INTRAOCULAR LENS AND METHOD FOR MAKING SAME

BACKGROUND OF THE INVENTION

The present invention relates to an improved intraocular lens. More particularly, the present invention relates to soft-type intraocular lens having improved bonding strength between the haptic or haptics and the optic of the lens.

The use of intraocular lenses (IOLs) to improve vision and/or to replace damaged or diseased natural lenses in human eyes, particularly natural lenses impaired by cataracts, has obtained wide acceptance. Accordingly, a variety of IOLs has been developed for surgical implantation in the posterior or anterior chambers of the eye according to a patient's needs.

Known IOLs comprise an optical lens portion or optic which includes an optical zone, and one or more, preferably two, supporting structures, called fixation members or haptics, for contacting eye tissue to fix or hold the IOL in the proper position after implantation. The optic may comprise a soft, resilient material, such as any of a variety of flexible elastomers, or a relatively hard or rigid material such as, for example, polymethylmethacrylate (PMMA). The haptics typically comprise a filament constructed of resilient metal or polymeric substance, such as PMMA or polypropylene.

Each of the filament haptics is preferably flexible to reduce trauma to sensitive eye structures and to be yielding during insertion of the IOL. In addition, filament haptics generally have a memory retaining capability, e.g., springiness, so that after implantation of an associated IOL, the filament haptics automatically tend to return to their normal orientations.

As an alternative to filament haptics, some IOLs are provided with footplate-type haptics. These footplates generally extend radially outwardly from the optic (in the plane of the optic) and terminate in rounded or blunted ends configured for placement in an eye chamber. The materials for such footplates have included soft materials, for example 2-hydroxyethyl methacrylate or silicone. However, footplate-type haptics are attended by disadvantages, such as the addition of extra material weight to the IOL and reduced flexibility as compared to filament haptics leading to poor fixation and consequent migration or dislocation of the IOL.

Although the filament haptics are preferred over the footplate-type haptics for several reasons, certain difficulties remain. For example, filament haptics and soft or deformable optics tend to be formed from dissimilar materials which do not ordinarily chemically bond together. As a result, filament haptics have been designed having a variety of attachment end configurations or structures, e.g., anchor structures for providing a physical interlock between the haptic and optic. Polypropylene haptics, for example, have heretofore been secured into silicone polymer-based optics by means of a mechanical lock. This lock may comprise a small loop or other anchor formed at the attachment end of the haptic through and/or around which the silicone-based optic precursor material is poured or molded and then cured. Christ et al U.S. Pat. No. 4,790,846 discloses the molding of an optic around a haptic having a small loop or other anchor to effect a secure haptic connection.

Christ et al U.S. Pat. No. 4,790,846 further discloses a method for making an IOL in which a region of an elongated filament haptic has a different configuration, e.g., a bulbous enlargement, which cooperates with the optic of the IOL to form a mechanical interlock between this different configuration and the optic and to attach to the optic. If desired, the bulbous enlargement may have its outer surface roughened to improve adhesion of the material of the optic.

Koziol, et al U.S. Pat. Nos. 4,615,702 and 4,702,865 disclose a one-piece haptic structure which comprises an annular loop portion for surrounding the optical pathway or zone through the optic, and having a pair of mounting arms extending radially outwardly from the loop. The loop is embedded within the optic during molding and polymerization of the optic to provide a mechanical interfit. However, the loop can be aesthetically displeasing, and can interfere with peripheral sight through the optic. Also, due to the lack of chemical interaction between the haptic and the optic, gaps can form at the haptic-optic interface which further impair the optical integrity of the optic.

Kaplan et al U.S. Pat. No. 4,668,446 discloses an alternative method of attaching haptics to the optic of an IOL wherein an enlarged attachment end of the haptic is secured in the optic. This method involves an ethanol induced swelling of a bore hole in the optic, insertion of the enlarged end of the haptic into this bore hole, and removal of the ethanol to shrink the bore hole around the enlarged end of the haptic, thereby producing a mechanical anchoring.

Freeman U.S. Pat. No. 4,718,905 discloses an IOL including an optic composed of PMMA and haptics fashioned from polypropylene strand material. Each haptic strand is coated, using ion beam implantation, with a biocompatible protective covering material to protect it from the bioerodable effects of ocular tissue. This patent does not teach, or even suggest, enhanced haptic-optic bonding. Also, there is no teaching that the haptic is subjected to ion beam implantation prior to being secured to the optic.

Bruns et al U.S. Pat. No. 4,737,322 discloses an IOL including haptics with anchoring struts which are located in the optic and surround or partially surround the center of the optical zone portion of the optic. These struts provide sufficient anchoring of the haptic in the optic to withstand a tensile pull force of from 50 to 115 grams.

Notwithstanding these known structures and methods, there remains a need for a method of efficiently and effectively securing a haptic to the optic of an IOL, preferably without the use of mechanical interlocking structures, so that the strength of the haptic-optic bond is sufficient to resist detachment of the haptic under normal implantation and wear conditions.

The use of gas plasmas to activate and/or add functional groups to surfaces or fibers is well known. For example, see: "Plasma Treatment Effect in the Surface Energy of Carbon and Carbon Fibers", J. B. Donnet, et al, Carbon, Vol. 24, No. 6 pp 757–770 (1986); and "Introduction of Functional Groups Onto Carbon Electrode Via Treatment With Radio-Frequency Plasma", J. F. Evans, et al, Analytical Chemistry, Vol. 51, No. 3, pp 358–365 (1979). Further, Goan U.S. Pat. No. 3,776,829 discloses reacting carbon fibers with ammonia plasma to form amino groups on the fiber surfaces. The amine groups act as cross linking agents for an epoxy resin matrix in the preparation of sized fibers, preimpregnated tapes, and compositions containing the fibers. Heretofore, however, the known prior art has