STRUCTURALLY-COLORED ARTICLES AND METHODS FOR MAKING AND USING STRUCTURALLY-COLORED ARTICLES

BACKGROUND

Structural color is caused by the physical interaction of light with the micro- or nano-features of a surface and the bulk material as compared to color derived from the presence of dyes or pigments that absorb or reflect specific wavelengths of light based on the chemical properties of the dyes or pigments. Color from dyes and pigments can be problematic in a number of ways. For example, dyes and pigments and their associated chemistries for fabrication and incorporation into finished goods may not be environmentally friendly.

SUMMARY

According to a first aspect of the present invention, there is provided a bladder comprising:

a bladder wall having an interior-facing side and an exterior-facing side, wherein the interior-facing side defines at least a portion of an interior region of the bladder, and wherein the bladder wall further includes an average wall thickness between the interior-facing side and exterior-facing side that is less than 5 millimeters; and

a multi-layer optical film having a first side and a second opposing side, wherein the first side of the multi-layer optical film is operably disposed on the exterior-facing side of the bladder wall, and wherein the multi-layer optical film imparts a structural color to the bladder wall,

the multi-layer optical film comprising a multilayer filter or multilayer reflector such that the structural color has a single hue regardless of viewing angle or multihued having two or more hues where the hue changes abruptly between hues as the angle of observation or illumination changes.

According to a second aspect of the present invention, there is provided a method of making a bladder, the method comprising:

operably disposing a multi-layer optical film onto an exterior-facing side of a first bladder wall of a bladder, wherein the multi-layer optical film has a first side and a second opposing side, wherein the first side of the multi-layer optical film or the second side of the multi-layer optical film is disposed on the exterior-facing side of the bladder wall, and wherein the multi-layer optical film imparts a structural color to the bladder wall,

and wherein the multi-layer optical film comprising a multilayer filter or multilayer reflector such that the structural color has a single hue regardless of viewing angle or multihued having two or more hues where the hue changes abruptly between hues as the angle of observation or illumination changes.

BRIEF DESCRIPTION OF THE DRAWINGS

Further aspects of the present disclosure will be more readily appreciated upon review of the detailed description of its various embodiments, described below, when taken in conjunction with the accompanying drawings.

Figure 1 illustrates an article of footwear that includes the multi-layer optical films of the present disclosure.

What is claimed is:

1. A bladder comprising:

a bladder wall having an interior-facing side and an exterior-facing side, wherein the interior-facing side defines at least a portion of an interior region of the bladder, and wherein the bladder wall further includes an average wall thickness between the interior-facing side and exterior-facing side that is less than 5 millimeters; and

a multi-layer optical film having a first side and a second opposing side, wherein the first side of the multi-layer optical film is operably disposed on the exterior-facing side of the bladder wall, and wherein the multi-layer optical film imparts a structural color to the bladder wall,

the multi-layer optical film comprising a multilayer filter or multilayer reflector such that the structural color has a single hue regardless of viewing angle or multihued having two or more hues where the hue changes abruptly between hues as the angle of observation or illumination changes.

2. The bladder of claim 1, wherein the bladder wall exhibits a nitrogen gas transmission rate of 15 cm^3/m^2•atm•day or less.

3. The bladder of claim 1, wherein the bladder wall further comprises alternating first and second polymeric layers, wherein the first polymeric layers each comprise one or more thermoplastic polyurethanes, and wherein the second polymeric layers each comprise one or more thermoplastic ethylene-vinyl alcohol polymers.

4. The bladder of claim 1, wherein the bladder wall comprises one or more thermoplastic polyurethanes.

5. The bladder of claim 1, wherein the multi-layer optical film comprises:

a first layer compositionally comprising a non-oxide metal; and

a second layer compositionally comprising a first metal oxide.

6. The bladder of claim 5, and further comprising a third layer compositionally comprising a second metal oxide that is different from the first metal oxide.

7. The bladder of claims 1, wherein the multi-layer optical film comprises:

a first layer compositionally comprising a first metal oxide; and

a second layer compositionally comprising a second metal oxide different from the first metal oxide.

8. The bladder of claim 1, further comprising a primer layer disposed on the exterior-facing side of the bladder wall, and wherein the first side of the multi-layer optical film is disposed on the primer layer.

9. The bladder of claim 1, wherein the bladder is an inflated bladder and further comprises a gas retained within the interior region of the bladder.

10. The bladder of claim 1, wherein the bladder further comprises a plurality of topographical structures extending from the exterior-facing side of at least one of the one or more sidewalls such that the multi-layer optical film covers the plurality of topographical structures.

11. The bladder of claim 1, wherein each color visible at each possible angle of observation is assigned to a single hue selected from the group consisting of the primary, secondary and tertiary colors on the red yellow blue (RYB) color wheel, all of the assigned hues fall into a single hue group, wherein the single hue group is one of a) green-yellow, yellow, and yellow-orange; b) yellow, yellow-orange and orange; c) yellow-orange, orange, and orange-red; d) orange-red, and red-purple; e) red, red-purple, and purple; f) red-purple, purple, and purple-blue; g) purple, purple-blue, and blue; h) purple-blue, blue, and blue-green; i) blue, blue-green and green; and j) blue-green, green, and green-yellow.

12. The bladder of claim 1, wherein the structural color imparted to the bladder wall has a metallic appearance.

13. The bladder of claim 1, wherein the multi-layer optical film comprises a multilayer reflector having at least two adjacent layers having different refractive indices, wherein at least one of the layers of the multilayer reflector has a thickness that is about one fourth of the wavelength of visible light to be reflected by the multi-layer optical film to impart the structural color.

14. The bladder of claim 1, wherein the bladder is a cushioning element for an article of footwear.

15. A method of making a bladder, the method comprising:

operably disposing a multi-layer optical film onto an exterior-facing side of a first bladder wall of a bladder, wherein the multi-layer optical film has a first side and a second opposing side, wherein the first side of the multi-layer optical film or the second side of the multi-layer optical film is disposed on the exterior-facing side of the bladder wall, and wherein the multi-layer optical film imparts a structural color to the bladder wall,

and wherein the multi-layer optical film comprising a multilayer filter or multilayer reflector such that the structural color has a single hue regardless of viewing angle or multihued having two or more hues where the hue changes abruptly between hues as the angle of observation or illumination changes.

16. The method of claim 15, further comprising disposing a primer layer onto the exterior-facing side prior to the step of operably disposing the multi-layer optical film, and wherein the step of disposing the primer layer comprises depositing a metal oxide using a deposition process.

17. The method of claim 15, wherein the multi-layer optical film comprises:

a first layer compositionally comprising a first metal oxide; and

a second layer compositionally comprising a second metal oxide different from the first metal oxide.

18. The method of claim 15, wherein the bladder further comprises a plurality of topographical structures extending from the exterior-facing side of at least one of the one or more sidewalls such that the multi-layer optical film covers the plurality of topographical structures.

19. The method of claim 15, wherein each color visible at each possible angle of observation is assigned to a single hue selected from the group consisting of the primary, secondary and tertiary colors on the red yellow blue (RYB) color wheel, all of the assigned hues fall into a single hue group, wherein the single hue group is one of a) green-yellow, yellow, and yellow-orange; b) yellow, yellow-orange and orange; c) yellow-orange, orange, and orange-red; d) orange-red, and red-purple; e) red, red-purple, and purple; f) red-purple, purple, and purple-blue; g) purple, purple-blue, and blue; h) purple-blue, blue, and blue-green; i) blue, blue-green and green; and j) blue-green, green, and green-yellow.

20. The method of claim 15, wherein the structural color imparted to the bladder wall has a metallic appearance.