Claims

1. A thermal control system comprising an inorganic phase change material and an organic phase change material, wherein:

the organic phase change material and the inorganic phase change material are present at a ratio in the range of 1:1 to 1:5, and

the inorganic phase change material comprises a salt and a first additive, wherein the first additive is selected from the group consisting of carbon-based fibre, fumed silica, porous silica, aerogel and glass sphere.

2. The thermal control system according to claim 1, wherein the inorganic phase change material and the organic phase change material are physically mixed with each other, or wherein the inorganic phase change material forms a first layer and the organic phase change material forms a second layer, whereby the first layer and the second layer are physically distinct from each other.

3. The thermal control system according to claim 1 or 2, wherein the organic phase change material and the inorganic phase change material is independently present at a thickness in the range of 5 mm to 3 cm.

4. The thermal control system according to claim 2 or 3, wherein the first layer and the second layer are separated by a layer of fluid or are in direct contact with each other, or wherein the first layer is the inner layer and the second layer is the outer layer, or the first layer is the outer layer and the second layer is the inner layer, relative to an item to be cooled, wherein the inner layer at least partially surrounds the item to be cooled, and the outer layer at least partially surrounds the inner layer, and wherein the outer layer and inner layer are of the same temperature, or wherein the outer layer is of a relatively lower temperature than the inner layer.

5. The thermal control system according to any one of the preceding claims, wherein the salt comprises a first metal selected from group 1, group 2, group 7, group 8, group 9, group 10, group 12 or group 13 of the Periodic Table of Elements, and an anion, and wherein the first additive is a nano-sized material, a micro-sized material or a mixture thereof, or wherein the thermal conductivity of the first additive is in the range of ~~about~~ 0.005 W/(m*K) to ~~about~~ 0.07 W/(m*K).

6. The thermal control system according to claim 5, wherein the inorganic phase change material comprises 5 wt% to 35 wt% salt.

7. The thermal control system according to claim 5 or 6, wherein the inorganic phase change material comprises:

70 wt% to 80 wt% water;

15 wt% to 25 wt% $CaCl_2.6H_2O$

3 wt% to 4 wt% NaCl;

0.2 wt% to 0.7 wt% porous silica microstructure; and

0.5 wt% to 1.5 wt% carbon fiber nanostructure,

such that the total wt% of each component adds to 100 wt%.

8. The thermal control system according to any one of the preceding claims, wherein the organic phase change material comprises a hydrocarbon and a second additive, wherein the hydrocarbon is an optionally functionalized aliphatic and wherein the second additive is a nano-sized material, a micro-sized material or a mixture thereof, or wherein the thermal conductivity of the second additive is in the range of 20-50 W/(m*K).

9. The thermal control system according to claim 8, wherein the organic phase change material comprises 50 wt% to 98 wt% hydrocarbon.

10. The thermal control system according to claim 8 or 9, wherein the organic phase change material comprises:

65 wt% to 75 wt% $C_{11}H_{24}$ hydrocarbon;

15 wt% to 25 wt% $C_{12}H_{26}$ hydrocarbon;

2.5 wt% to 7.5 wt% $C_{13}H_{28}$ hydrocarbon;

1.5 wt% to 2.5 wt% carbon nanotube; and

2.5 wt% to 3.5 wt% copper nanoparticle,

such that the total wt% of each component adds to 100 wt%.

11. The thermal control system according to any one of claims 8 to 10, wherein the organic phase change material comprises:

5 wt% to 15 wt% hydrocarbon selected from the group consisting of $C_{10}H_{22}$, $C_{11}H_{24}$ and $C_{14}H_{30}$;

25 wt% to 35 wt% $C_{12}H_{26}$ hydrocarbon;

55 wt% to 65 wt% $C_{13}H_{28}$ hydrocarbon; and

0.5 wt% to 2 wt% carbon nanostructure;

such that the total wt% of each component adds to 100 wt%.

12. The thermal control system according to any one of the preceding claims comprising:

35 wt% to 40 wt% water;

7.5 wt% to 12.5 wt% $CaCl_2.6H_2O$

1.5 wt% to 2 wt% NaCl;

0.1 wt% to 0.35 wt% porous silica microstructure;

0.25 wt% to 0.75 wt% carbon fiber nanostructure,

32.5 wt% to 37.5 wt% $C_{11}H_{24}$ hydrocarbon;

7.5 wt% to 12.5 wt% $C_{12}H_{26}$ hydrocarbon;

1.25 wt% to 3.75 wt% $C_{13}H_{28}$ hydrocarbon;

0.75 wt% to 1.25 wt% carbon nanotube; and

1.25 wt% to 1.75 wt% copper nanoparticle,

such that the total wt% of each component adds to 100 wt%.

13. The thermal control system according to any one of claims 1 to 11 comprising:

35 wt% to 40 wt% water;

7.5 wt% to 12.5 wt% $CaCl_2.6H_2O$

1.5 wt% to 2 wt% NaCl;

0.1 wt% to 0.35 wt% porous silica microstructure;

0.25 wt% to 0.75 wt% carbon fiber nanostructure,

2.5 wt% to 7.5 wt% hydrocarbon selected from the group consisting of $C_{10}H_{22}$, $C_{11}H_{24}$ and $C_{14}H_{30}$;

12.5 wt% to 17.5 wt% $C_{12}H_{26}$ hydrocarbon;

27.5 wt% to 32.5 wt% $C_{13}H_{28}$ hydrocarbon; and

0.25 wt% to 1 wt% carbon nanostructure;

such that the total wt% of each component adds to 100 wt%.

14. The thermal control system according to any one of the preceding claims, further comprising a thermally insulating material at least partially surrounding the inorganic phase change material and the organic phase change material.

15. The thermal control system according to claim 14, comprising an inner thermally insulating material which at least partially surrounds the inorganic and organic phase change

material, and an outer thermally insulating material which at least partially surrounds the inner thermally insulating material.

16. A method of preparing a thermal control system, the method comprising the step of contacting an inorganic phase change material with an organic phase change material, wherein:

the organic phase change material and the inorganic phase change material are present at a ratio in the range of 1:1 to 1:5, and

the inorganic phase change material comprises a salt and a first additive, wherein the first additive is selected from the group consisting of carbon-based fibre, fumed silica, porous silica, aerogel and glass sphere.

17. The method according to claim 16, wherein the contacting step results in direct contact between the inorganic phase change material and the organic phase change material, or wherein the contacting step comprises the step of bringing the inorganic phase change material and the organic phase change material together with a layer of fluid in between.

18. The method according to claim 16 or 17, further comprising the step of at least partially surrounding an item to be cooled with the inorganic phase change material and the organic phase change material, or further comprising the step of at least partially surrounding the inorganic phase change material and the organic phase change material with a thermally insulating material.

19. A method for maintaining a temperature of an item, the method comprising the step of providing a thermal control system comprising an inorganic phase change material and an organic phase change material, wherein:

the organic phase change material and the inorganic phase change material are present at a ratio in the range of 1:1 to 1:5, and

the inorganic phase change material comprises a salt and a first additive, wherein the first additive is selected from the group consisting of carbon-based fibre, fumed silica, porous silica, aerogel and glass sphere.

20. The method according to claim 19, further comprising the steps of pre-cooling the organic phase change material and/or the inorganic phase change material to a temperature below -15 °C, and contacting or at least partially surrounding an item to be cooled with the thermal control system.