

More homogeneous crystal nucleation in microgravity

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Modeling nucleation rate of crystals during levitation in microgravity is interesting not only for pure sciences but also for the application to space sciences. Although we have been investigating the growth kinetics of chondrules and other cosmic materials from supercooled melts or gas phases, respectively, the quantitative analysis on nucleation rate at various gravity levels has not been achieved so far, because of the technical problems at high temperature.

Nucleation experiments in microgravity have thus been done using aqueous solution grown crystals in an airplane. Rate of nucleation of calcite, apatite, ferric oxide and protein crystals have been measured by rapid dynamic light scattering method, which enables us to measure the diameter of nucleus from a few nm to a few thousands nm at every 1 or 2 seconds. This new method was first applied to the crystals with very small solubility (~mg/l). Crystallization was initiated by mixing two solutions rapidly in less than 50ms.

It was a general tendency that the primary phase appeared in the solution was either amorphous or metastable crystalline phases and then these metastable phases dissolved as the stable crystalline phase appeared. When we measured Ca^{2+} ions in situ during the nucleation of apatite, the metastable phase was found to behave like a buffer to keep the Ca^{2+} concentration constant in the solution. This is because the interfacial free energy between the solution and the metastable phase is much smaller than that for crystalline phases, which will lead not only easier nucleation and growth but also easier dissolution when the solution became undersaturated as more stable phase appeared.

It was also found that nucleation rate in microgravity is 10,000 times less than that in normal gravity. This delay was well interpreted due to more homogeneous nucleation during levitation in reduced gravity [1].

[1] X.Y. Liu, K. Tsukamoto, M. Sorai, New Kinetics of CaCO_3 Nucleation and Microgravity Effect, *Langmuir* (2000) 16, 5499-5502.