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Biomimetic gelatine coating for less-biodegradable and surface bioactive Mg alloys

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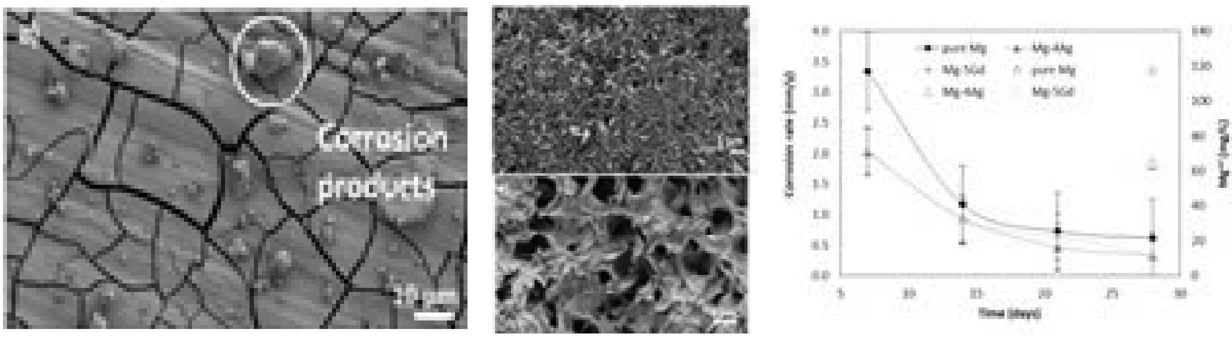
Magnesium (Mg) alloys have emerged as innovative orthopaedic implant materials due to their excellent degradability, which eliminates the need for a second surgery for their removal. However, rapid degradation of Mg alloys and subsequent loss of mechanical integrity before the tissue regeneration limits their application. The Mg-4Ag and Mg-5Gd binary alloys` degradation and corrosion properties were studied under *in vitro* conditions (in a simulated body fluid solution of pH 7.4 at 37°C) by using various analytical techniques and time-frame windows (up to 3 vs. 28 days), and compared with the pure (99.9 wt%) Mg alloy, before and after a biomimetic gelatin (GEL) coating via dopamine. Different kinetics and mechanisms of the alloys` degradation were identified, influencing their corrosion rates` dynamics. The EIS measurements of uncoated alloys, being performed for up to 3 days, revealed that the corrosion of all three alloys are under a kinetic-controlled mechanism, among which only pure Mg and Mg-4Ag show a repassivation ability in this time-frame. However, the corrosion rates of binary alloys were lower, reaching a value of around 0.33 mm/y and a release of 64 mg/L Mg^{2+} ions after 28 days of incubation, that was accompanied by a lower pH change (up to pH 8.3), compared to the pure Mg alloy, getting additionally reduced by GEL coating. The spectroscopic (FTIR, XRD, EDXS) and microscopic (SEM) studies revealed the formation of MgO products, as well as apatite formation on the pure Mg alloy surface, while thick and homogenous layers of differently-shaped and chemically secondary-phased $Mg(OH)_2$ products were identified on both binary alloys after 28 days. Besides, a protective interface layer between the alloy surface and SBF solution was formed on GEL-coated alloys, which further stimulates the mineralization of calcium phosphate compounds, being patterned by GEL macromolecules conformation. Among the binary alloys tested, the Mg-4Ag alloy seems to be the most appropriate biomaterial regarding the in-vitro degradation process that would lead to a suitable healing process at the implantation site, compared to the others available from the literature.



SEM images of (a) pure Mg, (c) Mg-4Ag and (e) Mg-5Gd alloys` surface with corresponding corrosion rates and Mg^{2+} ions release, after 28 days of immersion in SBF at 37±0.5°C.

Recent publications

1. Tiyyagura H R, Gorgieva S, Fuchs-Godec R, Mohan M K and Kokol V Biomimetic gelatine coating for less-corrosive and surface bioactive AZ91 Mg alloy. J. Mater. Res. submitted revision JMR-2017-0979.
2. Tiyyagura H R, Rudolf R, Gorgieva S, Fuchs-Godec R, Venkatappa Rao B, et al. (2016) The chitosan coating and processing effect on the physiological corrosion behaviour of porous magnesium monoliths. Progress in Organic Coatings 99(4):147-156.

3. Podlipec R, Gorgieva S, Jurašin D, Urbančič I, Kokol V, et al. (2014) Molecular mobility of scaffolds' biopolymers influences cell growth. ACS Appl. Mater. Interfaces 6(18): 15980-15990.
4. Gorgieva S, Štrancar J and Kokol V (2014) Evaluation of surface/interface-related physicochemical and microstructural properties of gelatin 3D scaffolds, and their influence on fibroblast growth and morphology. J. Biomed. Mater. Res. Part A 102(11): 3986-3997.
5. Gorgieva S, Kokol V. Processing of gelatin-based cryogels with improved thermo-mechanical resistance, pore size gradient and high potential for sustainable protein-drug release. J. Biomed Mater. Res. Part A, 2015, 103(3), 1119-1130.

Biography

Assoc. Prof. Vanja Kokol PhD got a PhD in area of Textile chemistry in 2001 at University of Maribor, Faculty of Mechanical Engineering (UM-FS). She have been employed at UM-FS from 1994, currently as a research counsellor with the habilitation of Assoc. Prof.. Her research work in the last decade is oriented in modification and functionalization of fibers and biopolymers, and their processing in highly-engineered materials for different applications (from technical to biomedical). Special attention is attributed to the development of biopolymeric 2D and 3D materials with targeted and biocompatible antimicrobial activity. She is author of more than 90 papers, 3 book chapters, 3 patents, was supervisor of several (seven) doctoral and post-doctoral (five) students, and have been active in research programme Textile chemistry (from 1999) and Center of Excelence (from 2010) for advanced materials and technologies, area of Soft biomaterials. She was involved (leading or collaborating) in many national (ARRS-L2-7576, ARRS-J2-7018), bilateral (SLo-CZ, Slo-IT, SLO-IND, SLO-DE), international (E!3100 CAWAB, E!3654 BIOPOLS, EraNet Manunet NANOWEL, EraNet Matera Plus ANTIMICROB PEPTIDES, E!4956 MAGNET, EraNet MNT TABANA, EraNet MNT n-POSSCOG) and EU (H2020-PILOTS-03-2017-760601-2-NanoTexSurf, FP7-NMP-2011-SMALL-5-280519-NANOSELECT, FP7-NMP-2011-LARGE-5-280759-NANOBARRIER, Erasmus-Mundus (EMA2)-2013–2540/001–EUPHRATES, Marie Curie ToK/DEV FP6-MTKD-CT-2005-029540-POLYSURF, FP6-2004-SME-COOP-032877-ENZUP) funded research projects.

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