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Article / Book Information

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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

Mg-Zn-Zr magnesium alloys have gained increasing attention for temporary orthopedic implant devices because Mg alloys exhibit biodegradability, suitable mechanical strength and avoid stress shielding effect. However, the high corrosion rate limits their clinical application. Surface coating with calcium phosphate layers is an effective approach to solve this issue. In the chemical conversion method, initial properties of the substrate (i.e., corrosion, microstructure and second phases) influence on the formation of the calcium phosphate coatings, which controls strongly the performance of the biomaterial during implantation. However, their formation and effects on ZK60 alloy for bio-application have been seldom investigated. Therefore, this thesis aims to study the formation of calcium phosphate coatings on ZK60 alloy; after that, the influences of the coatings on corrosion behavior, biocompatibility and mechanical integrity of the alloy were also investigated.

In methodology, several calcium phosphate coatings were formed on as-extruded ZK60 alloy by changing pH conditions to 6.5, 7.0, 7.8 and 10.2 in the chemical conversion method. Immersion tests in body-simulated solution were carried out to investigate the corrosion behavior of the coated samples. Biocompatibility of the samples was examined in cell culture tests using MC3T3-E1 osteoblasts and subcutaneous implantations in rabbits. Compression tests were performed on the immersed samples to evaluate their mechanical integrity after several immersion periods.

It was found that the coatings contain a dense inner layer and a porous outer layer. The inner layer plays a dominant role in corrosion protection. The pH conditions governed the coating type, morphology and thickness. At pH 6.5, an octacalcium phosphate (OCP) single phase layer was formed. At pH 7.0, an OCP+hydroxyapatite (HAp) mixture layer was formed. A HAp single layer and a HAp layer with an intermediate $Mg(OH)_2$ layer were formed at pH 7.8 and 10.2, respectively. The sample coated at pH 7.8 showed the lowest corrosion rate thanks to the thickest inner layer and uniformity of the HAp coating. HAp corrosion product was deposited only on this sample, suggesting the biocompatibility of this sample after corrosion.

After that, *in vitro* cell culture tests, the surface properties of the coatings controlled the cell morphology and proliferation. The coating morphology is more dominant than the coating type and corrosion protectiveness. Osteoblastic cells were vanished on the uncoated sample and shrunk severely on the sample coated at pH 10.2. Meanwhile, cells proliferated well on the samples coated at pH 6.5 and 7.8 with a density that was about double the seeding density after 3 days. Cells showed better morphology on the sample coated at pH 7.8. In rabbits, this coated sample showed a lower degradation rate and a reduction of gas cavities, compared to the uncoated sample. The HAp coating formed at pH 7.8 also degraded during the implantation, which is desired for degradable biomaterials.

The samples were degraded mainly by localized corrosion, especially pitting, both *in vitro* and *in vivo*. Pitting occurred through micrometer defects inside the coatings. Filiform propagated due to the $Mg(OH)_2$ intermediate layer between the coating and substrate. Under mechanical stress, pitting conditioned for crack initiation and growth. The coated sample had better corrosion resistance but suffered pitting more slightly than the uncoated sample. There was a negligible difference in the ultimate compressive strength between the uncoated and coated samples. Therefore, the coating showed insignificant effects on the mechanical integrity of the ZK60 alloy. Because of the initial high strength, the uncoated alloy still showed good mechanical strength even after corrosion, compared to human bone.

In conclusion, although showed no effects on its mechanical integrity, the coating formed at pH 7.8 improved significantly corrosion resistance and biocompatibility of the alloy. Hence, ZK60 alloy coated at pH 7.8 is an outstanding candidate for temporary orthopedic implantation.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).