

TITLE

PACKAGING INCLUDING PHASE CHANGE MATERIALS

BACKGROUND

[0001] The present disclosure generally relates to food products and storage. More specifically, the present disclosure relates to packaging including phase change materials.

[0002] During transportation, large quantities of temperature sensitive products such as food products are generally stored on pallets located in storage units such as the trailer of a semi truck. The food products may be wrapped in a support material to keep them on the pallets. Nevertheless, the support material does not usually provide adequate insulation, and the food products take on the ambient temperature of the storage unit. The temperature of the storage unit can significantly fluctuate due to the higher temperatures during the day and the lower temperatures at night or as a result of differing temperatures of various locations during transport and distribution. As a result, the food products are exposed to the fluctuating temperatures of the storage unit, which can lead to a decrease in quality of the food products during storage, transport and distribution.

SUMMARY

[0003] The present disclosure relates to packaging and storage assemblies having one or more phase change materials and methods of using the packaging and storage assemblies. In a general embodiment, the present disclosure provides a packaging including one or more temperature barrier layers each having one or more phase change materials. The phase change material can be stored within the temperature barrier layer.

[0004] In an embodiment, the layer includes a second phase change material stored within the temperature barrier layer. In another embodiment, the packaging can include a second temperature barrier layer having a second phase change material.

[0005] In an embodiment, the packaging includes a layer including at least one of a reflective material and an insulating material. The packaging can include a multilayer film having an outer layer including a reflective material, a middle layer including an

insulating material, and an inner temperature barrier layer including the phase change material.

[0006] In an embodiment, the phase change material includes sodium sulfate decahydrate. Alternatively, the phase change material can include a mixture of water and varying amounts of propylene glycol and/or calcium chloride. The concentration of the phase change materials in the temperature barrier layers can be varied to obtain a desired melting point for specific temperature conditions.

[0007] In another embodiment, the present disclosure provides a packaged product including a temperature sensitive product and a packaging including at least one temperature barrier layer having a phase change material surrounding the temperature sensitive product. The phase change material can be stored within the temperature barrier layer. The temperature sensitive product can be a food product. The food product can be a nutritional composition.

[0008] In an embodiment of the packaged product, the packaging material includes a second phase change material stored within the temperature barrier layer. Alternatively, the packaging can include a second temperature barrier layer having a second phase change material. The packaging can include a layer including at least one of a reflective material and an insulating material. For example, the packaging can include a multilayer film having an outer layer including a reflective material, a middle layer including an insulating material, and an inner temperature barrier layer including the phase change material.

[0009] In an alternative embodiment, the present disclosure provides a container assembly including a support, a temperature sensitive product positioned on the support, and a packaging including at least one temperature barrier layer having a phase change material surrounding the temperature sensitive product and the support. The temperature sensitive product can be a food product. The food product can be a nutritional composition. The support is a pallet or a slip sheet.

[0010] In an embodiment of the container assembly, the phase change material is stored within the temperature barrier layer. Alternatively, the packaging can include a second phase change material stored within the same temperature barrier layer. The packaging can also include a second temperature barrier layer having a second phase change material. The packaging can include a layer including at least one of a reflective material and an insulating material. For example, the packaging can include a multilayer

film having an outer layer including a reflective material, a middle layer including an insulating material, and an inner temperature barrier layer including the phase change material.

[0011] In yet another embodiment, the present disclosure provides a storage assembly including a storage unit, a temperature sensitive product located within the storage unit, and a packaging including at least one temperature barrier layer having a phase change material attached to at least one wall of the storage unit. The temperature sensitive product can be a food product. The food product can be a nutritional composition. The storage unit can be a trailer, refrigerator, freezer, cargo container or a combination thereof.

[0012] In yet another embodiment, the present disclosure provides a temperature sensitive product located outside a storage unit (such as: on a dock, roadside, or area exposed to the elements) and a packaging including at least one temperature barrier layer having a phase change material. The temperature sensitive product can be a food product. The food product can be a nutritional composition.

[0013] In an embodiment of the storage assembly, the phase change material can be stored within the temperature barrier layer. The layer can also include a second phase change material stored within the same temperature barrier layer. The packaging can include a second temperature barrier layer having a second phase change material. The packaging can include a layer including at least one of a reflective material and an insulating material. For example, the packaging can include a multilayer film having an outer layer including a reflective material, a middle layer including an insulating material, and an inner temperature barrier layer including the phase change material.

[0014] In still another embodiment, the present disclosure provides a moving storage assembly including, a transporter, a storage unit and attached to the transporter, a temperature sensitive product located within the storage unit, and a packaging including at least one temperature barrier layer having a phase change material attached to at least one wall of the storage unit. The temperature sensitive product can be a food product. The food product can be a nutritional composition. The storage unit can be a trailer, refrigerator, freezer, cargo container or a combination thereof. The transporter can be a car, truck, semi-truck, airplane, helicopter, boat, train or ship.

[0015] In an embodiment of the moving storage assembly, the phase change material can be stored within the temperature barrier layer. The layer can also include a

second phase change material stored within the same temperature barrier layer. The packaging can include a second temperature barrier layer having a second phase change material. The packaging can include a layer including at least one of a reflective material and an insulating material. For example, the packaging can include a multilayer film having an outer layer including a reflective material, a middle layer including an insulating material, and an inner temperature barrier layer including the phase change material.

[0016] In an alternative embodiment, the present disclosure provides a packaging including a multilayer film having an outer layer including a reflective material, a middle layer including an insulating material, a first temperature barrier layer including a first phase change material, and a second temperature barrier layer including a second phase change material.

[0017] In another embodiment, the present disclosure provides a packaging including a multilayer film having an outer layer including a reflective material, a middle layer including an insulating material, and an inner temperature barrier layer including a first phase change material and a second phase change material.

[0018] In an alternative embodiment, the present disclosure provides a shrink wrap film including at least one temperature barrier layer having a phase change material. The shrink wrap film is constructed and arranged to conform to a surface of a temperature sensitive product. The phase change material can be stored within the temperature barrier layer. The temperature barrier layer can also comprise a second phase change material stored within the layer. Alternatively, the shrink wrap film can include a second temperature barrier layer comprising a second phase change material.

[0019] In an embodiment, the present disclosure provides a method of protecting a temperature sensitive product from fluctuating temperatures during storage or transport. The method comprises placing a temperature sensitive product in a packaging including the temperature sensitive layer having the phase change material.

[0020] In another embodiment, the present disclosure provides a method of protecting a temperature sensitive product from fluctuating temperatures during storage or transport. The method comprises placing a temperature sensitive product in a container assembly utilizing the phase change material in embodiments of the present disclosure.

[0021] In an alternative embodiment, the present disclosure provides a method of protecting a temperature sensitive product from fluctuating temperatures during storage or

transport. The method comprises placing a temperature sensitive product in a storage assembly utilizing the phase change material in embodiments of the present disclosure.

[0022] In yet another embodiment, the present disclosure provides a method of protecting a temperature sensitive product from fluctuating temperatures during storage or transport. The method comprises placing a temperature sensitive product in a moving storage assembly utilizing the phase change material in embodiments of the present disclosure.

[0023] In an embodiment, the present disclosure provides a method of reducing distribution or transporting costs of a temperature sensitive product. The method comprises placing a temperature sensitive product in a packaging, container assembly, storage assembly or moving storage assembly utilizing the phase change material in embodiments of the present disclosure, and transporting the temperature sensitive product from one location to another location.

[0024] An advantage of the present disclosure is to provide an improved packaging for protecting temperature sensitive products from being adversely affected by temperature fluctuations.

[0025] Another advantage of the present disclosure is to provide an improved storage assembly for protecting temperature sensitive products from being adversely affected by temperature fluctuations during storage.

[0026] Yet another advantage of the present disclosure is to provide an improved moving storage assembly for protecting temperature sensitive products from being adversely affected by temperature fluctuations during distribution.

[0027] Additional features and advantages are described herein, and will be apparent from the following Detailed Description and the figures.

BRIEF DESCRIPTION OF THE FIGURES

[0028] FIG. 1 shows a partial view of a packaging having a phase change material in an embodiment of the present disclosure.

[0029] FIG. 2 shows a partial view of a packaging having two phase change materials in an embodiment of the present disclosure.

[0030] FIG. 3 shows a partial view of a packaging having two temperature barrier layers each including a phase change material in an embodiment of the present disclosure.

[0031] FIG. 4 shows a partial view of a packaging having a temperature barrier layer including a plurality of phase change materials in an embodiment of the present disclosure.

[0032] FIG. 5 shows a partial view of a storage unit wall including a packaging having a phase change material in an embodiment of the present disclosure.

[0033] FIG. 6 shows a partial view of a storage unit wall including a packaging having two phase change materials in an embodiment of the present disclosure.

[0034] FIG. 7 shows a partial view of a storage unit wall including a packaging having two layers each having a phase change material in an embodiment of the present disclosure.

[0035] FIG. 8 is a graph illustrating a preferred melting point range of suitable phase change materials at high temperatures in an embodiment of the present disclosure.

[0036] FIG. 9 is a graph illustrating a preferred melting point range of suitable phase change materials at low temperatures in an embodiment of the present disclosure.

[0037] FIG. 10 is a graph illustrating a preferred melting point range of suitable phase change materials at low temperatures in another embodiment of the present disclosure.

[0038] FIG. 11 is a graph illustrating a preferred melting point range of suitable phase change materials in a two part system in an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0039] The present disclosure relates to packaging including one or more phase change materials and storage assemblies including the phase change materials. The packaging can include one or more temperature barrier layers each having one or more phase change materials that can be used to protect temperature sensitive products from being exposed to fluctuating temperatures during storage. The temperature sensitive products can be food products such as, for example, nutritional compositions to promote the health and well-being of a consumer. The packaging including the phase change materials can ensure quality of the food product for consumer and ensure regulatory compliance (e.g., probiotic viability).

[0040] The temperature barrier layers of the packaging in embodiments of the present disclosure work by having the phase change materials absorbing or emitting

energy during changing temperatures surrounding the package. For example, the energy absorbed or emitted in a phase transition of the phase change material is normally very high compared to energy needed for temperature rise (sensible heat). Therefore, a small amount of properly-chosen phase change materials could be used to protect a large mass of the temperature sensitive product from detrimental temperature swings.

[0041] Any suitable phase change materials as understood by the skilled artisan can be used in the temperature barrier layers of the packaging in embodiments of the present disclosure. Such suitable phase change materials can be determined according to “Phase Change Materials: Science and Applications” (2009 – ISBN: 978-0-387-84873-0), which is incorporated herein by reference.

[0042] An example of a suitable phase change material for any embodiments of the present disclosure is sodium sulfate decahydrate. This chemical goes through a phase change at 32 °C. During the day, with air temperatures approaching perhaps 40 °C, the chemical would melt and absorb energy from the air, thus protecting the temperature sensitive product. At night, with air temperatures dropping below 32 °C, the chemical will give the heat back by re-crystallizing. The temperature sensitive product temperature below the blanket would never exceed 32 °C. In other embodiments, the phase change material can include a mixture of water and varying amounts of propylene glycol and/or calcium chloride.

[0043] The concentrations of the phase change materials within the temperature barrier layer of the packaging can vary depending on the degree of temperature change that the packaging and the temperature sensitive product is exposed to. For example, generally speaking, a higher concentration of the phase change material will allow for exposure of the packaging and temperature sensitive product to a greater fluctuation in temperature without the temperature sensitive product being affected by the change in temperature. This is because a greater amount of energy (from a greater temperature change) can be absorbed by a higher concentration of the phase change materials within the temperature barrier layer.

[0044] As used herein, the term “nutritional composition” includes, but is not limited to, complete nutritional compositions, partial or incomplete nutritional compositions, and disease or condition specific nutritional compositions. A complete nutritional composition (i.e. those which contain all the essential macro and micro nutrients) can be used as a sole source of nutrition for the patient. Patients can receive

100% of their nutritional requirements from such complete nutritional composition. A partial or incomplete nutritional composition does not contain all the essential macro and micro nutrients and cannot be used as a sole source of nutrition for the patient. Partial or incomplete nutritional compositions can be used as a nutritional supplements.

[0045] A disease or condition specific nutritional composition is a composition that delivers nutrients or pharmaceuticals and can be a complete or partial nutritional composition. Disease or condition specific nutritional compositions are those designed to aid with a given situation, such as Impact® sold by Nestlé Nutrition to decrease post-operative infections, Diabetisource AC® sold by Nestlé Nutrition for people with diabetes or hyperglycemia, and Novasource® Pulmonary sold by Nestlé Nutrition for those patients with pulmonary disease or those requiring ventilator support.

[0046] In a general embodiment shown in FIG. 1, the present disclosure provides a packaging 2 including one or more temperature barrier layers 12 having one or more phase change materials 14. Phase change material 14 can be stored within temperature barrier layer 12 as shown by FIG. 1 such as within a pocket or passage of temperature barrier layer 12. Packaging 2 can be used to partially or completely surround any suitable temperature sensitive product 20 such as a food product.

[0047] Packaging 2 can also include a layer including a reflective material and/or a layer including an insulating material. As shown by FIG. 1, packaging 2 includes a multilayer film 10 having an outer layer 16 including a reflective material, a middle layer 18 including an insulating material, and inner temperature barrier layer 12 including phase change material 14. It should be appreciated that packaging 2 can have the reflective material, insulating material and phase change material in any suitable order in multilayer film 10.

[0048] In an embodiment shown in FIG. 2, the present disclosure provides a packaging 30 including one or more temperature barrier layers 34 having at least two phase change materials 36 and 38. Phase change materials 36 and 38 can each be stored within in pockets of temperature barrier layer 34 as shown by FIG. 2. Packaging 30 can be used to partially or completely surround any suitable temperature sensitive product 40 such as a food product.

[0049] Packaging 30 can also include a layer including a reflective material and/or a layer including an insulating material. As shown by FIG. 2, packaging 30 includes a multilayer film 32 having an outer layer 42 including a reflective material, a middle layer

44 including an insulating material, and inner temperature barrier layer 34 including phase change materials 36 and 38. It should be appreciated that packaging 30 can have the reflective material, insulating material and phase change material in any suitable order in multilayer film 32.

[0050] In an embodiment shown in FIG. 3, temperature barrier layer 34 is shown in further detail. Temperature barrier layer 36 includes pockets 46 and 48 including phase change materials 36 and 38 stored inside each pocket 46 and 48, respectively. Any portion of a packaging can include temperature barrier layer 36 having one or more phase change materials in any one or more of the pockets.

[0051] In an embodiment, two or more phase change materials are mixed together in the same pocket.

[0052] In an embodiment, two or more phase change materials are placed in individual compartments so no mixing occurs. These pockets of two or more phase change materials can be arranged in an alternating row or column pattern or random pattern. The materials can serve different purposes, for example, one can help protect against freezing while the other will prevent the temperature from rising too high.

[0053] In an embodiment, there are multiple phase change materials that can be used, each changing phase at different temperatures to slow the progression of temperature change of the product. Any two phase change materials can be in any ratio, for example, 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, 1:8, 1:9, 1:10, and arranged in any pattern (rows, columns random, or a purposeful pattern (i.e a phase change material in pockets that will protect from the heat of the sun on top of the product, and one that will protect against freezing wind on the side of the product).

[0054] In an embodiment shown in FIG. 4, the present disclosure provides a packaging 60 including a first temperature barrier layer 64 and a second temperature barrier layer 66. First temperature barrier layer 64 and second temperature barrier layer 66 each have separate phase change materials 70 and 72, respectively. Phase change materials 70 and 72 can be stored within first temperature barrier layer 64 and second temperature barrier layer 66, respectively, as shown by FIG. 4. Packaging 60 can be used to partially or completely surround any suitable temperature sensitive product 68 such as a food product.

[0055] Packaging 60 can also include a layer including a reflective material and/or a layer including an insulating material. As shown by FIG. 4, packaging 60 includes a

multilayer film 62 having an outer layer 74 including a reflective material, a middle layer 76 including an insulating material, intermediate layer 64 including phase change material 70 and inner temperature barrier layer 66 including phase change material 72. It should be appreciated that packaging 60 can have the reflective material, insulating material and phase change material in any suitable order in multilayer film 62.

[0056] In an alternative embodiment, the present disclosure provides a container assembly including a support, a temperature sensitive product positioned on the support, and a packaging including at least one temperature barrier layer having a phase change material surrounding the temperature sensitive product and the support. The temperature sensitive product can be a food product. The food product can be a nutritional composition.

[0057] The support can be a pallet or slip sheet on which one or more of the temperature sensitive products is placed for storage or transport. By wrapping the temperature sensitive product and the pallet or slip sheet in the packaging, the entire container assembly can be exposed to varying temperatures of the environments when moved or transported without adversely impacting the temperature sensitive product. The pallet or slip sheet (or case) is wrapped with a “chemical blanket” designed to go through a temperature phase transition around a relevant temperature (e.g., distribution temperature).

[0058] In yet another embodiment shown in FIG. 5 showing a partial view of a wall of a storage unit, the present disclosure provides a storage assembly including a storage unit 100, a temperature sensitive product 110 located within storage unit 100 having a wall 112, and a packaging 102 including at least one temperature barrier layer 104 having a phase change material 106 attached to wall 112 of storage unit 100. Packaging 102 can be attached to and line all of the walls of storage unit 100.

[0059] Packaging 102 can also include an additional layer 114 including at least one of a reflective material and an insulating material. Temperature sensitive product 110 can be a food product. The food product can be a nutritional composition. In an embodiment, storage unit 100 can be a trailer, refrigerator, freezer, cargo container or a combination thereof that can be readily moved or transported.

[0060] In still another embodiment shown in FIG. 6 showing a partial view of a wall of a storage unit, the present disclosure provides a storage assembly including a storage unit 120 having a wall 132, a temperature sensitive product 130 located within

storage unit 120, and a packaging 122 including at least one temperature barrier layer 124 having a first phase change material 126 and a second phase change material 128 attached to wall 132 of storage unit 120. First phase change material 126 and second phase change material 128 can be stored within layer temperature barrier 124.

[0061] Packaging 122 can be attached to and line all of the walls of storage unit 120. Packaging 122 can also include an additional layer 134 including at least one of a reflective material and an insulating material. Temperature sensitive product 130 can be a food product. The food product can be a nutritional composition. In an embodiment, storage unit 120 can be a trailer, refrigerator, freezer, cargo container or a combination thereof.

[0062] In an alternative embodiment shown in FIG. 7 showing a partial view of a wall of a storage unit, the present disclosure provides a storage assembly including a storage unit 150 having a wall 162, a temperature sensitive product 160 located within storage unit 150, and a packaging 152 including a first temperature barrier layer 154 and a second temperature barrier layer 156 attached to wall 162 of storage unit 150. First temperature barrier layer 154 and second temperature barrier layer 156 have a first phase change material 170 and a second phase change material 172, respectively, stored within each layer.

[0063] Packaging 152 can also include an additional layer 164 including at least one of a reflective material and an insulating material. Temperature sensitive product 160 can be a food product. The food product can be a nutritional composition. In an embodiment, storage unit 150 can be a trailer, refrigerator, freezer, cargo container or a combination thereof.

[0064] In still another embodiment, the present disclosure provides a moving storage assembly including, a transporter, a storage unit and attached to the transporter, a temperature sensitive product located within the storage unit, and a packaging including at least one temperature barrier layer having a phase change material attached to at least one wall of the storage unit. The temperature sensitive product can be a food product. The food product can be a nutritional composition. The storage unit can be a trailer, refrigerator, freezer, cargo container or a combination thereof. The transporter can be a car, truck, semi-truck, airplane, helicopter, boat, train or ship capable of moving the storage unit.

[0065] In an embodiment of the moving storage assembly, the phase change material can be stored within the temperature barrier layer. The temperature barrier layer can also include a second phase change material stored within the layer. The packaging can include a second temperature barrier layer having a second phase change material. The packaging can include a layer including at least one of a reflective material and an insulating material. For example, the packaging can include a multilayer film having an outer layer including a reflective material, a middle layer including an insulating material, and an inner layer including the phase change material.

[0066] In an alternative embodiment, the present disclosure provides a shrink wrap film including at least one temperature barrier layer having a phase change material. The shrink wrap film is constructed and arranged to conform to a surface of a temperature sensitive product. The phase change material can be stored within the temperature barrier layer. The temperature barrier layer can also comprise a second phase change material stored within the layer. Alternatively, the shrink wrap film can include a second temperature barrier layer comprising a second phase change material. The shrink wrap film can be constructed and arranged for a single use (e.g., can be mailed or cut off at a distribution center). For example, the shrink wrap film can be produced on rolls that can be conveniently unwound and wrapped around the temperature sensitive products or pallets containing the products.

[0067] In an embodiment, the temperature barrier layer can include an indicator of the phase or transition change of the phase change material. The indicator can be a color or design change of the temperature barrier layer. This allows a user to see the temperature condition inside a storage unit or trailer quickly and easily.

[0068] In alternative embodiments, the packaging having temperature barrier layer can be used to insulate a trailer (e.g., in walls of trailer or liner inside trailer). The packaging having temperature barrier layer can be used inside the walls of a carton (e.g., reusable carton). The packaging having temperature barrier layer can be in the form of reusable "blankets" to cover/wrap pallets or as hanging curtains/separators in storage unit or trailer.

[0069] In an embodiment, the present disclosure provides a method of maintaining a constant temperature of a temperature sensitive product. The method comprises warming or heating the temperature sensitive product to a specified temperature, and

[0070] A suitable phase change material will maintain temperature of the warmed or heated temperature sensitive product over time. In an embodiment, one or more warmed or heated temperature sensitive products are placed on a support (e.g., pallet) and wrapped in the packaging having the temperature sensitive product. This allows the temperature from the center of pallet to reach the outer temperature sensitive products and equilibrate the temperature throughout the wrapped products so that all of the temperature sensitive products can achieve the same temperature during storage and distribution.

[0071] In another embodiment, the present disclosure provides a method of maintaining a constant temperature of a temperature sensitive product. The method comprises cooling or freezing the temperature sensitive product to a specified temperature, and placing the temperature sensitive product in a packaging comprising at least one temperature barrier layer comprising a phase change material. time for temperature from center of pallet and outer to get closer/equilibrate.

[0072] A suitable phase change material will maintain temperature of the cooled or frozen temperature sensitive product over time. In an embodiment, one or more cooled or frozen temperature sensitive products are placed on a support (e.g., pallet) and wrapped in the packaging having the temperature sensitive product. This allows the temperature from the center of pallet to reach the outer temperature sensitive products and equilibrate the temperature throughout the wrapped products so that all of the temperature sensitive products can achieve the same temperature during storage and distribution.

[0073] In an embodiment, the present disclosure provides a method of reducing distribution or transporting costs of a temperature sensitive product. The method comprises placing a temperature sensitive product in a packaging, container assembly, storage assembly or moving storage assembly utilizing the phase change material in embodiments of the present disclosure, and transporting the temperature sensitive product from one location to another location.

[0074] Advantages of using the packaging, container assembly, storage assembly or moving storage assembly having the phase change materials include reduced costs achieved by using fewer reefers (e.g., refrigerated containers/refrigerated vehicles) during the transporting of the temperature sensitive product. The reduced costs can be achieved by less fuel usage for a reefer during the transporting of the temperature sensitive product

in the reefer. The reduced costs can be achieved by not having to have someone attend to a reefer used during the transporting of the temperature sensitive product in the reefer. Palates having temperature sensitive products and left out on a dock (e.g., sitting out) can be protected from freezing – the packaging having the phase change material freezes before product contained therein.

[0075] The reduced costs can also be achieved by fewer temperature sensitive products becoming unusable during the transporting of the temperature sensitive product. For example, the temperature sensitive products can be transported during hot days and cold night without adversely impacting the products (protects against temperatures that might cause the product to freeze at night/melt during day). The packaging, container assembly, storage assembly and moving storage assembly keep product temperature change minimal to avoid damaging the product.

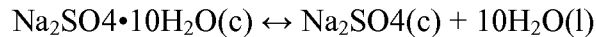
[0076] Reversible packaging having a temperature barrier layer in alternative embodiments can be produced for different reasons. The reversible packaging can include an absorption layer (e.g., black or dark layer) on one side, a shiny or reflective layer on the other side and a temperature barrier layer having the phase change material in the middle. The absorption layer facing outward can be designed to absorb radiation. The shiny reflective layer facing outward can be designed to reflect radiation. To protect a temperature sensitive product from freezing (e.g., during cold or winter seasons), the absorption layer can face outward with the reflective layer facing inward. To protect a temperature sensitive product from getting too hot (e.g., during warm or summer seasons), the reflective layer can face outward with the absorption layer facing inward. A passive insulation layer can also be placed between the temperature barrier layer and the absorption or reflective layer

EXAMPLES

[0077] By way of example and not limitation, the following examples are illustrative of various embodiments of the present disclosure. Percentages used herein are by weight unless specified otherwise.

EXAMPLE 1

[0078] One chemical that is a suitable phase change material is sodium sulfate decahydrate, or Glauber's salt. Glauber's salt goes thru phase transition at 32°C, which seems about ideal. The characteristics of Glauber's salt are as follows:



Heat of melting is 252 kJ/kg. For reference, ice to water is 334 kJ/kg.

252 - Heat of melting sodium sulfate decahydrate (kJ/kg)

4.184 - Water heat capacity (kJ/kg°C)

60 - weight of water 1 kg of salt can buffer against 1°C rise (kg)

Conversions

2.205 lb/kg

0.0009486 BTU/J

1.8 F/C

BTU/lb-F 4.184 kJ/Kg-C

Air buffering

0.24 Air heat cap. (BTU/lb-F)

1.004 Air heat cap. (kJ/kg-C)

0.0735 Density of air, 80°F (lb/cu ft)

2,376 40-ft shipping container volume (cu ft)

174.6 Air mass (lbs)

397.7 Energy necessary to heat air 5°C (KJ)

1.58 Amount of Na₂SO₄•10H₂O(c) necessary to buffer against air temp rise (kg)

Product/package buffering

1.26 Product/package heat capacity (kJ/kg°C)

6 Depth into pallet in question (inches)

48 Pallet width (in)

40 Pallet depth (in)

72 Pallet height (in)

900 Pallet weight (kg)

138,240 Volume total (cu in)

60,480 Volume inside (cu in)

56% % of weight in outer layer

506 Mass of product in outside layer of pallet (kg)

3,177 Energy necessary to heat product/package 5°C (kJ)

12.6 Amount of Na₂SO₄•10H₂O(c) necessary to buffer against product/package temp rise (kg)

EXAMPLE 2

[0079] To protect a product from reaching a particular temperature, a packaging having a temperature barrier layer should be created between the ideal temperature and the

dangerous temperature (e.g., temperature at which the product will become ruined). For a phase change material to be effective as the barrier, the change or transition from one form to another form (e.g., solid to liquid) should happen between a temperature that is acceptable (and most common) in storage or distribution and the dangerous temperature.

[0080] FIG. 8 shows a hypothetical situation for suitable temperature barrier layer designed a temperature sensitive product. The temperature barrier layer will protect the temperature sensitive product from being exposed to undesirable higher temperatures. The sinusoidal line 200 represents the fluctuation of ambient temperature over a period of several days. The shaded region represents the appropriate phase transition temperature (“PTT”).

[0081] In this example, the temperature barrier layer should prevent the temperature sensitive product from being exposed to a temperature above approximately 37 °C shown by dashed line 202. The lowest dashed line 204 represents the average temperature during storage or distribution, which in this case is 30 °C. The temperature barrier layer should include a sufficient amount of a phase change material having a transition phase (e.g., melting point) between 30 °C and 37 °C. Glaubert’s salt (having a melting point of 32 °C as shown by dashed line 206) could work as the phase change material of the temperature barrier layer in this case.

EXAMPLE 3

[0082] FIG. 9 shows the PTT to protect a temperature sensitive product from freezing. The temperature barrier layer will protect the temperature sensitive product from being exposed to undesirable lower temperatures. The sinusoidal line 210 represents the fluctuation of ambient temperature over a period of several days.

[0083] In this example, the temperature barrier layer should prevent the temperature sensitive product from being exposed to a temperature below approximately – 4 °C shown by dashed line 212. The higher dashed line 214 represents the average temperature during storage or distribution, which in this case is 0 °C. The temperature barrier layer should include a sufficient amount of a phase change material having a transition phase (e.g., melting point) between 0 °C and – 4 °C. A selection of 10% propylene glycol/90% water could work as the phase change material of the temperature barrier layer in this case.

EXAMPLE 4

[0084] To protect ice cream product from thawing during the frozen distribution, the ice cream product can be nominally kept at -30°C . The ice cream product should not be allowed to get above -22°C . As shown in FIG. 10, the line 220 represents the fluctuation of ambient temperature over a period of several days.

[0085] In this example, the temperature barrier layer should prevent the temperature sensitive product from being exposed to a temperature above approximately -22°C shown by dashed line 222. The lowest dashed line 226 represents the average continuous temperature during storage or distribution, which in this case is -30°C . The middle dashed line 224 represents the overall average temperature during storage or distribution, which in this case is -27°C .

[0086] The temperature barrier layer should include a sufficient amount of a phase change material having a transition phase between -22°C and -27°C . A selection of 40 % propylene glycol solution or 22% CaCl_2 could work as the phase change material of the temperature barrier layer in this case (see Table 1). Similarly, an ethanol/water or NaCl /water solution may work as the phase change material.

Table 1: Transition Phase Temperatures for Aqueous Solutions of Propylene Glycol and CaCl_2

Temperature ($^{\circ}\text{C}$)	Temperature ($^{\circ}\text{F}$)	Propylene Glycol (% weight)	CaCl_2 (% weight)
0	32	0	0
-3	26	10	5
-8	18	20	12
-14	7	30	17
-22	-8	40	22
-34	-29	50	28

EXAMPLE 5

[0087] Another application of the phase change materials is to keep a temperature sensitive product from both extreme lows and extreme highs during storage. In this

application, two temperature barrier layers each having a different phase change material (or two phase change materials in the same layer) can be used in the packaging. Protection against high temperatures would be offered by an appropriately selected solid phase change materials (e.g., solid at ideal distribution temperature). Protection against low temperatures would be offered by an appropriately selected liquid phase change materials (e.g., liquid at ideal distribution temperature). This may be particularly useful if a product has a narrow acceptable temperature window or if a product is shipped from a cold environment to a warm environment, or vice versa.

[0088] In the example shown in FIG. 11, sinusoidal line 300 represents the temperature fluctuation during storage or distribution. Downward sloping line 310 represents the average daily temperature.

[0089] one temperature barrier layer should prevent the temperature sensitive product from being exposed to a temperature above approximately 37 °C shown by dashed line 302. The dashed line 304 represents the average temperature during storage or distribution, which in this case is 27 °C. The temperature barrier layer should include a sufficient amount of a phase change material having a transition phase (e.g., melting point) between 27 °C and 37 °C. For example, a phase change material having a transition phase at 32 °C would work as shown by dashed line 306.

[0090] The second temperature barrier layer should prevent the temperature sensitive product from being exposed to a temperature below approximately – 4 °C shown by dashed line 312. Dashed line 308 the lower end of the average daily temperature of 5 °C. As a result, the second temperature barrier layer should include a sufficient amount of a phase change material having a transition phase (e.g., freezing point) between – 4 °C and 5 °C.

[0091] As long as the “daily average temperature” falls between the upper phase change material’s melting point and the lower phase change material’s freezing point, the phase change material selections should be adequate. Acceptable regions of the transition phases for suitable phase change materials are shaded in FIG. 11.

[0092] As used herein, “about,” is preferably understood to refer to numbers in a range of numerals. Moreover, all numerical ranges herein should be understood to include all integer, whole or fractions, within the range.

[0093] It should be understood that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the

art. Such changes and modifications can be made without departing from the spirit and scope of the present subject matter and without diminishing its intended advantages. It is therefore intended that such changes and modifications be covered by the appended claims.

CLAIMS

The invention is claimed as follows:

1. A packaging comprising a temperature barrier layer comprising at least one phase change material, said phase change material is within at least one compartment in the temperature barrier layer.
2. The packaging of Claim 1, wherein the temperature barrier layer comprises a second phase change material stored within the temperature barrier layer comprising a second phase change material.
3. The packaging of Claim 1 further comprising a layer including at least one of a reflective material and an insulating material.
4. The packaging of Claim 1 further comprising a layer including at least two of a reflective material or an insulating material or combinations thereof.
5. The packaging of Claim 1, wherein the phase change material comprises propylene glycol, calcium chloride, sodium sulfate decahydrate, or combinations thereof.
6. The packaging of Claim 1, wherein the phase change material comprises sodium sulfate decahydrate.
7. The packaging of Claim 1, wherein the temperature barrier layer is a shrink wrap film, the shrink wrap film constructed and arranged to conform to a surface of a temperature sensitive product.
8. The packaging of Claim 1, further comprising at least one indicator for determining the phase or transition change of the phase change material.
9. A packaged product comprising:
a temperature sensitive product;

and the packaging of any one of claims 1 to 8.

10. The packaged product of Claim 9, wherein the temperature sensitive product comprises a food product.
11. The packaged product of Claim 10, wherein the food product comprises a nutritional composition.
12. A container assembly comprising:
 - a support;
 - a temperature sensitive product positioned on the support;
 - and the packaging of any one of claims 1 to 8.
13. The container assembly of Claim 12, wherein the temperature sensitive product comprises a food product.
14. The container assembly of Claim 13, wherein the food product comprises a nutritional composition.
15. The container assembly of Claim 12, wherein the support comprises at least one of: a pallet, a slip sheet or combinations thereof.
16. A storage assembly comprising:
 - a storage unit;
 - a temperature sensitive product located within the storage unit;
 - and the packaging of any one of claims 1 to 8 attached to at least one wall of the storage unit.
17. The storage assembly of Claim 16, wherein the temperature sensitive product comprises a food product.
18. The storage assembly of Claim 17, wherein the food product comprises a nutritional composition.

19. The storage assembly of Claim 16, wherein the storage unit is selected from the group consisting of trailer, refrigerator, freezer, cargo container and combinations thereof.
20. The storage assembly of Claim 16, further comprising; a transporter; wherein the storage assembly is attached to the transporter.
21. The storage assembly of Claim 20, wherein the temperature sensitive product comprises a food product.
22. The storage assembly of Claim 21, wherein the food product comprises a nutritional composition.
23. The storage assembly of Claim 20, wherein the transporter is selected from the group consisting of car, truck, semi-truck, airplane, helicopter, boat, train and ship.
24. A method of protecting a temperature sensitive product from fluctuating temperatures during storage or transport, the method comprising: placing a temperature sensitive product in a packaging as claimed in any one of Claims 1 to 8, 12 and 16.
25. The method of Claim 24, wherein one or more of the warmed or heated temperature sensitive products are placed on a support, wherein the support and the temperature sensitive products are wrapped with the packaging.
26. The method of Claim 24, further comprising reducing distribution or transporting costs of a temperature sensitive product.