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(54) Title: CONTACT LENS

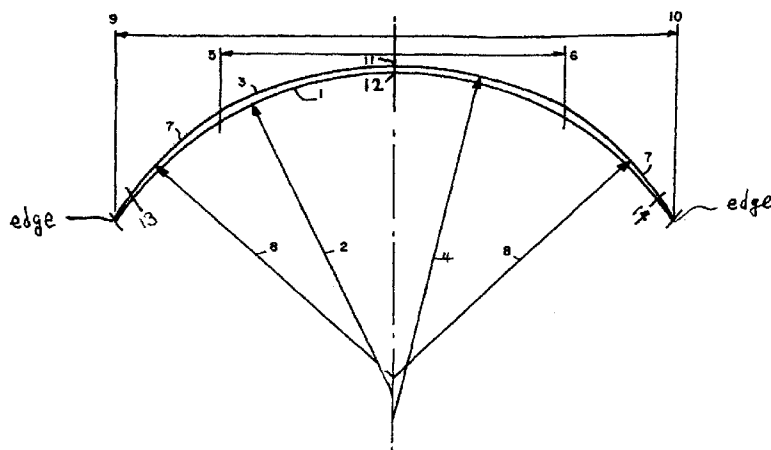


FIGURE 1

(57) Abstract: Disclosed are silicone-containing contact lenses having a center thickness less than about 50 μm .

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CONTACT LENS

BACKGROUND OF THE INVENTION

1. Technical Field

The generally relates to a silicone-containing contact lens such as a silicone hydrogel contact lens.

2. Description of the Related Art

Contact lenses in wide use today fall into two general categories. First, there are the hard or rigid type lenses that are formed from materials prepared by the polymerization of acrylic esters, such as poly(methyl methacrylate). Secondly, there are the gel, hydrogel or soft type lenses.

Conventional soft hydrogel contact lenses are often composed of copolymers of hydrophilic monomers such as hydroxyethylmethacrylate, N-vinylpyrrolidone and the like, and can be prepared by lathe-cutting methods, spin casting methods, cast molding methods or combinations thereof, followed by a swelling treatment in a physiological saline and/or phosphate buffer solution to obtain lenses with water contents of about 20% or about 30% to about 80% by weight. Medical devices such as ophthalmic lenses made from silicone-containing materials have been investigated for a number of years.

Soft contact lenses made from silicone-containing materials have been investigated for a number of years. An advantage of a silicone-containing contact lens such as silicone hydrogels over conventional hydrogels is that silicone hydrogels typically have higher oxygen permeability due to the inclusion of the silicone-containing monomer. Oxygen permeability is a desirable property for many contact lenses since the human cornea will be damaged if it is deprived of adequate oxygen for an extended period of time. For example, soft silicon or silicone hydrogel contact lenses have been

suggested for continuous wear for extended periods of time, e.g., some silicone hydrogel contact lenses are intended to be worn during the day and removed overnight or to be worn overnight. Other silicone hydrogel contact lenses can be worn continuously for about two weeks, while some silicone hydrogel contact lenses can be worn continuously for about one month. Such continuous wear lenses have had relatively high oxygen permeabilities to provide for oxygen access to the cornea during the extended wearing of such lenses.

One example of a known silicon hydrogel contact lens is a silicone hydrogel contact lens available under the tradename O2 Optix (available from CIBA Vision Corporation) having a water content of about 33%, a Dk of about 110 barrers and a center thickness of about 80 μm .

Another example is a silicone hydrogel contact lens available under the tradename Acuvue Advance (available from Johnson & Johnson), having a water content of about 46 to 47%, a Dk of about 65 barrers and a center thickness of about 70 μm .

Yet another example is a silicone hydrogel contact lens available under the tradename Acuvue Oasys (available from Johnson & Johnson), having a water content of about 38%, a Dk of about 105 barrers and a center thickness of about 70 μm .

Still yet another example is a silicone hydrogel contact lens available under the tradename PureVision (available from Bausch & Lomb), having a water content of about 36%, a Dk of about 100 barrers and a center thickness of about 90 μm .

There continues to be a need for new silicone-containing contact lenses such as silicone-containing hydrogel contact lenses which have advantageous combinations of properties such as, for example, enhanced oxygen permeability, better wettability, and/or better lens designs that can be made in a simple, cost efficient manner.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, a silicone-containing contact lens having a center thickness less than about 50 μm is provided.

In accordance with a second embodiment of the present invention, a silicone-containing contact lens having a center thickness less than about 50 μm and an edge thickness of about 20 to about 200 μm is provided.

In accordance with a third embodiment of the present invention, a silicone-containing contact lens having a center thickness less than about 50 μm and a peripheral thickness of about 50 to about 500 μm is provided.

In accordance with a fourth embodiment of the present invention, a silicone-containing contact lens having a center thickness less than about 50 μm , an edge thickness of about 50 to about 90 μm and a peripheral thickness of about 100 to about 200 μm is provided.

In accordance with a fifth embodiment of the present invention, a hydrated silicone hydrogel contact lens having a center thickness less than about 50 μm is provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view of a representative silicone-containing contact lens according to an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is directed to a silicone-containing contact lens having a center thickness less than about 50 μm . A representative example of a silicone-containing contact lens of the present invention is generally depicted in FIG. 1. The inner surface of the lens, frequently referred to as posterior surface, comprises base curve 1 having radius 2. The base curve 1 is preferably a monocurve, i.e., the posterior surface

of the lens is smooth and of a single radius. However, the base curve may also be provided with one or more peripheral curves (not shown in the drawing). If the base curve with one or more peripheral curves is present, the peripheral curve has a maximum band width of about 4 mm.

The front surface of the lens, frequently referred to as the anterior surface, comprises power or prescription curve 3 having radius 4. The width of power curve 3 is known as the optical zone of the lens (defined between points 5 and 6 of the drawing). This width is generally sufficient to cover most, and preferably all, of the cornea and usually varies between about 6 to about 10 mm and more typically between about 7.5 to about 9 mm.

The anterior surface of the lens also is provided with lenticular curve 7 having radius 8. The lenticular curve extends from its junction with the optical curve to the outer periphery or edge of the lens.

The overall diameter or chord of the lens is defined as the distance between points 9 and 10. This diameter is at least about 12 mm, and usually varies between about 13 to about 17 mm and preferably about 14 mm.

The silicone-containing contact lenses of the present invention will have a center thickness less than about 50 μm and preferably varying between about 20 and about 50 μm . The center thickness of the lens is defined between points 11 and 12 of FIG. 1. The silicone-containing contact lenses of the present invention are thinner than those of the prior art, and the reduced thickness represents a departure from the prior art. The reduced center thickness advantageously permits increased oxygen diffusion through the lens thus avoiding corneal swelling that would otherwise result as a consequence of oxygen deprivation on the corneal surface for an extended period of time.

The silicone-containing contact lenses of the present invention will have a peripheral thickness of about 50 to about 500 and preferably from about 100 to about 200. The peripheral thickness of the lens is generally defined as the thickest point outside the optic zone, i.e., from the edge of the lens to point 5 or the edge of the lens to point 6 of FIG. 1. The peripheral thickness can be thicker than the remainder of the lens without seriously compromising corneal metabolism though it is preferred to maintain the overall cross-sectional thickness of the lens as small as possible as this reduces the mass of the lens that rests on the surface of the eye.

The silicone-containing contact lenses of the present invention will have an edge thickness of about 20 to about 200 and preferably from about 50 to about 90. The edge thickness of the lens is defined as the point between the edge of the lens and point 13 or the edge of the lens to point 14 of FIG. 1. A reduced edge thickness within the limits set forth above is desirable as the edge will have relatively less interference with the eyelid with normal blinking, hence reduced movement, thereby creating stable vision and enhanced comfort.

The radius 2 of base curve 1 is within known limits and is to some extent dependent upon the shape of the eye to which the lens is fitted. The radius 4 of power curve 3 is also within known limits and is dependent upon the correction provided by the lens. Finally, radius 8 of lenticular curve 7 is that necessary to provide the desired edge thickness of the lens. The lenticular curve extends from its junction with the power curve to the outermost edge of the lens and to reduce edge thickness, the curve is typically steeper than the power curve. Hence, the radius 8 of the lenticular curve 7 is shorter than radius 4 of power curve 3. It should be noted that where the lenticular curve

is steeper than the power curve and particularly, in the absence of posterior peripheral curvatures, the mass of the lens is substantially reduced.

The silicone-containing contact lenses of the present invention may also have increased lubricity, i.e., a contact lens having a reduced value of coefficient of friction (hereinafter CoF) relative to a contact lens having a center thickness greater than 50 μm , wherein both contact lenses are made of the same material. CoF is an important parameter that may affect on-eye movement and, therefore, the comfort of wearing the contact lens. A high CoF may increase the likelihood of damaging mechanically the ocular epithelia and/or may lead to ocular discomfort.

The study of how two surfaces interact with each other when in relative motion is known as tribology. One aspect of tribology that may be of importance to contact lenses is friction. Friction is a measure of a material's resistance to lateral motion when placed against a specific substrate. The relative friction between two surfaces may be described in terms of a COF, which is defined as the ratio of the lateral force (F_x) that is required to initiate and then sustain movement to the normal force (F_N). Further, there are two friction coefficients that may be considered, the peak (or static) and average (or kinetic). The static COF is a measure of how much F_x is needed to initiate relative motion of two surfaces and is typically the larger of the two values. Practically, for contact lenses, the static COF is related to the amount of force needed to start a blink cycle or for the lens to begin moving over the cornea. The kinetic COF is a measure of how much lateral force is needed to sustain movement at a particular velocity averaged over a finite period of time. This value is related to the amount of force required to sustain the blink over the course of the entire cycle and the ease of motion of the lens on the cornea (which may be further related to how much the lens moves on the cornea).

Tribological testing can be performed on a CETR Model UMT-2 micro-tribometer. Generally, each lens is clamped on an HDPE holder that initially mates with the posterior side of the lens. A poly(propylene) clamping ring is then used to hold the edge region of the lens. Once the lens is mounted in the holder the assembly is placed in a stationary clamping device within the micro-tribometer. A polished stainless steel disc containing 1mL of a solution, typically a phosphate buffered saline (PBS), is brought into contact with the lens and F_N is adjusted to 2 grams over the course of the run for the frictional measurements. After the load equilibrates, the stainless steel disc is rotated at a velocity of, for example, 12 cm/sec for a duration of 20 sec in both the forward and reverse directions and the peak (static) and average (kinetic) COF values are recorded. Each value represents the average of from, for example, 9 to 10 lenses. All data is normalized to the average values obtained from the lens holder in the absence of a lens tested in PBS.

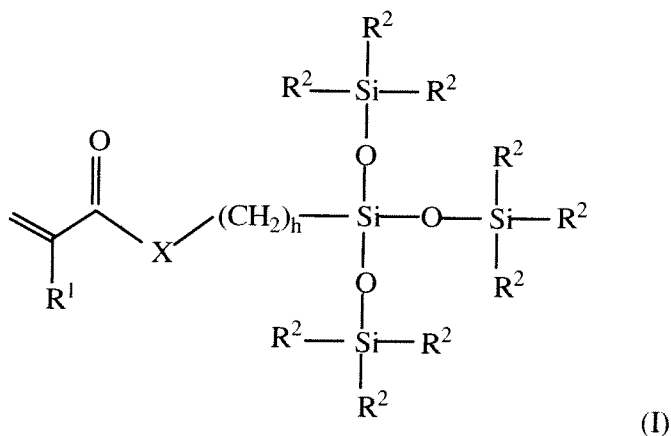
Generally, the silicone-containing contact lenses of the present invention can have a static CoF ranging from about 0.05 to about 8 and preferably from about 0.05 to about 2. The silicone-containing contact lenses of the present invention can have a kinetic CoF ranging from about 0.05 to about 0.5 and preferably from about 0.05 to about 0.3.

The silicone-containing contact lenses of the present invention can be any type of silicone-containing contact lenses such as, for example, soft contact lenses, e.g., a soft, hydrogel lens; soft, non-hydrogel lens, a soft gas permeable lens having less than 5% water and the like, hard contact lenses, e.g., a rigid, gas permeable lens and the like. As is understood by one skilled in the art, a lens is considered to be "soft" if it can be folded back upon itself without breaking.

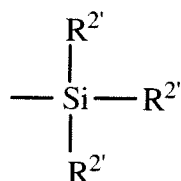
The silicone-containing contact lenses of the present invention are applicable to a wide variety of materials. In one embodiment, such materials are prepared by polymerizing a mixture containing at least one silicone-containing monomer and at least one hydrophilic monomer. Typically, either the silicone-containing monomer or the hydrophilic monomer functions as a crosslinking agent (a crosslinker being defined as a monomer having multiple polymerizable functionalities) or a separate crosslinker may be employed.

Hydrogels in general are a well-known class of materials that comprise hydrated, cross-linked polymeric systems containing water in an equilibrium state. Silicone hydrogels generally have a water content greater than about 5 weight percent and more commonly between about 10 to about 80 weight percent. Applicable silicone-containing monomeric units for use in the formation of silicone hydrogels are well known in the art and numerous examples are provided in U.S. Patent Nos. 4,136,250; 4,153,641; 4,740,533; 5,034,461; 5,070,215; 5,260,000; 5,310,779; and 5,358,995.

Representative examples of applicable silicon-containing monomers for use in preparing the silicone-containing contact lenses of the present invention include bulky polysiloxanylalkyl (meth)acrylic monomers represented by the structure of Formula I:

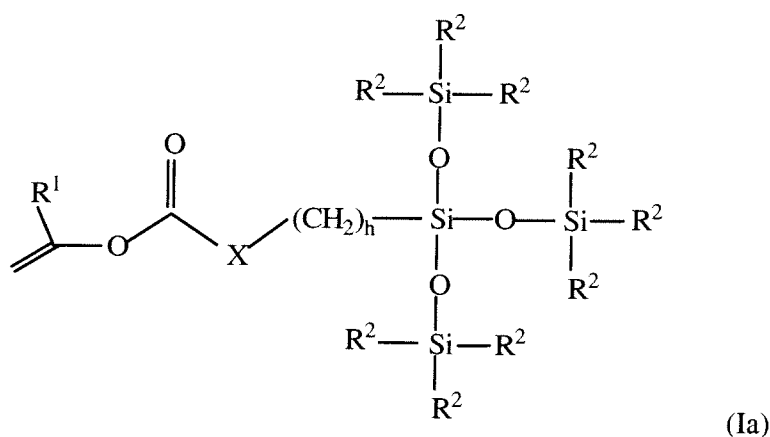


wherein X denotes —O— or —NR—; each R¹ independently denotes hydrogen or methyl; each R² independently denotes a lower alkyl radical, phenyl radical or a group represented by

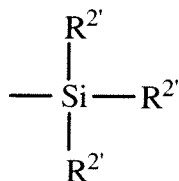


wherein each R^{2'} independently denotes a lower alkyl or phenyl radical; and h is 1 to 10.

Representative examples of other applicable silicon-containing monomers includes, but are not limited to, bulky polysiloxanylalkyl carbamate monomers as generally depicted in Formula Ia:



wherein X denotes—NR—; wherein R denotes hydrogen or a C₁-C₄ alkyl; R¹ denotes hydrogen or methyl; each R² independently denotes a lower alkyl radical, phenyl radical or a group represented by



wherein each R^{2'} independently denotes a lower alkyl or phenyl radical; and h is 1 to 10, and the like.

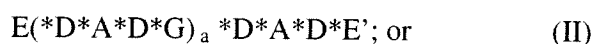
Examples of bulky monomers are 3-methacryloyloxypropyltris(trimethylsiloxy)silane or tris(trimethylsiloxy)silylpropyl methacrylate, sometimes referred to as

TRIS, tris(trimethylsiloxy)silylpropyl vinyl carbamate, sometimes referred to as TRIS-VC, 3-[tris(trimethylsiloxy)silyl]propyl allyl carbamate and the like and mixtures thereof.

Such bulky monomers may be copolymerized with a silicone macromonomer, such as a poly(organosiloxane) capped with an unsaturated group at two or more ends of the molecule. U.S. Patent No. 4,153,641 discloses, for example, various unsaturated groups such as acryloyloxy or methacryloyloxy groups.

Another class of representative silicone-containing monomers includes, but are not limited to, silicone-containing vinyl carbonate monomers such as, for example, 1,3-bis[4-vinyloxycarbonyloxy]but-1-yl]tetramethyl-disiloxane; 3-(trimethylsilyl)propyl vinyl carbonate; 3-(vinyloxycarbonylthio)propyl-[tris(trimethylsiloxy)silane]; 3-[tris(trimethylsiloxy)silyl]propyl vinyl carbonate; t-butyl dimethylsiloxyethyl vinyl carbonate; trimethylsilylethyl vinyl carbonate; trimethylsilylmethyl vinyl carbonate and the like and mixtures thereof.

Another class of silicon-containing monomers includes polyurethane-polysiloxane macromonomers (also sometimes referred to as prepolymers), which may have hard-soft-hard blocks like traditional urethane elastomers. They may be end-capped with a hydrophilic monomer such as 2-hydroxyethyl methacrylate (HEMA). Examples of such silicone urethanes are disclosed in a variety of publications, including PCT Published Application No. WO 96/31792 discloses examples of such monomers, which disclosure is hereby incorporated by reference in its entirety. Representative examples of silicone urethane monomers are represented by Formulae II and III:



wherein:

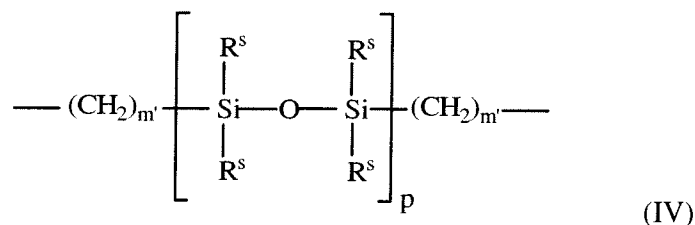
D independently denotes an alkyl diradical, an alkyl cycloalkyl diradical, a cycloalkyl diradical, an aryl diradical or an alkylaryl diradical having 6 to about 30 carbon atoms;

G independently denotes an alkyl diradical, a cycloalkyl diradical, an alkyl cycloalkyl diradical, an aryl diradical or an alkylaryl diradical having 1 to about 40 carbon atoms and which may contain ether, thio or amine linkages in the main chain;

* denotes a urethane or ureido linkage;

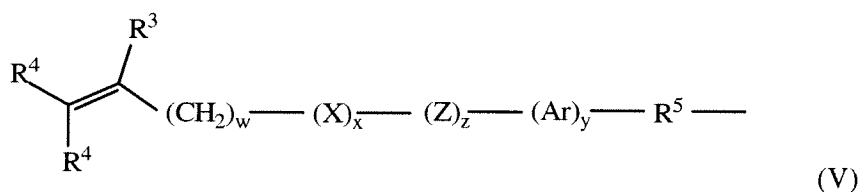
a is at least 1;

A independently denotes a divalent polymeric radical of Formula IV:



wherein each R^s independently denotes an alkyl or fluoro-substituted alkyl group having 1 to about 10 carbon atoms which may contain ether linkages between the carbon atoms; m' is at least 1; and p is a number that provides a moiety weight of about 400 to about 10,000;

each of E and E' independently denotes a polymerizable unsaturated organic radical represented by Formula V:



wherein: R^3 is hydrogen or methyl;

R^4 is hydrogen, an alkyl radical having 1 to 6 carbon atoms, or a ---CO---Y---R^6 radical wherein Y is ---O--- , ---S--- or ---NH--- ;

R^5 is a divalent alkylene radical having 1 to about 10 carbon atoms;

R^6 is a alkyl radical having 1 to about 12 carbon atoms;

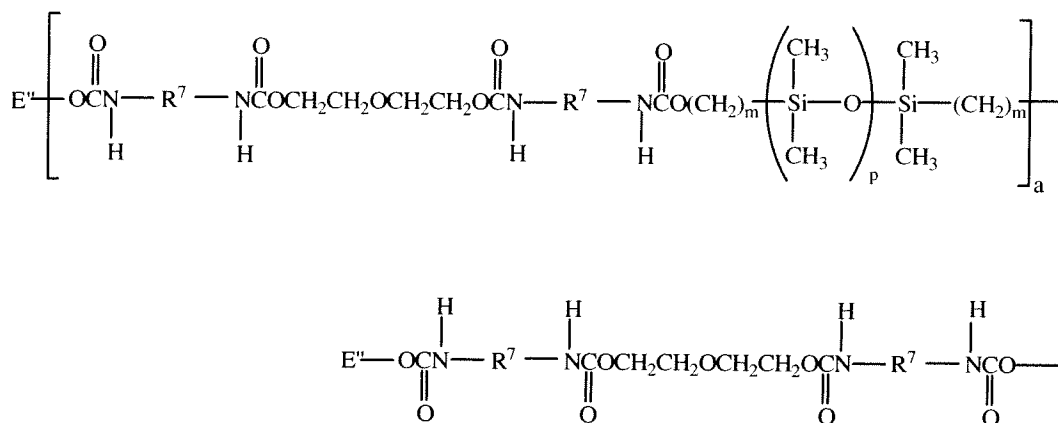
X denotes ---CO--- or ---OCO--- ;

Z denotes ---O--- or ---NH--- ;

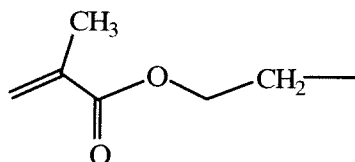
Ar denotes an aromatic radical having about 6 to about 30 carbon atoms;

w is 0 to 6; x is 0 or 1; y is 0 or 1; and z is 0 or 1.

A preferred silicone-containing urethane monomer is represented by Formula VI:



wherein m is at least 1 and is preferably 3 or 4, a is at least 1 and preferably is 1, p is a number which provides a moiety weight of about 400 to about 10,000 and is preferably at least about 30, R⁷ is a diradical of a diisocyanate after removal of the isocyanate group, such as the diradical of isophorone diisocyanate, and each E'' is a group represented by:



In another embodiment of the present invention, a silicone hydrogel material comprises (in bulk, that is, in the monomer mixture that is copolymerized) about 5 to about 70 percent, and preferably about 10 to about 60, by weight of one or more silicone macromonomers, about 5 to about 60 percent, and preferably about 10 to about 60 percent, by weight of one or more polysiloxanylalkyl (meth)acrylic monomers, and about 20 to about 60 percent, and preferably about 10 to about 50 percent, by weight of a hydrophilic monomer. In general, the silicone macromonomer is a poly(organosiloxane) capped with an unsaturated group at two or more ends of the molecule. In addition to the end groups in the above structural formulas, U.S. Patent No. 4,153,641 discloses additional unsaturated groups, including acryloyloxy or methacryloyloxy groups.

Fumarate-containing materials such as those disclosed in U.S. Patent Nos. 5,310,779; 5,449,729 and 5,512,205 are also useful substrates in accordance with the invention. Preferably, the silane macromonomer is a silicon-containing vinyl carbonate or vinyl carbamate or a polyurethane-polysiloxane having one or more hard-soft-hard blocks and end-capped with a hydrophilic monomer.

The above materials are merely exemplary, and other materials for use as silicone-containing contact lenses and have been disclosed in various publications and are being continuously developed can also be used. For example, a silicone-containing contact lens for use herein can be formed from at least a cationic material such as a cationic silicone-containing material. In another embodiment, a silicone-containing contact lens for use herein can be formed from at least a fluorinated silicone-containing material. Such material have been used in the formation of, for example, fluorosilicone hydrogels to reduce the accumulation of deposits on contact lenses made therefrom, as disclosed in, for example, U.S. Patent Nos. 4,954,587; 5,010,141 and 5,079,319. The use of silicone-containing monomers having certain fluorinated side groups, i.e., $-(CF_2)_n-H$, can also be used herein, such as those disclosed in, e.g., U.S. Patent Nos. 5,321,108 and 5,387,662.

Suitable hydrophilic monomers include one or more unsaturated carboxylic acids, vinyl lactams, amides, polymerizable amines, vinyl carbonates, vinyl carbamates, oxazolone monomers, and the like and mixtures thereof. Useful amides include acrylamides such as N,N-dimethylacrylamide and N,N-dimethylmethacrylamide. Useful vinyl lactams include cyclic lactams such as N-vinyl-2-pyrrolidone. Examples of other hydrophilic monomers include poly(alkene glycols) functionalized with polymerizable groups. Examples of useful functionalized poly(alkene glycols) include poly(diethylene

glycols) of varying chain length containing monomethacrylate or dimethacrylate end caps. In a preferred embodiment, the poly(alkene glycol) polymer contains at least two alkene glycol monomeric units. Still further examples are the hydrophilic vinyl carbonate or vinyl carbamate monomers disclosed in U.S. Patent No. 5,070,215, and the hydrophilic oxazolone monomers disclosed in U.S. Patent No. 4,910,277. Other suitable hydrophilic monomers will be apparent to one skilled in the art.

In one embodiment, the silicone-containing contact lenses are prepared by polymerizing a mixture containing at least one of the foregoing silicone-containing monomers and at least one hydrophilic polymer. Suitable hydrophilic polymers include, by way of example, poly(vinylpyrrolidone), polysaccharides, poly(vinylalcohol) and the like and mixtures thereof. The hydrophilic polymers can further contain one or more reactive groups or polymerizable groups such as (meth)acrylate-containing groups, (meth)acrylamide-containing groups, vinylcarbonate-containing groups, vinylcarbamate-containing groups, styrene-containing groups, itaconate-containing groups, vinyl-containing groups, vinyloxy-containing groups, fumarate-containing groups, maleimide-containing groups, vinylsulfonyl groups and the like.

In another embodiment, the silicone-containing contact lenses are prepared by polymerizing a mixture containing at least one of the foregoing silicone-containing monomers and at least one fluoro-containing monomers. Suitable fluoro-containing monomers include, by way of example, fluorine-containing monomers having one or more polymerizable ethylenically unsaturated-containing radicals attached thereto. Representative examples of a "polymerizable ethylenically unsaturated-containing radical" include, by way of example, (meth)acrylate-containing radicals, (meth)acrylamide-containing radicals, vinyl-containing radicals such as vinyl carbonate-

containing radicals, vinyl carbamate-containing radicals and the like, styrene-containing radicals, itaconate-containing radicals, vinyloxy-containing radicals, fumarate-containing radicals, maleimide-containing radicals, vinyl sulfonyl radicals and the like. The polymerizable ethylenically unsaturated-containing radicals can be attached to the fluorine-containing monomer as pendent groups, terminal groups or both. In one embodiment, useful polymerizable fluorine-containing monomers include fluorine substituted hydrocarbons having one or more polymerizable ethylenically unsaturated-containing radicals attached thereto and optionally containing one or more ether linkages, e.g., fluorine substituted straight or branched C₁-C₁₈ alkyl groups having one or more polymerizable ethylenically unsaturated-containing radicals attached thereto which may include ether linkages therebetween; fluorine substituted C₃-C₂₄ cycloalkyl groups having one or more polymerizable ethylenically unsaturated-containing radicals attached thereto which may include ether linkages therebetween; fluorine substituted C₅-C₃₀ aryl groups having one or more polymerizable ethylenically unsaturated-containing radicals attached thereto which may include ether linkages therebetween and the like.

Examples of suitable fluorine-containing monomers include, but are not limited to, 2,2,2-trifluoroethyl (meth)acrylate, 2,2,3,3-tetrafluoropropyl (meth)acrylate, 2,2,3,3,3-pentafluoropropyl (meth)acrylate, 1-trifluoromethyl-2,2,2-trifluoroethyl (meth)acrylate, 1H,1H,5H-octafluoropentyl (meth)acrylate, hexafluoroisopropyl (meth)acrylate, 2,2,3,3,4,4-hexafluorobutyl (meth)acrylate, pentafluorophenyl (meth)acrylate, pentafluorohexyl (meth)acrylate and the like and mixtures thereof.

The monomer mixture used in forming the silicone-containing contact lenses can further include one or more crosslinking agents, strengthening agents, free radical

initiators and/or catalysts, dyes, ultraviolet (UV) blockers and the like as is well known in the art.

The silicone-containing contact lenses of the present invention can be prepared by mold polymerization or casting polymerization. Any mold material can be used for mold polymerization or casting polymerization, so long as it is sized and configured to provide the lenses of the present invention having the center, edge and peripheral thicknesses discussed hereinabove. The mold material should also be substantially insoluble to monomer mixture. For example, polyolefin resins such as polypropylene and polyethylene can be used, and materials having polar groups at a surface are preferable. As used herein, a polar group means an atomic group with strong affinity with water and include, by way of example, hydroxyl groups, nitrile groups, carboxyl groups, polyoxyethylene groups, amide groups, urethane groups and the like. Examples of other mold material include polyacrylonitriles, polyesters, polyimides, polyamides, polysulfones, polyvinylidene fluorides, polyvinyl alcohols and copolymers thereof. In one embodiment, the mold material is a resin described in U.S. Patent. No. 3,426,102 and available from British Petroleum under the trademark "Barex". Generally, a Barex resin is a rubber modified copolymer containing about 75% acrylonitrile and about 25% methyl acrylate. In another embodiment, the mold material is a polyimide such as a polyetherimide or a copolymer thereof. Such resins are commercially available from General Electric under the trademark "Ultem". In yet another embodiment, the mold material is a polyvinyl alcohol or a copolymer thereof such as an ethylene vinyl alcohol copolymer.

The method of polymerization or cure is not critical to the practice of this invention, except that this invention is particularly suitable to free radical polymerization

systems as are well known in the contact lens art. Thus, the polymerization can occur by a variety of mechanisms depending on the specific composition employed. For example, thermal, photo, X-ray, microwave, and combinations thereof which are free radical polymerization techniques can be employed herein. Preferably, thermal and photo polymerizations are used in this invention with UV polymerization being most preferred.

If desired, an organic diluent can be included in the initial monomeric mixture in order to minimize phase separation of polymerized products produced by polymerization of the monomeric mixture and to lower the glass transition temperature of the reacting polymeric mixture, which allows for a more efficient curing process and ultimately results in a more uniformly polymerized product. Sufficient uniformity of the initial monomeric mixture and the polymerized product is of particular importance for silicone hydrogels, primarily due to the inclusion of silicone-containing monomers which may tend to separate from the hydrophilic comonomer.

Suitable organic diluents include, for example, monohydric alcohols such as C₆-C₁₀ straight-chained aliphatic monohydric alcohols, e.g., n-hexanol and n-nonanol; diols such as ethylene glycol; polyols such as glycerin; ethers such as diethylene glycol monoethyl ether; ketones such as methyl ethyl ketone; esters such as methyl enanthate; and hydrocarbons such as toluene. Preferably, the organic diluent is sufficiently volatile to facilitate its removal from a cured article by evaporation at or near ambient pressure. Generally, the diluent may be included at about 5 to about 60 percent by weight of the monomeric mixture, with about 10 to about 50 percent by weight being preferred. If necessary, the cured lens may be subjected to solvent removal, which can be accomplished by evaporation at or near ambient pressure or under vacuum. An elevated temperature can be employed to shorten the time necessary to evaporate the diluent.

It is also possible to perform the polymerization in the absence of diluent to produce a xerogel. The xerogels may then be hydrated to form hydrogels as is well known in the art.

The silicone-containing contact lenses of the present invention can be subjected to optional machining operations. The machining step includes, for example, buffing or polishing a lens edge and/or surface. Generally, such machining processes may be performed before or after the article is released from a mold part. As an example, the lens can be dry released from the mold. Alternatively, the lens can be wet released from the mold with an organic solvent, or mixture of solvent and water.

If desired, the surfaces of the silicone-containing contact lenses of the present invention may be modified by, for example, applying plasma treatment, ozone treatment, corona discharge, chemical reaction and/or other treatment, graft polymerization and the like as known in the art. The surfaces of the contact lenses may be modified to increase surface wettability, that is, to increase the wettability of the surface or surfaces of the lens, for example, after molding the lens.

The silicone-containing contact lenses of the present invention may be in any suitable configuration effective to satisfy the needs of the lens wearer. For example, the lenses may have a single refractive power or two or more refractive powers, such as a bifocal or multifocal lens, or may have no refractive power. The lenses can provide spherical corrections, aspherical corrections, cylinder corrections, wave front corrections, corrections of aberrations and the like. The lenses can be configured to be rotationally stabilized, for example, including ballasts, other rotationally stabilizing features and the like. The lenses can be untinted, tinted, colored, e.g., with iris-simulating patterns, and the like.

The silicone-containing contact lenses may then be transferred to individual lens packages containing a buffered saline solution. The saline solution may be added to the package either before or after transfer of the lens. Appropriate packaging designs and materials are known in the art. A plastic package is releasably sealed with a film. Suitable sealing films are known in the art and include foils, polymer films and mixtures thereof. The sealed packages containing the lenses are then sterilized to ensure a sterile product. Suitable sterilization means and conditions are known in the art and include, for example, autoclaving.

It will be understood that various modifications may be made to the embodiments disclosed herein. Therefore the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. For example, the functions described above and implemented as the best mode for operating the present invention are for illustration purposes only. Other arrangements and methods may be implemented by those skilled in the art without departing from the scope and spirit of this invention. Moreover, those skilled in the art will envision other modifications within the scope and spirit of the features and advantages appended hereto.

WHAT IS CLAIMED IS:

1. A silicone-containing contact lens having a center thickness less than about 50 μm .
2. The silicone-containing contact lens of Claim 1, having an edge thickness of about 20 to about 200 μm .
3. The silicone-containing contact lens of Claim 1, having an edge thickness of about 50 to about 90 μm .
4. The silicone-containing contact lens of Claim 1, having a peripheral thickness of about 50 to about 500 μm .
5. The silicone-containing contact lens of Claim 1, having a peripheral thickness of about 100 to about 200 μm .
6. The silicone-containing contact lens of Claim 1, having an edge thickness of about 20 to about 200 μm and a peripheral thickness of about 50 to about 500 μm .
7. The silicone-containing contact lens of Claim 1, having an edge thickness of about 50 to about 90 μm and a peripheral thickness of about 100 to about 200 μm .
8. The silicone-containing contact lens of Claim 1, having a center thickness of about 20 to about 50 μm , an edge thickness of about 50 to about 90 μm and a peripheral thickness of about 100 to about 200 μm .
9. The silicone-containing contact lens of Claim 1, having a static coefficient of friction of about 0.05 to about 8.
10. The silicone-containing contact lens of Claim 1, having a static coefficient of friction of about 0.05 to about 2.

11. The silicone-containing contact lens of Claim 1, having a kinetic coefficient of friction of about 0.05 to about 0.5.

12. The silicone-containing contact lens of Claim 1, having a kinetic coefficient of friction of about 0.05 to about 0.3.

13. The silicone-containing contact lens of Claim 1, having a static coefficient of friction of about 0.05 to about 8 and a kinetic coefficient of friction of about 0.05 to about 0.5.

14. The silicone-containing contact lens of Claim 1, having a static coefficient of friction of about 0.05 to about 2 and a kinetic coefficient of friction of about 0.05 to about 0.3.

15. The silicone-containing contact lens of Claim 1, comprising a polymerization product of a monomeric mixture comprising a silicon-containing monomer and a hydrophilic monomer.

16. The silicone-containing contact lens of Claim 15, wherein the silicon containing monomer comprises a silicon containing monomer selected from the group consisting of a silicon containing vinyl carbonate, silicon containing vinyl carbamate, polyurethane-polysiloxane having one or more hard-soft-hard blocks and end-capped with a hydrophilic monomer, fumarate containing silicon containing monomer, poly(organosiloxane) capped with an unsaturated group at two or more ends of the molecule, polyurethane-polysiloxane macromonomer and mixtures thereof.

17. The silicone-containing contact lens of Claim 15, wherein the hydrophilic monomer is selected from the group consisting of an unsaturated carboxylic acid, vinyl lactam, acrylamide, polymerizable amine, vinyl carbonate, vinyl carbamate, oxazolone monomer and mixtures thereof.

18. The silicone-containing contact lens of Claim 15, wherein the hydrophilic monomer is selected from the group consisting of methacrylic and acrylic acids, 2-hydroxyethylmethacrylate, N-vinylpyrrolidone, methacrylamide, N,N-dimethylacrylamide and mixtures thereof.

19. The silicone-containing contact lens of Claim 1, comprising a polymerization product of a mixture comprising a silicon containing monomer and a hydrophilic polymer.

20. The silicone-containing contact lens of Claim 19, wherein the hydrophilic polymer comprises a reactive group or polymerizable group.

21. The silicone-containing contact lens of Claim 1, comprising a polymerization product of a monomeric mixture comprising a silicon-containing monomer and a fluoro-containing monomer.

22. The silicone-containing contact lens of Claim 1, which is a silicone hydrogel contact lens.

23. The silicone-containing contact lens of Claim 1, which is a rigid gas permeable lens, a soft gas permeable lens having less than 5% water or a xerogel.

24. The silicone-containing contact lens of Claim 1, wherein the surface of the lens is surface-modified.

25. The silicone-containing contact lens of Claim 24, wherein the surface-modified lens is a plasma treated surface modified lens.

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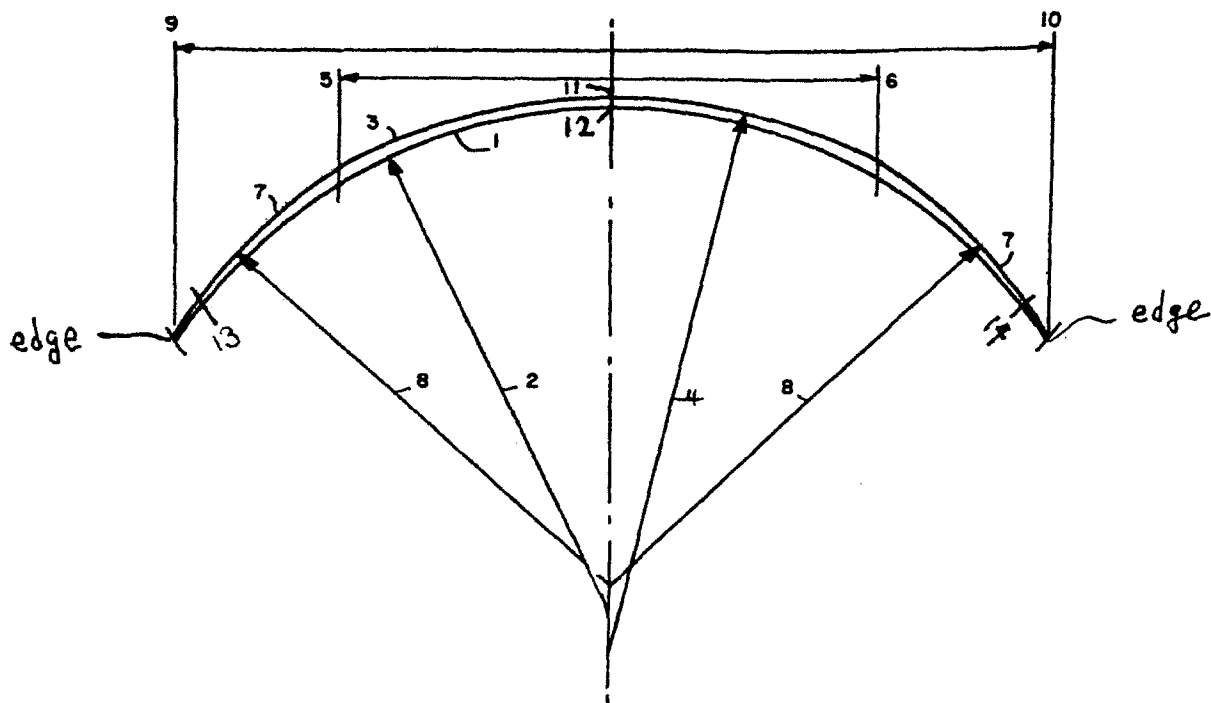


FIGURE 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/031526

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02C7/04

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)
G02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 2008/074611 A1 (MEYERS WILLIAM E [US] ET AL) 27 March 2008 (2008-03-27) paragraph [0040] paragraph [0042] figures	1-25
X	US 4 681 295 A (HAARDT HENRY [US] ET AL) 21 July 1987 (1987-07-21) abstract column 2, line 45 - line 49 column 8, line 11 - column 9, line 57 figures 1,2,4	1-25
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance

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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.

8 document member of the same patent family

Date of the actual completion of the international search

3 April 2009

Date of mailing of the international search report

20/04/2009

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/031526

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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