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PHOTOCHROMIC NAPHTHOXAZINE COMPOUNDS

DESCRIPTION OF THE INVENTION

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The present invention relates to certain novel spiro(indoline)naphthoxazine compounds. More particularly, this invention relates to novel photochromic spiro(indoline) naphthoxazine compounds, and to compositions and articles containing
10 such novel naphthoxazine compounds. When subjected to ultraviolet irradiation, photochromic compounds become activated and change light transmission properties. Subsequently, activated reversible photochromic compounds revert to their original color or inactivated state when the initial ultraviolet light source is removed.

15 The photochromism of certain spiro(indoline)naphthoxazine compounds is well known and is disclosed, for example, in U.S. Patent Nos. 3,562,172, 3,578,602, and 4,342,668. The compounds described in U.S. Patents 3,562,172 and 3,578,602 are naphthoxazine derivatives with substituents on the indoline portion of the
20 molecule. U.S. Patent No. 4,342,668 describes naphthoxazine derivatives with substituents on the 8' or 9' position, one of which substituents is halogen or lower alkoxy - the other being hydrogen. These compounds have been described as having enhanced photocolorability, i.e., a relatively large change in optical
25 density between the activated and inactivated state.

The present invention relates to novel spiro(indoline) naphthoxazines which have been found to have improved photocolorability and an unexpectedly higher absorption maxima than the corresponding unsubstituted compounds. These compounds have
30 certain substituents on the 8' and 9' positions of the naphthoxazine portion of the molecule.

DETAILED DESCRIPTION OF THE INVENTION

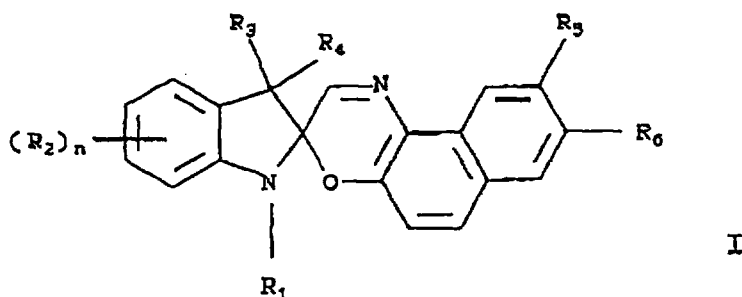
In recent years, photochromic plastic materials,
35 particularly plastic materials for optical applications, have been the subject of considerable attention. In particular, photochromic

ophthalmic plastic lenses have been investigated because of the weight advantages they offer, *vis-a-vis*, glass lenses. Moreover, photochromic transparencies for vehicles such as cars and airplanes have been of interest because of the potential safety features that 5 such transparencies offer.

Ideally, photochromic compounds used in optical applications, such as conventional ophthalmic lenses, are those which possess (a) a high quantum efficiency for coloring in the near ultraviolet, (b) a low quantum yield for bleaching with white light 10 and (c) a relatively fast thermal fade at ambient temperature but not so rapid a thermal fade rate that the combination of white light bleaching and thermal fade prevent coloring by the ultraviolet component of strong sunlight.

In accordance with the present invention, certain novel 15 spiro(indoline)naphthoxazine compounds having a high quantum efficiency for coloring in the near ultraviolet, improved photocolorability and an acceptable rate of fade have been discovered. These compounds may be graphically represented by the following graphic Formula I:

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In graphic formula I, R_1 may be a C_1 - C_8 alkyl, phen(C_1 - C_4)alkyl, naphth(C_1 - C_4)alkyl, allyl, acrylyloxy(C_2 - C_6)alkyl, methacrylyloxy(C_2 - C_6)alkyl, C_1 - C_4 acyloxy(C_2 - C_6)alkyl, 35 carboxy(C_2 - C_6)alkyl, cyano(C_2 - C_6)alkyl, hydroxy(C_2 - C_6)alkyl, C_1 - C_6



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alkoxy(C₂-C₄)alkyl or (C₂H₄O)_m·CH₃, wherein m is an integer from 1 to 6. Preferably, R₁ is allyl, C₁-C₃ alkoxy(C₂-C₄)alkyl or C₁-C₄ alkyl, e.g., methyl, ethyl, propyl or butyl. Each R₂ may be a C₁-C₅ alkyl, C₁-C₅ alkoxy, nitro, cyano, C₁-C₈ alkoxycarbonyl, C₁-C₄ acyloxy, halo, C₁-C₄ monohaloalkyl or C₁-C₄ polyhaloalkyl.

Preferably, R₂ is C₁-C₃ alkoxy, e.g., methoxy, ethoxy or propoxy, or C₁-C₃ alkyl, e.g., methyl, ethyl or propyl. The halogen and halo substituents may be chloro, fluoro, iodo or bromo, preferably chloro or fluoro, and n is the integer 0, 1 or 2.

10 R₃ and R₄ may each be C₁-C₅ alkyl, benzyl, phenyl, mono- or di-substituted phenyl, said phenyl substituents being C₁-C₅ alkyl or C₁-C₅ alkoxy, or R₃ and R₄ may together form a cyclic ring containing from 5 to 8 carbon atoms which includes the spiro carbon atom, norbornyl or adamantyl. Preferably, each R₃ and R₄ is a C₁-C₃ 15 alkyl, i.e., methyl, ethyl or propyl, or R₃ and R₄ may together form a cyclic ring containing from 5 to 7 carbon atoms which includes the spiro carbon atom.

R₅ is the group -C(O)X, wherein X is the group -OR₇ or -N(R₈)R₉, wherein R₇ is selected from C₁-C₆ alkyl, benzyl, C₁-C₆ 20 alkyl substituted benzyl, C₁-C₆ alkoxy substituted benzyl, C₁-C₆ alkoxy(C₂-C₄)alkyl, allyl, or C₁-C₆ mono- or di- haloalkyl, e.g., chloro, fluoro, bromo and iodoalkyl, particularly chloro- and fluoroalkyl, and wherein R₈ and R₉ are each selected from hydrogen, C₁-C₅ alkyl, C₅-C₇ cycloalkyl, phenyl, and substituted phenyl, or R₈ 25 and R₉ may together with the nitrogen form a substituted or unsubstituted heterocyclic ring having from 5 to 6 ring atoms, which ring includes the nitrogen atom, and optionally one additional hetero atom of nitrogen or oxygen, said phenyl and heterocyclic ring substituents being C₁-C₅ alkyl or C₁-C₆ alkoxy. Preferably R₇ is 30 allyl or C₁-C₆ alkyl, e.g., methyl, ethyl, propyl, butyl, pentyl or hexyl.

R₆ is the group, -O-Y, wherein Y may be hydrogen, C₁-C₆ alkyl, benzyl, C₁-C₆ alkyl substituted benzyl, C₁-C₆ alkoxy substituted benzyl, C₁-C₆ alkoxy (C₂-C₄)alkyl, C₁-C₆ haloalkyl, 35 e.g., chloro, fluoro, bromo or iodoalkyl, allyl or the group,

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-C(O)Z, wherein Z is C₁-C₆ alkyl, phenyl, C₁-C₆ alkyl substituted phenyl, C₁-C₆ alkoxy substituted phenyl, C₁-C₆ alkoxy, phenoxy, C₁-C₆ alkyl substituted phenoxy, C₁-C₆ alkoxy substituted phenoxy, C₁-C₆ alkylamino, phenylamino, C₁-C₆ alkyl substituted phenylamino
5 or C₁-C₆ alkoxy substituted phenylamino. Preferably R₆ is the group, O-Y, wherein Y is hydrogen, C₁-C₃ alkyl or the group, -C(O)Z, wherein Z is C₁-C₃ alkyl, e.g., methyl. As used in the specification and claims herein, the term alkyl is intended to include linear and branched alkyls.

- 10 Compounds represented by graphic formula I may be prepared by esterification of the carboxylic acid group of 3,7-dihydroxy-
2-naphthoic acid using sodium bicarbonate and the corresponding R₇
halide, e.g., alkyl halide, such as methyl iodide, in
dimethylformamide (DMF) followed by nitrosation using sodium nitrite
15 and acetic acid in methylene chloride to yield the corresponding
3,7-dihydroxy-8-nitroso naphthoate. To prepare the corresponding
amide, the ester may be reacted with the appropriate primary or
secondary amine or ammonia followed by nitrosation as described
above. Condensation of this material with a Fisher's Base, as shown
20 in the following equation, produces the corresponding
spiro(indoline)naphthoxazine. This naphthoxazine may be subjected
to further reactions, such as alkylation or acylation, to produce
the desired R₆ substituent at the 8' position.

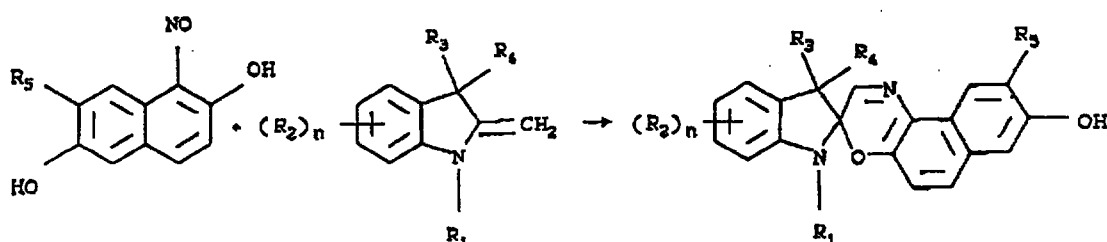
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On irradiation of the compounds of graphic formula I with ultraviolet light, the naphthoxazine ring is reported to open reversibly at the carbon-oxygen bond between the spiro carbon atom and the ring oxygen. The formation of the open form of the colorless compound is believed to be responsible for the coloring observed on exposure to ultraviolet light. It is also believed that the extension of the chromophore by the claimed substituents on the 8' and 9' positions may be responsible for the improved photocolerability and the bathochromic shift in the UV spectrum relative to the naphthoxazine compounds disclosed in U.S. Patent No. 4,342,668. The colored form of the photochromic compounds of graphic formula I fade to the colorless state at normal ambient temperatures when the ultraviolet light source is removed.

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Compounds represented by graphic formula I may be used alone or in combination with other photochromic compounds in those applications in which organic photochromic substances may be employed, such as optical lenses, e.g., ophthalmic and plano lenses, 5 face shields, goggles, visors, camera lenses, windows, automotive windshields, aircraft and automotive transparencies, e.g., T-roofs, sidelights and backlights, plastic films and sheets, novelty items, e.g., toys and posters, textiles and coatings, e.g., coating compositions such as paints, and verification marks on security 10 documents, e.g., documents such as banknotes, passports and drivers' licenses for which authentication or verification of authenticity may be desired. Naphthoxazines represented by graphic formula I exhibit color changes from colorless to colors ranging from green to blue.

15 Examples of particularly contemplated naphthoxazines are the following:

- (1) 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxy-carbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine]
- 20 (2) 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxy-carbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine]
- (3) 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxy-carbonyl-8'-methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4] oxazine]
- 25 (4) 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxy-carbonyl-8'-methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine]
- (5) 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxy-carbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4] oxazine]
- 30 (6) 1-propyl-3-ethyl-3-methyl-9'-methoxycarbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4] oxazine]
- (7) 1-propyl-3,3-dimethyl-5-methoxy-9'-methoxycarbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine]
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- (8) 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxy-
carbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-
[1,4]oxazine]
- 5 (9) 1-methoxyethyl-3,3-dimethyl-9'-allyloxycarbonyl-8'-
benzoyloxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]-
oxazine]
- (10) 1-allyl-3,3-spirocyclohexyl-9'-benzyloxycarbonyl-8'-
chloroacetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]-
oxazine]

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Commercially available photoreactive inorganic glass lenses
containing silver halide particles darken to a neutral color, such
as gray or brown, in unfiltered sunlight. In order to duplicate
this color change in a plastic lens using the organic photochromic
15 naphthoxazines of graphic formula I, it is contemplated that such
naphthoxazines be used in combination with other appropriate
complementary organic photochromic materials so that together they
produce the desired gray or brown color shade when the plastic lens
containing such photochromic materials is exposed to ultraviolet
20 light.

For example, a compound which colors to yellow may be
blended with a compound that colors to an appropriate purple to
produce a brown shade. Similarly, a compound which is orange in its
colored state will produce a shade of gray when used in conjunction
25 with an appropriate blue coloring compound. Also contemplated is
the use of various combinations of photochromic compounds that color
orange, yellow, blue, and purple with naphthoxazine compounds of
graphic formula I to produce the desired neutral color. U.S. Patent
No. 4,968,454 describes how two (or more) organic photochromic
30 substances can be combined to produce variable light transmittance
articles, such as ophthalmic lens.

The relative amounts of naphthoxazine compounds of graphic
formula I and other complementary organic photochromic compounds
used in combination will vary and depend in part upon the relative

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intensities of the color of the activated species of such compounds, and the ultimate color desired. Generally, the weight ratio of the aforescribed naphthoxazine compound(s) to the other complementary photochromic compound(s) will vary from about 1:3 to 5 about 3:1, e.g., between about 0.75:1 and about 2:1.

Particularly contemplated classes of complementary organic photochromic compounds that may be used with the naphthoxazines of the present invention include: spiro(indoline)-type compounds such as other spiro(indoline) naphthoxazines, spiro(benzindoline)naph-
10 thoxazines, spiro(indoline)pyridobenzoxazines, spiro(benzindoline)-pyridobenzoxazines, spiro(indoline)naphthopyrans, spiro(benzindoline)naphthopyrans, spiro(indoline)benzopyrans, spiro(indoline)benzoxazines, spiro(benzindoline)benzoxazines, chromenes, e.g., benzopyrans and naphthopyrans, metal dithizonate
15 compounds, fulgides or fulgimides and spiro(di)hydroindolizines.

More particularly, the contemplated classes of complementary organic photochromic compounds include the naphthopyran photochromic compounds disclosed in U.S. Patent No. 5,066,818, which color to yellow-orange when activated;
20 spiro(indoline)pyridobenzoxazine photochromic compounds described in U.S. Patents 4,637,698 and 4,720,547; and spiro(indoline) naphthoxazines described in U.S. Patents 3,562,172, 3,578,602, 4,215,010 and 4,342,668, which are reported to color to blue when activated. See the disclosure of U.S. Patent No. 5,066,818 from
25 column 6, line 30 to column 13, line 34, which may be incorporated herein, for examples of the aforesaid spiro(indoline) type compounds.

Photochromic compounds of the present invention, mixtures of such compounds with other photochromic compounds, or compositions containing same (hereinafter "photochromic substances") may be
30 applied to or incorporated into a host material by various methods described in the art. Such methods include dissolving or dispersing the substance within the host material, e.g., imbibition of the photochromic substance into the host material by immersion of the host material in a hot solution of the photochromic substance or by



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thermal transfer; providing the photochromic substance as a separate layer between adjacent layers of the host material, e.g., as a part of a polymer film; and applying the photochromic substance as part of a coating placed on the surface of the host material.

5 The term "imbibition" or "imbibe" is intended to mean and include permeation of the photochromic substance alone into the host material, solvent assisted transfer absorption of the photochromic substance into a porous polymer, vapor phase transfer, and other such transfer mechanisms.

10 The amount of photochromic substance or composition- containing same applied to or incorporated into a host material is not critical provided that a sufficient amount is used to produce a photochromic effect discernible to the naked eye upon activation. Generally such amount can be described as a photochromic amount.

15 The particular amount used depends often upon the intensity of color desired upon irradiation thereof and upon the method used to incorporate or apply the photochromic substances. Typically, the more compound applied or incorporated, the greater is the color intensity. Generally, the amount of each photochromic substance
20 incorporated into or applied to a photochromic optical host material may range from about 0.15 to about 0.35 milligrams per square centimeter of surface to which the photochromic substance(s) is incorporated or applied.

Compatible (chemically and color-wise) tints, i.e., dyes,
25 may be applied to the host material to achieve a more aesthetic result, for medical reasons, or for reasons of fashion. The particular dye selected will vary and depend on the aforesaid need and result to be achieved. In one embodiment, the dye may be selected to complement the color resulting from the activated
30 photochromic substances, e.g., to achieve a more neutral color or absorb a particular wavelength of incident light. In another embodiment, the dye may be selected to provide a desired hue to the host matrix when the photochromic substances is in an inactivated state.

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The polymer host material will usually be transparent, but may be translucent or even opaque. The polymer product need only be transparent to that portion of the electromagnetic spectrum, which activates the photochromic substance, i.e., that wavelength of ultraviolet (UV) light that produces the open form of the substance and that portion of the visible spectrum that includes the absorption maximum wavelength of the substance in its UV activated form, i.e., the open form. Further, the resin color should not be such that it masks the color of the activated form of the photochromic substance, i.e., so the change in color is readily apparent to the observer. Preferably, the host material article is a solid transparent or optically clear material.

Examples of host materials which may be used with the photochromic substances or compositions described herein include:

15 polymers, i.e., homopolymers and copolymers, of polyol(allyl carbonate) monomers, polymers, i.e., homopolymers and copolymers, of polyfunctional acrylate monomers, polyacrylates, poly(alkylacrylates) such as poly(methyl methacrylate), cellulose acetate, cellulose triacetate, cellulose acetate propionate, cellulose acetate butyrate, poly(vinyl acetate), poly(vinyl alcohol), poly(vinyl chloride), poly(vinylidene chloride), polyurethanes, polycarbonates, poly(ethylene terephthalate), polystyrene, copoly(styrene-methylmethacrylate), copoly(styrene-acrylonitrile), polyvinylbutyral and polymers, i.e.,

25 homopolymers and copolymers, of diallylidene pentaerythritol, particularly copolymers with polyol (allyl carbonate) monomers, e.g., diethylene glycol bis(allyl carbonate), and acrylate monomers. Blends of transparent polymers are also suitable as host materials.

30 Preferably, the host material is an optically clear polymerized organic material prepared from a polycarbonate resin, such as the carbonate-linked resin derived from bisphenol A and phosgene, which is sold under the trademark, LEXAN; a poly(methyl methacrylate); such as the material sold under the trademark,



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PLEXIGLAS; polymerizates of a polyol(allyl carbonate) monomer, especially diethylene glycol bis(allyl carbonate), which monomer is sold under the trademark, CR-39, and polymerizates of copolymers of a polyol (allyl carbonate), e.g., diethylene glycol bis(allyl carbonate), with other copolymerizable monomeric materials, such as copolymers with vinyl acetate, e.g., copolymers of from 80-90 percent diethylene glycol bis(allyl carbonate) and 10-20 percent vinyl acetate, particularly 80-85 percent of the bis(allyl carbonate) and 15-20 percent vinyl acetate, and copolymers with a polyurethane having terminal diacrylate functionality, as described in U.S. patents 4,360,653 and 4,994,208; cellulose propionate, cellulose butyrate, cellulose acetate butyrate, polystyrene and copolymers of styrene with methyl methacrylate, vinyl acetate and acrylonitrile.

The present invention is more particularly described in the following examples which are intended as illustrative only, since numerous modifications and variations therein will be apparent to those skilled in the art.

20

EXAMPLE 1

STEP 1

Sixty grams (0.3 mole) of 3,7-dihydroxy-2-naphthoic acid and 42 grams (0.5 mole) of sodium bicarbonate were suspended with stirring in 250 milliliters of dimethylformamide (DMF) in a 500 milliliter round bottom flask equipped with a reflux condenser and nitrogen pad. The mixture was warmed to 60°C and held there for 2 hours. Afterwards, the mixture was cooled to room temperature and methyl iodide (57 grams, 0.4 mole) was added. The stirred reaction was then gradually warmed to 70°C where it was kept for 2 hours. Subsequently, the contents of the flask were poured into four volumes of ice and water to precipitate the product. The resulting yellow solid was suction filtered and washed with a sodium bicarbonate solution in order to remove any unreacted starting material. The yellow solid was next washed with water and air

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dried. High-performance liquid chromatographic (HPLC) analysis revealed that the solid consisted of two products. The yield of methyl 3,7-dihydroxy-2-naphthoate, which contained a small amount of methyl monohydroxy naphthoate, was 57 grams.

5

STEP 2

Methyl 3,7-dihydroxy-2-naphthoate (21.8 grams, 0.1 mole) from Step 1 was suspended with stirring in 200 milliliters of methylene chloride containing 6 grams of acetic acid. The mixture
10 was cooled to 0°C. Eight grams of sodium nitrite, as an aqueous solution, was added dropwise over a period of thirty minutes. The mixture was stirred an additional 2 hours at 5°C and then vacuum filtered. The resulting solid product was washed with methylene chloride and then slurried in water. The solid was again suction
15 filtered and air dried until a constant weight was obtained. The resulting yield of methyl 3,7-dihydroxy-8-nitroso-2-naphthoate was 24 grams.

STEP 3

20 0.01 mole of 1,2,3,3,4,5(or 1,2,3,3,5,6)-hexamethyl indolium iodide (Fisher's base precursor) in 100 milliliters of chloroform was mixed with 100 milliliters of a 10 weight percent aqueous sodium hydroxide solution and the two phase system stirred vigorously for 15 minutes. At this point the chloroform layer was
25 separated and washed two times with water. 0.01 mole of product prepared in Step 2 was added to the 0.01 mole of Fisher's base solution in the washed chloroform layer. The mixture was stirred and refluxed under nitrogen overnight. The resulting dark solution was then cooled and passed through a silica plug contained in a
30 filtering funnel. The silica plug was washed with 50 milliliters of chloroform. The filtrate and the washings were combined and the solvent was removed by using a rotary evaporator. Addition of 20 milliliters of a 2:1 hexane:ethyl acetate solution resulted in the rapid crystallization of the product. The crystals were suction
35 filtered and washed with a small amount of fresh solvent.

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The recovered crystalline product (2.3 grams), hereinafter designated the principal product of Example 1, melted at 221-222°C., was 94% pure, as determined by HPLC analysis, and had a nuclear magnetic resonance (NMR) spectrum that was consistent with the product, 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxycarbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine]. Of particular note is that a diethylene glycol dimethyl ether solution of the product had a slight yellow cast but changed to green when irradiated with ultraviolet light. The solution returned to its original slightly colored condition after the ultraviolet light was removed.

Additional products were prepared by using the aforescribed procedure with different Fisher's base precursors. The melting point range (MPR) was determined for each product. The resulting products and their MPR included the following:

1,3,3-trimethyl-9'-methoxycarbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine], MPR of 237-238°C; 1-propyl-3-ethyl-3-methyl-9'-methoxycarbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4] oxazine], MPR of 178-180°C; 1-propyl-3,3-dimethyl-5-methoxy-9'-methoxycarbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine], MPR of 228-229°C; and 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxycarbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine], MPR of 197-199°C .

EXAMPLE 2

Two grams of the principal product of Example 1 were taken up in 100 milliliters of reagent grade acetone. One and one-half grams each of dimethyl sulfate and powdered potassium carbonate were added to the acetone solution and the stirred mixture refluxed overnight under a nitrogen pad. The acetone was removed by using a rotary evaporator and 50 milliliters each of water and methylene chloride was added. The mixture was stirred for 15 minutes to destroy excess dimethyl sulfate. The methylene chloride layer was

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separated, washed once with water, and the solvent removed on a rotary evaporator. The resulting residue was dissolved in a small amount of chloroform, placed on a silica column and eluted with a 2:1 mixture of hexane:ethyl acetate. The photochromic fractions
5 were combined and the solvent was removed by using a rotary evaporator. The product began to precipitate as yellow crystals during the evaporation procedure. The crystals were collected by vacuum filtration and washed with a few milliliters of the hexane:ethyl acetate mixture.

10 The recovered crystalline product (1.8 grams), hereinafter designated the principal product of Example 2, melted at 218-220°C., was 97% pure as determined by HPLC analysis, and had a nuclear magnetic resonance (NMR) spectrum that was consistent with the product, 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxycarbonyl-
15 8'-methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine]. A diethylene glycol dimethyl ether solution of the product was colorless but changed to blue when irradiated with ultraviolet light. The solution returned to its original colorless condition after the ultraviolet light was removed.

20 Additional products were prepared by using the aforescribed procedure with products prepared in Example 1 from different Fisher's base precursors. The melting point range (MPR) was determined for each product. The resulting products and their MPR included the following: 1,3,3-trimethyl-9'-methoxycarbonyl-8'-
25 methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine], MPR of 213-215°C; 1-propyl-3-ethyl-3-methyl-9'-methoxycarbonyl-8'-methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4] oxazine], MPR of 149-150°C; 1-propyl-3,3-dimethyl-5-methoxy-9'-methoxycarbonyl-8'-methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine], MPR of
30 176-177°C; and 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxycarbonyl-8'-methoxy-spiro[indoline-2, 3'-[3H]naphth[2,1-b][1,4]oxazine], MPR of 196-198°C.

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One and one-half grams of the principal product of Example 1 was dissolved in 75 milliliters of methylene chloride along with 2 grams of triethylamine and 100 milligrams of dimethylamino pyridine (DMAP). Fifty milliliters of a 10 weight percent aqueous sodium hydroxide solution was added and the two phase mixture cooled in an ice bath. Two grams of acetyl chloride (an excess) was then added dropwise to the rapidly stirred mixture. After five minutes, TLC analysis showed that a new (lower) photochromic spot had formed and that the starting material was completely gone. The organic phase was separated and washed twice with water followed by removal of the methylene chloride using a rotary evaporator. The residual oil readily crystallized. The crystalline product was broken into pieces, washed with hexane, suction filtered and dried.

The recovered crystalline product (1.5 grams), hereinafter designated the principal product of Example 3, melted at 175-178°C., was 98% pure as determined by HPLC analysis, and had a nuclear magnetic resonance (NMR) spectrum that was consistent with the product, 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxycarbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine]. A diethylene glycol dimethyl ether solution of the product was colorless but changed to blue when irradiated with ultraviolet light. The solution returned to its original colorless condition after the ultraviolet light was removed.

Additional products were prepared by using the aforescribed procedure with products prepared in Example 1 from different Fisher's base precursors. The melting point range (MPR) was determined for each product. The resulting products and their MPR included the following: 1,3,3-trimethyl-9'-methoxycarbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine], MPR of 165-166°C; 1-propyl-3-ethyl-3-methyl-9'-methoxycarbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4] oxazine], MPR of 114-116°C; 1-propyl-3,3-dimethyl-5-methoxy-9'-methoxycarbonyl-

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8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine], MPR of 140-141.5°C; and 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxycarbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine], MPR of 126-127°C.

5

EXAMPLE 4

The principal products of Examples 1, 2 and 3 were dissolved in diethylene glycol dimethyl ether. The concentrations of the resulting solutions were approximately 0.5 milligrams per 10 milliliter. Each solution was tested in a UV spectrophotometer to determine its lambda max. The lambda max reported in Table 1 is the wavelength in the ultraviolet range closest to the visible spectrum or in the threshold range, i.e., 390 to 410 nanometers, of the visible spectrum, at which the maximum absorption and activation of 15 the photochromic compound occurs in diethylene glycol dimethyl ether.

Comparative testing was conducted on the principle product of Example 3 and certain photochromic compounds described in U.S. Patents 4,342,668 and 4,637,698. These compounds were imbibed by 20 thermal transfer into test squares of a polymeric matrix prepared from a diethylene glycol bis(allyl carbonate) composition by the following procedure: Each photochromic compound was dissolved in toluene to form a 4 weight percent solution of the compound. A piece of No. 4 Whatman filter paper was saturated with the toluene 25 solution of the photochromic compound and allowed to air dry. The dried filter paper was placed on one side of the polymer test square, which measured 1/8 inch (0.3 centimeter) x 2 inch (5.1 centimeters) x 2 inch (5.1 centimeters). A piece of untreated filter paper was placed on the other side of the polymer test square 30 and the resulting sandwich placed between two plates of flat aluminum metal plates. The entire assembly was then placed in a 155°C. oven for a time sufficient to thermally transfer the photochromic compound into the polymer test square. Residence times in the oven were adjusted to imbibe comparable amounts of the



photochromic compounds in order to yield a comparable UV absorbance at their λ max. The imbibed test squares were washed with acetone after removal from the oven.

The imbibed polymer test squares were tested for
5 photochromic response rates on an optical bench. The samples were illuminated by a 150 watt Xenon lamp fitted with a copper sulfate bath and a neutral density filter at an intensity of about one sun. A second beam of light provided by a filtered tungsten lamp arranged to pass through the sample area exposed by the UV source was used to
10 monitor changes in transmission of the sample over different wavelength ranges in the visible region of the spectrum. The intensity of the monitoring beam after passing through the sample was measured by means of an IL-1500 radiometer equipped with a silicon detector head and matching filters.

15 The Δ OD/min., which represents the sensitivity of the photochromic compound's response to UV light, was measured using photopic filters on the silicon detector. The response of the filtered detector approximated the luminosity curve. The Δ OD was measured over the first five (5) seconds of UV exposure, then
20 expressed on a per minute basis. The saturation optical density (OD) was taken under identical conditions as the Δ OD/min., except UV exposure was continued for 20 minutes. The λ max reported in Table 2 is the wavelength in the ultraviolet range closest to the visible spectrum or in the threshold range, i.e., 390 to 410
25 nanometers, of the visible spectrum at which the maximum absorption and activation of the photochromic compound occurs in the polymer matrix test squares.

The bleach rate $T_{1/2}$ (sec.) is the time interval in seconds for the absorbance of the activated form of the photochromic
30 compounds in the test polymer to reach one half the highest absorbance at 25.7 ± 0.5 °C. after removal of the source of activating light. Results are tabulated in Tables 1 and 2.



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TABLE 1

	PRINCIPAL PRODUCT OF	LAMBDA MAX
	Example 1	403
5	Example 2	383
	Example 3	374

TABLE 2

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	COMPOUND	LAMBDA	Δ OD/min.	Δ OD @	BLEACH RATE
	<u>SAMPLE</u>	<u>MAX</u>	<u>SENSITIVITY</u>	<u>SATURATION</u>	<u>T 1/2 (SEC.)</u>
	A ¹	336	0.15	0.11	70
15	B ²	350	0.44	0.36	69
	C ³	374	0.46	0.42	136
	D ⁴	346	0.21	0.11	47
20	1.	1-propyl-3,3,5,6-tetramethyl-9'-methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine]; cf. Example III of U.S. Patent No. 4,342,668.			
	2.	1-propyl-3,3,5,6-tetramethyl-spiro[indoline-2,3'-[3H]pyrido-[3,2-f][1,4]benzoxazine]; cf. claim 2 of U.S. Patent No.			
25		4,637,698.			
	3.	1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxy-carbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine] (Example 3).			
30	4.	1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine].			

The results in Table 1 for the principle products of Examples 1, 2 and 3 show the relatively high lambda max values of the photochromic naphthoxazine compounds of the present invention

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compared to those of compound samples A, B and D of Table 2. The results tabulated in Table 2 for compound C, the principal product of Example 3, as compared to the other compounds, show an improved sensitivity, higher optical density at saturation, and an acceptable
5 bleach rate. Compound C also had an absorption maxima in the UV spectrum unexpectedly higher than compounds A, B and D.

Although the present invention has been described with reference to the specific details of particular embodiments thereof, it is not intended that such details be regarded upon the scope of
10 the invention except insofar as to the extent that they are included in the accompanying claims.

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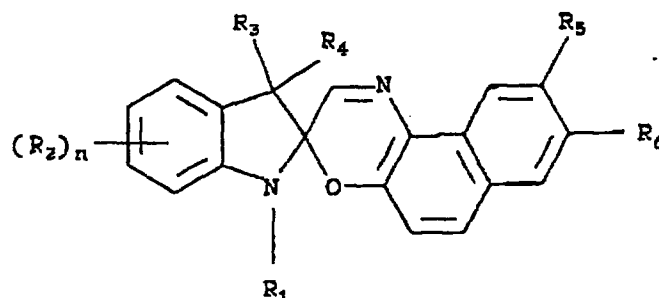
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I claim;

- 5 1. A naphthoxazine compound represented by the following graphic formula:

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20 wherein:

(a) R_1 is C_1-C_8 alkyl, phen(C_1-C_4)alkyl, naphth(C_1-C_4)alkyl, allyl, acrylyloxy(C_2-C_6)alkyl, methacrylyloxy(C_2-C_6)alkyl, C_1-C_4 acyloxy(C_2-C_6)alkyl, 25 carboxy(C_2-C_6)alkyl, cyano(C_2-C_6)alkyl, hydroxy(C_2-C_6)alkyl, C_1-C_6 alkoxy(C_2-C_4)alkyl or $(C_2H_4O)_m \cdot CH_3$, wherein m is an integer from 1 to 6;

(b) each R_2 is C_1-C_5 alkyl, C_1-C_5 alkoxy, nitro, cyano, C_1-C_8 alkoxycarbonyl, C_1-C_4 acyloxy, halo, C_1-C_4 monohaloalkyl or 30 C_1-C_4 polyhaloalkyl;

(c) R_3 and R_4 are each C_1-C_5 alkyl, benzyl, phenyl, mono- or di-substituted phenyl, said phenyl substituents being C_1-C_5 alkyl or C_1-C_5 alkoxy, or R_3 and R_4 taken together form a cyclic ring containing from 5 to 8 carbon atoms which includes the spiro carbon 35 atom, norbornyl or adamantyl;





(d) R_5 is the group $-C(O)X$, X being $-OR_7$ or $-N(R_8)R_9$, wherein R_7 is allyl, C_1-C_6 alkyl, benzyl, C_1-C_6 alkyl substituted benzyl, C_1-C_6 alkoxy substituted benzyl, C_1-C_6 alkoxy(C_2-C_4)alkyl, or C_1-C_6 haloalkyl, and wherein R_8 and R_9 are each selected from 5 hydrogen, C_1-C_5 alkyl, C_5-C_7 cycloalkyl, phenyl and substituted phenyl, or R_8 and R_9 together with the nitrogen form a substituted or unsubstituted heterocyclic ring containing from 5 to 6 ring atoms, which ring includes as the hetero atom said nitrogen atom alone or one additional hetero atom of nitrogen or oxygen, said 10 phenyl and heterocyclic ring substituents being selected from C_1-C_5 alkyl and C_1-C_6 alkoxy;

(e) R_6 is the group, $-O-Y$, wherein Y is hydrogen, C_1-C_6 alkyl, benzyl, C_1-C_6 alkyl substituted benzyl, C_1-C_6 alkoxy substituted benzyl, C_1-C_6 alkoxy (C_2-C_4) alkyl, C_1-C_6 haloalkyl, 15 allyl or the group, $-C(O)Z$, wherein Z is C_1-C_6 alkyl, phenyl, C_1-C_6 alkyl substituted phenyl, C_1-C_6 alkoxy substituted phenyl, C_1-C_6 alkoxy, phenoxy, C_1-C_6 alkyl substituted phenoxy, C_1-C_6 alkoxy substituted phenoxy, C_1-C_6 alkylamino, phenylamino, C_1-C_6 alkyl substituted phenylamino, or C_1-C_6 alkoxy substituted phenylamino; and 20 (f) n is the integer 0, 1, or 2, said halo substituents being chloro, fluoro, iodo or bromo.

2. A naphthoxazine compound according to Claim 1, wherein R_1 is allyl, C_1-C_3 alkoxy(C_2-C_4)alkyl or C_1-C_4 alkyl; R_3 and R_4 are 25 each C_1-C_3 alkyl or R_3 and R_4 taken together form a cyclic ring containing from 5 to 7 carbon atoms which includes the spiro carbon atom; each R_2 is C_1-C_3 alkoxy or C_1-C_3 alkyl; X is the group, $-OR_7$, wherein R_7 is C_1-C_3 alkyl or allyl; and Y is hydrogen, C_1-C_3 alkyl or the group, $-C(O)Z$, wherein Z is C_1-C_3 alkyl.

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3. A naphthoxazine compound according to Claim 2, wherein R_1 is methyl or propyl; each R_2 is methoxy or methyl; R_3 and R_4 are each methyl or ethyl; R_7 is methyl; and Z is methyl.





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4. A naphthoxazine compound wherein the compound is
- (a) 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxy-carbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]-oxazine];
- 5 (b) 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxy-carbonyl-8'-hydroxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]-oxazine];
- (c) 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxy-carbonyl-8'-methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]
- 10 oxazine];
- (d) 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxy-carbonyl-8'-methoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]-oxazine];
- (e) 1,3,3,4,5(or 1,3,3,5,6,)-pentamethyl-9'-methoxy-
- 15 carbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]-oxazine];
- (f) 1-propyl-3-ethyl-3-methyl-9'-methoxy-carbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine];
- 20 (g) 1-propyl-3,3-dimethyl-5-methoxy-9'-methoxy-carbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine];
- (h) 1-propyl-3,3,4,5(or 3,3,5,6)-tetramethyl-9'-methoxy-carbonyl-8'-acetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-
- 25 [1,4]oxazine];
- (i) 1-methoxyethyl-3,3-dimethyl-9'-allyloxy-carbonyl-8'-benzoyloxy-spiro[indoline-2,3'-[3H]naphth[2,1-b]-[1,4]oxazine]; or
- (j) 1-allyl-3,3-spirocyclohexyl-9'-benzyloxycarbonyl-
- 30 8'-chloroacetoxy-spiro[indoline-2,3'-[3H]naphth[2,1-b][1,4]oxazine].



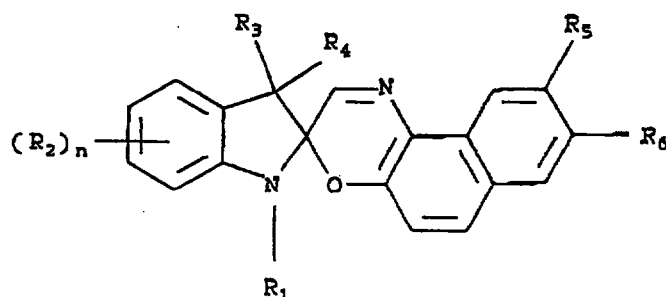
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5. A photochromic article comprising an organic host material and a photochromic amount of a naphthoxazine compound represented by the following graphic formula:

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wherein:

- (a) R_1 is C_1-C_8 alkyl, phen(C_1-C_4)alkyl, naphth(C_1-C_4)alkyl, allyl, acrylyloxy(C_2-C_6)alkyl, methacrylyloxy(C_2-C_6)alkyl, C_1-C_4 acyloxy(C_2-C_6)alkyl, carboxy(C_2-C_6)alkyl, cyano(C_2-C_6)alkyl, hydroxy(C_2-C_6)alkyl, C_1-C_6 alkoxy(C_2-C_4)alkyl or $(C_2H_4O)_m \cdot CH_3$, wherein m is an integer from 1 to 6;
- (b) each R_2 is C_1-C_5 alkyl, C_1-C_5 alkoxy, nitro, cyano, C_1-C_8 alkoxycarbonyl, C_1-C_4 acyloxy, halo, C_1-C_4 monohaloalkyl or C_1-C_4 polyhaloalkyl;
- (c) R_3 and R_4 are each C_1-C_5 alkyl, benzyl, phenyl, mono- or di-substituted phenyl, said phenyl substituents being C_1-C_5 alkyl or C_1-C_5 alkoxy, or R_3 and R_4 taken together form a cyclic ring containing from 5 to 8 carbon atoms which includes the spiro carbon atom, norbornyl or adamantyl;
- (d) R_5 is the group $-C(O)X$, X being $-OR_7$ or $-N(R_8)R_9$, wherein R_7 is allyl, C_1-C_6 alkyl, benzyl, C_1-C_6 alkyl substituted benzyl, C_1-C_6 alkoxy substituted benzyl, C_1-C_6 alkoxy(C_2-C_4)alkyl,





or C_1-C_6 haloalkyl, and wherein R_8 and R_9 are each selected from hydrogen, C_1-C_5 alkyl, C_5-C_7 cycloalkyl, phenyl and substituted phenyl, or R_8 and R_9 together with the nitrogen form a substituted or unsubstituted heterocyclic ring containing from 5 to 6 ring
5 atoms, which ring includes as the hetero atom said nitrogen atom alone or one additional hetero atom of nitrogen or oxygen, said phenyl and heterocyclic ring substituents being selected from C_1-C_5 alkyl and C_1-C_6 alkoxy;

(e) R_6 is the group, $-O-Y$, wherein Y is hydrogen, C_1-C_6
10 alkyl, benzyl, C_1-C_6 alkyl substituted benzyl, C_1-C_6 alkoxy substituted benzyl, C_1-C_6 alkoxy (C_2-C_4) alkyl, C_1-C_6 haloalkyl, allyl or the group, $-C(O)Z$, wherein Z is C_1-C_6 alkyl, phenyl, C_1-C_6 alkyl substituted phenyl, C_1-C_6 alkoxy substituted phenyl, C_1-C_6 alkoxy, phenoxy, C_1-C_6 alkyl substituted phenoxy, C_1-C_6 alkoxy
15 substituted phenoxy, C_1-C_6 alkylamino, phenylamino, C_1-C_6 alkyl substituted phenylamino, or C_1-C_6 alkoxy substituted phenylamino; and

(f) n is the integer 0, 1, or 2, said halo substituents being chloro, fluoro, iodo or bromo.

20 6. The photochromic article of Claim 5 wherein the organic host material is a polymer of polyol(allyl carbonate) monomers, polyacrylates, poly(alkylacrylates), polyfunctional acrylate monomers, cellulose acetate, cellulose triacetate, cellulose acetate propionate, cellulose acetate butyrate, poly(vinyl
25 acetate), poly(vinyl alcohol), poly(vinyl chloride), poly(vinylidene chloride), polycarbonate, polyurethane, poly(ethylene terephthalate), polystyrene, copoly(styrene-methylmethacrylate), copoly(styrene-acrylonitrile), polyvinylbutyral, or a polymer of diallylidene pentaerythritol.

30

7. The photochromic article of Claim 6 wherein R_1 is allyl, C_1-C_3 alkoxy(C_2-C_4)alkyl or C_1-C_4 alkyl; R_3 and R_4 are each C_1-C_3 alkyl or R_3 and R_4 taken together form a cyclic ring containing from 5 to 7 carbon atoms which includes the spiro carbon





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atom; each R_2 is C_1-C_3 alkoxy or C_1-C_3 alkyl; X is the group, $-OR_7$, wherein R_7 is C_1-C_3 alkyl or allyl; and Y is hydrogen, C_1-C_3 alkyl or the group, $-C(O)Z$, wherein Z is C_1-C_3 alkyl.

5 8. The photochromic article of Claim 7 wherein R_1 is methyl or propyl; each R_2 is methoxy or methyl; R_3 and R_4 are each methyl or ethyl; R_7 is methyl; and Z is methyl.

 9. The photochromic article of Claim 8 wherein the
10 organic host material is a solid transparent homopolymer or copolymer of diethylene glycol bis(allyl carbonate), poly(4,4'dioxydiphenol-2,2-propane), poly(methylmethacrylate), polyvinylbutyral or a polyurethane.

15 10. The photochromic article of Claim 9 wherein the photochromic compound is present in an amount of from about 0.15 to 0.35 milligrams per square centimeter of organic host material surface to which the photochromic substance(s) has been applied.

20 11. The photochromic article of Claim 10 wherein the article is a lens.

 12. A photochromic article comprising a solid transparent polymerized organic host material and a photochromic amount of each
25 of (a) a first photochromic substance wherein said first photochromic substance is a spiro(indoline)naphthopyran, spiro(indoline)benzopyran, spiro(indoline)pyridobenzoxazine, spiro(indoline)benzoxazine or a chromene, and (b) a naphthoxazine compound represented by the following graphic formula:



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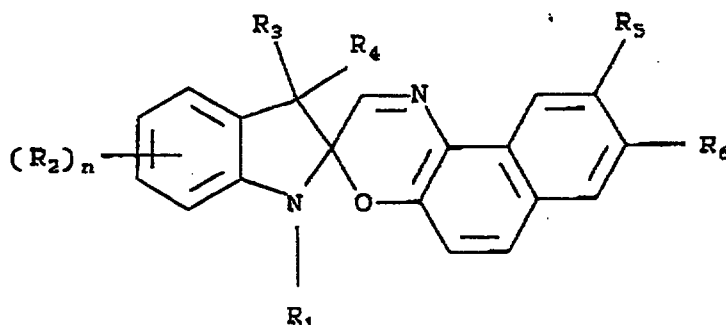
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15 wherein:

(a) R_1 is C_1-C_8 alkyl, phen(C_1-C_4)alkyl, naphth(C_1-C_4)alkyl, allyl, acrylyloxy(C_2-C_6)alkyl, methacrylyloxy(C_2-C_6)alkyl, C_1-C_4 acyloxy(C_2-C_6)alkyl, carboxy(C_2-C_6)alkyl, cyano(C_2-C_6)alkyl, hydroxy(C_2-C_6)alkyl, C_1-C_6 alkoxy(C_2-C_4)alkyl or $(C_2H_4O)_m \cdot CH_3$, wherein m is an integer from 1 to 6;

(b) each R_2 is C_1-C_5 alkyl, C_1-C_5 alkoxy, nitro, cyano, C_1-C_8 alkoxy carbonyl, C_1-C_4 acyloxy, halo, C_1-C_4 monohaloalkyl or C_1-C_4 polyhaloalkyl;

25 (c) R_3 and R_4 are each C_1-C_5 alkyl, benzyl, phenyl, mono- or di-substituted phenyl, said phenyl substituents being C_1-C_5 alkyl or C_1-C_5 alkoxy, or R_3 and R_4 taken together form a cyclic ring containing from 5 to 8 carbon atoms which includes the spiro carbon atom, norbornyl or adamantyl;

30 (d) R_5 is the group $-C(O)X$, X being $-OR_7$ or $-N(R_8)R_9$, wherein R_7 is allyl, C_1-C_6 alkyl, benzyl, C_1-C_6 alkyl substituted benzyl, C_1-C_6 alkoxy substituted benzyl, C_1-C_6 alkoxy(C_2-C_4)alkyl, or C_1-C_6 haloalkyl, and wherein R_8 and R_9 are each selected from hydrogen, C_1-C_5 alkyl, C_5-C_7 cycloalkyl, phenyl and substituted



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phenyl, or R_8 and R_9 together with the nitrogen form a substituted or unsubstituted heterocyclic ring containing from 5 to 6 ring atoms, which ring includes as the hetero atom said nitrogen atom alone or one additional hetero atom of nitrogen or oxygen, said 5 phenyl and heterocyclic ring substituents being selected from C_1-C_5 alkyl and C_1-C_6 alkoxy;

(e) R_6 is the group, $-O-Y$, wherein Y is hydrogen, C_1-C_6 alkyl, benzyl, C_1-C_6 alkyl substituted benzyl, C_1-C_6 alkoxy substituted benzyl, C_1-C_6 alkoxy (C_2-C_4) alkyl, C_1-C_6 haloalkyl, 10 allyl or the group, $-C(O)Z$, wherein Z is C_1-C_6 alkyl, phenyl, C_1-C_6 alkyl substituted phenyl, C_1-C_6 alkoxy substituted phenyl, C_1-C_6 alkoxy, phenoxy, C_1-C_6 alkyl substituted phenoxy, C_1-C_6 alkoxy substituted phenoxy, C_1-C_6 alkylamino, phenylamino, C_1-C_6 alkyl substituted phenylamino, or C_1-C_6 alkoxy substituted phenylamino; and 15 (f) n is the integer 0, 1, or 2, said halo substituents being chloro, fluoro, iodo or bromo.

13. The photochromic article of Claim 12 wherein the organic host material is polymer of polyol(allyl carbonate) 20 monomers, polyacrylates, poly(alkylacrylates), polyfunctional acrylate monomers, cellulose acetate, cellulose triacetate, cellulose acetate propionate, cellulose acetate butyrate, poly(vinyl acetate), poly(vinyl alcohol), poly(vinyl chloride), poly(vinylidene chloride), polycarbonate, polyurethane, poly(ethylene 25 terephthalate), polystyrene, copoly(styrene-methylmethacrylate), copoly(styrene-acrylonitrile), polyvinylbutyral, or a polymer of diallylidene pentaerythritol.

14. The photochromic article of Claim 13 wherein R_1 is 30 allyl, C_1-C_3 alkoxy(C_2-C_4)alkyl or C_1-C_3 alkyl; R_3 and R_4 are each C_1-C_3 alkyl or R_3 and R_4 taken together form a cyclic ring containing from 5 to 7 carbon atoms which includes the spiro carbon atom; each R_2 is C_1-C_3 alkoxy or C_1-C_3 alkyl; X is the group, $-OR_7$, wherein R_7 is C_1-C_3 alkyl or allyl; and Y is hydrogen, C_1-C_3 alkyl 35 or the group, $-C(O)Z$, wherein Z is C_1-C_3 alkyl.



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15. The photochromic article of Claim 14 wherein R_1 is methyl or propyl; each R_2 is methoxy or methyl; R_3 and R_4 are each methyl or ethyl; R_7 is methyl; and Z is methyl.

5

16. The photochromic article of Claim 15 wherein the organic host material is a solid transparent homopolymer or copolymer of diethylene glycol bis(allyl carbonate), poly(4,4'-dioxydiphenol-2,2-propane), poly(methylmethacrylate),
10 polyvinylbutyral or a polyurethane.

17. The photochromic article of Claim 16 wherein the total photochromic substance is present in an amount of from about 0.15 to 0.35 milligrams per square centimeter of organic host material
15 surface to which the photochromic substance(s) has been applied.

18. The photochromic article of Claim 17 wherein the weight ratios of the first photochromic substance to the naphthoxazine compound is from about 1:3 to about 3:1.

20

19. The photochromic article of Claim 18 wherein the article is an ophthalmic lens.

