Calcium Phosphate Coatings on Magnesium Alloy

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Statement of Purpose: Magnesium (Mg) and its alloys are currently being investigated for its potential applications as a biodegradable metallic implant including orthopedic fracture fixation devices. The elastic moduli of current metals used for fracture fixation devices are not well matched with that of natural bone tissue, resulting in stress shielding effects that can lead to reduced stimulation of new bone growth and remodeling which decreases implant stability. Permanent metallic fracture fixation devices have reports of metal ions dissolution that could trigger infections, causing an increase in the number of surgical interventions. Present biodegradable polymer fixation devices do not possess sufficient mechanical properties and furthermore also cause stress shielding due to mismatch of elastic modulus[1].

Development of biodegradable fracture fixation devices made up of magnesium offers various advantages in comparison to current materials used for fracture fixation devices. The fracture toughness of magnesium is greater than ceramic biomaterials such as hydroxyapatite, while the elastic modulus and compressive yield strength of magnesium are closer to those of natural bone than is the case for other commonly used metallic implants. The in vivo corrosion of magnesium based implant involves the formation of a soluble, non-toxic oxide that is harmlessly excreted in the urine. Magnesium is also essential to human metabolism and is naturally found in bone tissue. Mg alloys have also shown to have osteoconductive and osteoinductive properties. One of the main challenges in the use of magnesium and its alloys for biomedical applications is its poor corrosion resistance in physiological environments[2].

In this abstract we report the electro deposition of hydroxyapatite (HA) on magnesium alloy using ionic liquids and its subsequent characterization. HA is the principal inorganic compound of natural bone and can accelerate the growth of bone. It is hypothesized that the HA coating would slower the degradation of magnesium in physiological conditions while providing a coating that is conducive to bone growth.

Materials and Methods: The substrate material was magnesium AZ31 alloy with a size of 1.5 cm x 5 cm x 0.25mm. Prior to electrochemical deposition, the samples were pre-treated in alkaline solution by dipping the samples in 1 M NaOH solution for 1 hour at 70°C. Electrolyte for preparing calcium phosphate deposits was made by mixing a solution of 0.61 M $Ca(NO_3)_2$ with 0.36 M $NH_4H_2PO_4$ in the ionic liquid (1-butyl-2,3 dimethylimidazolium tetrafluoroborate) in 1:2 molar ratio. A platinum electrode was used as an anode and magnesium AZ31 specimen was used as cathode. Electrodeposition was carried out at a current of 0.4 amperes at room temperature for 90 minutes using a DC power supply. After electrodeposition of HA on magnesium substrates the coated samples were removed from the electrochemical solution and rinsed in distilled water. The samples were then immersed in 1 M NaOH solution for 1 hour at 70°C for the post treatment process to convert the di-calcium phosphate dihydrate into HA coating. The sample was then dried and subsequently characterized.

Results: Figure 1 shows the optical microscopy images of bare magnesium (figure 1A) and that of HA coated magnesium (figure 1B). The optical images clearly show presence of a white porous coating on the magnesium substrate. Figure 2 shows the FTIR spectra of HA coated magnesium samples. The speak at 1411cm^{-1}, represents the calcium peaks and the peaks at 560, 601 and 1021cm^{-1} represent phosphate peaks in HA. These peak values are in agreement with reported literature peaks of HA[3].

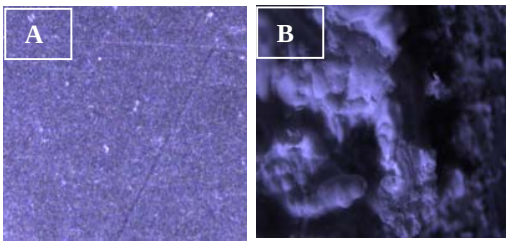

Figure 1. Optical microscopy images of (a) bare magnesium and (b) HA coated magnesium

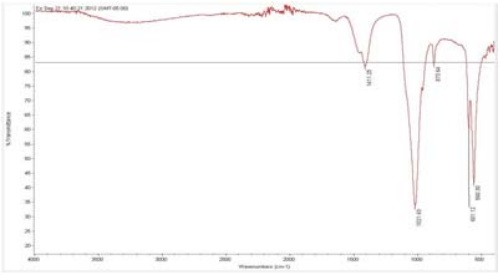

Figure 2. FTIR spectra of HA coated magnesium sample

Conclusions: Hydroxyapatite was successfully coated on magnesium substrates via electro deposition in ionic liquids. Surface characterization using optical microscope and FTIR successfully confirmed formation of HA coatings on magnesium substrates.

References:

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