Laser surface structuring: a method to change topography, promote coating deposition and reduce corrosion rate

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INTRODUCTION: High degradation rate of Mg alloys is an important limitation for their use in biomedical implants [1]. The deposition of a biodegradable coating is a well-established strategy allowing the control of the degradation rate [2]. Morphology, structure and adhesion of the deposited layer are strongly affected by the substrate topography, so that a surface pre-treatment, for example by laser, plays a fundamental role in the definition of the final properties of the coating [3]. In this work, a Mg alloy (AZ31) surface was laser treated to produce a series of finishing with different features; the treated surfaces were then coated with a layer by layer (LbL) technique, to produce a multi-layered polysaccharide coating. The relation between surface topography and corrosion mechanism is analysed.

METHODS: AZ31 Mg-alloy samples were laser cut from sheet with of 0.4 mm of thickness (R_a= 255±10 nm). Pulsed fibre laser source was used to obtain surfaces at higher roughness (R_a=1069±50 nm) and lower roughness (R_a=216±10 nm) [4]. The treated surfaces were evaluated by the sessile drop method for contact angle assessment: the non-structured surface showed a contact angle of 61°, while the high and low roughness surface showed respectively a contact angle of 22° and 69° Both as-received and laser treated surfaces were coated by a cellulose acetate (CA) primer, followed by LbL alternate layers of carboxymethyl cellulose (CMC) and chitosan (CHI). In order to compare the degradation behaviour of all the treated samples, a static immersion test was carried out in phosphate buffer saline solution for 14 days according to ASTM NACE/ASTMG31-12a.

RESULTS: Figure 1 shows SEM images of coated samples with different surface topographies. The surface topography exhibits high influence on the generated coating morphology. Non-structured and surfaces with reduced roughness show porous and non-homogeneous coating. On the contrary surface with increased roughness presents a denser coating morphology. This result is related to the evidences of degradation test. As it is showed by results in table 1, surface with increased roughness exhibits the lowest average corrosion rate value.

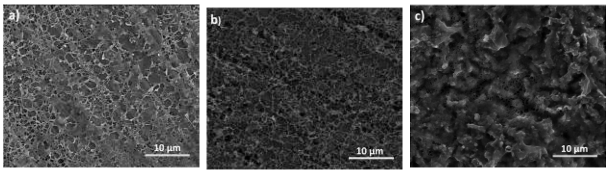

Fig. 1: Coating morphologies on a) non-structured, b) reduced roughness, c) increased roughness.

Table 1. Average corrosion rates (CR) different sample types

Surface	Non-coated CR [mm.yr^{-1}]	Coated CR [mm.yr^{-1}]
Non-structured	1.37 ± 0.02	1.17 ± 0.05
Increased roughness	1.52 ± 0.05	1.27 ± 0.01
Reduced roughness	1.32 ± 0.01	1.15 ± 0.01

CONCLUSIONS: The bio-degradation rate of Mg alloys can be significantly decreased with the proposed coating strategy. Moreover, the coating morphology is highly influenced by the underlying surface morphology and wettability. This gives way to tailoring surface morphologies to enhance and control the bio-degradation rate of Mg alloys.

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