Nanostructured Ag- and Cu- doped ZnO antibacterial magnetron sputtered coatings for biomedical applications

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INTRODUCTION: The formation of bacterial biofilms on the surfaces of medical implants and non-critical surfaces represents an increasing problem in medical practice. [1] Antibacterial modification of surfaces is considered a promising approach in preventing biofilm formation. Among different possible coatings, nanostructured magnetron sputtered metal oxide thin films are gaining attention as the physico-chemical properties can be controlled by simply changing the experimental conditions which consequently affects and modulates biological responses. In this study, for the first time, we compared the properties of magnetron sputtered ZnO thin films doped with Ag or Cu. In addition, the possibility of increasing the biocompatibility of the prepared coatings by biomimetic deposition of calcium phosphates on their surface was tested.

EXPERIMENTAL: Thin Ag- and Cu- doped ZnO films of different compositions were prepared by simultaneous magnetron deposition in a multi-source sputtering system. To increase their bioactivity, calcium phosphates were biomimetically deposited on their surface. The structure and composition of the obtained coatings were determined by grazing incidence small-angle X-ray scattering (GISAXS) and X-ray diffraction (XRD), while the morphology was observed by atomic force microscopy (AFM), helium-ion microscopy (HIM) and scanning electron microscopy (SEM). The content and distribution of elements was determined by energy dispersive spectroscopy (EDS), while ion release was determined by inductively coupled plasma mass spectrometry (ICP-MS). The viability of the human osteoblastic cell line MG-63 on thin films was determined by MTT cell test. The formation of *Staphylococcus aureus* and *Pseudomonas aeruginosa* biofilms was determined as well.

RESULTS AND DISCUSSION: The results show formation of nanoparticles in all films, having composition-dependant size and shape properties. The obtained results indicated that increasing Ag or Cu amount in the thin films caused opposite effects on structure of the nanoparticles forming thin films, grain size and water contact angle. EDS confirmed that the grains are mixture of Ag and ZnO or Cu and ZnO, and XRD analysis suggested incorporation of Ag or Cu into ZnO structure. Calcium phosphates were successfully deposited onto the surfaces, resulting in slightly less elemental and released amount of Ag, Cu, and Zn. However, this deposition resulted in better biocompatibility, especially for Ag doped ZnO thin film, and better control of biofilms formation.

CONCLUSIONS: These results confirm that magnetron sputtering holds promising potential not only for coating materials for biomedical applications but also for a wide range of other applications because of its versatility and effectiveness in modifying surface properties.

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