BACTERIOSTATIC LAYERS FORMED ON Ti-15Mo ALLOY SURFACE

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[ENGINEERING OF BIOMATERIALS 153 (2019) 23]

Introduction

The process of implantation as a process interfering with the human body requires protection against bacteria attack (for example against *Staphylococcus* group of bacteria) that may cause the septic bone infection [1]. Due to the increasing resistance of bacteria to antibiotics, there is a necessity of developing research on alternative antibacterial agents increases [2]. An example of such an agent may be zinc [3], which has not only good efficacy against Gram-positive and Gram-negative bacteria but it also has biological properties that are beneficial to the human body [4]. In order to incorporate zinc into implant material, the plasma electrolytic oxidation (PEO) can be used. During this process the bioactive, porous oxide layer is formed [5,6].

Materials and Methods

Ti-15Mo alloy surface was treated by plasma electrolytic oxidation process in three different baths. All three of them consisted of 0.1 M $Ca(H_2PO_2)_2$ but different additives were used: ZnO, $Zn_3(PO_4)_2$ or the mixture of $Zn_3(PO_4)_2$ and $Ca_3(PO_4)_2$. During the PEO process the applied voltage was 150-300 V and the current density was 150 mA/cm^2. Using a scanning electron microscope equipped with energy dispersive X-Ray spectroscopy (Phenom Pro-X) the surface morphology, roughness and chemical composition of the oxide coatings was determined. The chemical composition was also determined by the XPS technique. The surface wettability was determined using water contact angle measurements (DataPhysics, OCA 15EC, Germany). In order to investigate the antibacterial properties of zinc containing Ti-15Mo oxide layers, the bacteria adhesion test was carried out using bacteria strains: reference *Staphylococcus aureus* (ATCC 25923), clinical *Staphylococcus aureus* (MRSA 1030), reference *Staphylococcus epidermidis* (ATCC 700296) and clinical *Staphylococcus epidermidis* (15560).

Results and Discussion

FIG. 1 presents the 3D SEM image of Ti-15Mo alloy surface after PEO process in bath containing $Ca(H_2PO_2)_2$ and ZnO. The pores and increased surface roughness visible on the images are the effect of PEO treatment. EDX analysis showed that the highest Ca/Ti and Ca/P ratio was obtained for the Ti-15Mo alloy surface anodised in condition of applied voltage 300 V and this value of voltage was chosen as the most optimal for the following tests. The wettability of Ti-15Mo alloy surface was measured and it changed after PEO process. The water contact angles decreased for surfaces anodised in all three investigated baths resulting in increasing the wettability of materials. The XPS survey spectra confirmed the presence of calcium, zinc, titanium, phosphorous and oxygen in PEO layer. The bacteria adhesion tests showed that all three types of investigated surfaces indicate bacteriostatic effect against *S. aureus* (ATCC 25923, MRSA 1030) and *S. epidermidis* (ATCC 700296, 15560). The amount of adhered bacteria decreased 10-100 times comparing to the reference bacteria concentration (~$1\cdot10^6$ CFU/mL).

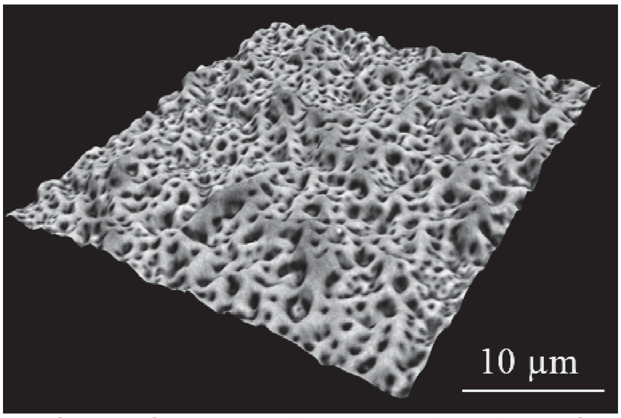

FIG. 1. 3D SEM image of Ti-15Mo surface after PEO (300 V, 150 mA/cm^2) treatment in 0.1 M $Ca(H_2PO_2)_2$ bath with an addition of 10 g/L ZnO.

Conclusions

Ti-15Mo alloy surface was modified by PEO in baths containing zinc compounds in order to obtain porous oxide layers with bioactive and bacteriostatic properties. As a result of PEO process, the roughness and wettability of Ti-15Mo surface increased. The presence of zinc in oxide layer was confirmed by the XPS technique. Obtained oxide layers with incorporated zinc indicated the bacteriostatic effect.

Acknowledgments

This work was supported by the Ministry of Science and Higher Education, number of project: 04/010/DG_18/0088.

References

[1] W.H. Song, H. S. Ryu, S.H. Hong. Journal of Biomedical Materials Research Part A, 246-254
[2] L. W. Kleiner, J. C. Wright, Y. Wang. Journal of Controlled Release, 181, 2014, 1-10
[3] H. Hu, W. Zhang, Y. Qiao, X. Jiang, X. Liu, C. Ding. Acta Biomaterialia, 8, 2012, 904-915
[4] K. Rokosz, T. Hryniewicz, K. Pietrzak, W. Malorny. Advances in Materials Science, 17, 2017, 41-54
[5] A. Krząkała, A. Kazek-Kęsik, W. Simka. RSC Adv., 3, 2013, 19725–19743
[6] P. K. Chu, J. Y. Chen, L. P. Wang, N. Huang. Mater. Sci. Eng. R, 36, 2002, 143-206