LIGHT TRANSPARENT FLUOROPOLYMER COMPOSITION AND ARTICLE

Cross Reference To Related Application

This application claims the benefit of U.S. Provisional Patent Application Number 62/013796, filed June 18, 2014, the disclosure of which is incorporated by reference herein in its entirety.

Background

[0001] Extrusion processing of fluoropolymers can cause degradation by-products such as hydrofluoric acid which has a corrosive effect on common extrusion processing equipment and can create an undesirable environment for workers. A relatively expensive solution is to make the fluoropolymer extrusion processing equipment out of high nickel content stainless steels such as HASTELLOY and INCONEL. This solution does not address the undesirable environment for workers. In addition, high nickel content stainless steels are softer and have a tendency to wear more quickly. Alternative extrusion processing of fluoropolymers that address these corrosive effects on common extrusion processing equipment and undesirable environment for workers is desired.

Summary

[0002] The present disclosure describes a light transparent fluoropolymer composition having less than 2 percent haze, comprising at least one of alkali metal (e.g., lithium, sodium, and potassium) cation, alkali metal (e.g., lithium, sodium, and potassium) and a corresponding anion (e.g., CO_3,OH, $OOCCH_3$), alkaline earth metal cation (e.g., calcium, magnesium, strontium, and barium), or alkaline earth metal cation (e.g., calcium, magnesium, strontium, and barium) and a corresponding anion (e.g., CO_3,OH, $OOCCH_3$), wherein the light transparent fluoropolymer has at least 90 (in some embodiments, at least 95, 96, 97, 98, or even greater than 99) % visible light transmission. In some examples, light transparent fluoropolymer compositions described herein, comprise at least 0.01 (in some examples, at least 0.05, or even at least 0.1; in some examples, up to 1.0; in some examples, in a range from 0.01 to 1, 0.05 to 1.0, or even, 0.1 to 1.0) percent by weight of the alkali metal ionic species and alkaline earth metal ionic species present, based on the total weight of the composition.

[0003] The present disclosure describes an article having a surface structured light transparent fluoropolymer film comprising at least one of alkali metal (e.g., lithium, sodium, and potassium) cation, alkali metal (e.g., lithium, sodium, and potassium) and a corresponding anion (e.g., CO_3,OH, $OOCCH_3$), alkaline earth metal cation (e.g., calcium, magnesium, strontium, and barium), or alkaline earth metal cation (e.g., calcium, magnesium, strontium, and barium) and a corresponding anion

(e.g., CO_3,OH, $OOCCH_3$), wherein the surface structured light transparent fluoropolymer film has at least 95 (in some embodiments, at least 96, 97, 98, or even greater than 99) % visible light transmission. In some examples, at least 0.01 (in some examples, at least 0.05, or even at least 0.1; in some examples, up to 1.0; in some examples, in a range from 0.01 to 1.0, 0.05 to 1.0, or even, 0.1 to 1.0) percent by weight of the alkali metal ionic species and alkaline earth metal ionic species present, based on the total weight of the surface structured light transparent fluoropolymer in the film.

[0004] Exemplary uses of light transparent fluoropolymer compositions described herein include films (e.g., solar reflective films, solar transparent frontside photovoltaic films, commercial graphic overlay film, outdoor tape, and tubing (e.g., transparent tubing for medical applications, solar thermal heating of liquids)). Exemplary forms of articles described herein include surface structured anti-reflective films for the front side of photovoltaic modules and solar thermal panels.

[0004a] According to one aspect, there is provided a multilayer optical film comprising at least 5 layers, wherein the optical film comprises an optical stack with alternating film layers of: a first film layer comprising a light transparent fluoropolymer composition wherein the fluoropolymer composition comprises at least one fluoropolymer and 0.01 to 1 percent by weight, based on the total weight of the fluoropolymer composition, of at least one of: an alkali metal cation, an alkali metal and a corresponding anion, or an alkaline earth metal cation, and an alkaline earth metal and a corresponding anion, wherein in a range from 0.01 to 1 percent by weight of the alkali metal cations and alkaline earth metal cations are present, based on the total weight of the composition, and wherein the first film layer light transparent fluoropolymer composition has at least 95% visible light transmission and less than 2 percent haze as measured with a haze meter; and a second polymeric film layer.

Brief Description of the Drawings

[0005] FIG. 1 is a cross-sectional view of an exemplary fluoropolymer film described herein.

[0006] FIG. 2 is a cross-sectional view of an exemplary fluoropolymer film with an adhesive layer described herein.

[0007] FIG. 3 is a cross-sectional view of an exemplary multi-layer fluoropolymer film described herein.

[0008] FIG. 4 is a cross-sectional view of an exemplary multi-layer optical film comprising hundreds of alternating layers of fluoropolymer with hundreds of alternating layers of another polymer. Not all layers are shown.

[0009] FIG. 5 is a cross-sectional view of an exemplary fluoropolymer film having a structured surface.

[0010] FIG. 6 is a cross-sectional view of an exemplary surface structured fluoropolymer film with an adhesive layer.

[0011] FIG. 7 is a cross-sectional view of an exemplary multi-layer surface structured fluoropolymer film with a second polymer layer.

[0012] FIG. 8 is a cross-sectional view of an exemplary multi-layer optical film with a structured surface comprising hundreds of alternating layers of fluoropolymer with hundreds of alternating layers of another polymer. Not all layers are shown.

[0013] FIG. 9 is a photoelectromicrograph image of alkali earth metal nanoparticles coated onto a fluoropolymer pellet.

What is claimed is:

1. A multilayer optical film comprising at least 5 layers, wherein the optical film comprises an optical stack with alternating film layers of:

a first film layer comprising a light transparent fluoropolymer composition wherein the fluoropolymer composition comprises at least one fluoropolymer and 0.01 to 1 percent by weight, based on the total weight of the fluoropolymer composition, of at least one of:

an alkali metal cation,

an alkali metal and a corresponding anion,

an alkaline earth metal cation, and

an alkaline earth metal and a corresponding anion,

wherein the first film layer has at least 95% visible light transmission and less than 2 percent haze as measured with a haze meter; and

a second polymeric film layer.

2. The optical film of claim 1, wherein the fluoropolymer is at least one of tetrafluoroethylene (TFE), vinylidene fluoride (VDF), vinyl fluoride (VF), hexafluoropropylene (HFP), chlorotrifluoroethylene (CTFE), fluoroalkyl vinyl ethers, fluoroalkoxy vinyl ethers, fluorinated styrenes, fluorinated siloxanes, hexafluoropropylene oxide (HFPO), homopolymers of TFE, copolymers of ethylene and TFE copolymers; copolymers of TFE, HFP, and VDF; homopolymers of VDF; copolymers of VDF; homopolymers of VF; copolymers of HFP and TFE; copolymers of TFE and propylene; copolymers of TFE and (perfluorovinyl) ether; copolymers of TFE, (perfluorovinyl) ether, and (perfluoromethyl vinyl) ether; copolymers of HFP, TFE, and ethylene; homopolymers of chlorotrifluoroethylene; copolymers of ethylene and CTFE; homopolymers of HFPO; homopolymers of 4-fluoro-(2-trifluoromethyl)styrene; copolymers of TFE and norbornene; copolymers of HFP and VDF; combinations thereof , or copolymers of tetrafluoroethylene, hexafluoropropylene, and vinylidene fluoride.

3. The optical film of claim 1 or 2, wherein the first film layer further comprises polymethylmethacrylate (PMMA).

4. The optical film of any preceding claim, wherein the first film layer further comprises at least one UV absorber.

5. The optical film of any preceding claim, wherein the first film layer comprises at least one HALS light stabilizer.

6. The optical film of any preceding claim, wherein the optical film has an anti-reflective, structured major surface.

7. The optical film of any preceding claim, wherein the optical stack comprises at least 50 layers.

8. The optical film of any preceding claim, wherein the optical stack comprises at least 100 layers.

9. The optical film of any preceding claim, further comprising protective, non-optical skin layers on opposed major surfaces of the optical stack.

10. The optical film of claim 9, wherein the non-optical skin layers comprise an ultraviolet absorber.

11. The optical film of any preceding claim, wherein the optical film has an elongation at break of 10% to 200% at 25°C.

12. The optical film of any preceding claim, wherein the second polymeric film layer is chosen from polymethylmethacrylate (PMMA), polyethyl methacrylate (PEMA), copolymers of PMMA (CoPMMA), polyolefin copolymers, functionalized polyolefins, and combinations thereof.

13. The optical film of any preceding claim, wherein the alkali metal is chosen from lithium, sodium, and potassium.

14. The optical film of any preceding claim, wherein the alkaline earth metal is chosen from calcium, magnesium, strontium and barium.

15. The optical film of any preceding claim, wherein the alkaline earth metal is calcium, and the corresponding anion is chosen from CO_3, OH, and $OOCCH_3$.

16. The optical film of any preceding claim, wherein the alkaline earth metal and corresponding anion comprise $CaCO_3$.