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Impedance and light scattering measurements of calcite nucleation in microgravity of a rocket experiment
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Introduction

It has been demonstrated for many years that the crystal growth experiments of calcite under microgravity conditions have provided new understandings of its crystallization processes as follows. Liu et al. (2000), Liu and Tsukamoto (2002) described the CaCO3 nucleation under gravity and microgravity conditions using a parabolic flight experiment, especially, using the light scattering measurements. They found that lack of the gravitational sink in solution leads an elimination of a convection under microgravity indicating heterogeneous nucleation process. More recently, Maruyama et al. (2006) studied surface tension between solution (Asparic acid-Asp) and calcite using light scattering methodology under microgravity provided by parabolic flights. They concluded that the calcite crystals from the Asp system grow faster than pure system. However, these authors were not able to get a relatively long microgravity conditions as they used the parabolic flight experiment giving 20 sec duration only.

Here, we present preliminary results of CaCO3 crystallization under a rocket experiment giving five minutes low-gravity duration. It is a purpose of this study to understand more about the transition of crystalline and amorphous states of carbonates as well as determination of the heterogeneous and homogeneous nucleation by means of impedance and light scattering measurements.

Experimental Procedure

The calcite experiment (CAL) has a cell system containing total of 16 channels for the solutions (0-11) and for test (12-15), which was developed by Takasago Electric Inc for this study. The cell has special syringe pumps and valves, which are able to introduce the solutions simultaneously into the cell at the moment when microgravity is started.

Solutions were produced by dissolving calcium chloride (CaCl2) and sodium carbonate (Na2CO3) in the double-destillated water (ultrapure water) with various mixed concentrations as follows: 2, 2.5, 2.75, 3, 3.2, 3.4, 3.6, 3.8, 4, 4.25, 4.5 and 5 mM.

CaCO3 solutions were prepared after the mixtures of CaCl2 and Na2CO3 solutions under the microgravity environment, which was based on the following chemical reactions.

CaCl2 (aq)+Na2CO3 (aq)—-2NaCl (aq)+CaCO3 (s)

Results and Discussion

As a function of increasing concentration, there is a systematic increase of the impedance intensity (in unit of micro Amper) among 7 selected cells, which are a good agreement with the light scattering data, too. Compared to data obtained at the laboratory, rapid crystallization (around 1 sec) occurs at relatively high concentrations of 4, 4.5, and 5 mM solutions of the rocket experiment. Other cells (at medium or low concentartions of 3.8, 3.6, 3.2, and 2.25 mM) show relatively low induction time.

Supersaturation of the CaCO3 solutions were calculated by using a phreeqC interactive software, which was based on inputs of average temperature (22.5 C) in the chamber, pH (10.5) and number of Ca and CO3 ions as well as the estimated induction time in sec.

Consequently, supersaturation data indicate a homogeneous nucleation in our microgravity experiment as it was suggested by Liu et al. (2000) and Liu and Tsukamoto (2002).

References

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