Effects of impurities on crystal growth in sucrose crystallization using a photomicroscopic technique

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The influences of glucose on the growth kinetics of sucrose crystals from aqueous solution are studied using a photomicroscopic technique in an isothermal, continuous -flow chamber. The phenomena of size-independent growth and growth rate dispersion are observed. A schematic diagram of the cell with a description of features is shown in Figure 1. The cell has a chamber for crystal nucleation and growth in the upper part and a chamber for temperature -controlled water in the lower part. Examples of characteristic size versus time plots for so me individual crystals at T=30 are shown in Figure 2. It is evident, and confirmed by high correlation coefficients, that a linear relation exists between the size and time. Since the slope of the line is equal to growth rate, these plots imply a single, size-independent growth rate. The lines also have different slopes, indicating a distribution of growth rates, i.e., growth rate dispersion.

The presence of glucose is found to enhance growth rate of sucrose crystals in the aqueous sucrose solution. A model is presented to describe the enhanced growth phenomenon studied here. This model assumes that the growth rate increases with increasing surface coverage (θ) by impurity adsorbed on the crystal surface, and an effectiveness factor (α) is introduced to take into account the growth promoting ability of the impurity adsorbed on the crystal surface. The linear growth rate in the presence of impurities is propos ed as $G = G_0[(1-\theta) + \alpha\theta]$. Where G_0 is the linear growth rate in the pure system. When $\alpha > 1$, the impurity adsorbed on the crystal surface has a promoting effect on crystal growth. When $\alpha < 1$, the impurity adsorbed on the crystal surface has a retarding effect on crystal growth. When $\alpha = 1$, the impurity adsorbed on the crystal surface does not affect crystal growth.

Figure 3 depicts the relative growth rate G/G_0 as a function of impurity mole ratio x for three levels of supersaturation. The experimental data are found to be satisfactorily fitted well by the proposed model. It is apparent that the growth rate is enhanced as the impurity concentration is increased and then an asymptotic value of a/σ has been approached at the higher impurity concentrations, which indicates that the adsorption equilibrium of the impurity on crystal surface is reached and thus the maximum promot ing effect on crystal growth is reached. As the diffusion process proceeds very fast in this work, the adsorption process of the impurity on the crystal surface is assumed to reach the equilibrium state and the Langmuir adsorption isotherm is applied to relate the fractional coverage of the impurity on the crystal surface with the impurity concentration in solution. In the end, α and the Langmuir constant (K) are determined by fitting the experimental data with the proposed model.

References

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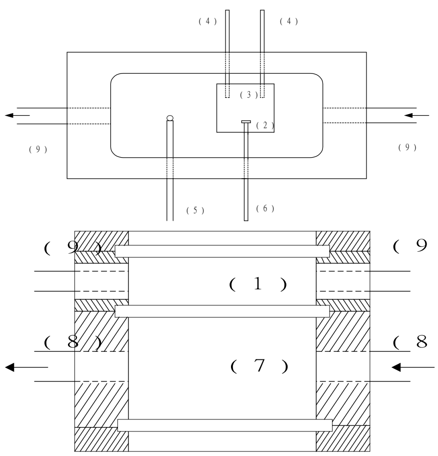

Fig 1. Schematic diagram of nucleation cell with the features (1) chamber containing solution (2) parent crystal (3) glass cover slip where parent crystal is slid (4) support rods for glass cover slip (5) thermistor (6) movable rod holding parent crystal (7) chamber containing constant temperature water (8) water inlet and outlet and (9) solution inlet and outlet

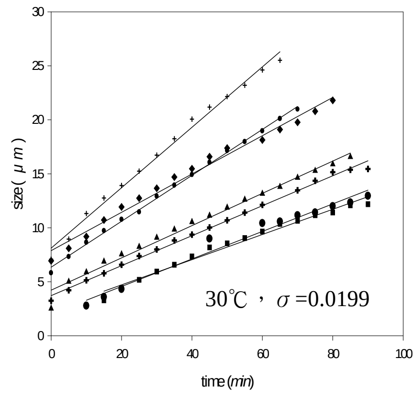

Fig 2. Characteristic size vs. time plots for several individual crystals

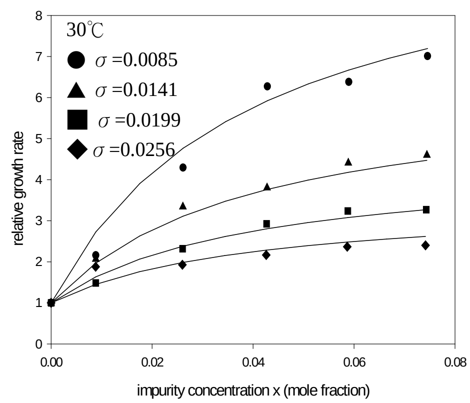

Fig 3. Relative growth rate versus impurity concentration