

Protein sorption on soft contact lenses: a comparison between materials and superficial characteristics

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Introduction

The deposition on contact lenses of substances derived from the tear film is a well known clinical complication, resulting in reductions in comfort, vision, and increased inflammatory responses.

Above all, in the last years, numerous studies have been done on the adhesion of proteic deposits on soft contact lenses. This because the accumulation of lachrymal components, until today, remains a problem not totally solved that may lead to intolerance of the wearer and hence to a consequent drop-out

This study is aimed at observing and quantifying tear protein deposits in hydrogel and silicone-hydrogel lenses as a function of time of use, tear characteristics and material properties (ionic charge and surface roughness). In the end, we compared the results with the degree of comfort declared by participants.

Methods

The study has been carried out on contact lenses used by real patients with different lachrymal characteristics. 32 patients, 16 men and 16 women, with a average age of 24,39 (SD 4,39, range 20-38).

In the preliminary phase all the participants have been widely informed on the modality of use (daily time of use, use of artificial tears, etc.) both in words and by means of a general and specific daily questionnaire indicating conformity and complaints. For the sake of impartiality, the choice of the proper contact lens for the different participants was done at random and performed by a person not directly involved in the analysis of the results, provided the lens parameters were compatible with corneal geometry (within the manufacturing limits) and assigning hydrogel materials for the right eye and silicone-hydrogel for the left one.

The contact lenses we use in this study, all commercial, are made with hydrogel materials (Methafilcon A, Alphafilcon A, Vifilcon A, Omafilcon A) and silicone hydrogel (Lotrafilcon B, Lotrafilcon A, Galyfilcon A, Balafilcon A). The patients are given three pairs of lenses: the first to wear for 4 hours, the second pair for 24 hours continuously night and day, and the last pair for a period of three weeks only in daily use.

During the three weeks, the participants used a care solution of isotonic saline, thymerosal (0,001%) , and clorexidine (0,005%) with bactericide effects without affecting the protein deposition.

The surface analysis of the different materials was conducted by atomic force microscopy (AFM) both for dry and hydrated state.

The surfaces have been monitored in tapping mode where the cantilever oscillates with a proper resonance frequency and after each oscillation touches the surface. In this case, the information on the topography is given by the variation of the oscillation amplitude with respect to the surface. The contact force is very low, about 10^{-9} N. By this technique, the roughness of the surface is deduced. Moreover, the tendency towards dehydration has been studied for the different types of lenses.

The quantitative analysis of protein deposits on the different materials has been mainly performed by spectroscopy in the UV-Vis region with transmittance and photoluminescence measurements. In particular, the typical absorption bands of the aromatic rings of aminoacid residues at 280 nm and the emission band centered at 330 nm have been monitored. Absorbance measurements were performed at normal incidence and at room temperature, with resolution down to 2 nm, using a Perkin-Elmer Lambda 900 spectrometer with a spot light about 50 mm² in size. The methods provide quantitative measurements and can be analyzed for comparative purposes.

Photoluminescence emission (PL) measurements were performed with a home-made apparatus equipped with a nitrogen cooled charge-coupled-device detector and a Xe lamp as excitation source. The spectral resolution was better than 1nm and the spectra were correct for the instrument spectral response.

Results

The photoluminescence and spectroscopy results show a particular adsorption band (centered at 280nm. Fig. 2) and of emission (centered at 330nm fig.1) relevant to aromatic rings of residuo amminoacidici such band is more pronounced in some materials then in others, thus indicating a different proteic adsorptions. This band increases in intensity as a function of the time of use. In the photoluminescence results a slight shift has been observed in the position of the maximum of emission towards lower wavelength, which indicates a possible change in the polarity depending on deposit denaturation.

AFM analysis shows that the roughness of the surface depends on the method of construction of the lenses. The entire analysis shows an increase of roughness when the lenses are measured in dry status, except the Galyfilcon A. An homogeneous layer distribution has been observed already after 24 hours of continuous wear in ionic material. For the lenses in Alphafilcon A was not possible to do many measurements, because after only 5 min. the lens (due to the heat produced by the laser of the tool) showed a pronounced deformation because of dehydration (the only non ionic material among hydrogels)

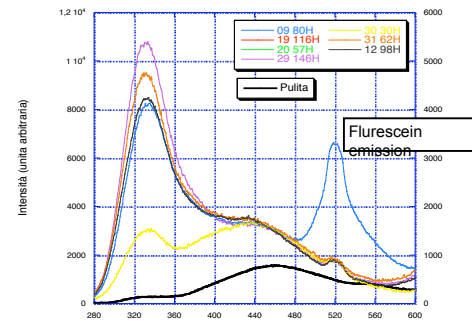


Fig. 1 Photo Luminescence Analysis Lunghezza d'onda (nm)

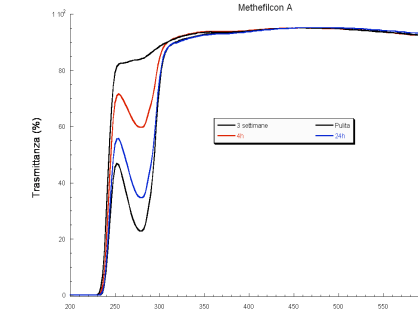


Fig. 2 Spectroscopy Analysis Lunghezza d'onda (nm)

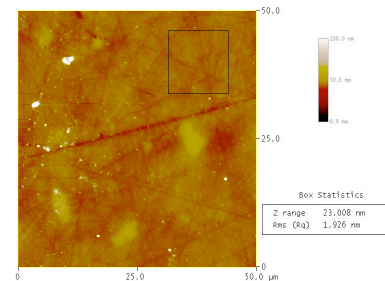


Fig. 3 Roughness Analysis with AFM

Discussion and Conclusion

In general, protein deposition is predominantly controlled by the ionic charge of the lens material, as deduced from few investigations reported in literature. Furthermore, ionic material containing more than 50% water (IV FDA group) show higher protein adsorption. Besides the ionicity there was evidence that all those lenses, able to adsorb the lowest protein quantity are made of PVP which however makes them similar to lipid deposits.

The amount of deposits increases with the hours of wear, mainly between 4 and 24 hours for hydrogel materials. On the contrary, silicone-hydrogel lenses have a reduced affinity with proteins and, in some cases, no differences have been detected between those used for 4 hours and 3 weeks.

Protein sorption is not dependent on superficial characteristics. Greater roughness doesn't give a greater discomfort, in particular the general trend is a greater discomfort in the left eye especially in the first hours of wear as a consequence of the higher stiff modulus of the silicone-hydrogen contact lenses with respect to the hydrogel ones. By the slit lamp observation during the lens wear, after three weeks the left eye showed lower limbal redness probably due to high values of oxygen transmissibility (Dk/t) of the silicone-hydrogel lenses.

The comfort expressed by the participants at the end of 4hrs wear is lower for those lenses which have accumulated more proteic deposits. This co-relation occurs for all tipe of material which showed a band at 280nm, but it disappears within 24hrs and within 3 weeks. That could mean the ocular system adapts to the situation by diminishing the personal sensibility or alternatively one could assume that after a certain time of wear (hours) the deposit becomes regular on the surface thus creating less friction and reducing the sensation of annoyance

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