

11.5.3 Concentration

Continuous melt crystallization could also be used to concentrate juice, beer and desalinate sea water by freezing. Margolis *et al.*⁶ studied the desalination process in a well stirred continuous crystallizer to produce ice by direct contact refrigeration. By investigating the nucleation and growth kinetics as well as the permeabilities of ice beds, they found that larger ice production rates per unit crystallizer volume could be achieved without sacrifice of crystal size. Huige *et al.*⁴⁹ investigated the nucleation and growth kinetics of ice from dextrose solutions in a continuous stirred tank crystallizer with supercooled feed. Results showed that supercooling is the key factor to influence the crystallization kinetics, while crystal surface area also played an important role in the crystal nucleation process, which helped to verify that nucleation occurs by breakage of dendrites from the surface of parent crystals.

11.6 Outlook

As a green separation technique, continuous melt crystallization has drawn intense attention for the purification of fine chemicals, food, pharmaceuticals, inorganic materials, and so on. However, current work has mainly focused on the feasibility or separation effectiveness of given mixtures or materials. Further theoretical research has not been fully conducted. To fully understand and better apply continuous melt crystallization, more work needs to be done on the following aspects.^{1,5,34,50-52}

1. Further understanding of the mechanisms of the melt crystallization process, such as the combined mass and heat transfer processes. Establishment of common mathematical models of melt crystallization will help to predict the crystallization results and guide the industrialization process.
2. Development of new separation techniques, including better solid-liquid separation (application of magnetic fields, new slurry transportation methods, *etc.*) and hybrid separation methods which combine melt crystallization and distillation, extraction, *etc.* to deal with low concentration systems and take advantage of different separation methods.
3. Development of effective crystallizers which are easy to scale-up and have higher separation effects. Currently, most of the commercial continuous melt crystallizers include complicated internal components which make the scale up of laboratory or pilot apparatus difficult. Besides, the maintenance cost is also quite high for industrial processes.
4. Energy integration technology to save energy costs, especially for systems with low melting points. As for materials with low melting points, refrigeration costs could increase operation fee profoundly. Cascade