The crystallization by the interaction between organic materials and inorganic minerals is called “biomineralization”. The formation of bivalve shell is a biomineralization of calcium carbonate (CaCO₃) crystal. Some kinds of bivalve shell consist of calcite and aragonite which are polymorphs of CaCO₃ crystal. Although aragonite is metastable at normal temperature and pressure, some mollusks make aragonite stable by organic matrices [1], [2]. Amino acid sequences of some special proteins were reveal which are contained in the organic matrices of the shell, and it was confirmed that many aspartic acids are included in the proteins [3], [4].

In this study, we carried out in situ observation of aragonite formation by addition of the synthetic polypeptide which consisted of 15 amino acid residues and had periodic arrangement of six aspartic acids [3].

First of all, supersaturated solution of CaCO₃ with the synthetic polypeptide and magnesium (ω=0.86, [Mg²⁺]=0.05 M, the concentration of the polypeptide = 50 µg/ml) was loaded on the calcite crystal which was cleaved on (10-14) face, then the surface was observed in atomic level. In order to observe the change of the surface pattern in atomic resolution, in situ and in solution, the Frequency Modulation Atomic Force Microscopy (FM-AFM) was employed. In this solution, we succeeded to observe the moment of aragonite formation at 90 minutes after the solution was loaded. The boundary of the atomic patterns of calcite and aragonite was observed in 10 nm², and aragonite and calcite were in the same layer.

Secondly, the concentration of the synthetic polypeptide was lowered to 30 µg/ml. In this solution, some adsorbents were observed on only calcite surface, and they adsorbed along calcium sequence of calcite [010]. The length of adsorbents is 3 - 6 nm. This is close to the length of monomolecular of the synthetic polypeptide.

These results show that calcite transforms to aragonite in the surface layer of seed crystal, and the adsorbents are likely to be the synthetic polypeptide. Because aspartic acids in the synthetic polypeptide can bond to calcium atoms on the surface by carboxyl group.

Our results strongly suggest the new model of aragonite formation under normal condition by the transformation.

References:

Keywords: biomineralization, atomic force microscopy

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