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Analyzing the Wettability of Ophthalmic Materials

Contact lenses are worn by millions of people worldwide and many more have been implanted with intraoccular lenses (IOL's **)** to replace the natural lens in the eye after afflictions with glaucoma or other sight impairment diseases. The degree of wettability or hydrophilicity of the polymeric materials used to make these devices is an important issue that contributes to the functionality of the product. Issues such as comfort, protein deposition, lipid and bacterial adsorption, oxygen permeability, and ease of use determine the ultimate success of the product and must be carefully considered when engineering a new device. Given the proper choice of a polymeric lens material that meets the criteria for strength and durability, the surface properties of these materials can make the difference between success and failure in the marketplace. To characterize these materials, wettability analysis by the Dynamic Contact Angle (DCA) technique is now an established tool widely used throughout the industry.

When characterizing the wettability of these materials, there are a number of parameters that can be explored in addition to the overall wettability or hydrophilicity of the lens. For example, the cleanliness of a lens material can be explored using contact angle hysteresis (defined as the difference between advancing and receding contact angles) and an important indicator of surface homogeneity. If the surface is uniformly clean and homogenous, for example, the hysteresis profile will typically show less hysteresis than a comparable but heterogenous surface.

The total surface energy and polarity of a lens material can also be determined by measuring the dynamic contact angle with two or more liquids of known surface tension and polarity. If the surface of the lens has been modified with a hydrophilic coating or oxidized with an oxygen plasma, for example, the resulting "percent polarity" of the surface will be increased, making the surface more wettable than the virgin polymer. Knowledge of the surface polarity can also be helpful in predicting the adhesion of certain proteins to the surface of the lens and in engineering the surface to minimize the adhesion of various proteins, bacteria, lipids and minerals to the lens material.

Perhaps the most interesting aspect of polymeric materials used for ophthalmic devices is the reorientation phenomenon that is observed as mobile surface groups are free to orient their polar and apolar constituents at the polymer/water or polymer/air interface to minimize free energy. At the polymer/air interface, for example, the thermodynamic driving force is to minimize the free energy by orienting the hydrophilic groups away from the air phase, exposing the hydrophobic groups to the air environment.

When the surface of the lens is covered by an aqueous phase (i.e. water), however, the surface groups can reorient to expose the hydrophilic groups and bury the hydrophobic groups into the less polar environment of the bulk polymer. In using the DCA to characterize this phenomenon, it is possible to capture the dynamics of the reorientation by programming the instrument to cycle repeatedly between advancing and receding angles.

Another aspect of the manufacturing process with some lens materials that can have an impact on the surface wettability of the final product is the interaction or contact between the polymer and the mold used to shape the lens or lens blank. By characterizing the surface of the mold and the lens product, it is possible to learn how to control the transfer process and thus influence the wetting properties of the lens after mold release.

While it is possible with a mathematical model to correct for the shape of an actual contact lens or IOL in a DCA experiment, working with standard rectangular samples with constant perimeters is recommended for easily interpretable quantitative results. When running DCA experiments with a lens blank or an actual lens sample, the geometrical irregularities must be factored out mathematically if quantitative wetting angles or surface energies are sought. However, when comparing differences between lens samples of identical geometry, overlays of the wetting curves can be illustrative enough without need for mathematical corrections.

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