MODIFICATION OF TITANIUM IMPLANT SURFACE FOR ANIMALS

Alicja Kazek-Kęsik[1,2]*, Alicja Sadkowska[1], Katarzyna Reczyńska-Kolman[2], Izabela Kalemba-Rec[4], Monika Śmiga-Matuszowicz[1], Elżbieta Pamuła[2], Wojciech Simka[1]

[1] Faculty of Chemistry,
Silesian University of Technology, Poland
[2] Biotechnology Centre,
Silesian University of Technology, Poland
[3] Faculty of Materials Science and Ceramics,
AGH University of Science and Technology, Poland
[4] Faculty of Metals Engineering
and Industrial Computer Science,
AGH University of Science and Technology, Poland
*e-mail: alicja.kazek-kesik@polsl.pl

[Engineering of Biomaterials 163 (2021) 16]

Introduction

Animals are very specific and special patients. Time after material implantation to animal bone is very important. It is difficult to treat animals infection. On the other hand, for some owners it is difficult to appropriate dose an antibiotic for their animals. Modification of the titanium implants surface may enhance a osseointegration process and reduce time to return an animal to their daily activities. One of the technique for the surface treatment is plasma electrolytic oxidation process. The result of titanium implant treatment is formation a porous oxide layer on a metal surface [1-3]. The oxide layer is enriched in bioactive calcium and phosphorous compounds. However, the oxide layer does not protect against bacteria. To add antibacterial properties, on the oxide layer a thin polymer coating is formed using dip-coating technique. A polymer layer, such as poly(adipic sebacine) is deposited on the implant surface with amoxicillin. The aim of this work is formation the oxide-polymer layer on the titanium bone wedge implants. The layer should be cytocompatible and protect the surface against bacteria and formation bacteria biofilm.

Materials and Methods

Titanium implant (bone wedge, IWET, Poland) was anodized in solution composed of 0.1 M $Ca(H_2PO_2)_2$) at 300 V. Applied current density was 100 mA/cm^2 and time of the process was 5 min. Then, the anodized implant was immersed in 0.5% poly(sebacic anhydrite) solution with 5% (w/w) amoxicillin in trichloromethane with controlled immersion and withdraw speed: 100 mm/min. The surface of the implant was analysed using scanning electron microscope (Phenom ProX), non-contact optical profilometer (Wyko N9300, Veeco). Surface wettability was analysed using a goniometer (DataPhysics OCA 15EC). Drug release and drug loaded into the coating was analysed using high-performance liquid chromatography (Shimadzu, LC2030C Plus Prominence-i). Cytocompatibility of the polymer and antibiotic was evaluated using a mouse fibroblast L929 cells.

Results and Discussion

The porous oxide layer was formed on whole titanium implant surface. The layer was formed also on the corner of the implant. Polymer layer was formed on the previously anodized implant surface using a dip coating technique. Contact angle for only anodized implant surface was 31.1° ± 2.8, for implant with oxide-polymer layer was lower: 19.2° ± 2.7. Average surface roughness (Ra) for the only anodized implant (FIG. 1A) was 2.20 µm ± 0.15, whereas for the implant with oxide-polymer layer the Ra was 1.13 µm ± 0.12 (FIG. 2A).

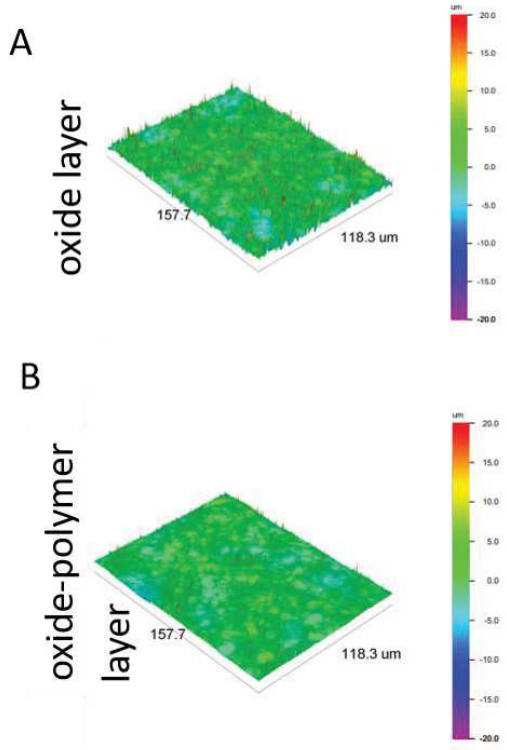

FIG. 1. Images of surface roughness of the samples form a selected area of a) oxide layer, b) oxide-polymer layer formed on a bone wedge.

HPLC analysis was applied to determined total loaded amoxicillin in polymer coating, and it was 79.68 µg/cm^2 of the bone wedge. Drug release from modified implant surface was analysed in Ringer solution, and after 30 min of the implant immersion concentration of amoxicillin was 191.69 µg/mL After 8h of implant immersion concentration of amoxicillin in Ringer solution increased to 203.00 µg/mL It was a 16.44% of the total loaded amoxicillin in polymer deposited on previously anodized bone wedge. Cytocompatibility test showed that concentration of amoxicillin up to 150 µg/mL does not significant decrease cell viability. Extract of the polymer used in this experiment is not toxic for the cells when the concentration does not exceed 1.5 wt.%.

Conclusions

Titanium bone wedge was anodized in solution with bioactive compounds. The polymer layer deposited on anodized Ti implant was loaded with amoxicillin with concentration up to 80 µg/cm^2. The concentration of loaded drug is not cytotoxic for the L929 cells. The drug is release from the coating in relatively short time, and it is concentration could be favourable to prevent bacteria adhesion and formation biofilm on the implant surface.

Acknowledgments

This work was supported by the National Centre for Research and Development, Poland, according to the LIDER XI programme. Project "Technology of hybrid coatings formation on titanium implants for animals" no. LIDER/12/0048/L-11/19/NCBR/2020.

References

[1] I.R. J.M. Cordeiro, T. Beline, A. Lúcia *et al.,* Dent. Mater. 33 (2017) 1244-1257.
[2] A. Krząkała, A. Kazek-Kęsik, W. Simka. RSC Adv. 3 (2013) 19725–19743.
[3] A. Kazek-Kęsik *et al.,* Bioactive Materials 5 (2020) 553-563.