

PLASMA POLYMERS AND SOME BIOMEDICAL APPLICATIONS

H.Biederman

Dept of Macromolecular Physics, Charles University, Prague, Czech Republic.

INTRODUCTION: Plasma polymer films that have been extensively studied since the sixties of the last century have been mostly used for surface modification of solids or as functional thin films in microelectronics and optics. In recent ten years a growing interest has been in the applications in biomedical field [1]. In our laboratory an enhanced durable wettability of solids was studied by depositing a hydrocarbon plasma polymer film on a solid surface [2]. This study was inspired by the need of surface modification of hard contact lenses. In the other group of studies amine rich plasma polymer coatings were investigated for modification of CA (cellulose acetate) membranes and quartz crystals. The motivation was the application of a modified membrane for single-layer enzyme electrode and quartz crystal biosensors [3-5]. Plasma polymerization can be used as a convenient method for preparation of nanocomposite metal/plasma polymer films [6,7]. For example composite Ag/hydrocarbon plasma polymer films have antibacterial properties. The first results of these coatings function in contact with cells and microorganism are considered.

METHODS: The plasma polymerization process is usually carried out by means of the two types of reactors: 1) a tubular (silica or glass) type reactor with an external coil or ring electrodes for the excitation of rf discharge, 2) bell-jar type reactor with the internal parallel plate electrodes. In this case also dc or ac (up to 50 kHz) voltage can be used along the most frequently used rf (100 kHz –30 MHz). For some plasma polymerization processes microwave discharges have been favored usually in the multimode cavity mode.

RESULTS & DISCUSSION: Plasma polymerization of Ar/n-hexane/H₂O mixture and the incorporation of polar groups such as OH and C=O were studied in order to achieve a stable wettability of the coated surface [2]. In the second direction amine rich coatings were deposited on CA membranes in a tubular reactor using EDA (ethylene diamine) and n-BA (n-butylamine) [3]. After the membrane surface activation by glutaraldehyde the covalent binding of the enzyme can be achieved. FTIR-ATR, XPS, contact angle, and enzyme immobilization activity (enzyme immobilization method using radiolabeled glucose oxidase [^{99m}Tc-GOD]) were used to characterize modified AC surfaces. The best modification results were

obtained with EDA at a working gas pressure 27 Pa and deposition conditions - power and deposition period: 5W and 30 min and 15 W and 10 min, respectively [3]. In the following studies EDA and DACH (diaminocyclohexane) monomers have been plasma polymerized in a CW (continuous wave) and pulse modes. It has been shown that the variation of the duty cycle does not produce a considerable effect on the retention of amine groups into the film while power and t_{on} play an important role [4,5]. In the next group of studies nanocomposite metal/plasma polymer films have been deposited using a dc unbalanced magnetron with a metallic target (Ag, Ni, and Mo) and operated in argon/n-hexane working gas mixture at 0.4 to 2 Pa. Ag, Ni, and Mo were incorporated into the hydrocarbon plasma polymer in the form of clusters (grains) in size of 1 nm to 100 nm [6,7]. These composite films have been also recently produced by rf co-sputtering from the two magnetrons equipped with polyethylene and e.g. Ag targets, respectively [8]. The behavior of cells (endothelial cells, line CPAE) and microorganism (E. Coli) in contact with this film surface are investigated.

CONCLUSIONS: Plasma polymer films may be used for the modification of surface energy and amine rich coatings for enzyme attachment. Composite metal/plasma polymer films can be considered for antibacterial coatings.

REFERENCES: ¹H. Biederman, D. Slavinska (2000) *Surf. and Coat. Technol.* **125**: 371-376. ²H. Biederman, P. Hlídaek, J. Zemek et al.(1995) *Vacuum* **46**: 1414-1418. ³H. Biederman, I.H.Boyaci, P.Bilkova, et al. (2001) *J. Appl. Polymer.Sci.* **81**: 1341-1352. ⁴A. Choukourov, H. Biederman, I. Kholodkov et al., (2003) accepted *J. Appl. Polymer Sci.*, ⁵A. Choukourov, H. Biederman, D. Slavinska et al. (2003) accepted *Surf. and Coat. Technol.* ⁶H. Biederman, P. Hlídaek, J. Pešička et al. (1996) *Vacuum* **47**: 1385-1389. ⁷H. Biederman, R. P. Howson, D. Slavinska et al. (1997) *Vacuum* **48**: 883 – 886. ⁸H. Biederman et al. In Proc. of ISPC 16, (ed. R. d'Agostino) Taormina, Italy, June 22-27,2003, paper No 346.

ACKNOWLEDGEMENTS: This work was supported by the projects OE 57 (EUREKA 2080), OC 527.10 (COST527) and by the Research Program BM MSM 113200002 from the Ministry of Education, Youth and Sports of the Czech Republic.