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Impurity partitioning in colloidal crystallization

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Colloidal crystals are regarded as a promising tool to investigate diverse basic physical phenomena. We have applied this colloidal crystal to impurity partitioning in the melt growth. Since no research has been focused to detail partitioning behavior of colloidal crystals, the objective of the present work is to reveal a partitioning behavior during colloidal crystallization.

A few amount of impurities (2 percent) were doped to the colloidal dispersion, from which colloidal crystals were grown with convective assembly method. Polystyrene particles (PS) were used for fabricating colloidal crystals, and different sizes of PS and fluorescent bearing PS (w/fluor.) were doped as impurity particles.

In each particle size for two kinds of impurity, effective partition coefficient (k_{eff}) were measured at various growth rates. Obtained keff gives k_0 by using BPS plot. The k_0 is decreased as the difference between the size of the impurity and the 500 nm host particle increased. The k_0 of each w/fluor. was larger than that of the corresponding pure PS. Moreover, the value of k0 for the 520 nm w/fluor. surpassed unity, whereas the PS is always less than unity.

We have employed a Thurmond and Struthers (T&S) model (J. Phys. Chem. 57, 831 (1953)) to discuss the difference of k_0 for PS and w/fluor. particles. T&S model shows k_0 as; k_0 = exp((Δ G_{Tr} –Δ H)/RT). Here, Δ G_{Tr} is free energy difference between the solid and liquid phases of an impurity at the transition temperature, T, Δ H is the excess enthalpy which is caused by incorporation of the impurity into the host material, and R is a gas constant. We have determined the phase transition volume fraction for PS and w/fluor. to evaluate the Δ G_{Tr}. It was shown that Δ G_{Tr} of w/fluor. is positive whereas PS is zero. This leads to larger Δ G_{Tr} –Δ H of w/fluor. than that of PS, which corresponds to larger k_0 of w/fluor., and in a small –Δ H range, k_0 of w/fluor. surpasses unity. We have found the difference of k_0 for different kinds of impurity particles, and succeeded in applying concept of T&S model to partitioning of colloidal crystals.

Keywords: Colloidal crystal, Impurity partitioning