Effect of Polymer Characteristics on the Degradation Behavior of 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 for applications in cardiovascular (stent) and orthopedic (fracture fixation) devices. Current metallic materials used for stents and fracture fixation devices have reports of metal ions dissolution that could trigger infections, causing an increase in the number of surgical interventions. Biodegradable polymers have been explored for their potential use as biodegradable stents and bone screws, plates however they do not possess the appropriate mechanical properties when compared to the metals used for those applications[1].

Development of biodegradable metallic implant devices made up of magnesium offers various advantages. 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 has favorable mechanical properties as compared to biodegradable polymers for the chosen cardiovascular and orthopedic applications. One of the main challenges in the use of magnesium and its alloys for biomedical applications is its poor corrosion resistance in physiological environments[1]. Various coating strategies including polymers have been investigated to control the degradation of magnesium however limited knowledge exists on the effect polymer characteristics on the degradation behavior of magnesium alloy.

In this abstract we investigate the effect of polymer characteristics on the degradation behavior of magnesium alloy. Poly-caprolactone (PCL) of varying thickness and molecular weights were coated on magnesium substrates and their effect on the degradation behavior of Mg studies.

Materials and Methods: Commercially available magnesium AZ31 alloy with a size of 1.5 cm x 5 cm x 0.25mm were used as substrates for the study.

Table1: Characteristics of Polymer Coatings on Magnesium Alloy

	Molecular Weight of PCL: Mn=70,000-90,000	Molecular Weight of PCL: Mn=45,000
Coating thickness: 160 µm	H10: average thickness 159 µm	M-H10: average thickness 158 µm
Coating thickness: 930 µm	H40: average thickness 933 µm	M-H10: average thickness 924 µm

PCL of varying molecular weights and thickness (table 1) were formed by dip coating on magnesium alloy substrates and subsequent air dying. PCL of varying molecular weights (Mn=10,000 Mn=45,000 and Mn=70,000-90,000) were purchased from Sigma Aldrich and coatings of uniform thickness were formed to compare effect of molecular weights while effect of thickness were compared at constant molecular weights. The PCL with Mn=10,000 did not give an intact coating hence was discarded for the purpose of study. Corrosion rates were determined for the polymer coated magnesium using electrochemical methods (tafel plots).

Results: Figure 1 shows that the polymer coatings effectively retarded the corrosion rate of magnesium. Figure 2 shows the effect of polymer characteristics on the degradation behavior of magnesium alloy. Comparing coatings with varying thickness (M-H10 vs M-H40 and H-10 vs H-40) we can see that the increasing the coating thickness results in lowering overall corrosion rate. Figure 2 also shows that within the range of molecular weight studied, there was no effect of molecular weight on corrosion rate (M-H10 vs H10 and M-H40 vs H40).

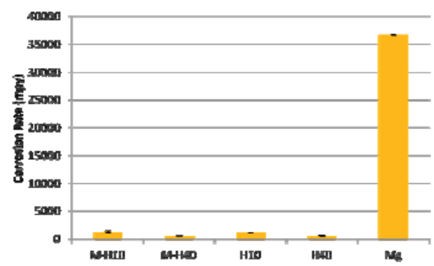

Figure 1. Effect of polymer coatings on the degradation behavior of magnesium alloy

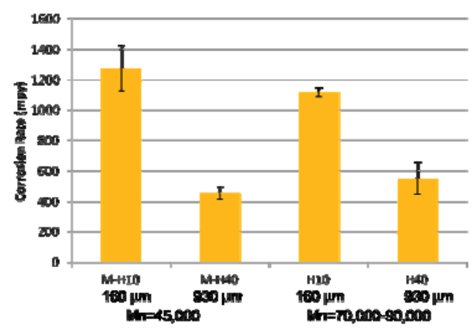

Figure 2. Effect of polymer characteristics on the overall corrosion rate of Mg coated samples

Conclusions: Based on the results we concluded that within the range of molecular weight studied, there was no effect of molecular weight on corrosion rate and that increasing the coating thickness results in lowering overall corrosion rate.

References:

1.Witte F, Hort N, Vogt C, Cohen S, Kainer KU, Willumeit R, Feyerabend F. Current Opinion in Solid State and Materials Science 2008;12(5-6):63-72.