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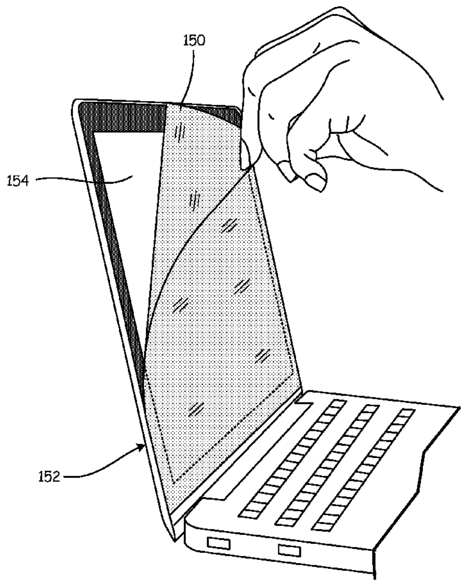

Fig. 1B

(57) Abstract: A shield 200 for a device 202 is provided. In one embodiment, the shield 200 for a device 202 comprises a polymer substrate. The shield 200 may also comprise an absorbing agent 1002 dispersed within the polymer substrate. The shield 200 may also reduce a transmissivity of an ultraviolet range of light by at least 90%, wherein the ultraviolet range of light comprises a range between 380 and 400 nanometers, and wherein the shield 200 also reduces a transmissivity of a high energy visible light range by at least 10%, wherein the high energy visible light range comprises a range between 415 and 555 nanometers, and wherein the shield also reduces a transmissivity of a red light range by at least 10%, wherein the red light range comprises a range between 625 and 740 nanometers. Additionally, the shield 200 may also be configured to transmit sufficient light generated by the device 202 such that an image generated by the device 202 is substantially unaltered by the shield 200.

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LIGHT EMISSION REDUCING FILM FOR ELECTRONIC DEVICES

BACKGROUND

[0001] Electronic digital devices typically emit a spectrum of light, consisting of rays of varying wavelengths, of which the human eye is able to detect a visible spectrum between about 350 to about 700 nanometers (nm). It has been appreciated that certain characteristics of this light, both in the visible and nonvisible ranges, may be harmful to the user, and lead to health symptoms and adverse health reactions, such as, but not limited to, eyestrain, dry and irritated eyes, fatigue, blurry vision and headaches. There may be a link between exposure to the blue light found in LED devices and human health hazards, particularly with potentially harmful risks for the eye. Some believe that exposure to the blue light and/or high energy visible light, such as that emitted by screens of digital devices could lead to age related macular degeneration, decreased melatonin levels, acute retinal injury, accelerated aging of the retina, and disruption of cardiac rhythms, among other issues. Additional research may reveal additional musculoskeletal issues that result from prolonged exposure to the blue light spectrum.

SUMMARY

[0002] A shield for a device is provided. In one embodiment, the shield for a device comprises a polymer substrate. The shield may also comprise an absorbing agent dispersed within the polymer substrate. The shield may also reduce a transmissivity of an ultraviolet range of light by at least 90%, wherein the ultraviolet range of light comprises a range between 380 and 400 nanometers, and wherein the shield also reduces a transmissivity of a high energy visible light range by at least 10%, wherein the high energy visible light range comprises a range between 415 and 555 nanometers, and wherein the shield also reduces a transmissivity of a red light range by at least 10%, wherein the red light range comprises a range between 625 and 740 nanometers. Additionally, the shield may also be configured to transmit sufficient light generated by the device such that an image generated by the device is substantially unaltered by the shield. These and various other features and advantages that characterize the claimed embodiments will become apparent upon reading the following detailed description and upon reviewing the associated drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIGS. 1A- 1C illustrate an exemplary film that may be useful in one embodiment of the present invention.

[0004] FIG. 1D – 1E illustrate a plurality of transmission curves for different films that may be useful in one embodiment of the present invention.

[0005] FIG. 2A illustrates an exemplary interaction between a device and an eye with an exemplary film that may be useful in one embodiment of the present invention.

[0006] FIG. 2B illustrates exemplary effectiveness wavelength absorbance ranges of a plurality of films that may be useful in one embodiment of the present invention.

[0007] FIG. 2C illustrates a plurality of absorbing compounds that may be utilized to achieve the desired characteristics of a film, in one embodiment of the present invention

[0008] FIG. 3 depicts a graph illustrating transmission as a function of wavelength for a variety of films that may be useful in one embodiment of the present invention.

[0009] FIG. 4A-4C depict a plurality of methods for generating a light-absorbing film for a device in one embodiment of the present invention.

DETAILED DESCRIPTION

[0010] The present invention relates to material for making optical filters, and more particularly, to optical filters with defined transmission and optical density characteristics for visible wavelength transmissivity and an organic dye impregnated polycarbonate composition for making such filters, in one embodiment.

[0011] High energy visible (HEV) light emitted by digital devices is known to increase eye strain more than other wavelengths in the visible light spectrum. Blue light can reach deeper into the eye than, for example, ultraviolet light and may cause damage to retinas. Additionally, there may also be a causal link between blue light exposure and the development of Age-related Macular Degeneration (AMD) and cataracts. Additionally, the use of digital electronic devices is known to cause eye strain symptoms. The damage is thought to be caused by HEV light that penetrates the macular pigment, causing more rapid retinal changes.

[0012] Additionally, blue light exposure suppresses melatonin for about twice as long as green light and shifts circadian rhythms by twice as much. Blue wavelengths of light seem to be the most disruptive at night. Studies have also shown that blue light frequencies, similar to those generated by LEDs from electronic devices, such as smart phones, are 50 to 80 times more efficient in causing photoreceptor death than green light. Exposure to the blue light spectrum seem to accelerate AMD more than other areas of the visible light spectrum. However, it is also suspected that exposure to the red and green light spectrums may also present health risks, which can be mitigated by absorption of light produced by devices in that wavelength range.

[0013] Further, ultraviolet A (UVA) light (in the 320-400 nm range) is of particular concern to eye care professionals. UVA light is considered to be damaging because it directly affects the crystalline lens of the human eye. In one embodiment, the filter 200 reduces the High Energy Visible light in accordance with the standards set by the International Safety Equipment Association, specifically the ANSI/ISEA Z87.1 – 2010 standard, which weighs the spectral sensitivity of the eye against the spectral emittance from the 400-1400 nm range.

[0014] Although the light generated by LEDs from digital devices appears normal to human vision, a strong peak of blue light ranging from 460-500 nanometers is also emitted within the white light spectrum produced by the screens of such digital devices. As this blue light corresponds to a known spectrum for retinal hazards, a means for protecting users from exposure to such light is needed.

[0015] Optical filters are used in a wide range of applications including light filters for LCD retardation films. LCD retardation films use alternate layers of materials comprised of an electroplated pigment, pigment impregnated or a printing method materials. These methods are compromised when they experience friction, heat or moisture and may cause a ghosting effect. Optical density transmissivity and sustainability requirements may also fail due to moisture and mechanical integrity.

[0016] Current film substrate technologies exist, however, they often lack desired optical properties such as stability to UV light, selective transmissivity in the visible range, and absorption in the UV and high intensity blue light range, or other absorption characteristics. Current film substrates also lack the desired mechanical properties such as heat resistance and mechanical robustness at the desired thinness. Glass, polycarbonate, acrylic, and nylon lenses and films exist, but may be unable to sustain the dye or pigment dispersion and achieve an optical density sufficient to maintain the high transmission values at this thickness. In one embodiment, an F700 film, such as that produced by Kentek Corporation, is resistant to moisture and humidity. Such a film is preferable to glass, which may require re-polishing. Increased color resolution, repeatability and the lack of a binder agent requirement are other benefits. A film is needed that provides at least some protection to a device from wear and tear, as well as protection to a user from the potentially harmful light emitted by the device. Additionally, the film should provide the necessary protection while maintaining transparency and substantially true color rendition.

FILM AND FILM PROPERTIES

[0017] FIGS. 1A- 1C illustrate an exemplary film that is useful in one embodiment of the present invention. A plurality of film materials may be appropriate for any of the embodiments described below. A film material may be chosen for a specific application based on a variety of properties, for example hardness, scratch resistance, transparency, conductivity, etc. In one embodiment, the film is made from a polymer material, and may include any one or more of the polymers listed below in Table 1, below.

TABLE 1: POLYMER BASES FOR ABSORBANCE FILM

Polymer base	**Characteristics**
Acrylic	impact modified, chemical resistance, superb weatherability, UV resistance and transparency
Epoxy	Resistivity to energy and heat
Polyamide	Thermoformabilty, abrasion resistance, good mechanical properties; High tensile strength and elastic modulus, impact and crack resistance
Polycarbonate	Impact strength even at low temperatures. dimensional stability, weather resistance, UV resistance, flame retardant, super-weather resistance and heat stability, optical properties
Polyester	Optics, mechanical Strength, Solvent Resistant, Tear and puncture resistant
Co-polyester (PETG, PCTG)	printable, scratch hardness
Polyethylene	Geomembrane windows, global recylability, good moisture barrier, clarity, strength, toughness
Polyolefin	Good chemical resistance
Polypropylene	High impact and puncture resistance, excellent extensibility
Polystyrene	good printablity, high impact resistance, good dimensional stability, easy to thermoform
Polysolfone	high strength, amorphous thermoplastic, clarity and toughness, high-heat deflection temperature, excellent thermal stability, excellent hydrolitic stability
Polyurethane	Excellent laminated transparency, microbial resistance, UV stability, contains adhesion promoter, medium Durometer, Medium Modulus, Excellent Cold impact
Polyvinyl Chloride	Weathering resistance, abrasion resistance, chemical resistance, flow characteristics, stable electrical properties

Styrene Acrylonitrile	superior mechanical strength, chemical resistance, heat resistance, durability, simplicity of production, recyclability, impact strength, heat resistance, good impact resistance, excellent hygiene, sanitation and safety benefits.

[0018] In one embodiment, any one or more of the polymers listed in Table 1 is combined with one or more absorbing compounds, for example those listed below in Table 2, to generate a film 100 that can be utilized with one or more devices, for example smartphones, laptops, tablets, glasses, or any other transparent surface utilized with an electronic display device. In one embodiment, the polymer base for the film 100 is chosen, at least in part, based on transparency, such that a user can still view a screen of an electronic display device through the film 100. In another embodiment, the polymer base is chosen, at least in part, based on its compatibility with a desired absorbing compound.

[0019] In accordance with one embodiment, as shown in FIG. 1A, a film 100 is applied to a device 102 with a screen 104. While FIG. 1A shows the device 102 as a smartphone, the film 100 can illustratively be designed to be applied to any other device, such as, for example the laptop 152 with film 150 over screen 154 shown in FIG. 1B. Additionally, in another embodiment, the film 100 could be incorporated into a layer of a device, such as a contact lens or lenses of a pair of glasses.

[0020] Film 100 is formed of a suitable material, such as a polymer, and one or more light absorption dyes that selectively reduce the peaks and slopes of electromagnetic emission from occupational and personal electronic devices. Other examples of electronic devices with which such a film may be used may include for example, LEDs, computer monitors, equipment screens, televisions, tablets, cellular phones, etc. However, it could also be used on the user-end of a viewing experience, for example incorporated into contact lenses or glasses.

[0021] FIG. 1C illustrates two layers of a film 100. In one embodiment, the film includes no antiglare coating as shown by film 170. In another embodiment, the film 100 includes a coating 172, wherein the coating 172 comprises an antiglare coating 172, a hard coating 172, and / or a tack coating 172. In one embodiment, the absorbing compound may be incorporated into the coating material directly, instead of the base film layer. This may be done, for example, due to compatibility between the absorbing compound and the desired polymer substrate.

[0022] The film 100, in one embodiment, has a slight color tint, as a result at least in part of the absorbing compound selected, and works as a filter to reduce light emission from the screen 104. In one embodiment, under a CIE light source D65, a film 100 having a 7.75 mil thickness is a light blue-green color with (L,a,b) values of (90.24, -12,64, 3.54) with X-Y-Z values of (67.14, 76.83,78.90) respectively. In another embodiment, the film 100 appears lighter due to reduced loading.

[0023] In one embodiment, film 100 is configured to reduce light emission across a broad spectrum of light, for example, the 200nm to the 3000nm range. In another example, film 100 can be configured to reduce light emission in only a portion of this broad spectrum, for example, only within the visible spectrum 390nm to 700nm, or only within a portion of the visible spectrum.

[0024] In one embodiment, film 100 is configured to normalize the light emission from screen 104 such that peaks of light intensity across the spectrum are reduced. In one example, the light emission intensity is normalized to a maximum absorbance level between 0.0035 and 0.0038.

[0025] In the illustrated embodiment of FIG. 1A, film 100 is configured for use with devices having touch screens (e.g. a capacitive touch screen). When used with a capacitive touch screen, such as screen 104, film 100 may be configured to have suitable electrical properties such that the user touch inputs are accurately registered by the device. For example, film 100 may have a dielectric constant that is less than 4. In another example, the dielectric constant is less than 3. In one particular embodiment, the dielectric constant of film 100 is between 2.2 and 2.5.

[0026] In one embodiment, film 100 has a thickness between 10-30 mil and a hardness above 30 Rockwell R. In one embodiment, the hardness of film 100 is between 45-125 Rockwell R.

[0027] While embodiments shown in FIGS. 1A – 1C are described in the context of a film applied to an electronic device after manufacture, it is noted that the described features can be used in other applications, such as, but not limited to, application to eye wear (e.g. glasses, contacts, etc.) as well as applications on windows, for example, to protect against lasers. It may also be used on any other surface through which light is transmitted and may be received by a human eye. In one embodiment, film 100 is applied to eyewear lenses, such as corrective lens glasses, sunglasses, safety glasses, etc. While the film 100 is shown in FIGS. 1A and 1B as being applied as an aftermarket feature to a device 102, and provided to a user as shown in FIG. 1C, in another embodiment, the film 100 is included within a device 102 during a manufacture of the device 102 such that the film 100 is located behind a screen 104 or comprises the screen 104 of the device 102.

[0028] FIGS. 1D – 1E illustrate a plurality of transmission curves for different films that may be useful in embodiments of the present invention. The transmission characteristics of a film, for example film 100, may be defined by a transmission curve, such as those shown in FIG. 1D or 1E. Specifically, curve 180 illustrates an exemplary transmission curve of filter glass. Curve 182 illustrates an exemplary transmission curve of a film 100 with a thickness of 4 mil. Curve 184 illustrates an exemplary transmission curve for a film 100 with a thickness of 7.75 mil. The transmission curve includes a transmission local maximum in a visible light wavelength range and a first and second transmission local minimums proximate each end of the visible light wavelength range.

[0029] In one embodiment, the transmission local maximum is at a location between 575nm and 425nm, the first transmission local minimum being at or around a location of about 700nm or greater, and the second transmission local minimum being at or around a location of about 300nm or less. The transmission local maximum may have a transmission of 85% or greater. The transmission local maximum may further have a transmission of 90% or greater. The first and second transmission local minimums may have a transmission of less than 30%, in one embodiment. In another embodiment, the first and second transmission local minimums may have a transmission of less than 5%. The transmission curve, in one embodiment, may also include a first and second 50% transmission cutoff between the respective transmission local minimums and the transmission local maximum.

[0030] The transmission curve may also include, in one embodiment, a curve shoulder formed by a reduced slope for at least of the transmission curve between 750nm and 575nm, which increases transmission for wavelengths at this end of the visible spectrum (e.g. red light). In one embodiment, the curve shoulder passes through a location at 644nm ± 10nm. In other embodiments, the curve shoulder may pass through a location at 580nm ± 10nm. One of the 50% transmission cutoffs may coincide with the curve shoulder, for example, at 644nm ± 10nm.

[0031] As used herein, the terms “optical density” and “absorbance” may be used interchangeably to refer to a logarithmic ratio of the amount of electromagnetic radiation incident on a material to the amount of electromagnetic radiation transmitted through the material. As used herein, “transmission” or “transmissivity” or “transmittance” may be used interchangeably to refer to the fraction or percentage of incident electromagnetic radiation at a specified wavelength that passes through a material. As used herein, “transmission curve” refers to the percent transmission of light through an optical filter as a function of wavelength. “Transmission local maximum” refers to a location on the curve (i.e. at least one point) at which the transmission of light through the optical filter is at a maximum value relative to adjacent locations on the curve. “Transmission local minimum” refers to a location on the curve at which transmission is at a minimum value relative to adjacent locations on the curve. As used herein, “50% transmission cutoff” refers to a location on the transmission curve where the transmission of electromagnetic radiation (e.g. light) through the optical filter is about 50%.

[0032] In one embodiment, the transmission characteristics of the optical filters, for example those shown in FIG. 3 below, may be achieved, in one embodiment, by using a polycarbonate film as a polymer substrate, with a blue-green organic dye dispersed therein. The organic dye impregnated polycarbonate film may have a thickness less than 0.3 mm. In another embodiment, the polycarbonate film may have a thickness less than 0.1 mm. The thinness of the polycarbonate film may facilitate the maximum transmission of greater than 90% of light produced by a device. In at least one embodiment, the organic dye impregnated film may have a thickness between 2.5mils - 14mils. The combination of the polycarbonate substrate and the blue green organic dye is used in one or more embodiments of the present disclosure to provide improved heat resistant and mechanical robustness even with the reduced thickness.

[0033] The polycarbonate film may include any type of optical grade polycarbonate such as, for example, LEXAN 123 R. Although polycarbonate provides desirable mechanical and optical properties for a thin film, other polymers may also be used such as a cyclic olefilm copolymer (COC).

[0034] In one embodiment, similar transmission characteristics may also be achieved, for example, by using an acrylic film with a blue-green organic dye dispersed therein. The organic dye impregnated acrylic film may have a thickness less than 0.3 mm. In another embodiment, the acrylic film may have a thickness less than 0.1 mm. The thinness of the acrylic film may facilitate the maximum transmission of greater than 90% of light produced by a device. In at least one embodiment, the organic dye impregnated film may have a thickness between 2.5mils - 14mils. The combination of the acrylic substrate and the blue green organic dye may be used, in one or more embodiments, to provide improved heat resistant and mechanical robustness even with the reduced thickness.

[0035] In another embodiment, similar transmission characteristics may also be achieved, for example, by using an epoxy film with a blue-green organic dye dispersed therein. The organic dye impregnated epoxy film may have a thickness less than 0.1 mm. In another embodiment, the epoxy film may have a thickness less than 1 mil. The thinness of the epoxy film may facilitate the maximum transmission of greater than 90% of light produced by a device. The combination of the epoxy substrate and the blue green organic dye may be used, in one or more embodiments, to provide improved heat resistant and mechanical robustness even with the reduced thickness.

[0036] In a further embodiment, similar transmission characteristics may also be achieved, for example, by using a PVC film with a blue-green organic dye dispersed therein. The organic dye impregnated PVC film may have a thickness less than 0.1 mm. In another embodiment, the PVC film may have a thickness less than 1 mil. The thinness of the PVC film may facilitate the maximum transmission of greater than 90% of light produced by a device. The combination of the PVC substrate and the blue green organic dye may be used, in one or more embodiments, to provide improved heat resistant and mechanical robustness even with the reduced thickness.

[0037] The organic dye impregnated polycarbonate film may, in one embodiment, also have the desired optical characteristics at this reduced thickness with a parallelism of up to 25 arcseconds and a 0-30° chief ray of incident angle. The organic dye impregnated polycarbonate film may further provide improved UV absorbance with an optical density of greater than 5 in the UV range. The exemplary combination of a polycarbonate substrate with a blue-green dye is provided for example purposes only. It is to be understood that any of the absorbing compounds described in detail below could be combined with any of the polymer substrates described above to generate a film with the desired mechanical properties and transmissivity.

[0038] Embodiments of the optical filter 100, as described herein, may be used for different applications including, without limitation, as a light filter to improve color rendering and digital imaging, an LCD retardation film with superior mechanical properties, an excellent UV absorbance, a light emission reducing film for an electronic device to reduce potentially harmful wavelengths of light, and an optically correct thin laser window with high laser protection values. In these embodiments, the optical filter may be produced as a thin film with the desired optical characteristics for each of the applications.

ABSORBANCE AND ABSORBING MATERIALS

[0039] Absorbance of wavelengths of light occurs as light encounters a compound. Rays of light from a light source are associated with varying wavelengths, where each wavelengths is associated with a different energies. When the light strikes the compound, energy from the light may promote an electron within that compound to an anti-bonding orbital. This excitation occurs, primarily, when the energy associated with a particular wavelength of light is sufficient to excite the electron and, thus, absorb the energy. Therefore, different compounds, with electrons in different configurations, absorb different wavelengths of light. In general, the larger the amount of energy required to excite an electron, the lower the wavelength of light required. Further, a single compound may absorb multiple wavelength ranges of light from a light source as a single compound may have electrons present in a variety of configurations.

[0040] FIG. 2A illustrates an exemplary interaction between a device and an eye with an exemplary film that may be useful in one embodiment of the present invention. In one embodiment, the film 200 comprises a film placed on the device 202, for example as an after-market addition. In another embodiment, the film 200 comprises a portion of the device 202, for example the screen of device 202. In a further embodiment, the film is a physical barrier worn on or near the eye 250, for example as a contact lens, or as part of the lenses of a pair of glasses; either as an after-market application or part of the lenses themselves.

[0041] As shown in FIG. 2A, device 202 produces a plurality of wavelengths of light including, high intensity UV light 204, blue violet light 212, blue turquoise light 214 and visible light 218. High intensity UV light may comprise, in one embodiment, wavelengths of light in the 315-380nm range. Light in this wavelength range is known to possibly cause damage to the lens of an eye. In one embodiment, blue-violet light 212 may comprise wavelengths of light in the 380-430nm range, and is known to potentially cause age-related macular degeneration. Blue-turquoise light 214 may comprise light in the 430-500nm range and is known to affect the sleep cycle and memory. Visible light 218 may also comprise other wavelengths of light in the visible light spectrum.

[0042] As used herein, “visible light” or “visible wavelengths” refers to a wavelength range between 380 to 750nm. “Red light” or “red wavelengths” refers to a wavelength range between about 620 to 675nm. “Orange light” or “orange wavelengths” refers to a wavelength range between about 590 to 620nm. “Yellow light” or “yellow wavelengths” refers to a wavelength range between about 570 to 590nm. “Green light” or “green wavelengths” refers to a wavelength range between about 495 to 570nm. “Blue light” or “blue wavelengths” refers to a wavelength range between about 450 to 495nm. “Violet light” or “violet wavelengths” refers to a wavelength range between about 380 to 450nm. As used herein, “ultraviolet” or “UV” refers to a wavelength range that includes wavelengths below 350nm, and as low as 10nm. “Infrared” or “IR” refers to a wavelength range that includes wavelengths above 750nm, and as high as 3,000nm.

[0043] When a particular wavelength of light is absorbed by a compound, the color corresponding to that particular wavelength does not reach the human eye and, thus, is not seen. Therefore, for example, in order to filter out UV light from a light source, a compound may be introduced into a film that absorbs light with a wavelength below 350 nm. A list of some exemplary light-absorbing compounds are presented in Table 2 below, and correspond to exemplary absorption spectra shown in FIG. 2D.

TABLE 2: ABSORBING MATERIALS AND WAVELENGTH RANGES

Exemplary Polymer Substrate	**260-400 nm Target Range**	**400-700 nm Target Range**	**Infrared Target Range**
Polycarbonate	1002	1004	1006
PVC	1008	1010	1020
Epoxy	1022	1018	1026
Polyester	1028	1024	1032
Polyethylene	1040	1030	1038
Polyamide	1046	1036	1044
		1042	1050
		1048	

[0044] In one embodiment, a filter 200 is manufactured by choosing one of the substrates from the first column of Table 2, and selecting one absorbing column from one or more of columns 2-4, depending on the wavelength range to be targeted for absorption. In an embodiment, a UV-targeting absorbing compound is not needed when the polymer substrate contains a UV inhibitor, a UV stabilizer, or otherwise inherently possesses UV absorbing properties. Absorbing compounds then can be selected from any of the columns 2-4 for addition in order to increase absorption of light produced in the target wavelength ranges. Absorbing compounds can be selected in combination, provided that high transmission of light is maintained, and the color tint is maintained, such that color integrity produced by a device remains true. In one embodiment, the absorbing compounds are provided in a polymer or pellet form and coextruded with the polymer substrate to produce the film 200. In another embodiment, the absorbing compound is provided in a separate layer from the polymer substrate, for example as a component in a coating layer applied to the polymer substrate, or an additional scratch resistance layer.

[0045] Additionally, many of the exemplary compounds described in each of columns 2, 3 and 4 can be substituted to produce the desired characteristics in other polymer substrates. For example, while compound 1002 is listed as an ideal compound for combination with a polycarbonate substrate, compound 1002 is also known as a compatible compound for impregnation with PVC, acetals and cellulose esters. Some potential exemplary combinations of the compounds and polymer substrates presented in Table 2 are described in further detail in the examples below. However, it is to be understood that other possible combinations, including with polymer substrates listed in Table 1 and not presented again in Table 2, are possible.

[0046] In one embodiment, the organic dye dispersed in the polymer substrate provides selective transmission characteristics including, for example, reducing transmissivity for blue light wavelengths and / or red light wavelengths. The reduction of these unnaturally high emissivity levels of a particular band or wavelength to a level more representative of daylight helps to decrease some of the undesirable effects of the use of digital electronic devices. In addition, the optical film may reduce the HEV light in the range that is emitted by a device 202. However, the optical filter 200 is, in one embodiment, also configured in order to allow other blue wavelengths of light, for example the color cyan, through in order to preserve color rendition by the device 202.

Polycarbonate Example

[0047] In one embodiment, the filter 200 comprises a polycarbonate substrate impregnated with an absorbing compound 1002 selected to target light produced in the 260-400 nm range. In one embodiment, absorbing compound 1002, is selected for a peak absorption in the 300-400 nm range. One exemplary absorbing compound is, for example, Tinuvin®, provided by Ciba Specialty Chemicals, also known as 2-(2H-benzotriazol-2-yl)-p-cresol. However, any other exemplary absorbing compound with strong absorption characteristics in the 300-400nm range would also be suitable for absorbing UV light. In an embodiment where Tinuvin® is utilized to provide UV protection, other polymer substrates, such as those listed in Table 1, would also be suitable for the generation of filter 200.

[0048] In one embodiment, the filter 200 comprises a polycarbonate substrate impregnated with an absorbing compound 1004 selected to target light produced in the 400-700 nm range.

In one embodiment, absorbing compound 1004 is selected for a peak absorption in the 400-700 nm range. Specifically, in one embodiment, absorbing compound 1004 is selected for peak absorption in the 600-700 nm range. Even more specifically, in one embodiment, absorbing compound is selected for peak absorption in the 635-700 nm range. One exemplary absorbing compound is a proprietary compound produced by Exciton®, with commercial name ABS 668. However, any other exemplary absorbing compound with strong absorption in the 600-700 nm range of the visible spectrum may also be suitable for the generation of filter 200. In another embodiment, compound 1004 may also be combined with a different polymer substrate from Table 1.

[0049] In one embodiment, the filter 200 comprises a polycarbonate substrate impregnated with an absorbing compound 1006 selected to target light produced in the infrared range. In one embodiment, absorbing compound 1006 is selected to target light produced in the 800-1100 nm range. Specifically, in one embodiment, absorbing compound 1006 is selected for a peak absorption in the 900-1000 nm range. One exemplary compound may be the NIR1002A dye produced by QCR Solutions Corporation. However, any other exemplary absorbing compound with strong absorption in the infrared range may also be suitable for the generation of filter 200. In another embodiment, compound 1006 may also be combined with a different polymer substrate from Table 1.

[0050] In one embodiment, a polymer substrate is impregnated with a combination of compounds 1002, 1004, and 1006 such that any two of compounds 1002, 1004, and 1006 are both included to form filter 200. In another embodiment, all three of compounds 1002, 1004, and 1006 are combined within a polymer substrate to form filter 200.

[0051] In another embodiment, the polycarbonate substrate is provided in a filter 200 along with any one of compounds 1002, 1008, 1022, 1028, 1040 or 1046. This may be, in one embodiment, in combination with any one of compounds 1004, 1010, 1018, 1024, 1030, 1036, 1042 or 1048. This may be, in one embodiment, in combination with any one of compounds 1006, 1020, 1026, 1032, 1038, 1044 or 1050.

PVC Filter Example

[0052] In one embodiment, the filter 200 comprises a poly-vinyl chloride (PVC) substrate impregnated with an absorbing compound 1008 selected to target light produced in the 260-400 nm range. In one embodiment, absorbing compound 1008, is selected for a peak absorption in the 320-380 nm range. One exemplary absorbing compound is DYE VIS 347, produced by Adam Gates & Company, LLC. However, any other exemplary absorbing compound with strong absorption characteristics in the 300-400nm range would also be suitable for absorbing UV light. In an embodiment where DYE VIS 347 is utilized to provide UV protection, other polymer substrates, such as those listed in Table 1, would also be suitable for the generation of filter 200.

[0053] In one embodiment, the filter 200 comprises a PVC substrate impregnated with an absorbing compound 1010 selected to target light produced in the 400-700 nm range. Specifically, in one embodiment, absorbing compound 1010 is selected for peak absorption in the 550-700 nm range. Even more specifically, in one embodiment, absorbing compound is selected for peak absorption in the 600-675 nm range. One exemplary absorbing compound is ADS640PP, produced by American Dye Source, Inc., also known as 2-[5-(1,3-Dihydro-3,3-dimethyl-1-propyl-2H-indol-2-ylidene)-1,3-pentadienyl]-3,3-dimethyl-1-propyl-3H-indolium perchlorate. However, any other exemplary absorbing compound with strong absorption in the 600-700 nm range of the visible spectrum may also be suitable for the generation of filter 200. In another embodiment, compound 1010 may also be combined with a different polymer substrate from Table 1.

[0054] In one embodiment, a polymer substrate is impregnated with a combination of compounds 1008 and 1010. In another embodiment, the PVC substrate is provided in a filter 200 along with any one of compounds 1002, 1008, 1022, 1028, 1040 or 1046. This may be, in one embodiment, in combination with any one of compounds 1004, 1010, 1018, 1024, 1030, 1036, 1042 or 1048. This may be, in one embodiment, in combination with any one of compounds 1006, 1020, 1026, 1032, 1038, 1044 or 1050.

Epoxy Example

[0055] In one embodiment, the filter 200 comprises an epoxy substrate impregnated with an absorbing compound 1016 selected to target light produced in the 260-400 nm range. In one embodiment, absorbing compound 1016, is selected for a peak absorption in the 300-400 nm range. Specifically, in one embodiment, absorbing compound 1016 is selected for peak absorption in the 375-410 range. One exemplary absorbing compound is, for example, ABS 400, produced by Exciton, with a peak absorbance at 399 nm. However, any other exemplary absorbing compound with strong absorption characteristics in the 300-400nm range would also be suitable for absorbing UV light. In an embodiment where ABS 400 is utilized to provide UV protection, other polymer substrates, such as those listed in Table 1, may also be suitable for the generation of filter 200.

[0056] In one embodiment, the filter 200 comprises an epoxy substrate impregnated with an absorbing compound 1018 selected to target light produced in the 400-700 nm range. In one embodiment, absorbing compound 1018 is selected for a peak absorption in the 400-700 nm range. Specifically, in one embodiment, absorbing compound 1018 is selected for peak absorption in the 600-700 nm range. Even more specifically, in one embodiment, absorbing compound is selected for peak absorption in the 650-690 nm range. One exemplary absorbing compound is a proprietary compound produced by QCR Solutions Corporation, with commercial name VIS675F and peak absorption, in chloroform, at 675nm. However, any other exemplary absorbing compound with strong absorption in the 600-700 nm range of the visible spectrum may also be suitable for the generation of filter 200. In another embodiment, compound 1018 may also be combined with a different polymer substrate from Table 1.

[0057] In one embodiment, the filter 200 comprises an epoxy substrate impregnated with an absorbing compound 1020 selected to target light produced in the infrared range. In one embodiment, absorbing compound 1020 is selected to target light produced in the 800-1100 nm range. Specifically, in one embodiment, absorbing compound 1020 is selected for a peak absorption in the 900-1080 nm range. In one embodiment, absorbing compound is a proprietary compound produced by QCR Solutions Corporation, with commercial name NIR1031M, and peak absorption, in acetone, at 1031 nm. However, any other exemplary absorbing compound with strong absorption in the infrared range may also be suitable for the generation of filter 200. In another embodiment, compound 1020 may also be combined with a different polymer substrate from Table 1.

[0058] In one embodiment, a polymer substrate is impregnated with a combination of compounds 1016, 1018, and 1020 such that any two of compounds 1016, 1018, and 1020 are both included to form filter 200. In another embodiment, all three of compounds 1016, 1018, and 1020 are combined within a polymer substrate to form filter 200.

[0059] In another embodiment, the epoxy substrate is provided in a filter 200 along with any one of compounds 1002, 1008, 1022, 1028, 1040 or 1046. This may be, in one embodiment, in combination with any one of compounds 1004, 1010, 1018, 1024, 1030, 1036, 1042 or 1048. This may be, in one embodiment, in combination with any one of compounds 1006, 1020, 1026, 1032, 1038, 1044 or 1050.

Polyamide Example

[0060] In one embodiment, the filter 200 comprises a polyamide substrate impregnated with an absorbing compound 1022 selected to target light produced in the 260-400 nm range. In one embodiment, absorbing compound 1022, is selected for a peak absorption in the 260-350 nm range. One exemplary absorbing compound is, for example, produced by QCR Solutions Corporation with product name UV290A. However, any other exemplary absorbing compound 1022 with strong absorption characteristics in the 260-400 nm range would also be suitable for absorbing UV light. In an embodiment where UV290A is utilized to provide UV protection, other polymer substrates, such as those listed in Table 1, would also be suitable for the generation of filter 200.

[0061] In one embodiment, the filter 200 comprises a polyamide substrate impregnated with an absorbing compound 1024 selected to target light produced in the 400-700 nm range. In one embodiment, absorbing compound 1024 is selected for a peak absorption in the 600-700 nm range. Specifically, in one embodiment, absorbing compound 1024 is selected for peak absorption in the 620-700 nm range. One exemplary absorbing compound is a proprietary compound produced by Adam Gates & Company, LLC with product name DYE VIS 670, which also has an absorption peak between 310 and 400 nm. However, any other exemplary absorbing compound with strong absorption in the 600-700 nm range of the visible spectrum may also be suitable for the generation of filter 200. In another embodiment, compound 1024 may also be combined with a different polymer substrate from Table 1.

[0062] In one embodiment, the filter 200 comprises a polyamide substrate impregnated with an absorbing compound 1026 selected to target light produced in the infrared range. In one embodiment, absorbing compound 1026 is selected to target light produced in the 800-1200 nm range. Specifically, in one embodiment, absorbing compound 1026 is selected for a peak absorption in the 900-1100 nm range. One exemplary absorbing compound is a proprietary compound produced by QCR Solutions Corporation, with product name NIR1072A, which has an absorbance peak at 1072 nm in acetone. However, any other exemplary absorbing compound with strong absorption in the infrared range may also be suitable for the generation of filter 200. In another embodiment, compound 1026 may also be combined with a different polymer substrate from Table 1.

[0063] In one embodiment, a polymer substrate is impregnated with a combination of compounds 1022, 1024, and 1026 such that any two of compounds 1022, 1024, and 1026 are both included to form filter 200. In another embodiment, all three of compounds 1022, 1024, and 1026 are combined within a polymer substrate to form filter 200.

[0064] In another embodiment, the polyamide substrate is provided in a filter 200 along with any one of compounds 1002, 1008, 1022, 1028, 1040 or 1046. This may be, in one embodiment, in combination with any one of compounds 1004, 1010, 1018, 1024, 1030, 1036, 1042 or 1048. This may be, in one embodiment, in combination with any one of compounds 1006, 1020, 1026, 1032, 1038, 1044 or 1050.

Polyester Example

[0065] In one embodiment, the filter 200 comprises a polyester substrate impregnated with an absorbing compound 1036 selected to target light produced in the 400-700 nm range. In one embodiment, absorbing compound 1036 is selected for a peak absorption in the 600-750 nm range. Specifically, in one embodiment, absorbing compound 1036 is selected for peak absorption in the 670-720 nm range. One exemplary absorbing compound is a proprietary compound produced by Exciton®, with commercial name ABS 691, which has an absorption peak at 696 nm in polycarbonate. However, any other exemplary absorbing compound with strong absorption in the 600-700 nm range of the visible spectrum may also be suitable for the generation of filter 200. In another embodiment, compound 1036 may also be combined with a different polymer substrate from Table 1.

[0066] In one embodiment, the filter 200 comprises a polyester substrate impregnated with an absorbing compound 1038 selected to target light produced in the infrared range. In one embodiment, absorbing compound 1038 is selected to target light produced in the 800-1300 nm range. Specifically, in one embodiment, absorbing compound 1038 is selected for a peak absorption in the 900-1150 nm range. One exemplary absorbing compound 1038 is a proprietary compound produced by Adam Gates & Company, LLC, with product name IR Dye 1151, which has an absorbance peak at 1073 nm in methyl-ethyl ketone (MEK). However, any other exemplary absorbing compound with strong absorption in the infrared range may also be suitable for the generation of filter 200. In another embodiment, compound 1038 may also be combined with a different polymer substrate from Table 1.

[0067] In one embodiment, a polymer substrate is impregnated with a combination of compounds 1036, and 1038. In another embodiment, the polyester substrate is provided in a filter 200 along with any one of compounds 1002, 1008, 1022, 1028, 1040 or 1046. This may be, in one embodiment, in combination with any one of compounds 1004, 1010, 1018, 1024, 1030, 1036, 1042 or 1048. This may be, in one embodiment, in combination with any one of compounds 1006, 1020, 1026, 1032, 1038, 1044 or 1050.

Polyethylene Example

[0068] In one embodiment, the filter 200 comprises a polyethylene substrate impregnated with an absorbing compound 1042 selected to target light produced in the 400-700 nm range. In one embodiment, absorbing compound 1042 is selected for a peak absorption in the 600-750 nm range. Specifically, in one embodiment, absorbing compound 1042 is selected for peak absorption in the 670-730 nm range. One exemplary absorbing compound is a proprietary compound produced by Moleculum, with commercial name LUM690, which has an absorption peak at 701 nm in chloroform. However, any other exemplary absorbing compound with strong absorption in the 600-700 nm range of the visible spectrum may also be suitable for the generation of filter 200. In another embodiment, compound 1042 may also be combined with a different polymer substrate from Table 1.

[0069] In one embodiment, the filter 200 comprises a polyethylene substrate impregnated with an absorbing compound 1044 selected to target light produced in the infrared range. In one embodiment, absorbing compound 1044 is selected to target light produced in the 800-1100 nm range. Specifically, in one embodiment, absorbing compound 1044 is selected for a peak absorption in the 900-1100 nm range. One exemplary absorbing compound is a proprietary compound produced by Moleculum, with commercial name LUM1000A, which has an absorption peak at 1001 nm in chloroform. However, any other exemplary absorbing compound with strong absorption in the infrared range may also be suitable for the generation of filter 200. In another embodiment, compound 1044 may also be combined with a different polymer substrate from Table 1.

[0070] In one embodiment, a polymer substrate is impregnated with a combination of compounds 1040, 1042, and 1044 such that any two of compounds 1040, 1042, and 1044 are both included to form filter 200. In another embodiment, all three of compounds 1040, 1042, and 1044 are combined within a polymer substrate to form filter 200.

[0071] In another embodiment, the polycarbonate substrate is provided in a filter 200 along with any one of compounds 1002, 1008, 1022, 1028, 1040 or 1046. This may be, in one embodiment, in combination with any one of compounds 1004, 1010, 1018, 1024, 1030, 1036, 1042 or 1048. This may be, in one embodiment, in combination with any one of compounds 1006, 1020, 1026, 1032, 1038, 1044 or 1050.

Other Exemplary Embodiments

[0072] The blue green organic absorbing compound may be selected to provide the selective transmission and/or attenuation at the desired wavelengths (e.g. by attenuating blue light relative to red light). The blue green organic dye may include, for example, a blue green phthalocyanine dye that is suitable for plastic applications and provides good visible transmittance, light stability, and thermal stability with a melting point of greater than 170° C. The organic dye impregnated polycarbonate compound may include about 0.05% to 2% absorbing compound, by weight. The blue green phthalocyanine dye may be in the form of a powder that can be dispersed in a molten polycarbonate during an extruding process. The blue-green dye may also be dispersed within polycarbonate resin beads prior to an extruding process.

[0073] In another embodiment, one or more additional dyes may be dispersed within the film. To add infrared protection, for example, an additional IR filtering dye may be used to provide an optical density of 9 or greater in the IR range. One example of an IR filtering dye may include LUM1000A. The organic dye impregnated polycarbonate mixture may include about 0.05% to 2% absorbing compound, by weight.

[0074] In one embodiment, an optical filter for a digital electronic device is provided with defined electromagnetic radiation transmission characteristics with selective transmission at visible wavelengths. In one embodiment, the optical filter is engineered to block or reduce transmission of light in a plurality of wavelength ranges, for example in both the blue light wavelength range and the red light wavelength range. The optical filter may be used for a variety of applications including, without limitation, a light filter, a light emission reducing film for electronic devices, and an LCD retardation film. The optical filter is made of a composition including, in one embodiment, an organic dye dispersed or impregnated in a polymer substrate such as polycarbonate film. In another embodiment, any one or more polymer substrates may be selected from Table 1, above.

[0075] As shown in FIG. 2A, light of wavelengths 210, 212, 214 and 218 is generated by the device 202. These wavelengths of light then encounter the film 200, in one embodiment. When the wavelengths of light encounter the film 200, the film 200 is configured to allow only some of the wavelengths of light to pass through. For example, in one embodiment as shown in FIG. 2A, UV light is substantially prevented from passing through the film 200. Blue-violet light is also substantially prevented from passing through the film 200. Blue-turquoise light 214 is at least partially prevented from passing through the film 200, while allowing through some other ranges of blue light wavelengths 216 through. These may, in one embodiment, comprise wavelengths of light in the cyan color range. However, visible light 218, which may be safe for a user to view, is allowed to pass through the film in one embodiment. Once the wavelengths of light have encountered and passed through film 200, in one embodiment, they are then perceived by a human eye of a user using the device 202. In one embodiment, as shown in FIG. 2A, a region of the eye 252 is known to be highly affected by UV light, and a region of the eye 254 is known to be highly affected by blue light. By interposing a film 200 between the device 202 and the eye 250, the light rays likely to cause damage to the eye in regions 252 and 254 are thus substantially prevented from reaching the eye of a user.

[0076] FIG. 2B illustrates exemplary effectiveness wavelength absorbance ranges of a plurality of films that may be useful in one embodiment of the present invention. Film 200 may comprise, in one embodiment, a one or more absorption compounds configured to absorb light in one or more wavelength ranges. A range of wavelengths may be blocked by a film 272, in one embodiment, where at least some rays of light in the ranges of 300-400 nm are blocked from reaching the eye of a user by film 272, but the remainder of the wavelength spectrum of is substantially unaffected. In another embodiment, a film 274 substantially reduces light in the 300-650 nm range from reaching the eye of a user, but the remainder of the wavelength spectrum of is substantially unaffected. In a further embodiment, film 276 reduces the amount of light in the 300-3,000 nm range from reaching the eye of a user, but the remainder of the wavelength spectrum of is substantially unaffected. Depending on different conditions affecting a user of a device 202, different films 272, 274 and 276 may be applied to the user's devices 202 in order to treat or prevent a medical condition.

[0077] FIG. 2C, and the examples above, illustrate a plurality of absorbing compound spectra that may be utilized, either alone or in combination, to achieve the desired characteristics of a film, in one embodiment of the present invention. In one embodiment, one or more of the absorbing agents illustrated in FIG. 2C are impregnated within a polymer substrate to achieve the desired transmissivity.

[0078] In one embodiment, film 272 is configured to substantially block 99.9% of UV light, 15-20% of HEV light, and 15-20% of photosensitivy (PS) light. In one embodiment, film 272 comprises a UV-inhibiting polycarbonate substrate with a thickness of at least 5 mils. In one embodiment, the thickness is less than 10 mils. In one embodiment, film 272 also comprises a UV-inhibiting additive, comprising at least 1% of the film 272. In one embodiment, the UV-inhibiting additive comprises at least 2% of the film, but less than 3% of the film 272. In one embodiment, film 272 also comprises a hard coat. In one embodiment, film 272 can also be characterized as having an optical density that is at least 3 in the 280-380 nm range, at least 0.7 in the 380-390 nm range, at least 0.15 in the 390-400 nm range, at least 0.09 in the 400-600 nm range, and at least 0.04 in the 600-700 nm range.

[0079] In one embodiment, film 274 substantially blocks 99.9% of UV light, 30-40% of HEV light, and 20-30% of PS light. In one embodiment, film 274 comprises a UV-inhibiting polycarbonate substrate with a thickness of at least 5 mils. In one embodiment, the thickness is less than 10 mils. In one embodiment, film 274 also comprises a UV-inhibiting additive, comprising at least 1% of the film 274. In one embodiment, the UV-inhibiting additive comprises at least 2% of the film, but less than 3% of the film 274. In one embodiment, the film 274 also comprises phthalocyanine dye, comprising at least 0.0036% of the film 274. In one embodiment, the phthalocyanine dye comprises at least 0.005%, or at least 0.008%, but less than 0.01% of the film 274. In one embodiment, the film 274 comprises a hard coating. In one embodiment, film 274 can also be characterized as having an optical density that is at least 4 in the 280-380 nm range, at least 2 in the 380-390 nm range, at least 0.8 in the 290-400 nm range, at least 0.13 in the 400-600 nm range, and at least 0.15 in the 600-700 nm range.

[0080] In one embodiment, film 276 blocks 99.9% of UV light, 60-70 of HEV light, and 30-40% of photosensitivity (PS) light. In one embodiment the film 276 comprises a UV-inhibiting polycarbonate substrate with a thickness of at least 5 mils. In one embodiment, the thickness is less than 10 mils. In one embodiment, film 276 also comprises a UV-inhibiting additive, comprising at least 1% of the film 276. In one embodiment, the UV-inhibiting additive comprises at least 2% of the film, but less than 3% of the film 276. In one embodiment, the film 274 also comprises phthalocyanine dye, comprising at least 0.005% of the film 274. In one embodiment, the phthalocyanine dye comprises at least 0.01%, or at least 0.015%, but less than 0.02% of the film 276. In one embodiment, the film 276 comprises a hard coating. In one embodiment, film 276 can also be characterized as having an optical density that is at least 4 in the 280-380 nm range, at least 2 in the 380-390 nm range, at least 0.8 in the 290-400 nm range, at least 0.13 in the 400-600 nm range, and at least 0.15 in the 600-700 nm range.

[0081] In one embodiment, film 278 blocks 99% of UV light, 60-70% of HEV light, and 30-40% of PS light. In one embodiment, film 278 comprises a UV-inhibiting PVC film, with a thickness of at least 8 mils. In one embodiment, the thickness is at least 10 mils, or at least 15 mils, but less than 20 mils thick. In one embodiment, film 278 also comprises an elastomer.

[0082] FIG. 3 depicts a graph illustrating transmission as a function of wavelength for a variety of films that may be useful in one embodiment of the present invention. In one embodiment, absorption spectra 300 is associated with a generic stock film manufactured by Nabi. Absorption spectra 302 may be associate with another stock film provided by Nabi. Absorption spectra 304 may be associate with an Armor brand film. Absorption spectra 306 may be associated with film 272, in one embodiment. Absorption spectra 308 may be associated with a film 276, in one embodiment. Absorption spectra 310 may be associated with a film 278, in another embodiment including an elastomer. Absorption spectra 312 may be associated with a film 274, in one embodiment. As shown in FIG. 3, using any of the films 272, 274, 276 or 278 produces a reduction in the absorption spectra produced by a device. For example, absorption spectra 306 shows that a maximum transmissivity in the blue light range is reduced from 1.00 to 0.37, approximately. Thus, applying any of the films 272, 274, 276 or 278 to a device, for example device 202, may result in a reduction of the harmful rays of light in the known wavelength ranges and, therefore, any of the plurality of eye related problems described above.

[0083] In one embodiment, application of any one of the films shown in FIG. 3 provides a measurable change in the transmission of light from a device to a user, as shown below in Table 3. Table 3 illustrates a percentage of energy remaining in each wavelength range after passing through the indicated applied film.

TABLE 3: ENERGY REMAINING AFTER FILM APPLICATION

	Wavelength (nm)	Nabi	Nabi care kit	Armor	Film 272	Film 274	Film 276	Film 278
UV	380-400	100%	100%	76%	1%	1%	1%	92%
HEV Blue	415-455	100%	93%	88%	90%	79%	64%	33%
All Blue	400-500	100%	93%	89%	86%	78%	66%	37%
Cyan	500-520	100%	94%	90%	86%	82%	69%	36%
Green	520-565	100%	93%	88%	91%	84%	69%	36%
Yellow	565-580	100%	93%	88%	92%	82%	68%	33%

Orange	580-625	100%	93%	88%	93%	74%	64%	28%
Red	625-740	100%	92%	83%	89%	45%	52%	21%

[0084] As shown in Table 3 above, any of the films described herein provide a significant reduction in the energy remaining in a plurality of wavelength ranges after filtering between the light produced by a device, for example device 202, and the eye 250. Films 272, 274, 276 and 278 almost completely absorb the UV light emitted by a device 202.

[0085] An organic dye impregnated film, such as film 272, 274, 276 or 278 may, in one embodiment be provided in the form of a rectangular shaped, or square shaped piece of film, as shown in FIG. 1C. One or more optical filters of a desired shape may then be cut from the film. As shown in FIG. 1A, for example, one embodiment of an optical film may include a substantially rectangular shape for a smartphone with a circle removed for a button of the smartphone. In another embodiment, an optical filter may include a circle filter design, for example, to cover a digital image sensor in a camera of a cell phone or other electronic device. In a further embodiment, the optical filter is provided either to a manufacturer or user in a sheet such that the manufacturer or user can cut the film to a desired size. In another embodiment, the film is provided with an adhesive backing such that it can be sized for, and then attached, to the desired device.

[0086] One or more additional layers of material or coating may also be provided on a film. An additional layer of material may include a hard coating to protect the film, for example, during shipping or use. Transmissivity can be improved by applying certain anti-reflection properties to the film, including at the time of application of any other coatings, including, in one embodiment, a hard coating layer. The film may also, or alternatively, have an antiglare coating applied or a tack coating applied.

[0087] According to one method of manufacturing, the organic dye is produced, dispersed in the film material (e.g. polycarbonate, in one embodiment), compounded into pellets, and then extruded into a thin film using techniques generally known to those skilled in the art. The organic dye impregnated film composition may thus be provided in the form of pellets, or in the form of an extruded film that may be provided on a roller and then cut to size depending on a specific application.

METHODS FOR CREATING A LIGHT-ABSORBING FILM

[0088] FIG. 4A-4C depict a plurality of methods for generating a light-absorbing film for a device in accordance with one embodiment of the present invention. As shown in FIG. 4A, method 400 begins at block 402 wherein a user obtains their device. The device may be a smartphone, laptop, tablet, or other light emitting device, such as device 102. The user then obtains and applies a film, such as film 100, as shown in block 404. The user may select a film 100 based on a particular eye problem, or the desire to prevent one or more particular eye-related problems. After the user obtains a device, they may apply the film 100, for example, by utilizing an adhesive layer. The adhesive layer may be found on an aftermarket film, such as film 272, 274, 276 or 278.

[0089] As shown in FIG. 4B, method 410 illustrates a method for a manufacturer of a device to provide a safer screen to a user, where the safer screen comprises a film with properties such as those described above with respect to films 272, 274, 276 and/or 278. In one embodiment, the method 140 begins at block 420 wherein the manufacturer produces a screen with a combination of one or more absorbing compounds. In one embodiment, the dye may be selected from any of those described above, in order to reduce the transmission of a specific wavelength(s) of light from the device. The manufacturer may produce the screen such that the dyes are impregnated within the screen itself, and are not applied as a separate film to the screen. The method then continues to block 422, where the manufacturer applies the screen to the device, for example using any appropriate mechanism, for example by use of an adhesive. In one embodiment, the method then continues to block 424 wherein the manufacturer provides the device to a user, this may comprise through a sale or other transaction.

[0090] FIG. 4C illustrates a method for producing a film with specific absorption characteristics in accordance with an embodiment of the present invention. In one embodiment, method 430 starts in block 440 with the selection of wavelengths for the film to absorb, or otherwise inhibit them from reaching the eye of a user. The method then continues to block 442 wherein one or more absorbing compounds is selected in order to absorb the chosen wavelength ranges, for example from Table 1 above. The method then continues to block 444 wherein an appropriate film base is selected. The appropriate film base may be the screen of a device. In another embodiment, the appropriate film base may be one of any series of polymers that is compatible with the chosen dye. In one embodiment, the user may first select an appropriate film, for example based on device characteristics, and then select appropriate dyes, thus reversing the order of blocks 442 and 444.

[0091] The method 430 continues in block 446 where the dye impregnated film is produced. In one embodiment, this may involve co-extrusion of the film with a plurality of absorbing compounds. The film may be provided as a series of resin beads and may be mixed with a series of resin beads comprising the absorbing compounds desired. In an alternative embodiment, the absorbing compounds may be provided in a liquid solution. However, any other appropriate mechanism for producing a dye impregnated film may also be used in block 446. In one embodiment, it may also be desired for the film to have another treatment applied, for example a glare-reducing or a privacy screen feature. In another embodiment, the film may be treated to have a hard coating, or may be treated with a tack coating. In one embodiment, any or all of these treatments may be provided in block 448.

[0092] In one embodiment, the method continues in block 450 where the film, for example film 100, is provided to the device, for example device 102. As described previously, this may involve the manufacturer applying a screen, such as screen 102, with the desired characteristics to the device 100 using an appropriate manufacturing procedure. It may also comprise providing dye impregnated aftermarket film to a user who then applies the film to the device, for example through either method 400 and 410 described previously.

[0093] In one embodiment, for example when used as a light filter, the organic dye impregnated film allows for targeted transmission cutoff at a particular wavelength, for example proximate the ends of the visible wavelength spectrum. In this application, the curve should further increase the overall transmission of visible wavelengths, for example, red wavelengths. The light filter may improve the true color rendering of digital image sensors, using silicon as a light absorber in one embodiment, by correcting the absorption imbalances at red and blue wavelengths, thereby yielding improved picture quality through improved color definition.

[0094] When used as an LCD retardation film, consistent with another embodiment, the organic dye impregnated film provides desired optical properties, such as 0 to 30° chief ray of incident angle and selective visible wavelengths at the 50% transmission cutoff, as well as superior mechanical robustness at less than 0.01mm thickness. Fundamentally, pigments tend to stay on the surface, as do some dyes given either the process of applying the dyes or the substrates. Our products embody dye particles throughout the carrying substrate – therefore light that hits the substrate will collide with dye particles somewhere enroute through the substrate. Therefore, the substrate is designed, in one embodiment, to be safe at a minimum incidence angle of 30°. The LCD retardation film may also provide better UV absorbance than other conventional LCD retardation films.

[0095] When used as a light emission reducing film, consistent with a further embodiment, the organic dye impregnated film reduces light emissions from an electronic device at certain wavelengths that may be harmful to a user. The light emission reducing film may reduce peaks and slopes of electromagnetic emission (for example, in the blue light range, the green light range and the orange light range) to normalize the emission spectra in the visible range. The emission spectra may be normalized, for example, between 0.0034 – 0.0038. These optical characteristics may provide the greatest suppression of harmful radiation in the thinnest substrate across the visible and near infrared range, while still meeting the industry standard visible light transmission requirements.

WHAT IS CLAIMED IS:

1. A shield for a device, the shield comprising:

a polymer substrate;

an absorbing agent dispersed within the polymer substrate;

wherein the shield reduces a transmissivity of an ultraviolet range of light by at least 90%, wherein the ultraviolet range of light comprises a range between 380 and 400 nanometers, and wherein the shield also reduces a transmissivity of a high energy visible light range by at least 10%, wherein the high energy visible light range comprises a range between 415 and 555 nanometers, and wherein the shield also reduces a transmissivity of a red light range by at least 10%, wherein the red light range comprises a range between 625 and 740 nanometers; and

wherein the shield is configured to transmit sufficient light generated by the device such that an image generated by the device is substantially unaltered by the shield.

2. The shield of claim 1, wherein the shield further reduces a transmissivity of a blue light range of wavelengths by at least 10%, wherein the blue light range comprises a range between 400 and 500 nanometers.

3. The shield of claim 1, wherein the shield further reduces a transmissivity of a blue light range by at least 20%, wherein the blue light range comprises a range between 400 and 500 nanometers.

4. The shield of claim 3, wherein the shield further reduces a transmissivity of an orange light range by at least 20%, wherein the orange light range comprises a range between 580 and 625 nanometers.

5. The shield of claim 4, wherein the shield further reduces a transmissivity of a red light range by at least 50%, wherein the red light range comprises a range between 625 and 740 nanometers.

6. The shield of claim 1, wherein the shield further reduces a transmissivity of a blue light range by at least 30%, wherein the blue light range comprises a range between 400 and 500 nanometers.

7. The shield of claim 1, wherein the shield further reduces a transmissivity of a green light range by at least 20%, wherein the green light range comprises a range between 520 and 565 nanometers.

8. The shield of claim 1, wherein the shield further reduces a transmissivity of a red light range by at least 40%, wherein the red light range comprises a range between 625 and 740 nanometers.

9. The shield of claim 1, wherein the polymer substrate comprises polycarbonate.

10. The shield of claim 1, wherein the absorbing compound comprises a Phthalocyanine dye.

11. The shield of claim 1, wherein the polymer substrate further comprises an elastomer.

12. The shield of claim 1, wherein the film substrate is polycarbonate.

13. The shield of claim 1, further comprising an IR filtering dye dispersed in the film substrate to provide substantially zero transmission in an IR range.

14. A method of limiting exposure to harmful wavelengths of light, the method comprising:

selecting an absorbing compound;

dispersing the absorbing compound within a polymer substrate;

affixing the polymer substrate to a device such that a light generated by the device passes through the polymer substrate prior, and such that a portion of the light is absorbed by the absorbing compound, wherein the portion of the light absorbed at least comprises 90% of an ultraviolet light range, at least 90% of an infrared light range, and at least 10% of a high energy visible light range, wherein, once affixed, the polymer substrate is configured to allow transmission of sufficient light that an image produced by the device is clearly visible.

15. The method of claim 14, wherein affixing the polymer substrate to the device comprises placing the polymer substrate behind a screen of the device during a manufacturing process.

16. The method of claim 14, wherein affixing the polymer substrate to the device comprises applying the polymer substrate to the device as an aftermarket feature.

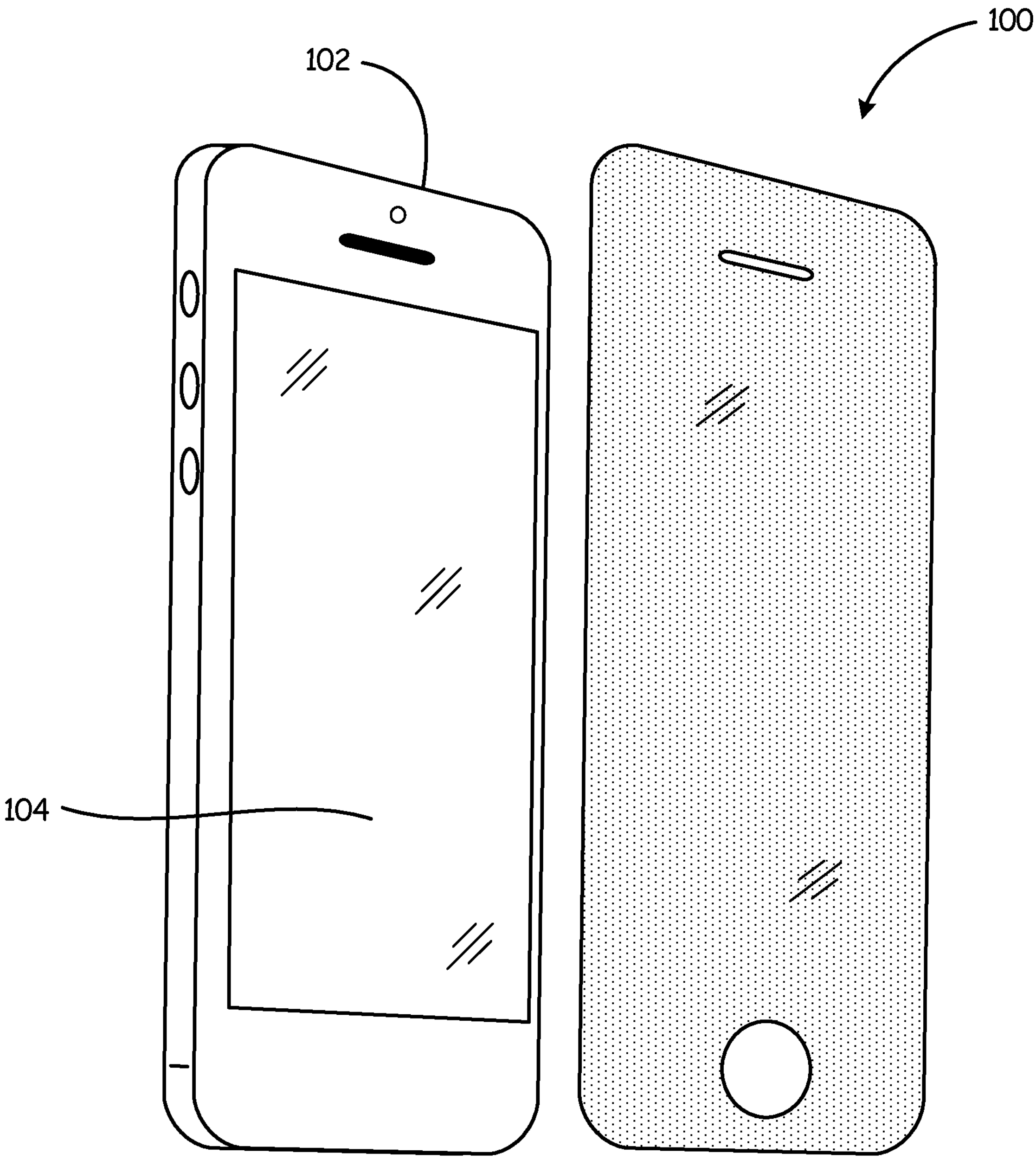


Fig. 1A

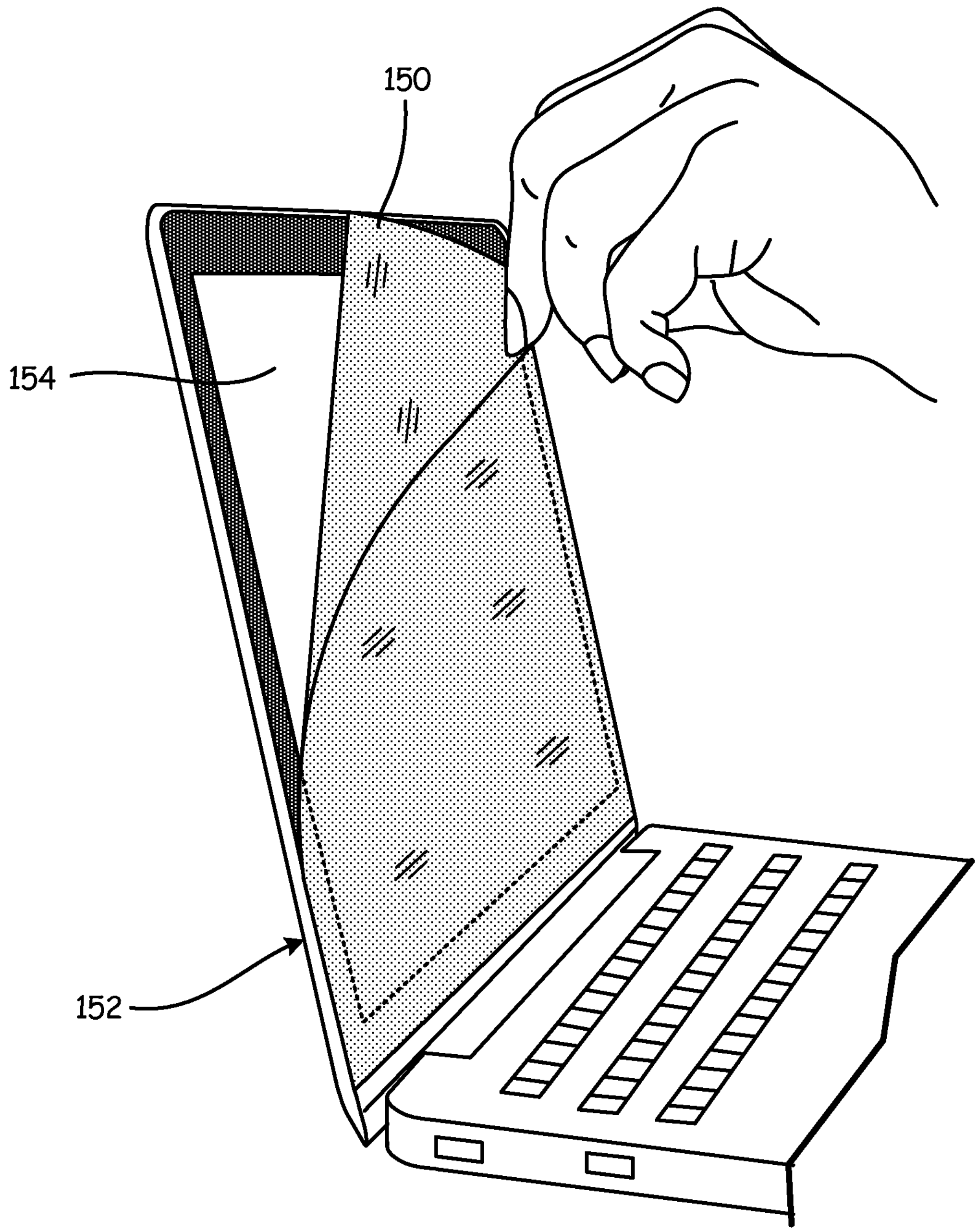


Fig. 1B

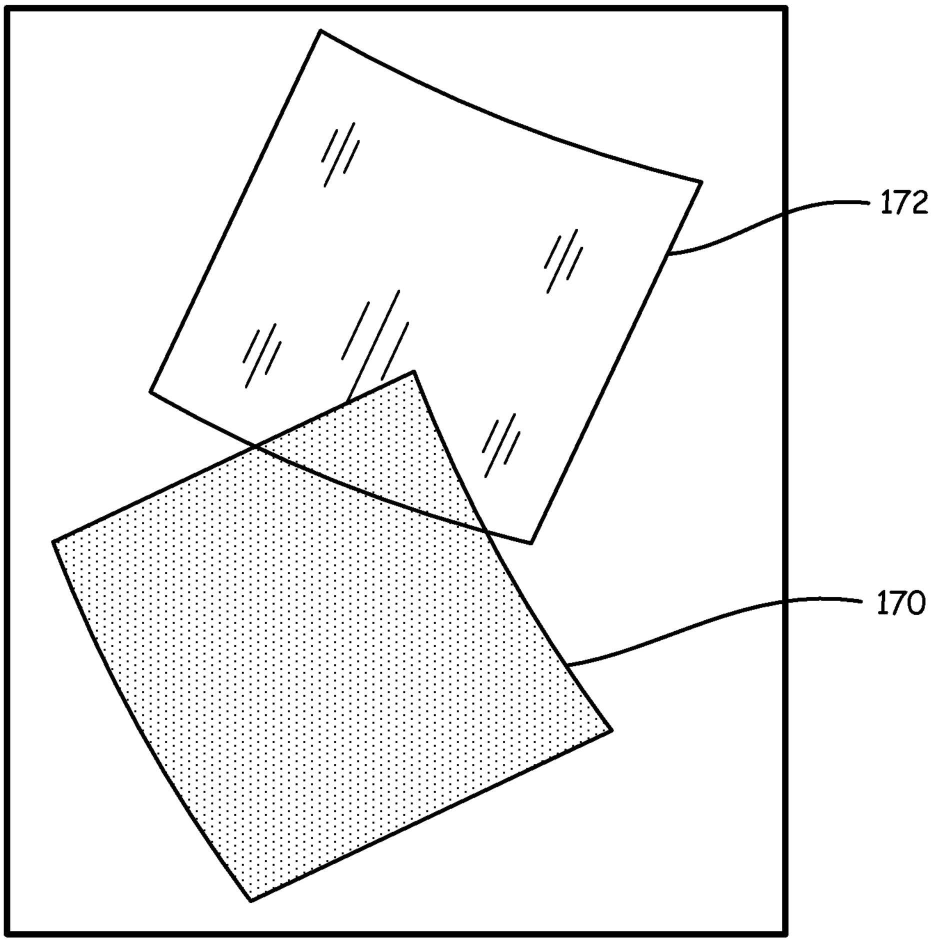


Fig. 1C

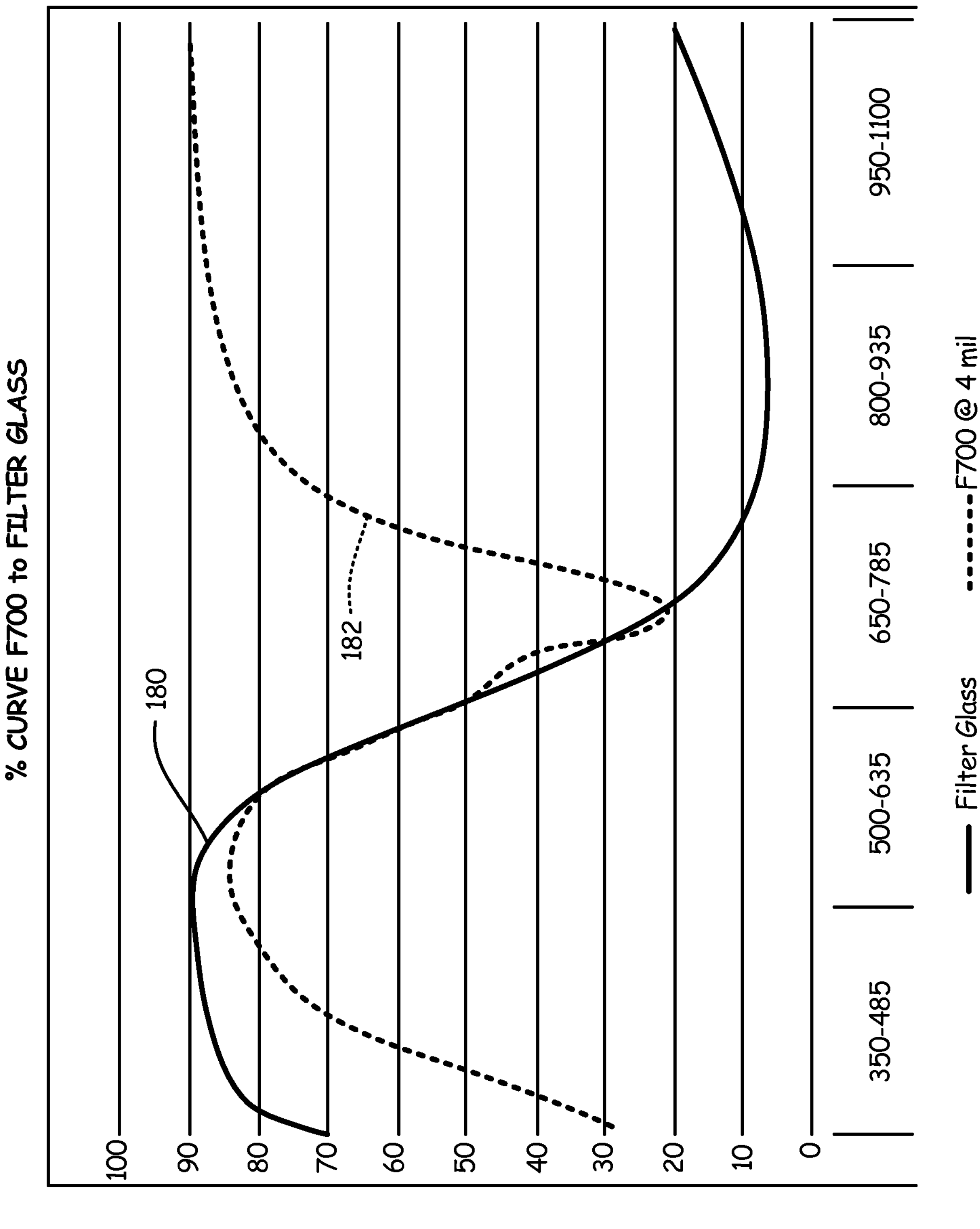

% CURVE F700 to FILTER GLASS
100
90
80
70
60
50
40
30
20
10
0
350-485
500-635
650-785
800-935
950-1100
180
182
Filter Glass
F700 @ 4 mil

Fig. 1D

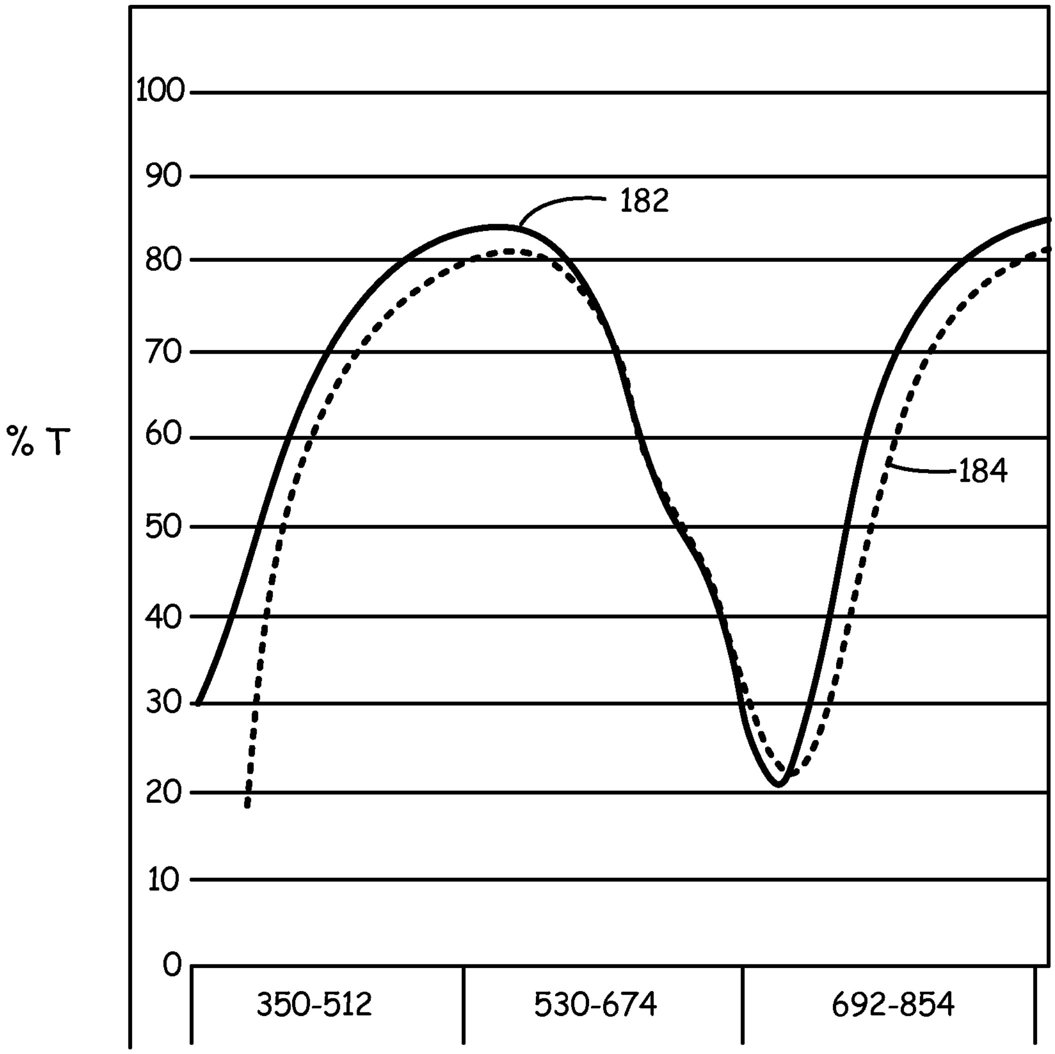


Fig. 1E

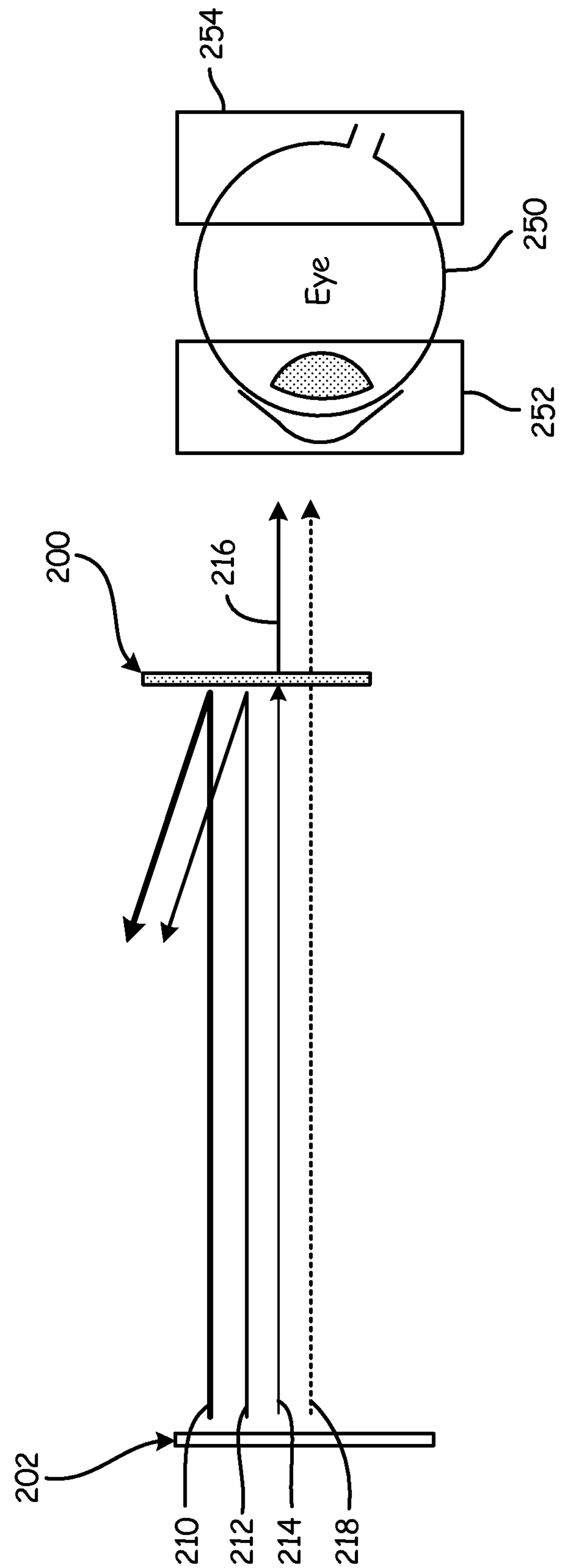


Fig. 2A

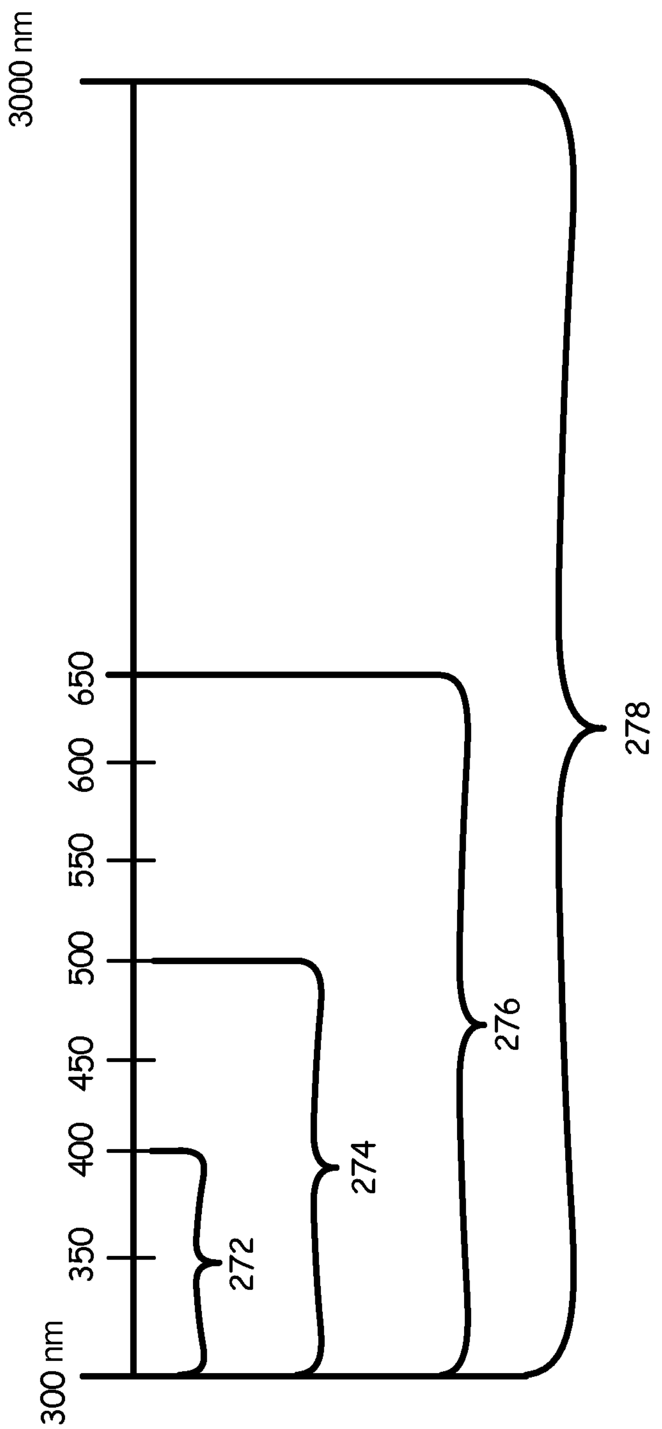
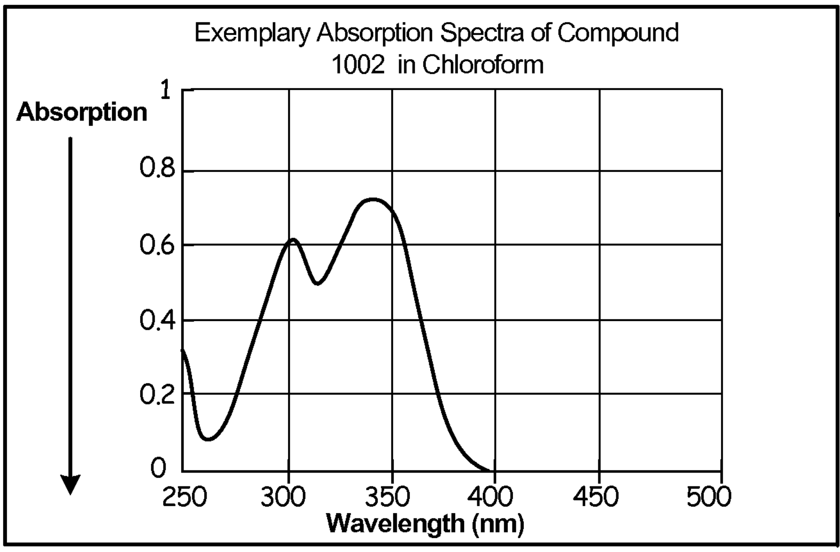


Fig. 2B



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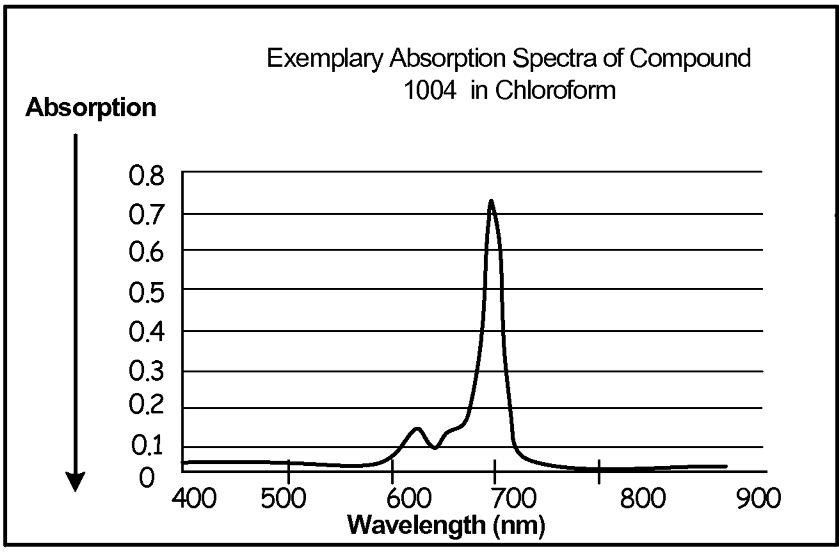

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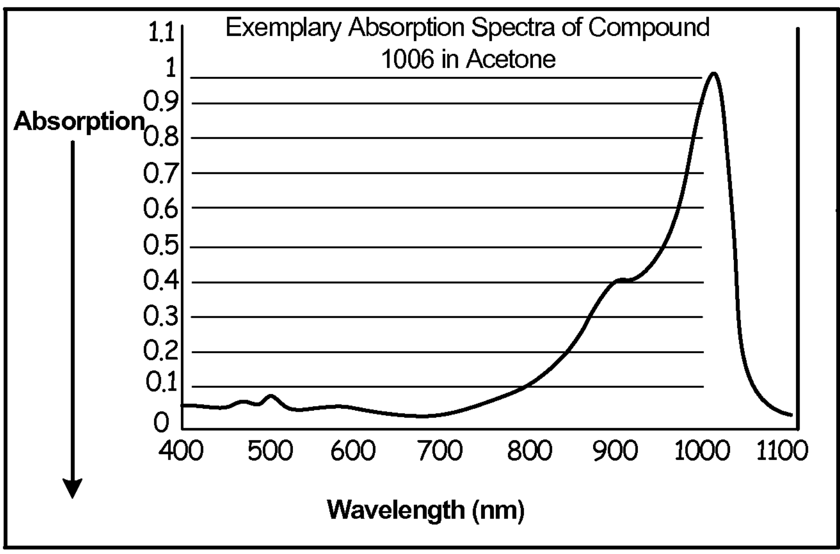

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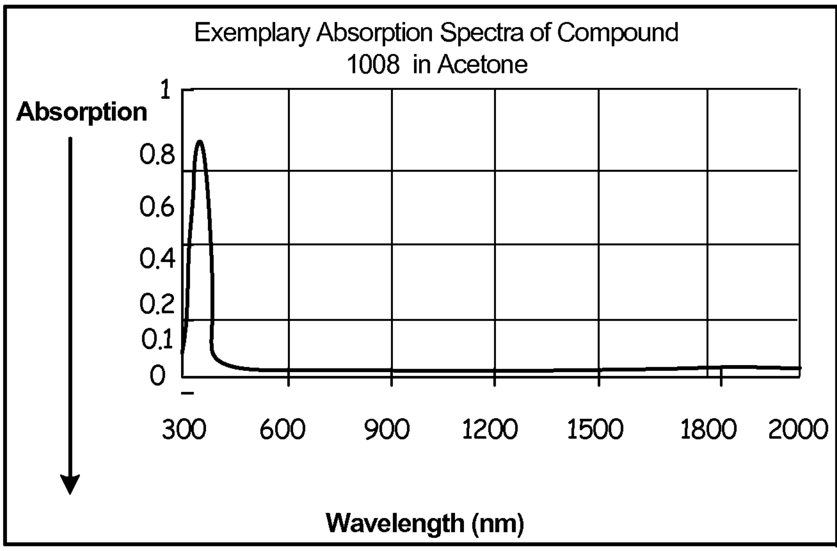
Fig. 2C-1



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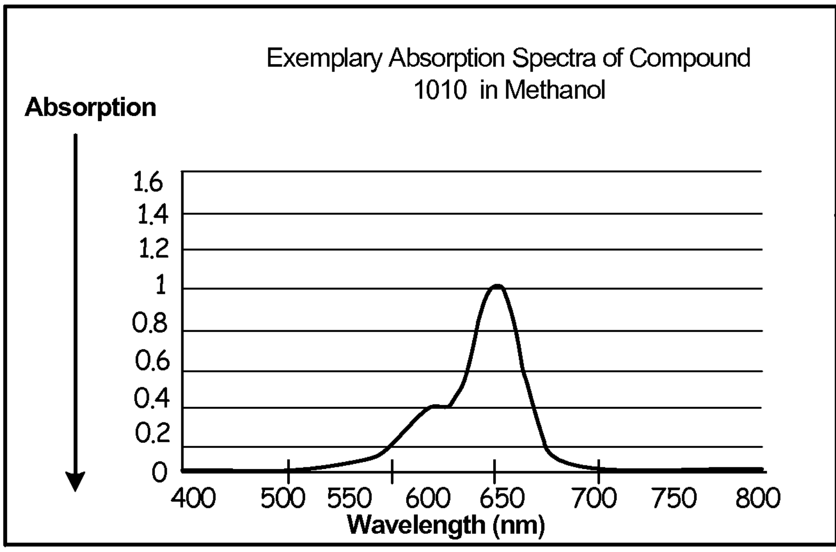

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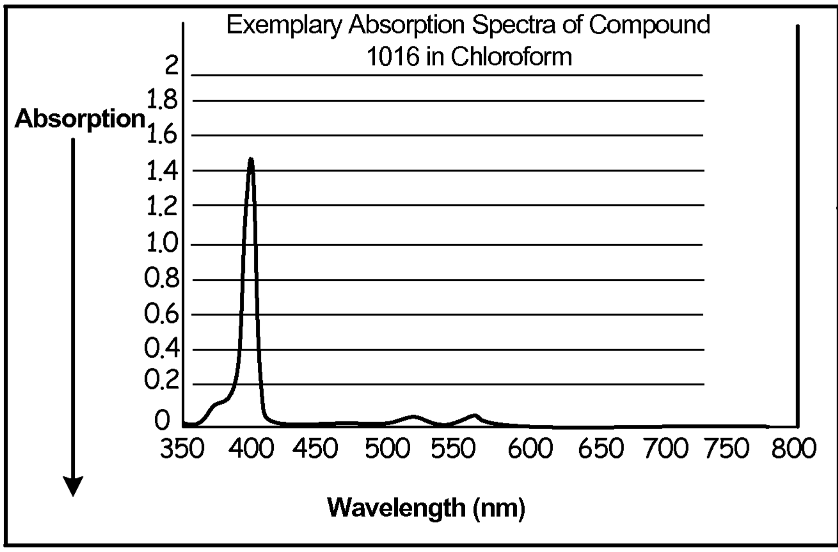


1016

Fig. 2C-2

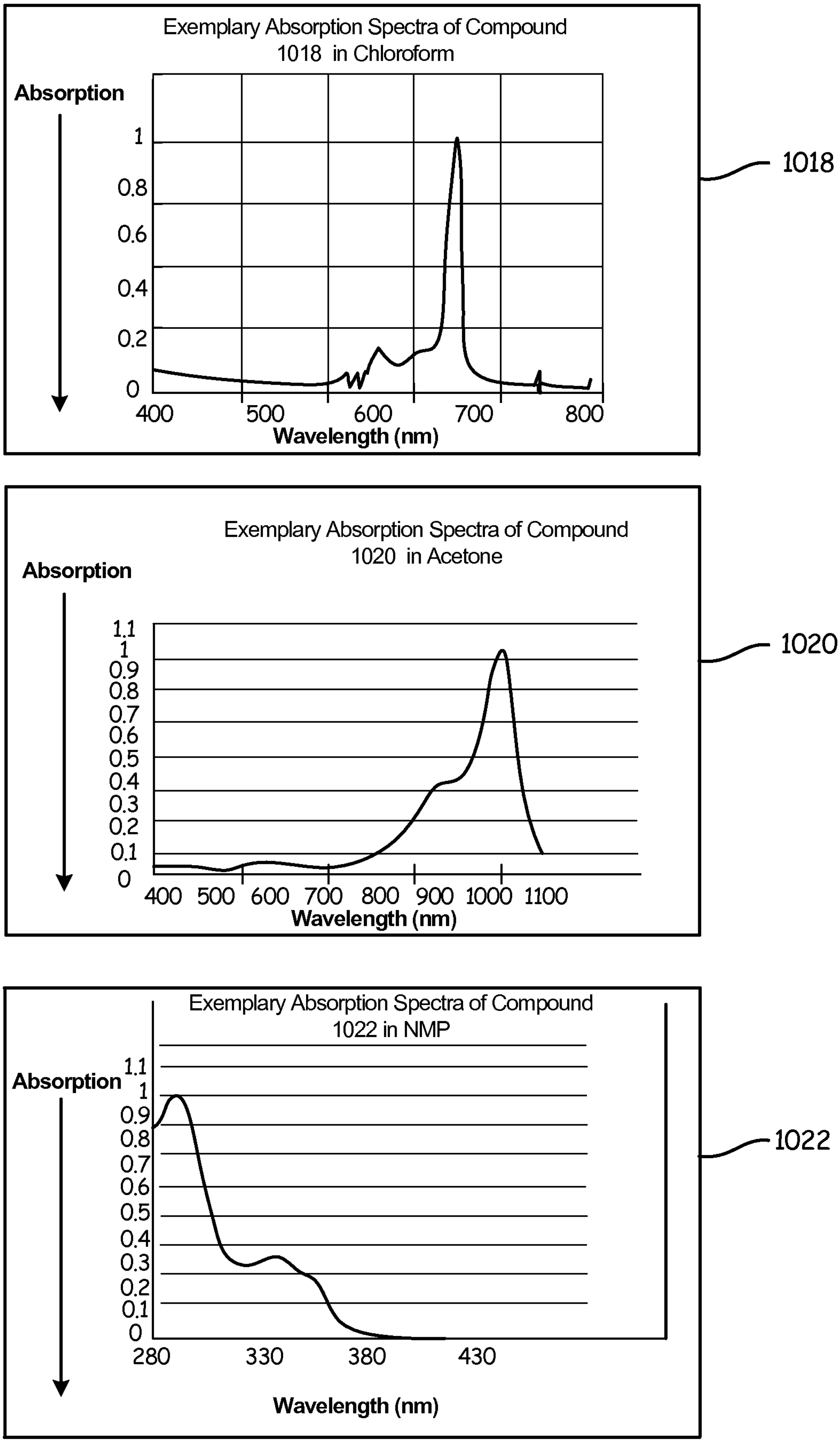

Exemplary Absorption Spectra of Compound 1018 in Chloroform
Absorption
1
0.8
0.6
0.4
0.2
0
400 500 600 700 800
Wavelength (nm)
1018
Exemplary Absorption Spectra of Compound 1020 in Acetone
Absorption
1.1 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
400 500 600 700 800 900 1000 1100
Wavelength (nm)
1020
Exemplary Absorption Spectra of Compound 1022 in NMP
Absorption
1.1 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
280 330 380 430
Wavelength (nm)
1022

Fig. 2C-3

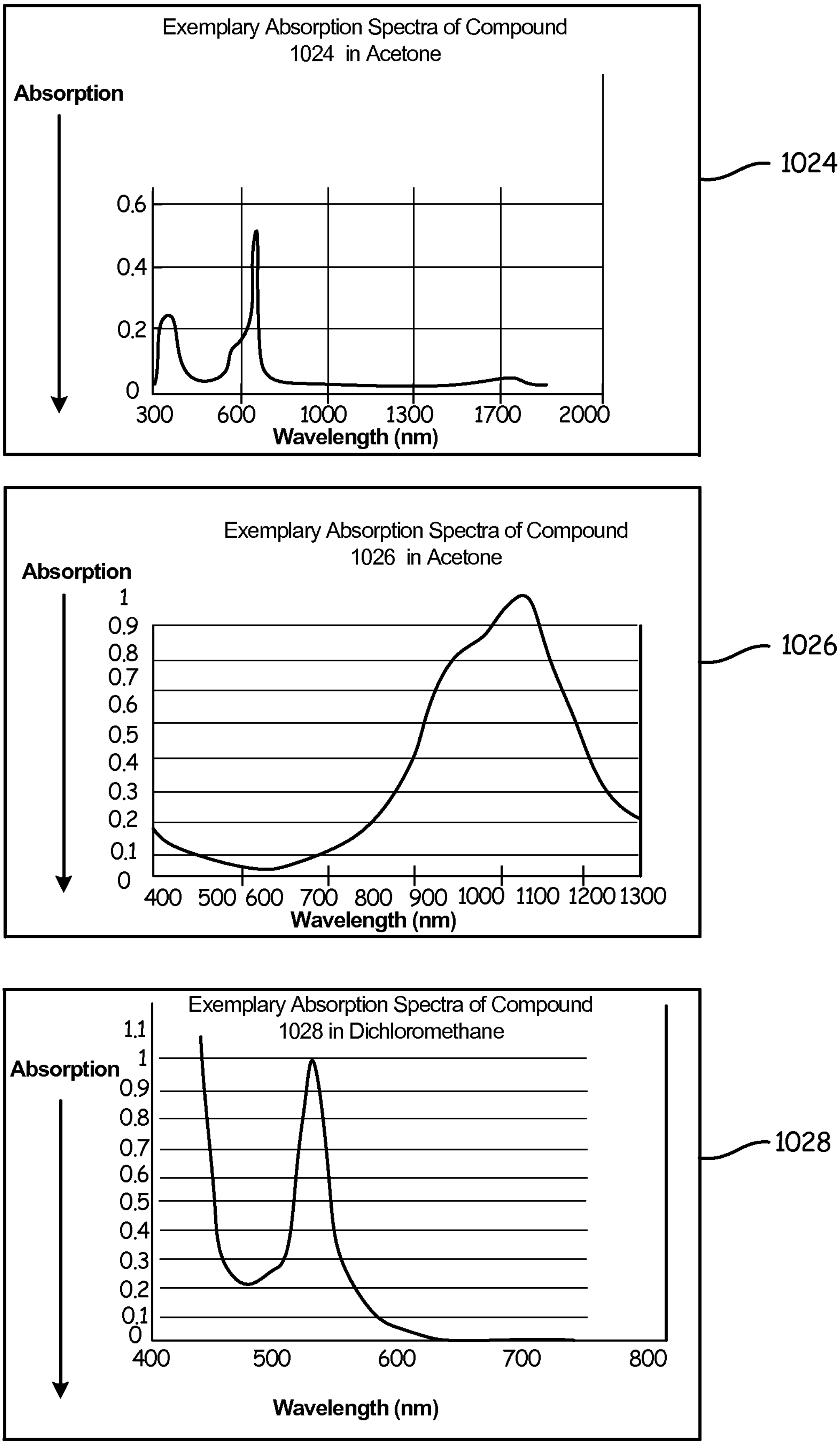

Exemplary Absorption Spectra of Compound
1024 in Acetone
Absorption
0.6
0.4
0.2
0
300
600
1000
1300
1700
2000
Wavelength (nm)
1024
Exemplary Absorption Spectra of Compound
1026 in Acetone
Absorption
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
400
500
600
700
800
900
1000
1100
1200
1300
Wavelength (nm)
1026
Exemplary Absorption Spectra of Compound
1028 in Dichloromethane
Absorption
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
400
500
600
700
800
Wavelength (nm)
1028

Fig. 2C-4

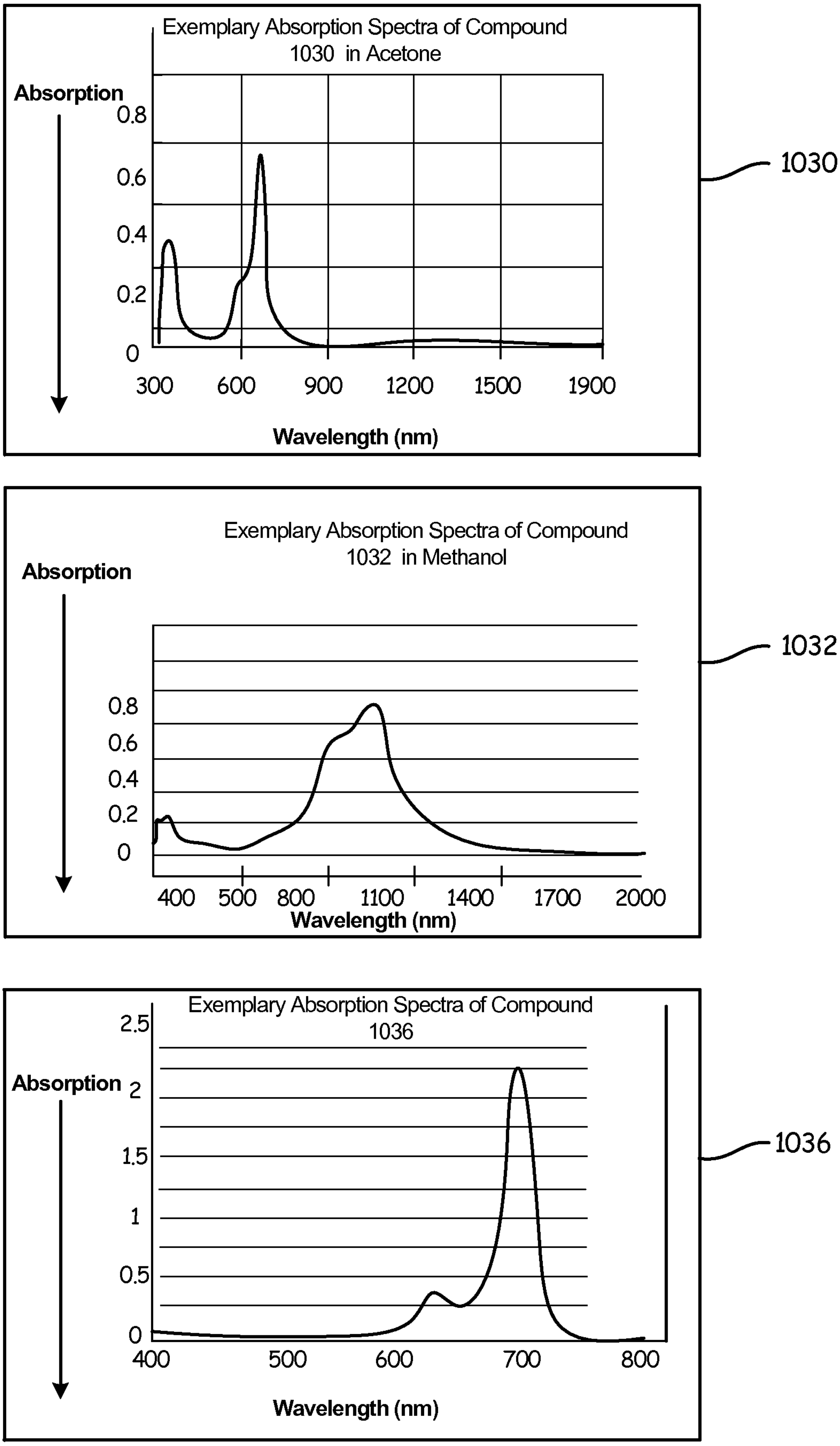
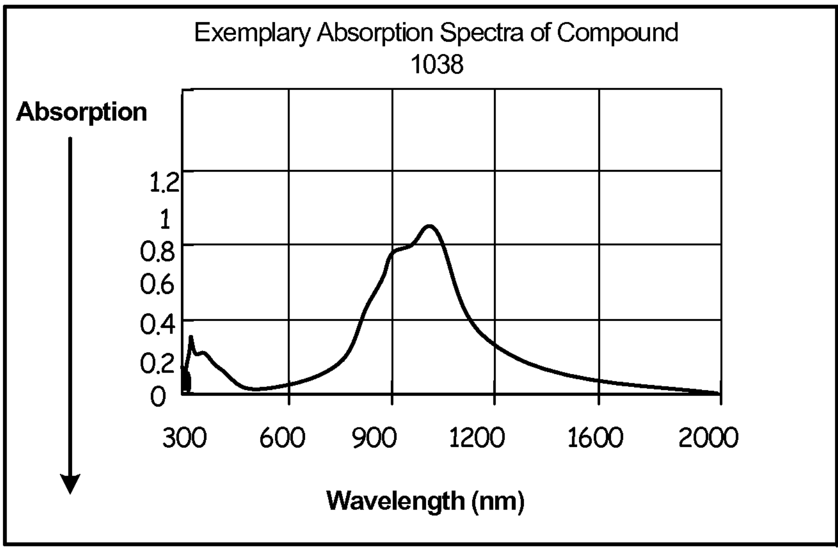

Exemplary Absorption Spectra of Compound
1030 in Acetone
Absorption
0.8
0.6
0.4
0.2
0
300
600
900
1200
1500
1900
Wavelength (nm)
1030
Exemplary Absorption Spectra of Compound
1032 in Methanol
Absorption
0.8
0.6
0.4
0.2
0
400
500
800
1100
1400
1700
2000
Wavelength (nm)
1032
Exemplary Absorption Spectra of Compound
1036
2.5
Absorption
2
1.5
1
0.5
0
400
500
600
700
800
Wavelength (nm)
1036

Fig. 2C-5



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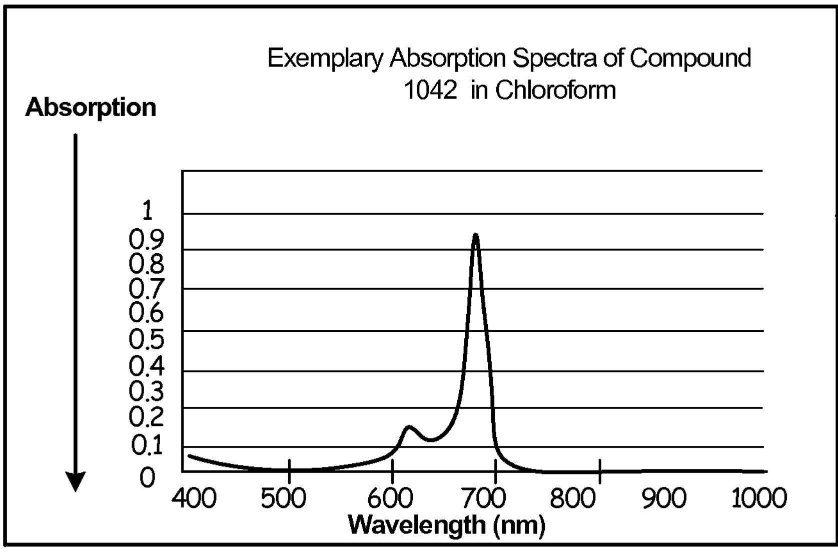

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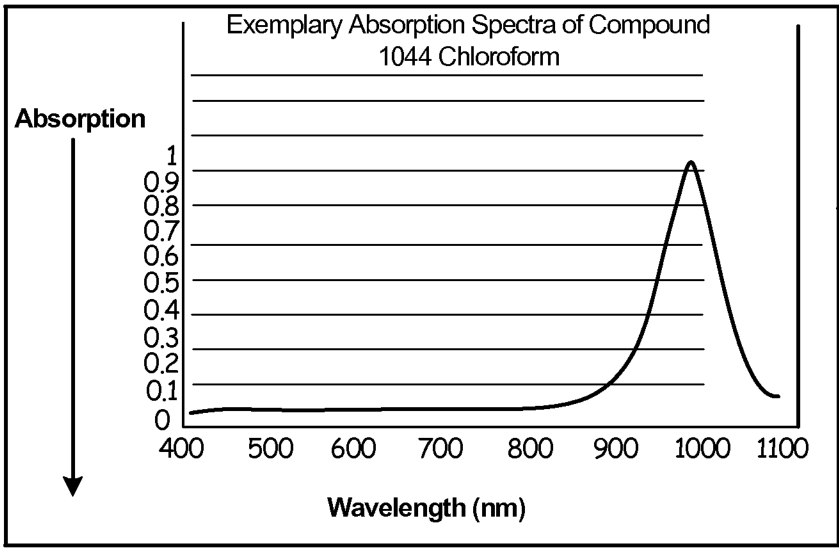
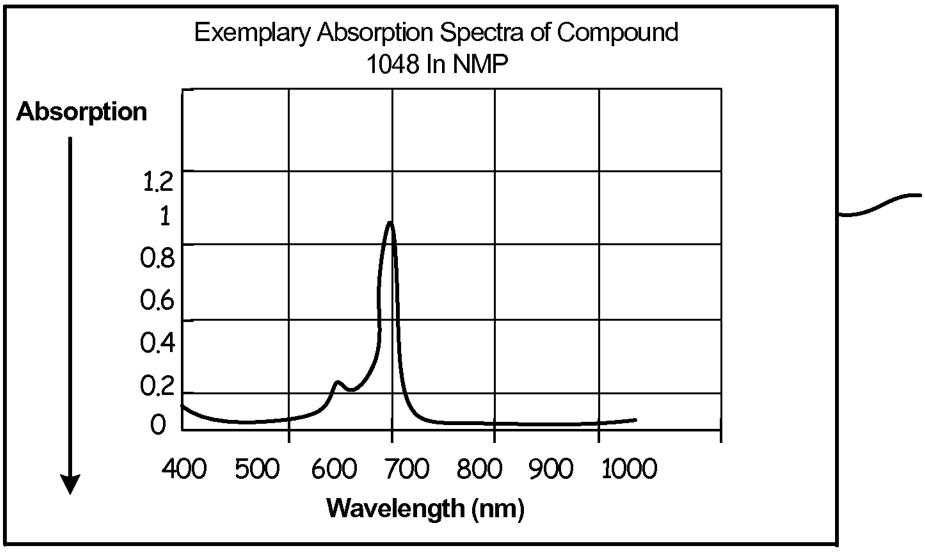


1044

Fig. 2C-6



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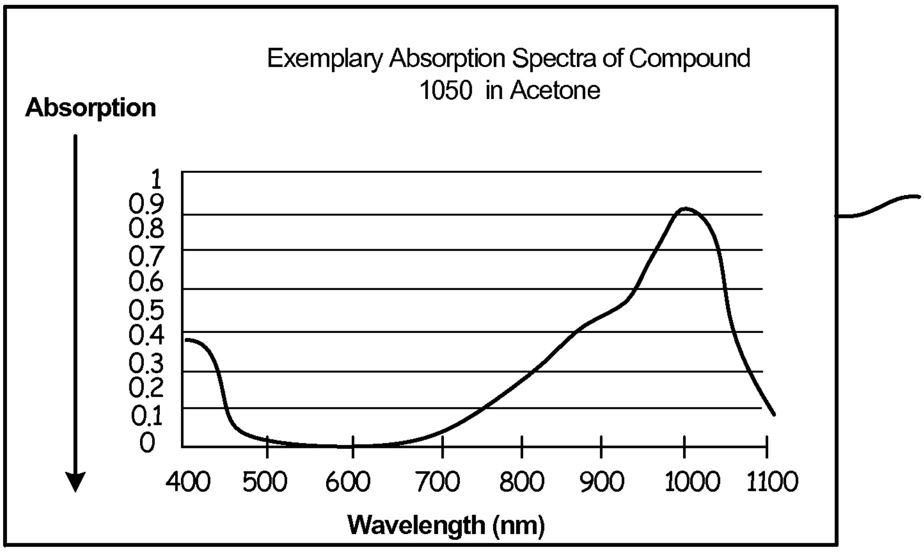
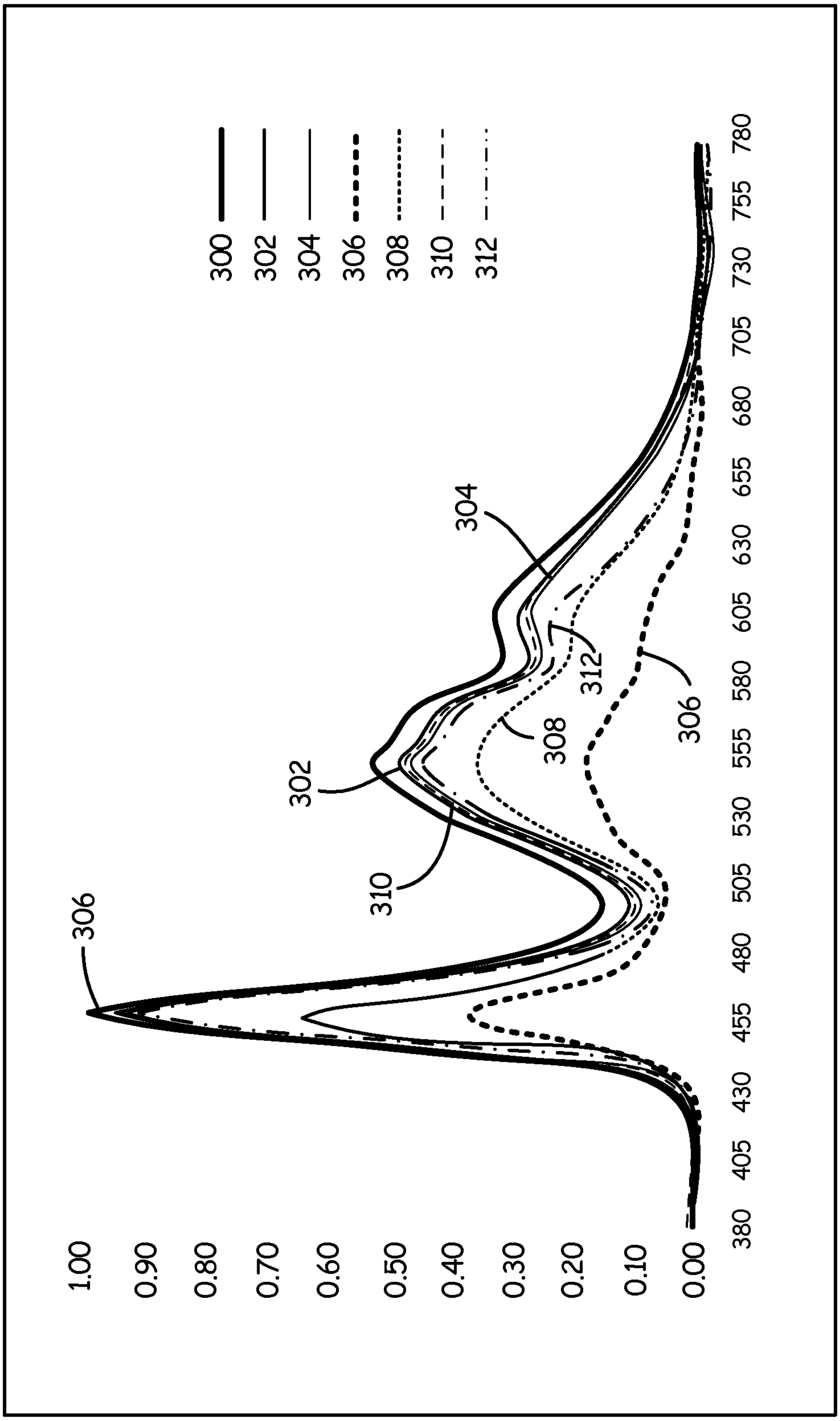


1050

Fig. 2C-7


1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
380
405
430
455
480
505
530
555
580
605
630
655
680
705
730
755
780
300
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302
310
304
308
312
306

Fig. 3A

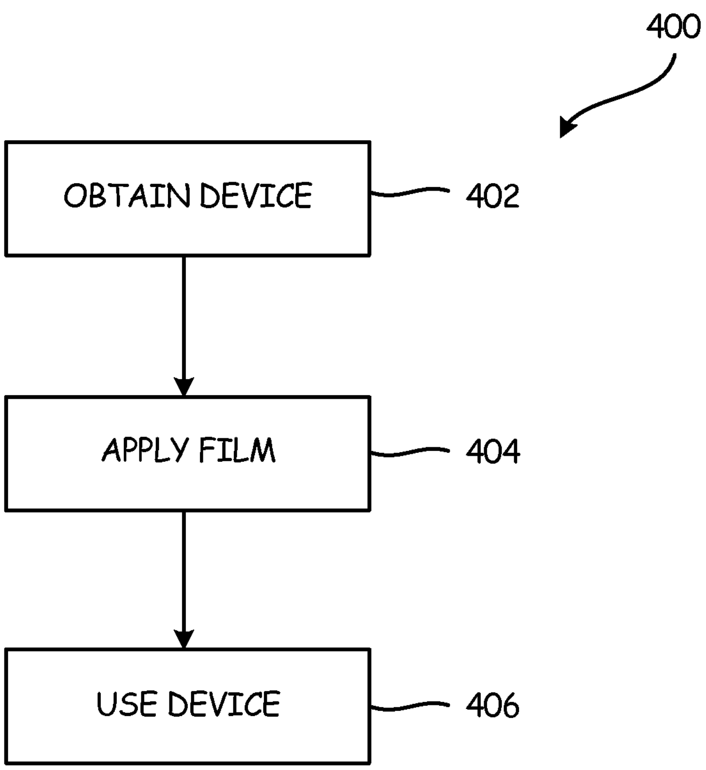
400
OBTAIN DEVICE
402
APPLY FILM
404
USE DEVICE
406

Fig.4A

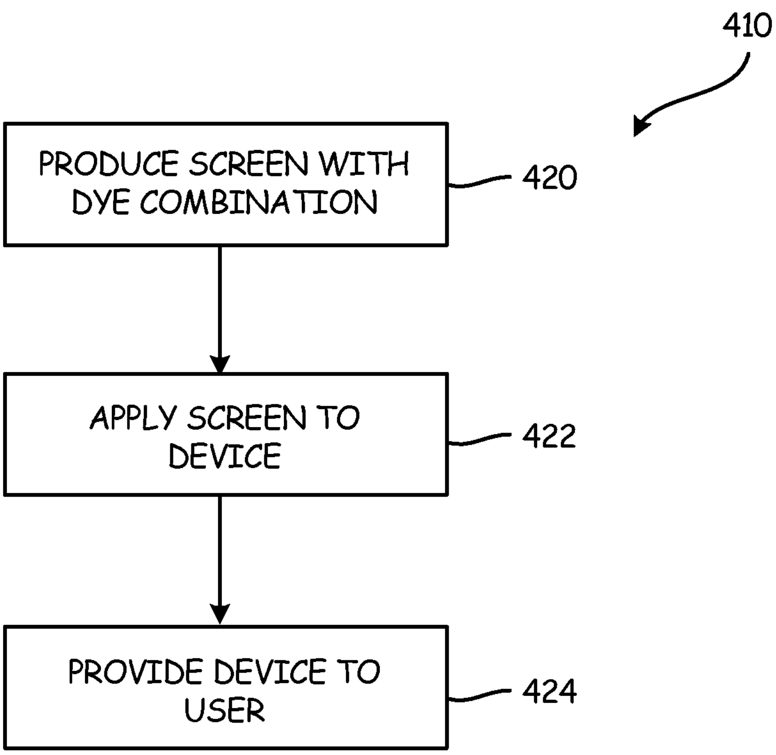
410
PRODUCE SCREEN WITH DYE COMBINATION
420
APPLY SCREEN TO DEVICE
422
PROVIDE DEVICE TO USER
424

Fig.4B

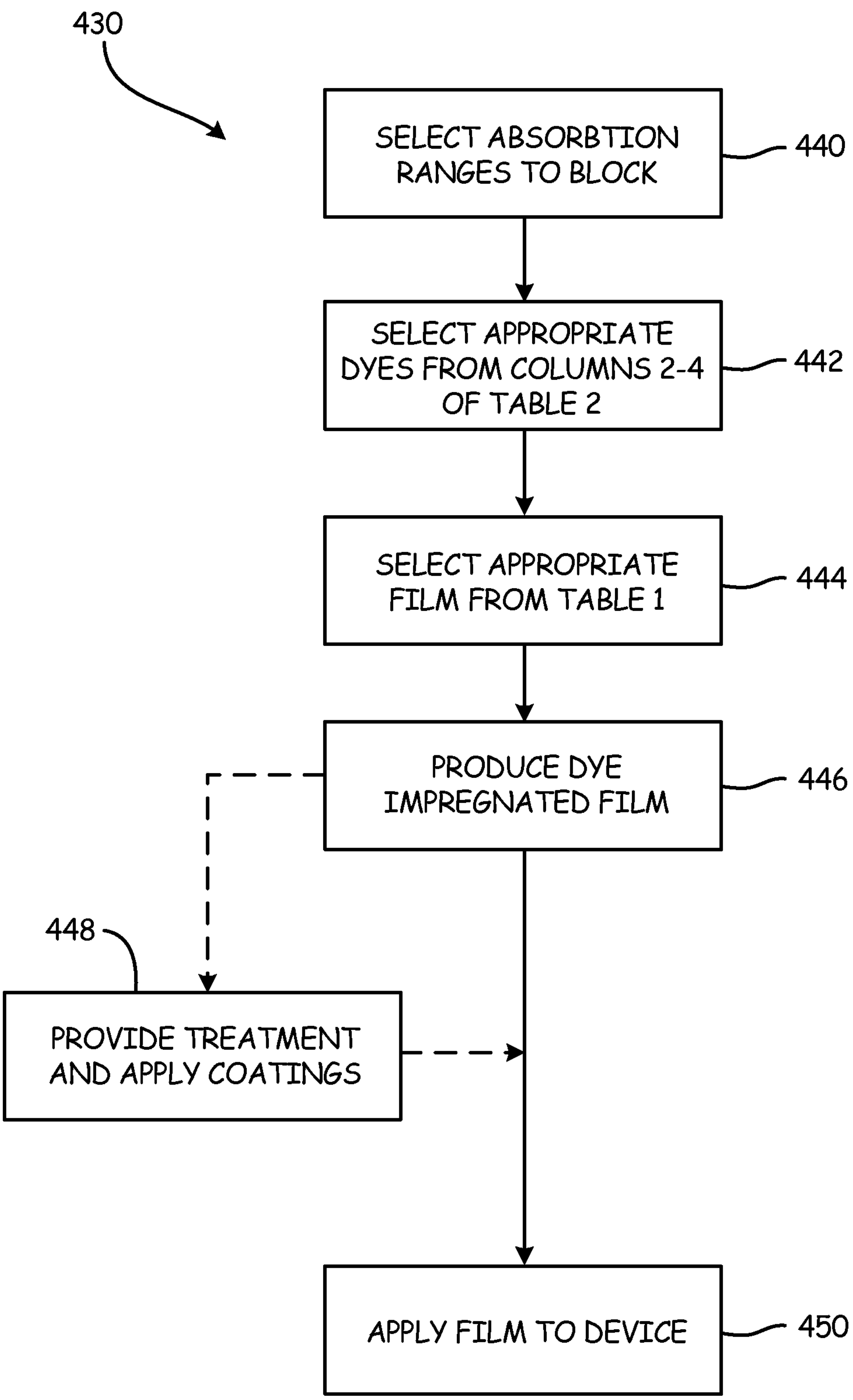
430
SELECT ABSORBTION RANGES TO BLOCK
440
SELECT APPROPRIATE DYES FROM COLUMNS 2-4 OF TABLE 2
442
SELECT APPROPRIATE FILM FROM TABLE 1
444
PRODUCE DYE IMPREGNATED FILM
446
448
PROVIDE TREATMENT AND APPLY COATINGS
APPLY FILM TO DEVICE
450

Fig. 4C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/032175

A. CLASSIFICATION OF SUBJECT MATTER

B32B 27/08(2006.01)i, B32B 7/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B32B 27/08; G02B 5/22; G02B 5/20; B32B 5/00; C09K 19/00; C08J 5/18; B32B 27/18; C08K 5/3492; B32B 27/36; B32B 7/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: shield, transmissivity, ultraviolet, absorbing agent, polycarbonate, phthalocyanine

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2013-067811 A (ADEKA CORP.) 18 April 2013 See abstract; paragraphs [0027], [0029]; claims 1, 5; and figure 2.	1-9,11-16
Y		10
Y	US 2007-0275184 A1 (LEE, B. H. et al.) 29 November 2007 See abstract; claims 1, 4, 5; and figures 1, 2.	10
A	WO 2005-106542 A1 (ACE DIGITECH, LTD.) 10 November 2005 See abstract; claims 1, 2, 5, 6; and figure 1.	1-16
A	JP 2014-000819 A (MITSUBISHI PLASTICS, INC.) 09 January 2014 See abstract; and claims 1, 2.	1-16
A	US 2010-0134879 A1 (YOSHIHARA, M. et al.) 03 June 2010 See abstract; and claim 1.	1-16

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 August 2015 (27.08.2015)	**28 August 2015 (28.08.2015)**

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CHO, Han Sol
Telephone No. +82-42-481-5580

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/032175

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		WO 2014-088057 A1	12/06/2014
US 2007-0275184 A1	29/11/2007	CN 100529804 C	19/08/2009
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WO 2005-106542 A1	10/11/2005	KR 10-0671401 B1	18/01/2007
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		KR 10-2006-0047579 A	18/05/2006
JP 2014-000819 A	09/01/2014	None	
US 2010-0134879 A1	03/06/2010	CN 101669050 A	10/03/2010
		CN 101669050 B	01/06/2011
		KR 10-2010-0015898 A	12/02/2010
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