

Chiral molecule movement and adsorption at calcite steps

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Calcite is one of the most abundant mineral in the calcium carbonate group. It is known that calcite changes its shape or surface pattern in the presence of impurities. Recently, asymmetrical growth and dissolution patterns on the calcite {10(-)14} face in a solution with chiral amino acid was reported (Orme et al., 2001). However, the dependence of supersaturation effect on the shape of the calcite steps with chirality of aspartic acid has not been clarified.

We have employed a newly developed Phase-Shift Interferometry (PSI) to measure the very small step velocity of calcite as low as 10^{-3} nm/s. The concentrations of calcite and amino acid were varied from 0 to 0.8 and from 0 to 0.01 mol/l, respectively. Normal growth rate and the slope of spiral hillocks in pure calcite solution were successfully measured by PSI. Normal growth rate ranges from 0 to 0.05 nm/sec. When 0.01 mol/l L-aspartic acid is added to the solution, the dependency of step velocity on supersaturation is non-linear with maximum velocity at supersaturation = 0.2. Surprisingly, the step velocity with 0.01 mol/l L-aspartic acid at supersaturation = 0.2 was calculated to be 680% larger than that of pure solution. Aspartic acids act as promoter rather than inhibitor under such conditions, and this is a remarkable impurity effect. Up to now no theoretical models exist how impurities promote crystal growth.

We suggested that Asp changes the interface tension between calcite and solution, and thus promotes calcite growth. In order to obtain the interface free energy between solution and the crystal, which is the key parameter to determine the nucleation rate and the dissolution rate, the induction time vs. supersaturation has successfully been measured. Interface tension can be calculated from a relation between supersaturation and induction time of nucleus (Shonel and Mullin, 1978) (Liu et al., 2000).

The reduction of interfacial free energy in the presence of aspartic acid was obtained from this experiment. Lowered interfacial free energy resulted in an easier nucleation and an increase of the step velocity due to the step roughing (Chernov, 1984).