



Tensile Tests of SynergEyes Hybrid Duette Contact Lens to Assess Junction of RGP and SiHy

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Purpose

SynergEyes hybrid contact lenses are comprised of a high-Dk rigid gas permeable (RGP) center surrounded with a silicone hydrogel (SiHy) skirt. The junction between RGP and SiHy skirt is treated with HyperBond®, a proprietary treatment, and intricately designed to prevent separation resulting from the lens wearer's daily pinching during lens removal. The purpose of the study was to evaluate the bond strength at the junction of SynergEyes Duette hybrid contact lens by measuring its tensile strength. Tensile strength indicates how strong the material is when pulled or stretched.

Methods

Twenty-one (21) samples of SynergEyes Duette lens design were used in the experiment. The tensile strength of each lens was measured with Instron 3342. The samples were fabricated to mimic a traditional dog-bone tensile sample, with the thinnest area of 200µm at the junction of RGP and SiHy. The samples were designed according to the ASTM D882¹. The length of the tensile samples was 20mm. Samples were fully hydrated and tested at room temperature and humidity. The Instron was set at crosshead speed of 10mm/minute. The samples were clamped between two opposing grips. A load (N) was applied to the sample as the grips elongated until failure occurred. Testing stopped when the applied load has dropped 40%. Maximum applied load (N) and elongation (mm) were recorded.

The tensile strength equates to the tensile stress (σ) at maximum applied load (F) to the cross-sectional area (A) of the sample. The elongation ((d) divided by the original length ((L₀) of the sample yields the strain. Strain (ϵ) is the amount of stretch or deformation of the given sample².

$$\sigma = \frac{F}{A} \quad \epsilon = \frac{\delta}{L_0}$$

Results

The average maximum load used to stretch the lenses was 8.5 Newtons (N); the highest maximum load was 10.2 N and the lowest maximum load was 5.8 N. The average tensile strain of the lenses at maximum load was 73.9%; the highest tensile strain at maximum load was 78.9% and the lowest tensile strain at maximum load was 53.2%. The average tensile strength of the lenses was 0.95MPa; the highest tensile strength was 1.13MPa and the lowest tensile strength was 0.64MPa. None (0%) of the samples had failure at the junction; 100% of samples had breakage within SiHy skirt. All (100%) of the samples displayed deformation beyond recovering before failure occurred.

Average Max Load (N)	Average Tensile Strength (σ)	Average Strain (ϵ)	Average Elongation (d)
8.5	0.95 MPa	73.9%	26.73 mm

Results (cont.)

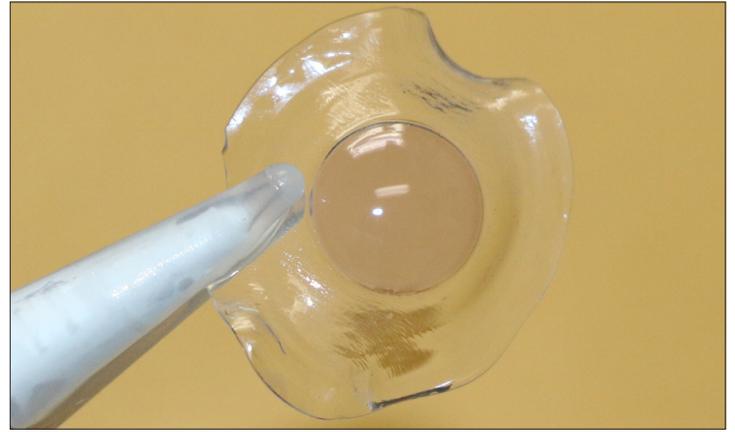


Img 1: SynergEyes hybrid Duette Lens designed to mimic a dog-bone sample for tensile tests. The sample is clamped between two opposing grips. Load is applied as the grips extend the sample until failure.

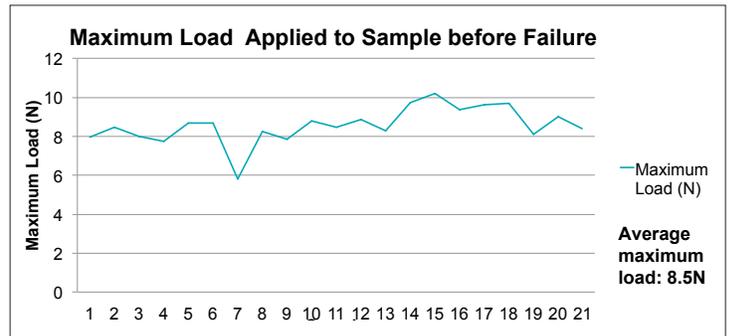


Intact Junction
Breakage occurred within the SiHy skirt

Img 2: Failure occurred at maximum load of 10.22N. The breakage occurred within the SiHy skirt. The junction of RGP and SiHy is intact.



Img 3: Lens was stretched beyond its point of recovery. The junction was still intact with no evidence of separation between RGP and SiHy at any point.



Conclusion

The strength of a material is measured by the level of stress it could withstand before point of breakage. The results from the study show the HyperBond treated junction of SynergEyes Duette hybrid contact lens does not separate. Studies by Shinohara et al. suggest the combined maximal force production of four fingers average to be $5.0N^3$. The tensile tests calculated with the Instron demonstrated 95% of the tested lens samples could withstand at least 7.5N before breakage. Also, results from laboratory tests conducted by Ocular Dynamics shown approximately 0.9N (0.2lbs) of force correlates strongly to the force applied by finger when cleaning contact lenses⁴. The tensile tests of the lens samples indicated they could withstand approximately 8.5 times the force applied by finger during cleaning before breakage.

The lenses were stretched beyond their point of recovery before breakage occurred (Img 3). The average maximum load for 21 samples was 8.5N. The point of breakage for 100% of the tested lenses occurred within the SiHy skirt. None (0%) of the tested lens separated at the junction. The occurrence of breakage within the SiHy skirt and not at the junction is indicative that the HyperBond strength at the junction of RGP and SiHy is higher than tensile strength of the SiHy skirt.

References:

1. ASTM Standard D882, "Standard Method for Tensile Properties of Thin Plastic Sheeting".
2. "Tensile Properties" <https://www.ndeed.org/EducationResources/CommunityCollege/Materials/Mechanical/Tensile.htm>
3. Shinohara, Minoru, Scholz, John P., Zatsiorsky, Vladimir M., Latash, Mark L., "Finger Interaction During Accurate Multi-Finger Force Production Tasks in Young and Elderly Persons". *Experimental Brain Research*. Vol.156 (3); pp282-292.
4. Laboratory data from: rub tests conducted by Ocular Dynamics

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