

Diffusion-Controlled Crystallization of Calcium Phosphate Using a Dual-Diffusion System

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Hydroxyapatite is one of the crystalline calcium phosphate and is the primary mineral that constitutes bones and teeth.^[1,2] Bone formation occurs through the interactions between calcium phosphate and collagen.^[3-5] Collagen provides a framework and spatial constraints for hydroxyapatite nucleation and growth through self-assembly. In the bone formation process, ions composing calcium phosphate and amorphous intermediate penetrate the gaps between collagen fibers.^[2] The mineralized collagen fiber bundles formed through this interaction regulate the stiffness of the bone based on the structural orientation and serve to distribute the load uniformly.^[6] Due to the importance of this physical and hierarchical structure of bone, it has been intensively studied to synthesize calcium phosphate by mimicking the physiological environment.^[1,7] To mimic microenvironment of bone formation, hydrogels have been applied to synthesize organic-inorganic composites.^[1-9] In addition, it is known that ion flux and local pH within hydrogel play an important role in determining the shape and the phases of calcium phosphate.^[6] In this study, calcium phosphate was synthesized by mimicking slow diffusion in biological systems through hydrogels and controlling pH. Using a hydrogel-based dual diffusion system, calcium and hydroxide ions diffused into the phosphate buffer hydrogel in an opposite direction. As the supersaturation level and pH varied by combination of calcium flux and hydroxide ions, plate-like dicalcium phosphate dihydrate, sea urchin-shaped hydroxyapatite, and spherical amorphous calcium phosphate were formed in a specific location in a hydrogel. It was confirmed that variation in ion concentration within the hydrogel affects the growth of calcium phosphate crystals. SAED analysis, the calcium phosphate phases formed in this system are hydroxyapatite and amorphous calcium phosphate. In XRD analysis, dicalcium phosphate dihydrate formed in the region closest to the Ca²⁺ reservoir, while hydroxyapatite formed as the OH⁻ reservoir approached. These results emphasize that the morphology of the crystal changed depending on the pH at the time of crystal formation.

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