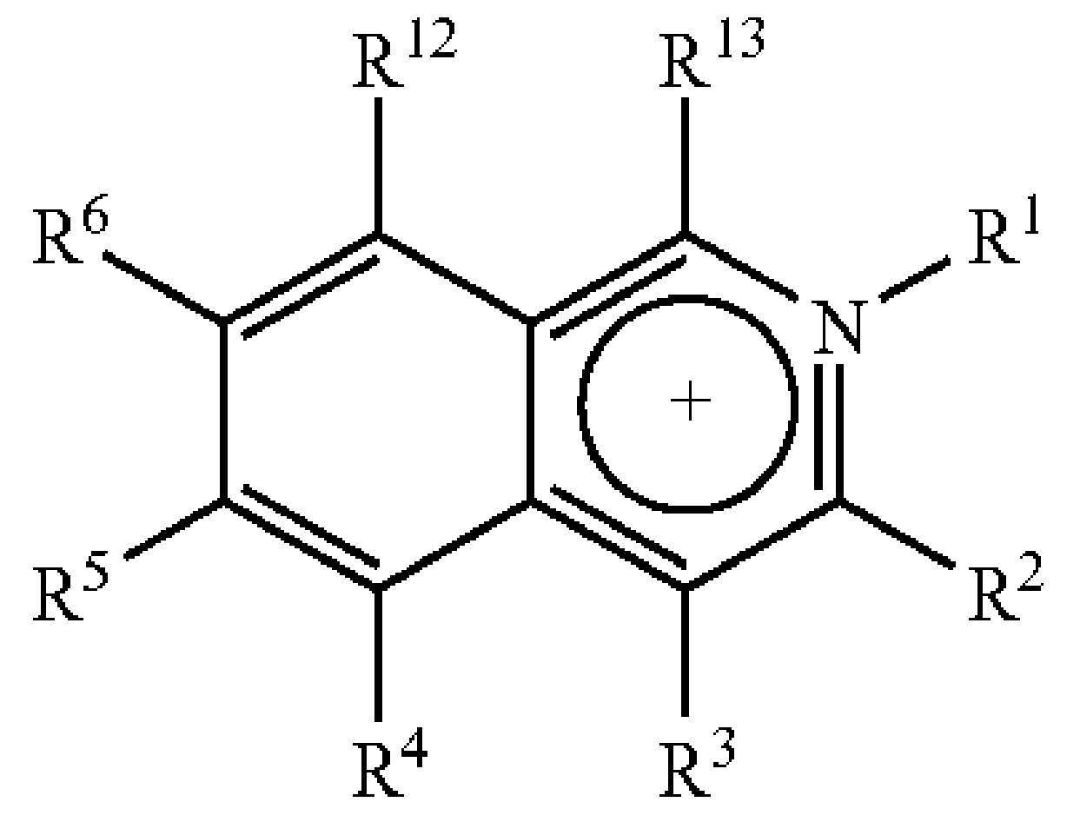

$$CH_3-\overset{CH_3}{\underset{H_3C}{N^{\oplus}}}-CH_2-CH_2-OH$$

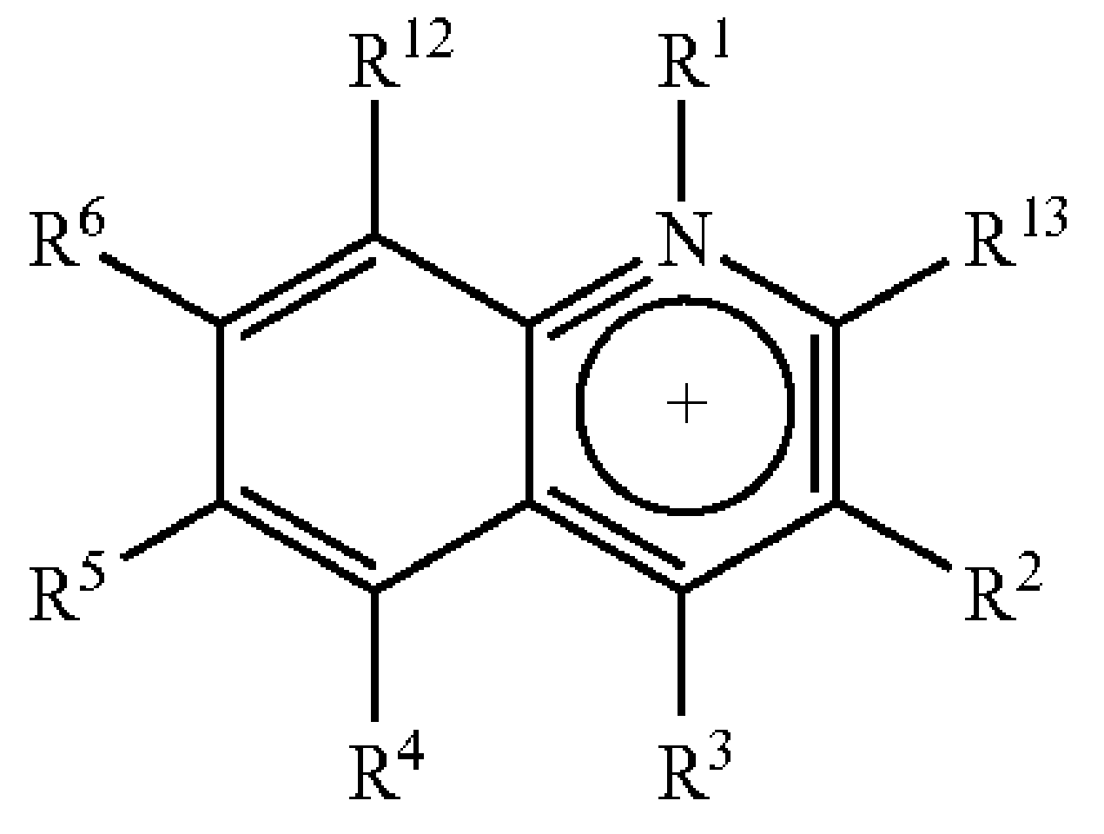
Choline

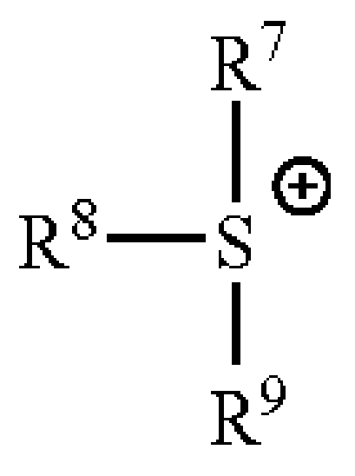

$$CH_3-\overset{CH_3}{\underset{H_3C}{P^{\oplus}}}-CH_2-CH_2-OH$$

Phosphonium Choline

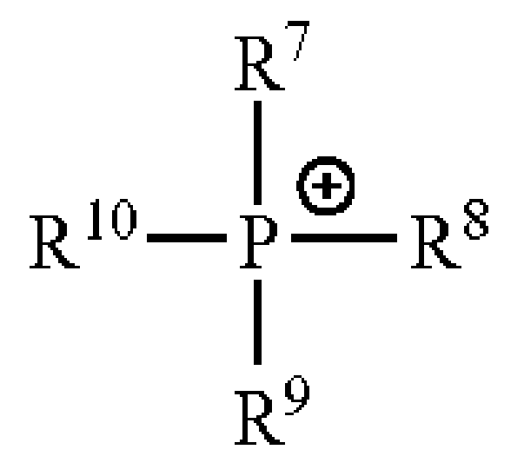

Guanidinium


Isoquinolinium


Quinolinium

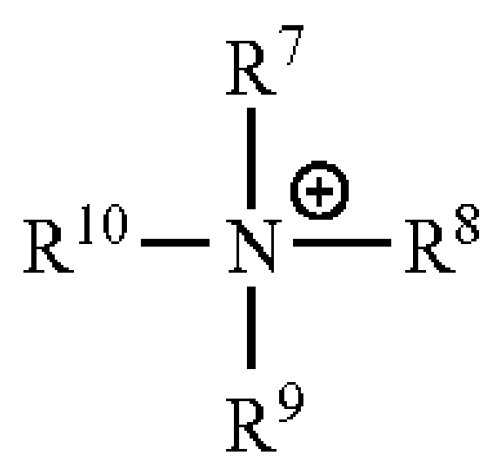

$$R^8-\overset{R^7}{\underset{R^9}{S^{\oplus}}}$$

Sulfonium


$$R^{10}-\overset{R^7}{\underset{R^9}{P^{\oplus}}}-R^8$$

Phosphonium

and


$$R^{10}-\overset{R^7}{\underset{R^9}{N^{\oplus}}}-R^8$$

Ammonium

wherein R^1, R^2, R^3, R^4, R^5, R^6, R^{12} and R^{13} are independently selected from the group consisting of:

(i) H

(ii) halogen

(iii) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;

(iv)-CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene comprising one to three heteroatoms selected from the group consisting of O, N, Si and S, and optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;

(v) C_6 to C_{20} unsubstituted aryl, or C_3 to C_{25} unsubstituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and

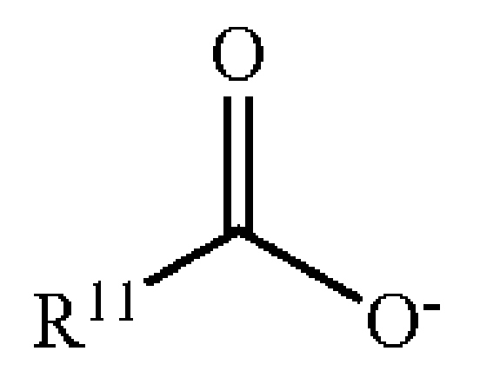
- (vi) C_6 to C_{25} substituted aryl, or C_3 to C_{25} substituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and wherein said substituted aryl or substituted heteroaryl has one to three substituents independently selected from the group consisting of:
  - (1) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F I, OH, NH_2 and SH,
  - (2) OH,
  - (3) NH_2, and
  - (4) SH;

and wherein R^7, R^8, R^9, and R^{10} are independently selected from the group consisting of:

- (i) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;
- (ii) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene comprising one to three heteroatoms selected from the group consisting of O, N, Si and S, and optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;
- (iii) C_6 to C_{25} unsubstituted aryl, or C_3 to C_{25} unsubstituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and
- (iv) C_6 to C_{25} substituted aryl, or C_3 to C_{25} substituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and wherein said substituted aryl or substituted heteroaryl has one to three substituents independently selected from the group consisting of:
  - (1) —CH_3, —C_2H_5, or C_3 to C_{25} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH,
  - (2) OH,
  - (3) NH_2, and
  - (4) SH;

and wherein optionally at least two of R^1, R^2, R^3, R^4, R^5, $R^{6,}$ R^7, R^8, R^9, and R^{10} can together form a cyclic or bicyclic alkanyl or alkenyl group; and

wherein the anion is selected from the group consisting of: $[CH_3CO_2]^-$, $[HSO_4]^-$, $[CH_3OSO_3]^-$, $[C_2H_5OSO_3]^-$, $[AlCl_4]^-$, $[CO_3]^{2-}$, $[HCO_3]^-$, $[NO_2]^-$, $[NO_3]^-$, $[SO_4]^{2-}$, $[PO_3]^3$, $[HPO_3]^2$, $[H_2PO_3]^1$, $[PO_4]^3$, $[HPO_4]^{2-}$, $[H_2PO_4]^-$, $[HSO_3]^-$, $[CUCl_2]^-$, Br^-, I^-, SCN^-; $BR^1R^2R^3R^4$, $BOR^1OR^2OR^3OR^4$, carborates (1-carbadodecaborate(1-)), optionally substituted with alkyl or substituted alkyl, carboranes (dicarbadodecaborate (1-)) optionally substituted with alkylamine, substituted alkylamine, alkyl or substituted alkyl; $[BF_4]^-$, $[PF_6]^-$, $[SbF_6]^-$, $[CF_3SO_3]^-$, $[HCF_2CF_2SO_3]^-$, $[CF_3HFCCF_2SO_3]^-$, $[HCClFCF_2SO_3]^-$, $[(CF_3SO_2)_2N]^-$, $[(CF_3CF_2SO_2)_2N]^-$, $[(CF_3SO_2)_3C]^-$, $[CF_3CO_2]^-$, $[CF_3OCFHCF_2SO_3]^-$, $[CF_3CF_2OCFHCF_2SO_3]^-$, $[CF_3CFHOCF_2CF_2SO_3]^-$, $[CF_2HCF_2OCF_2CF_2SO_3]^-$, $[CF_2ICF_2OCF_2CF_2SO_3]$, $[CF_3CF_2OCF_2CF_2SO_3]$, $[(CF_2HCF_2SO_2)_2N]^-$, $[(CF_3CFHCF_2SO_2)_2N]^-$; F^-; and anions of the Formula:



wherein R^{11} is selected from the group consisting of:

- (i) —CH_3, —C_2H_5, or C_3 to C_{10} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;
- (ii) –CH_3, —C_2H_5, or C_3 to C_{10} straight-chain, branched or cyclic alkane or alkene comprising one to three heteroatoms selected from the group consisting of O, N, Si and S, and optionally substituted with at least one member selected from the group consisting of Cl, Br, F, I, OH, NH_2 and SH;
- (iii) C_6 to C_{10} unsubstituted aryl, or C_3 to C_{10} unsubstituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and
- (iv) C_6 to C_{10} substituted aryl, or C_3 to C_{10} substituted heteroaryl having one to three heteroatoms independently selected from the group consisting of O, N, Si and S; and wherein said substituted aryl or substituted heteroaryl has one to three substituents independently selected from the group consisting of:
  - (1) —CH_3, —C_2H_5, or C_3 to C_{10} straight-chain, branched or cyclic alkane or alkene, optionally substituted with at least one member selected from the group consisting of Cl, Br, F I, OH, NH_2 and SH,
  - (2) OH,
  - (3) NH_2, and
  - (4) SH;

wherein optionally at least two of R^1, R^2, R^3, R^4, R^5, $R^{6,}$ R^7, R^8, R^9, and R^{10} can together form a cyclic or bicyclic alkanyl or alkenyl group.

4. The absorption power cycle system of claim **1**, wherein the working fluid comprises water or ammonia.

5. The absorption power cycle system of claim **1**, wherein the working fluid comprises a working fluid selected from the group consisting of hydrofluorocarbons, hydrochlorofluorocarbons, chlorofluorocarbons, fluorocarbons, nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), argon (Ar), hydrogen (H_2), non-fluorinated hydrocarbons, methanol and mixtures of any of the foregoing.

6. The absorption power cycle system of claim **5**, wherein the non-fluorinated hydrocarbon is selected from the group consisting of C_1 to C_7 straight-chain, branched or cyclic alkanes and C_1 to C_7 straight-chain, branched or cyclic alkenes.

7. The absorption power cycle system of claim **5**, wherein the working fluid comprises at least one hydrofluorocarbon or fluorocarbon selected from the group consisting of:

- (i) fluoroolefins of the formula E- or Z-$R^1CH{=}CHR^2$, wherein R^1 and R^2 are, independently, C_1 to C_6 perfluoroalkyl groups;
- (ii) cyclic fluoroolefins of the formula cyclo-$[CX{=}CY(CZW)_n-]$, wherein X, Y, Z, and W, independently, are H or F, and n is an integer from 2 to 5; and

(iii) fluoroolefins selected from the group consisting of:

tetrafluoroethylene ($CF_2=CF_2$); hexafluoropropene ($CF_3CF=CF_2$); 1,2,3,3,3-pentafluoro-1-propene ($CHF=CFCF_3$), 1,1,3,3,3-pentafluoro-1-propene ($CF_2=CHCF_3$), 1,1,2,3,3-pentafluoro-1-propene ($CF_2=CFCHF_2$), 1,2,3,3-tetrafluoro-1-propene ($CHF=CFCHF_2$), 2,3,3,3-tetrafluoro-1-propene ($CH_2=CFCF_3$), 1,3,3,3-tetrafluoro-1-propene$CHF=CHCF_3$), 1,1,2,3-tetrafluoro-1-propene ($CF_2=CFCH_2F$), 1,1,3,3-tetrafluoro-1-propene ($CF_2=CHCHF_2$), 1,2,3,3-tetrafluoro-1-propene ($CHF=CFCHF_2$), 3,3,3-trifluoro-1-propene ($CH_2=CHCF_3$), 2,3,3-trifluoro-1-propene ($CHF_2CF=CH_2$); 1,1,2-trifluoro-1-propene ($CH_3CF=CF_2$); 1,2,3-trifluoro-1-propene ($CH_2FCF=CF_2$); 1,1,3-trifluoro-1-propene ($CH_2FCH=CF_2$); 1,3,3-trifluoro-1-propene ($CHF_2CH=CHF$); 1,1,1,2,3,4,4,4-octafluoro-2-butene ($CF_3CF=CFCF_3$); 1,1,2,3,3,4,4,4-octafluoro-1-butene ($CF_3CF_2CF=CF_2$); 1,1,1,2,4,4,4-heptafluoro-2-butene ($CF_3CF=CHCF_3$); 1,2,3,3,4,4,4-heptafluoro-1-butene ($CHF=CFCF_2CF_3$); 1,1,1,2,3,4,4-heptafluoro-2-butene ($CHF_2CF=CFCF_3$); 1,3,3,3-tetrafluoro-2-(trifluoromethyl)-1-propene ($(CF_3)_2C=CHF$); 1,1,3,3,4,4,4-heptafluoro-1-butene ($CF_2=CHCF_2CF_3$); 1,1,2,3,4,4,4-heptafluoro-1-butene ($CF_2=CFCHFCF_3$); 1,1,2,3,3,4,4-heptafluoro-1-butene ($CF_2=CFCF_2CHF_2$); 2,3,3,4,4,4-hexafluoro-1-butene ($CF_3CF_2CF=CH_2$); 1,3,3,4,4,4-hexafluoro-1-butene ($CHF=CHCF_2CF_3$); 1,2,3,4,4,4-hexafluoro-1-butene ($CHF=CFCHFCF_3$); 1,2,3,3,4,4-hexafluoro-1-butene ($CHF=CFCF_2CHF_2$); 1,1,2,3,4,4-hexafluoro-2-butene ($CHF_2CF=CFCHF_2$); 1,1,1,2,3,4-hexafluoro-2-butene ($CH_2FCF=CFCF_3$); 1,1,1,2,4,4-hexafluoro-2-butene ($CHF_2CH=CFCF_3$); 1,1,1,3,4,4-hexafluoro-2-butene ($CF_3CH=CFCHF_2$); 1,1,2,3,3,4-hexafluoro-1-butene ($CF_2=CFCF_2CH_2F$); 1,1,2,3,4,4-hexafluoro-1-butene ($CF_2=CFCHFCHF_2$); 3,3,3-trifluoro-2-(trifluoromethyl)-1-propene ($CH_2=C(CF_3)_2$); 1,1,1,2,4-pentafluoro-2-butene ($CH_2FCH=CFCF_3$); 1,1,1,3,4-pentafluoro-2-butene ($CF_3CH=CFCH_2F$); 3,3,4,4,4-pentafluoro-1-butene ($CF_3CF_2CH=CH_2$); 1,1,1,4,4-pentafluoro-2-butene ($CHF_2CH=CHCF_3$); 1,1,1,2,3-pentafluoro-2-butene ($CH_3CF=CFCF_3$); 2,3,3,4,4-pentafluoro-1-butene ($CH_2=CFCF_2CHF_2$); 1,1,2,4,4-pentafluoro-2-butene ($CHF_2CF=CHCHF_2$); 1,1,2,3,3-pentafluoro-1-butene ($CH_3CF_2CF=CF_2$); 1,1,2,3,4-pentafluoro-2-butene ($CH_2FCF=CFCHF_2$); 1,1,3,3,3-pentafluoro-2-methyl-1-propene ($CF_2=C(CF_3)(CH_3)$); 2-(difluoromethyl)-3,3,3-trifluoro-1-propene ($CH_2=C(CHF_2)(CF_3)$); 2,3,4,4,4-pentafluoro-1-butene ($CH_2=CFCHFCF_3$); 1,2,4,4,4-pentafluoro-1-butene ($CHF=CFCH_2CF_3$); 1,3,4,4,4-pentafluoro-1-butene ($CHF=CHCHFCF_3$); 1,3,3,4,4-pentafluoro-1-butene ($CHF=CHCF_2CHF_2$); 1,2,3,4,4-pentafluoro-1-butene ($CHF=CFCHFCHF_2$); 3,3,4,4-tetrafluoro-1-butene ($CH_2=CHCF_2CHF_2$); 1,1-difluoro-2-(difluoromethyl)-1-propene ($CF_2=C(CHF_2)(CH_3)$); 1,3,3,3-tetrafluoro-2-methyl-1-propene ($CHF=C(CF_3)(CH_3)$); 3,3-difluoro-2-(difluoromethyl)-1-propene ($CH_2=C(CHF_2)_2$); 1,1,1,2-tetrafluoro-2-butene ($CF_3CF=CHCH_3$); 1,1,1,3-tetrafluoro-2-butene ($CH_3CF=CHCF_3$); 1,1,1,2,3,4,4,5,5,5-decafluoro-2-pentene ($CF_3CF=CFCF_2CF_3$); 1,1,2,3,3,4,4,5,5,5-decafluoro-1-pentene ($CF_2=CFCF_2CF_2CF_3$); 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)-2-butene ($(CF_3)_2C=CHCF_3$); 1,1,1,2,4,4,5,5,5-nonafluoro-2-pentene ($CF_3CF=CHCF_2CF_3$); 1,1,1,3,4,4,5,5,5-nonafluoro-2-pentene ($CF_3CH=CFCF_2CF_3$); 1,2,3,3,4,4,5,5,5-nonafluoro-1-pentene ($CHF=CFCF_2CF_2CF_3$); 1,1,3,3,4,4,5,5,5-nonafluoro-1-pentene ($CF_2=CHCF_2CF_2CF_3$); 1,1,2,3,3,4,4,5,5-nonafluoro-1-pentene ($CF_2=CFCF_2CF_2CHF_2$); 1,1,2,3,4,4,5,5,5-nonafluoro-2-pentene ($CHF_2CF=CFCF_2CF_3$); 1,1,1,2,3,4,4,5,5-nonafluoro-2-pentene ($CF_3CF=CFCF_2CHF_2$); 1,1,1,2,3,4,5,5,5-nonafluoro-2-pentene ($CF_3CF=CFCHFCF_3$); 1,2,3,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene ($CHF=CFCF(CF_3)_2$); 1,1,2,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene ($CF_2=CFCH(CF_3)_2$); 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)-2-butene ($CF_3CH=C(CF_3)_2$); 1,1,3,4,4,4-hexafluoro-3-(trifluoromethyl)-1-butene ($CF_2=CHCF(CF_3)_2$); 2,3,3,4,4,5,5,5-octafluoro-1-pentene ($CH_2=CFCF_2CF_2CF_3$); 1,2,3,3,4,4,5,5-octafluoro-1-pentene ($CHF=CFCF_2CF_2CHF_2$); 3,3,4,4,4-pentafluoro-2-(trifluoromethyl)-1-butene ($CH_2=C(CF_3)CF_2CF_3$); 1,1,4,4,4-pentafluoro-3-(trifluoromethyl)-1-butene ($CF_2=CHCH(CF_3)_2$); 1,3,4,4,4-pentafluoro-3-(trifluoromethyl)-1-butene ($CHF=CHCF(CF_3)_2$); 1,1,4,4,4-pentafluoro-2-(trifluoromethyl)-1-butene ($CF_2=C(CF_3)CH_2CF_3$); 3,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene ($(CF_3)_2CFCH=CH_2$); 3,3,4,4,5,5,5-heptafluoro-1-pentene ($CF_3CF_2CF_2CH=CH_2$); 2,3,3,4,4,5,5-heptafluoro-1-pentene ($CH_2=CFCF_2CF_2CHF_2$); 1,1,3,3,5,5,5-heptafluoro-1-butene ($CF_2=CHCF_2CH_2CF_3$); 1,1,1,2,4,4,4-heptafluoro-3-methyl-2-butene ($CF_3CF=C(CF_3)(CH_3)$); 2,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene ($CH_2=CFCH(CF_3)_2$); 1,4,4,4-tetrafluoro-3-(trifluoromethyl)-1-butene ($CHF=CHCH(CF_3)_2$); 1,1,1,4-tetrafluoro-2-(trifluoromethyl)-2-butene ($CH_2FCH=C(CF_3)_2$); 1,1,1,3-tetrafluoro-2-(trifluoromethyl)-2-butene ($CH_3CF=C(CF_3)_2$); 1,1,1-trifluoro-2-(trifluoromethyl)-2-butene ($(CF_3)_2C=CHCH_3$); 3,4,4,5,5,5-hexafluoro-2-pentene ($CF_3CF_2CF=CHCH_3$); 1,1,1,4,4,4-hexafluoro-2-methyl-2-butene ($CF_3C(CH_3)=CHCF_3$); 3,3,4,5,5,5-hexafluoro-1-pentene ($CH_2=CHCF_2CHFCF_3$); 4,4,4-trifluoro-2-(trifluoromethyl)-1-butene ($CH_2=C(CF_3)CH_2CF_3$); 1,1,2,3,3,4,4,5,5,6,6,6-dodecafluoro-1-hexene ($CF_3(CF_2)_3CF=CF_2$); 1,1,1,2,2,3,4,5,5,6,6,6-dodecafluoro-3-hexene ($CF_3CF_2CF=CFCF_2CF_3$); 1,1,1,4,4,4-hexafluoro-2,3-bis(trifluoromethyl)-2-butene ($(CF_3)_2C=C(CF_3)_2$); 1,1,1,2,3,4,5,5,5-nonafluoro-4-(trifluoromethyl)-2-pentene ($(CF_3)_2CFCF=CFCF_3$); 1,1,1,4,4,5,5,5-octafluoro-2-(trifluoromethyl)-2-pentene ($(CF_3)_2C=CHC_2F_5$); 1,1,1,3,4,5,5,5-octafluoro-4-(trifluoromethyl)-2-pentene ($(CF_3)_2CFCF=CHCF_3$); 3,3,4,4,5,5,6,6,6-nonafluoro-1-hexene ($CF_3CF_2CF_2CF_2CH=CH_2$); 4,4,4-trifluoro-3,3-bis(trifluoromethyl)-1-butene ($CH_2=CHC(CF_3)_3$); 1,1,1,4,4,4-hexafluoro-3-methyl-2-(trifluoromethyl)-2-butene $((CF_3)_2C=C(CH_3)(CF_3))$; 2,3,3,5,5,5-hexafluoro-4-(trifluoromethyl)-1-pentene $(CH_2=CFCF_2CH(CF_3)_2)$; 1,1,1,2,4,4,5,5,5-nonafluoro-3-methyl-2-pentene $(CF_3CF=C(CH_3)CF_2CF_3)$; 1,1,1,5,5,5-hexafluoro-4-(trifluoromethyl)-2-pentene $(CF_3CH=CHCH(CF_3)_2)$; 3,4,4,5,5,6,6,6-octafluoro-2-hexene $(CF_3CF_2CF_2CF=CHCH_3)$; 3,3,4,4,5,5,6,6-octafluoro1-hexene $(CH_2=CHCF_2CF_2CF_2CHF_2)$; 1,1,1,4,4-pentafluoro-2-(trifluoromethyl)-2-pentene $((CF_3)_2C=CHCF_2CH_3)$; 4,4,5,5,5-pentafluoro-2-(trifluoromethyl)-1-pentene $(CH_2=C(CF_3)CH_2C_2F_5)$; 3,3,4,4,5,5,5-heptafluoro-2-methyl-1-pentene $(CF_3CF_2CF_2C(CH_3)=CH_2)$; 4,4,5,5,6,6,6-heptafluoro-2-hexene $(CF_3CF_2CF_2CH=CHCH_3)$; 4,4,5,5,6,6,6-heptafluoro-1-hexene $(CH_2=CHCH_2CF_2C_2F_5)$; 1,1,1,2,2,3,4-heptafluoro-3-hexene $(CF_3CF_2CF=CFC_2H_5)$; 4,5,5,5-tetrafluoro-4-(trifluoromethyl)-1-pentene $(CH_2=CHCH_2CF(CF_3)_2)$; 1,1,1,2,5,5,5-heptafluoro-4-methyl-2-pentene $(CF_3CF=CHCH(CF_3)(CH_3))$; 1,1,1,3-tetrafluoro-2-(trifluoromethyl)-2-pentene $((CF_3)_2C=CFC_2H_5)$; 1,1,1,2,3,4,4,5,5,6,6,7,7,7-tetradecafluoro-2-heptene $(CF_3CF=CFCF_2CF_2C_2F_5)$; 1,1,1,2,2,3,4,5,5,6,6,7,7,7-tetradecafluoro-3-heptene $(CF_3CF_2CF=CFCF_2C_2F_5)$; 1,1,1,3,4,4,5,5,6,6,7,7,7-tridecafluoro-2-heptene $(CF_3CH=CFCF_2CF_2C_2F_5)$; 1,1,1,2,4,4,5,5,6,6,7,7,7-tridecafluoro-2-heptene $(CF_3CF=CHCF_2CF_2C_2F_5)$; 1,1,1,2,2,4,5,5,6,6,7,7,7-tridecafluoro-3-heptene $(CF_3CF_2CH=CFCF_2C_2F_5)$; and 1,1,1,2,2,3,5,5,6,6,7,7,7-tridecafluoro-3-heptene $(CF_3CF_2CF=CHCF_2C_2F_5)$.

8. The absorption power cycle system of claim **7**, wherein said fluoroolefin is selected from the group consisting of:

1,1,1,4,4,4-hexafluorobut-2-ene; 1,1,1,4,4,5,5,5-octafluoropent-2-ene; 1,1,1,4,4,5,5,6,6,6-decafluorohex-2-ene; 1,1,1,4,5,5,5-heptafluoro-4-(trifluoromethyl)pent-2-ene; 1,1,1,2,2,5,5,6,6,6-decafluorohex-3-ene; 1,1,1,4,4,5,5,6,6,7,7,7-dodecafluorohept-2-ene; 1,1,1,4,4,5,6,6,6-nonafluoro-5-(trifluoromethyl)hex-2-ene; 1,1,1,4,5,5,6,6,6-nonfluoro-4-(trifluoromethyl)hex-2-ene; 1,1,1,5,5,5-hexafluoro-4,4-bis(trifluoromethyl)pent-2-ene; 1,1,1,2,2,5,5,6,6,7,7,7-dodecafluorohept-3-ene; 1,1,1,2,2,5,6,6,6-nonafluoro-5-(trifluoromethyl)hex-3-ene; 1,1,1,4,4,5,5,6,6,7,7,8,8,8-tetradecafluorooct-2-ene; 1,1,1,4,4,5,5,6,7,7,7-undecafluoro-6-(trifluoromethyl)hept-2-ene; 1,1,1,5,5,6,6,6-octafluoro-4,4-bis(trifluoromethyl)hex-2-ene; 1,1,1,2,2,5,5,6,6,7,7,8,8,8-tetradecafluorooct-3-ene; 1,1,1,2,2,5,5,6,7,7,7-undecafluoro-6-(trifluoromethyl)hept-3-ene; 1,1,1,2,2,5,6,6,7,7,7-undecafluoro-5-(trifluoromethyl)hept-3-ene; 1,1,1,2,2,6,6,6-octafluoro-5,5-bis(trifluoromethyl)hex-3-ene; 1,1,1,2,2,3,3,6,6,7,7,8,8,8-tetradecafluorooct-4-ene; 1,1,1,2,5,6,6,6-octafluoro-2,5-bis(trifluoromethyl)hex-3-ene; 1,1,1,2,5,5,6,6,7,7,7-undecafluoro-2-(trifluoromethyl)hept-3-ene; 1,1,1,4,4,5,5,6,6,7,7,8,8,9,9,9-hexadecafluoronon-2-ene; 1,1,1,4,5,5,6,6,7,7,8,8,8-tridecafluoro-4-(trifluoromethyl)hept-2-ene; 1,1,1,6,6,6-octafluoro-4,4-bis(trifluoromethyl)hept-2-ene; 1,1,1,2,2,5,5,6,6,7,7,8,8,9,9,9-hexadecafluoronon-3-ene; 1,1,1,2,2,5,5,6,6,7,8,8,8-tridecafluoro-7-(trifluoromethyl)oct-3-ene; 1,1,1,2,2,6,6,7,7,7-decafluoro-5,5-bis(trifluoromethyl)hept-3-ene; 1,1,1,2,2,3,3,6,6,7,7,8,8,9,9,9-hexadecafluoronon-4-ene; 1,1,1,2,2,3,3,6,6,7,8,8,8-tridecafluoro-7-(trifluoromethyl)oct-4-ene; 1,1,1,2,2,3,3,6,7,7,8,8,8-tridecafluoro-6-(trifluoromethyl)oct-4-ene; 1,1,1,5,5,6,6,7,7,7-decafluoro-2,2-bis(trifluoromethyl)hept-3-ene; 1,1,1,2,5,5,6,6,7,7,8,8,8-tridecafluoro-2(trifluoromethyl)oct-3-ene; 1,1,1,2,5,5,6,7,7,7-decafluoro-2,6-bis(trifluoromethyl)hept-3-ene; 1,1,1,2,5,6,6,7,7,7-decafluoro-2,5-bis(trifluoromethyl)hept-3-ene; 1,1,1,2,6,6,6-heptafluoro-2,5,5-tris(trifluoromethyl)hex-3-ene; 1,1,1,2,2,5,5,6,6,7,7,8,8,9,9,10,10,10-octadecafluorodec-3-ene; 1,1,1,2,2,5,6,6,7,7,8,8,9,9,9-pentadecafluoro-5-(trifluoromethyl)non-3-ene; 1,1,1,2,2,6,6,7,7,8,8,8-dodecafluoro-5,5-bis(trifluoromethyl)oct-3-ene; 1,1,1,2,2,3,3,6,6,7,7,8,8,9,9,10,10,10-octadecafluorodec-4-ene; 1,1,1,2,2,3,3,6,6,7,7,8,9,9,9-pentadecafluoro-8-(trifluoromethyl)non-4-ene; 1,1,1,2,2,3,3,7,7,8,8,8-dodecafluoro-6,6-bis(trifluoromethyl)oct-4-ene; 1,1,1,2,5,5,6,6,7,7,8,8,9,9,9-pentadecafluoro-2-(trifluoromethyl)non-3-ene; 1,1,1,2,5,5,6,6,7,8,8,8-dodecafluoro-2,7-bis(trifluoromethyl)oct-3-ene; 1,1,1,2,6,6,7,7,7-nonafluoro-2,5,5-tris(trifluoromethyl)hept-3-ene; 1,1,1,2,2,3,3,4,4,7,7,8,8,9,9,10,10,10-octadecafluorodec-5-ene; 1,1,1,2,3,3,6,6,7,7,8,8,9,9,9-pentadecafluoro-2-(trifluoromethyl)non-4-ene; 1,1,1,2,2,3,6,6,7,7,8,8,9,9,9-pentadecafluoro-3-(trifluoromethyl)non-4-ene; 1,1,1,5,5,6,6,7,7,8,8,8-dodecafluoro-2,2,-bis(trifluoromethyl)oct-3-ene; 1,1,1,2,3,3,6,6,7,8,8,8-dodecafluoro-2,7-bis(trifluoromethyl)oct-4-ene; 1,1,1,2,3,3,6,7,7,8,8,8-dodecafluoro-2,6-bis(trifluoromethyl)oct-4-ene; 1,1,1,5,5,6,7,7,7-nonafluoro-2,2,6-tris(trifluoromethyl)hept-3-ene; 1,1,1,2,2,3,6,7,7,8,8,8-dodecafluoro-3,6-bis(trifluoromethyl)oct-4-ene; 1,1,1,2,2,3,6,7,7,8,8,8-dodecafluoro-3,6-bis(trifluoromethyl)oct-4-ene; 1,1,1,5,6,6,7,7,7-nonafluoro-2,2,5-tris(trifluoromethyl)hept-3-ene; and 1,1,1,6,6,6-hexafluoro-2,2,5,5-tetrakis(trifluoromethyl)hex-3-ene.

9. The absorption power cycle system of claim **7**, wherein said fluoroolefin is selected from the group consisting of:

1,2,3,3,4,4-hexafluorocyclobutene; 3,3,4,4-tetrafluorocyclobutene; 3,3,4,4,5,5,-hexafluorocyclopentene; 1,2,3,3,4,4,5,5-octafluorocyclopentene; and 1,2,3,3,4,4,5,5,6,6-decafluorocyclohexene.

10. The absorption power cycle system of claim **5** wherein the working fluid comprises at least one working fluid selected from the group consisting of difluoromethane (HFC-32), pentafluoroethane (HFC-125), 1,1,2,2-tetrafluoroethane (HFC-134), 1,1,1,2-tetrafluoroethane (HFC-134a), 1,1,1-trifluoroethane (HFC-143a), 1,1-difluoroethane (HFC-152a), fluoroethane (HFC-161), 1,1,1,3,3-pentafluoropropane (HFC-245fa), 1,1,1,3,3,3-hexafluoropropane (HFC-236fa), 1,1,1,2,3,3,3-heptafluoropropane (HFC-227ea), 1,1,1,3,3-pentafluorobutane (HFC-365mfc), 1,1,1,2,3,4,4,5,5,5-decafluoropentane (HFC-43-10mee), 1,1,1,2,2,3,4,5,5,6,6,7,7,7-tetradecafluoroheptane (HFC-63-14mcee), 2,3,3,3-tetrafluoropropene (HFO-1234yf), 1,3,3,3-tetrafluoropropene (HFO-1234ze), 1,2,3,3-tetrafluoropropene (HFO-1234ye), 3,3,3-trifluoropropene (HFO-1243zf), 1,2,3,3,3-pentafluoropropene (HFO-1225ye), 1,1,1,3,3-pentafluoropropene (HFO-1225zc), 1,1,1,2,2,4,5,5,6,6,7,7,7-tridecafluoro-3-heptene (HFO-162-13mczy) and 1,1,1,2,2,3,5,5,6,6,7,7,7-tridecafluoro-3-

heptene (HFO-162-13mcyz), dichlorodifluoromethane (CFC-12), fluorotrichloromethane (CFC-11), 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), 1,2-dichloro-1,1,2,2-tetrafluoroethane (CFC-114), chlorodifluoromethane (HCFC-22), 2-chloro-3,3,3-trifluoropropene (HCFO-1233xf), 1-chloro-3,3,3-trifluoropropene (HCFO-1233zd), perfluoromethane (FC-14), perfluoroethane (FC-116), perfluoropropane (FC-218, perfluorocyclobutane (FC-C318), octafluoro-2-butene (FO-1318my), methane, ethane, ethylene, propane, cyclopropane, propylene, n-butane, butane, isobutane, cyclobutane, n-pentane, isopentane, n-hexane, cyclohexane, n-heptane, nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), ammonia (NH_3), argon (Ar), hydrogen (H_2), and mixtures thereof.

11. The absorption power cycle system of claim **1**, further including a recirculation line between the generator and the first heat exchanger, and between the first heat exchanger and the absorber, for recirculating the absorbent and working fluid mixture back to the absorber.

12. The absorption power cycle system of claim **1**, wherein the working fluid comprises at least one working fluid selected from the group consisting of 2-chloro-3,3,3-trifluoropropene, cis- or trans-1-chloro-3,3,3-trifluoropropene, 3,4,4,4-tetrafluoro-3-trifluoromethyl-1-butene, cis- or trans-1,1,1,4,4,5,5,5-octafluoro-2-pentene, and combinations thereof.

13. The absorption power cycle system of claim **1**, wherein the working fluid comprises at least one azeotrope or azeotrope-like composition selected from the group consisting of:

about 51 weight percent to about 70 weight percent cis-HFO-1336mzz and about 49 weight percent to about 30 weight percent isopentane;

about 62 weight percent to about 78 weight percent cis-HFO-1336mzz and about 38 weight percent to about 22 weight percent n-pentane;

about 75 weight percent to about 88 weight percent cis-HFO-1336mzz and about 25 weight percent to about 12 weight percent cyclopentane;

about 25 weight percent to about 35 weight percent cis-HFO-1336mzz and about 75 weight percent to about 65 weight percent HCFC-123;

about 67 weight percent to about 87 weight percent cis-HFO-1336mzz and about 33 weight percent to about 13 weight percent trans-1,2-dichloroethylene; and

about 61 weight percent to about 78 weight percent trans-HFO-1438mzz and about 39 weight percent to about 22 weight percent isopentane.

14. A process for producing mechanical work comprising:

(a) forming an absorbent/working fluid mixture in an absorber;

(b) heating the absorbent/working fluid mixture to release working fluid vapor;

(c) sending the working fluid vapor to a device for producing mechanical work; and

(d) reforming the heated absorbent/working fluid mixture.

15. The process of claim **14**, further comprising between step (c) and (d):

(c-i) condensing said working fluid in a condenser;

(c-ii) partially vaporizing said working fluid in an expansion device; and

(c-iii) fully vaporizing said working fluid in an evaporator thereby producing cooling.

16. The process of claim **14**, further comprising between step (c) and (d):

(c-i) condensing said working fluid in a condenser thereby producing heat;

(c-ii) partially vaporizing said working fluid in an expansion device; and

(c-iii) fully vaporizing said working fluid in an evaporator.

17. The process of claim **14**, further comprising between step (c) and (d) absorbing heat from a stream to be cooled in a second heat exchanger, thus producing cooling of the stream to be cooled.

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