Hybrid composite coatings for osteostimulating implants in osteoporosis

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Additive manufacturing is incrementally deployed in the field of materials science of medical implants, as it allows the fabrication of individualized and highly complex implant structures. Due to high biocompatibility, titanium and titanium alloys are the material of choice for bone regeneration. However, these implants exhibit significant drawbacks - lack of rapid osteo- and angiogenesis and the presence of inflammatory processes.

In the present study, 2D and 3D implants were prepared with the coatings obtained by micro-arc oxidation (MAO) and electrolytes containing Ca, P, Sr, and Mg. The layers were coated with biodegradable polymers containing an anti-osteoporotic and pro-angiogenic drug to improve biocompatibility. Depending on electrolyte solution and MAO process parameters, a different coating thickness, various crystallite phase compositions, and significantly diverse biocompatibility were obtained. This approach proves a difference in deposited film thickness compared to the commonly employed one. The physicochemical properties and morphology of the fabricated MAO coating were investigated in detail. Biocompatibility of the three different coatings has been verified by endothelial cells (EA.hy 926), MG-63 cells (bone fibroblast, osteosarcoma), and adult human adipose-derived mesenchymal stem cells by investigation of cell adhesion, proliferation, and osteogenic differentiation. The relatively large MAO surfaces provided many attachment points for cell growth. It should be noted that by using various MAO modes and electrolytes with different compositions, it was possible to control the porosity of the coatings and thereby control the loading and the releasing of drugs from the layer. The porous morphology of the MAO coatings enhanced the binding of the implant and bone tissue, thus contributing to bone tissue regeneration.

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