Gas plasma treatment adds patient comfort to contact lenses

By Dr. Demetri Chrysostomou, Director of Technology, PVA TePla America, Inc.

Three important factors determining the wear comfort of contact lenses are:

a. Rigidity
b. Oxygen permeability
c. Wettability

Since the recent advent of silicone hydrogels, contact lenses can now be fabricated from a soft material with extremely high oxygen permeability. Unfortunately, hydrogels are also inherently "hydrophobic", meaning they have poor wettability characteristics that can cause discomfort during lens wear. To overcome this problem, the lenses are surface modified by plasma treatment, rendering them wettable to tear fluid and maximizing lens wear comfort.

What is plasma?

Plasma is a state of matter just as a solid, liquid or gas. Add enough energy to a gas and it becomes ionized into the plasma state. Chemically it is a highly reactive environment that is used to change the properties of surfaces without affecting the bulk material. Gas plasma processing is a powerful tool in solving surface preparation problems. It provides a reliable, consistent, and environmentally friendly method of increasing surface wettability, an essential characteristic in contact lens wear comfort and biocompatibility.

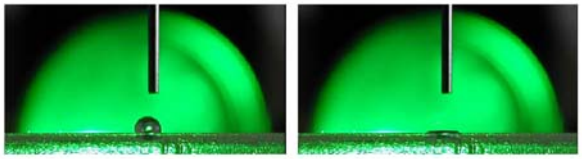
How does plasma surface treat the lens?

Increasing wettability of silicone hydrogel:

The surface characteristics of silicone hydrogel are altered by plasma treatment to render it wettable, or hydrophilic. This can be achieved by plasma oxidation of the silicone hydrogel to form thin silicate islands across the surface that remain intact when the hydrogel is hydrated (causing it to swell by 10 – 20% by volume) and autoclaved. Another method involves first plasma activating the lens material, followed by a plasma induced polymerization process of an organic species, which is then oxidized on the surface of the contact lens by an additional plasma step. Since polymerization requires covalent bonding to the polymer backbone of the substrate, the plasma induced coating adheres so well it is not removed from the surface by hydration and autoclaving, or through normal wear and handling, such as digital rubbing.

Improving contact lens biocompatability:

Tear fluid carries lipids and proteins which can deposit on the surface of the lens. The accumulated deposition of these materials can result in biocompatibility issues. In addition to improving patient wear comfort, the hydrophilic plasma treatment of hydrogel contact lenses also reduces their affinity for lipids.



Water contact angle before and after plasma treatment

Hydrophilic treatment of fluorinated, extended-continuous-wear contact lenses:

Fluorinated polymers, be they hydrogels or non-hydrogels, have been recognized as having very high oxygen permeability characteristics (denoted in the industry by their Dk value). As such they are particularly useful for extended continuous wear contact lenses as well as relatively thick lenses. Similar to traditional contact lens materials, fluoropolymers are inherently very hydrophobic. Plasma oxidation of these surfaces can result in weak boundary conditions that can result in delamination of the hydrophilized layer. Plasma solves this problem by inducing surface defluorination as a preliminary step to hydrophilization.

Hybrid lens manufacture:

In multilayered hybrid lenses, plasma can be used to ablate the surface layer to expose an underlying layer. Here, the application of plasma has replaced difficult, time consuming and costly wet chemical methods.

How do PVA TePla America validate their processes?

Contact angle measurements are used extensively as a measure of surface wettability. Untreated polymer surfaces are low in energy, and water

droplets applied to these surfaces bead-up with high contact angles. This is because the cohesive forces of the water are stronger than the adhesive forces of the surface. On plasma treated surfaces, water contact angles are very low, due to energy that has been added to the surface in the form of polar chemical groups. This energy is used to bind to the water molecules. These are hydrophilic, or wettable surfaces.

X-ray photoelectron spectroscopy (XPS) and surface derivatization techniques are used to quantify the percentage of the surface that has been treated with the desired coating and functionality. For example, when defluorinating materials to improve hydrophilicity, the extent of defluorination at the surface can be directly measured using XPS.

ESCA surface analysis tool

What does PVA TePla America offer?
At PVA TePla America we offer a full line of vacuum and atmospheric gas plasma systems. Our reliable, easy-to-operate products deliver some of the most advanced and innovative solutions for a wide variety of industrial applications.

Additionally, we offer free proof of processing as an incentive to evaluate our plasma technology. We also offer clean area contract processing services with ISO 9001:2008 certification.
This allows you to access gas plasma technology without up front capital expenditure on labor and/or facilities.

PVA TePla America Inc. Headquarters

251 Corporate Terrace
Corona, CA 92879-6000

www.pvateplaamerica.com

business: 951.371.2500
sales: 800.527.5667
fax: 951.371.9792

Certified System ™
ISO 9001
QMI-SAI Global