FORMATION OF FUNCTIONAL COATINGS ON Ti-6Al-7Nb ALLOY SURFACE

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Introduction

Selected titanium alloys, such as Ti-6Al-7Nb, Ti-15Mo, exhibit mechanical properties close to natural bone. The corrosion products of these Ti alloys are non-toxic and non-allergic for human organism [1]. Surface of titanium alloy is modified to obtain multifunctional material for bone replacement or regeneration [2]. Plasma electrolytic oxidation (PEO) is easy and cost-effective methods of surface treatment [3]. The one advantage of the PEO is possibility of anodization of various shapes Ti implants. Microstructure and chemical composition of porous oxide layer might be design to obtain materials which enhance osseointegration process [4]. The long-term exposure of the implant surface in organism may be complicated by infection, with pathogenic bacteria, adhering to the implant [5]. To prevent bacterial biofilm formation, the porous oxide layer is cover by thin polymer layer with biological active substance [6]. Drug release into surrounding tissue might be controlled by time degradation of polymer deposited on previously anodized surface. One of the biocompatible polymer which exhibit degradation in artificial saliva is poly(D,L-lactide-co-glycolide.

Materials and Methods

Surface of Ti-6Al-7Nb alloy was anodized in solution composed of $Ca(H_2PO_2)_2$ and $CaSiO_3$ at 350V. Time of surface treatment was 5 min, when current density was 150 mA/cm^2. On the porous oxide layer the biodegradable polymer (poly(D,L-lactide-co-glycolide-PLGA was deposited using dip coating method.
Hybrid, oxide-polymer coatings were characterized using scanning electron microscope (SEM, Phenom ProX), Raman spectroscopy with CDD detector. Degradation of polymers layer in artificial saliva was evaluated using ^{1}H NMR technique.

Results and Discussion

FIG. 1. presents representative SEM images of the anodized Ti-6A-7Nb surface and after additional surface treatment using biodegradable polymer.

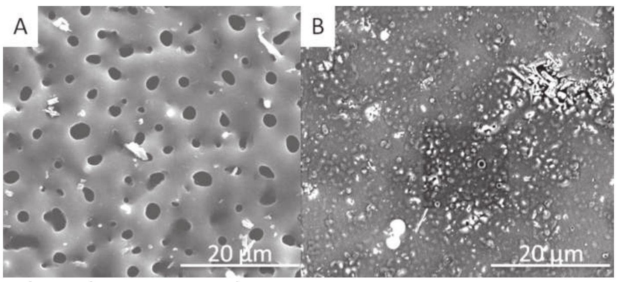

FIG. 1. SEM image of (A) porous oxide layer and hybrid oxide-polymer layers formed on Ti-6Al-7Nb alloy surface. Magnification: x2000.

PEO process caused that the coating was porous. Incorporated particles of wollastonite were clearly visible on the surface. After dip coating, pores of the oxide layer were filled by biodegradable polymer. However, still some wollastonite particles were visible on the top of the surface, which may indicate that the polymer layer wasn't too thick. Product of polymer degradation was detected by ^{1}H NMR technique, after 4 weeks of sample immersion in artifiial saliva. Results indicated that the polymer layer degradated in very short time.
FIG. 2. presents Raman spectra of the hybrid layer formed on the Ti alloy surface.

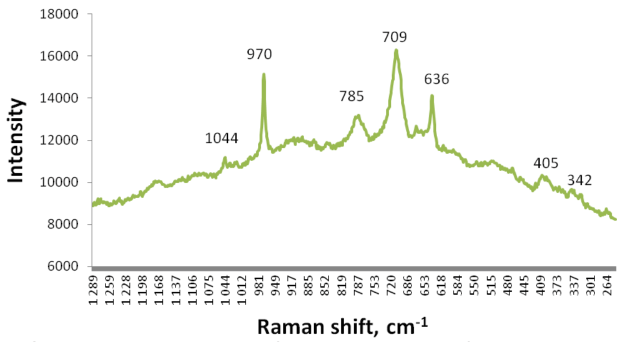

FIG. 2. Raman spectra of the hybrid layer formed on the Ti alloy surface.

The Si-O stretching signals at 636 cm^{-1} and 970 cm^{-1} were from wollastonite phase. The Ca-O stretching modes from the wollastonite was detected at 405 cm^{-1}. Signal at 342 cm^{-1} corresponds to TiO_2 anatase phase, when signals at 709 cm^{-1}, 785 cm^{-1} and 1044 cm^{-1} were detected for PLGA layer formed on anodized Ti surface.

Conclusions

Possibility of the anodization of Ti-6Al-7Nb surface allows design material which enhances integration of the implant surface with bone tissue. The polymer layer which was deposited on the porous oxide layer might be enrich with selected drugs such as doxycycline, vancomycin, gentamicin or clindamycin. Proposed surface treatment of the Ti alloy might exhibit antibacterial properties against bacteria strains such as: S. aureus, E. coli strains and coagulase-negative staphylococci (CoNS) as the most common infections pathogens.

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