

Wettability and bioproperties of PMMA used for eye prostheses in dependence on ultraviolet radiation

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Introduction. Poly-methyl metha acrylate material (PMMA) is widely used for eye prostheses. The tear liquid should moisten the PMMA eye prosthesis during its exploitation. This could be disturbed by sun ultraviolet radiation destroying molecular couples of the PMMA [1, 3, 4, 5]. Currently there are not experimental data on the soft Sun UV influence on PMMA surface wettability properties.

The latter could be influenced because of the PMMA chemical couples alteration [1, 3, 4, 5] and/or surface charging because of photo electron emission.

Methods and materials. The specimens were prepared from commercial material "Stoma" (*Ctoma*) and has the size of $\sim 1 \times 1$ cm², thickness about 2-4 mm. The polymerized PMMA was processed mechanically (slipping and polishing, the surface was smooth as possible like the mirror). Finally the specimens were washed in 96 % ethanol.

The UV irradiation was supplied from the Hamamatsu Spot Light Source equipped with Hg-Xe lamp (intensity at the source exit was 3500 mW/cm² at wavelength 365 nm). The light beam provided the spectrum similar to the Sun one. The specimens were placed at 0,4 m distance from the source exit, at the room air, the temperature $+20$ °C ± 2 °C and humidity 39 ± 7 mmHg. The temperature of the specimen's surface during radiation was not higher as in the room.

Modified Axisymmetric Drop Shape Analysis-Profile (ADSA-P) drop method was used to test wettability before and after the UV exposure. The physiological solution was used as the testing liquid. The contact angle of the drop with diameter ~ 10 mm was measured using the optical microscope MMI-2 (*MMII-2*). The image of the drop was projected via CCD camera (Imaging Source) to the PC screen. The contact angle was measured from images applying in the Photoshop software CS3 version. Before measurements each sample was cleaned with 96 % ethanol. The above described sequence was repeated 15 times for each sample to collect statistics.

The electron work function (ϕ) was measured to identify the surface charge alteration because of radiation. For this the pre-threshold photoelectron emission was induced from the specimens. The measurements were provided using the hand made spectrometer [7]. The photoelectron emission current was

detected in a range of the photon energy 4-6 eV. The duration (exposure) of each specimen the measurement was several times less in contrast to the above UV radiation.

To verify the UV influence biological properties of PMMA the yeast cells *sacharomyces cerevisiac 14* were deposited on the surface of the specimens for 4 days. Then the cells were washed out, dried and colored for optical microscopy (Olympus CX31 microscope). The dead cells were counted.

Results. UV radiation has a non monotonic influence on the wettability of the PMMA surface: the surface changed from hydrophobic to hydrophilic until 90 minutes of radiation and turned back to the hydrophobic, when the exposure increased to 160 minutes (Fig. 1). The surface relaxed during 2-2.5 months (Fig. 2).

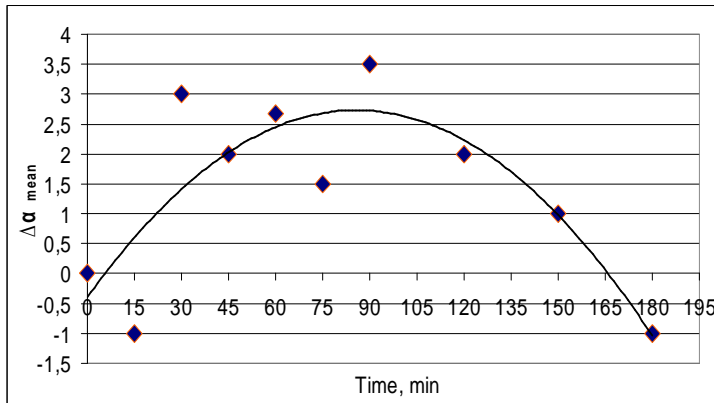


Fig.1. Contact angle (mean) increment after different irradiation exposures

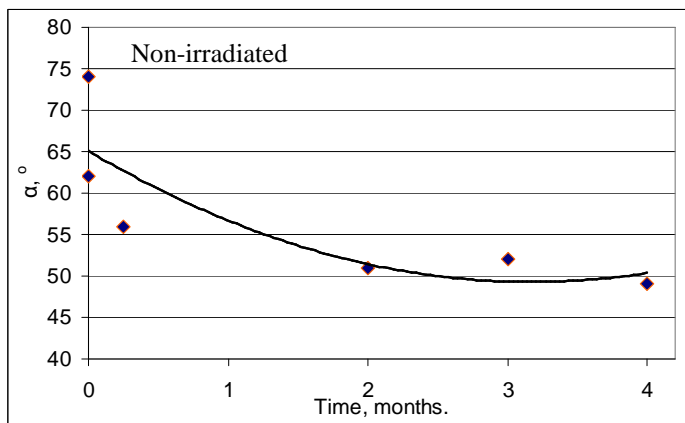


Fig. 2. Contact angle dependence on time. UV exposure 2 hours

The value of ϕ increased at the range of the exposure until 90 min (Fig. 3). This evidences that the surface acquired the negative charge.

The biological test demonstrated that yeast cell viability on the radiated surface falls down (Fig. 4).

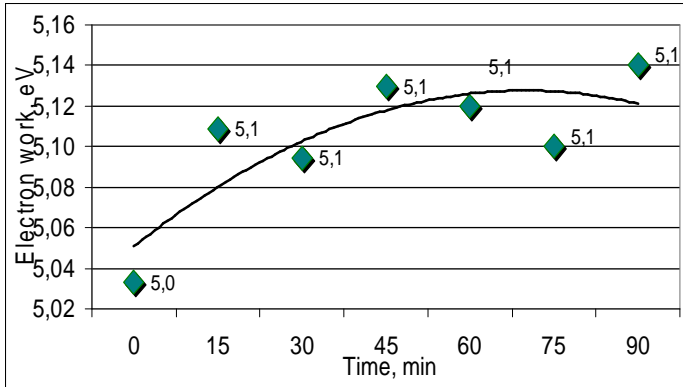


Fig.3. Electron work dependence on exposure time

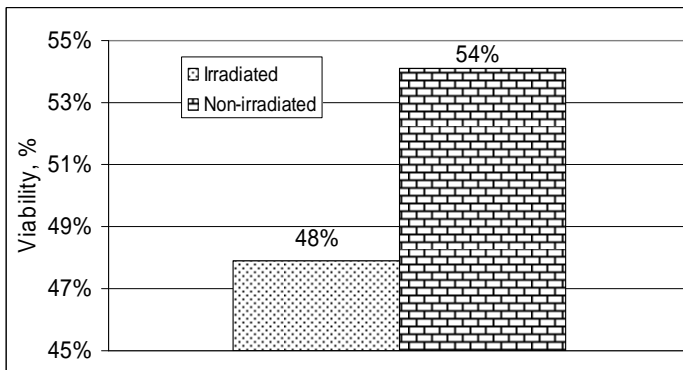


Fig.4. Yeast cell viability on PMMA surface (UV exposure 90 min)

Conclusion. UV radiation has an influence on PMMA wettability, surface electrical charge and biological properties. UV exposure to 90 minutes increased the contact angle with increment of 0 to 3.5 degrees, further increase of exposure to 180 minutes decreased the contact angle with increment till 4.5 degrees. Alongside the electron work function increased from 5.03 to 5.14 eV in the exposure range until 90 minutes. The viability of the yeast cells decreased on 6 % with contact angle increase from 49 to 53 degrees and electron work function increase from 5.03 to 5.14 eV.

References

1. Ratner B. D., Hoffman A. S., Schoen F. J., Lemons J. E. Biomaterial science. Academic press., New York, 484, (1996).
2. Dekhtyar Yu., Polyaka N., Sammons R. Electrically charged hydroxyapatite enhances immobilization and proliferation of osteoblasts // IFMBE proc. Springer , 20, 357-360, (2008).
3. Ranby J., Rabek JF. Photodegradation // Photo-oxidation and Photostabilization of Polymers. London: John Wiley, 156, (1975)
4. Caykara T., Guven O., UV degradation of poly(methyl methacrylate) and its vinyltriethoxysilane containing copolymers, Department of Chemistry, Faculty of Art and Science, Gazi University, Hacettepe University, Ankara, Turkey, 225-229, (1999).
5. Lican Lu, Nianfa Yang, Yuanli Cai, Well-controlled reversible addition-fragmentation chain transfer radical polymerisation under ultraviolet radiation at ambient temperature. College of Chemistry, Xiangtan University, Xiangtan, Hunan, China, 5287-5288, (2005).
6. Kaariainen T.O., Cameron D.C., Improving the adhesion of sputtered coatings on PMMA using ALD interlayers, Advanced Surface Technology Research laboratory, Lappeenranta University of Technology, Mikkeli, Finland, 23, (2009).
7. Akmene R. J., Balodis A. Dekhtyar J. D., Markelova G. N., Matvejev J. V., Polyaka N., Rozenfeld L. B., Sagalovich G. L., Samrnov J. S., Tolkaov A. A., Upmish A. I. Exoelectron emission spectrometer complete set of surface local investigation. Surface. Physics, mechanics, chemistry. N 8, 125.-128, (1993).

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The article describes influence of simulated ultraviolet sun radiation on the PMMA surface wettability, electrical charge and biological properties. UV exposure to 90 minutes increased the contact angle with increment of 0 to 3.5 degrees, further increase of exposure to 180 minutes decreased the contact angle with increment till 4.5 degrees. Alongside the electron work function increased from 5.03 to 5.14 eV in the exposure range until 90 minutes. The viability of the yeast cells decreased on 6 % with contact angle increase from 49 to 53 degrees and electron work function increase from 5.03 to 5.14 eV.