Enhanced corrosion protection in Mg-Al Alloys with bioactive PEO/Sol-Gel Coatings for biodegradable orthopaedics implants

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Abstract

Magnesium alloy systems with bioactive ceramic coatings developed by plasma electrolytic oxidation (PEO) are considered promising biomaterials for biodegradable implants due to their high biocompatibility. However, their main challenge consists in the high corrosion rate of the system, caused by both the substrate and the high internal porosity of the ceramic coatings, which can lead to a loss of mechanical integrity in the implant. In order to solve this problem, a multilayer system was designed to control the degradation of the implant. The Mg-Al alloy was modified using the PEO process, which produced a ceramic coating incorporating fluorine (F) and silicon (Si) with a porous surface. A sol-gel coating with a rough surface texture was then applied by dip coating technique. The surface morphology, composition and microstructure of the PEO layer were characterized by EDS, SEM and XRD, while the sol-gel layer was analyzed by SEM, FT-IR and Raman spectroscopy. The corrosion behavior of the substrate, as well as of the Mg-Al/PEO and Mg-Al/PEO/Sol-gel systems, was evaluated by electrochemical measurement (EIS) and immersion tests carried out during one week in the simulated human body conditions (Simulated Body Fluid at 37°C). The PEO coating (~10 µm thick) consisted of MgO, MgF_2 and Mg_2SiO_4 phases, while the sol-gel coating (~30 µm thick) consisting of a three-dimensional network of Si-O-Si and Si-O-Zr bonds, sealing the pores and defects of the PEO layer successfully. The Mg-Al/PEO/Sol-gel multilayer system exhibited higher corrosion resistance than the Mg-Al/PEO system, due to the sealing effect of the sol-gel layer. Therefore, the developed coatings are considered promising candidates for functionalization by incorporation of active agents.