PHYSICAL PROPERTIES OF PLGA BIODEGRADABLE POLYMER COATINGS CONTAINING HYDROXYAPATITE ON Ti6Al7Nb SUBSTRATE

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Introduction

Titanium alloys are now one of the most widely used metallic biomaterials in medicine, especially as implants for osteosynthesis. Low density, high corrosion resistance and good biocompatibility in environmental of tissue and body fluids are properties which determine their usefulness [1]. However, after many years of research, was proved that they are not biologically inert, but may cause allergies and other adverse reaction [2]. For this reason and to improve biocompatibility, bioactivity and corrosion resistance, the use of a titanium alloy requires proper surface treatment [3,4]. One of the available modification methods may be the use of biodegradable polymer coatings, which, apart from improving biocompatibility by limiting the penetration of metal ions into the tissue environment, can be also a matrix for the release of the mineral and active substances. Released substances may have a beneficial effect on the bone tissue healing process and also reduce the need for systemic drug therapy [5]. Moreover, the degradation of the polymer will not deteriorate the mechanical properties of the implant, since the stability is ensured by the metal substrate [6]. Due to the frictional forces occurring in the implant-bone system, the adhesion and tribological properties of the coating are significant.

The aim of the study was to determine the properties of biodegradable polymer coating PLGA containing hydroxyapatite.

Materials and Methods

Ti6Al7Nb alloy samples were taken from a rod of 25 mm in diameter. The surface was subjected to modification, which included mechanical grinding, sandblasting and anodic oxidation. The anodic oxidation was performed in a bath containing phosphoric and sulfuric acid at 97 V at room temperature for 2 minutes. Polymer coating based on poly(D,L-lactide-coglycolide) PLGA(85/15) was synthesized in bulk by the ring opening polymerization of glycolide (Purac) and D,L-lactide (Purac) (first, at 130°C for 24 hours and next, at 120°C for 48 hours at argon atmosphere using Zirconium (IV) acetylacetonate $(Zr(acac)_4)$ (Aldrich) as a non-toxic initiator. Solution of 1% PLGA in CH_2Cl_2 was enriched with 5%, 10%, 15% or 20% synthetic hydroxyapatite powder (<60 nm particle size) (Sigma Aldrich).

The substrate was coating by ultrasonic spray system ExactaCoat (Sono-Tek) with Impact nozzle. The coating process was carried out with ultrasound frequency 60 kHz and power 1.5 W. Flow rate of solution was 1 cm^3/min and speed of nozzle motion 5 mm/s. Coatings were composed of 5, 10 or 15 layers.

The scope of the research included microscopic observation of surface, wettability, adhesion and tribological tests.

The observations of the samples' surface were analyzed with a Zeiss Stereo Discovery V8 stereoscopic microscope (Zeiss) with a MC5s digital camera.

Wettability measurements were performed with distilled water and diiodomethane using a drop of liquid with a volume of 1.5 mm^3 The measurements were performed by applying the SURFTENS UNIVERSAL optical goniometer (OEG) and computer software Surftens 4.5 for. Tests were carried out at room temperature in 60 seconds with a sampling rate of 1 Hz.

Tests of adhesion of the polymer coatings to the Ti6Al7Nb substrate were carried out using the scratch test method, using an open platform equipped with a CSM Micro-Combi Tester. The tests were carried out with increasing loading force from 0,03 N to 30 N, loading speed 10 N/min, table speed 1 mm/min and crack length 3 mm.

Tribological tests were performed with Tribometr Pin-On-Disc (Anton Paar). Based on research from the literature [7] following parameters were accepted: friction rate 0,1 m/s and friction radius 8 mm.

Results and Discussion

The physical properties of PLGA polymer coatings containing various amounts of HAp (5, 10, 15, 20%) were determined using the wetting angle and surface free energy, the coating friction coefficient and its abrasion, as well as adhesion to the metal substrate. The coatings before and after the tests were observed with stereoscopic microscope.

Conclusions

The physical properties of biodegradable PLGA polymer coatings enriched with hydroxyapatite depend on the content of hydroxyapatite and the thickness of the coating.

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