Title of project*: Surface micro- and nano-mechanics of hydrogel polymers used in contact lenses: Adhesion, friction, modulus and viscoelasticity during dehydration.*

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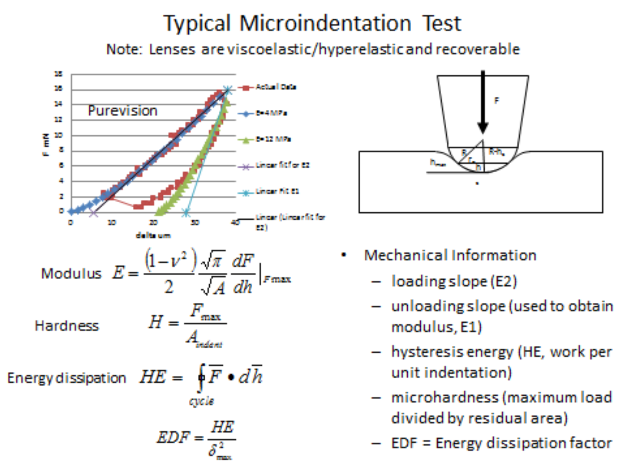
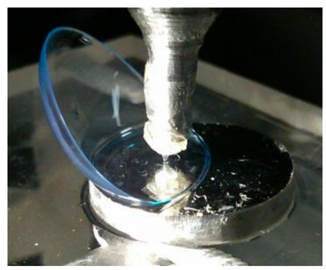
Project description: The hydrogel-based polymers used in contact lens applications are a complex mix of multiple different monomers. These silicone and vinyl based hydrogels can have between 40 and 80% water in the fully saturated state. Contact lenses are required to meet a significant set of complex conditions for appropriate long-term performance including good oxygen permeability, stable hydration, some adhesion to the substrate cornea and low friction interaction between the eyelid tissue and the anterior lens surface. Additionally, lens solutions, which are themselves a complex mix of water, boric acid, hyaluronic acid and other constituents including surfactants, may be taken up by the lens and affect performance. To date, the contact lens community does not have suitable surface micromechanical testing methods available to measure local surface mechanics.





The primary goal of this project is to develop new testing methods to directly assess surface micromechanics and nanomechanics of contact lenses. The surface mechanics involved include indentation testing to obtain modulus, hardness and viscoelastic characteristics. These tests, using micron-scale indenters, are highly capable of local property measurement, profiling of properties across lens surfaces, and tracking changes in surface mechanics with hydration state. This project will also develop indentation-based methods to measure frictional interactions and adhesive interactions of the lens surface with an indenter.

This work will be primarily experimental and developmental. The methods to be developed are new for hydrogel lenses. The project will involve test method development, interfacing data acquisition and control software with micromechanical devices (sensors, actuators, etc.) and development of modeling techniques that bring concepts of viscoelasticity to the understanding of surface micromechanical behavior. Additional structural and mechanical characterization methods will be required including scanning electron microscopy, atomic force microscope, dynamic mechanical analysis, and other methods as appropriate.

The structure and properties of the surface of these complex polymer systems in the partially hydrated and continuously changing conditions of the eye are poorly understood. Tear composition varies widely amongst the population with varying amounts of proteins and lipids that may alter surface behaviors. Additionally, the amount of adhesion and the micromechanical properties exhibited by hydrogels, are highly dependent on hydration state and time of contact with the opposing surface. Another element of behavior includes the variation in the polymer structure and properties with location about the surface of the lens and through its cross section. This work will seek to address many of these issues by studying lenses under controlled hydration states and exposed to known environmental conditions.