Characteristics of the microstructure and corrosion resistance of sintered $Mg_{65}Zn_{30}Ca_4Au_1$ alloy

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Abstract

Statement of the Problem: Magnesium alloys are suitable materials used for biodegradable implants due to their excellent properties and ability to control their corrosion behavior with various alloy additives. Additionally, manufacturing processes influence their properties. Processing of biodegradable Mg alloys is classified as solid state and liquid state techniques. Powder metallurgy is the solid state synthesis technique by blending the metal powders for the desired composition, and compaction followed by sintering the material below its solidus temperature.
The paper presents the $Mg_{65}Zn_{30}Ca_4Au_1$ alloy obtained by powder metallurgy (mechanical alloying - MA and spark plasma sintering – SPS) method. Sintered $Mg_{65}Zn_{30}Ca_4Au_1$ alloy after 20 and 70 h of milling was subjected to corrosion resistance tests, X-ray diffraction method, and observations using scanning electron microscopy. X-ray diffraction studies performed on the sintered samples revealed the presence of solid solutions of Mg, Zn, and $MgZn_2$ and Mg_3Au phases.
Electrochemical tests were performed in Ringer's solution. The determined average values of corrosion current density - j_{corr} and polarization resistance - R_p (Stern's method) for sintered samples of the $Mg_{65}Zn_{30}Ca_4Au_1$ alloy were: j_{corr} = 451 μA/cm^2, R_p = 63 Ωcm^2, and j_{corr} = 76 μA/cm^2, R_p = 372 Ωcm^2 for the samples after 20 and 70 h MA, respectively. The samples were also examined using electrochemical impedance spectroscopy (EIS) and their equivalent electrical systems were determined to describe their electrochemical behavior. The values of R_s - electrolyte resistance (Ringer's solution), R_{pore} - electrolyte resistance in pores, CPE_{pore} - capacitance of the porous (top) layer, R_{ct} and CPE_{dl} - resistance and capacitance of the double layer were determined. Surface morphology and EDS analysis of the sintered $Mg_{65}Zn_{30}Ca_4Au_1$ alloy after corrosion testing revealed the presence of, in addition to alloying elements, also oxygen, and chlorine on the tested surface.

Conclusion & Significance: The results of corrosion resistance tests of alloys show that a sinter made from powder milled for 70 h has a higher value of polarization resistance. The developed method of producing sintered magnesium-based alloys for medical applications, combining the MA and SPS processes, may be an attractive alternative to currently used technologies for producing biomaterials.

Image

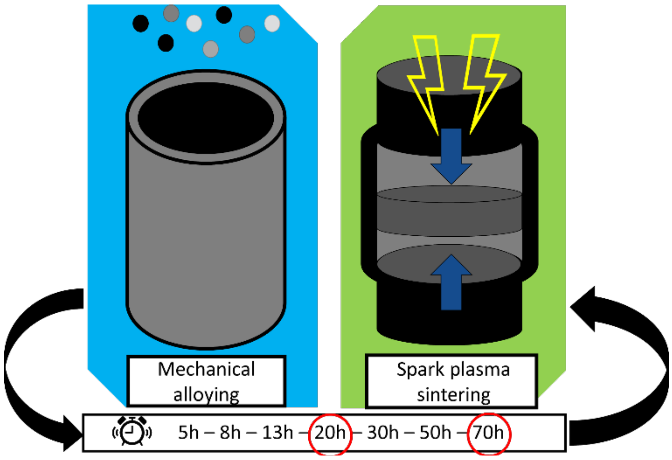

Fig. 1. The fabrication technology of studied magnesium alloy: powder metallurgy (mechanical alloying and spark plasma sintering)

Publications

1. Szyba D, Bajorek A, Babilas D, Temleitner L, Łukowiec D, Babilas R (2022) New resorbable Ca-Mg-Zn-Yb-B-Au alloys: Structural and corrosion resistance characterization. Materials & Design 213; 110327:1-16.
2. Pathote D, Jaiswal D, Singh V, Behera C.K (2022) Optimization of electrochemical corrosion behavior of 316L stainless steel as an effective biomaterial for orthopedic applications. Materials today 57;1:265-269.
3. Amukarimi S, Mozafari M (2022) Biodegradable magnesium biomaterials—road to the clinic. Bioengineering 9;107:1-20.
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Photograph

Biography

Prof. Sabina Lesz has expertise in materials engineering. Her fields of interest are degradable biomaterials, amorphous and nanostructured materials, steels, mechanical alloying, and powder metallurgy.

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