Tricalcium phosphate embedded poly(vinylidene fluoride) coating on magnesium for biomedical applications

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Introduction: Magnesium has a great potential as a biodegradable implant materials due to its favorable combination of mechanical properties, biodegradability and biocompatibility [1]. Recently it has been considered as a promising material for coronary stent applications because the biodegradability of Mg can eliminate potential long-term complications of other metal stents [2]. These beneficial characteristics notwithstanding, rapid corrosion of Mg in the physiological environment has limited its clinical use. Among the approaches to mitigate the degradation of Mg, protective polymer coatings are suitable in terms of flexibility for stents and effective in delaying initial corrosion. In this study, the surface of Mg was coated with PVDF containing TCP. TCP was embedded in PVDF to increase biocompatibility of the coatings. The effects of the coating layer on corrosion and biological properties were evaluated by *in vitro* studies.

Methods: Pure Mg plates polished to 1200 grit with SiC papers were prepared with dimensions of 15 mm × 15 mm × 2 mm. Prior to the coating process, poly(vinylidene fluoride) (PVDF) solution was prepared by dissolving PVDF pellets in N,N-dimethylacetamide (DMAc) with a concentration of 20 wt%. After complete dissolving, 2, 5 and 10 wt% of tricalcium phosphate (TCP) powder was mixed into the solution. Then, prepared PVDF solution was dropped on the Mg surfaces and spin-coated at a spin speed of 3000 rpm for 1 min. Subsequently, the specimens were placed inside a vacuum oven at 150 °C and dried for 2 h at a pressure of 10 mbar. To evaluate corrosion resistance, the Mg samples were soaked in simulated body fluid (SBF) and pH variation was measured at set intervals. In order to examine biological properties, *in vitro* cell tests were performed using MC3T3-E1 pre-osteoblast cells.

Results: Fig. 1 shows the surface morphologies of PVDF coated Mg (A) and that with 5 wt% of TCP (B). Highly porous structure with a pore size of 2~5 μm was formed and TCP particles were evenly distributed throughout the surface. In SBF, pH variation of the coated specimens was significantly mitigated compared to that of bare Mg (Fig. 2). In particular, 2 and 5 wt% TCP added samples showed better resistance. The MC3T3-E1 cells were cultured on the samples for 1 day (Fig. 3). Shape of the attached cells was getting favorable with increasing the amount of TCP till 5 wt%. Apparently TCP had a positive effect on bioactivity, but 10 wt% of TCP was too much, weakening stability of the coating. Same tendency was observed in cell proliferation analysis (Fig. 4). PVDF with 5 wt% TCP exhibited the highest level of DNA contents.

Conclusions: The protective PVDF layer with and without TCP were fabricated on Mg surface by spin coating process. Porous structure was formed and TCP powder was uniformly distributed on the surface. Corrosion resistance was improved with the coatings, resulting in the decrease of pH variation in SBF. The *in vitro* cell tests revealed that PVDF with TCP coating considerably enhanced the cellular response of the specimens. In conclusion, the PVDF coating with TCP significantly improved the corrosion resistance and the bioactivity of Mg.

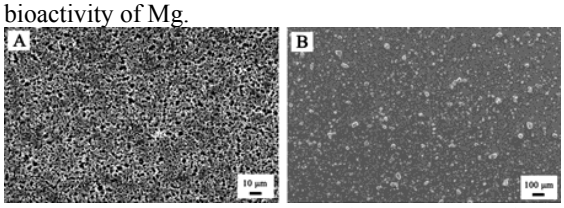

Fig. 1. SEM micrographs of (A) the PVDF coated Mg with 0 wt% and (B) 5 wt% TCP.

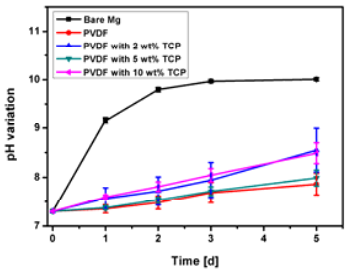

Fig. 2. Variation of pH in the simulated body fluid (SBF).

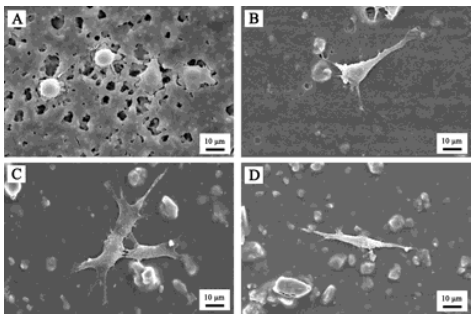

Fig. 3. SEM micrographs of the MC3T3-E1 cells on (A) the PVDF coated Mg with 0 wt%, (B) 2 wt%, (C) 5 wt% and (D) 10 wt% TCP.

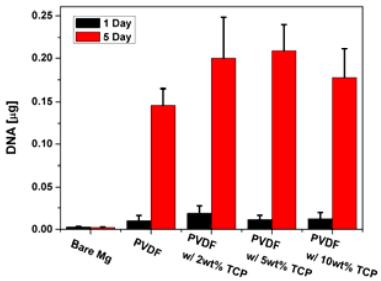

Fig. 4. DNA levels of the MC3T3-E1 cells that were cultured for 1 and 5 days.

References:

1. Staiger MP, Biomaterials. 2006;27:1728-34
2. Erne P, Cardiovasc Inter Rad. 2006;29:11-6.