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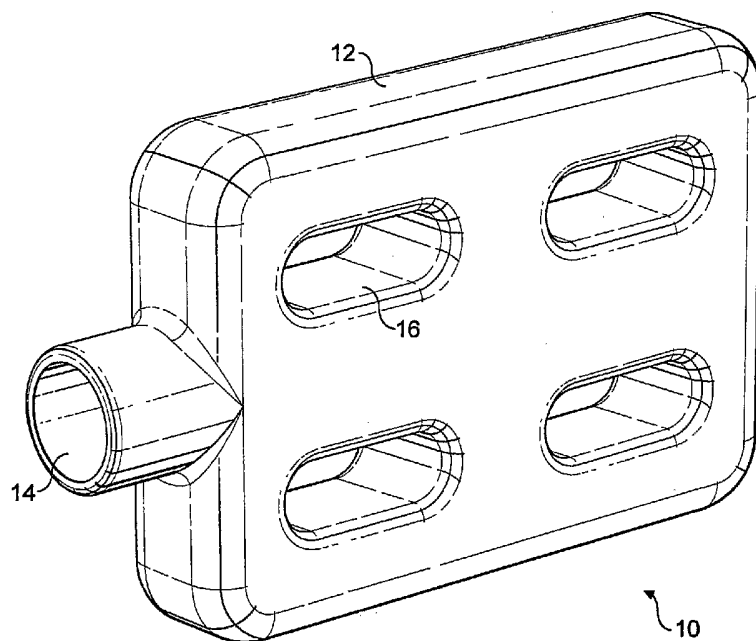
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(54) Title: AN EUTECTIC PLATE



(57) Abstract: An eutectic plate comprising: a housing containing a coolant, and a thermochromic material that undergoes a ther-
mochromic transition at a predefined temperature.

WO 2006/079828 A1

- 1 -

An Eutectic Plate

The present invention relates to an eutectic plate.

5 Temperature-sensitive products need to be stored within predetermined temperature ranges. For example, fresh foods, chilled foods and beverages and frozen foods have to be kept within particular temperature limits. The same is true for certain pharmaceutical products, such as medicines and
10 vaccines, as well as certain cosmetic products, for example, creams and lotions.

 Temperature-sensitive products are generally refrigerated and transported using cold-chain systems. In a
15 typical unpowered cold-chain system, the temperature-sensitive product is stored in an insulated container that is kept at a predetermined temperature or within a predetermined temperature range using one or more eutectic plates (also known as cold packs, cold dogs and cold gels).

20 An eutectic plate is a container that typically contains a phase change material, such as, for example, water or an aqueous solution. The eutectic plate is typically chilled in a refrigerator or freezer until the
25 phase change material freezes. The chilled plate is then placed in an insulated container containing the temperature-sensitive product. Heat from the container is absorbed by the chilled plate, causing the phase change material to melt. This change of state occurs without a change of
30 temperature; thus, the rate of change of temperature within the insulated container is reduced.

- 2 -

Various practices have been adopted to ensure that the insulated containers are maintained within target temperatures. Typically, the eutectic plates are chilled for prolonged periods of time to ensure that the plates are
5 sufficiently cold prior to use.

The present inventors have surprisingly found a number of disadvantages associated with this prior practice. For example, it has surprisingly been found that, in many
10 instances, the plates are chilled for far longer than necessary, leading to an increase refrigeration costs. In other instances, the plates are chilled to a lower temperature than necessary, causing the temperature-sensitive product to be chilled to too low a temperature.
15 This may have a detrimental effect on the temperature-sensitive product.

In other cases, it has been found that the eutectic plates are replaced with freshly chilled plates more
20 frequently than necessary, leading to an increase in refrigeration costs. It has also been found that, in some cases, more eutectic plates have been used in the insulated containers than necessary. Again, this leads to an increase in the cost of cold-chain distribution and storage.

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According to the present invention, there is provided an eutectic plate comprising:

a housing containing a coolant, and

a thermochromic material that undergoes a thermochromic
30 transition at a predefined temperature.

- 3 -

The thermochromic material undergoes a thermochromic transition at a predefined temperature. In one embodiment, the thermochromic material changes from a substantially transparent or clear state to a coloured state (or vice-versa) at the predefined temperature. In another embodiment, the thermochromic material changes from one colour to another at the predefined temperature.

The thermochromic transition may be used to provide a visual indication of whether the eutectic plate is at, above and/or below a target temperature.

Mixtures of thermochromic materials may be employed.

Preferably, the eutectic plate provides a visual indication of whether the eutectic plate is within or outside a target temperature range or at or above/below a target temperature. For example, the eutectic plate may exhibit a different colour or transparency depending on whether the eutectic plate is within the target temperature range, above the target temperature range or below the target range. In one embodiment, this is achieved by using a thermochromic material having more than one activation temperature. For example, when a thermochromic material having two activation temperatures is used, the material undergoes two thermochromic transitions at two different predefined temperatures. The first thermochromic change may occur when the temperature of the eutectic plate falls below the lower limit of the target temperature range and the second thermochromic change may occur when the temperature of the eutectic plate exceeds the upper limit of the target temperature range. As a result of these thermochromic

- 4 -

changes, the eutectic plate will have a different visual appearance depending on whether the eutectic plate is within the target temperature range, above the target temperature range or below the target range. Thermochromic materials
5 with three, four, five or more activation temperatures may be used.

Alternatively or additionally, two or more (e.g. three, four, five or more) thermochromic materials may be employed
10 to provide the necessary visual indications. For example, a first thermochromic material may be employed to exhibit a thermochromic change at the lower temperature limit of the target temperature range. As this thermochromic change causes the eutectic plate to adopt a particular appearance,
15 a user would therefore be able to determine if the temperature of the eutectic plate has fallen below this lower temperature limit simply by visual inspection. Similarly, a second thermochromic material may also be provided to exhibit a thermochromic change at the upper
20 temperature limit of the target temperature range. As this thermochromic change causes the eutectic plate to adopt a different appearance, a user would be able to determine if the temperature of the eutectic plate had exceeded the upper limit of the target temperature range by visual inspection.

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In one embodiment, the eutectic plate exhibits a red colour when it is above the target temperature range, a green colour when it is within the target temperature range and a blue colour when it is below the target temperature
30 range. In another embodiment, the eutectic plate exhibits a red colour when it is above the target temperature range, a blue colour when it is below the target temperature range

- 5 -

and is clear or transparent when it is within the target temperature range.

The target temperature range may be broad or narrow. Generally speaking, products that are highly sensitive to temperature changes are stored within narrow temperature ranges. On the other hand, the target temperature range may be broader for products that are less sensitive to temperature changes. The magnitude of the target temperature range may be 0.1 to 20°C, preferably, from 0.2 to 10°C, more preferably, 0.3 to 5°C, for example, 0.5 to 3°C. For highly temperature-sensitive products, the magnitude of the target temperature range may be 2°C or less, preferably 1°C or less, more preferably 0.5°C or less.

15

The eutectic plate may also provide a visual record of whether the temperature of the eutectic plate has changed over a predetermined period of time. For example, the eutectic plate may provide the user with a visual indication of whether the temperature of the eutectic plate exceeded the upper limit of the target temperature range and/or dropped below the lower limit of the target temperature range over a predetermined period of use. This information is preferably apparent to the user even if the current temperature of the eutectic plate is within the target temperature range. Thus, the eutectic plate may be used to provide the user with an indication of the temperature history of the eutectic plate.

In one embodiment, the eutectic plate is provided with a plurality of separate thermochromic materials which

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- 6 -

undergo thermochromic changes at different predefined temperatures. These thermochromic materials may be located at different locations on the eutectic plate, for example, in different thermochromic cells or areas. Each material
5 may undergo a thermochromic change at a characteristic predefined temperature. Thus, as the temperature of the eutectic plate increases, a series of thermochromic changes may occur. Each of these thermochromic changes may cause each thermochromic cell or area to adopt a particular
10 colour. Thus, a user would be able to determine by visual inspection how the temperature of the eutectic plate changed over a predetermined period of use. A chart (e.g. colour chart) may be provided, for example, on the surface of the eutectic plate, to assist the user in the "reading" of the
15 relevant temperature changes.

In one embodiment, the eutectic plate may be provided with an outer layer comprising the thermochromic material. The outer layer may surround a substantial portion of the
20 housing of the eutectic plate. For example, the outer layer may take the form of a sheath or jacket. Alternatively, the thermochromic material may be applied to at least a portion of the housing, for example, by painting, dip-coating, spraying or printing.

25

Preferably, the thermochromic material forms at least part of the housing. For example, in a preferred embodiment, the housing is moulded from a composition comprising the thermochromic material. As the thermochromic
30 material forms part of the housing itself, it advantageously provides an accurate indication of the temperature of the housing.

- 7 -

Alternatively or additionally, the thermochromic material may also be incorporated into the coolant. In this embodiment, the thermochromic material will form part of the eutectic plate itself. Thus, it can advantageously be used to provide an accurate indication of the temperature of the plate. For example, the thermochromic material may be dissolved or suspended in the coolant. Preferably, the coolant is visible through the housing. For example, the housing may be formed of a substantially transparent or clear material and/or include a substantially transparent or clear window through which the coolant may be viewed.

Any suitable material that exhibits a thermochromic transition at a predefined temperature may be used as the thermochromic material. As mentioned above, the thermochromic material may change colour or change from a substantially transparent or clear state to a coloured state (or vice-versa) at a predefined temperature. Preferably, the thermochromic transition is reversible. Thus, the thermochromic transition observed when the temperature of the material exceeds a particular threshold is reversed when the temperature of the material falls below that threshold.

When a reversible thermochromic material is employed, it may have a narrow or broad hysteresis. If a thermochromic material with a narrow hysteresis is heated above its predefined temperature and then cooled, it will return to its original state more quickly than a material with a broad hysteresis. Narrow hysteresis materials, therefore, are useful for providing an indication of the current temperature of the eutectic plate. Broad hysteresis

- 8 -

materials, on the other hand, are generally useful for providing an indication of the temperature history of the eutectic plate. Unlike narrow hysteresis materials, broad hysteresis materials can "memorise" previous thermochromic changes, as the shape of a curve formed by plotting the colour density of a broad hysteresis material against increasing temperature differs significantly from a curve formed by plotting colour density against decreasing temperature.

10

In one embodiment, one or more irreversible thermochromic material is employed in combination with one or more reversible thermochromic material. The irreversible thermochromic material may be used to provide a permanent visual indication of whether a predefined threshold temperature has been exceeded over a particular period of use or whether the temperature of the plate has dropped below a predefined threshold over a particular period of use.

20

The thermochromic material may be provided in the form of an ink, paint, crystals or in any other suitable form.

Suitable thermochromic materials include thermochromic polyacetylenes, such as those described in US 4,339,951, and thermochromic polythiophenes, such as those described in US 6,706,218.

In one embodiment, the thermochromic material comprises a thermochromic composition comprising a) an electron donating colour-developing organic compound, b) an electron-accepting compound and c) a reaction medium. The reaction

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- 9 -

medium typically plays an important role in determining the temperature at which the colour-developing reaction between components a) and b) arises. Examples of thermochromic compositions of this type are described in US 4,957,949, US 5 6,468,088, US 4,028,118 and US 4,732,810.

The electron-donating colour-developing organic compound (a) may be a colourless compound that forms a coloured product upon reaction with the electron-accepting 10 compound (b). Suitable electron-donating colour-developing organic compounds (a) include phenylmethanes, phthalides, phthalans, lactones, carbinols, auramines, lactams, indolines, spiropyrans and fluorans. For example, diaryl phthalides, indolylphthalides, polyarylcarbinols, leuco- 15 auramines, acylauramines, arylauramines, fluoran leuco compounds, triphenylmethane phthalide leuco compounds and lactam leuco compounds may be used.

Examples of compounds (a) include 3,3'- 20 dimethoxyfluoran, 3-chloro-6-phenylaminofluoran, 3-diethylamino-6-methyl-7-chlorofluoran, 3-diethyl-7,8-benzofluoran, 3,3',3"-tris(p-dimethylaminophenyl)phthalide, 3,3'-bis(p-dimethylaminophenyl)-7-phenylaminofluoran and 3-diethylamino-6-methyl-7-phenylaminofluoran.

25

Other examples of compounds (a) include Crystal Violet lactone, Malachite Green lactone, Michler's hydrol, Crystal Violet carbinol, Malachite Green carbinol, N-(2,3-dichlorophenyl)-leuco auramine, N-benzoyl auramine, N-acetyl 30 auramine, N-phenyl auramine, Rhodamine B lactam, 2-(phenylimonoethylidene)-3,3-dimethyl-indoline, N,3,3-trimethyl-indolinobenzo-spiropyran, 8'-methoxy-N,3,3-

- 10 -

trimethylindolino-spiropyran, 3-diethylamino-6-methyl-7-chloro-fluoran, 3-diethylamino-7-methoxy-fluoran, 3-dimethylamino-6-benzyloxy-fluoran, 1,2-benzo-6-diethylaminofluoran, 3,6-di-p-toluidino-4,5-dimethylfluoran-phenylhydrazide-gamma-lactam, 3-amino-5-phenyl-8methyl-fluoran, 2-methyl-3-amino-6-methyl-7-methyl-fluoran, 2,3-butylene-6-di-n-butylamino-fluoran, 3-diethylamino-7-anilino-fluoran, 3-diethylamino-7-(p-toluidino)-fluoran, 7-acetamino-3-diethylamino-fluoran, 2-bromo-6-cyclohexylamino-fluoran and 2,7-dichloro-3-methyl-6-n-butylamino-fluoran.

Suitable electron-accepting compounds (b) include phenolic compounds, such as phenolic hydroxyl compounds. Monophenolic and polyphenolic compounds may be employed. These may be substituted, for example, with alkyl, aryl, acyl, alkoxycarbonyl and/or halogen atoms. Azoles, organic acids, organic acids and organic salts may also be used.

Examples of suitable phenolic compounds include phenyl phenol, bisphenol A, cresol, resorcinol, chlorolucinol, β -naphthol, 1,5-dihydroxynaphthalene, pyrocatechol, pyrogallol, trimer of p-chlorophenol-formaldehyde condensate and the like.

Examples of azoles include benzotriazoles, such as 5-chlorobenzotriazole, 4-lauraminosulfobenzotriazole, 5-butylbenzotriazole, dibenzotriazole, 2-oxybenzotriazole, 5-ethoxycarbonyl-benzotriazole; imidazoles, such as oxybenzimidazole; tetrazoles and the like.

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Examples of organic acids include aromatic carboxylic acids, aliphatic carboxylic acids and substituted

- 11 -

derivatives thereof. Examples of aromatic carboxylic acids are salicylic acid, methylenebissalicylic acid, resorcylic acid, gallic acid, benzoic acid, p-oxybenzoic acid, pyromellitic acid, β -naphthoic acid, tannic acid, toluic acid, trimellitic acid, phthalic acid, terephthalic acid and anthranilic acid. Examples of aliphatic carboxylic acids include those containing about 1-20 carbon atoms, preferably about 3-15 carbon atoms, such as stearic acid, 1,2-hydroxystearic acid, tartaric acid, citric acid, oxalic acid and lactic acid. Examples of esters include alkyl esters of aromatic carboxylic acids in which the alkyl moiety has 1 to 6 carbon atoms, such as butyl gallate, ethyl p-hydroxybenzoate and methyl salicylate. Examples of salts include ammonium salt and metal salts of the above organic acids. The metal salts include, for example, lithium, sodium, calcium, magnesium, aluminium, zinc, tin, titanium, nickel or the like metal salts.

Other examples of electron-accepting compounds (b) include tert-butyl phenol, nonyl phenol, dodecyl phenol, styrenated phenol, 2,2'-methylene-bis(4-methyl-6-tert-butylphenol), alpha-naphthol, beta-naphthol, hydroquinone monomethyl ether, guaiacol, eugenol, p-chlorophenol, bromophenol, o-chlorophenol, o-bromophenol, o-phenylphenol, p-phenylphenol, p-(p-chlorophenyl)-phenol, o-(o-chlorophenyl)-phenol, methyl p-hydroxybenzoate, ethyl p-hydroxybenzoate, propyl p-hydroxybenzoate, octyl p-hydroxybenzoate, dodecyl phenol p-hydroxybenzoate, 3-isopropyl-catechol, p-tert-butyl-catechol, 4,4'-methylene-diphenol 4,4'-thio-bis(6-tert-butyl-3-methyl-phenol), bisphenol A, 1,2-dihydroxynaphthalene, 2,3-dihydroxynaphthalene, chlorocatechol, bromocatechol, 2,4-

- 12 -

dihydroxybenzophenone, phenol, phthalein, o-cresol
phthalein, methyl protococatechuate, ethyl protococatechuate,
propyl protococatechuate, octyl protococatechuate, dodecyl
protocatechuate, 2,4,6-trihydroxymethyl-benzene, methyl
5 gallate, ethyl gallate, ethyl gallate, propyl gallate, butyl
gallate, hexyl gallate, octyl gallate, dodecyl gallate,
cetyl gallate, 2,3,5-trihydronaphthalene, tannic acid and
phenol-formaldehyde prepolymers.

10 The reaction medium may be an alcohol, such as an
aliphatic monovalent alcohol. Preferably, the alcohol has
more than 8 carbon atoms. More preferably, the alcohol has
10 to 30 carbon atoms, for example, 12 to 20 carbon atoms.
Specific examples include fatty alcohols, such as lauryl
15 alcohol, myristyl alcohol, cetyl alcohol, stearyl alcohol,
docosyl alcohol and oleyl alcohol. Other examples include
octyl alcohol and dodecyl alcohol.

The ratio of components a), b) and c) may be varied to
20 suit requirements. Typically, the composition contains 1 to
50 weight %, preferably 5 to 20 weight % of component (a), 2
to 40 weight %, preferably, 5 to 30 weight % of component
(b) and 10 to 90 weight %, preferably 20 to 60 weight % of
component (c).

25

Components (a), (b) and (c) may be each a mixture of
two or more compounds.

Optionally, the thermochromic composition may further
30 comprise an alcohol ester (d). Suitable alcohol ester
components include octyl caprylate, decyl caprylate, octyl
caprate, decyl caprate, cetyl caprate, stearyl caprate,

- 13 -

- butyl laurate, octyl laurate, lauryl laurate, stearyl laurate, butyl myristate, decyl myristate, myristyl myristate, cetyl myristate, octyl palmitate, butyl stearate, decyl stearate, lauryl stearate, stearyl stearate, 12-
- 5 hydroxy stearic acid triglyceride and the like. The alcohol ester component may affect the sharpness and temperature of the colouration reaction. Component d) may optionally be present in an amount of 1 to 10 weight % of the composition.
- 10 The thermochromic composition may be microencapsulated prior to use. Any coating material may be used to microencapsulate the composition. Examples include polyurea, polyamide, polyurethane, polyester, epoxy resin, melamine resin, urea resin, methylcellulose,
- 15 carboxymethylcellulose, cationized starch, carboxymethylated starch, ethylcellulose, polystyrene, polyvinyl acetate, polyvinyl alcohol, polyvinylpyrrolidone, polyacrylic acid, polyacrylamides and polymers and copolymers of maleic acid. Other examples of coating materials include alginic acid and
- 20 salts thereof, carrageenan, pectin and gelatin.

The microcapsules may be prepared by any suitable method. Examples include interfacial polymerization, in-situ polymerization, submerged hardening, coating, phase

25 separation from an aqueous solution, phase separation from an organic solvent, melt dispersion cooling, air suspension coating and spray drying.

The microcapsules may have a particle diameter of from

30 0.01 to 100 μm , preferably from 0.01 to 50 μm , more preferably from 0.01 to 30 μm and yet more preferably 0.01 to 6 μm .

- 14 -

The microencapsulated or non-microencapsulated thermochromic material may be formulated as an ink, paint or dye before being used in the eutectic plate of the present invention. Alternatively, the thermochromic material may be employed in crystal form.

Suitable thermochromic materials are sold under the trademark ColorTell[™] of Clark R&D Limited and Chromicolor[™]. These materials contain thermochromic pigments supplied by the Matsui Shikiso Chemical Company (see, e.g. US 4,957,949).

The thermochromic material(s) may undergo a thermochromic transition(s) at a temperature from -60 to +60°C, preferably from -40 to +40°C. Within this range, the transition(s) may occur at a temperature from 10 to 35°C, preferably 15 to 30°C, for example, 20 to 25°C. Alternatively, the transition(s) may occur at a temperature of from 0 to 10°C, preferably 1 to 8°C, for example 2 to 4°C. In yet another alternative, the transition(s) may occur at a temperature of from -1 to -30°C, preferably, -5 to -10°C, for example -5 to -15°C. The transition(s) may alternatively occur at a temperature of from -10 to -60°C, for example -25 to -40°C.

The thermochromic material may be used in combination with a non-thermochromic pigment. Such pigments are background pigments that may take on a different appearance depending on the state of the thermochromic material. For example, if a thermochromic material that is transparent below a threshold temperature and yellow above a threshold

- 15 -

temperature is used in combination with a blue background pigment, the combination will appear blue below the threshold temperature and green above the threshold temperature. By selecting suitable background pigments, therefore, the colour changes may be tailored accordingly.

The housing may be made from any suitable material. Preferably, the housing is formed from a polymer, more preferably a thermosetting resin. Examples of suitable polymers include polyolefins (e.g. polypropylene and polyethylene), polyesters, polyurethanes, polyacrylates, poly(ethylene terephthalate)s, polystyrenes, polycarbonates, polyacrylics, polyacrylamides, polymethacrylics, polyvinylethers, polyvinylhalides (e.g. PVC), polyesters, polystyrene and polyamides.

The housing may be formed by any suitable technique. Preferably, the housing is injection moulded, rotor moulded or blow moulded into shape. As described above, the housing may be moulded from a moulding composition comprising the thermochromic material. The concentration of thermochromic material in the moulding composition may be from 0.1 to 30%, preferably 0.5 to 15%, for example 1 to 10%, of the total weight of the composition. In one embodiment, a thermochromic material is grounded or otherwise mixed with a polymer and the resulting composition is used to mould the housing.

Suitable moulding compositions comprising the thermochromic material are described in US 4,957,949. For example, the moulding composition may be formed from a thermochromic masterbatch comprising a wax having

- 16 -

substantially dispersed therein a thermochromic granular material which is microencapsulated as described above. The wax may be paraffin wax, microcrystalline wax, montan wax, carnuba wax, polystyrene wax, polyethylene wax, propylene wax or a mixture thereof. The granular material may be a mixture of a polymer resin and a thermochromic composition comprising a) an electron donating colour-developing organic compound, b) an electron-accepting compound and c) a reaction medium as described above. The polymer resin present in the thermochromic masterbatch is preferably compatible with or is the same as the polymer resin from which the housing is moulded. For example, when the housing is moulded from a polyolefin, the resin in the thermochromic masterbatch is preferably a polyolefin.

The thermochromic masterbatch may be ground or otherwise mixed with a polymer and the resulting mixture may be used to mould the housing.

In an alternative embodiment, the thermochromic material may be applied to the housing, for example, by painting or printing. The thermochromic material may comprise microcapsules of thermochromic composition.

The housing may be provided with an aperture through which coolant may be introduced. Preferably, the aperture may be sealed by a closure, such as a screw cap.

The housing may be shaped such that it can absorb heat from the surroundings in an efficient manner. For example, in one embodiment, the housing is a substantially flat container with a large surface area to volume ratio. The

- 17 -

outer surface of the housing may be provided with dimples or contours. Passages or apertures may also extend through the housing. These may assist the user in lifting and carrying the plates.

5

The housing is preferably substantially cuboid. However, housings that are, for example, substantially cylindrical in shape may be employed. When a substantially cuboid housing is used, the housing may have a width of 5 to 10 120 cm, preferably 10 to 100 cm, for example, 20 to 80 cm. The length of the housing may be 5 to 120 cm, preferably 10 to 100 cm, for example, 20 to 80 cm, whilst the depth of the housing may be 1 to 30 cm, preferably 2 to 20 cm, more preferably 3 to 15 cm, for example, 5 to 10 cm.

15

Any suitable coolant may be introduced into the housing. The coolant may be an antifreeze material. Antifreeze materials may be formed by dissolving inorganic salts, such as, for example, sodium chloride, magnesium 20 chloride, calcium chloride, potassium acetate, sodium acetate, ammonium phosphate and ammonium nitrate in a liquid such as water. Alternatively or additionally, organic compounds such as alcohols, glycols, lactates and urea may be dissolved in water. In one embodiment, the antifreeze 25 material comprises an aqueous solution of sugar alcohols, ethylene glycol and/or propylene glycol.

The coolant may also be a phase change material or eutectic liquid. When a phase change material melts, it 30 absorbs latent heat from its surroundings. The latent heat absorbed causes the phase change material to change state.

- 18 -

However, it does not cause the temperature of the phase change material to rise.

Suitable phase change materials include water and/or
5 organic liquids. Preferred phase change materials are obtainable under the trademark TEAP Energytm.

The coolant may have a melting/freezing point in the range of from -60 to +60°C, preferably from -40 to +40°C.
10 Within this range, the melting/freezing point of the coolant may be from 10 to 35°C, preferably, 15 to 30°C, for example, 20 to 25°C. Alternatively, the coolant may have a melting/freezing point of may be 0 to 10°C, preferably, 1 to 8°C, for example, 2 to 4°C. In yet another alternative, the
15 melting/freezing point of the coolant may be -1 to -30°C, preferably, -5 to -20°C, for example, -5 to -15°C. Coolants with melting/freezing points of from -10 to -60°C, preferably, -25 to -40°C, may also be employed.

20 The eutectic plate of the present invention may be used to provide a controlled temperature environment for a temperature-sensitive product. Therefore, the eutectic plate of the present invention is preferably used in combination with an insulated container. According to a
25 further aspect of the invention, there is provided a cold storage apparatus comprising an insulated container and the eutectic plate of the present invention.

In use, the eutectic plate of the present invention may
30 be chilled in a refrigerator or freezer until the phase change material freezes. If desired, the plate may be

- 19 -

chilled to a temperatures lower than the target temperature range and then left, for example, at room temperature to heat up to the desired temperature/temperature range prior to use. When the plate reaches its target temperature, the thermochromic material of the eutectic plate has a characteristic appearance. Thus, a user is able to determine whether the plate has reached its target temperature simply by visual inspection. The chilled plate may then be placed in an insulated container containing the temperature-sensitive product. Heat from the container is absorbed by the chilled plate. When a phase change material is used as the coolant, this absorption of heat causes the phase change material to melt. This change of state occurs without a change of temperature; thus, the rate of change of temperature within the insulated container is reduced.

After a period of time, however, the heat absorbed from the container may be sufficient to cause the temperature of the plate to rise. When the temperature of the plate rises above a predefined temperature, the thermochromic material undergoes a thermochromic change. Thus, by visual inspection, the user will know that the predefined temperature has been exceeded. This may provide the user with an estimate of the remaining "life" of the plate or indicate that the plate should be replaced with a freshly refrigerated plate.

The eutectic plate of the present invention may be used for cold chain distribution (transport) and storage applications. In particular, the eutectic plate of the present invention may be used to provide a controlled temperature environment for a temperature-sensitive product,

- 20 -

such as a food product, a beverage, a cosmetic product or a chemical or pharmaceutical product. Suitable food products include meat, fish, fruit, vegetables and dairy products. Suitable beverages include chilled drinks, fresh juices and milk. Suitable chemicals include inks and solvents. Suitable cosmetic products include creams, lotions and waxes. Suitable pharmaceutical products include medicines and vaccines.

10 The eutectic plate may be chilled and used to provide a target temperature range that typically falls between -60 and +60°C, preferably between -40 and +40°C. Within this range, so-called "room temperature" products may be stored at a target temperature range of, for example, from 10 to 15 35°C, preferably, 15 to 30°C, for example, 20 to 25°C. For chilled products, the target temperature range may be 1 to 10°C, preferably, 2 to 8°C, for example, 2 to 4°C. For frozen products, the target temperature range may be -1 to -30°C, preferably, -5 to -20°C, for example, -5 to -15°C. 20 Other frozen products may require target temperature ranges of -10 to -60°C, preferably, -25 to -40°C.

 The eutectic plate may be used to provide broad and narrow target temperature ranges. As described above, the 25 magnitude of the target temperature range may be 0.1 to 20°C, preferably, from 0.2 to 10°C, more preferably, 0.3 to 5°C, for example, 0.5 to 3°C. For highly temperature-sensitive products, the magnitude of the target temperature range may be 2°C or less, preferably 1°C or less, more 30 preferably, 0.5°C or less.

- 21 -

The eutectic plate may be used in, for example, vending machines for fresh, chilled and frozen foods, snacks and beverages; storage and/or transport containers for chilled and frozen foods, cosmetics, medicines and vaccines; and
5 vehicle refrigeration/freezing, for example, truck refrigeration/freezing and refrigeration/freezing onboard other vehicles such as ships and aeroplanes.

An embodiment of the present invention will now be
10 described with reference to the accompanying drawing which is a schematic diagram of a eutectic plate according to one embodiment of the present invention.

The eutectic plate 10 comprises a housing 12 moulded
15 from a moulding composition comprising a thermochromic material and a plastics material. The housing 12 is a substantially flat container comprising an aperture 14 for the introduction of an eutectic liquid (not shown). When the housing is filled, the aperture may be closed using a
20 screw cap (not shown). The outer surface of the housing 12 is provided with a plurality of apertures 16 that extend through the depth of the housing 12. The apertures make it easier for the eutectic plate to be lifted and held by a
25 user. They also increase the surface area over which heat may be absorbed.

EXAMPLE

Pellets of a thermochromic concentrate comprising 18%
30 of a microencapsulated thermochromic composition and 82% of a polyethylene resin (Chromicolourtm) were mixed with polyethylene pellets in a tumbling mixer in a weight ratio

- 22 -

of 1:9. The mixture was then injection moulded to form the housing shown in the drawing at a moulding temperature of 210°C, a mould temperature of 50°C and an injection pressure of 800 kg/cm³.

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The housing was colourless and clear at room temperature. However, when the housing was chilled to -4°C and below, the housing appeared coloured. The colour change was reversed when the temperature of the housing raised
10 above -4°C. The reversible colour change could be repeated over and over again.

- 23 -

CLAIMS

1. An eutectic plate comprising:
5 a housing containing a coolant, and
a thermochromic material that undergoes a thermochromic transition at a predefined temperature.
2. A plate as claimed in claim 1, wherein the coolant is
10 an anti-freeze or an eutectic liquid.
3. A plate as claimed in claim 1 or 2, which provides a visual indication of whether the eutectic plate is:
a) within a target temperature or target temperature
15 range,
b) above the a target temperature or target temperature range, and
c) below the a target temperature or target temperature range.
20
4. A plate as claimed in claim 3, which comprises a first thermochromic material and a second thermochromic material, wherein the first thermochromic material undergoes a thermochromic transition at a first predefined temperature
25 and the second thermochromic material undergoes a thermochromic transition at a second predefined temperature
5. A plate as claimed in claim 3 or 4, which comprises a thermochromic material that undergoes a first thermochromic
30 transition at a first predefined temperature and a second thermochromic transition at a second predefined temperature.

- 24 -

6. A plate as claimed in any one of the preceding claims, wherein the housing is provided with an outer layer comprising the thermochromic material.
- 5 7. A plate as claimed in claim 6, wherein the outer layer is applied by printing, painting or dip-coating.
8. A plate as claimed in claim 6, wherein the outer layer takes the form of a jacket or sheath.
- 10 9. A plate as claimed in any one of claims 1 to 5, wherein the housing is moulded from a material comprising the thermochromic material.
- 15 10. A plate as claimed in claim 9, wherein the housing is formed from a moulding composition comprising the thermochromic material and a polymer.
11. A plate as claimed in any one of claims 1 to 5, wherein
20 the thermochromic material is incorporated into the coolant.
12. A plate as claimed in claim 11, wherein the housing is provided with a transparent region through which the coolant may be viewed.
- 25 13. A plate as claimed in any one of the preceding claims, wherein the thermochromic material is provided in the form of crystals, a paint or an ink.
- 30 14. A plate as claimed in any one of the preceding claims, wherein the thermochromic material is microencapsulated.

- 25 -

15. A plate as claimed in any one of the preceding claims, wherein a non-thermochromic background pigment is used in combination with the thermochromic material.
- 5 16. A cold storage apparatus comprising an insulated container and an eutectic plate as claimed in any one of the preceding claims.
17. An apparatus as claimed in claim 16, which provides a
10 controlled temperature environment within -40 to +40°C.
18. An apparatus as claimed in claim 16 or 17, which comprises more than one eutectic plate.
- 15 19. An apparatus as claimed in any one of claims 16 to 18, wherein the insulated container contains a temperature-sensitive product selected from a food product, a beverage, a cosmetic product and a pharmaceutical product.
- 20 20. A method of maintaining a temperature-sensitive product within a target temperature range, said method comprising:
 providing an eutectic plate as claimed in any one of claims 1 to 15,
 placing the eutectic plate in a controlled temperature
25 environment,
 determining whether the eutectic plate is at a desired temperature or within a desired temperature range by visual inspection,
 placing the cooling eutectic plate in an insulated
30 container with the temperature-sensitive product.

- 26 -

21. A method as claimed in claim 20, wherein the eutectic plate is refrigerated or frozen prior to use.

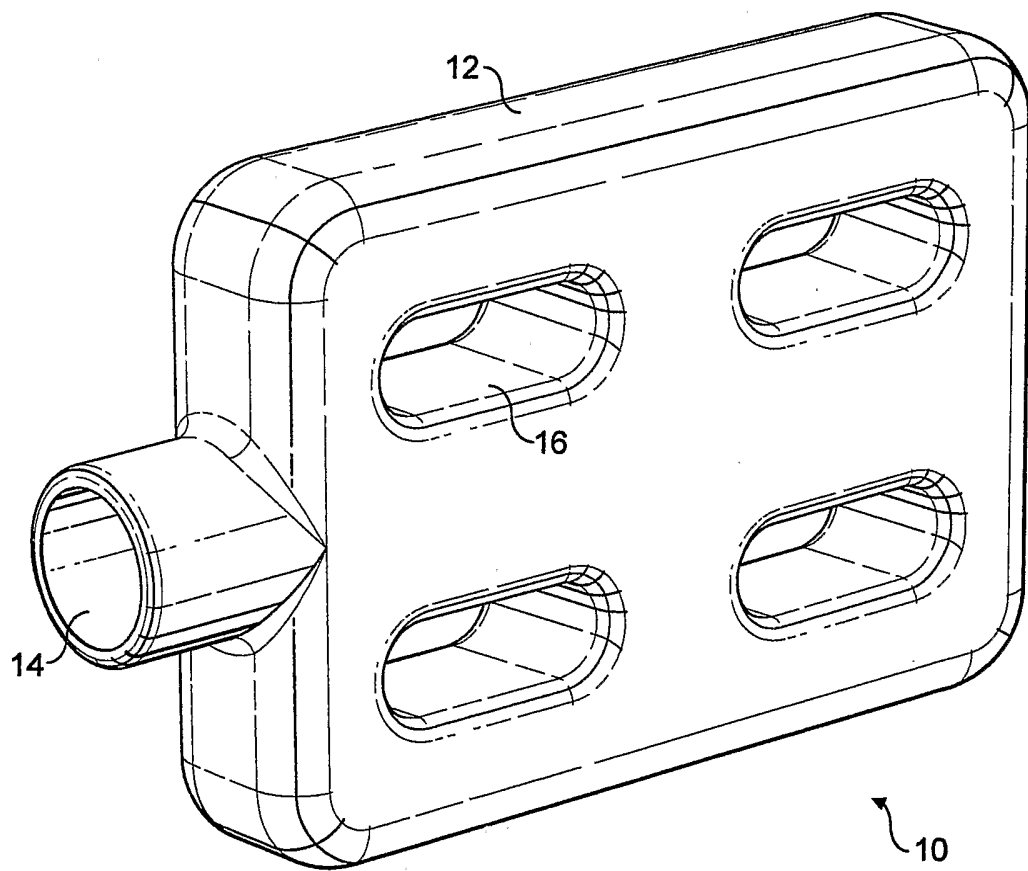
22. A method as claimed in claim 20 or 21, wherein the
5 eutectic plate is placed in a controlled temperature
environment and chilled to a lower temperature than desired
and then allowed to heat up to the desired temperature or
temperature range by exposing the plate to the ambient
temperature.

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INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2006/000286

A. CLASSIFICATION OF SUBJECT MATTER
F25D3/00

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
F25D

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

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

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	PATENT ABSTRACTS OF JAPAN vol. 2002, no. 09, 4 September 2002 (2002-09-04) -& JP 2002 129153 A (KANASUGI KOGEI:KK; NAKAGAWA KENICHI), 9 May 2002 (2002-05-09) abstract; figures 1-5	1-5, 11-22
X A	DE 30 31 176 A1 (ZORN, EDGAR) 1 April 1982 (1982-04-01) figure 1 page 5, paragraph 2 - page 6, paragraph 1	1-6, 14, 16-22 7
X	US 6 361 746 B1 (WLODARSKI JULIE ANN) 26 March 2002 (2002-03-26) abstract; figure 1 column 3, line 5 - line 11	1-3, 9, 10, 16, 17, 19-22
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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

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A	abstract; figure 1 paragraph [0026]	16,20-22
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A	figure claims 2,3	16,20-22

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2006/000286

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