STRUCTURALLY-COLORED ARTICLES AND METHODS OF 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 an aspect of the present invention, there is provided an article comprising:

a component forming at least a portion of the article, the component having a first surface; and

an optical element having a first side and a second side opposing the first side, wherein the first side of the optical element, the second side of the optical element, or both impart a structural color to the component;

wherein the first side of the optical element or the second side of the optical element is disposed on the first surface of the component;

wherein the structural color imparted is a single hued structural color, and the optical element includes at least one optical layer, wherein at least one of the layers of the optical element has a thickness that is about one fourth of the wavelength of visible light to be reflected by the optical element to impart the single hued structural color.

BRIEF DESCRIPTION OF THE DRAWINGS

Further embodiments 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.

Figures 1A-1M illustrate footwear, apparel, athletic equipment, containers, electronic equipment, and vision wear that include the optical elements of the present disclosure..

Figures 2A-2B illustrate side views of exemplary optical elements of the present disclosure.

What is claimed is:

1. An article comprising:

a component forming at least a portion of the article, the component having a first surface; and

an optical element having a first side and a second side opposing the first side, wherein the first side of the optical element, the second side of the optical element, or both impart a structural color to the component;

wherein the first side of the optical element or the second side of the optical element is disposed on the first surface of the component;

wherein the structural color imparted is a single hued structural color, and the optical element includes at least one optical layer, wherein at least one of the layers of the optical element has a thickness that is about one fourth of the wavelength of visible light to be reflected by the optical element to impart the single hued structural color.

2. The article of claim 1, wherein at least a portion of the first surface of the component onto which the first side of the optical element or the second side of the optical element is disposed is defined by a first polymeric material, wherein the optical element is disposed on the first polymeric material, with optionally a primer layer, optionally a textured surface, or optionally both, positioned between the optical element and the first polymeric material.

3. The article of claim 2, wherein the optional textured surface includes a plurality of profile features and flat planar areas, wherein the profile features extend above the flat areas of the textured surface, wherein the profile features and the flat areas result in at least one layer of the optical element having an undulating topography, wherein there is a planar region between neighboring elevated or depressed regions that is planar with the flat planar areas of the textured surface, wherein the dimensions of the profile features, a shape of the profile features, a spacing among the plurality of the profile features, in combination with the optical element impart the structural color.

4. The article of one of claims 1 to 3, wherein the at least one optical layer includes (i) multiple layers where each layer independently comprises a material selected from nitrides, oxynitrides, sulphides, sulfates, selenides and tellurides of the transition metals, the metalloids, the lanthanides and the actinides, (ii) one or more layers made of liquid crystals, or (iii) one or more layers made of silicone dioxide, titanium dioxide, zinc sulphide, magnesium fluoride, tantalum pentoxide, aluminium oxide or a combination thereof.

5. The article of any one of claims 1 to 4, wherein the optical element, as disposed on the component, when measured according to the CIE 1976 color space under a given illumination condition at three observation angles between -15 degrees and +60 degrees, has a first color measurement at a first angle of observation having coordinates L_1^* and a_1^* and b_1^*, and a second color measurement at a second angle of observation having coordinates L_2^* and a_2^* and b_2^*, and a third color measurement at a third angle of observation having coordinates L_3^* and a_3^* and b_3^*, wherein the L_1^*, L_2^*, and L_3^* values may be the same or different, wherein the a_1^*, a_2^*, and a_3^* coordinate values may be the same or different, wherein the b_1^*, b_2^*, and b_3^* coordinate values may be the same or different, and wherein the range of the combined a_1^*, a_2^* and a_3^* values is less than about 40% of the overall scale of possible a* values.

6. The article of any one of claims 2 to 5, wherein the first surface of the component includes a textile and at least an outer layer of the textile includes the first polymeric material, optionally wherein the textile is a nonwoven textile, a woven textile, a knit textile, or a synthetic leather textile.

7. The article of claim 6, wherein the textile comprises a first fiber or a first yarn, and the first fiber or first yarn includes the first polymeric material.

8. The article of claim 7, wherein a region of the textile onto which the optical element is disposed includes the first fiber or first yarn in a non-filamentous conformation.

9. The article of any one of claims 1 to 5, wherein the first surface of the component includes a film, and at least an outer layer of the film includes the first polymeric material, and optionally wherein the film is a multi-layer film.

10. The article of claim 9, wherein the film has a gas transmission rate of 15 cm^3/m^2•atm•day or less for nitrogen for an average film thickness of 20 mils.

11. The article of any one of claims 2 to 10, wherein the first surface of the component includes a surface of a bladder, and at least an outer layer of the bladder includes the first polymeric material, optionally, the surface of the bladder includes the textured surface, and the surface of the bladder is an externally-facing surface of bladder or an internally facing surface of the bladder.

12. The article of claim 11, wherein the first side of the optical element is disposed on the internally-facing surface of the bladder, optionally with a primer layer, the textured surface, or both, positioned on the second side of the optical element; or the optical element is disposed on the externally-facing surface of the bladder, optionally with a primer layer, the textured surface, or both, positioned between the optical element and the externally-facing surface of the bladder.

13. The article of claims 1-5, wherein the component comprises a foam, and at least an outer layer of the foam includes the first polymeric material.

14. The article of claims 2-13, wherein the first polymeric material is a thermoplastic material.

15. The article of claim 14, wherein the thermoplastic material comprises an elastomeric thermoplastic material, optionally including one or more thermoplastic polyurethanes, polyesters, polyamides, polyolefins, or a combination thereof.

16. The article of claims 2-13, wherein the first polymeric material is a thermoset material.

17. The article of any one of claims 1 to 16, wherein the article is an article of footwear; and the component is a footwear component, optionally an upper or a sole or a combination of both an upper and a sole.

18. The article of claim 12, wherein the footwear component is a cushioning element of a sole; optionally a foam or a bladder element.

19. The article of any of the proceeding claims, wherein the optical layer comprises a multilayer reflector or a multilayer filter.

20. The article of any of the proceeding claims, wherein the multilayer reflector has at least two layers, including at least two adjacent layers having different refractive indices.