FORMATION OF BACTERIOSTATIC COATINGS OF Ti ALLOY IMPLANTS

ALICJA KAZEK-KĘSIK[1]*, JOANNA PŁONKA[1], KATARZYNA LEŚNIAK[1], MONIKA ŚMIGA-MATUSZOWICZ[2], MONIKA BRZYCHCZY-WŁOCH[3]

[1] DEPARTMENT OF INORGANIC CHEMISTRY, ANALYTICAL CHEMISTRY AND ELECTROCHEMISTRY, SILESIAN UNIVERSITY OF TECHNOLOGY, POLAND
[2] DEPARTMENT OF PHYSICAL CHEMISTRY AND TECHNOLOGY OF POLYMERS, SILESIAN UNIVERSITY OF TECHNOLOGY, POLAND
[3] DEPARTMENT OF MICROBIOLOGY, JAGIELLONIAN UNIVERSITY MEDICAL COLLEGE, POLAND
*E-MAIL: ALICJA.KAZEK-KESIK@POLSL.PL

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Introduction

Titanium is widely used as long-term material for implantation [1,2]. Titanium alloys such as Ti-6Al-7Nb, Ti-13Nb-13Zr or gum-metal type Ti-2Ta-3Zr-36Nb exhibit mechanical properties close to a natural part of bone. Multi phases titanium alloys also are able for surface treatment [3]. Plasma electrolytic oxidation process allows formation of a porous oxide layer. However, the sensitive compounds like antibiotics cannot be incorporated into layer in their active form. Formation of hybrid oxide-polymer layer is a proposition for functionalization of titanium alloys to obtain bacteriostatic and/or surface with bactericidal properties.

Materials and Methods

Titanium alloy (Ti-2Ta-3Zr-36Nb) was anodized in a 0.1 M $Ca(H_2PO_2)_2$ solution at 300 V. All the conditions applied for surface treatment was presented in paper [4]. Poly(sebacic anhydride) (PSBA) layer was formed on previously anodized Ti alloy. The polymeric coating was loaded with cefazolin. Morphology, degradation of the layer were evaluated using a scanning electron microscope (Phenom, ProX, accelerating voltage 5kV) equipped with 3D surface roughness reconstruction software. HPLC technique (Merch-Hitachi chromatograph) was applied to determine concentration of the loaded drug and its stability in solution. The samples were immersed in artificial saliva at 37°C up to 10 h. The activity of the drug released from the coatings, as well as adhesion of the bacteria on the surfaces was determined using references *S. aureus* (ATCC 25923), *S. epidermidis* (ATCC 700296) and clinical *S. aureus* (MRSA 1030), and *S. epidermidis* (15560) strains.

Results and Discussion

FIG. 1A presents the representative surface of Ti alloy after plasma electrolytic oxidation. A porous microstructure of the layer was a result of the anodization process. The average surface roughness of the hybrid coatings was between 0.78 µm ±0.17 - 0.98 µm ±0.12. The determined concentration of cefazolin loaded in hybrid coating was 17.62 µg/cm^2 ±0.05. The average concentration of the drug in artificial saliva collected up to 10 h of material degradation is presented in FIG. 1B. During first hours of material immersion more than 20% of loaded drug was released to artificial saliva. ^{1}H NMR analysis showed that the PSBA was degraded in 77.8 mol.% after 7 days of material immersion.

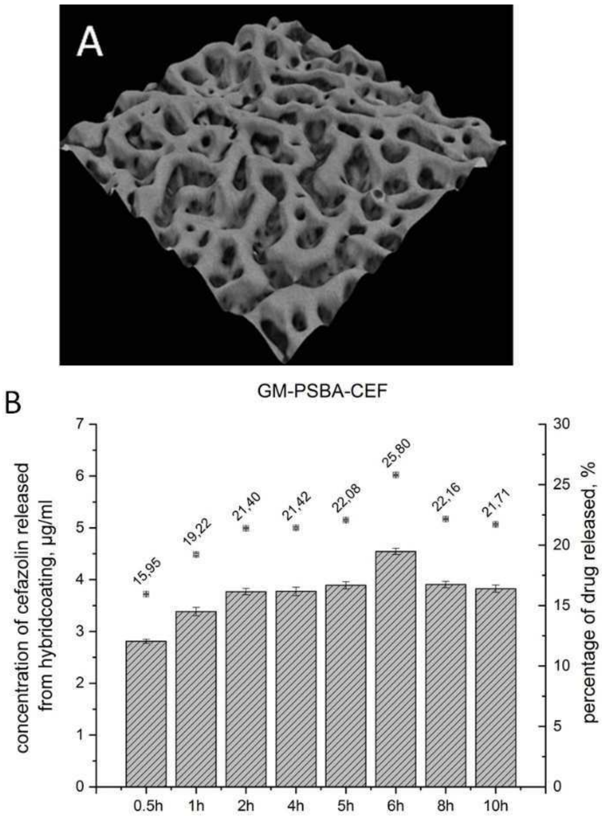

FIG. 1. The representative surface of Ti alloy after plasma electrolytic oxidation (1A); Average concentration of the drug in artificial saliva collected up to 10 h of material degradation (1B).

The minimal inhibitory concentration (MIC) was determined for cefazolin released after 30 min (2.81 µg/ml) of material immersion for reference bacteria strains. Growth of clinical bacteria was inhibited when the concentration of cefazolin increased up to 4.5 µg/ml. Amount of drug released from the coatings was enough to inhibit adhesion of reference and clinical bacteria strains as well.

Conclusions

Anodized Ti alloy surface is favourable for formation of a hybrid, oxide-polymer layer. Poly(sebacic anhydride) was deposited onto the anodized Ti without losing its characteristic microstructure. The cefazolin loaded in polymeric layer was stable and its concentration was enough to inhibit reference and clinical bacteria strains on surfaces.

Acknowledgments

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