



(51) International Patent Classification:
A61F 7/10 (2006.01)

(21) International Application Number:
PCT/US2013/043583

(22) International Filing Date:
31 May 2013 (31.05.2013)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **EMPIRE TECHNOLOGY DEVELOPMENT LLC** [US/US]; 2711 Centervill Road, Suite 400, Wilmington, DE 19808 (US).

(72) Inventors: **MILLAR, Benjamin, William**; 2/337a Gardeners Road, Rosebery, New South Wales 2018 (AU). **MANION, Michael, Keoni**; 4/24 Kurnell Road, Cronulla, New South Wales 2230 (AU). **PEPPOU, George, Charles**; 4 Armen Way, Hornsby Height, New South Wales 2077 (AU).

(74) Agent: **CHRISTENSEN, Michael, R.**; Knobbe, Martens, Olson & Bear, LLP, 2040 Main Street, 14th Floor, Irvine, CA 92614 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: DYNAMIC INSULATION

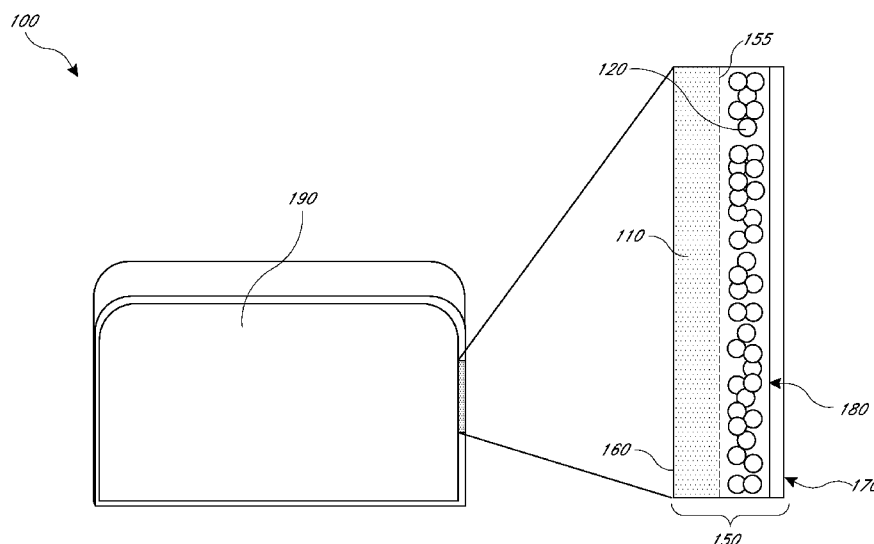


FIG. 1

(57) Abstract: Systems, devices and methods for providing temperature control and/or regulation are provided. In some embodiments, the systems and/or methods include at least one endothermic reactant, which can be activated to control a local temperature. In some embodiments, the systems and/or methods include at least one gas producing material, which can allow for the production of gas, which can be trapped for the provision of an insulating volume.

DYNAMIC INSULATION

Technical Field

[0001] Some embodiments provided herein generally relate to devices and methods for regulating temperature.

Background

[0002] A variety of devices and methods exist for controlling the temperature of various items and/or environments. Many devices and methods can be grouped as being either passive in nature (such as a traditional ice chest) or dependent upon an external source of energy (such as the requirement of many modern refrigerators on electricity).

SUMMARY

[0003] In some embodiments, an insulating system is provided. The insulating system can include at least one endothermic reactant separated from at least one solvent in a temperature dependent manner such that an increase in temperature results in the solvent solvating the endothermic reactant.

[0004] In some embodiments, a gas retaining enclosure is provided. The gas retaining enclosure can include at least one gas producing reactant separated from at least one solvent in a temperature dependent manner such that an increase in temperature results in the solvent solvating the at least one gas producing reactant.

[0005] In some embodiments, a method for regulating the temperature of a desired environment is provided. The method can include providing at least one endothermic reactant and providing at least one solvent separated from the at least one endothermic reactant. The method can include solvating the at least one endothermic reactant by changing a state of at least one of the solvent and/or a barrier separating the solvent from the at least one endothermic reactant to allow an endothermic reaction to occur. In some embodiments, the change in state occurs in response to an increase in temperature and thereby regulates a temperature of a desired environment.

[0006] In some embodiments, a cooling device is provided. The cooling device can include an exterior flexible layer, a dried endothermic reactant, a storage space

configured to support a frozen liquid, and a liquid permeable layer separating the storage space from the dried endothermic reactant.

[0007] In some embodiments, an insulating system is provided. The insulating system can include at least one endothermic reactant separated from at least one solvent at a first temperature. However, at a second temperature the solvent and the at least one endothermic reactant are combinable.

[0008] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] **Figure 1** is a drawing depicting some embodiments of an insulating system.

[0010] **Figures 2A-2D** are drawings depicting some embodiments of arrangements for separating a reactant from a solvent in an insulating system.

[0011] **Figure 3** is a flowchart depicting some embodiments of a method for regulating the temperature of an environment.

[0012] **Figure 4** is a drawing depicting some embodiments of a fractured barrier.

[0013] **Figure 5** is a drawing depicting some embodiments of a process for producing a gas.

[0014] **Figure 6** is a drawing depicting some embodiments of a process for cooling and/or insulating a desired environment.

DETAILED DESCRIPTION

[0015] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be used, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily

understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0016] Provided herein are devices and methods applicable for regulating the temperature of an environment. In some embodiments, the devices and methods include a solvent that is separated from a reactant (such as an endothermic reactant) in a temperature dependent manner. A change in temperature thereby allows the solvent to interact with the reactant, which allows an endothermic (or other type of) reaction to occur, resulting in a lowering (or, if appropriate, an increase) of the local temperature. As noted below, there are numerous options for applying these and related concepts. In some embodiments, the temperature dependent manner of separation can include, for example, a barrier (for example, a separation wall or an encapsulation) between the solvent and the endothermic reactant. In some embodiments, the temperature dependent manner of separation can include, for example a state of the solvent itself (for example, a transition of the solvent from a solid or gel state to a liquid state). When the solvent contacts the endothermic reactant, solvation of the endothermic reactant (which can be a single reactant or a combination of two or more reactants) produces an endothermic reaction for a cooling effect. In some embodiments, the solvation reaction produces a gas and/or a foam. For the sake of brevity, many of the embodiments described herein employ the example of an endothermic reactant for reducing a temperature; however, unless otherwise specified, all of these embodiments can also be used in the reverse arrangement. In particular, these embodiments can also be employed for the creation of heat, via solvation of an exothermic reactant, in response to a decrease in temperature (for example, a decrease in temperature results in condensation of a solvent into a liquid form, which then solvates the exothermic reactant). In some embodiments, the formation of a gas and/or foam (or other expanded liquid or gel) can be done as part of the endothermic (or exothermic) reaction. Trapping of the gas can provide both a desired change in temperature, as well as an increased buffer zone for heat regulation. In other embodiments, the production of the gas is done separately from the endothermic reaction or in a non-endothermic manner. Thus, in some embodiments, the gas can be produced in response to a change in temperature, but the reaction that produces the gas, need not be

used to raise or lower the temperature. Instead, it can instead be used to inflate an insulation zone around an environment whose temperature is to be maintained. In some embodiments, these devices and methods can be used to keep a local temperature relatively constant, for example, to keep a local temperature relatively cool. In some embodiments, the methods and devices can be used to lower and/or raise the local temperature.

[0017] Figure 1 depicts some embodiments of an insulating system. In some embodiments, the insulating system **100** includes at least one solvent **110** and at least one endothermic reactant **120** separated from the solvent **110** in a temperature dependent manner such that an increase in temperature results in the solvent solvating the endothermic reactant.

[0018] As shown in Figure 1, in some embodiments, the solvent **110** and the endothermic reactant **120** are contained within a chamber **150** of the insulating system **100**. In some embodiments, the chamber **150** includes a first wall **160** and a second wall **170**. In some embodiments, the solvent and the endothermic reactant are positioned between the first wall **160** and the second wall **170**.

[0019] In some embodiments, the chamber **150** further includes a flexible layer **180**. In some embodiments, the flexible layer is the same layer as the second wall **170** (and thus only one of the structures need be present). In some embodiments, the flexible layer can be on the outside of the device (and thus the position of the flexible layer **180** and the second wall **170** can be swapped). In some embodiments, there need not be a flexible layer **180**. As detailed herein, the optional flexible layer allows for the accumulation of gas that can, optionally, be produced in the reaction. The expansion of the flexible layer, by the accumulated gas allows for the production of an insulating buffer, in those embodiments in which it is desired.

[0020] In some embodiments, the chamber **150** includes a volume that is configured to support a frozen liquid, such as a frozen solvent **110**. As shown in Figure 1, as long as the solvent **110** is frozen, any interaction between the solvent and reactant **120** can be minimized. In some embodiments, the two parts can further be separated by a liquid permeable layer **155**. In some embodiments, a single type of reactant **120** is present. In some embodiments, the reactant includes two or more reactants for the endothermic reaction. For example, in some embodiments, two reactants, which would interact in

solution to create an endothermic reaction, can be in a solid form (such as a crystallized form) and thereby only adequately mix with one another once solvated. As the arrangement allows for solvation of the two reactants together upon a change in temperature (for example, the melting of the water or the breaching of a barrier), the system allows for a dynamic method of regulating temperature, via the temperature dependent initiation of these reactions.

[0021] In some embodiments, the first wall **160** faces an internal volume **190** that is configured (and/or desired) to retain an object to be kept cool (or heated as appropriate). Thus, in some embodiments, an increase in temperature of the internal volume **190**, results in a melting of a frozen solvent **110**, which liquid solvent can then solvate the endothermic reactant **120**, resulting in an endothermic reaction. The endothermic reaction removes heat from the environment, lowering the temperature of the internal volume **190** as appropriate. Thus, in some embodiments, Figure 1 depicts a cooling container, where items to be cooled can be placed in the internal volume **190**.

[0022] In some embodiments, the second wall **170** faces an external environment. The first and second walls can be made of any number of materials. In some embodiments, the external wall **170** can be made from an insulating material to reduce heat penetration. In some embodiments, the internal wall **160** can be made of an insulating material to further reduce heat penetration. In some embodiments, the external wall **170** can be made of a heat conducting material, so that changes in an external environment have a larger influence on the likelihood of the reaction proceeding. In some embodiments, the internal wall **160** can be made of a heat conducting material, so that changes in an internal environment have a larger influence on the likelihood of the reaction proceeding. In some embodiments, the internal wall **160** can be made of a heat conducting material, so that the reaction will have a larger influence on the internal volume **190**.

[0023] In some embodiments, any heat conducting material can be employed. The heat conducting material can include, for example, metal, carbon and carbon derivatives (for example, carbon fibers, nanotubes), ceramics, thermally conductive polymers (e.g. polymers comprising metallic, carbon or mineral particles). Any insulating material can also be used for the walls or surfaces, and includes, without limitation, glass, ceramics, plastic, polymer composites, elastomers (for example, rubber), foams, wood, and/or paper.

[0024] In some embodiments, at least one of the first wall **160** and second wall **170** are made of an insulating material. In some embodiments, the first wall **160** is made of an insulating material. In some embodiments, the second wall **170** is made of an insulating material. In some embodiments, the first and second walls are made of substantially the same material. In some embodiments, the first and second walls are made of different materials.

[0025] While Figure 1 depicts some embodiments of how a solvent and reactant can be arranged to allow for a temperature dependent solvation of the reactant, other arrangements are also contemplated. For example, the endothermic reactant **120** can be separated from the solvent **110** by a barrier and/or a phase state of the solvent, as shown in Figures 2A-D.

[0026] In some embodiments, the solvent need not be frozen and/or undergo a phase transition. As depicted in Figure 2A and 2B, in some embodiments a barrier **210** can be positioned between the solvent and the reactant. In such embodiments, the presence or absence, or integrity, of the barrier **210** can instead control whether or not the reactant will be solvated by the solvent. Such an arrangement can allow one to control the solvation (and thus reaction timing and/or temperature range) by selecting a barrier that melts within the desired temperature range.

[0027] In some embodiments, the barrier **210** can be positioned vertically, as shown in Figure 2A, so that localized changes along a surface of a wall can result in a localized melting of the barrier and localized cooling of that area.

[0028] In some embodiments, the barrier can be positioned horizontally, as shown in Figure 2B. Such an arrangement can allow for a more binary result when adequate heating occurs. For example, removal (for example by melting) of the barrier **210** can allow for all of the solvent **110** to mix with all of the reactant **120**, resulting in a more complete reaction upon a breach in the barrier **210**. Of course, in some embodiments, not all of the barrier **210** need be removed for the reaction to occur. For example, in some embodiments, only the lower section of the barrier **210** in Figure 2A melts (or is meltable), so that the breach only occurs at the bottom. Such a localized breach can allow for a localized cooling. In some embodiments, such a localized breach can allow for a slower or more controlled reaction. For example, a barrier that can only be breach at its bottom (for Figure 2A), will take more time to solvate the reactants **120**.

[0029] In some embodiments, the barrier need not separate various chambers or subparts of a chamber. For example, in some embodiments, the barrier **250** can encapsulate the endothermic reactant **120** such that it separates the endothermic reactant from the solvent **110**, as shown in Figure 2C. Such an arrangement can allow for an even more prolonged and/or controlled reaction. For example, such an arrangement allows for greater distribution of a barrier along a surface of the walls of the chamber **150**, so that localized changes in temperature on either side of the chamber can influence a barrier layer **250**, and thus, if appropriate, melt the barrier layer to allow for a localized reaction. Furthermore, such localized reactions can be relatively localized, as they occur in discrete units (as each encapsulated reactant is breached a reaction can occur). Furthermore, by controlling the size of the encapsulated reactants, one can control the amount of reactant that is going to be solvated upon the breach of the barrier **250**. Furthermore, as numerous encapsulated reactants **120** can be used, and as various barriers **250** can be used on each of the reactants, these items (type of reactant and type of barrier) can be varied so that the temperature sensitivity of the various barriers provides a wide spectrum of melting properties, and/or the effectiveness of the resulting endothermic reaction. Similarly, the thickness of the barriers **250** can be varied within a population as well, so that some barriers will be breached at lower temperatures and other barriers will be breached at higher temperatures, providing a greater range of options for controlling when and under what conditions the reactants will react.

[0030] While Figures 2A-2C depict embodiments in which a barrier is used and the breach of the barrier results in the onset of the reaction (via the mixing of the solvent with a reactant), a barrier is not required in all embodiments. In some embodiments, the solvent is in a state such that it is effectively separated from the endothermic reactant. For example, in some embodiments, the at least one endothermic reactant is separated from the solvent by the solvent **110** being contained as a solid or gel form, as shown in Figure 2D. Thus, no barrier is required in all embodiments. For example, in some embodiments, the temperature dependent manner comprises an arrangement in which the solvent is in a contained state (such as a solid or gel state) below a temperature threshold, and the solvent is in an uncontained state (such as a liquid) above the temperature threshold. In some embodiments, the solvent is separated from the endothermic reactant by being in contained state in addition to a barrier.

[0031] In some embodiments, one or more of the embodiments shown in Figures 1, 2A, 2B, 2C, and 2D can be combined for further control and/or refinement of the temperature responsiveness of the system or method. For example, a system can include a frozen solvent **110** with reactants **120**, separated as shown in Figure 2D, where the solvent melts and mixes with the reactants at 5 degrees Centigrade, and can further include a mixed population of encapsulated reactants with the barrier **250**, some of which melt at 20 degrees and others of which melts at 30 degrees. The system can further include, for example, an additional barrier **210**, separating the chamber from a final amount of reactant **120**. This additional barrier can have a transition point of 50 degrees. Thus, as the system experiences heat, first the solvent will melt and mix with the open reactant (as shown in 2D) to result in an endothermic reaction and a lowering of the temperature. Then if the system then experiences even more heat, the barriers **250** will melt at 20 and then 30 degrees to provide a second and third round of cooling (as shown in Figure 2C). Finally, if the system then experiences yet another round of heating (that exceeds 50 degrees), the barrier **210** can be breached and a final round of cooling, via the final amount of reactant **120**, can be provided.

[0032] As noted above, in some embodiments, the barrier is a temperature dependent material. In particular, the state and/or integrity of the barrier changes in response to a change in temperature, such that the barrier can be effectively breached upon a change in temperature. In some embodiment, the temperature dependent material is in a first state (for example, solid) at a first temperature and in a second state (for example liquid) at a second temperature. The temperature dependent material can also be in a contained state (such as a solid state) at a first temperature and an uncontained state at a second temperature. In some embodiments, the solvent itself is the item that is in a contained versus uncontained state. In some embodiments, the temperature dependent material is effectively impermeable to the solvent at a first temperature, but effectively permeable to the solvent at a second temperature. For example, in some embodiments, the temperature dependent material is in a solid state at a first temperature such that the solvent is separated from the endothermic reactant. However, the temperature dependent material is not in a solid state at a second temperature, thereby allowing the solvent to permeate the barrier, and/or or pass through the area where the barrier was, to then solvate the endothermic reactant. Thus, in some embodiments, the temperature dependent

material includes a barrier that changes its phase from solid to liquid at a desired and/or predetermined temperature. In some embodiments, the temperature dependent barrier is in the form of a horizontal or vertical wall between the solvent and the endothermic reactant (see, for example, Figures 2A-2B). In some embodiments, the temperature dependent barrier encapsulates the endothermic reactant (see, for example, Figure 2C). In some embodiments, the temperature dependent material encapsulates the at least one endothermic reactant in a temperature dependent coating. In some embodiments, the temperature dependent coating is suspended in the solvent.

[0033] The barrier can have any thickness, which can depend upon the desired properties of the system and/or method. In some embodiments, the barrier has a thickness of about 0.000001 mm to about 100 mm, for example, a thickness of about 0.000001, 0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, or 100 mm, including any range between any two of the proceeding values. It will be appreciated that in some embodiments the thickness of the barrier can impact certain properties of the system. For example, the thickness of the barrier can affect a rate of contact of the solvent and the endothermic reactant and thus a rate of cooling. As noted above, in some embodiments, the thickness of the barrier can vary so that different sections and/or barriers are breached at different times and/or temperatures.

[0034] In some embodiments, the temperature dependent material can include any suitable material capable of changing states (or simply being breakable) due to a change in temperature. In some embodiments, the temperature dependent material includes at least one of a wax, a polymer of desired transition point, or a shape memory polymer. In some embodiments, the barrier includes a wax. In some embodiments, the wax includes a paraffin wax. In some embodiments, the barrier includes a polymer blend to set particular transition points by altering molecular weight and distributions. In some embodiments, any of the materials provided can have a specific transition point modified through the use of additives or by varying composition (for example with paraffin the composition of long chain/short chain hydrocarbons dictates the melting point).

[0035] Depending upon the application, the temperature dependent material can have a transition point at any desired and/or predetermined value and/or range. In some embodiments, the temperature dependent material transitions and/or breaches in a range between about -100 °C to 500 °C, for example, a temperature of about -100, -50, -

10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 50, 100, 200, 300, 400, or 500 °C, including any range between any two of the preceding values or any range above any one of the preceding values. In some embodiments, the temperature dependent material transitions and/or breaches in a range between about 0 °C and about 20 °C for example, a temperature of about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 °C, including any range between any two of the preceding values, or any range above any one of the preceding values.

[0036] As mentioned above, in some embodiments, one or more barriers and/or parts of a single barrier can have different transition points, so as to allow multiple rounds and/or differential sensitivity to varying temperature fluctuations. Thus, in some embodiments, a method and/or barrier, and/or system can include 2, 3, 4, 5, 6, 7, 8, 9, 10 or more different temperature dependent materials (or additives to alter the transition point of the barrier), including any range defined between any two of the preceding values and any range above any one of the preceding values. In some embodiments, the combination of temperature dependent materials and/or barriers and/or thicknesses of the barriers is selected so as to allow for a more effective range of temperature control. Thus, in some embodiments, a first temperature dependent material has a first transition point at a first temperature, a second temperature dependent material has a second transition point at a second temperature, and a third temperature dependent material has a third transition point at a third temperature, etc. In some embodiments, the various temperature dependent materials have transition points at different, but overlapping ranges, for example -10 °C to 0 °C, -5 °C to 10 °C, and 5 °C to 20 °C. In some embodiments, the various temperature dependent materials have transition points at non-overlapping ranges, for example -20 °C to -10 °C, 0 °C to 5 °C, and 10 °C to 15 °C.

[0037] In some embodiments, the transition temperature of the temperature dependent material can be adjusted to a desired temperature by the use of additives to the material. For example, in some embodiments the alkane molecular mass composition distribution of the temperature dependent material can be altered. For example, the greater the proportion of high molecular weight alkanes, the higher the transition point.

[0038] As used herein, the “transition” point or temperature refers to the temperature at which the barrier is breached due to a change in temperature. This can

include, for example, a full melting of the barrier, or a localized softening of the barrier that results in a breach of the barrier. Thus, a barrier will have a transition point or temperature at the temperature at which a breach occurs. As will be appreciated by one of skill in the art, this can be expressed as a range of temperatures. In addition, additional environmental aspects can assist in determining the temperature at which a breach will occur. For example, in an embodiment as depicted in Figure 2B, the weight of the solvent **110** can apply a downward force to the barrier **210**, such that a breach can occur in the barrier **210** at a lower temperature than a breach for the encapsulated particles in Figure 2C.

[0039] In some embodiments, the barrier is fracturable or rupturable. In some embodiments, the barrier is already fractured or ruptured. In some embodiments, the barrier includes one or more holes or pores. In some embodiments, the barrier need not be made of a temperature dependent material, and can serve as a sieving device or general separating barrier, that can allow fluid to pass through but block or reduce the passage of, for example, a larger body of frozen solvent. Thus, in some embodiments, the barrier can be made of a temperature dependent material, but in other embodiments the barrier need not be made of a temperature dependent material. In some embodiments, a sieved barrier can be employed (that is not made from a temperature dependent material). In some embodiments, the sieved barrier is in the form of a horizontal or vertical wall between the solvent and the endothermic reactant (see, for example, Figure 1). A sieved barrier includes a fracturable or rupturable barrier, as well as such barriers that have already been fractured or ruptured. An “intact” fracturable layer denotes that the layer has not yet been fractured and can be impermeable to solvents. A “fractured” or “breached” fracturable layer denotes that the layer is now permeable to solvent. In some embodiments, the fracturable barrier fractures or ruptures when the solvent changes state from a first state to a second state. For example, in some embodiments, the fracturable barrier ruptures when the solvent changes from a liquid to a solid (upon the freezing of the solvent). Thus, in some embodiments, one can start with a solvent impermeable layer (that is fracturable upon freezing of the solvent), freeze the solvent, and thereby produce an arrangement such that subsequent thawing of the solvent allows the solvent to pass through the fractured (and previously impermeable) layer and solvate the endothermic reactant. Thus, in some

embodiments, the fracturable or rupturable layer is initially a solvent impermeable layer or seal.

[0040] The fracturable layer can have any thickness. In some embodiments, the thickness of the layer is determined by a desired mechanical property. In some embodiments, the fracturable layer is a thin film of relatively low strength and/or low flexibility (to allow for ease of fracturing upon freezing or other physical manipulation). In some embodiments, the wall has a thickness of about 0.000001 mm to about 100 mm, for example, a thickness of about 0.000001, 0.00001, 0.0001, 0.001, 0.01, 0.1 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, or 100 mm, including any range between any two of the proceeding values.

[0041] In some embodiments, the fracturable layer can include any suitable material capable of being fractured. In some embodiments, the fracturable layer includes a brittle polymer and/or a rupturable mechanical seal. In some embodiments, the fracturable layer includes a brittle polymer or a rupturable mechanical seal. In some embodiments, the brittle polymer includes at least one of polystyrene (PS), Polymethylmethacrylate (PMMA), embrittled phenolic resin. In some embodiments, the rupturable mechanical seal includes at least one of a non-brittle polymer, polyethylene (PE), polypropylene (PP), linear low-density polyethylene (LLPE), cellophane, polyethylene terephthalate (PET), or nylon. In some embodiments, the brittle polymer includes at least one of polystyrene, Polymethylmethacrylate (PMMA), embrittled phenolic resin, and the rupturable mechanical seal includes at least one of a non-brittle polymer, PE, PP, LLPE, cellophane, PET, or nylon.

[0042] In some embodiments, the barrier includes a material that is different from a material that makes up the solvent. Thus, the barrier is truly a separate structure from the solvent (be the solvent in liquid, gel, or solid form). In some embodiments, the barrier aspect can be provided by the state of the solvent. For example, the solvent can be frozen, and thus a barrier can be effectively provided by a difference in state between the solid solvent and a liquid solvent. In some embodiments, even when the solvent is frozen, a separate barrier structure can be provided. In some embodiments, the barrier can be made of metal, plastic, wood, ceramic, and/or carbon-fiber.

[0043] In some embodiments, the chamber 150 is part of or is positioned proximally to a storage space 190, in which one can place an item whose temperature is to be regulated. In some embodiments, one or more wall or internal surface of the storage

space can be defined by the barrier and the first wall or second wall (see, for example, Figures 1, 2A, 2B, 2C, or 2D). In some embodiments, the storage space 190 is defined by the first wall 160, the second wall 170, and/or the layer 155 (see, for example, Figure 1). In some embodiments, the storage space is defined by the first wall and the second wall (see, for example, Figure 2D). In some embodiments, the whole chamber 150 serves as a wall or surface of the storage space. In some embodiments, the chamber 150 is placed as a standalone structure, separate from the walls of the storage space, but positioned within the storage space. In some embodiments, the chamber 150 can be an internal surface of the storage space, such that it is immediately adjacent to the item to be stored. In other embodiments, the chamber 150 can be placed on an external surface of the storage space, such that any heat from an external environment must first pass through the chamber 150, before impacting the structure of the storage space.

[0044] As noted above, in some embodiments, the second wall **170** is flexible or deformable (and thus, can be the same structure as the flexible layer **180** (Figure 1)). In some embodiments, the second wall **170** is deformable by a gas that is generated by the solvation of the endothermic reactant and the solvent. Such an arrangement allows for the generated gas to inflate the deformable layer and provide an additional volume of air between one side of the chamber **150** and the other. In some embodiments, the second wall is flexible, but there is still a separate flexible layer **180**. Such an arrangement allows for one type of material to be used to capture the gas, while another type of material can be used to provide structure or protection to the chamber **150**.

[0045] In some embodiments, the second wall **170** is rigid. In some embodiments, the second wall **170** is not flexible or deformable. For example, in some embodiments, the second wall **170** is not deformable under pressure generated by solvation of the at least one endothermic reactant by the solvent. In some embodiments, any gas produced can still be trapped, but will not result in deformation of the walls. In some embodiments, any gas produced can be released through a valve. In some embodiments, the second wall 170 can be rigid, even when a flexible layer 180 is used. In such an embodiment, the flexible layer may only inflate into any space between the flexible layer 180 and the second wall 170.

[0046] The second wall **170** can have any desired shape. In some embodiments, the second wall **170** is curved. In embodiments where the second wall is

deformable, the shape of the second wall **170** can be defined by a pressure, such as an outward pressure, generated by the solvation of the reactant and the solvent. For example, in some embodiments, the shape of the second wall **170** is defined by an outward pressure generated between the first wall **160** and second wall **170**.

[0047] In some embodiments, a cooling device is provided. In some embodiments, the cooling device includes an exterior flexible layer, a dried endothermic reactant, a section of a chamber configured to support a frozen liquid, and a liquid permeable layer separating the section of the chamber from the dried endothermic reactant.

[0048] In some embodiments, the solvent solvates the endothermic reactant to elicit an endothermic effect or reaction. In some embodiments, the endothermic reaction absorbs energy from its surroundings in the form of heat. In some embodiments, the heat absorbed during the chemical reaction results in a decrease in temperature (or cooling) of the surroundings.

[0049] It will be appreciated that at low temperatures endothermic reactions proceed at a limited rate and the rate of the endothermic reaction can increase substantially with increasing temperature. In some embodiments, the cooling effect of the endothermic reaction effectively ceases the endothermic reaction with time. Accordingly, in some embodiments, the insulating system can be self-limiting or self-regulating. In some embodiments, the endothermic reaction consumes the available endothermic reactants (for example, the endothermic reactants that can interact with the solvent) as required by the reaction resulting in a lowered temperature of the surroundings. In some embodiments, the lowered temperature of the surroundings solidifies the solvent and/or the temperature dependent barrier thereby ceasing the endothermic reaction. For example, in some embodiments, the lowered temperature of the surroundings lowers the temperature of the solvent such that the solvent freezes, refreezes, or solidifies thereby separating the solvent from interacting with the endothermic reactants. In some embodiments, the lowered temperature of the surroundings re-solidifies the temperature dependent material thereby re-separating the solvent from interacting with the endothermic reactants. In some embodiments, the decrease in temperature simply reduces the rate of any further endothermic reaction, as the barriers and/or frozen solvent do not continue to melt (or melt as quickly).

[0050] In some embodiments, a gas producing insulating system is provided. In some embodiments, the gas produced by the reaction enhances the insulating and/or cooling properties of the systems described herein.

[0051] In some embodiments, a gas retaining enclosure is provided. The gas retaining enclosure includes at least one gas producing reactant separated from at least one solvent in a temperature dependent manner, such that an increase in temperature results in the solvent solvating the at least one gas producing reactant. In such embodiments, even though the production of the gas can occur in response to a change in temperature, the production of the gas itself need not change the temperature. Instead, the gas produced can be used to inflate a flexible layer so as to further buffer one area from an external source of heat (or cold). Thus, in some embodiments, the methods or systems provide insulating aspects, rather than having to also supply heating or cooling responses. Of course, in some embodiments, both aspects can be provided (for example, both insulating and cooling).

[0052] As noted above, in some embodiments, the insulating system **100** is configured to produce at least one gas by the solvation of the endothermic reactant. Thus, any of the embodiments described herein can include an expandable layer **180**. In some embodiments, the expandable layer **180** is configured to expand by production of the at least one gas. In some embodiments, the expandable layer **180** is a flexible wall. In some embodiments, the flexible wall expands upon the solvent solvating the at least one gas producing reactant. In some embodiments, the flexible layer can include a polymer, such as LDPE, polypropylene, PVC, nylons, and/or polyesters.

[0053] In some embodiments, the chamber **150** is sealed. For example, in some embodiments, the chamber is sealed such that the solvent, the endothermic reactant, and the solvated endothermic reactant are confined to the insulating system; however, the seal need not be gas tight. In some embodiments, the chamber is sealed such that the gas is confined to the insulating system, and thus, the chamber can be gas tight.

[0054] In some embodiments, the chamber **150** further includes at least one pressure valve (not shown) configured to release gas from inside of the chamber **150** to an exterior volume of gas. In some embodiments, the valve is embedded within the second or exterior wall. Any suitable pressure valve can be used. For example, the pressure valve can be any valve that regulates, directs, or controls the flow of any fluid from the

insulation system by opening, closing, or partially obstructing various passageways. In some embodiments, the pressure valve is a one way pressure valve. In some embodiments, the pressure valve is a relief valve.

[0055] In some embodiments, the gas produced can be at least partially or substantially vented or released from the gas producing insulating system. For example, in some embodiments, the pressure valve can release gas at any pressure above atmospheric thereby substantially venting the gas from the system. In some embodiments, the pressure valve can release gas at a set pressure (for example, higher than atmospheric to allow the retention of a portion of insulating gas) as desired.

[0056] In some embodiments, the gas produced can be at least partially or substantially vented or released from the gas producing insulating system by use of distending porosity. For example, in some embodiments, the flexible layer can include perforations. The flexible layer including perforations can be largely impermeable to gas under low internal pressure and expanded under pressure from produced gas. In some embodiments, as the flexible layer expands, the flexible layer becomes increasingly porous and/or permeable.

[0057] In some embodiments, rather than a gas being produced to add volume around a space to be cooled, in some embodiments a suspension and/or foam can be produced, thereby providing an insulating system that is responsive to a change in temperature. In some embodiments, any of the gas producing reactants provided herein can be used to form a suspension. Like the gas embodiments provided herein, the suspension can create added volume around a storage area, and thereby further isolate the storage area from an external environment. The mixture of the solvent and the reactant can be controlled in any of the temperature dependent manners provided herein. Thus, for example, a barrier can be melted by an increase in temperature, or a solvent can be melted by an increase in temperature. This allows the gas producing reactant to mix with the solvent and produce an emulsion involving the solvent, the reactant, and optionally, any other desired materials. In some embodiments, the emulsion can include the melted temperature dependent. In some embodiments, the gas producing reactant can be an endothermic reactant which can react with the solvent in an endothermic reaction to chemically remove heat from the surroundings and produce gas. The gas from the reaction causes the emulsion to expand as the endothermic reaction continues. In some

embodiments, as the endothermic reaction cools the surroundings, the expanded temperature dependent material transitions back to a first state (such as a solid or gel state). Thus, rather than merely having a pillow of air for added insulation, when a suspension embodiment is employed, one can be left with an inflated (or even uninflated) framework of the solidified emulsification product. Thus, in some embodiments, the transition temperature of the temperature dependent material can be set so that the temperature dependent material will re-solidify as soon as the temperature begins to decrease (in the case of an endothermic reactant). For example, in some embodiments, the suspension exists as a rigid solid-solid suspension if below 0 °C and as a gel-like suspension if above 0 °C.

[0058] In some embodiments, the suspension can sequester heat chemically and/or physically at a selected temperature. For example, in some embodiments, the suspension is a high viscosity suspension that sequesters a large volume of heat. In some embodiments, the natural reaction rate provides a scaled thermal response.

[0059] As evident from the disclosure herein, any suspension producing embodiment described herein can be used in combination with any gas producing embodiment described herein. For example, in some embodiments, the suspension producing insulating system includes one or more gas venting systems as described herein, such as a pressure valve and/or a perforation system.

[0060] In some embodiments, the at least one endothermic reactant 120 can include any reactant capable of reacting with the at least one solvent 110 to elicit an endothermic effect. In some embodiments, the endothermic reactant is a gas producing reactant. In some embodiments, the gas can be produced via an endothermic reaction. In some embodiments, the gas producing reaction need not be endothermic. Unless otherwise specified, the term “reactant” encompasses both a single reactant, which results in an appropriate reaction when solvated, as well as a combination of two or more reactants, both of which are required for the reaction to occur. The term “component reactant” denotes that at least two reactants are required for the relevant reaction, there being a first “component reactant” that reacts with at least a second “component reactant”.

[0061] In some embodiments, the endothermic reactant includes at least one of carbonate, urea, potassium nitrate, ammonium nitrate, potassium sulfate, ammonium chloride, potassium chloride, sodium carbonate, calcium carbonate, magnesium carbonate,

or a bicarbonate. In embodiments in which gas production is not desired, urea, potassium nitrate, ammonium nitrate, potassium sulphate, ammonium chloride, and/or potassium chloride can be employed (by way of example).

[0062] The endothermic reactant can be in any desired state. In some embodiments, the endothermic reactant is a dried endothermic reactant. In some embodiments, two or more endothermic reactant components are provided as the endothermic reactant, which when solvated, result in an endothermic reaction. For example, there can be 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 or more components which when combined and/or are solvated, result in an endothermic reaction (or, if desired, an exothermic reaction). In some embodiments, the endothermic reactant can be a powder. In some embodiments, the endothermic reactant can be crystalline. In some embodiments, the endothermic reactant can be a liquid. In some embodiments, the endothermic reactant can be frozen. In some embodiments, the endothermic reactant can be a gel. In some embodiments, endothermic reactant components are each separated from one another. Thus, when two or more components are used, each component can be separated from one another. The components can be separated in any number of ways, for example, spatially (whereby they come together upon the presence of, for example, a solvent in the area). The components can be separated by a barrier as well. Thus, for example, as shown in Figure 2C, the barrier **250** can surround the reactant **120**, but the various circular particles depicted can contain different component reactants, which when combined, provide an appropriate reaction (for example, an endothermic, an exothermic, and/or a gas producing reaction).

[0063] In some embodiments, the endothermic reaction can be a carboxylic acid-carbonate reaction. Such embodiments are endothermic, can absorb large quantities of heat, and/or can produce gas. In some embodiments, the reaction (and/or reactant) includes at least one of bicarbonate, citric acid, acetic acid, propanoic acid, tartaric acid with at least one of sodium carbonate or calcium carbonate. In some embodiments, stronger acids can be used. In some embodiments, bicarbonates can be used.

[0064] In some embodiments, the system and/or method further includes a surfactant. In some embodiments, the surfactant can be incorporated into or around the temperature dependent barrier. For example, in some embodiments, the surfactant can be incorporated into or around the barrier encapsulating the endothermic reactant. The

surfactant can reduce hydrophobicity within the encapsulated endothermic reactant thereby encouraging the release of the endothermic reactant when released. The particular surfactant can be selected based upon the particular reactants used.

[0065] In some embodiments, for example where an exothermic reaction is desired, one can employ the appropriate exothermic reactants. This can include, for example, an exothermic hydration of reagent (for example, water and calcium oxide), an exothermic solvation, an acid-base neutralization, a corrosion (for example, $\text{Fe} \rightarrow \text{Fe (III)}$), and/or a metal redox reactions (for example, magnesium and water).

[0066] A variety of solvents can be employed. In some embodiments, the solvent reacts directly with the reactant (and/or the solvent is part of the reactant). Thus, in some embodiments, the at least one solvent 110 can include any solvent capable of reacting with the at least one endothermic reactant 120 to elicit an endothermic effect (or, if appropriate, an exothermic effect and/or gas production). In some embodiments, this can be achieved by having part of the reaction already solvated in the solvent. In other embodiments, the solvent can simply allow for the combination of two or more components in the reaction. For example, in some embodiments, the reactant includes two components, but when the components are in a solid form, they are relatively inert, thus, the solvent serves to convert the inert solid form to a more reactive solvated form. In some embodiments, the solvent allows for the two or more components of the reactant to be brought together. For example, as shown in Figure 2C, individual barriers 250 can surround two or more components of the endothermic reactants 120. By being in a solvent, once the barrier 250 is breached, the endothermic reactants 120 will be solvated, and the endothermic reactant components more effectively mixed with one another. In some embodiments, the solvent allows for the production of gas when combined with the reactant. As noted above, the solvent can either be part of the reaction itself, or simply act as a carrier for combining the gas producing reactants.

[0067] In some embodiments, the solvent includes any suitable material that can transition to and/or from a substantially solid form, such as frozen or gel form to a liquid. In some embodiments, the solvent includes any material that can transition from a solid state to a liquid state at a predetermined and/or selected temperature. In some embodiments, the solvent is in a liquid state at room temperature. In some embodiments, the solvent is in a solid state at room temperature. In some embodiments, the solvent is in

a slurry state. In some embodiments, the solvent is solid at a temperature of less than 100, 90, 80, 70, 60, 50, 40, 30, 20, 10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90, or -100 degrees Centigrade. In some embodiments, the solvent is liquid at a temperature of more than 100, 90, 80, 70, 60, 50, 40, 30, 20, 10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90, or -100 degrees Centigrade.

[0068] In some embodiments, the solvent includes at least one of water, or an acid, such as citric acid, acetic acid, propanoic acid, succinic acid, formic acid, fumaric acid, lactic acid or tartaric acid. As noted herein, in some embodiments, the solvent can be converted from a gas to a liquid, such as by condensation, to allow for embodiments in which exothermic reactions can be used to maintain an elevated temperature.

[0069] In some embodiments, the solvent includes a dissolved first reactant (such as a first reactant component) which is separated from a second reactant (such as a second reactant component) in a temperature dependent manner. For example, in some embodiments, the first reactant is a carbonate and the second reactant is a dry acid. In some embodiments, the reactant can also be dissolved in the solvent for reaction with a dry acid upon the thawing and/or barrier being breached.

[0070] In some embodiments, the solvent includes water and the endothermic reactant includes dry powered acid and dry powered carbonate.

[0071] In some embodiments, solvation of the endothermic reactant produces at least one gas.

[0072] In some embodiments, the insulating systems provided herein can be employed in and/or as part of a container. For example, in some embodiments, the insulating system is part of a container, wherein the at least one endothermic reactant and the solvent are located between an outer wall of the container and an inner wall of the container, and wherein the inner wall defines at least part of an inner volume of the container. In some embodiments, any of the embodiments provided herein can be part of and/or included in a container so that the effectiveness of the endothermic reaction, gas producing reaction, and/or exothermic reaction can be associated and/or directed to a specific volume and/or item. The volume can be defined by the container itself (for example, the interior of an ice chest).

[0073] In some embodiments, the container further includes a lid configured to reversibly seal the inner volume of the container.

[0074] In some embodiments, the embodiments provided herein are part of a cold pack, a film, or an insulating barrier layer. In some embodiments, the container is a thermos, an ice chest, a drink sleeve, a shipping carton, a pharmaceutical container, food packaging, a rigid container, a bag, a sleeve, a wrapping, and/or an envelope. In some embodiments, the chamber **150**, as depicted in any one or more of Figures 1-2D, can be positioned within a wall of the container. In some embodiments, the chamber **150** can be separate from the wall of the container (for example, a protrusion from the inside of the chamber). In some embodiments, the chamber **150** can be an independent structure, which can be placed into or around the container.

[0075] In some embodiments, any of the containers or other systems or devices that include a chamber and/or temperature sensitive barrier or other arrangement provided herein can include multiple such arrangements. Thus, a device can include several discrete systems along one surface. Thus, in some embodiments, one or more of the systems can effectively be arranged in parallel. In some embodiments, one or more of the systems can be arranged in series. Thus, going outward from an inner chamber, there can be a first, second, third, fourth, etc., system, such that each one can, react, serially to a change in temperature. In such embodiments, repeated cycles of heating and/or cooling can thereby still be blunted by the system. For example, once the outer most system has been expended, the inner most system can still have its temperature sensitive barriers intact and still respond to changes in temperature.

[0076] In some embodiments, a liquid impermeable layer separates the storage space of the container from the endothermic reactant **120**. In some embodiments, the reactants and/or solvent can be placed within the storage volume of the container itself. In such embodiments, the reaction may be more efficient in absorbing heat from the contents of the container; however, an additional barrier between the solvent and the item to be stored can be desired. Thus, in some embodiments, the barrier encased reactant can be added to any container, along with, for example, ice, and the melting of the ice, along with the melting of breaching of the barrier, can allow for the endothermic reaction (or other reaction) to occur in a temperature dependent manner.

[0077] Figure 3 depicts some embodiments of a method for regulating a temperature of a desired environment (**300**).

[0078] Any of the various devices and components provided herein can be employed for a variety of methods. As outlined in Figure 3, in some embodiments, the method for regulating a temperature of a desired environment includes providing at least one solvent (block **310**) and providing at least one endothermic reactant (block **320**). In some embodiments, the solvent is separated from the endothermic reactant. In some embodiments, the method can then include solvating the endothermic reactant (block **330**). In some embodiments, this is achieved by a change in state of at least one of the solvent and/or a breaching of a barrier (if present) that is separating the solvent from the endothermic reactant in response to an increase in temperature. In some embodiments, the change in state of the solvent and/or integrity of the barrier allows an endothermic reaction to occur thereby regulating a temperature of a desired environment.

[0079] One skilled in the art will appreciate that, for this and other processes and methods disclosed herein, the functions performed in the processes and methods may be implemented in differing order. Furthermore, the outlined steps and operations are only provided as examples, and some of the steps and operations may be optional, combined into fewer steps and operations, or expanded into additional steps and operations without detracting from the essence of the disclosed embodiments.

[0080] In some embodiments, the method further (or alternatively) includes a process for producing a gas using a gas producing reactant (which can be endothermic or exothermic). As noted above the method for regulating a temperature of a desired environment can include providing at least one solvent and providing at least one gas producing reactant (which produces a gas when solvated and/or solvated with another reactant). In some embodiments, the solvent is separated from the reactant initially, but upon solvation, a gas is produced. As described herein, the gas can be captured and used to inflate a volume of space, which can serve as further insulation. In some embodiments, solvation is achieved by a change in state of at least one of the solvent and/or a breaching of a barrier (if present) that is separating the solvent from the reactant in response to an increase in temperature.

[0081] In some embodiments, the method further (or alternatively) includes a process for increasing a local temperature in response to a decrease in temperature. As noted above the method for regulating a temperature of a desired environment can include providing at least one solvent and providing at least one exothermic reactant (which

releases heat when solvated and/or solvated with another reactant). In some embodiments, the solvent is separated from the reactant initially, but upon solvation, an exothermic reaction is achieved, thereby raising the local temperature. In some embodiments, this can be achieved by providing two dried reactants, which when combined and solvated, result in an exothermic reaction. Temperature dependent solvation can occur in any number of ways, for example, by having a high humidity volume of gas, which will condense upon a surface when the surface is cooled beneath a desired point. The droplets of condensation can then solvate the reactants and allow for an exothermic reaction. The resulting increase in temperature can raise the temperature of the surface, thereby removing the condensation and stopping the reaction.

[0082] In some embodiments, the method further includes providing a layer between the solvent (whether it be in liquid or frozen form) and the at least one endothermic reactant. In some embodiments, the layer is a barrier as described herein. In some embodiments, the barrier can be liquid permeable. In some embodiments, the barrier is solvent impermeable. In some embodiments, the barrier is a temperature dependent barrier, which can be breached (sufficiently to allow a solvent to pass through) upon a change in temperature.

[0083] In some embodiments, the barrier separates the solvent from the at least one endothermic reactant when the barrier is in a solid or unbreached state. In some embodiments, the barrier can start off within the device or system in a solvent impermeable state and then be changed to a fractured state. In some embodiments, the barrier starts off as a solvent impermeable barrier but transitions to a liquid state to allow the solvent to solvate the endothermic reactant.

[0084] In some embodiments, the method includes a process where a temperature dependent barrier transitions due to a change in temperature to allow the solvent to solvate the endothermic reactant. For example, in some embodiments, the temperature dependent barrier at least partially transitions to a liquid state to allow the solvent to solvate the at least one endothermic reactant. In some embodiments, the temperature dependent barrier completely transitions to a liquid state to allow the solvent to solvate the at least one endothermic reactant. In some embodiments, the method only involves a breach of the barrier, sufficient to allow the solvent to enter and the reaction to proceed, or the reactant to leave and be solvated by the solvent. In some embodiment, less

than 100 percent of the barrier melts or transitions from the solid state, for example, less than about 90, 80, 70, 60, 50, 40, 30, 20, 10, 5, 1, 0.1, 0.01, 0.001 percent, or less of the barrier transitions from the solid state. As noted herein, in some embodiments, a temperature dependent barrier need not be employed.

[0085] In some embodiments, the at least one endothermic reactant is separated from the at least one solvent at a first temperature, but at a second temperature the solvent and the at least one endothermic reactant are combined or are combinable. In some embodiments, the first temperature is lower than the second temperature. In some embodiments, the at least one solvent does significantly not solvate the endothermic reactant at the first temperature. In some embodiments, the at least one solvent does significantly solvate the endothermic reactant at the second temperature.

[0086] As will be appreciated by one of skill in the art, there are a number of ways of making and/or combining the various systems and/or devices provided herein. In some embodiments, the method includes maintaining a suspension of the various ingredients at a temperature below the transition temperature of the temperature dependent material (or encapsulating cover) during manufacturing. Thus, any arrangement that allows for one to keep the barrier intact, where commencement of the reaction occurs upon breach of the barrier, can be employed.

[0087] In some embodiments, a liquid permeable layer **155** can be employed. In some embodiments, these arrangements can be created by combining the parts in any order (where the solvent is kept from solvating the reactants, for example by keeping the solvent frozen, or otherwise separated from the reactants). However, in some embodiments, the creation of the liquid permeable layer can be achieved via the manufacture of the system itself. As shown in **Figure 4**, in some embodiments, the process for creating a liquid permeable layer occurs via the freezing of a solvent **110**. In some embodiments, the process includes providing a barrier **210** (though it need not be temperature dependent, merely solvent impermeable) between the solvent **110** and the at least one endothermic reactant **120** (left hand side of Figure 4). This arrangement can then be chilled to freezing, resulting in (for the case of water) the fracturing the layer by freezing the solvent to form a fractured layer or liquid permeable layer **155**. Thus, in some embodiments, the process uses an ice pressure ruptured wall to separate reaction initiating water from dry powdered acid and carbonate reactants. In such embodiments, the system

will result in an endothermic reaction upon the thawing of the frozen solvent. Thus, in some embodiments, the system should be kept at a temperature below the melting point of the solvent (for example, 0°C). In some embodiments, the fracturable barrier (separating wall) takes the form of a thin film of low strength, low flexibility polymer (for example, polystyrene) which is intact and water impermeable during the manufacture of the packaging (containing water is in the liquid phase), but is ruptured by pressure from volume expansion of ice formation during freezing once in use. It will be appreciated that water expands between 8 and 11% on freezing, producing substantial pressure, which is sufficient to rupture a fragile barrier layer when the barrier (internal wall) is rigid. In some embodiments, the freezing of the device is a process in manufacture of the device.

[0088] In some embodiments, when the frozen device is removed from refrigeration and begins to thaw, the frozen solvent (for example, ice) contained within the device melts and mixes with the endothermic reactants through the now permeable layer 155, allowing the endothermic reaction to commence, providing a substantial compensatory cooling effect at a rate appropriate to external conditions.

[0089] In some embodiments, the assembly of the system is performed at a temperature beneath that of the transition point of the barrier and/or the melting of the solvent. In some embodiments, the reactants are spray coated with a solution and/or melted form of the barrier, and allowed to cool. In some embodiments, the reactants are dipped into a solution and/or melted form of the barrier and allowed to cool.

[0090] Figure 5 is a schematic depicting some embodiments of a process for producing a gas in the insulating system. In some embodiments, the process includes providing a gas producing endothermic reactant. In some embodiments, the process includes forming a gas upon solvation of the at least one endothermic reactant. For example, in some embodiments, a substantial volume of CO₂ is produced when an acid-carbonate reaction is used.

[0091] As shown in Figure 5, some gas producing systems 500 include a solvent 110, a reactant 120, an optional barrier 210 (which can be a temperature dependent barrier or a permeable layer), an optional gas permeable layer 560 and a flexible layer (such as a flexible polymer layer) 580. The flexible layer 580 is positioned in fluid communication with the solvent, the reactant, or both the solvent and reactant. As shown in Figure 5, the flexible layer 580 can be positioned as the outer wall. In other

embodiments, it can be in addition to an outer wall, and/or as an inner wall or positioned elsewhere as provided herein. The gas producing reaction can occur by any of the embodiments provided herein (for example, the arrangements in any one of Figures 1-2D). In some embodiments, as the reaction proceeds the gas produced **530** can permeate the gas permeable layer **580** and create an additional insulating volume **540** by expanding outward on the flexible layer **580**. In some embodiments, the containment of this gas, and more importantly, the additional volume **540**, serves as an additional insulating layer. In some embodiments, the gas produced can be vented or at least a portion of the gas can be contained in the system. In some embodiments, the gas can be contained between the gas permeable layer **560** and the flexible layer **580**. In some embodiments, there is no gas permeable layer **560**. In some embodiments, the gas permeable layer is permeable to gas, but not to liquid; thus, the solvent can be kept separate from the volume **540**, if desired. As provided herein, the flexible layer **580** can also be part of a different section of the system. In some embodiments, the reactant is an endothermic reactant.

[0092] In some embodiments, rather than a relatively pure gas inflating the volume, an additional volume can be created (and thus an added insulating aspect provided) via the generation of a foam and/suspension. Thus, the volume can be a filled volume in some embodiments. Figure 6 is a schematic depicting some embodiments of a process for producing such a suspension using some of the embodiments provided herein.

[0093] In some embodiments, the process for producing a suspension includes providing a gas producing reactant **120**. While any of the embodiments described herein can be used (for example, Figures 1-2D), in some embodiments, the gas producing reactant **120** is encapsulated in a temperature dependent barrier (or covering layer) **610**. In some embodiments, an increase in temperature causes the temperature dependent barrier **610** to become breached, allowing the solvent **110** to solvate the gas producing reactant **120**, producing a gas (second and third panels of Figure 6). However, in some embodiments, rather than a gas bubbling off, the gas can produce a foam or suspension of smaller bubbles. This results in a foam or aerated solution that includes the partially melted temperature dependent barrier **610**, and the solvent **120**, in a larger volume (third panel of Figure 6). In some embodiments, a cooling of the system then allows for the resolidification of the temperature dependent barrier (not back to its original conformation, but from wherever it randomly drops out of solution), which assists in forming a

framework to support the additional insulating volume **640**. In such an embodiment, the gas can be allowed to leave the system, once the system has cooled, as the solidified foam or suspension provides the increased insulating volume **640**, with or without the presence of the generated gas. As noted above, the system can include a flexible layer **680** to allow for the expansion. However, any arrangement that allows for an expansion in volume can also be employed. In some embodiments, the reactant is an endothermic reactant, and thus, both an insulating volume and a temperature reduction is supplied.

[0094] In some embodiments, the emulsion gassing aspect can be one used in the expansion of industrial emulsion explosives for sensitization. In some embodiments, a gas producing chemical agent is employed with a high viscosity, gel-like water in oil emulsion (as the solvent). The reaction then produces a substantial increase in volume.

[0095] In some embodiments, no gas need be produced, although an endothermic reaction can still be employed. In some embodiments, a suitable reactant such as urea is encapsulated in wax (or other barrier) and dissolves on melting of the barrier.

[0096] In some embodiments, using the gas produced by the reaction provides a large gain in insulating properties only when required (for example, when exposed to warm external temperatures), allowing more rapid cooling when desired and reducing the bulk of insulation to be shipped and stocked.

[0097] In some embodiments, goods contained in a package featuring embodiments provided herein can maintain low temperature outside of refrigeration more reliably than allowed by standard insulative packaging. The temperature triggered response and thermally increased reaction rate at higher temperature provide the measured response to allow this.

[0098] In some embodiments, this technology is included in the primary packaging of food and pharmaceuticals or larger shipping cartons.

[0099] In some embodiments, the system can be part of a backup system in a freezer or fridge. In embodiments in which this is part of a backup system in a freezer, the solvent for the system can be a solvent that is frozen in the freezer, and thus when it starts to melt, it provides additional cooling benefits to the freezer.

[0100] In some embodiments, the system and/or method can provide active compensatory cooling in conjunction with dynamic insulation. In some embodiments,

active cooling is provided by multiple methods, increasing heat sequestration density. In some embodiments, cooling and insulating effects are provided at a definable critical temperature. In some embodiments, temperature is maintained at a steady level effectively. In some embodiments, the rate of the cooling and insulating response is directly related to increasing temperature, responding appropriately to fluctuations. In some embodiments, reactions and reactants used can be very food safe and very well known.

[0101] In some embodiments a carbonate can be dissolved in the solvent for reaction with dry acid on thawing and/or breach of the barrier.

[0102] In some embodiments, the barrier need not melt for a breach. For example, in some dry ice and similar compositions can be used to create the insulating volume in a temperature dependent manner. For example, a sample of dry ice, or other gas producing material, can be used to drive gas production (even without a solvent) upon an increase in temperature. Typically, such an application could be applied for lower temperature regulation, such as for cryogenic temperatures in cryogenic storage.

[0103] In some embodiments, the acids can be dissolved in a solvent before the solvent is frozen. Thus, while in some embodiments, one or more reactants can be present in a solid form (or at least separated from the solvent), in some embodiments, one or more of the reactants can also start as being solvated within the solvent. Such an arrangement allows the system to be ready for reaction upon thawing with a reactant, such as a dry carbonate.

EXAMPLE 1

AN INSULATING SYSTEM WITH A SOLVENT PHASE SEPARATION

[0104] The present example outlines an insulating system with a temperature dependent separation including a frozen solvent.

[0105] A frozen solvent (water) is provided in the system. The frozen solvent can be provided by providing a liquid solvent in the chamber of the system and then lowering the temperature of the system to freeze the solvent. An endothermic reactant (urea), is then be added to the chamber of the system. Because the solvent is frozen it is unavailable to react with the endothermic reactant when the combination is made.

[0106] As the temperature of the system increases (due to an increase in external temperatures) the frozen solvent transitions to a liquid state. The liquid solvent then reacts with the endothermic reactant to produce a cooling effect in the insulation system.

EXAMPLE 2

AN INSULATING SYSTEM WITH A FRACTURABLE WALL SEPARATION

[0107] The present example outlines an insulating system with temperature dependent separation including a fracturable separation wall.

[0108] A thin film of polystyrene is provided in the chamber of the system as a horizontal separation wall between the endothermic reactant (potassium nitrate) and the solvent (water). The temperature of the system and packaging is lowered to a temperature at or below freezing. The polystyrene wall is fractured as the volume of the solvent expands as it freezes. The ruptured wall is then permeable to the solvent and reactant.

[0109] Alternatively, the polystyrene wall can be a horizontal separation wall.

[0110] As the temperature of the system increases (due to higher external temperatures) the frozen solvent melts and dissolved the potassium nitrate, resulting in an endothermic reaction that cools the insulating system.

EXAMPLE 3

AN INSULATING SYSTEM WITH A TEMPERATURE DEPENDENT BARRIER SEPARATION

[0111] The present example outlines an insulating system with a temperature dependent barrier (as depicted in Figures 2A and 2B).

[0112] A paraffin wax layer is provided as a horizontal separation barrier in the chamber of the system between the endothermic reactant (citric acid) and the solvent (water with sodium carbonate). As the temperature of the system increases (due to higher external temperatures) the paraffin wax wall at least partially melts, allowing the solvent to mix with the endothermic reactant on the other side of the wall. This allows an endothermic reaction to proceed.

[0113] Alternatively, the paraffin wax wall can be a horizontal separation barrier.

EXAMPLE 4

AN INSULATING SYSTEM WITH TEMPERATURE DEPENDENT REACTANT
ENCAPSULATION

[0114] The present example outlines an insulating system with a temperature dependent barrier including a reactant encapsulated in a temperature dependent barrier (as depicted in Figure 2C).

[0115] A paraffin wax is provided as a barrier around one part citric acid and, as a separate barrier, one part calcium carbonate. The two encapsulated components are suspended within a water solvent. As the temperature of the system increases due to the placement of a hot item close to the system, the paraffin wax barriers around both the citric acid and the calcium carbonate at least partially melt. The at least partially melted encapsulating layers are then permeable to the water.

[0116] As the water is made available to solvate both the citric acid and the calcium carbonate, an endothermic reaction occurs to produce a cooling effect on the local environment.

EXAMPLE 5

A GAS PRODUCING INSULATION SYSTEM

[0117] The present example outlines an insulating system including a gas producing endothermic reactant (as outlined in Figure 5).

[0118] The physical arrangement of the system of anyone of Examples 1-4 can be used. A gas producing endothermic reactant, citric acid with sodium carbonate is provided. The use of 100g of combined reactant consumes 16 kJ of heat, and produces 9.5 L of CO₂ at standard temperature and pressure. This is sufficient energy intake to cool 375 ml of water by 10 degrees, and provide excess gas for further insulation. Absorbed energy is approximately 800 J/g of reactants at a stoichiometric ratio.

[0119] The gas produced can be at least partially vented with a pressure valve or contained in the system as described in Example 6.

EXAMPLE 6

A GAS RETAINING ENCLOSURE WITH EXPANDABLE WALL

[0120] The present example outlines an insulating system with a gas retaining enclosure including an expandable wall.

[0121] The system of Example 5 further includes a gas permeable wall and flexible layer. The CO₂ produced in the reaction permeates the gas permeable wall but is kept from escaping by the presence of the flexible layer. Under the pressure of the created gas, the flexible layer expands, creating an insulating layer (of relatively cold gas), which provides further insulating benefits to the insulating system.

EXAMPLE 7

A SUSPENSION PRODUCING INSULATION SYSTEM

[0122] The present example outlines an insulating system that includes a suspension, for example as shows in Figure 6.

[0123] A carbonate encapsulated in a paraffin wax barrier is dispersed in an aqueous organic acid solution. As the temperature of the system increases (due to higher external temperatures) the paraffin wax barrier partially melts. A surfactant is present in the solvent and aids in the release of the carbonate as the paraffin wax encapsulating barrier partially melts. The partially melted encapsulating layer is then permeable to the organic acid solution and gas producing reactant.

[0124] The carbonate and acid react endothermically and remove heat from the local environment. The now melted wax forms an oil and water emulsion and during the reaction, CO₂ gas is produced, causing expansion of the gel-like emulsion. The temperature drop caused by the endothermic reaction causes the re-solidification of the now redistributed wax, which reforms in an expanded, skeletal like framework as the wax is brought back below its transition point.

[0125] The gas produced can be at least partially vented with a pressure valve or contained in the system using an expandable wall.

EXAMPLE 8

COOLING CONTAINER AND METHOD FOR REGULATING TEMPERATURE

[0126] The present example outlines how to regulate the temperature of an environment using the systems of any of Examples 1-7.

[0127] A container that includes any of the systems of Examples 1-7 can be used as a packaging that encloses a desired storage volume whose temperature is to be regulated. An item to be preserved is placed within the container. When the temperature rises above freezing, the endothermic reactant is solvated by the solvent as outlined in the examples above, thereby producing a cooling effect on the desired storage volume.

[0128] The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods, reagents, compounds, compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

[0129] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0130] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as “open” terms (e.g., the term “including” should be interpreted as “including but not limited to,” the term “having” should be interpreted as “having at least,” the term “includes” should be interpreted as “includes but is not limited to,” etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory

phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0131] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0132] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also

encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as “up to,” “at least,” and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

[0133] From the foregoing, it will be appreciated that various embodiments of the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope and spirit of the present disclosure. Accordingly, the various embodiments disclosed herein are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

WHAT IS CLAIMED IS:

1. An insulating system comprising:
at least one solvent; and
at least one endothermic reactant, wherein the at least one endothermic reactant is separated from the solvent in a temperature dependent manner such that an increase in temperature results in the solvent solvating the endothermic reactant.
2. The insulating system of claim 1, wherein the at least one endothermic reactant is separated from the solvent by the solvent being contained in a solid or gel form.
3. The insulating system of claim 1, wherein the at least one endothermic reactant is separated from the solvent by a solvent impermeable layer or seal.
4. The insulating system of claim 3, wherein the solvent impermeable layer is fracturable or rupturable upon freezing of the solvent such that subsequent thawing of the solvent allows the solvent to solvate the endothermic reactant.
5. The insulating system of claim 4, wherein the solvent impermeable layer comprises a brittle polymer or a rupturable mechanical seal.
6. The insulating system of claim 5, wherein the brittle polymer comprises at least one of polystyrene, Polymethylmethacrylate (PMMA), embrittled phenolic resin, and wherein the rupturable mechanical seal comprises at least one of a non-brittle polymer, PE, PP, LLPE, cellophane, PET, or nylon.
7. The insulating system of claim 1, wherein the solvent is frozen.
8. The insulating system of claim 1, wherein the at least one endothermic reactant is separated from the solvent by a temperature dependent material.
9. The insulating system of claim 8, wherein the temperature dependent material comprises at least one of a wax, a polymer of desired transition point, or a shape memory polymer.
10. The insulating system of claim 9, wherein the wax comprises a paraffin wax.
11. The insulating system of claim 8, wherein the temperature dependent material encapsulates the at least one endothermic reactant in a temperature dependent coating.
12. The insulating system of claim 11, wherein the temperature dependent coating is suspended in the solvent.

13. The insulating system of claim 12, wherein the solvent is in a liquid state.
14. The insulating system of any one of claims 1-13, wherein the solvent and the at least one endothermic reactant are contained within a chamber.
15. The insulating system of claim 14, wherein the chamber is sealed.
16. The insulating system of claim 15, wherein the chamber further comprises a pressure valve configured to release gas from inside of the chamber to an exterior volume of gas.
17. The insulating system of any one of claims 1-16, wherein solvation of the endothermic reactant produces at least one gas.
18. The insulating system of claim 17, further comprising an expandable layer.
19. The insulating system of claim 18, wherein the expandable layer is configured to expand by production of the at least one gas.
20. The insulating system of any one of claims 1-19, further comprising a first wall and a second wall, wherein the solvent and the at least one endothermic reactant are positioned between the first wall and the second wall.
21. The insulating system of claim 20, wherein the first wall faces an internal volume configured to retain an object to be kept cool.
22. The insulating system of claim 21, wherein the second wall faces an external environment.
23. The insulating system of claim 22, wherein the second wall is deformable by a gas that is generated by the solvation of the endothermic reactant and the solvent.
24. The insulating system of claim 23, wherein the second wall is curved.
25. The insulating system of claim 23, wherein a shape of the second wall is defined by an outward pressure, wherein the outward pressure is generated between the first wall and second wall.
26. The insulating system of any one of claims 20-25, wherein the second wall is not deformable under pressure generated by solvation of the at least one endothermic reactant by the solvent.
27. The insulating system of any one of claims 20-26, wherein the second wall is rigid.

28. The insulating system of any one of claims 20-27, wherein the second wall is made of a heat conducting material to allow heat to pass through it to the solvent and the at least one endothermic reactant.

29. The insulating system of any one of claims 20-28, wherein the first wall is made of an insulating material.

30. The insulating system of any one of claims 1-29, wherein the insulating system is part of a container, wherein the at least one endothermic reactant and the solvent are located between an outer wall of the container and an inner wall of the container, and wherein the inner wall defines at least part of an inner volume of the container.

31. The insulating system of claim 30, wherein the container is a thermos, an ice chest, a drink sleeve, a shipping carton, a pharmaceutical container, food packaging, a rigid container or a bag.

32. The insulating system of claim 30, wherein the container further comprises a lid configured to reversibly seal the inner volume.

33. The insulating system of any one of claims 1-29, wherein the insulating system is part of a cold pack, a film, or an insulating barrier layer.

34. The insulating system of any one of claims 1-33, wherein the at least one endothermic reactant comprises at least one of carbonate, urea, potassium nitrate, ammonium nitrate, potassium sulfate, ammonium chloride, potassium chloride, sodium carbonate, calcium carbonate, magnesium carbonate, or a bicarbonate.

35. The insulating system of any one of claims 1-34, wherein the solvent comprises a material that can transition from solid to liquid form at a predetermined temperature.

36. The insulating system of any one of claims 1-34, wherein the solvent comprises at least one of: water, an acid, citric acid, acetic acid, propanoic acid, succinic acid, formic acid, fumaric acid, lactic acid or tartaric acid.

37. The insulating system of any one of claims 1-36, wherein the solvent comprises water, and wherein the at least one endothermic reactant comprises dry powered acid and dry powered carbonate.

38. The insulating system of claim 37, wherein the water is frozen.

39. A gas retaining enclosure comprising:
at least one solvent; and

at least one gas producing reactant, wherein the at least one gas producing reactant is separated from the solvent in a temperature dependent manner, wherein an increase in temperature results in the solvent solvating the at least one gas producing reactant.

40. The gas retaining enclosure of claim 39, wherein the enclosure further comprises a flexible wall that expands upon the solvent solvating the at least one gas producing reactant.

41. The gas retaining enclosure of claim 39, wherein the temperature dependent manner comprises a barrier that changes its phase from solid to liquid at a desired temperature.

42. The gas retaining enclosure of claim 41, wherein the barrier comprises a wax.

43. The gas retaining enclosure of claim 39, wherein the temperature dependent manner comprises an arrangement in which the solvent is in a solid state below a temperature threshold, and wherein the solvent is in a liquid state above the temperature threshold.

44. A method for regulating a temperature of a desired environment, the method comprising:

providing at least one solvent;

providing at least one endothermic reactant, wherein the solvent is separated from the at least one endothermic reactant; and

solvating the at least one endothermic reactant by changing a state of at least one of:

a) the solvent,

b) a barrier separating the solvent from the at least one endothermic reactant, or

c) both a) and b),

to allow an endothermic reaction to occur, wherein the change in state occurs in response to an increase in temperature and thereby regulate a temperature of a desired environment.

45. The method of claim 44, wherein the solvent is provided in a solid state, and wherein the solvent at least partially transitions to a liquid state to solvate the at least one endothermic reactant.

46. The method of claim 44, wherein the barrier separates the solvent from the at least one endothermic reactant when the barrier is in a solid state, and wherein the barrier at least partially transitions to a liquid state to allow the solvent to solvate the at least one endothermic reactant.

47. The method of claim 46, wherein the barrier comprises a material that is different from a material that makes up the solvent.

48. The method of claim 46, wherein the barrier comprises a wax.

49. The method of claim 44, further comprising providing a layer between the solvent and the at least one endothermic reactant.

50. The method of claim 49, further comprising fracturing the layer by freezing the solvent to form a fractured layer.

51. The method of any one of claims 44-50, further comprising forming a gas upon solvation of the at least one endothermic reactant.

52. The method of claim 51, further comprising trapping at least some of the gas to inflate a flexible layer.

53. The method of claim 51, wherein the gas forms a foam of a combination of the solvent and the at least one endothermic reactant.

54. A cooling device comprising:

an exterior flexible layer;

a dried endothermic reactant;

a storage space configured to support a frozen liquid; and

a liquid permeable layer separating the storage space from the dried endothermic reactant.

55. An insulating system comprising:

at least one solvent; and

at least one endothermic reactant, wherein the at least one endothermic reactant is separated from the at least one solvent at a first temperature, but at a second temperature the solvent and the at least one endothermic reactant are combinable.

56. The system of claim 55, wherein the first temperature is lower than the second temperature.
57. The system of claim 55, wherein the at least one solvent does not solvate the endothermic reactant at the first temperature.
58. The system of claim 57, wherein the at least one solvent does solvate the endothermic reactant at the second temperature.

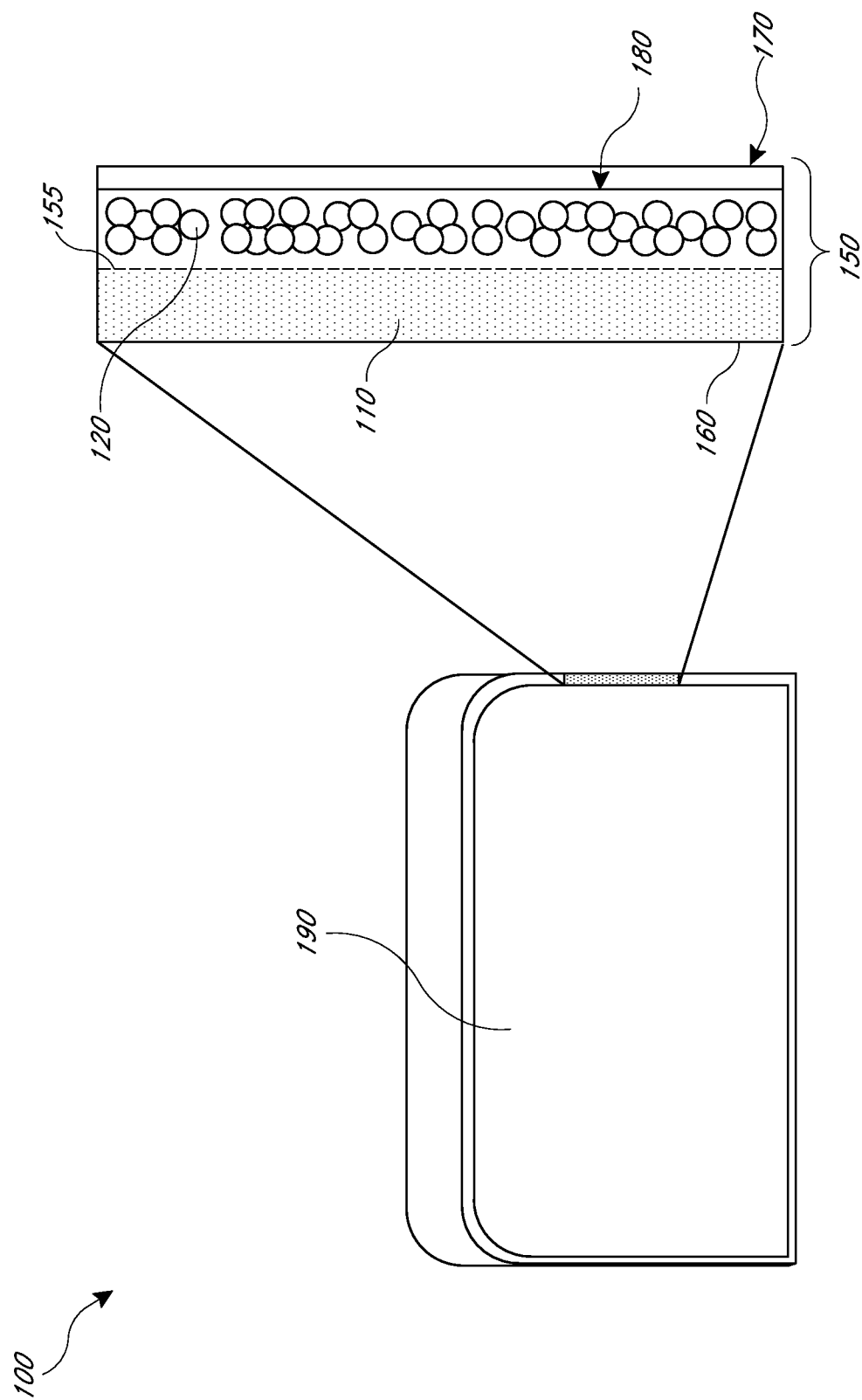


FIG. 1

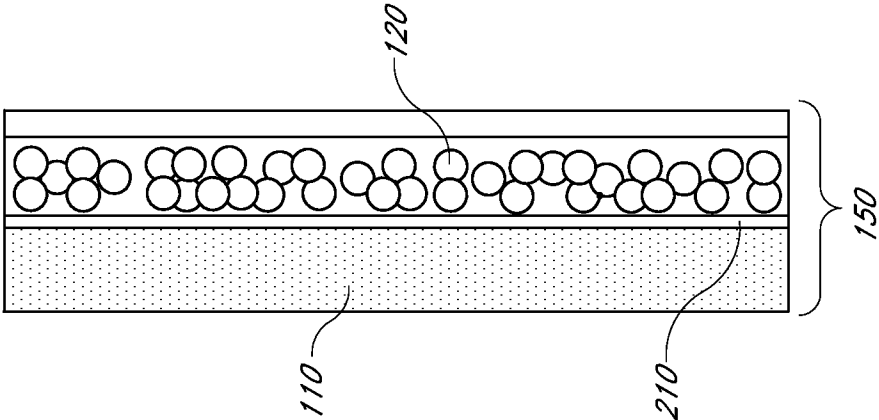


FIG. 2A

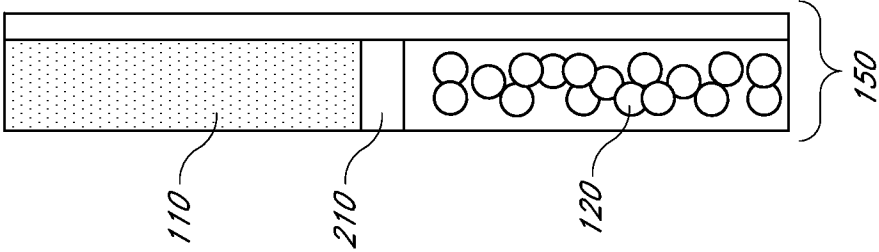


FIG. 2B

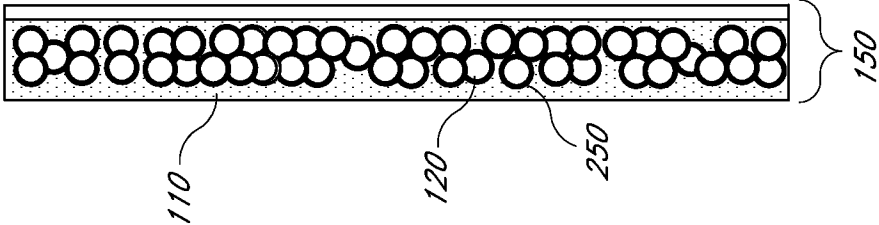


FIG. 2C

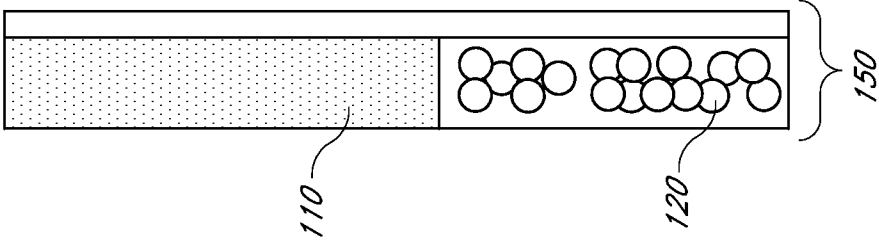


FIG. 2D

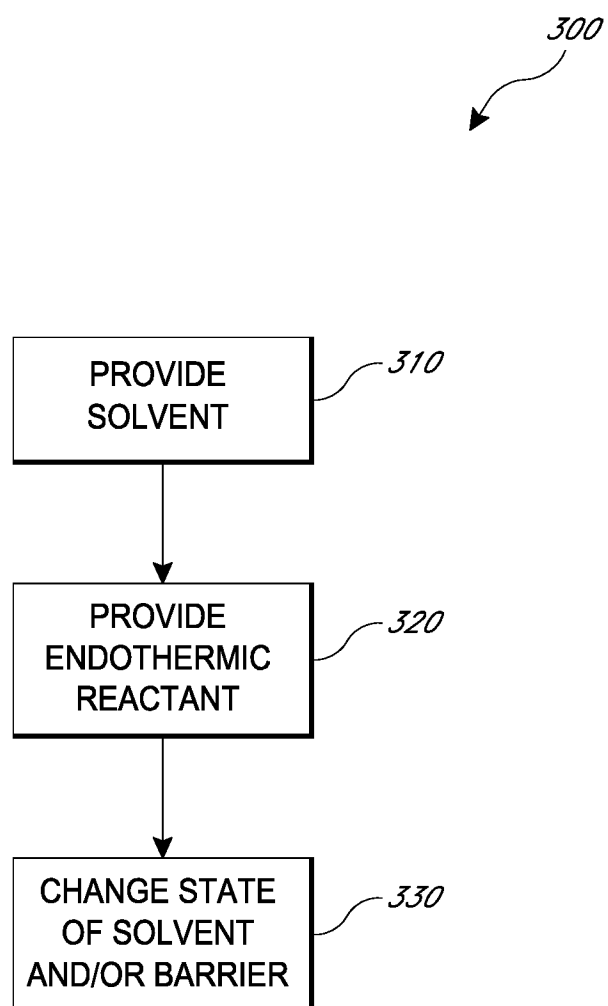


FIG. 3

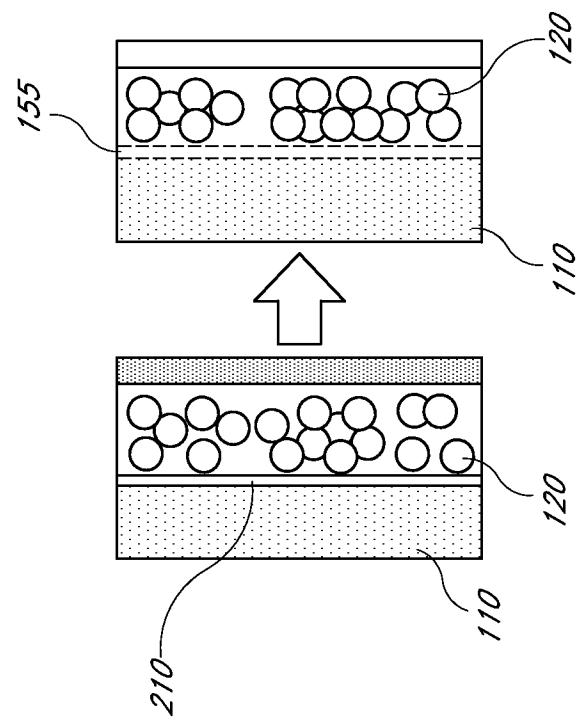


FIG. 4

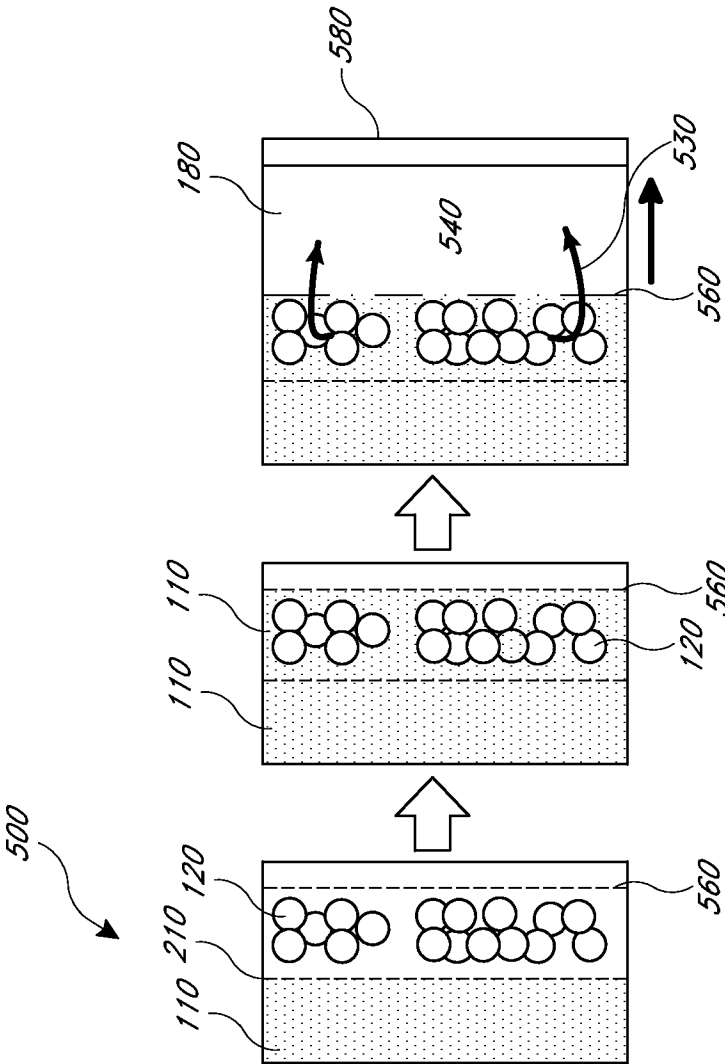


FIG. 5

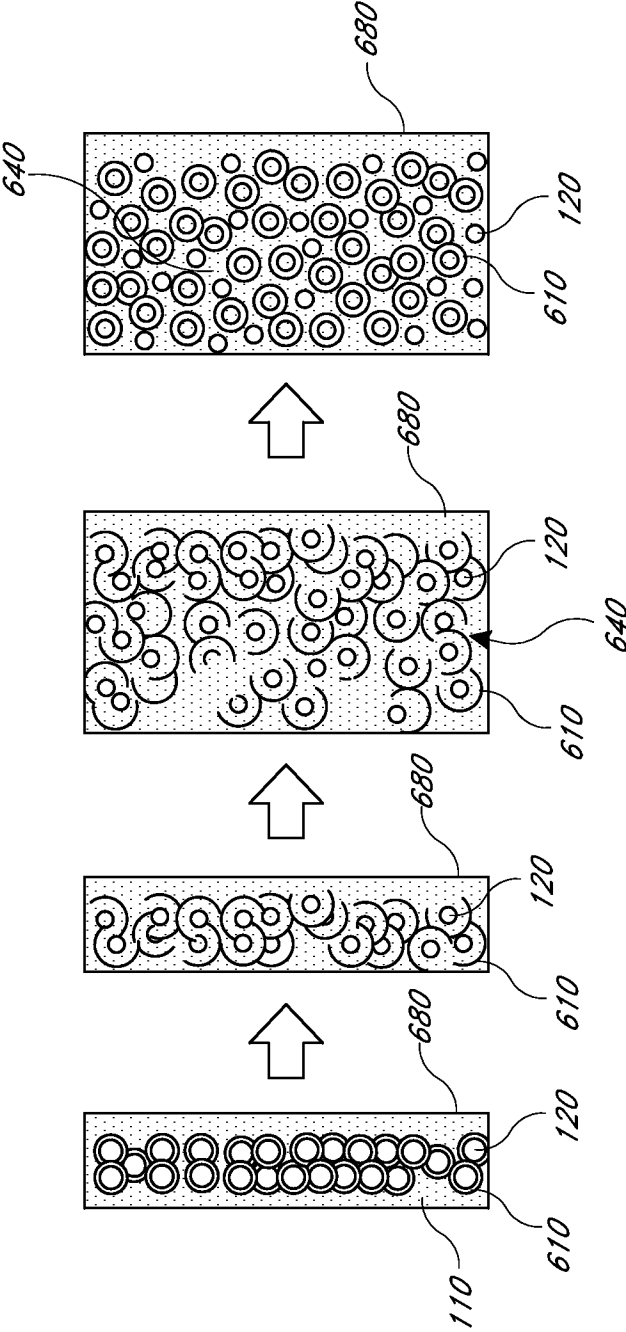


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/043583

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61F 7/10 (2013.01)

USPC - 607/96

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A61F 7/00, 7/02, 7/10 (2013.01)

USPC - 220/500, 577, 903; 607/96, 114

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

CPC - A61F 7/00, 7/0085, 7/02, 7/10, 7/106 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit.com, Google Patents, Public AppFT and PatFT, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/0186541 A1 (AGARWAL et al) 23 September 2004 (23.09.2004) entire document	1-16, 55-58
Y	US 2011/0271692 A1 (RASMUSSEN et al) 10 November 2011 (10.11.2011) entire document	1-16, 39-58
Y	US 2012/0083043 A1 (GRANDE TELLERIA et al) 05 April 2012 (05.04.2012) entire document	4-7, 39-54, 57, 58
Y	US 2008/0233368 A1 (HARTMANN et al) 25 September 2008 (25.09.2008) entire document	9-13
Y	US 2004/0065315 A1 (FISH et al) 08 April 2004 (08.04.2004) entire document	53

☐ Further documents are listed in the continuation of Box C.


* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

28 October 2013

Date of mailing of the international search report

14 NOV 2013

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/043583

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 17-38
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.