In one embodiment, the silane may be 50% to 60% of the hybrid sol-gel by weight, and the solvent may be 40% to 50% of the hybrid sol-gel by weight. Accordingly, the weight ratio of silane to solvent may be between 1.5:2 and 1:1. In another embodiment, the silane may be between 52% and 58% of the hybrid sol-gel by weight, and the solvent may be between 42% and 46% of the hybrid sol-gel by weight. In a more particular embodiment, the silane may be about 56% of the hybrid sol-gel by weight, and the solvent may be about 44% of the hybrid sol-gel by weight. Accordingly, the weight ratio of silane to solvent may be about 1.3:1. As used herein, the term "about" means within two to three percent. In one embodiment, the hybrid sol-gel may consist essentially of the silane and solvent materials.

In another embodiment, the base composition of the hybrid sol-gel may be modified with other, additional materials. For example, the hybrid sol-gel may be doped with a dopant or doping material, for instance, an ultraviolet blocking material. Accordingly, materials for providing strengthening and ultraviolet blocking properties may be applied in only one step. Accordingly, an ultraviolet blocking material need not be applied in a coating step separate from the hybrid sol-gel coating step. As used herein, the phrase "ultraviolet blocking" includes reducing ultraviolet transparency and not necessarily resulting in 100% ultraviolet opacity. The ultraviolet blocking material may include one or more metal oxides, for example, at least one of cerium oxide, titanium oxide, zinc oxide, bismuth oxide, or barium titanate. In another embodiment, the ultraviolet blocking material may include one or more metal alkoxides, for example, at least one of cerium alkoxide or titanium dialkoxide. Accordingly, in this embodiment, the doped hybrid sol-gel may include, and preferably may consist essentially of, the

Claims

1.

A method of coating an exterior surface of a glass container that includes the steps of:

(a) providing a heated hybrid sol-gel having a composition including at least one silane and at least one solvent, wherein said hybrid sol-gel is heated to a temperature between 70 degrees Celsius and 130 degrees Celsius;

(b) coating an exterior glass surface of a glass container (10 or 110) with said heated hybrid sol-gel, wherein said coating step is carried out at a temperature between 90 degrees Celsius and 130 degrees Celsius; and

(c) heating said coated exterior glass surface of the glass container to cross-link said hybrid sol-gel and result in a coating on said exterior glass surface of the glass container having greater than 90% silicate-based material by weight.

2.

The method set forth in claim 1 wherein said composition in step (a) includes between 50% and 60% by weight of at least one silane and between 40% and 50% by weight of at least one solvent, and said heating step (c) is carried out at a temperature of between 130 degrees Celsius and 170 degrees Celsius and for a time between ten minutes and ten hours.

3.

The method set forth in claim 1 wherein said composition in step (a) includes between 52% and 58% by weight of at least one silane and between 42% and 46% by weight of

at least one solvent, said temperature in step (a) is between 90 degrees Celsius and 110 degrees Celsius, said temperature in step (b) is between 95 degrees Celsius and 125 degrees Celsius, and said heating step (c) is carried out at a temperature of between 140 degrees Celsius and 160 degrees Celsius.

4.

The method set forth in claim 1 wherein said composition in step (a) includes about 56% by weight of at least one silane and about 44% by weight of at least one solvent, said temperature in step (a) is about 100 degrees Celsius, said temperature in step (b) is about 110 degrees Celsius, and said heating step (c) is carried out at a temperature of about 150 degrees Celsius.

5.

The method set forth in claim 1 wherein said at least one silane in step (a) includes at least one of methyltriethoxysilane, dimethyldiethoxysilane, phenyltriethoxysilane, diphenyldiethoxysilane, phenyltrimethoxysilane, diphenyldimethoxysilane, 3 glycidoxypropyltrimethoxisilane, 3 glycidoxypropyldimethoxyethoxysilane, aminopropylmethyldimethosilane, aminopropyltrimethoxysilane, gamma mercaptopropyltrimethoxysilane, or vinyltrimethoxysilane, and wherein said at least one solvent in step (a) includes at least one of denatured ethanol, anhydrous ethanol, methanol, normal propanol, isopropanol, butanol, diethylene glycol, acetones, methylethylketones, tryethyleneglycols, vinylpyrrolidones, toluene, glycerine, phenol, benzyl alcohol, or dioxane.

6.

The method set forth in claim 1 wherein said at least one silane in step (a) includes methyltriethoxysilane and dimethyldiethoxysilane, and wherein said at least one solvent includes at least one of denatured ethanol or anhydrous ethanol.

7.

The method set forth in claim 1 wherein said at least one silane in step (a) includes phenyltriethoxysilane and diphenyldiethoxysilane, and wherein said at least one solvent includes anhydrous ethanol.

8.

The method set forth in claim 1 wherein said at least one silane in step (a) includes phenyltrimethoxysilane and diphenyldimethoxysilane, and wherein said at least one solvent includes methanol.

9.

The method set forth in claim 1 wherein said composition in step (a) includes a silane to solvent weight ratio of between 1.5:1 and 1:1.

10.

The method set forth in claim 1 wherein said composition in step (a) includes a silane to solvent weight ratio of about 1.3:1.

11.

The method set forth in claim 1 wherein said hybrid sol-gel is doped with an ultraviolet blocking material, wherein ultraviolet blocking material is not applied in a separate step.

12.

The method set forth in claim 11 wherein said ultraviolet blocking material is at least one of cerium oxide, titanium oxide, zinc oxide, bismuth oxide, or barium titanate.

13.

The method set forth in claim 1 wherein said hybrid sol-gel is doped with at least one metal alkoxide that is not applied in a separate step.

14.

The method set forth in claim 13 wherein said at least one metal alkoxide is at least one of cerium alkoxide or titanium dialkoxide.

15.

The method set forth in claim 1 wherein said at least one silane includes at least one of methyltriethoxysilane, dimethyldiethoxysilane, phenyltriethoxysilane, diphenyldiethoxysilane, phenyltrimethoxysilane, diphenyldimethoxysilane, 3 glycidoxypropyltrimethoxisilane, 3 glycidoxypropyldimethoxyethoxysilane,

aminopropylmethyldimethosilane, aminopropyltrimethoxysilane, gamma mercaptopropyltrimethoxysilane, or vinyltrimethoxysilane.

16.

The method set forth in claim 1 wherein said at least one solvent includes at least one of denatured ethanol, anhydrous ethanol, methanol, normal propanol, isopropanol, butanol, diethylene glycol, acetones, methylethylketones, tryethyleneglycols, vinylpyrrolidones, toluene, glycerine, phenol, benzyl alcohol, or dioxane.

17.

A glass container made by the method set forth in claim 1

In one embodiment, the silane may be 50% to 60% of the hybrid sol-gel by weight, and the solvent may be 40% to 50% of the hybrid sol-gel by weight. Accordingly, the weight ratio of silane to solvent may be between 1.5:1 and 1:1. In another embodiment, the silane may be between 52% and 58% of the hybrid sol-gel by weight, and the solvent may be between 42% and 46% of the hybrid sol-gel by weight. In a more particular embodiment, the silane may be about 56% of the hybrid sol-gel by weight, and the solvent may be about 44% of the hybrid sol-gel by weight. Accordingly, the weight ratio of silane to solvent may be about 1.3:1. As used herein, the term "about" means within two to three percent. In one embodiment, the hybrid sol-gel may consist essentially of the silane and solvent materials.

In another embodiment, the base composition of the hybrid sol-gel may be modified with other, additional materials. For example, the hybrid sol-gel may be doped with a dopant or doping material, for instance, an ultraviolet blocking material. Accordingly, materials for providing strengthening and ultraviolet blocking properties may be applied in only one step. Accordingly, an ultraviolet blocking material need not be applied in a coating step separate from the hybrid sol-gel coating step. As used herein, the phrase "ultraviolet blocking" includes reducing ultraviolet transparency and not necessarily resulting in 100% ultraviolet opacity. The ultraviolet blocking material may include one or more metal oxides, for example, at least one of cerium oxide, titanium oxide, zinc oxide, bismuth oxide, or barium titanate. In another embodiment, the ultraviolet blocking material may include one or more metal alkoxides, for example, at least one of cerium alkoxide or titanium dialkoxide. Accordingly, in this embodiment, the doped hybrid sol-gel may include, and preferably may consist essentially of, the

Claims

1.

A method of coating an exterior surface of a glass container that includes the steps of:

(a) providing a heated hybrid sol-gel having a composition including at least one silane and at least one solvent, wherein said hybrid sol-gel is heated to a temperature between 70 degrees Celsius and 130 degrees Celsius;

(b) coating an exterior glass surface of a glass container (10 or 110) with said heated hybrid sol-gel, wherein said coating step is carried out at a temperature between 90 degrees Celsius and 130 degrees Celsius; and

(c) heating said coated exterior glass surface of the glass container to cross-link said hybrid sol-gel and result in a coating on said exterior glass surface of the glass container having greater than 90% silicate-based material by weight.

2.

The method set forth in claim 1 wherein said composition in step (a) includes between 50% and 60% by weight of at least one silane and between 40% and 50% by weight of at least one solvent, and said heating step (c) is carried out at a temperature of between 130 degrees Celsius and 170 degrees Celsius and for a time between ten minutes and ten hours.

3.

The method set forth in claim 1 wherein said composition in step (a) includes between 52% and 58% by weight of at least one silane and between 42% and 46% by weight of

at least one solvent, said temperature in step (a) is between 90 degrees Celsius and 110 degrees Celsius, said temperature in step (b) is between 95 degrees Celsius and 125 degrees Celsius, and said heating step (c) is carried out at a temperature of between 140 degrees Celsius and 160 degrees Celsius.

4.

The method set forth in claim 1 wherein said composition in step (a) includes about 56% by weight of at least one silane and about 44% by weight of at least one solvent, said temperature in step (a) is about 100 degrees Celsius, said temperature in step (b) is about 110 degrees Celsius, and said heating step (c) is carried out at a temperature of about 150 degrees Celsius.

5.

The method set forth in claim 1 wherein said at least one silane in step (a) includes at least one of methyltriethoxysilane, dimethyldiethoxysilane, phenyltriethoxysilane, diphenyldiethoxysilane, phenyltrimethoxysilane, diphenyldimethoxysilane, 3 glycidoxypropyltrimethoxisilane, 3 glycidoxypropyldimethoxyethoxysilane, aminopropylmethyldimethosilane, aminopropyltrimethoxysilane, gamma mercaptopropyltrimethoxysilane, or vinyltrimethoxysilane, and wherein said at least one solvent in step (a) includes at least one of denatured ethanol, anhydrous ethanol, methanol, normal propanol, isopropanol, butanol, diethylene glycol, acetones, methylethylketones, tryethyleneglycols, vinylpyrrolidones, toluene, glycerine, phenol, benzyl alcohol, or dioxane.

6.

The method set forth in claim 1 wherein said at least one silane in step (a) includes methyltriethoxysilane and dimethyldiethoxysilane, and wherein said at least one solvent includes at least one of denatured ethanol or anhydrous ethanol.

7.

The method set forth in claim 1 wherein said at least one silane in step (a) includes phenyltriethoxysilane and diphenyldiethoxysilane, and wherein said at least one solvent includes anhydrous ethanol.

8.

The method set forth in claim 1 wherein said at least one silane in step (a) includes phenyltrimethoxysilane and diphenyldimethoxysilane, and wherein said at least one solvent includes methanol.

9.

The method set forth in claim 1 wherein said composition in step (a) includes a silane to solvent weight ratio of between 1.5:1 and 1:1.

10.

The method set forth in claim 1 wherein said composition in step (a) includes a silane to solvent weight ratio of about 1.3:1.

11.

The method set forth in claim 1 wherein said hybrid sol-gel is doped with an ultraviolet blocking material, wherein ultraviolet blocking material is not applied in a separate step.

12.

The method set forth in claim 11 wherein said ultraviolet blocking material is at least one of cerium oxide, titanium oxide, zinc oxide, bismuth oxide, or barium titanate.

13.

The method set forth in claim 1 wherein said hybrid sol-gel is doped with at least one metal alkoxide that is not applied in a separate step.

14.

The method set forth in claim 13 wherein said at least one metal alkoxide is at least one of cerium alkoxide or titanium dialkoxide.

15.

The method set forth in claim 1 wherein said at least one silane includes at least one of methyltriethoxysilane, dimethyldiethoxysilane, phenyltriethoxysilane, diphenyldiethoxysilane, phenyltrimethoxysilane, diphenyldimethoxysilane, 3 glycidoxypropyltrimethoxisilane, 3 glycidoxypropyldimethoxyethoxysilane,

aminopropylmethyldimethosilane, aminopropyltrimethoxysilane, gamma mercaptopropyltrimethoxysilane, or vinyltrimethoxysilane.

16.

The method set forth in claim 1 wherein said at least one solvent includes at least one of denatured ethanol, anhydrous ethanol, methanol, normal propanol, isopropanol, butanol, diethylene glycol, acetones, methylethylketones, tryethyleneglycols, vinylpyrrolidones, toluene, glycerine, phenol, benzyl alcohol, or dioxane.

17.

A glass container made by the method set forth in claim 1.

18.

The method set forth in claim 1 wherein said hybrid sol-gel has a solids content of greater than 90% by volume.