MmeBi09-001

Development and Evaluation of Zn-Mg-X Alloys for Low-Cost Bioresorbable Metallic Biomaterials

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The sustainable development of new materials for biomedical applications is in line with objectives 3 and 9 of the UN's 2030 Agenda, and from the point of view of public health, especially about the Unified Health System (SUS) in Brazil, to develop low cost bioresorbable metallic biomaterials can resolve several issues involving surgeries to remove temporary orthopedic implants. Metallic materials with biodegradable characteristics have been the subject of systematic investigations aiming at their application in the form of temporary implants due to an adequate combination of mechanical properties and biocompatibility. The main objective of this research is to develop Zn-Mg-(X) alloys (where X = Ca, Mn, Sn, Cu) for use as low-cost bioresorbable metallic biomaterials. The development of new alloys for biomaterials requires a complete metallurgical, mechanical, chemical, and biological evaluation [1]. The samples of the alloys analyzed were obtained by the unidirectional solidification technique [2], which is a versatile technique since it allows obtaining samples with a wide range of microstructures due to the variation in cooling rate resulting from transient solidification in unsteady state conditions. The microstructural characterization involved X-ray diffraction, X-ray fluorescence, light microscopy, and scanning electron microscopy analyses. The mechanical strength was evaluated by microhardness. Corrosion resistance was characterized through linear polarization and electrochemical impedance spectroscopy tests. The Zn-1wt.%Mg-X (X = 0.5wt.% Ca; Mn; Sn, or 1wt.%Cu) alloys showed a microstructural morphology essentially constituted by an equiaxed ?-Zn phase dendritic matrix with the eutectic compound in the interdendritic regions. The mechanical strength mainly depends on the grain size and the presence of second phases more resistant than the matrix. Cu showed the best contribution to the increase in microhardness of the Zn-1wt.% Mg alloy, generating an increase of 70%. The corrosion behavior will primarily depend on the formation of galvanic pairs between the phases that make up the microstructure. The corrosion resistance was evaluated through the corrosion rate per year (CRy). The CRy value decreased in the following order of solute addition: Zn-1wt.% Mg-0.5wt.%Sn > Zn-1wt.%Mg-0.5wt.%Mn > Zn-1wt.%Mg-0.5wt. %Ca > Zn-1wt.%Mg. The results obtained were promising, as they point to a range of different properties.
Acknowledgments: The authors acknowledge the financial support provided to FAPESP (grant: 2022/15696-0 and 2014/50502-5)
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