Ultra Violet Radiation Regulates Wettability Property of Prosthetic PMMA.

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***Abstract* – Prosthetic poly (methyl methacrylate) is widely used for medical applications like lenses and eye prostheses. For prosthetic products biocompatibility is essential, different methods have been developed to control it by controlling surface wettability property. This article is targeted to describe a possible simple solution how to influence alterations of PMMA wettability by non-ionizing UV radiation in range of 200-400nm. Processed material was examined by means of detecting contact angle, electron work function and absorption spectra to find correlation between wettability and other surface properties. Results show non-linear tendency of surface wetting alteration and peculiarities in electron work function and absorption spectras. UV radiation could be used to functionalize PMMA surface by not influencing its structure with UV exposures under 60 minutes.**

***Index Terms* – Poly(methyl methacrylate), wettability, UV radiation, surface properties, electron work function**

I. INTRODUCTION

Poly (methyl methacrylate) is a widely used material in various fields. Because of its good biocompatibility, PMMA is used for prosthetic applications, the ways to enhance surface properties of PMMA are being searched. Basically surface properties are the ones that influence interaction between polymer and environment and the ones to be modified [1]. Surface wettability is of high importance in oral prosthetics [2], eye lenses [3], etc.

Wettability depends on material's surface energy that, in turn, could be influenced by the electrical charge, deposited on to the surface. Evaluating material's electron work function, connected with surface charge and surface potential, may show regularity between the described above and might be used to control wettability.

Ultraviolet (UV) radiation has already been used for surface charge modification [4-5], though more unsophisticated method and insufficiently investigated wavelength range 200 – 400 nm to be employed is described in this article.

II. METHODS AND MATERIALS

The specimens were prepared in identical manner as eye prostheses.

After polymerization of commercial powder "Stoma" mechanical treatment was applied (slipping and polishing) to reach the specimens with diameter of ~1cm. The specimens were cleaned with 96% ethanol to remove foreign bodies.

After that irradiation process was implemented in room air (+ 20^0C +/-2^0C) by means of Hamamatsu Spot Light Source equipped with Hg-Xe lamp with intensity 3.5W/cm^2 at 365nm. Specimens were placed at 0,4 m distance to avoid overheating and ensure room temperature on the PMMA surface. Irradiation was amassed by different exposure sessions (15, 30 or 90 minutes of exposure was accumulated).

Wettability was tested before and after UV irradiation using Axisymmetric Drop Shape Analysis-Profile (ADSA-P) method. This method was adjusted to use in set with optical microscope MMI-2 and CCD camera (Imaging Source) to project drop to the PC. Optical microscope was used to define the drop of physiological solution (~10mm in diameter). Measurements were repeated 15 times, contact angle each time was applied in the Photoshop software (CS3). Before measurements each sample was cleaned with distilled water.

The hand-made spectrometer [6] ensured induction of photoelectron emission from the PMMA material to measure electron work function that is directly proportional to a surface charge.

To reveal possible reconstruction of the chemical couples optical absorption was measured in a range of 200 – 400nm with a step 0.5nm Helios photo spectrometer was used. The data of the spectra were collected with VISIONlite (Scan Version 2.1) software, after that digital data were imported to Excel for further processing. PMMA specimens before and directly after each irradiation session were measured.

To evaluate alterations of surface morphology and distribution of the charge/potential over the surface at the nano/micro scale, the specimens were scanned using Solver P-47 Pro atomic force microscope in semi – contact topography and Kelvin probe modes. The NSC01 platinum coated conducting tip was applied.

To characterize local electrical charges distance influence on the electrical potential the autocorrelation function of the several potential distributions realizations over the surface. When the autocorrelation function reached the zero value, the distance (correlation length) was assumed as the localized charge distance length.

III. RESULTS

UV influences contact angle (Fig.1). When the exposure increased until 60 min, the contact angle decreased. However, at the exposure > 60 min the angle increased.

At the same time the contact angle value positively correlated with an radiation induced increment of the electron work function (Fig. 2) that characterized the alteration for the surfaced charge density (higher value of the electron work function relates to the greater value of the negative charge) .

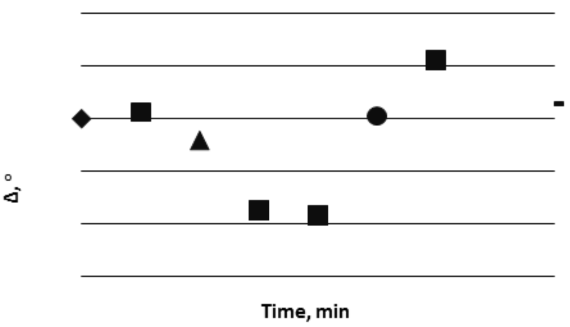

Fig.1. Contact angle increment dependence on UV exposure

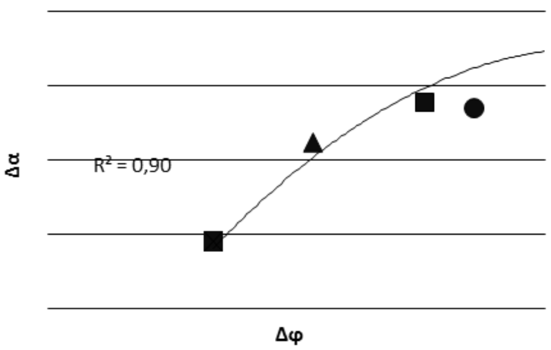

Fig.2.Correlation between angle and electron work function increment

The absorption spectra demonstrated a minimum at about 3.25eV or 380nm (Fig.3) when the UV exposure was <60 min. However at the exposure > 60 min the minimum disappeared. .

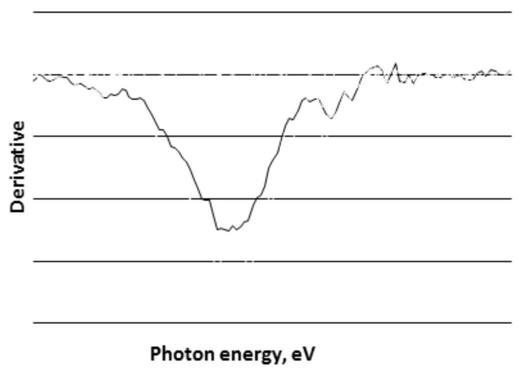

Fig. 3. Absorption data. Derivative dependence on photon energy value

The morphology of the surface was not influenced by radiation. However the surface electrical potential demonstrated connection with radiation exposure. The correlation length correlated with the contact angle influenced because of UV radiation (Fig.4).

DISCUSSION

Alteration of the contact angle influence by UV radiation can be stipulated because of radiation induced reconstruction of the PMMA surface layer or deposition of the electrical charge. The latter could be provided because of the emission of the electrons escaped from PMMA due to the UV photons. Unchangeable absorption spectra minimum at exposure > 60 min gives a possibility to assume that such exposures do not have an influence on the PMMA surface layer structural peculiarities. However, the alteration of the contact angle at exposure < 60 min evidences that the electrical charge factor contributes wettability. Absence of the absorption minimum at > 60 min signals that UV reconstructs the PMMA surface layer.

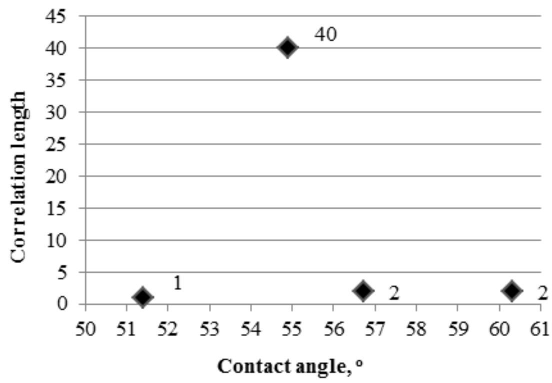

Fig.4. Correlation length depending on contact angle value

Perhaps both structural alterations and deposition of the electrical charge influences the correlation length.

IV. CONCLUSIONS

1. UV radiation supplied from the Hg-Xe lamp with intensity 3.5W/cm^2 at 365nm to the PMMA surface located at the distance 0.4 m from the UV source supplies the surface with both structural alteration and electrical charge, when the exposure was > 60 min. However, if the exposure < 60 min the structural alteration were not observed.
2. The deposited electrical charge is characterized with decreasing of the correlation length when the contact angle > 55 ^{o}.
3. The contact angle depends on UV exposure.
4. The UV radiation could be employed to functionalize PMMA wettability, the structure uninfluenced radiation mode being available at exposure < 60 min.
5.

REFERENCES

[1] Y.Wang, J.Robertson, W.Spillman et al., "Effects of the Chemical Structure and the Surface Properties of Polymeric Biomaterials on Their Biocompatibility", Pharmaceutical Research, Vol.21, p.1362, Aug.2004

[2] O.Etienne, C.Picart, C.Taddei et al., "Polyelectrolyte Multilayer Film Coating and Stability at the Surfaces of Oral Prosthesis Base Polymers: an in vitro and in vivo Study", J Dent Res, Vol.85, p.44, Sept.2005

[3] N.Lee, S.Moon, S.Kang et al., "The Effect of Wettability of Nickcl Mold Insert On the Surface Quality of Molded Micro lenses", Optical Review, vol.10, p.240, June 2003

[4] J.Deng, L.Wang, L.Liu et al., "Developments and new applications of UV-induced surface graft polymerizations", Progress in polymer science, Vol.34, p.156, Oct.2008

[5] X.Lu, Y.Jin, S.Tan et al., "A Simple Approach for Fabricating a Superhydrophobic Surface Based on Poly(Methyl Methacrylate)", J Adhes Sc Techn, Vol.22, p.1841, 2008

[6] RJ. Akmene, A.Balodis, Y. Dekhtyar et al., "Exoelectron emission specrometer complete set of surface local investigation", Phys Chem Mech Surface, Vol.8, p.125, 1993