What is claimed is:

1. A method for producing silicone hydrogel contact lenses, comprising the steps of:

(1) obtaining a polymerizable composition which is clear at room temperature, wherein the polymerizable composition comprises

(a) at least one siloxane-containing polymerizable component which comprises at least one siloxane-containing vinylic monomer, at least one polysiloxane vinylic crosslinker, or a combination thereof,

(b) from 25% to 65% by weight of at least one hydrophilic polymerizable component relative to the total weight of the polymerizable composition, wherein said at least one hydrophilic polymerizable component comprises (preferably consists essentially of, more preferably consists of) (i) at least one hydrophilic N-vinyl amide monomer and/or (ii) at least one hydrophilic acrylic monomer,

(c) optionally at least one non-silicone vinylic crosslinker,

(d) from 5% to 30% by weight of at least one hydrophobic acrylic monomer relative to the total weight of the polymerizable composition, wherein the hydrophobic acrylic monomer is capable of forming a homopolymer having a glass-transition temperature T_g of at least 60°C, wherein the hydrophobic acrylic monomer is capable of dissolving components (a) to (c) to form a solution with a concentration of at least 5% by weight of the components (a) to (c) relative to the solution,

(e) from 0 to 16% by weight of at least one organic solvent having 2 to 8 carbon atoms relative to the total weight of the polymerizable composition,

(f) at least one photochromic vinylic monomer, and

(g) at least one thermal free radical initiator, wherein the sum of the amounts of components (a) to (c) is at least 67%, by weight relative to the total weight of the polymerizable composition, wherein weight ratio of component (d) over the sum of components (d) and (e) is at least 0.24;

(2) introducing the polymerizable composition into a lens mold, wherein the lens mold comprises a male mold half having a first molding surface and a female mold half having a second molding surface, wherein the male and female mold halves are configured to receive each other such that a mold cavity is formed between the first and second molding surfaces when the mold is closed;

(3) curing thermally the polymerizable composition in the lens mold to form a unprocessed photochromic silicone hydrogel lens precursor within the lens mold; and

(4) subjecting the unprocessed photochromic silicone hydrogel lens precursor to one or

more post-molding processes selected from the group consisting of extraction, hydration, packaging, sterilization, and combinations thereof, to form a photochromic silicone hydrogel contact lens.

2. The method of claim 1, wherein the hydrophobic acrylic monomer is methyl methacrylate, ethyl methacrylate, isopropyl methacrylate, sec-butyl methacrylate, tert-butyl methacrylate, cyclohexyl methacrylate, isobornyl acrylate, isobornyl methacrylate, phenyl methacrylate, or a combination thereof.
3. The method claim 1 or 2, wherein the organic solvent has 3 to 5 carbon atoms.
4. The method of any one of claims 1 to 3, wherein the organic solvent is 1-propanol, isopropanol, 1-butanol, sec-butanol, isobutanol, tert-butyl alcohol, 1-pentanol, 2-pentanol, 3-pentanol, 3-methyl-2-butanol, 2-methyl-1-butanol, 2,2-dimethyl-1-propanol, tert-amyl alcohol, 1-methoxy-2-propanol, 3-ethoxy-1-propanol, 1-ethoxy-2-propanol, or a combination thereof.
5. The method of any one of claims 1 to 4, further comprising: before step (4), a step of separating the mold into the male and female mold halves, with the unprocessed photochromic silicone hydrogel adhered on a lens-adhered mold half which is one of the male and female mold halves; and a step of removing the unprocessed photochromic silicone hydrogel lens precursor from the lens-adhered mold half before the unprocessed photochromic silicone hydrogel lens precursor is contacted with water or any liquid.
6. The method of claim 5, wherein the step of removing the unprocessed photochromic silicone hydrogel lens precursor from the lens-adhered mold half is performed by (a) bringing a ultrasonic horn in direct contact with at least one area of a non-optical surface of the lens-adhered mold half having the unprocessed photochromic silicone hydrogel lens precursor attached thereon and (b) applying a ultrasonic vibrational energy of from 0.2 to 18 J to the at least one area of the non-optical surface of the lens-adhered mold half having the unprocessed photochromic silicone hydrogel lens precursor attached thereon so as to remove the unprocessed photochromic silicone hydrogel lens precursor from the lens-adhered mold half.
7. The method of any one of claims 1 to 6, wherein said at least one hydrophilic polymerizable component comprises (i) at least one hydrophilic N-vinyl amide monomer and (ii) at least one hydrophilic acrylic monomer.
8. The method of claim 7, wherein weight ratio of component (b)(i) over component (b)(ii) is 2.0 or less and is selected to ensure that the formed photochromic silicone hydrogel contact lens having a specified equilibrium water content and a specified elastic modulus.
9. The method of claim 8, wherein the specified equilibrium water content is from 40% to

65% by weight and a specified elastic modulus of from 0.3 to 1.5 MPa.

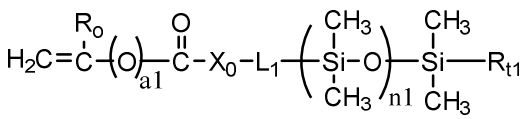
10. The method of any one of claims 1 to 9, wherein the thermal free radical initiator is an azo-containing radical initiator having a 10-hour half life temperature of from 70°C to 110°C.

11. The method of any one of claims 1 to 10, wherein the thermal free radical initiator is present in an amount of from 0.1% to 2.0% by weight relative to the total weight of the polymerizable composition.

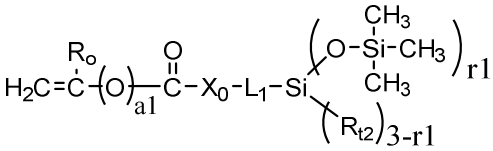
12. The method of any one of claims 1 to 11, wherein the polymerizable composition comprises (c) 2.0% or less by weight of at least one non-silicone vinylic crosslinker relative to the total weight of all polymerizable components in the polymerizable composition, wherein said at least non-silicone vinylic crosslinker is ethyleneglycol di-(meth)acrylate, diethyleneglycol di-(meth)acrylate, triethyleneglycol di-(meth)acrylate, tetraethyleneglycol di-(meth)acrylate, glycerol di-(meth)acrylate, 1,3-propanediol di-(meth)acrylate, 1,3-butanediol di-(meth)acrylate, 1,4-butanediol di-(meth)acrylate, glycerol 1,3-diglycerolate di-(meth)acrylate, ethylenebis[oxy(2-hydroxypropane-1,3-diyl)] di-(meth)acrylate, bis[2-(meth)acryloxyethyl] phosphate, trimethylolpropane di-(meth)acrylate, and 3,4-bis[(meth)acryloyl]tetrahydrofuan, diacrylamide (i.e., N-(1-oxo-2-propenyl)-2-propenamide), dimethacrylamide (i.e., N-(1-oxo-2-methyl-2-propenyl)-2-methyl-2-propenamide), N,N-di(meth)acryloyl-N-methylamine, N,N-di(meth)acryloyl-N-ethylamine, N,N'-methylene bis(meth)acrylamide, N,N'-ethylene bis(meth)acrylamide, N,N'-dihydroxyethylene bis(meth)acrylamide, N,N'-propylene bis(meth)acrylamide, N,N'-2-hydroxypropylene bis(meth)acrylamide, N,N'-2,3-dihydroxybutylene bis(meth)acrylamide, 1,3-bis(meth)acrylamide-propane-2-yl dihydrogen phosphate (i.e., N,N'-2-phophonyloxypropylene bis(meth)acrylamide), piperazine diacrylamide (or 1,4-bis(meth)acryloyl piperazine), tetraethyleneglycol divinyl ether, triethyleneglycol divinyl ether, diethyleneglycol divinyl ether, ethyleneglycol divinyl ether, triallyl isocyanurate, triallyl cyanurate, trimethylopropane trimethacrylate, pentaerythritol tetramethacrylate, bisphenol A dimethacrylate, or combinations thereof.

13. The method of any one of claims 1 to 12, wherein the polymerizable composition comprises (a) from 15% to 55% by weight of said at least one siloxane-containing polymerizable component relative to the total weight of the polymerizable composition.

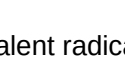
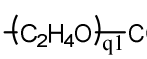
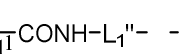
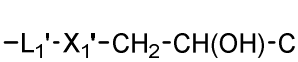
14. The method of any one of claims 1 to 13, wherein the polymerizable composition comprises at least one siloxane-containing vinylic monomer which is a vinylic monomer of formula (M1) or (M2)



(M1)



(M2)

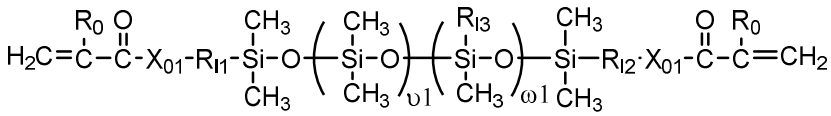
in which: a1 is zero or 1; R_o is H or methyl; X_o is O or NR_1; L_1 is a C_2-C_8 alkylene divalent radical or a divalent radical of , , , , , , , ; L_1' is a C_2-C_8 alkylene divalent radical which has zero or one hydroxyl group; L_1" is C_3-C_8 alkylene divalent radical which has zero or one hydroxyl group; X_1 is O, NR_1, NHCOO, OCONH, $CONR_1$, or NR_1CO; R_1 is H or a C_1-C_4 alkyl having 0 to 2 hydroxyl group; R_{t1} and R_{t2} independent of each other are a C_1-C_4 alkyl; X_1' is O or NR_1; q1 is an integer of 1 to 20; q2 is an integer of 0 to 20; n1 is an integer of 3 to 25; and r1 is an integer of 2 or 3.

15. The method of any one of claims 1 to 14, wherein the polymerizable composition comprises at least one siloxane-containing vinylic monomer which is: tris(trimethylsilyloxy)silylpropyl (meth)acrylate, [3-(meth)acryloxy-2-hydroxypropyloxy]propylbis(trimethylsiloxy) methylsilane, [3-(meth)acryloxy-2-hydroxypropyloxy]propylbis(trimethylsiloxy)butylsilane, 3-(meth)acryloxy-2-(2-hydroxyethoxy)-propyloxy)propylbis(trimethylsiloxy)methylsilane, 3-(meth)acryloxy-2-hydroxypropyloxy)propyltris(trimethylsiloxy)silane, N-[tris(trimethylsiloxy)silylpropyl]-(meth)acrylamide, N-(2-hydroxy-3-(3-(bis(trimethylsilyloxy)methylsilyl)propyloxy)-propyl)-2-methyl (meth)acrylamide, N-(2-hydroxy-3-(3-(bis(trimethylsilyloxy)-methylsilyl)-propyloxy)propyl) (meth)acrylamide, N-(2-hydroxy-3-(3-(tris(trimethylsilyloxy)silyl)-propyloxy)propyl)-2-methyl acrylamide, N-(2-hydroxy-3-(3-(tris(trimethylsilyloxy)silyl)-propyloxy)propyl) (meth)acrylamide, N-[tris(dimethylpropylsiloxy)silylpropyl]-(meth)acrylamide, N-[tris(dimethylphenylsiloxy) silylpropyl] (meth)acrylamide, N-[tris(dimethylethylsiloxy)silylpropyl] (meth)acrylamide, N,N-bis[2-hydroxy-3-(3-(bis(trimethylsilyloxy)methylsilyl)propyloxy)propyl]-2-methyl (meth)acrylamide, N,N-bis[2-hydroxy-3-(3-(bis(trimethylsilyloxy)methylsilyl)propyloxy)-propyl] (meth)acrylamide, N,N-bis[2-hydroxy-3-(3-(tris(trimethylsilyloxy)silyl)propyloxy)-propyl]-2-methyl (meth)acrylamide, N,N-bis[2-hydroxy-3-(3-(tris(trimethylsilyloxy)-silyl)propyloxy)propyl] (meth)acrylamide, N-[2-hydroxy-3-(3-(t-butyldimethylsilyl)-propyloxy)propyl]-2-methyl (meth)acrylamide, N-[2-hydroxy-3-(3-(t-butyldimethylsilyl)propyloxy)propyl] (meth)acrylamide, N,N-bis[2-hydroxy-3-(3-(t-

butyldimethylsilyl)propyloxy)propyl]-2-methyl (meth)acrylamide, N-2-(meth)acryloxyethyl-O-(methyl-bis-trimethylsiloxy-3-propyl)silyl carbamate, 3-(trimethylsilyl)propylvinyl carbonate, 3-(vinyloxycarbonylthio)-propyl-tris(trimethyl-siloxy)silane, 3-[tris(trimethylsiloxy)silyl]propylvinyl carbamate, 3-[tris(trimethylsiloxy)silyl] propyl allyl carbamate, 3-[tris(trimethylsiloxy)silyl]propyl vinyl carbonate, α-(meth)acryloxypropyl terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-(meth)acryloxy-2-hydroxypropyloxypropyl terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-(2-hydroxyl-methacryloxypropyloxypropyl)-ω-C_1-C_4-alkyl-decamethylpentasiloxane, α-[3-(meth)acryloxyethoxy-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acryloxy-propyloxy-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acryloxyisopropyloxy-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acryloxybutyloxy-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acryloxyethylamino-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acryloxypropylamino-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acryloxy-butylamino-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-(meth)acryloxy(polyethylenoxy)-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[(meth)acryloxy-2-hydroxypropyloxy-ethoxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[(meth)acryloxy-2-hydroxypropyl-N-ethylaminopropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[(meth)acryloxy-2-hydroxypropyl-aminopropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[(meth)acryloxy-2-hydroxypropyloxy-(polyethylenoxy)propyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-(meth)acryloylamidopropyloxypropyl terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-N-methyl-(meth)acryloylamidopropyloxypropyl terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acrylamidoethoxy-2-hydroxypropyloxy-propyl]-terminated ω-C_1-C_4-alkyl polydimethylsiloxane, α-[3-(meth)acrylamidopropyloxy-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acrylamidoisopropyloxy-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acrylamidobutyloxy-2-hydroxypropyloxypropyl]-terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, α-[3-(meth)acryloylamido-2-hydroxypropyloxypropyl] terminated ω-C_1-C_4-alkyl polydimethylsiloxane, α-[3-[N-methyl-(meth)acryloylamido]-2-

hydroxypropyloxypropyl] terminated ω-C_1-C_4-alkyl terminated polydimethylsiloxane, N-methyl-N'-(propyltetra(dimethylsiloxy)dimethylbutylsilane) (meth)acrylamide, N-(2,3-dihydroxypropane)-N'-(propyltetra(dimethylsiloxy)dimethylbutylsilane) (meth)acrylamide, (meth)acryloylamidopropyltetra(dimethylsiloxy)dimethylbutylsilane, α-vinyl carbonate-terminated ω-C_1-C_4-alkyl-terminated polydimethylsiloxanes, α-vinyl carbamate-terminated ω-C_1-C_4-alkyl-terminated polydimethylsiloxane, or a mixture thereof.

16. The method of any one of claims 1 to 15, wherein the polymerizable composition comprises at least one polysiloxane vinylic crosslinker which is a vinylic crosslinker of formula (I)



(I)

in which:

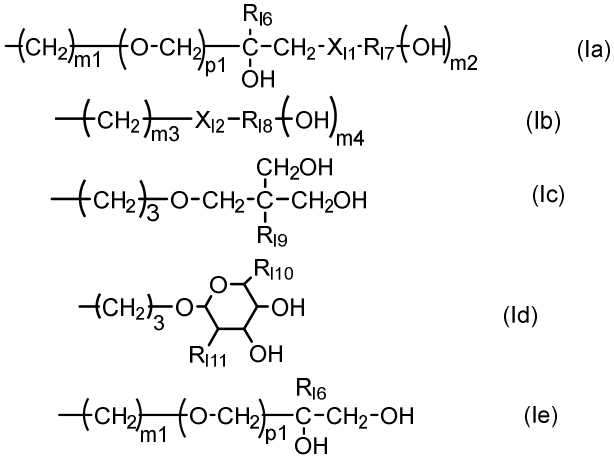
υ1 is an integer of from 30 to 500 and ω1 is an integer of from 1 to 75, provided that ω1/υ1 is from 0.035 to 0.15;

X_{01} is O or NR_N in which R_N is hydrogen or C_1-C_{10}-alkyl;

R_o is hydrogen or methyl;

R_{I1} and R_{I2} independently of each other are a substituted or unsubstituted C_1–C_{10} alkylene divalent radical or a divalent radical of $–R_{I4}–O–R_{I5}–$ in which R_{I4} and R_{I5} independently of each other are a substituted or unsubstituted C_1–C_{10} alkylene divalent radical;

R_{I3} is a monovalent radical of any one of formula (Ia) to (Ie)



(Ia)

(Ib)

(Ic)

(Id)

(Ie)

p1 is zero or 1; m1 is an integer of 2 to 4; m2 is an integer of 1 to 5; m3 is an integer of 3 to 6; m4 is an integer of 2 to 5;

R_{I6} is hydrogen or methyl;

R_{I7} is a C_2-C_6 hydrocarbon radical having (m2+1) valencies;

R_{I8} is a C_2-C_6 hydrocarbon radical having (m4+1) valencies;

R_{I9} is ethyl or hydroxymethyl;

R_{I10} is methyl or hydromethyl;

R_{I11} is hydroxyl or methoxy;

X_{I1} is a sulfur linkage of –S– or a teriary amino linkage of $–NR_{I12}–$ in which R_{I12} is C_1-C_1 alkyl, hydroxyethyl, hydroxypropyl, or 2,3-dihydroxypropyl; and

X_{I2} is an amide linkage of $-NR_{I13}-\overset{O}{\overset{\|}{C}}-$ or $-\overset{O}{\overset{\|}{C}}-NR_{I13}-$ in which R_{I13} is hydrogen or C_1-C_{10} alkyl.

17. The method of any one of claims 1 to 16, wherein the polymerizable materials comprise at least one silicone-containing vinylic crosslinker which is α,ω-bis[3-(meth)acrylamidopropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxyethoxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxypropyloxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxy-isopropyloxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxybutyloxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acrylamidoethoxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acrylamidopropyloxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acrylamidoisopropyloxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acrylamidobutyloxy-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxyethylamino-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxypropylamino-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acryloxybutylamino-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[(meth)acrylamidoethylamino-2-hydroxypropyloxy-propyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acrylamidopropylamino-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[3-(meth)acrylamide-butylamino-2-hydroxypropyloxypropyl]-terminated polydimethylsiloxane, α,ω-bis[(meth)acryloxy-2-hydroxypropyloxy-ethoxypropyl]-terminated polydimethylsiloxane, α,ω-bis[(meth)acryloxy-2-hydroxypropyl-N-ethylaminopropyl]-terminated polydimethylsiloxane, α,ω-bis[(meth)acryloxy-2-hydroxypropyl-aminopropyl]-polydimethylsiloxane, α,ω-bis[(meth)acryloxy-2-hydroxypropyloxy-(polyethylenoxy)propyl]-terminated polydimethylsiloxane, α,ω-

bis[(meth)acryloxyethylamino-carbonyloxy-ethoxypropyl]-terminated polydimethylsiloxane, α,ω-bis[(meth)acryloxyethylamino-carbonyloxy-(polyethylenoxy)propyl]-terminated polydimethylsiloxane, or a combination thereof.

18. The method of any one of claims 1 to 17, wherein said at least one hydrophilic N-vinyl amide monomer is N-vinylpyrrolidone, N-vinyl piperidone, N-vinyl caprolactam, N-vinyl-N-methyl acetamide, N-vinyl formamide, N-vinyl acetamide, N-vinyl isopropylamide, N-vinyl-N-methyl acetamide, N-vinyl-N-ethyl acetamide, N-vinyl-N-ethyl formamide, or a mixture thereof.

19. The method of any one of claims 1 to 18, wherein said at least one hydrophilic acrylic monomer is N,N-dimethyl (meth)acrylamide, (meth)acrylamide, N-hydroxylethyl (meth)acrylamide, N-hydroxypropyl (meth)acrylamide, hydroxyethyl methacrylate, glycerol methacrylate (GMA), di(ethylene glycol) (meth)acrylate, tri(ethylene glycol) (meth)acrylate, tetra(ethylene glycol) (meth)acrylate, poly(ethylene glycol) (meth)acrylate having a number average molecular weight of up to 1200, poly(ethylene glycol)ethyl (meth)acrylamide having a number average molecular weight of up to 1200, ethylene glycol methyl ether (meth)acrylate, di(ethylene glycol) methyl ether (meth)acrylate, tri(ethylene glycol) methyl ether (meth)acrylate, tetra(ethylene glycol) methyl ether (meth)acrylate, polyethylene glycol (meth)acrylate having a number average molecular weight of up to 1200, polyethylene glycol C_1-C_4-alkyl ether (meth)acrylate having a number average molecular weight of up to 1200, *N*-[tris(hydroxymethyl)methyl]-acrylamide, (meth)acrylic acid, ethylacrylic acid, 2-(meth)acrylamidoglycolic acid, phosphorylcholine-containing vinylic monomers, and combinations thereof.

20. The method of any one of claims 1 to 19, wherein said at least one photochromic vinylic monomer is a polymerizable naphthopyran, a polymerizable benzopyran, a polymerizable indenonaphthopyran, a polymerizable phenanthropyran, a polymerizable spiro(benzindoline)naphthopyran, a polymerizable spiro(indoline)benzopyran, a polymerizable spiro(indoline)naphthopyran, a polymerizable spiro(indoline)quinopyran, a polymerizable spiro(indoline)pyran, a polymerizable naphthoxazine, a polymerizable spirobenzopyran, a polymerizable spirobenzopyran, a polymerizable spirobenzothiopyran, a polymerizable naphthacenedione, a polymerizable spirooxazine, a polymerizable spiro(indoline)naphthoxazine, a polymerizable spiro(indoline)pyridobenzoxazine, a polymerizable spiro(benzindoline)pyridobenzoxazine, a polymerizable spiro(benzindoline)naphthoxazine, a polymerizable spiro(indoline)benzoxazine, a polymerizable diarylethene, or a combination thereof.