BIOACTIVE CERAMIC COATING FORMED ON Ti BONE WEDGE

Alicja Kazek-Kęsik[1]*, Małgorzata Krok-Borkowicz[2], Elżbieta Pamuła[2], Wojciech Simka[2]

[1] Faculty of Chemistry,
Silesian University of Technology, Gliwice, Poland
[2] Faculty of Materials Science and Ceramics,
AGH University of Science and Technology,
Krakow, Poland
*e-mail: alicja.kazek-kesik@polsl.pl

[Engineering of Biomaterials 158 (2020) 50]

Introduction

Bone tissue implant material should be characterised by good biocompatibility ensuring the osseointegration of implant and bone and shows appropriate mechanical properties [1]. Bone wedge implant usually are made by Ti-6Al-4V alloy. There is a wide range of surface modification methods which aim is to enhance the osseointegration between implantable material and bone tissue. One of the promising surface treatment is the plasma electrolytic oxidation (PEO) process [2]. The foundation of PEO treatment is an application of voltage higher than oxide layer breakdown voltage during the anodization and a coating with characteristic morphology is formed. The formed oxide layer can be additionally enriched with elements or compounds from the anodizing bath increasing the bioactivity and biocompatibility of the implant. Coating formation using the sol-gel technique allows the design of a surface with desirable chemical and phase compositions [3]. The aim of this work was formation ceramic coatings on the bone wedge Ti implant for animal bone.

Materials and Methods

The Ti bone wedge (IWET, Poland) was anodized in 0.1 M $Ca(H_2PO_2)_2$ solution (Alfa Aesar, Germany) with $Ca_3(PO_4)_2$ (Avantor, Poland) particles at 350 V. Next, an additional sol-gel coating was formed on the previously anodized sample from solutions composed of hydroxyapatite precursors. The bone wedge was heat treated for 30 min in a furnace at 660°C with a controlled ramp rate (10°C/min) in the air condition. The morphology of the modified sample was examined by scanning electron microscopy (SEM) (Hitachi; TM-3000; BSE mode). A cross-section of the implant was also analyzed, and the surface roughness and wettability, as well [4]. Evaluation of titanium alloy sample cytocompatibility was carried out using human osteoblast-like MG-63 cells seeded at an initial density of 8,000 cells per sample (representative samples of medical Ti-6Al-4V alloy with the ceramic coatings). Cell metabolic activity, attachment and distribution of the adhered cells were evaluated as described previously [4].

Results and Discussion

The titanium bone wedge implant was anodized in a $Ca_3(PO_4)_2$ suspension, and then the additional layer was formed by the sol-gel technique to obtain a mixture of the calcium phosphate compounds (FIG. 1A). The oxide layer was porous, and additional ceramic particles were formed after sol-gel treatment (FIG. 1B). After the sol-gel process the Ca/P content in the total ceramic layer increased up to 0.89 (FIG. 1C). Cross-section analysis of the coatings also confirmed that the thickness of the ceramic layer increased around 5 μm after additional posttreatment process. Formation the additional ceramic particles on the top of the implants surface caused that the surface roughness increased from 0.91 μm ±0.21 to 1.07 μm ±0.11. The average surface roughness was determined based on 2D and 3D profiles of the SEM images (FIG. 1D). Wettability of the surface was also changed to become more hydrophilic, which is favourable for bone cell adhesion.

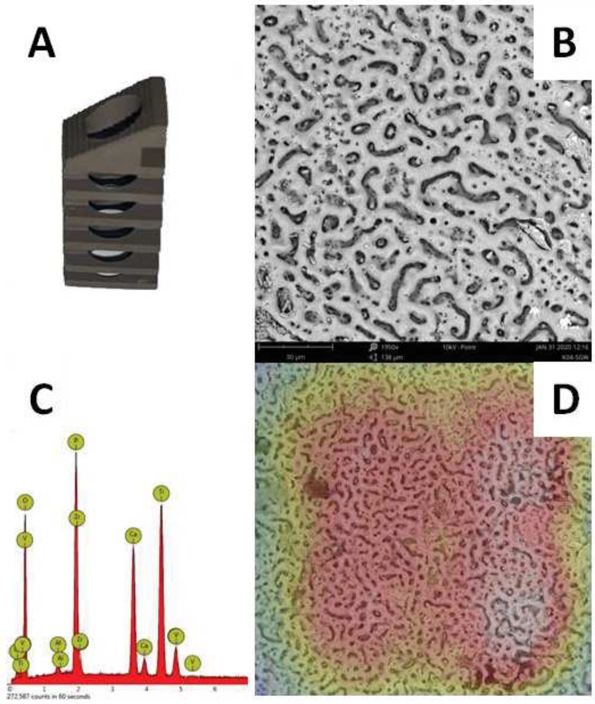

FIG. 1. Image of a bone wedge with ceramic coating (A), surface morphology of the modified implant surface (B), EDX analysis of the coating (B) and their surface roughness profile analyzed based on the SEM images (D).

Surface modification such as formation of the hybrid ceramic layer influenced the differences in the number of osteoblast-like MG-63 cells compared with the unmodified titanium sample. The cells were well adhered and their number increased with time of their culture.

Conclusions

The results showed that a hybrid ceramic layer containing amount of calcium and phosphate-related compounds can be formed on the bone wedge implant. Application of the plasma electrolytic oxidation process and sol-gel technique is favourable for surface treatment of the animal implant for bone tissue. The hybrid, ceramic coating was cytocompatible with osteoblast-like MG-63 cells.

Acknowledgments

This work was supported by the National Centre for Research and Development and by Polish National Science Centre according to the project TANGO 3 (TANGO3/427207/NCBR/2019).

References

[1] M. Geetha *et al.,* Prog. Mater. Sci. 54 (2009) 397-425.
[2] K. Rokosz *et al.,* Materials 13 (2020) 2468 - 2490.
[3] L. Le Guéhennec *et al*., Dent Mater. 23 (2007) 844-54.
[4] A. Kazek-Kęsik *et. al*., Mater. Sci. Eng. C Mater. Biol. Appl. 94 (2019) 998-1008.