

A Novel Method for Measuring Contact Lens Tensile Properties

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Introduction

- ❑ Silicone hydrogel (SH) contact lens (CL) materials are known to have different mechanical properties than traditional hydrogels.
- ❑ However, the mechanical properties of CL are difficult to measure because an essential feature of the lenses is that they vary in thickness due to both power and design.
- ❑ Although engineering methods might be used to account for these variations and for localized effects associated with specimen attachment, data quality is typically limited.
- ❑ A new tensile test apparatus with associated motion tracking and analysis software makes it possible to collect, analyze and validate data from which CL mechanical properties can be determined.

Purpose

- ❑ To examine the utility of a new tensile test apparatus to determine the mechanical properties of SH CL materials.

Methods

- ❑ Thickness profiles of -8.00D, -3.25D and +4.00D SH and conventional CL (Table 1) were obtained using a custom-modified electronic gauge (Rehder Corp).
- ❑ Five by 14 mm diametrical specimens were cut and mounted in a CellScale BioTester 5000 (www.cell-scale.com).
- ❑ Specimens were attached along their short edges using a BioRake attachment system, consisting of 5 electrochemically sharpened tungsten tines (Figure 1).
- ❑ Powdered graphite was sprinkled on the specimens to facilitate digital tracking in the collected images.
- ❑ A virtual rectangular grid consisting of 11 by 10 points was superimposed on the initial image of each specimen and the point motions were tracked through the full image set. These data were used to construct a strain field map and – together with thickness data, force data and continuum mechanics equations – allowed stress-strain curves to be computed in each region of the specimen.
- ❑ Specimens were stretched at a rate of 1%/s to a nominal strain of 20% in physiological medium.



Figure 1: Sample mounted

Results

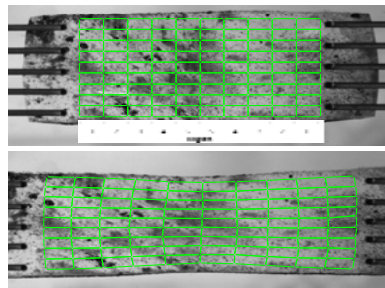


Figure 2: Top image shows the initial grid prior to the stretching taking place and the lower image shows the specimen during the stretching process at 20% nominal strain (-8.00D OASYS).

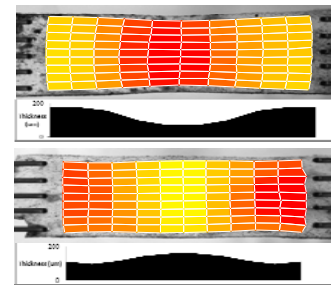


Figure 3: Top image shows a -8D OASYS and the lower image shows a +4D OASYS during the stretching process. The black and white profiles show the associated specimen thicknesses as determined by the electronic gauge.

- ❑ Fig 2 show a -8.00D specimen with the overlaid tracked grid before and after it was elongated to 20% nominal strain. Fig 3 shows the regional strains that were calculated using the tracked points for a -8.00D and +4.00D specimen. Applied loads were divided by specimen width and by regional thicknesses to obtain regional stresses.
- ❑ When stress-strain data for each of the regions were plotted on a single graph (Fig. 4), the curves laid one on top of the other, indicating a high degree of uniformity of the mechanical properties within the specimens and confirming the validity of the protocols.
- ❑ High uniformity was found from multiple specimens of a given material with little dependence on lens power, but significant property differences were found between senofilcon A, etafilcon A, and lotrafilcon A (Table 1 and Fig 5).
- ❑ The stiffness values of the materials seemed to vary inversely with temperature, but further tests are required to determine if the difference is statistically significant.

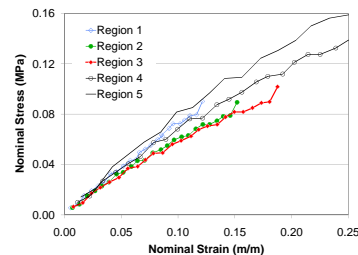


Figure 4: Stress-strain curves for Figure 2. The regions on the graph relate to the top image in Figure 2 (with the scale bar on the bottom). The middle 2 columns of grid squares are Region 5 and so on until the outermost columns of grid squares are Region 1.

Lens	Prescription	Temperature (°C)	Modulus (MPa)
Acuvue OASYS (senofilcon A)	-8.00D	23	0.556
	+4.00D	23	0.526
	-3.25D	23	0.595
	-3.25D	37	0.493
Acuvue2 (etafilcon A)	-8.00D	23	0.392
	+4.00D	23	0.352
	-3.25D	23	0.384
	-3.25D	37	0.360
CIBA Vision Night & Day (lotrafilcon A)	-8.00D	23	1.727
	+4.00D	23	1.892

Table 1: Lenses Examined

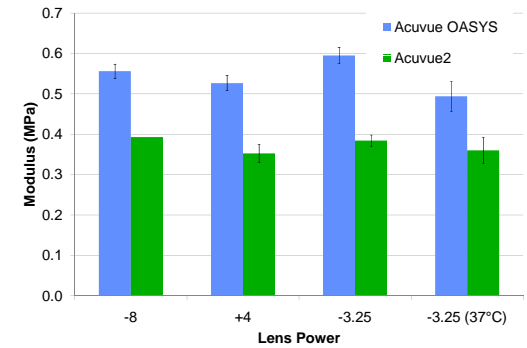


Figure 5: Modulus values for Acuvue OASYS and Acuvue 2 at various back vertex powers. The modulus for the -3.25D lens was repeated at both room temperature and body temperature and the modulus values are seen to reduce, particularly for the OASYS material. Error bars represent the standard deviation of 3 tests, except for -8.00D Acuvue2, which was only performed once.

Discussion

- ❑ The perpetually high degree of consistency from one region to another within a single lens demonstrated uniformity of the mechanical properties within the specimen and the validity of the test protocols.
- ❑ The technique presented here overcomes two primary obstacles to accurate measurement of CL mechanical properties; namely, specimen attachment and dealing with thickness changes across the lens.
- ❑ The tests showed that material property variations were small within individual lenses of the types measured, but that substantial property variations can occur between lenses made from different materials.

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