Nanomechanical and Nanotribological Properties of Contact Lenses – Effect of Hydration and Temperature

Michelle E. Dickinson
Hysitron Inc. Minneapolis, USA

Statement of Purpose:

The nanomechanical and nanotribological properties of contact lenses are known to affect both the comfort level and durability of the lens. These properties are therefore of major importance when designing new lenses as there is a correlation between the level of comfort felt and the coefficient of friction of an individual lens.

Contact lenses and many other biomaterials are known to have varying mechanical properties depending on environmental testing conditions such as temperature and hydration.

Contact lenses are designed to have a high water content to aid oxygen permeability and thus testing of these samples should be carried out with the lens hydrated to the level that it would be on the eye. Even a small amount of dehydration within the sample can cause a change in mechanical properties of the lens material.

Temperature is well known to have an effect on the properties of soft polymers including contact lenses and care must be taken to ensure test conditions are accurately controlled to mimic those in vivo.

Sample mounting is also an important consideration, as cutting or stretching the lens to fit a flat sample holder can create residual stresses resulting in an unrealistic material response upon testing. By using a spherical substrate, mimicking the size and shape of a human eyeball, the lens can be tested without creating any additional stresses within the polymer.

The testing of soft polymer based materials in fluid and elevated temperature is not trivial, and considerations such as tip shape and size, drift correction time, time dependence effects, adhesion and pull off force need to be determined to create an accurate test procedure.

Methods:

Commercial contact lenses were obtained and kept hydrated in the provided solution until needed. Each lens to be tested was mounted on a spherical glass ball, mimicking that of a human eye in dimensions and the base of each lens attached to a pre-wet wicking cloth to promote lens hydration. The samples were placed in a TriboIndenter (Hysitron, MN) and sealed in the sample chamber. Humidity and temperature were controlled with room temperature and humidity being the lowest conditions, and 37°C and 85% RH being the highest conditions. The contact lenses were subject to nanoindentation to obtain reduced elastic modulus values and nanoscratch for coefficient of friction results. Care was taken to test the same area of each lens to eliminate variations in residual stresses within the lens structure.

Results / Discussion:

Lenses tested at room temperature and 85% RH using nanoindentation, were found to have a reduced modulus of 1000 kPa which was much lower than the 1600 kPa of the same lenses tested at 37°C and 85% RH.

The coefficient of friction measured using nanoscratch was found to decrease with an increased hydration level.

Conclusions:

This investigation used nanoindentation to test the nanomechanical and nanotribological properties of commercial contact lenses at different temperatures and hydration levels to emphasize the importance of accurate and realistic environmental control before data collection. There was found to be a significant increase in reduced elastic modulus with increasing temperature, and an increase in friction coefficient with decreasing hydration level. By understanding how relatively small fluctuations in these conditions can create large changes in the measured mechanical properties, and defining tip selection and load functions, more accurate test protocols can be determined for the nanoscale testing of biomaterials. This will allow a better prediction of comfort and durability of contact lens materials before the final product is actually made.