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Relationship between supercooling stability and solution structure in sodium acetate aqueous solution

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Abstract

We have observed the solution structure of the supercooled sodium acetate aqueous solution, especially for the existence of clusters and their crystallization process, by means of Scanning electron microscopy (SEM) with the freeze replica method. Microscopic internal structure of sodium acetate trihydrate crystals mainly constitutes the aggregates of 100-200 nm in diameter, which consists of the clusters of 10-20 nm in diameter. In the case of a supercooled aqueous solution of 293 K, two types of aspect in the vitrified aqueous solution mainly exist: one is the clusters of 10-20 nm in diameter; the other is the smooth zone without any structure. At 263 K, The relationship among clusters of 10-20 nm and their aggregates of 100-200 nm was clearly observed. The aggregates construct the three-dimensional loose networks, which are not fully packed, different from the crystal.

KEYWORDS. A1.Supercooling; A1.Solution structure; A1.Cluster; A1.Nucleation; A1.Freeze replica method; A1.Growth models

1. Introduction

Crystallization technology has been utilized in various chemical engineering fields commercially producing pharmaceuticals, chemicals, foods, advanced materials (such as nano-materials, bio-materials, and electronic devices) as well as separating and recovering valuable resource from the wastewater and waste materials. Basically, crystallization is the engineering to design equipment and operation method for the generation of crystal nuclei in the liquid phase and their growth to a desired particle size or size distribution. There are many unsolved areas in the mechanism such as heterogeneous nucleation from a supersaturated aqueous solution.

In general, when taking a certain degree of supercooling, crystallization starts. Neither the degree of supercooling nor the time required until the initial crystallization begins is logically understood, only in experience. By applying the external stimuli such as an electrical stimulation, a physical stimulation, and etc., there is a case where crystallization begins [1-3]. Though there are some reports that the crystallization is affected by the temperature history, such as melting point and cooling rate, they are only qualitative description [4-8].

From the viewpoint of energy saving, thermal storage technology has been focused in order to utilize the waste heat beyond the space-time. One of the representative thermal storage materials is sodium acetate

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