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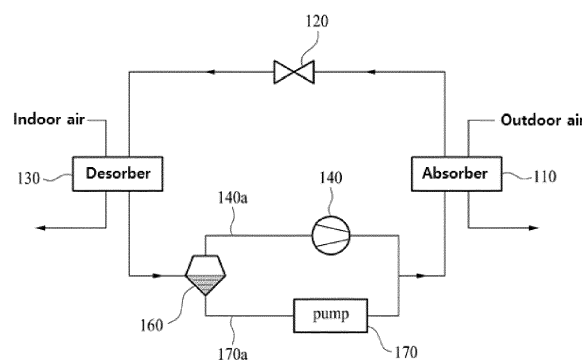
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(54) **HEATING AND COOLING APPARATUS USING GAS REFRIGERANT AND IONIC LIQUIDS**

(57) The heating and cooling apparatus using gas and ionic liquid of the present invention comprises an absorber wherein gas and ionic liquid flow in and the in-flowed gas is absorbed in the ionic liquid to produce an ionic liquid mixture; an expansion valve through which the ionic liquid mixture released from the absorber flows and the pressure of the ionic liquid mixture can be lowered; a desorber wherein the ionic liquid mixture released from the expansion valve exchanges heat with the first heating medium while it is flowing therein and the gas included in the ionic liquid mixture is evaporated by the heat provided from the first heating medium and thereby the ionic liquid mixture is separated into gas and ionic liquid; a gas-liquid separator in which the gas and the ionic liquid released from the desorber flow in; a liquid-phase line through which the ionic liquid separated in the gas-liquid separator flows; a pump equipped in the liquid-phase line; a gas-phase line wherein the gas separated in the gas-liquid separator flows; and a compressor which is equipped in the gas-phase line to increase the pressure of the gas.

Figure 2



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a heating and cooling apparatus using gas and ionic liquid, more precisely using gas absorption properties of ionic liquid.

2. Description of the Related Art

[0002] Carbon dioxide is a natural refrigerant which was widely used in the early 20th century, and was discontinued after the commercialization of synthetic refrigerants. However, the use of fluorinated gas-based synthetic refrigerants is gradually limited recently and instead carbon dioxide has been reexamined as an alternative refrigerant candidate. Carbon dioxide is an environmentally friendly, non-toxic, non-flammable material with remarkably low ozone layer destruction index and global warming index. Carbon dioxide is a natural refrigerant that satisfies stability, environmental friendliness, and availability. It is highly likely to be used as an alternative refrigerant in the future.

[0003] According to the vapor compression heating and cooling system using the conventional carbon dioxide refrigerant, the operation pressure is 3 ~ 5 times higher than other heating and cooling systems due to the thermodynamic properties of carbon dioxide and the equipment and installation are heavily required because of the high pressure, so that the system is limited in use and can be only applied to a large scale system.

[0004] Noble cooling systems have been introduced to overcome the disadvantages in the process economy and an example of them is the system using heat of vaporization or heat of dissolution of carbon dioxide included in ionic liquid instead of using heat of vaporization of carbon dioxide itself.

[0005] Particularly, as shown in Figure 1, the newly introduced heating and cooling system is composed of an absorber (10), an expansion valve (20), a desorber (30), and a compressor (40). In this system, carbon dioxide gas and ionic liquid absorb and release heat while flowing through the cycle.

[0006] That is, the carbon dioxide and the ionic liquid flow through the absorber (10) and are cooled through the supplied heating medium (for example, outdoor air). In the process, the carbon dioxide in the gas phase is dissolved in the ionic liquid, and at this time the heat of dissolution is released to the outside.

[0007] The ionic liquid mixture released from the absorber (10) passes through the expansion valve (20), during which the pressure thereof is lowered and then the mixture continues to flow in the desorber (30).

[0008] While the ionic liquid mixture flows in the desorber (30), it absorbs heat from the provided heating medium (such as indoor air). Carbon dioxide is then evaporated

from the ionic liquid mixture by the heat absorbed. Therefore, the mixture is separated into carbon dioxide and ionic liquid.

[0009] The separated carbon dioxide and the ionic liquid pass through the compressor (40), during which the pressure thereof is increased, and they continue to flow in the absorber (10) again. While the cycle repeats, cooling is achieved by the heat absorption in the desorber (30) and heating is achieved by the heat dissipation in the absorber (10).

[0010] However, this system has a disadvantage of low efficiency because two different phased materials, the gas and the liquid, flow together through each part composing the cycle, which needs to be overcome.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide a heating and cooling system to induce efficient absorption and deaeration of the two different phased materials, the gas and the ionic liquid, to overcome the disadvantage of the prior art mentioned above.

[0012] The spirit and scope of the present invention are not limited to the object above, and other objects which are not mentioned herein can be understood as illustrated hereinafter by those in the art.

[0013] To achieve the object above, the present invention provides a heating and cooling apparatus using gas and ionic liquid comprising an absorber wherein gas and ionic liquid flow in and the in-flowed gas is absorbed in the ionic liquid to produce an ionic liquid mixture; an expansion valve through which the ionic liquid mixture released from the absorber flows and the pressure of the ionic liquid mixture can be lowered; a desorber wherein the ionic liquid mixture released from the expansion valve exchanges heat with the first heating medium while it is flowing therein and the gas included in the ionic liquid mixture is evaporated by the heat provided from the first heating medium and thereby the ionic liquid mixture is separated into gas and ionic liquid; a gas-liquid separator in which the gas and the ionic liquid released from the desorber flow in; a liquid-phase line through which the ionic liquid separated in the gas-liquid separator flows; a pump equipped in the liquid-phase line; a gas-phase line wherein the gas separated in the gas-liquid separator flows; and a compressor which is equipped in the gas-phase line to increase the pressure of the gas.

[0014] In the apparatus, the gas-phase line can additionally include a first heat exchanger for cooling the gas pressurized while passing through the compressor.

[0015] The absorber can additionally include a line mixer wherein the ionic liquid mixture flows and a second heat heating medium supply unit for the heat exchange of the second heating medium of the ionic liquid mixture. At this time, multiple line mixers can be arranged in parallel.

[0016] In the shear of the absorber, a line mixer can be additionally equipped for mixing the gas and the ionic

liquid. The absorber, at this time, can additionally include a second heat exchanger wherein the ionic liquid mixture flowing into the expansion valve, the gas discharged from the desorber and the ionic liquid flow while being heat-exchanged.

[0017] The ionic liquid above is an ionic liquid composition prepared by dissolving the second ionic liquid in the phase of solid at the temperature range of $-20 \sim 120^{\circ}\text{C}$ in the first ionic liquid in the liquid phase at the temperature range of $-20 \sim 120^{\circ}\text{C}$, and the ionic liquid mixture can have gas and ionic liquid comprising the ionic liquid composition above.

[0018] The first ionic liquid herein can include at least one of those ionic compounds selected from the group consisting of 1-butyl-3-methylimidazoliumhexafluorophosphate ([BMIM][PF₆]), 1-butyl-3-methylimidazoliumtetrafluoroborate ([BMIM][BF₄]), 1-hexyl-3-methylimidazolium bistrifluoromethylsulfonylimide ([HIMIM][TF₂N]), 1-ethyl-3-methylimidazoliumtetrafluoroborate ([EMIM][PF₄]), 1-butyl-3-methylimidazolium acetate ([BMIM][ACETATE]), and 1-ethyl-3-methylimidazolium bistrifluoromethylsulfonylimide ([EMIM][TF₂N]).

[0019] The second ionic liquid can include at least one of those compounds selected from the group consisting of poly(p-vinylbenzyl)trimethylammoniumtetrafluoroborate (p[VB_TMA][BF₄]), poly(p-vinylbenzyl)trimethylammoniumtrifluoromethylsulfonylimide ([p[VB_TMA][TF₂N]], poly(p-vinylbenzyl)trimethylammoniumhexafluorophosphate (p[VB_TMA][PF₆]), poly (p-vinylbenzyl)trimethylammoniumchloride (p[VB_TMA][Cl]), poly(p-vinylbenzyl)trimethylammonium o-benzoic sulfonylimide (p[VB_TMA][Sac]), poly(p-vinylbenzyl)triethylammoniumtetrafluoroborate (p[VB_TEA][BF₄]), and poly(p-vinylbenzyl)tributylammoniumtetrafluoroborate (p[VB_TBA][BF₄]).

[0020] The concentration of the second ionic liquid in the ionic liquid composition above is preferably 5 ~ 20 weight%, and the gas herein can be carbon dioxide.

ADVANTAGEOUS EFFECT

[0021] The transfer object counting apparatus of the present invention to achieve the above objects has the following effects.

First, the gas and the ionic liquid separated from the desorber are separated and compressed and pressurized, so that it is not necessary to use an expensive compressor for simultaneously pressurizing the gas phase and the liquid phase. Further, there is also an advantage of controlling the pressure of the gas and the ionic liquid separately in order to increase the solubility of the gas efficiently.

Second, in the apparatus of the invention, a heat exchanger is equipped for separating the gas-phase line and the liquid-phase line and separately cooling only the gas flowing in the gas-phase line. Therefore, it is possible to cool the gas to flow the absorber and

to increase the gas solubility in the absorber according to the cooling of the gas.

Third, as the gas-phase line and the liquid-phase line are connected to one pipe by using the line mixer, it is possible to prevent the gas and the ionic liquid from separating and flowing into the absorber. Thus, the gas can be distributed evenly in the ionic liquid before it flows in the absorber, and as a result the contact area can be enlarged, resulting in the increase of the solubility of the gas in the absorber.

Fourth, an external heat source is provided to the line mixer itself so that the gas can be dissolved in the ionic liquid while it flows through the line mixer. Thus, the solubility of the gas can be increased by using the line mixer without any additional heat exchanger.

Fifth, it is possible to reduce the noise and vibration generated when the gas and the liquid phase gas and the ionic liquid are flowing together.

[0022] The effects of the present invention are not limited to the above, and other effects not mentioned herein can be included in the criteria of claims of the invention, which is easily understood by those in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The application of the preferred embodiments of the present invention is best understood with reference to the accompanying drawings, wherein:

Figure 1 is a diagram illustrating the schematic configuration of the cooling cycle using gas and ionic liquid as disclosed in the prior art;

Figure 2 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the first Example of the present invention;

Figure 3 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the second Example of the present invention;

Figure 4 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the third Example of the present invention;

Figure 5 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the fourth Example of the present invention;

Figure 6 is a diagram illustrating the separation process of the gas and the ionic liquid when they flow in one pipe according to the present invention;

Figure 7 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the fifth Example of the present invention;

Figure 8 is a schematic diagram illustrating the ionic

liquid absorption amount measurement device for measuring the carbon dioxide absorption amount of the ionic liquid of the present invention;

Figure 9 is a graph illustrating the changes of the pressure-dependent solubility of carbon dioxide in each liquid.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] Hereinafter, the preferable embodiments wherein the object of the present invention can be practically realized are described with the attached figures. In the description herein, the same name and the same mark are used for the same constitution, and at this time the additional explanation is skipped.

[0025] The present invention provides cooling or heating using heat absorption and heat dissipation in the process of gas absorption in ionic liquid or separation and the entire cycle is regulated to provide the efficient absorption and separation conditions of gas and ionic liquid

[0026] The gas of the present invention can be any gas that exists in a gaseous state at room temperature and atmospheric pressure, and particularly such gas having an ozone layer destruction index close to 0 or 0 and a global warming coefficient index of 10 or less is preferred. For example, carbon dioxide, ammonia, air, and isobutane can be used as the gas of the invention. Hereinafter, carbon dioxide will be used as a reference in the present embodiment.

[0027] Figure 2 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the first example of the present invention.

[0028] As shown in Figure 2, the heating and cooling apparatus of the example of the invention is composed of an absorber (110), an expansion valve (120), a desorber (130), a gas-liquid separator (140), a liquid-phase line (170a), a pump (170), a gas-phase line (140a), and a compressor (140).

[0029] Carbon dioxide and ionic liquid are introduced into the absorber (110), where they exchange heat with the second heating medium. Various heat sources can be used as the second heating medium for heat exchange, and in this invention, outdoor air is used as the heating medium.

[0030] While carbon dioxide and the ionic liquid are flowing in the absorber (110), they exchange heat with outdoor air, and accordingly carbon dioxide becomes dissolved in the ionic liquid, resulting in the ionic liquid mixture.

[0031] The reaction in which carbon dioxide is dissolved in the ionic liquid is an exothermic reaction, and the generated heat is discharged to the outside through the second heating medium. So, the heat generated during the process of dissolving carbon dioxide in the ionic liquid can be supplied to the region needed.

[0032] In the meantime, various heat exchangers that

are used in the evaporative cooling system can be used for the absorber (110). The absorber of the example of the invention has similar functions to those of a condenser of the cooling system and can include a blower (not shown) to flow outdoor air in the heat exchanger.

[0033] The ionic liquid mixture (the ionic liquid wherein carbon dioxide is dissolved) whose temperature has been lowered while it passed through the absorber (110) flows through the expansion valve (120), during which the pressure and the temperature continue to be lowered.

[0034] Particularly, the low temperature/high pressure ionic liquid mixture discharged from the absorber (110) passes through the expansion valve (120), during which the pressure goes down, resulting in the low temperature/low pressure ionic liquid mixture (at this time, some of carbon dioxide dissolved therein can be separated from the ionic liquid and accordingly the temperature of the ionic liquid mixture can be reduced in some systems).

[0035] The low temperature/low pressure ionic liquid mixture is functioning as a refrigerant while it passes through the desorber (130) to accomplish cooling the area. The temperature of the desorber (130) is comparatively higher than that of the low temperature ionic liquid mixture. The high temperature herein corresponds to the temperature of indoor air which is the subject to be cooled.

[0036] While the low temperature/low pressure ionic liquid composition passes through the desorber (130), carbon dioxide dissolved in the ionic liquid composition is evaporated, during which it absorbs external heat and cools the surrounding area. The evaporation of carbon dioxide is defined as the endothermic reaction. The cooling effect is just as much as the absorbed heat of reaction. The cooling system of the example of the present invention uses the dissolution/evaporation of carbon dioxide which is only operated by external temperature parameters, indicating that it does not require a high pressure environment.

[0037] In the desorber (130), various types of heat exchanger can be applied thereto as in the evaporative cooling system. That is, the desorber in an example of the invention is functioning similarly to the evaporator of the evaporative cooling system, and can comprise a blower (not shown) for the flow of outdoor air through in the heat exchanger.

[0038] In the gas-liquid separator (160), the gaseous carbon dioxide separated from the desorber (130) and the liquid ionic liquid are separated.

[0039] The separated gaseous carbon dioxide flows in the gas-phase line (140a) and passes through the compressor (140), during which the gas becomes compressed and pressurized. The separated ionic liquid flows in the liquid-phase line (170a) and is circulated through the pump (170).

[0040] In an example of the present invention, as explained in the conventional system, carbon dioxide and the ionic liquid pass through the same pipe, and are not compressed in the same compressor but are separated,

so that carbon dioxide is compressed in the compressor (140) and the ionic liquid is pressurized in the pump (170).

[0041] In general, the equipment for simultaneous compression of gas and liquid is very expensive but has a low compressible efficiency. In a preferred embodiment of the invention, carbon dioxide evaporated from the ionic liquid mixture in the desorber (130) and the ionic liquid excluding carbon dioxide move through different pipes. At this time, the pressure is increased by using the compressor (140) and the pump (170).

[0042] Therefore, according to the present invention, the compressible efficiency can be increased simply by using the compressor (140) and the pump (170) instead of an expensive compressor. In the present invention, carbon dioxide and the ionic liquid are pressurized by using the compressor (140) and the pump (170), suggesting that the increasing level of pressure of each carbon dioxide and the ionic liquid can be independently regulated with considering the whole system efficiency.

[0043] In the meantime, the gas-phase line (140a) and the liquid-phase line (170a) are connected to the same pipe, which are extended to the absorber (110), making the whole cycle.

[0044] Figure 3 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the second example of the present invention.

[0045] As shown in Figure 3, the total composition and the operation system of the cooling system using carbon dioxide and the ionic liquid of the example of the invention are as illustrated in example 1. Hereinafter, the differences are explained.

[0046] The gas-phase line (140a) of a preferred embodiment of the invention includes the first heat exchanger (180) to cool down the gas pressurized while passing through the compressor (140).

[0047] In general, the heat of compression of gas is very high, and therefore the temperature of carbon dioxide that passes through the compressor (140) is comparatively high, compared with the ionic liquid that passes through the liquid-phase line (170a). When the high temperature carbon dioxide flows in the absorber (110), the absorption rate of the ionic liquid is reduced.

[0048] In a preferred embodiment of the present invention, the solubility of carbon dioxide is increased in the absorber (110) by lowering the temperature of carbon dioxide passed through the compressor (140) by using the first heat exchanger (180). As the solubility of carbon dioxide is increased, the heat dissipation is also increased. As a result, the temperature of the ionic liquid mixture in the outlet of the absorber (110) is reduced.

[0049] Figure 4 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the third example of the present invention.

[0050] As shown in Figure 4, the total composition and the operation system of the apparatus of the example are similar to those of example 1 and example 2. Here-

inafter, the differences are explained.

[0051] In a preferred embodiment of the invention, the absorber (110) additionally includes the second heat exchanger (150) for exchanging heat between the ionic liquid mixture flowing through the expansion valve (120) and the carbon dioxide and the ionic liquid discharged from the desorber (130).

[0052] The temperature of the ionic liquid mixture is more decreased by passing through the second heat exchanger (150) in the absorber (110), but the temperatures of carbon dioxide and the ionic liquid passing through the desorber (130) are comparatively increased.

[0053] That is, the second heat exchanger (150) is to cool the ionic liquid mixture once again before flowing it in the expansion valve (120). Carbon dioxide that is not dissolved in the ionic liquid while passing through the absorber (110) in some systems can be additionally dissolved once again in the ionic liquid mixture.

[0054] Figure 5 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the fourth example of the present invention. As shown in Figure 5, the line mixer (190) can be additionally equipped in the shear of the absorber (110).

[0055] The gaseous carbon dioxide and the ionic liquid pass through the gas-phase line (140a) and the liquid-phase line (170a) respectively, and then flow in the same pipe. At this time, they have different phases while flowing in the pipe so that they might not be mixed together in the pipe.

[0056] Unlike the conventional system, gas in the gas and the liquid are separated from each other and proceeds to compression or pressurization. That is, according to the conventional system, the gaseous carbon dioxide and the ionic liquid are compressed in the same compressor, so that some carbon dioxide can be dissolved in the ionic liquid or they can be mixed together to some degree. When the gaseous carbon dioxide and the ionic liquid flow in the absorber (110) as mixed together, the gaseous carbon dioxide can be evenly distributed in the ionic liquid. As a result, the contact area between them is enlarged, making carbon dioxide be dissolved more easily in the ionic liquid.

[0057] In this invention, the gas-phase line and the liquid-phase line are separated from each other, indicating the compression and pressurization progress separately, so that the degree of mixing of carbon dioxide and the ionic liquid is low, compared with the prior art. In particular, the gas and the liquid might be separated in the course of combining together in one pipe (see Figure 6).

[0058] In that case, the liquid and the gas flow in the absorber pipe as separated, so that the absorption rate of carbon dioxide in the ionic liquid drops significantly.

[0059] Therefore, in a preferred embodiment of the present invention, the line mixer (190) is equipped in the shear of the absorber (110) to mix the liquid and the gas together, so that the properly combined mixture can flow in the pipe of the absorber (110).

[0060] That is, the present invention provides a composition wherein the gas-phase line (140a) and the liquid-phase line (170a) are separated from each other but the line mixer (190) is additionally equipped, so that the absorption rate of carbon dioxide can be satisfactorily increased and further the cooling efficiency of the whole system can also be improved.

[0061] When the gaseous carbon dioxide and the ionic liquid flow separately, vibration and noise can be generated in the heating and cooling apparatus of the invention. However, such vibration and noise can be reduced by mixing two different phases of carbon dioxide and the ionic liquid by using the line mixer (190) additionally equipped therein.

[0062] Figure 7 is a diagram illustrating the schematic configuration of the heating and cooling apparatus using gas and ionic liquid according to the fifth example of the present invention.

[0063] As shown in Figure 7, the absorber of the example can be replaced with the line mixer (190').

[0064] In example 4, carbon dioxide and the ionic liquid are mixed while flowing through the line mixer (190), during which some carbon dioxide is absorbed in the ionic liquid. Therefore in this invention, carbon dioxide can be absorbed in the ionic liquid through the line mixer (190') taking a place of the construction of the absorber.

[0065] In examples above, the absorber has a structure of the conventional heat exchanger. Even though there is a difference among the selected heat exchangers, most of them has the structure wherein carbon dioxide and the ionic liquid flow through a pipe and are cooled by the supplied outdoor air, during which carbon dioxide can be absorbed in the liquid.

[0066] However, in a preferred embodiment of the present invention, the conventional heat exchanger type absorber is replaced with a line mixer, so that carbon dioxide and the ionic liquid are mixed together while flowing through the line mixer and at this time the second heating medium (for example, outdoor air) is supplied for heat exchange, resulting in the increase of carbon dioxide absorption rate.

[0067] To compose the structure of the system of the invention, there is no need to purchase or equip an additional heat exchanger and instead the required absorption rate of carbon dioxide can be satisfied with only the line mixer and the second heating medium supplying unit (for example, a blower for the blast of outdoor air).

[0068] In particular, when the system is used only for cooling, it is possible to secure a sufficient carbon dioxide absorption rate by adopting the configuration of the line mixer and the blower without adopting the configuration of the expensive heat exchanger as the absorber.

[0069] In that case, a plurality of line mixers can be arranged in series or in parallel to meet the flow capacity of carbon dioxide and the ionic liquid flowing in the whole system.

[0070] The ionic liquid of the present invention can be a liquid mixture of various ionic liquids. According to an

example of the present invention, the composition for the absorption of carbon dioxide comprises the first ionic liquid staying in the liquid phase at the temperature range of -20 ~ 120°C and the second ionic liquid that is in the solid phase in the temperature range of -20 ~ 120°C but dissolved and staying in the liquid phase in the composition.

[0071] The second ionic liquid includes a polymer type ionic compound which stays in the solid phase not only in the temperature range above but also in the temperature up to 1000°C. The second ionic liquid is included as dissolved in the first ionic liquid herein, so that the contact area can be increased in the solution more than before it stayed as a solid phase, resulting in the increase of carbon dioxide absorption rate. Therefore, to select the first ionic liquid, it is important to consider the kind of the second ionic liquid in order to maximize the solubility of the second ionic liquid.

[0072] Particularly, the second ionic liquid herein can be a polymer type ionic compound staying as a solid phase in the operation temperature of the cooling system (200) above. For example, the second ionic liquid is exemplified by poly(p-vinylbenzyl)trimethylammoniumtetrafluoroborate (p[VBTMA][BF4]), poly(p-vinylbenzyl)trimethylammoniumtrifluoromethylsulfonylimide ([p[VBTMA][TF2N]], poly(p-vinylbenzyl)trimethylammoniumhexafluorophosphate (p[VBTMA][PF6]), poly(p-vinylbenzyl)trimethylammoniumchloride (p[VBTMA][Cl]), poly(p-vinylbenzyl)trimethylammonium o-benzoic sulfonylimide (p[VBTMA][Sac]), poly(p-vinylbenzyl)triethylammoniumtetrafluoroborate (p[VBTEA][BF4]), and poly(p-vinylbenzyl)tributylammoniumtetrafluoroborate (p[VBTEA][BF4]). The ionic compound above can be used independently to make the ionic liquid mixture or a combination of at least two of those compounds can be added to the ionic liquid mixture above.

[0073] The second ionic liquid can absorb carbon dioxide basically as in the solid phase but when carbon dioxide is distributed evenly in the first ionic liquid, the contact area with the carbon dioxide using as a refrigerant is maximized, so that the carbon dioxide absorption rate can be improved.

[0074] The first ionic liquid acting as a solvent for the second ionic liquid can be an ionic compound with high stability and high carbon dioxide solubility, which is exemplified by such ionic compounds as imidazolium cationic compounds.

[0075] Particularly, 1-butyl-3-methylimidazolium hexafluorophosphate ([BMIM][PF6]), 1-butyl-3-methylimidazolium tetrafluoroborate ([BMIM][BF4]), 1-hexyl-3-methylimidazolium bistrifluoromethylsulfonylimide ([HIMIM][TF2N]), and 1-butyl-3-methylimidazolium acetate ([BMIM][ACETATE]) can be selected.

[0076] The ionic liquid can be substituted with other ionic liquids except those ionic liquids above, according to the characteristics of the applied carbon dioxide absorption system or the intension of the operator. The ionic liquid mentioned above can be mixed with the second

ionic liquid independently or multiple ionic liquids can be combined thereto.

[0077] The concentration of the second ionic liquid in the ionic liquid composition above is preferably 5 ~ 20 weight%. If the concentration of the second ionic liquid is more than 20 weight%, the viscosity would be increased rapidly, resulting in the decrease of the workability and the carbon dioxide absorption.

[0078] The ionic liquid composition above can additionally include various additives including a viscosity controlling agent with considering workability in addition to the absorption according to the absorption system applied or the characteristics of the application.

[0079] Hereinafter, the following experiment performed to investigate the improvement of carbon dioxide absorption rate of the ionic liquid composition and the results are described in more detail.

Evaluation of carbon dioxide absorption performance

[0080] Carbon dioxide absorption performance was compared and evaluated with the control and experimental liquids below.

Control group 1: general solvent (methylimidazolium: MIM)

Control group 2: ionic liquid ([BMIM][BF₄])

Experimental group: [BMIM][BF₄] + 7.5% [PVBt-MA][BF₄] ionic liquid mixture

[0081] Figure 8 is a schematic diagram illustrating the ionic liquid absorption amount measurement device for measuring the carbon dioxide absorption amount of the ionic liquid of the present invention.

[0082] As shown in Figure 8, the carbon dioxide provided from the carbon dioxide supply unit (110) flows in the apparatus after opening the first valve (122) but closing the second valve (124), which was then stored in the carbon dioxide storage tank (140). The pressure in the apparatus is measured by the pressure gauge (130). Once the storage tank (140) is filled with carbon dioxide, the first valve (122) is closed. Then, carbon dioxide in the storage tank (140) can be measured accurately by using the pressure measured before (P1V1). Then, the first valve (122) is closed and the second valve (124) is opened, followed by flowing of carbon dioxide in the reactor (150). The reactor (150) contains the ionic liquid (152) for the experiment. Carbon dioxide (154) flowed in the reactor (150) is dissolved in the ionic liquid (152) and absorbed. At this time, the amount of carbon dioxide (154) flowed therein is equal to that of carbon dioxide staying in the carbon dioxide storage tank (150). After the dissolution reaction becomes equilibrated, if carbon dioxide (154) stayed still there without being absorbed at all, the amount of carbon dioxide in the closed system should be the same as the amount of carbon dioxide staying in the storage tank (150) before opening the second valve (154) (P1V1=P2V2). But, if carbon dioxide is

absorbed, the amount of carbon dioxide absorbed in the ionic liquid can be evaluated as the difference in the amount of carbon dioxide in the gas phase.

[0083] Figure 9 is a graph illustrating the changes of the pressure-dependent solubility of carbon dioxide in each liquid. As shown in Figure 9, as a result of the measurement of the absorption amount of carbon dioxide, the experimental group ionic liquid mixture displayed significantly higher carbon dioxide solubility than the control group. That is, the carbon dioxide absorption capability of the experimental group ionic liquid mixture was significantly increased. In particular, the pressure-dependent solubility was also higher than that of the control. When the mixed refrigerant composed of the experimental group ionic liquid mixture and carbon dioxide was running under the operation pressure of 20 ~ 30 atm in a cooling system, the carbon dioxide absorption amount could be more increased, and accordingly the cooling effect was also expected to be higher.

<BRIEF DESCRIPTION OF THE MARK OF DRAWINGS>

[0084]

110: absorber 120: expansion valve
130: desorber 140: compressor
150: second heat exchanger
160: gas-liquid separator
170: pump 180: first heat exchanger
190: line mixer

[0085] Those skilled in the art will appreciate that the conceptions and specific embodiments disclosed in the foregoing description may be readily utilized as a basis for modifying or designing other embodiments for carrying out the same purposes of the present invention. Those skilled in the art will also appreciate that such equivalent embodiments do not depart from the spirit and scope of the invention as set forth in the appended Claims.

Claims

1. A heating and cooling apparatus using gas and ionic liquid, which comprises:

an absorber wherein gas and ionic liquid flow in and the in-flowed gas is absorbed in the ionic liquid to produce an ionic liquid mixture;
an expansion valve through which the ionic liquid mixture released from the absorber flows and the pressure of the ionic liquid mixture can be lowered;
a desorber wherein the ionic liquid mixture released from the expansion valve exchanges heat with the first heating medium while it is flow-

- ing therein and the gas included in the ionic liquid mixture is evaporated by the heat provided from the first heating medium and thereby the ionic liquid mixture is separated into gas and ionic liquid;
- a gas-liquid separator in which the gas and the ionic liquid released from the desorber flow in;
- a liquid-phase line through which the ionic liquid separated in the gas-liquid separator flows;
- a pump equipped in the liquid-phase line;
- a gas-phase line wherein the gas separated in the gas-liquid separator flows;
- a compressor which is equipped in the gas-phase line to pressurize the gas.
2. The heating and cooling apparatus using gas and ionic liquid according to claim 1, wherein the gas-phase line is provided with a first heat exchanger for cooling the pressurized gas while passing through the compressor.
 3. The heating and cooling apparatus using gas and ionic liquid according to claim 1, Wherein the absorber further includes a line mixer through which the ionic liquid mixture flows and a second heat medium supply unit for supplying the second heat medium to allow heat exchange between the ionic liquid mixture and the second heat medium.
 4. The heating and cooling apparatus using gas and ionic liquid according to claim 3, Wherein A plurality of the line mixers are provided in parallel.
 5. The heating and cooling apparatus using gas and ionic liquid according to claim 1, Wherein a line mixer for mixing the gas and the ionic liquid is further provided at the front end of the absorber.
 6. The heating and cooling apparatus using gas and ionic liquid according to claim 1 further comprises the ionic liquid mixture flowing from the absorber to the expansion valve, and the second heat exchanger exchanging heat while flowing gas and ionic liquid from the desorber.
 7. The heating and cooling apparatus using gas and ionic liquid according to claim 1, Wherein the ionic liquid comprises an ionic liquid composition in which the second ionic liquid having a solid phase in a temperature range of -20 to 120 °C is in a dissolved state in the first ionic liquid having a liquid phase in a temperature range of -20 to 120 °C.
 8. The heating and cooling apparatus using gas and ionic liquid according to claim 7, Wherein the first ionic liquid comprises at least one ionic compound selected from the group consisting of 1-butyl-3-methylimidazolium hexafluorophosphate ([BMIM] [PF6]), 1-butyl-3-methylimidazolium tetrafluoroborate ([BMIM] [BF4]), 1-hexyl-3-methylimidazolium bistrifluoromethylsulfonylimide ([HIMIM] [TF2N]), 1-ethyl-3-methylimidazolium tetrafluoroborate ([EMIM] [PF4]), 1-butyl-3-methylimidazolium acetate ([BMIM] [ACETATE]) and 1-ethyl-3-methylimidazolium bistrifluoromethylsulfonylimide ([EMIM] [TF2N]).
 9. The heating and cooling apparatus using gas and ionic liquid according to claim 7, Wherein the second ionic liquid comprises at least one compound selected from the group consisting of Poly (p-vinylbenzyl) trimethylammonium tetrafluoroborate (p [VBTMA] [BF4]), Poly (p-vinylbenzyl) trimethylammonium trifluoromethylsulfonylimide ([p [VBTMA] [TF2N]]), Poly (p-vinylbenzyl) trimethylammonium hexafluorophosphate (p [VBTMA] [PF6]), Poly (p-vinylbenzyl) trimethylammonium chloride (p [VBTMA] [Cl]), Poly (p-vinylbenzyl) trimethylammonium o-benzooxysulfonylimide (p [VBTMA] [Sac]), Poly (p-vinylbenzyl) triethylammonium tetrafluoroborate (p [VBTEA] [BF4]) and Poly (p-vinylbenzyl) tributylammonium tetrafluoroborate (p [VBTBA] [BF4]).
 10. The heating and cooling apparatus using gas and ionic liquid according to claim 7, Wherein the content of the second ionic liquid in the ionic liquid composition is 5 to 20 wt%.
 11. The heating and cooling apparatus using gas and ionic liquid according to claim 7, Wherein the gas is carbon dioxide.

Figure 1

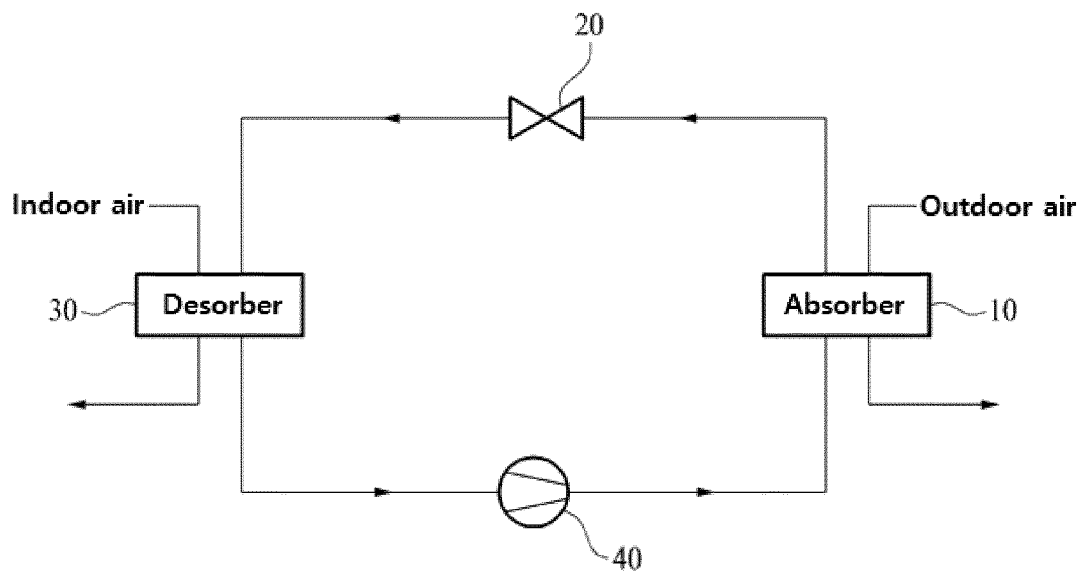


Figure 2

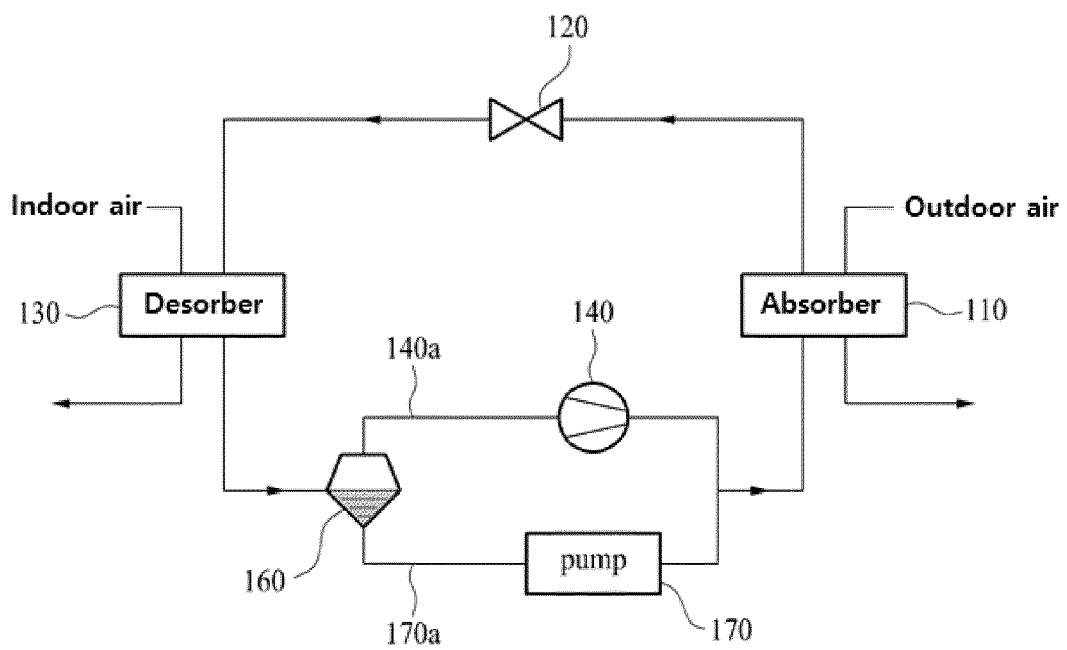


Figure 3

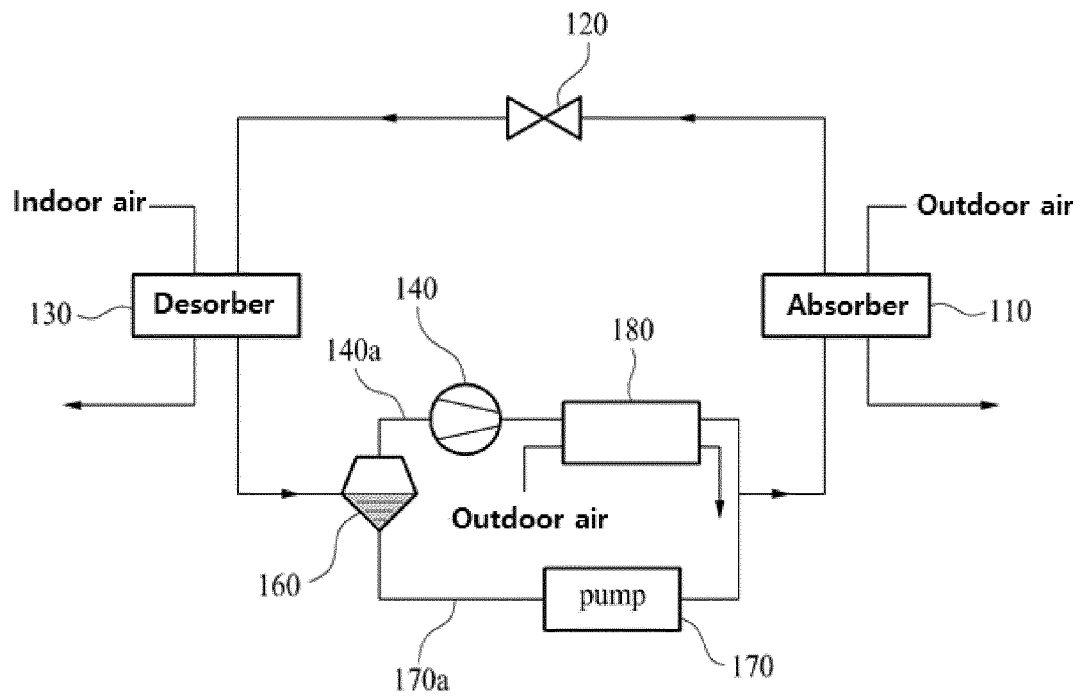


Figure 4

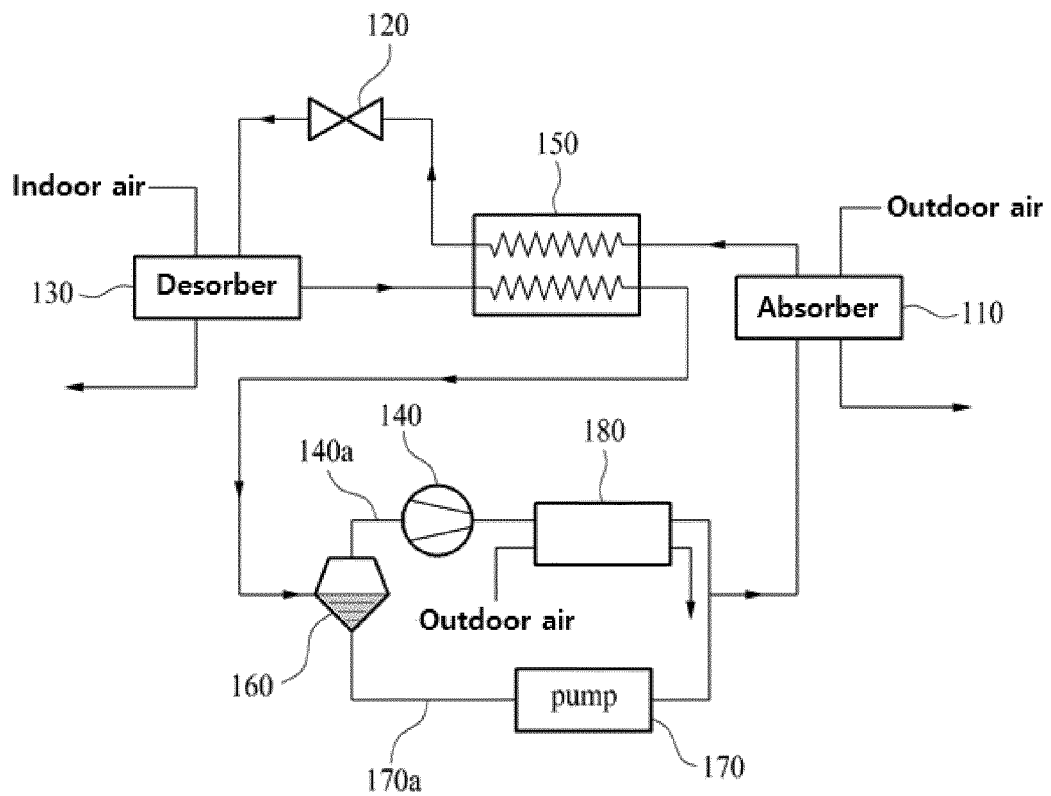


Figure 5

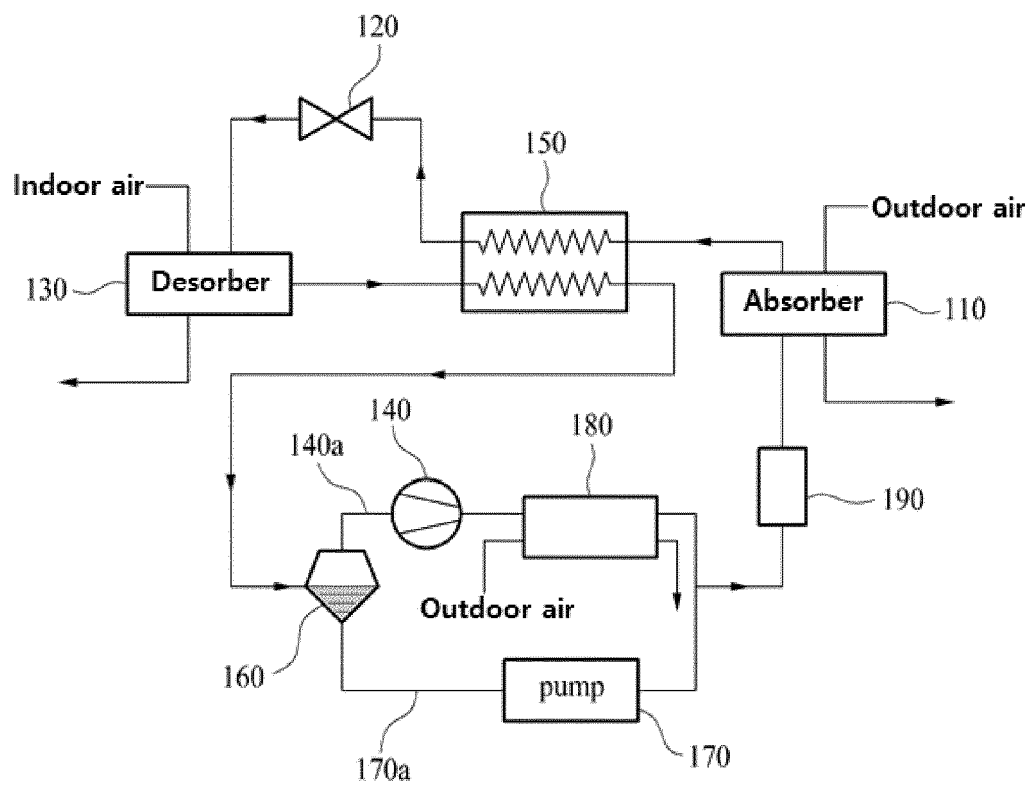


Figure 6

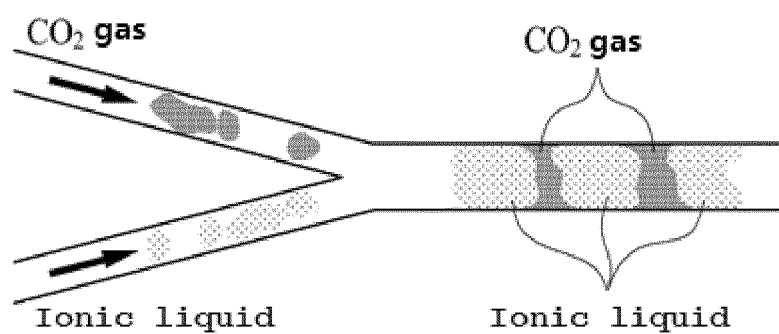


Figure 7

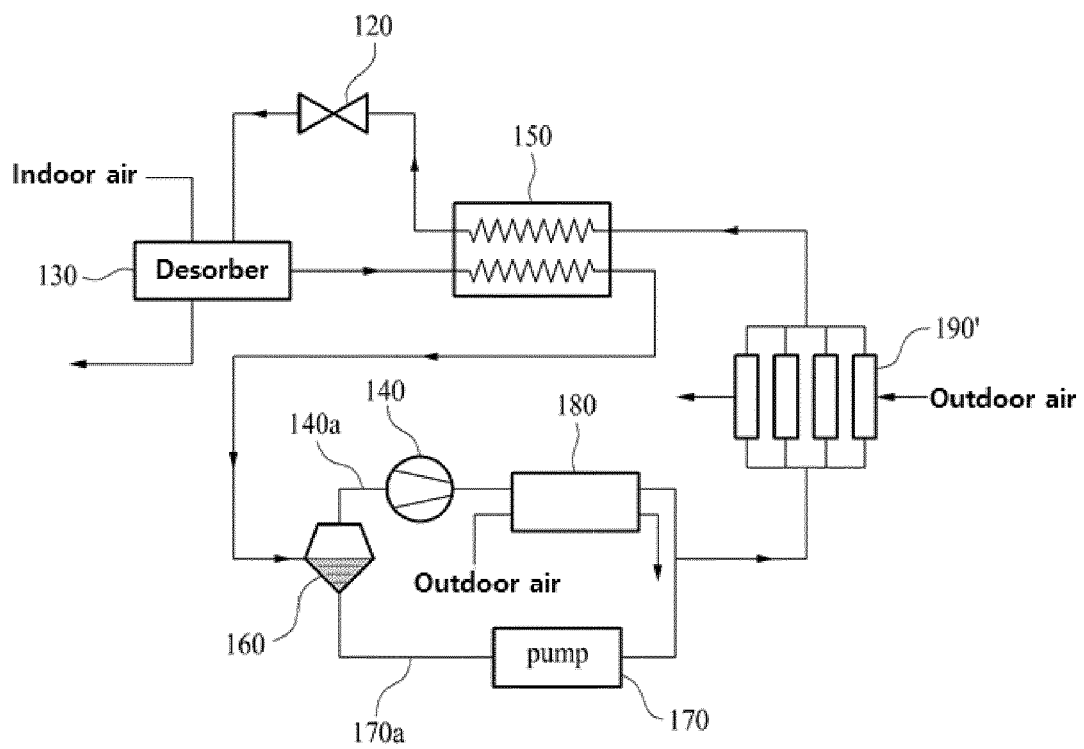


Figure 8

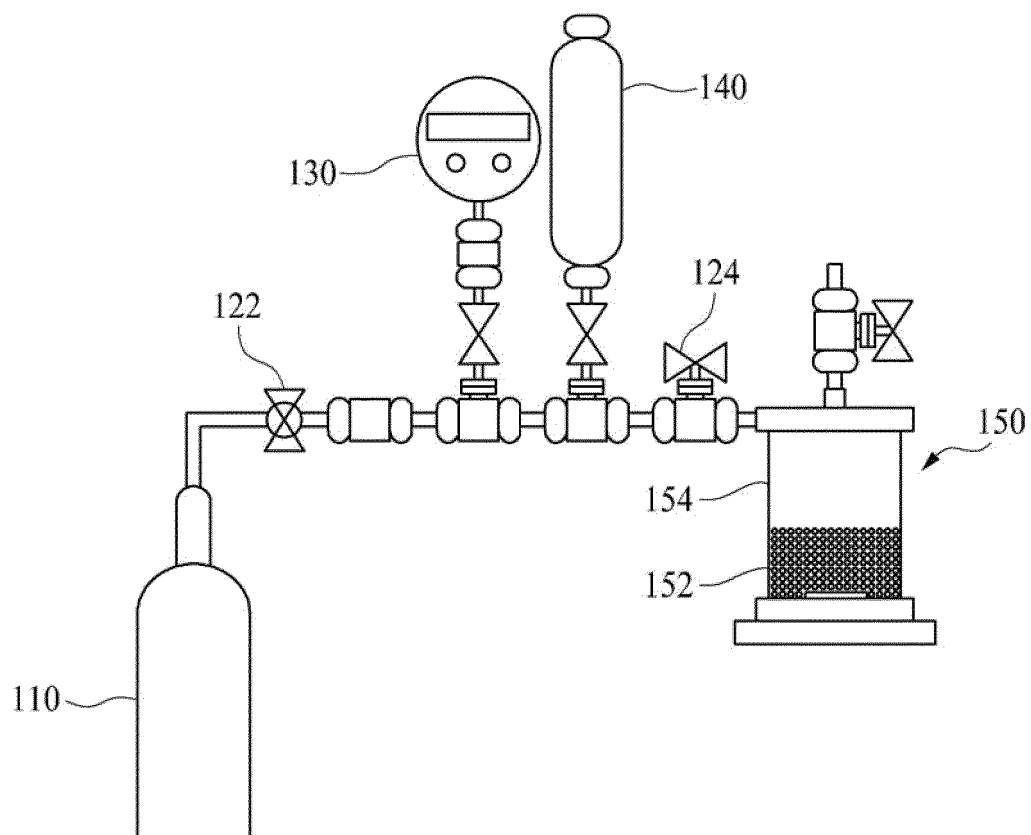
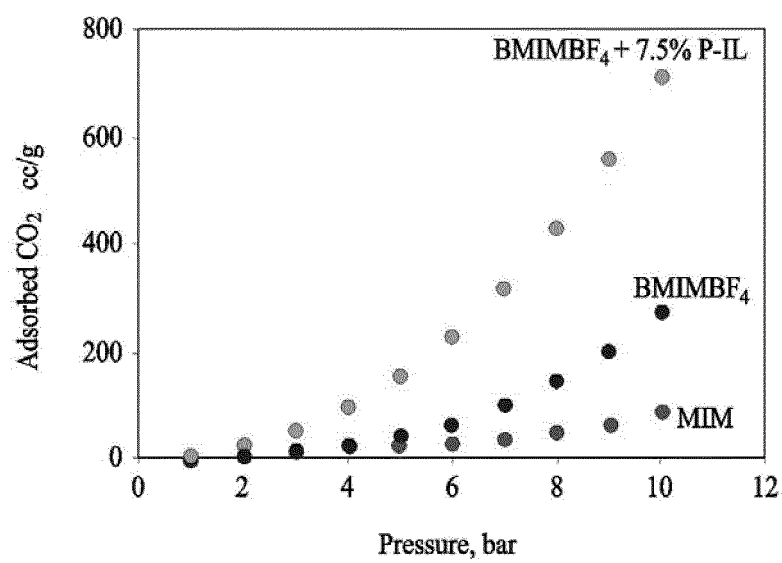


Figure 9





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Application Number
EP 17 16 8799

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A	WO 98/29701 A1 (SJOEBLOM HANS [SE]; SJOEBLOM ANDERS [SE]) 9 July 1998 (1998-07-09) * page 7 - page 11; figures 2-5 *	1-11	
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			F25B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 August 2017	Examiner Amous, Moez
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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The members are as contained in the European Patent Office EDP file on
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