C_2 could be obtained. By repeating the heating and cooling thermal cycles, purity of products could be increased step by step. Although multiple theoretical stages are needed to purify the materials, there is no separation limit for solid solution forming systems. Similarly, crystallization kinetic effects and the non-complete solid–liquid separation call for post crystallization processes to improve the purification efficiency.

11.2.2 Crystallization Kinetics

As mentioned above, crystallization kinetics could significantly influence the separation efficiency of melt crystallization. Therefore, a good understanding of crystal nucleation and growth will help to improve the process development and design.

11.2.2.1 Crystal Nucleation[15,16]

Nyvlt characterized nucleation kinetics by an empirical relationship between the metastable zone width Δc_{max} and the nucleation rate N_{m}, expressed as:

$$N_{\mathrm{m}} = k_{\mathrm{n}} \Delta c^{m}{}_{\mathrm{max}} \tag{11.1}$$

where k_{n} is the nucleation rate constant and m is the apparent order of crystal nucleation.

With respect to the nucleation process with a constant cooling rate, the relationship between the biggest supercooling degree and cooling rate could be written as:

$$\log b = \log\left(k_{\mathrm{n}}\left(\mathrm{d}c^{*}/\mathrm{d}T\right)^{m-1}\right) + m \log \Delta T_{\mathrm{m}} \tag{11.2}$$

where b is the cooling rate, ΔT_{m} is the maximum allowable supercooling, taken as the difference between the equilibrium temperature and the temperature at which nucleation happens, and c^* is the equilibrium concentration.

By plotting log b against log ΔT_{m}, crystal nucleation kinetic parameters could be obtained for the specific crystallization system.

11.2.2.2 Crystal Growth[15–17]

Crystal growth rate could also be expressed as an exponential equation as:

$$G = k_{\mathrm{G}} \Delta w^{a} \tag{11.3}$$

where G is the growth rate, Δw is the supercooling defined as the difference between the weight fraction of the melt at any time and the equilibrium value, k_{G} is the growth rate constant and a is the order of crystal growth.