Surface Characterization and Corrosion Behavior of Silanized Magnesium Coated With Graphene for Biomedical Application

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Statement of Purpose: Magnesium (Mg) and its alloys have recently received as a biodegradable metal for bone substitute applications [1, 2]. However, the rapid corrosion of Mg and its alloys in chloride containing solutions including human body fluid or plasma has limited their clinical applications [3]. Therefore, it is very important to improve the corrosion resistance of Mg and its alloys in order that they can be applied clinically. There have been some methods available for improving the corrosion resistance of Mg and its alloys, such as chemical conversion coatings, electrodeposition, thermal spray, polymer plating, anodic oxidation, physical vapor deposition and chemical vapor deposition [4, 5] were used for enhancing efficiently the corrosion resistance of Mg and its alloys. Among the different techniques, silane based anti-corrosive coatings for Mg and its alloys has been proven to be effective, inexpensive and environmentally friendly [6]. In addition graphene- based protective layers could be used to prevent corrosive degradation of metallic surfaces [7]. The present work reports an innovative approach for surface functionalization of Mg surface with functional hybrid silane layers and then further coated with functionalized graphene oxide (GO) for improving corrosion resistance of Mg.

Methods: Pure Mg with dimensions 2 ×1.5 × 0.4 cm^3 was polished with SiC papers upto grit 2000, ultrasonically cleaned with acetone and immersed in 5M NaOH solution for 2h to produce uniform –OH layers on Mg surface. Then the Mg sample was immersed in 3-aminopropyltriethoxysilane (v/v) (5% silane, 90% ethanol and 5% water) solution at room temperature for 1h, dried cured at 120°C for 1h and denoted as Mg-silane. Further, Mg silane was immersed in 50ml (0.5mg/ml) of GO suspension for 4h. The bilayered samples were denoted as Mg-silane-GO. Prepared samples surface were characterized by FE-SEM, FT-IR, XRD, Raman spectroscopy and potentiodynamic polarization test.

Results: A successful two-step treatment combining the formation of hybrid silane films and GO was developed for the pure Mg. FT-IR shows Si-O network and protonated amino groups from aminosilane. FE-SEM showed that the GO nanoplatelet uniformly coated on the Mg surface. Raman study shows there is no detectable Raman signal for bare Mg. However, Mg-silane gave rise to Raman signals of silane groups. Raman spectra of Mg-silane-GO demonstrated well-known D band at 1355 cm^{-1} and G band at 1576 cm^{-1} confirms the uniform graphene layer on the Mg surface (Fig. 1A). Fig. 1B, C and D depicts the potentiodynamic polarization test, Nyquist plots and Bode plots to commercial saline environments, respectively. The results evidence a marked increased of corrosion potential and the impedance of the graphene oxide coated materials than only silane coatings and bare Mg. Thus, the graphene oxide coated Mg surface has higher corrosion resistance.

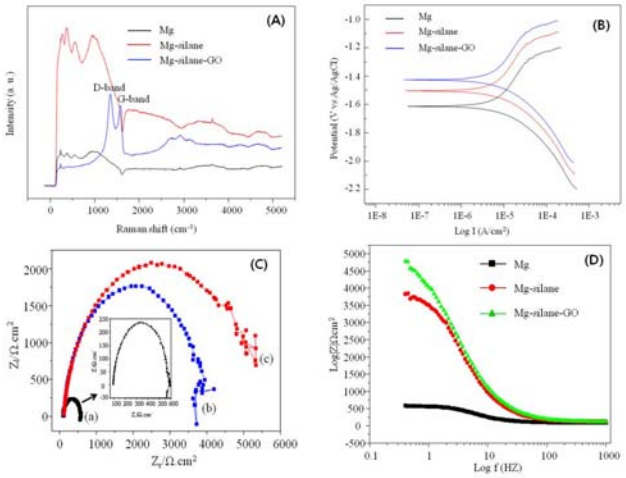

Figure 1. (A) Raman spectroscopy (B) Potentiodynamic polarization test (C) Nyquist plots of (a) Mg, (b) Mg-silane (c) Mg-silane-GO (D) Bode plots

Conclusions: The corrosion resistance of pure Mg, Mg-silane and Mg-silane-GO in commercial saline solution was investigated by electrochemical measurement. Comparatively to bare Mg and Mg-silane, the corrosion resistance and barrier properties of Mg-silane-GO, a synergistic effect is evidenced. It is believed that a graphene material which is coated on the metal surface would be an effective strategy for improving the anticorrosion performance of various engineering materials. This proposed method of corrosion passivation is quite versatile and is applicable to arbitrary metallic surfaces that are either smooth or rough. Furthermore, the suitable thickness of coated GO on metallic substrates is promising for the preparation of biocompatible materials.

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