

Application note

Silicones in ophthalmic applications

Medical devices accomplish big feats on a small scale. This is especially the case with ophthalmic applications like contact or intraocular lenses, in which whole devices are no larger than the eye and virtually unnoticeable.

Intraocular lenses, or IOLs, are similar to contact lenses, except that they are implanted into the eye while contact lenses are not¹. Both are virtually unnoticeable not only for their size but perhaps even more so for their transparency/optical clarity. As their function is to improve sight, these devices must be highly optically clear.

Contact and intraocular lenses are often made with silicone, which has been used in medical device applications since the 1950s. This is because silicone provides chemical stability, dynamic mechanical properties, and biocompatibility. Additionally, silicone chemistry lends itself to optimization. So, for instance, attaining a specific viscosity and varying the degree of optical clarity and permeability are readily achievable goals.

One reason for silicone's versatility is due to the relatively large bond angles² of the repeating helical silicon-oxygen (Si-O) bonds



Figure 1. Intraocular Lens

on the polymer backbone and the variability of the substituent, or R', groups attached to the open valences of the silicon atoms. The bond angles yield large amounts of free volume, leaving space for design or, more specifically, for managing the amount and type of substituent group and filler, such as resin, that are often assimilated into a silicone system.

Phenyl groups incorporated into the siloxane (Si-O) polymer backbone of a silicone can influence the silicone's permeability as well as its refractive index. Refractive index, or RI, is defined as the ratio of the velocity of light in a vacuum to the velocity of light in a material³. When light passes through a lens or thin film, it is refracted, meaning it passes through, twice – once when it enters and once when it exits. However, not all light striking a surface or interface will refract; some light is reflected instead of transmitted through the material. The more light a material refracts and the less it reflects, the more transparent it will appear. The more slowly light passes through the silicone, the larger its RI. Optically clear silicones are highly responsive to light, meaning that far more light waves are transmitted through the material than reflected back out.

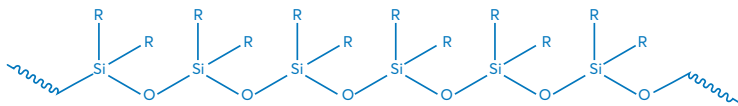


FIGURE 2: Basic structure of polysiloxane chain.

Clarity of vision is governed by the eye's reception of light. Blurred vision is the result of what is known as refractive error. Variations of this occur as complications with light refraction by the cornea and the crystalline lens or with light transmittance to the retina—or both—in which the optical power of the eye is diminished. One of the reasons silicone is used in ophthalmic applications is

because of the opportunity it affords for RI adjustment according to different requirements for repairing or enhancing sight. In this way, silicone is accommodating to the function of intraocular and contact lenses.

Low consistency silicone elastomers (LCEs) lend themselves for attainment in lens applications of the mechanical and physical properties needed to make the device not only effectively undetectable but also comfortable so that the user experiences no discomfort—only clearer vision. These are resin-reinforced and flowable, often at 1 MM cps when used in lenses, and they are easily tailored to achieve desired levels of permeability to accommodate and even imitate rather than change the eye's environment.

Assuming a natural rather than intrusive feel is a task of medical devices, and silicone rises to the challenge to help achieve this. In ophthalmic applications, silicone allows the benefits and not the burden of a device to meet the eye.

References:

1. "Ocular Implants", College of Optometrists, Charity no: 1060431, <http://www.college-optometrists.org/>.
2. Mark, James E, "Some Interesting Things about Polysiloxanes", Accounts of Chemical Research, Volume 37 No. 12, 946-953, 2004.
3. "Guide to Selecting Refractive Index" TN118, Horiba Instruments, Inc., 2004.

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