Physico-chemical and biological characterization of Ag- and Cu-doped ZnO thin films coated with calcium phosphates

Ana-Marija Milisav[1], Dr. Maja Mičetić[1], Dr. Pavo Dubček[1], Lamborghini Sotelo[2,3], Cristina Cantallops Villà[4], Dr. Tommaso Fontanot[5], Dr. Ina Erceg[1,5], Dr. Krunoslav Bojanić[1], Dr. Željka Fiket[1], Dr. Maja Ivanić[1], Prof. Dr. Silke Christiansen[3,5], Assist. Prof. Dr. Edwige Meurice[4], Dr. Tihomir Car[1], Dr. Maja Dutour Sikirić[1]
[1]Ruđer Bošković Institute, Zagreb, Croatia, [2]Friedrich-Alexander Universität Erlangen-Nürnberg, Erlangen, Germany, [3]Innovations-Institut für Nanotechnologie und Korrelative Mikroskopie, Forchheim, Germany, [4]CERAMATHS, Université Polytechnique Hauts-de-France, Cambrai, France, Cambrai, France, [5]Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Forchheim, Germany

Background incl. aims
Bacterial contamination of biomedical surfaces is a serious threat that can lead to nosocomial infections, with a prevalence reported up to 10 %.1 Treatment of such infections is complicated by emerging antimicrobial resistance.2 Potential solution lies in the development of novel antibacterial surfaces that prevent the initial bacterial adhesion. In this sense, magnetron sputtered ZnO thin films are attracting attention as the properties, including biological, of the thin films can be regulated by changing the sputtering conditions. In addition, doping ZnO with elements from group I and IB (e.g. Ag and Cu) can influence the structural and morphological properties of the thin films. However, a major disadvantage for the biomedical application of this material is the lack of porosity.3 The aim of this research was to evaluate the differences between Ag and Cu doping of ZnO and to determine whether changes in surface morphology due to the coating with calcium phosphate can influence the biological responses of the material.

Methods
Ag- and Cu-doped ZnO thin films were prepared by magnetron sputtering, followed by biomimetic deposition of calcium phosphate to potentially improve bioactivity. Characterization focused on microscopy techniques including scanning electron microscopy (SEM), helium ion microscopy (HIM) and atomic force microscopy (AFM) to investigate microstructural changes. Additional characterization of structure and composition included grazing incidence small-angle X-ray scattering (GISAXS), energy dispersive spectroscopy (SEM/EDX), and X-ray diffraction (XRD). Wettability and surface free energy were assessed, and ion release was measured using inductively coupled plasma mass spectrometry (ICP-MS). Biological characterization included cell viability assays with MG-63 cells and biofilm formation assays with Staphylococcus aureus and Pseudomonas aeruginosa.

Results
Microscopic analysis revealed that the thin films have irregular granular structures in all cases, with Ag or Cu doping influencing the size and shape of grains. Increased Ag or Cu content had opposite effects on the grain size of the nanostructured thin film. Further SEM/EDX and XRD analyzes indicated that Ag or Cu were incorporated into the ZnO crystal structure. Calcium phosphates were successfully deposited as individual crystals or aggregates. The deposition of calcium phosphates slightly improved cell viability, with the effect being greater for Ag-doped ZnO. The addition of calcium phosphates also showed better prevention of biofilm formation.

Conclusion
Ag- and Cu-doped ZnO thin films with calcium phosphates were investigated as antibacterial surfaces for biomedical applications. The doping allowed control over the morphology of the

nanoparticles, while the deposition of calcium phosphates showed the potential to improve cell viability and inhibit biofilm formation. These results are promising for the development of effective coatings to prevent nosocomial infections and for a variety of other antimicrobial applications.

Keywords:

Magnetron sputtering, calcium phosphates, biofilms

Reference:

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