SUMMARY OF Ph.D. DISSERTATION

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Title

Comprehensive Control of Crystal Growth by Biomimetic Mineralization
-Toward to Establish a New Bottom-up Microfabrication Technology -

Abstract

Material synthesis mimicking biomineralization has attracted a considerable amount of attention because of its potential for preparation of highly tailored microscopic architectures consisting of organic-inorganic composites through ecological processing. The morphological study on crystal growth of calcium carbonate has been mainly performed using various kinds of organic additives as a biomimetic mineralization. However, understanding of the essence for the structural control of inorganic crystals with organic agents is still insufficient for development of bottom-up microfabrication technique for a wide variety of inorganic materials. In this work, therefore, I investigated the influence of soluble and insoluble polymeric organic agents on the morphology, crystallographic orientation and polymorphism of calcium carbonate and successfully produced various architectures consisting of the microcrystals. Moreover, the mechanisms of the formation of specific morphologies and the control of the polymorphs were clarified in order to apply the biomimetic mineralization technique to functional materials.

Chapter 1 summarizes the background and previous studies, and then describes the objective of this study.

Chapter 2 describes the formation mechanism of calcium carbonate films in the presence of organic polymers. Soluble polymers containing carboxy group promoted the surface nucleation on a substrate and miniaturized the crystal grains through suppression of the crystal growth with adsorption on specific surfaces. The films were formed by synergetic effects of the soluble polymers. The role of insoluble polyalcohol polymers is assistance of adsorption of the soluble organic polymers on a substrate.

Chapter 3 describes three-dimensional development of calcium carbonate films. Various kinds of microarrays of calcium carbonate were successfully produced by subsequent growth technique. The crystal structure and orientation of the micrograins were fundamentally inherited from the basal crystals. Alternation of the growth mode from two-dimension in the presence of specific polymeric agents into three-dimension without organic additives would be essential for the control of the microarchitectures.

Chapter 4 describes the control of the polymorphs of calcium carbonate using organic agents. The selective production of a particular crystal structure was achieved by templating with soluble polymers adsorbed on the surface of an insoluble polyalcohol substrate. The arrangement of the adsorbed polymers was found to depend on the molecular weight of soluble polymer and temperature of the solution.

Chapter 5 describes the similarity of silicate anions and organic polymers containing carboxy groups for the crystal growth of carbonate crystals. Planar films of calcium, strontium and barium carbonates were obtained on the insoluble polyalcohol substrate with silicate anions under a high pH condition.

Chapter 6 describes the summary of this study and the future outlook of the biomimetic mineralization.