

Bioresorbable composite materials with controlled resorption rate for bone tissue bioengineering

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Results

Morphology of the prepared composites were analyzed by SEM and showed grain size of 20 to 100 μm veined with calcium phosphate ceramic. It is shown that formation of a PEO coating provides protective functions and largely depends on the composition of the substrate. The studied morphology and composition of the substrate-oxide layer interface made it possible to allocate a non-porous magnesium fluoride sublayer formed during plasma electrolytic oxidation at the initial stage near the metal surface. In addition, silicon is uniformly distributed throughout the coating thickness, which suggests the presence of magnesium orthosilicate (Mg_2SiO_4) in an amount sufficient for XRD detection. It has been shown that obtained coatings substantially reduce corrosion current density in comparison with bare Mg ($2.54 \cdot 10^{-5} \rightarrow 1.05 \cdot 10^{-8} \text{ A/cm}^2$). Application of the PEO layer reduces the substrate corrosion rate by more than 6 times ($4.21 \rightarrow 0.65 \text{ mm/year}$).

Conclusions

The obtained biodegradable matrices based on magnesium with a significant content of the bioactive component in the volume and on the surface are as close as possible to the properties of bone tissue in terms of morphological structure (porosity that promotes proliferation) and fullness of calcium phosphate compound. Varying the composition of the electrolyte for the formation of a PEO layer makes it possible to regulate the thickness and phase composition of the protective layer by controlling the rate of resorption of the formed material.

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Introduction

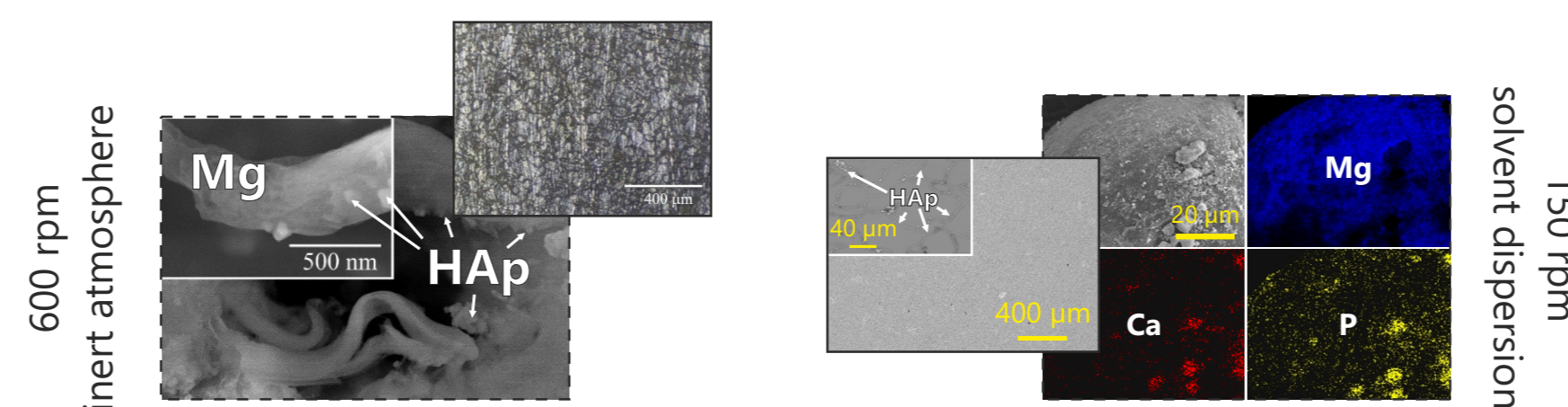
The experience of the pandemic has shown that it is expected to increase the cost not only for healthcare, but also for developments in the field of medicine to increase the production of competitive medical devices and new generation materials. In China, as the most populous country, has more than 15 million people with limited limb function.

About 200 million people worldwide suffer from osteoporosis and 8.9 million fractures occur each year [1]. By 2050, the number of osteoporotic fractures of the femoral neck is expected to increase to 1 million cases annually in Europe; the mortality associated with osteoporotic fractures exceeds oncological ones in most cases. Design of modern tissue-compatible frameworks (scaffolds) imitating the structure of bone tissue, as well as a bioresorbable composite materials allows for complete replacement of the bone defect and preserves the functionality of the limbs [2-6].

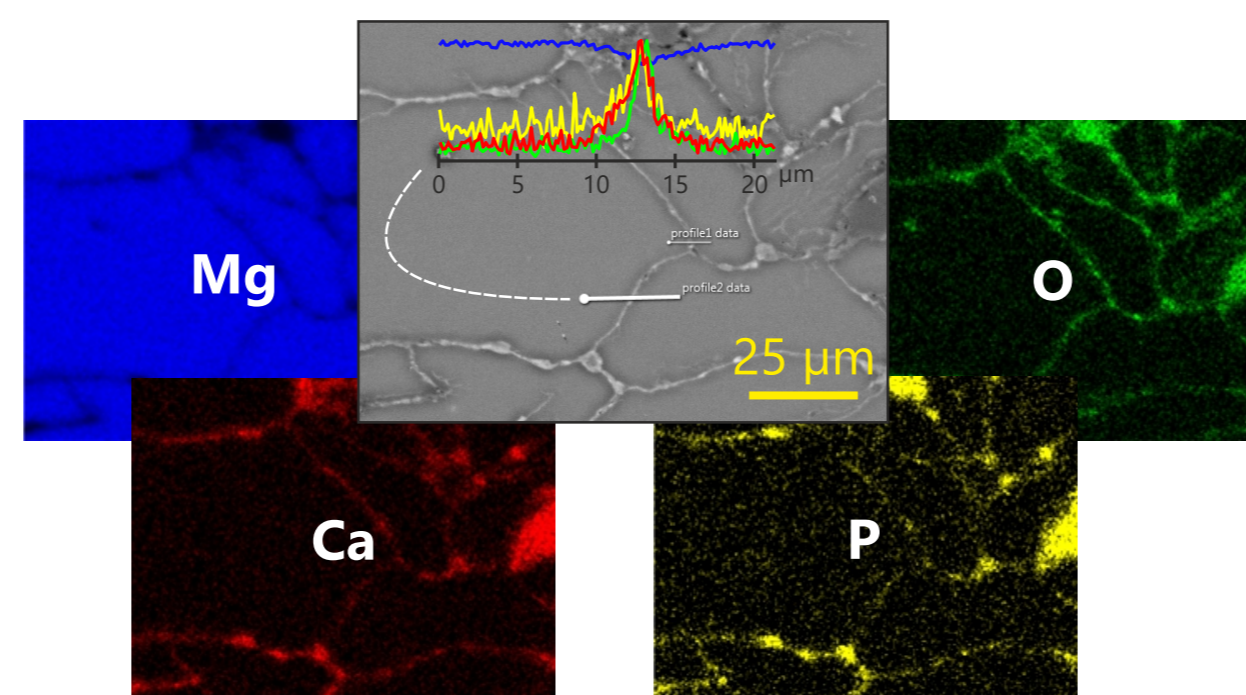
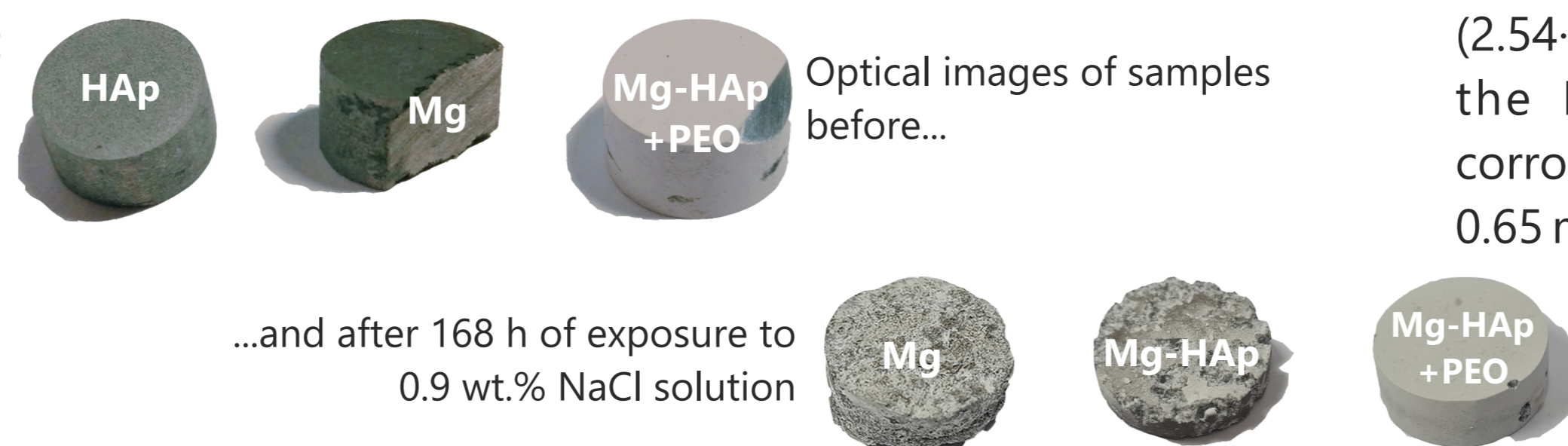
Directional synthesis of a composite material combining acceptable elastoplastic properties close to bone (magnesium) and bioactivity of the ceramic component (hydroxyapatite) as an osteointegration basis for the formation of new bone tissue are at the forefront of global research in the field of development of materials for implantology. Since the corrosiveness of magnesium is too high and does not allow the mechanical properties of a temporary implant to be maintained for the period necessary for the bone splicing, its necessary to protect the metal base from destruction, including through forming a coating [7].

Objectives, methods

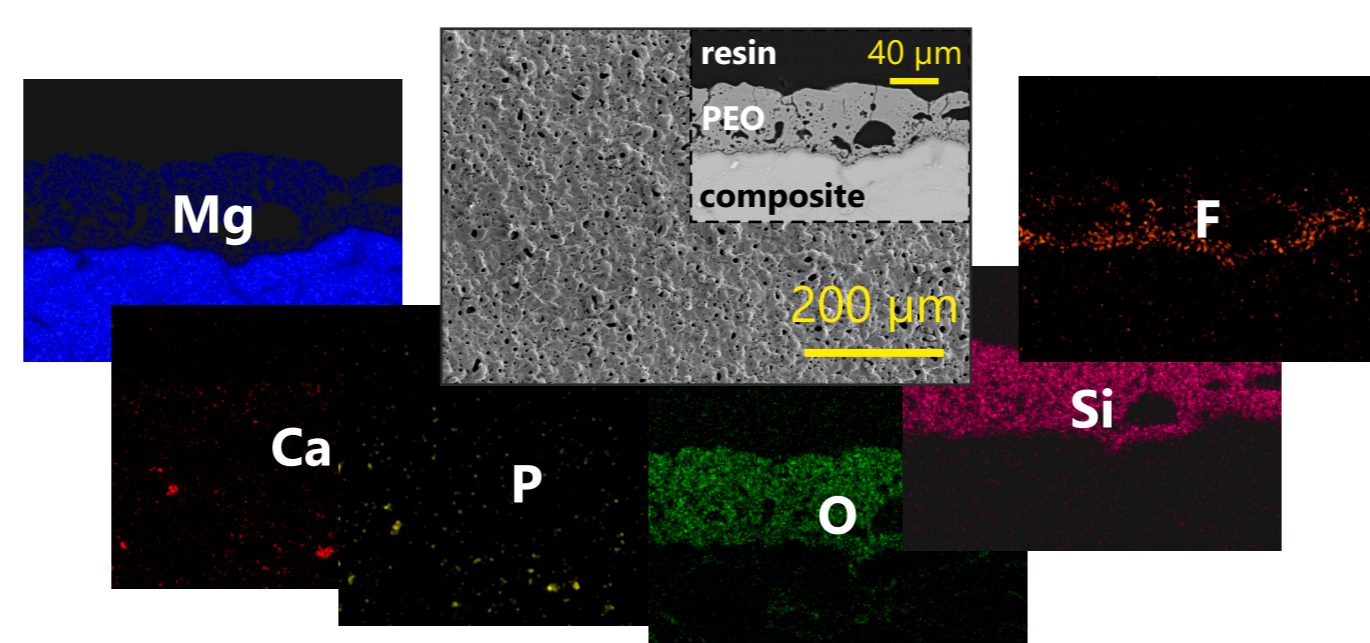
Pure magnesium ($\geq 99.9\%$, size $\leq 40 \mu\text{m}$, Merck) and hydroxyapatite ($\leq 80 \text{ nm}$, precipitation-microwave synthesis) powders were used as starting materials for Mg-HAp composition. Composites were sintered using spark plasma sintering of powders on the SPS-515S installation of the "Dr. Sinter-LAB TM" company (Japan). An oxide coating by the method of plasma electrolytic oxidation was applied to the surface of the composites formed by SPS technology. The obtained materials were analyzed for phase composition, shape and particle size, etc.



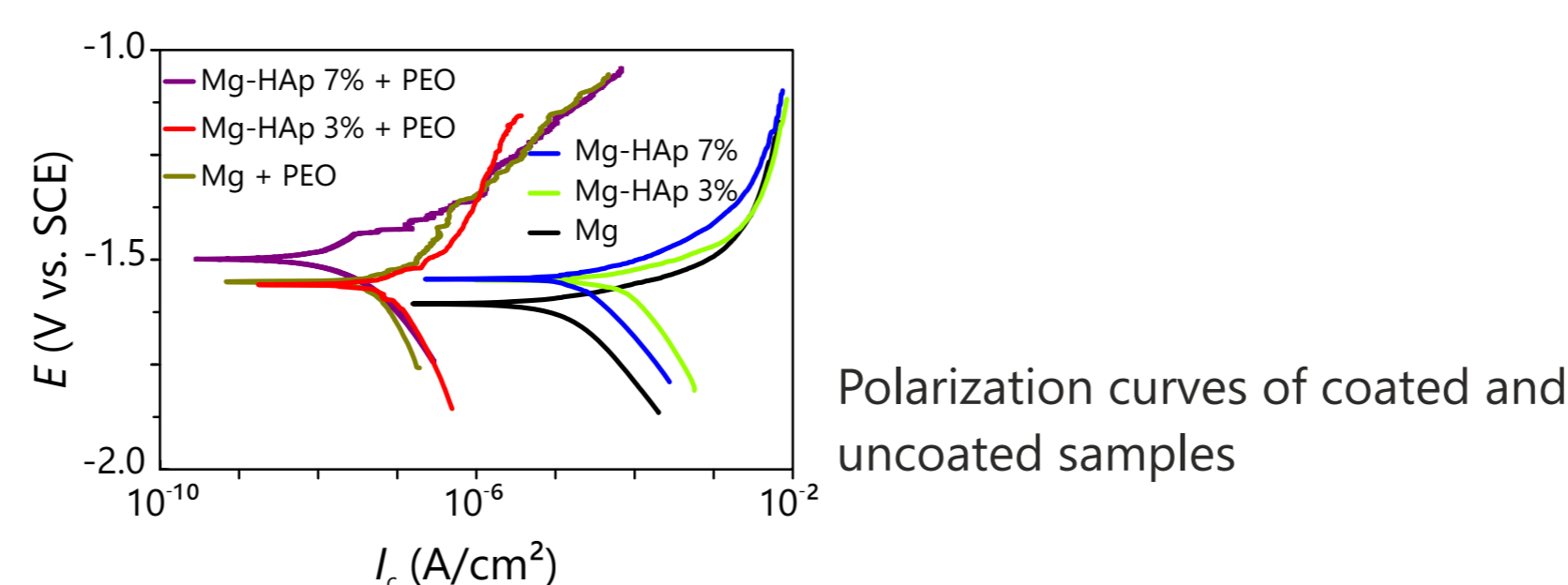
Optical, SEM and SEM-EDX images of the initial composition formed under different conditions as well as obtained material



SEM image of the sintered Mg-HAp composite microstructure and the distribution of elements (Mg, Ca, P, O) over the cross-section surface



SEM-image of Mg-HAp 7% PEO sample: surface and cross-section with the distribution of elements over the coating thickness



Polarization curves of coated and uncoated samples

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