Flexible HA coating on magnesium for orthopedic implant applications

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Statement of Purpose: Magnesium (Mg) has great potential as a biodegradable implant material due to its good biocompatibility and degradability [1]. However, the rapid corrosion in the physiological environment has limited the clinical use of Mg. One approach to control the degradation rate of Mg is surface modification, such as micro-arc oxidation (MAO) or coating. Bioactive coatings particularly impede the initial corrosion of Mg and promote the direct contact of hard tissue [2]. However, the inorganic coatings are very susceptible to failure when the mechanical strain was applied, which can be occurred during surgical procedure. In this study, bioactive hydroxyapatite (HA) was coated on Mg with poly(ε-caprolactone) interlayer to enhance the bioactivity of Mg and at the same time to retain the HA coating during Mg substrate bending. HA was deposited on the PCL coated Mg using aerosol deposition and the coating failure was examined after the substrate bending.

Methods : Pure magnesium samples with dimensions of 35mm × 6mm × 2mm were prepared and ground with SiC papers. Then, PCL was coated on the Mg samples by spin coating. PCL solution (5% w/v in tetrahydrofuran) was prepared, coated on Mg at 2000 rpm for 1 min, and dried in air. Subsequently, HA was deposited on the PCL coated Mg using aerosol deposition method. To examine the flexibility of HA coating during bending, the HA coated sample with or without PCL interlayer was bent. Then, the surface of the HA coating was observed using SEM. The middle part of the sample was observed where the maximum strain (0.09) was induced.

Results: Figure 1 shows the surface morphology of the coated sample. The spin-coated PCL was uniform and the rough HA layer was successively formed on the polymeric interlayer. The coated sample was bent using 3-point bending test jig (Fig. 2). The maximum tensile strain was calculated to be 0.09 at the middle of the coating (yellow circle in Fig. 2). After bending, different coating behaviors were observed between two coating systems. The HA coating without a PCL interlayer was severely cracked, as shown in Figure 3(A). In contrast, no visible crack was detected in the HA coating with a PCL interlayer, as shown in Figure 2(B).

Conclusions: Flexible HA was coated on Mg in this study. Stretchable PCL was coated on the pure Mg as an interlayer and then bioactive HA was deposited on it using aerosol deposition. The SEM observation indicated that the HA coating was well formed on the PCL interlayer and remained intact after the mechanical strain was imposed on the Mg substrate.
Further studies are in progress to confirm the potential use of HA/PCL coated Mg as a flexible implant material.

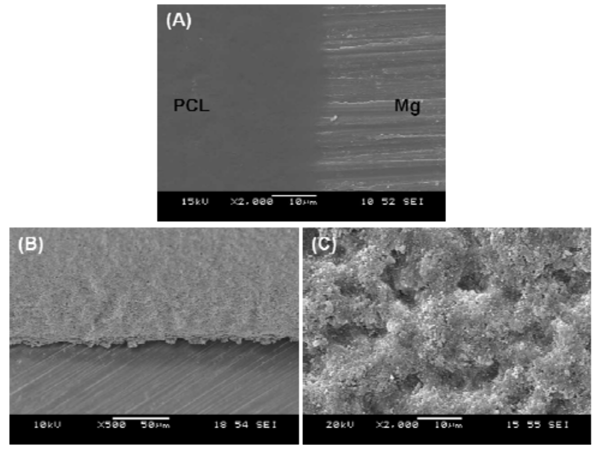

Fig 1. SEM micrographs of the (A) PCL and (B) HA/PCL coated Mg.

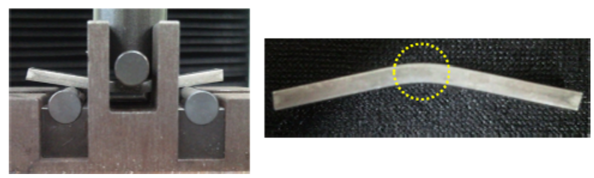

Fig 2. Optical images showing bending procedure and sample after bending.

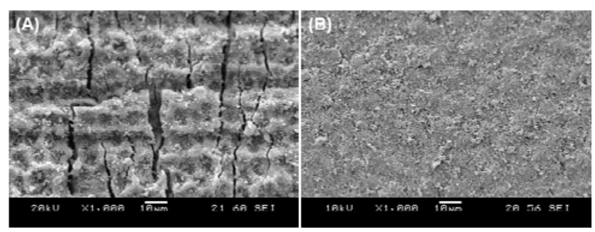

Fig 3. SEM images of HA layers (A) without and (B) with PCL interlayer after bending.

References:
1. Staiger MP, Pietak AM, Huadmi J, Dias G. Biomaterials. 2006;27:1728-1734.
2. Xu L, Pan F, Yu G, Yang L, Zhang E, Yang K. Biomaterials. 2009;30:1512-1523.