BIOACTIVE AND ANTIBACTERIAL COMPOSITE COATINGS FOR MAGNESIUM ALLOYS

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Introduction

Biodegradable composite biomaterials based on polymers offers a wide range of possibilities to introduce various modifications and hence tailor properties of resulting material. It is also possible to use them as e.g. metal coatings. One of the most promising metals nowadays are magnesium and its many alloys, mainly applied for bone and cardiovascular implants [1,2]. In orthopaedic applications, it is important to secure proper bioactivity, which can be achieved for example by addition of various calcium-phosphates, such as hydroxyapatite or tricalcium phosphate [3]. Other essential factor is the bacterial resistance. Bactericidal properties are possible to achieve by incorporation of antibacterial agents, like zinc oxide. Also, Mg itself has the ability to fight bacterial-related infections [4,5].

The aim of this study was to evaluate possibility of using polymer-matrix composite systems modified with tricalcium phosphate and/or zinc oxide for biodegradable coatings of magnesium alloy wires that should protect them from rapid degradation and enhance their biological properties.

Materials and Methods

Magnesium alloy wires (Mg, Leibniz University of Hannover, Institute of Materials Science; d=0.97 mm) with following alloy content: up to 88% Mg, 3% Al, 9% Li and up to 1% of Ca, were etched for 30 s in etching solution (19 g 100% acetic acid, 5 g sodium nitrate (V), 100 ml distilled water), rinsed with dH_2O and dried (20 mins, 70°C). As prepared samples were covered with different polymer solutions by dip-coating method. Coating solutions were prepared by dissolving poly(ε-caprolactone) (PCL, Sigma-Aldrich, Mn=80 000) in dichloromethane (Avantor Performance Materials Poland S.A.) (10% w/v). In case of composite coatings, tricalcium phosphate (TCP) and/or zinc oxide (ZnO) (5% wt.) were dissolved in DCM, homogenised by sonification and then added to polymer solutions to achieve the same final concentration of 10% w/v.

Polycaprolactone and its composite used for coatings were mechanically characterized by tensile test on universal testing machine (Zwick 1435) – tensile strength (Rm, MPa), Young's modulus (E, MPa) and elongation at maximum force (ε_{Fmax}, %) were calculated. To evaluate potential bioactivity, samples were immersed in simulated body fluid (SBF) in 37°C for 4 weeks, with weekly pH monitoring. Morphology and chemical composition of the precipitates were assessed by SEM with EDS and FTIR analysis.

Results and Discussion

Tensile test revealed that addition of TCP or ZnO alone to polymer matrix does not alter the mechanical properties. However, when two types of particles were incorporated at the same time (PLA/TCP/ZnO system) and in consequence total content of the fillers increased to 10% (in comparison with only 5% when one type was added), there was a significant decrease in tensile strength and even higher reduction of elongation at maximum force observed together with increase in E modulus value.

Immersion in SBF test allows to predict bioactivity of a material. SEM (FIG. 1) with EDS results confirmed presence of calcium-phosphate precipitations on the surface of the samples incubated in SBF for 2 and 4 weeks. Due to degradation of magnesium alloy wires, also some magnesium oxides were visible. The most calcium phosphate precipitated on the surface of the TCP-modified samples (PCL/TCP and PCL/TCP/ZnO coated Mg).

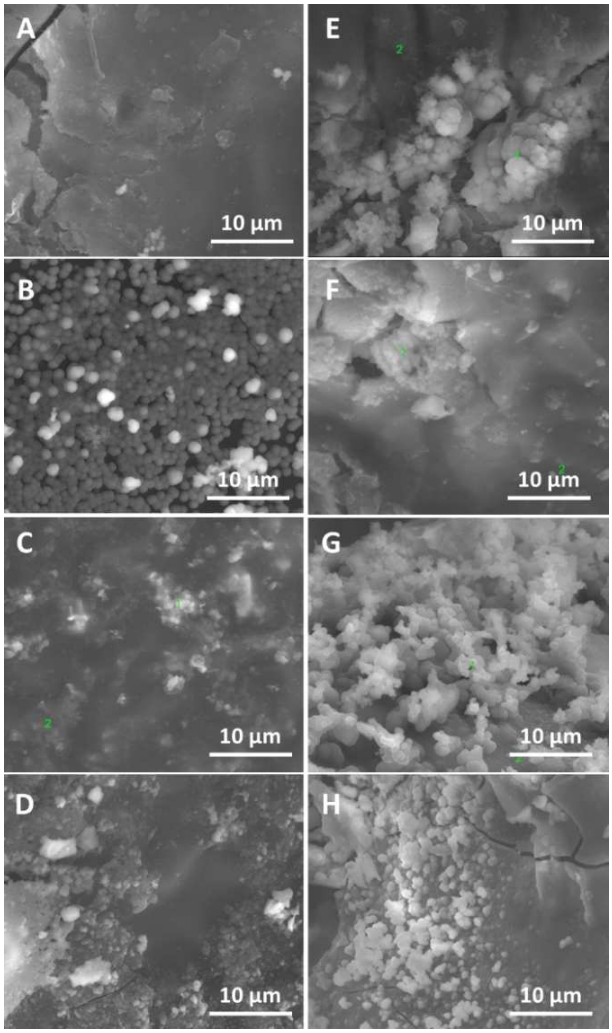

FIG. 1. SEM images of Mg alloy wires covered with (A,E) PCL, (B,F) PCL/TCP, (C,G) PCL/ZnO and (D,H) PCL/TCP/ZnO immersed in SBF for 2 (first column A-D) and 4 (second column E-H) weeks.

Conclusions

The study confirmed that polycaprolactone based composites modified with TCP and ZnO are promising candidates for magnesium alloys coatings with potential bioactivity and sufficient mechanical properties.

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