THE PROPERTIES OF NANOSILVER AND NANOCOPPER – DOPED NANOHYDROXYAPATITE COATING

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[ENGINEERING OF BIOMATERIALS 163 (2021) 91]

Introduction

Titanium and its alloys are nowadays the most frequently used materials for orthopedic implants because of their appropriate mechanical properties, high corrosion resistance, and biocompatibility [1].
To improve proper cells response and ensure adequate mechanical properties, surface modification techniques are applied including deposition of calcium phosphate coatings, usually hydroxyapatite coatings. Electrophoretic deposition technique is in particular suitable to develop thin films on implants. 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].
In the present research, the effects of nanoAg, and nanoCu together on the nanoHAp coating properties, especially the mechanical properties, were investigated and discussed.

Materials and Methods

The specimens of 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 an average particle size of about 20 nm (MK Nano Canada) (specimen A), 0.005 g of nanosilver with an average particle size of about 30 nm, and 0.005 g of nanocopper with average particle size about 80 nm (Hongwu International Group LTD, China) 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 of 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 nanomechanical studies were conducted with the nanoindenter (NanoTest Vantage; Micro Materials, UK) equipment using a Berkovich indenter. The maximum force of 5 mN, the loading, and unloading times 20 s each, the dwell period at full load 10 s, and the distance between the subsequent indents 20 μm were set up in nanoindentation tests. The Oliver-Pharr method was used to calculate the contact area of the indenter. The nanoscratch tests were performed at the maximum load of 400 mN and loading rate of 1.3 mN/s at a distance of 1000 μm. In the nanoscratch test the spherical diamond indenter with a 5 μm radius was used. The adhesion of the coating was determined as corresponding to the abrupt change in friction force.

Results and Discussion

For nanoHAp and nanoHAp/nanoAg/nanoCu coatings, the obtained values of nanohardness were 0.032 ± 0.009 GPa and 0.067 ± 0.055 GPa, respectively. Large standard deviations are characteristic for nanoindentation measurements of porous materials like the tested nanoHAp-based coatings. Furthermore, the addition of nanometals in our tests resulted in a change of hardness from 0.03 to 0.07 GPa, Young's modulus from 5 to 12 GPa, and H^3/E^2 from 1.25 to 1.01 MPa, which could be assumed as a substantial effect. FIG. 1. shows the maps of the distribution of Young's modulus for nanoHAp and nanoHAp/nanoAg coatings. The mechanical properties of implant coatings are expected to be close to those of human cortical bone [4].

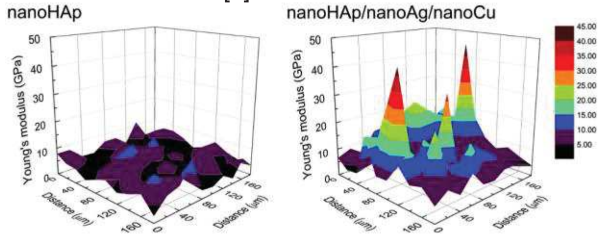

FIG. 1. The maps the distribution of Young's modulus for nanoHAp and nanoHAp/nanoAg/nanoCu coatings.

The nanoscratch-test studies proved the positive effect of the addition of nanomemetals. The value of the critical force of 106.77 ± 37.51 mN and 220.91 ± 62.19 mN, respectively for the nanoHAp and nanoHAp/nanoAg/nanoCu coatings were obtained. The single nanoscratch test curve for nanoHAp/nanoAg/nanoCu coating is presented on FIG. 2.

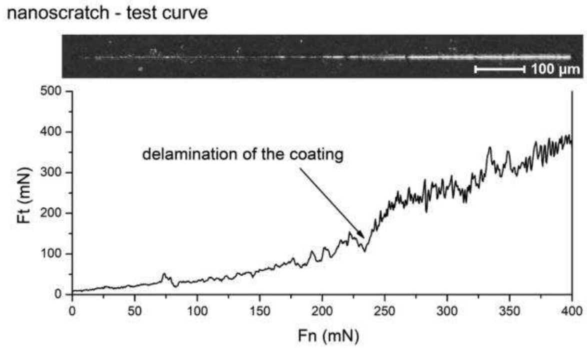

FIG. 2. Nanoscratch test curve.

Conclusions

The addition of nanometals positively influenced the nanomechanical properties, including the adhesion of the coatings determined by the nanoscratch test .

References

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