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Degradation rate control of MgxZnyCa alloys by PEO coatings

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Abstract: Magnesium alloys are actively researched for biodegradable implants in order to avoid an implant-removal surgery after the healing process. However, high degradation rate of Mg leads to hydrogen evolution and may increase the pH of the environment causing inflammatory response. In the present work, bioactive plasma electrolytic oxidation (PEO) coatings on three MgxZnyCa alloys (two cast alloys and one extruded; x=1, 3 or 0.5; y=1 or 0.3), manufactured by Helmholtz-Zentrum Geesthacht, were generated in order to enhance the corrosion resistance, bioactivity and cytocompatibility of the alloys. AC PEO process was carried out in two environmentally friendly alkaline electrolytes containing Ca, P and Si as bioactive elements. The electrolytes were a true solution and a particle suspension. F-free electrolyte design was employed to ensure cytocompatibility of the coatings with different types of cells. The materials were characterized by SEM, EDS, XRD and optical profilometry. The corrosion behavior was evaluated by EIS and hydrogen evolution measurements during 5 days of immersion in 0.9% NaCl and α-MEM solutions, a complete one and an inorganic part only, at 37ºC. PEO coatings (7-13 μm-thick, Sa= 1.85-4.19 μm) were constituted by MgO, Ca3(PO4)2, Ca5(PO4)3(OH) and Mg2SiO4 phases. Both PEO coatings decreased the degradation rate of Mg alloys; corrosion resistance of coated samples in inorganic α-MEM increased by more than an order of magnitude (|Z|10mHz, Ω·cm2): MgZnCa = 746, MgZnCa/PEO = 8544…28277). All materials exhibited considerably greater corrosion rates in 0.9% NaCl than in α-MEM, where phosphate-based additives acted as corrosion inhibitors. Corrosion rates were slightly greater in complete α-MEM than in inorganic α-MEM due to the presence of complexing aminoacids. The developed coatings are considered suitable candidates for the subsequent development of hybrid hierarchical ceramic/biodegradable polymer systems.

Keywords: magnesium; biodegradable implants; plasma electrolytic oxidation; corrosion resistance