



## Hydrophilic Nanocoatings for Daily Silicone Hydrogels

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Contact lenses have two requirements that allow a comfortable user experience, high oxygen permeability and good wetting. Oxygen permeability is needed to prevent damage to the cornea, while good wetting minimizes the “foreign object” feel when blinking. Unfortunately, the best oxygen permeable materials are based on silicone rubber, which is highly hydrophobic and doesn’t wet at all. Modern lenses overcome part of the problem by blending silicones with highly wetting polymers to create silicone hydrogels. These materials allow good oxygen transfer while exhibiting acceptable wetting.

However, silicone hydrogels still have large parts of the surface that are comprised of the non-wetting silicone rubber, limiting the overall comfort of the wearer. To deal with this problem, contact lens manufacturers use complex solutions that add expense to daily silicone hydrogel lenses. Lotus Leaf Coatings, Inc., has developed a hydrophilic nanocoatings that is compatible with silicone rubbers. The result is a silicone hydrogel contact lens with significantly improved wettability.

### The Problem

The fundamental problem is that current solutions to making comfortable silicone hydrogel contact lenses add significant processing time and expense. As a result, companies must often decide between comfort and affordability for their daily silicone hydrogel lens offerings.

### The Solution

The Lotus Leaf Coatings’ unique solution is to cover only the areas of exposed hydrophobic silicone with a hydrophilic coating thereby enhancing the wettability of the contact lens. The effect of Lotus Leaf Coatings’ HydroPhil-CL nanocoating can be seen in the photographs below. Figure 1 shows the static water contact angle on a standard commercially available and acquired silicone hydrogel contact lens. Figure 2 shows the same silicone hydrogel contact lens after being coated with HydroPhil-CL. The result is a static contact angle below 20°, in the super-hydrophilic range.



Figure 1 Standard Silicone Hydrogel Lens



Figure 2: Silicone Hydrogel Lens w/HydroPhil-CL



This difference is also observable in the water film breakup time test. While an uncoated lens shows dry spots after 5 seconds, the coated lens stays wet for at least 30 seconds in air. The wettability of the silicone hydrogel lens is greatly enhanced by HydroPhil-CL without impact to the functionality or breathability of the lens.

### **Process Compatibility**

Our current process for coating the lenses is comprised of a DI water rinse, HydroPhil-CL dip, and a DI water rinse. Each of the steps requires only a quick exposure in the water or solution. We believe that the coating process could become part of the hydration step in the manufacturing process.

### **Testing**

**Wettability – Contact Angle:** Using the Sessile Drop Test the contact angle measurement shows a significant improvement in wettability due to the HydroPhil-CL. These changes show a reduction in static contact angle from above 90° to a coated static contact angle below 20°.

**Wettability – Water Breakup:** Using the Water Breakup Test protocol the coated HydroPhil-CL lenses pass the minimum 20 second pass/fail time and can stay wet for up to a minute.

**Mechanical Cleaning–** The coated lenses were subjected to finger wash cycles in Alcon Opti-Free. The wash had no effect on the contact angle of the coated lens.

**Disinfecting –** The coated lenses were subjected to two weeks of continuous exposure to the Alcon Clear Care disinfecting solution. The disinfecting process had no effect on the contact angle of the coated lens.

**Safety:** HydroPhil-CL coated lenses have undergone toxicology and biocompatibility testing. The specific results of the tests are not owned by Lotus Leaf Coatings. However, the results were consistent with our initial belief that there would be no issues with toxicology or biocompatibility due to the materials and processing method.

**Stability:** Contact lenses coated with HydroPhil-CL can and have been autoclaved. The processing conditions for autoclaving are unique to HydroPhil-CL

### **Conclusion**

The Company's HydroPhil-CL coating offers a unique, cost effective solution to the most pressing issue related to silicone hydrogel contact lens wear comfort. The coating, less than 100 nm thick, does not change the optical properties of the base lens, and can be integrated into production without redesign of the lens. In addition, the coating can be optimized for different surface materials to provide maximum wettability for contact lens wearers.