THE PROPERTIES OF NANOSILVER – DOPED NANOHYDROXYAPATITE COATING

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Introduction

The titanium alloy (Ti6Al4V, Ti6Al7Nb and Ti13Zr13Nb) nowadays are the most frequently used materials for orthopedic implants because of their high biocompatibility, high corrosion resistance in body fluids environment and proper mechanical properties [1].

To improve biocompatibility and mechanical properties, the surface modification techniques like laser treatment, hydroxyapatite or nanohydroxyapatite coatings deposition or nanooxidation were used. Electrophoretic deposition technique could be applied to obtain thin films of hydroxyapatite and nanohydroxyapatite. To provide antibacterial properties of the hydroxyapatite coatings, the doping of nanosilver or nanocopper nanoparticles with similar bactericidal effects as antibiotics was investigated [2,3].

The aim of this research was to study the properties of nanohydroxyapatite (nanoHAp) and nanohydroxyapatite doped with nanosilver (nanoHAp/nanoAg) coatings obtained by an electrophoretic deposition process on the Ti13Zr13Nb.

Materials and Methods

The specimens made of the Ti13Zr13Nb alloy were polished with abrasive paper, grid 2000# as the last.

The electrophoretic deposition (EPD) was carried out in a suspension prepared by dispersing 0.1 g of HAp nanopowder with average particle size about 20 nm (MK Nano Canada) (specimen “a”) and 0.1 g of HAp nanopowder and 0.01 g of nanosilver with average particle size about 30 nm (Hongwu International Group LTD, China) (specimen “b”) in 100 mL of anhydrous ethanol. The suspensions were obtained by ultrasonic mixing for 60 min at room temperature. The electrodes were placed parallel to each other within a distance 10 mm and connected to the DC power source (MCP/SPN110-01C, Shanghai MCP Corp., China). The electrophoretic deposition was performed at 30 V for 2 min at room temperature. Specimen were air dried at room temperature for 24 h. Finally, the coated Ti13Zr13Nb specimens were thermally treated in a tubular furnace (PROTHERM PC442, Ankara, Turkey) in a vacuum at 800°C for 120 min.

The coatings` surfaces and cross-sections were observed using a high resolution SEM (JEOL JSM-6480).

Results and Discussion

FIG. 1. shows the SEM images of nanoHAp and nanoHAp/nanoAg coatings. The agglomerations of nanoHAp powder and cracks appear on both types of coatings, in particular on the nanoHAp coating, for which a greater number of longer cracks is seen.

FIG. 2. illustrates the thickness of the coatings. The thickness of the nanoHAp coatings was 3.84 ± 0.43 μm and of nanoHAp/nanoAg was 2.29 ± 0.32 μm.

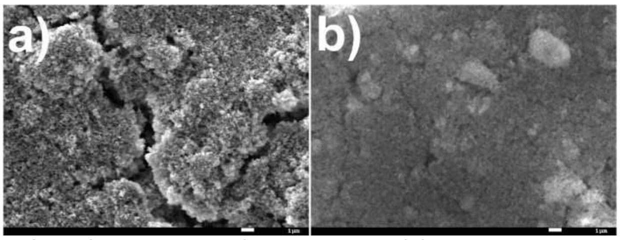

FIG. 1. SEM images of the nanoHAp (a) and nanoHAp/nanoAg (b) coatings after thermal treatment.

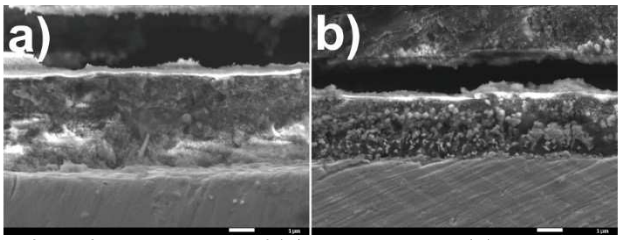

FIG. 2. Cross-sections of (a) nanoHAp and (b) nanoHAp/nanoAg coatings after thermal treatment.

The agglomeration of nanoHAp particles probably is due to faster kinetics of the migration process and low time to find and occupy the most suitable positions to form a uniform coating [4,5]. NanoHAp/nanoAg coating compared with the nanoHAp coating is characterized by a smaller number of cracks what may be due to the presence of silver nanoparticles inside the coating and reducing the internal stress inside the coating after the thermal treatment. The cross-sections illustrate that both nanoHAp coatings are well adjacent to the titanium substrate without any delamination and that nanosilver presence reduces thickness of coating. This effect is probably caused by disturbed migration of less conductive nanoHAp powder particles by perfect conductive nanosilver particles.

Conclusions

The electrophoretic deposition process (EPD) is the method which allows for obtaining homogeneous, thin nanoHAp/nanoAg coatings on the Ti13Zr13Nb alloy. The presence of nanosilver particles has a significant effect on homogeneity, quality and thickness of the nanohydroxyapatite coatings.

References

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