CLAIMS

What is claimed is:

1. A multi-layer thermal-regulating surface coating, comprising:

an outer layer comprising a material having a porous structure, wherein:

in a dry state, a first refractive index of the material mismatches a second refractive index of air in pores of the porous structure to exhibit a first solar transmittance; and

in a wet state, the first refractive index of the material matches a third refractive index of water in the pores of the porous structure to exhibit a second solar transmittance; and

a middle layer disposed adjacent an inner surface of the outer layer, wherein the middle layer comprises a photo-thermal material comprising a MXene compound.

2. The surface coating of claim 1, wherein the photo-thermal material also comprises carbon.

3. The surface coating of claim 1 or 2, further comprising an inner layer disposed adjacent an inner surface of the middle layer, wherein:

the material of the outer layer comprises a polymeric structure of an organic material;

each of the middle layer and the inner layer also comprise the polymeric structure of the organic material; and

a thickness of the outer layer and a thickness of the middle layer are each smaller than a thickness of the inner layer.

4. The surface coating of claim 3, wherein the organic material comprises cellulose acetate (CA) and/or polyvinylidene fluoride (PVDF).

5. The surface coating of claim 3 or 4, wherein the middle layer comprises less than 10 mg/cm^3 of the photo-thermal material disposed in the polymeric structure of the organic material.

6. The surface coating of any one of claims 3 to 5, wherein the thickness of the inner layer is greater than 1 mm.

7. The surface coating of any one of claims 3 to 6, wherein the outer layer, the middle layer and the inner layer comprise a fire-retardant material disposed in the polymeric structure of the organic material.

8. The surface coating of claim 7, wherein the fire-retardant material comprises bromide.

9. The surface coating of any one of the preceding claims, wherein the material of the outer layer further comprises a hydrophilic structure.

10. The surface coating of any one of the preceding claims, wherein the first solar transmittance of the outer layer in the dry state is lower than the second solar transmittance of the outer layer in the wet state.

11. The surface coating of any one of the preceding claims, wherein the outer layer further comprises a viral-phobic and/or bacterial-phobic nanomaterial disposed on an outer surface of the outer layer.

12. The surface coating of claim 11, wherein the viral-phobic and/or bacterial-phobic nanomaterial comprises nanoparticles of TiO_2 and/or nanoparticles of Ag.

13. A method for fabricating a multi-layer thermal-regulating surface coating, comprising:

fabricating an outer layer comprising a material having a porous structure, wherein:

in a dry state, a first refractive index of the material mismatches a second refractive index of air in pores of the porous structure to exhibit a first solar transmittance; and

in a wet state, the first refractive index of the material matches a third refractive index of water in the pores of the porous structure to exhibit a second solar transmittance; and

fabricating a middle layer, wherein the middle layer is disposed adjacent an inner surface of the outer layer, and wherein the middle layer comprises a photo-thermal material comprising a MXene compound.

14. The method of claim 13, wherein fabricating the middle layer comprising the photo-thermal material comprises fabricating the middle layer comprising a photo-thermal material comprising the MXene compound and carbon.

15. The method of claim 13 or 14, further comprising fabricating an inner layer adjacent an inner surface of the middle layer,
wherein:

fabricating the outer layer comprises fabricating the outer layer of a material comprising a polymeric structure of an organic material and fabricating the outer layer to have a thickness smaller than a thickness of the inner layer;

fabricating the inner layer comprises fabricating the inner layer of a material having the same polymeric structure of the organic material as the material of the outer layer; and

fabricating the middle layer comprises fabricating the middle layer of a material having the same polymeric structure of the organic material as the material of the outer layer and fabricating the middle layer to have a thickness smaller than the thickness of the inner layer.

16. The method of claim 15, wherein fabricating the middle layer further comprises disposing less than 10 mg/cm^3 of the photo-thermal material in the polymeric structure of the organic material of the middle layer.

17. The method of claim 15 or 16, wherein fabricating the outer layer, fabricating the middle layer and fabricating the inner layer each further comprise disposing a fire-retardant material in the polymeric structure of the organic material of the outer layer, the middle layer and the inner layer.

18. The method of any one of claims 13 to 17, wherein fabricating the outer layer further comprises fabricating a hydrophilic structure in the material of the outer layer.

19. The method of any one of claims 13 to 18, further comprising disposing a viral-phobic and/or bacterial-phobic nanomaterial on an outer surface of the outer layer.

20. The method of any one of claims 15 to 17 comprising:
applying the inner layer on a surface;
applying the middle layer on the inner layer; and
applying the outer layer on the middle layer.

21. The method of any one of claims 15 to 17 further comprising applying the multi-layer thermal-regulating surface coating comprising the inner layer, the middle layer and the outer layer on a surface.