In situ curable accommodating implant

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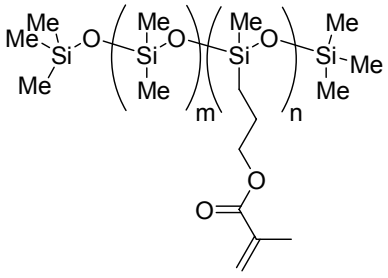
Introduction: Due to the aging population there is considerable interest in finding an effective and more convenient solution to presbyopia. Presbyopia, a condition which affects everyone as they age is due to hardening of the crystalline lens resulting in the loss of the ability of the eye to change focus. Since the proposal of the concept by Kessler in the mid-1960's,[1] researchers have been attempting to restore the eye's ability to change focus by refilling the natural lens with a soft gel. Vision CRC has been developing polymers suitable for restoring accommodation to presbyopes. This paper describes the mechanical properties of our polymers and initial results from a primate trial testing of one of these polymers.

Methods: Siloxane macromonomers (1) are prepared in-house as this allows us to tailor the properties to the application. Siloxane prepolymers were prepared by ring opening D4 and D4'and HMDS. The macromonomer is prepared by introducing polymerisable groups by hydrosilylation of the prepolymer with allyl methacrylate. The polymers are designed to be cured *in situ* by exposure to blue light (400-500nm) resulting in a crosslinked gel.



(1)

Lens capsule refilling (phaco-ersatz) was used for *ex vivo* and *in vivo* analysis to examine the suitability of the gels to allow accommodation *in situ*.[2] Briefly, lens extraction (endocapsular phacoaspiration) was performed, a capsular valve was installed to stop leakage of the polymer during filling and the capsular bag was refilled with the macromomer. The eyes were then exposed to blue light for 30 to 120 seconds to cure the macromonomer.

Results / Discussion: An important criterion for a polymer for this application is its ability to be injected into an empty capsular bag though a small bore cannula. The viscosity of the uncured macromonomers was measured using parallel plate rheometery. By altering the concentration of end groups (HMDS) in the polymer synthesis, the viscosity of the polymer could be altered. Heys *et al.*[3] have reported that the modulus of the crystalline lens cortex increases by almost 1000 times with age. Therefore, to ensure that the cured polymer would alter shape (enable a change in lens power) following ciliary muscle contraction/relaxation, the modulus of the cured polymer would need to approach that of a young pre-presbyopic crystalline lens. By varying the concentration of polymerisable groups along the polymer back-bone the post-cure modulus of the crosslinked polymer can be controlled. Polymers with a post-cure modulus of <1 to 40 kPa were prepared. The materials were tested in an *ex vivo* accommodation simulator (EVAS) developed in-house, which measures the change in refractive power of a lens with a controlled amount of force or distance of stretching of the ciliary body.[4] EVAS stretching studies showed an average accommodation amplitude loss of 38% comparing the refilled lenses to natural cadaver lenses. The polymers were tested *in vivo* in rabbits. The eyes were quiet; however, as expected in a rabbit model, the refilled lens became opacified with time due to lens epithelial cell regeneration. As rabbits do not exhibit accommodation, the rhesus monkey was used as a model to demonstrate accommodation *in vivo*. Following subconjunctival injections of pilocarpine (used to chemically induce contraction of the ciliary muscles) 6-12 dipoters of accommodation was recorded in the implanted eye (Figure 1).

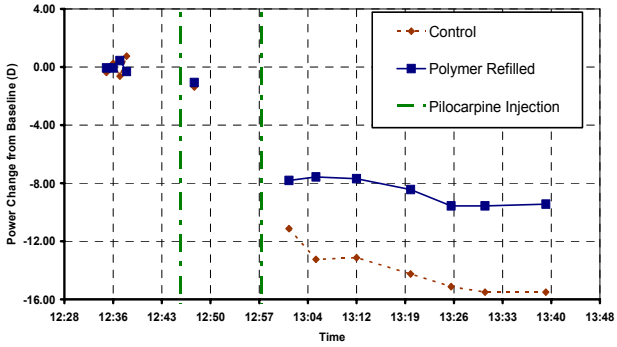


Figure 1: Change in accommodation of control and refilled rhesus eyes following pilocarpine treatment

Conclusions: Siloxane macromonomer (1) with suitable properties could be prepared by altering the molecular weight and polymerisable group concentration. Accommodation in non-presbyopic monkeys was maintained following implantation (6-12D). Siloxane macromonomers show promise as an injectable *in situ* curable accommodating implant.

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References:

1. Kessler J., *Arch Opthalmo*l., 1964, **71**, 412.
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3. Heys K., Cram S.L., and Truscott R.J.W.., Molecular Vision, 2005, **10**, 956.
4. Acosta, A. C., *et al. Invest. Ophthalmol. Vis. Sci.* 2005, **46**(5):740.