1.3 Continuous Crystallization

A continuous crystallization process will have a clear undersaturated solution as a feed flow and a crystal suspension as an outgoing flow. The method with which a supersaturated solution with $S > 1$ is created in a crystallizer defines the crystallization method used.

By decreasing the temperature of a solution generally the solubility of a crystalline solid decreases and if it is changed to below the solution concentration *cooling crystallization* can take place. A continuous cooling crystallization would have a hot, concentrated but undersaturated feed and a cold suspension as an outflow representative of the crystallizer bulk composition and temperature.

In case of *evaporative crystallization* the concentration is increased by solvent evaporation. Since solvent evaporation rate is fast at the boiling point of a solution, evaporative crystallization usually takes place close to the three-phase equilibrium point between crystals, solution and solvent vapor. This point can be shifted for process optimization since the boiling temperature decreases with decreasing pressure. A continuous evaporative crystallization process would have a hot undersaturated feed, a suspension outflow taken from the base of the crystallizer and an additional evaporated solvent flow. One process challenge is to ensure sufficient height difference between the boiling surface and the outlet to ensure sufficient hydrostatic head to suppress boiling in the outlet stream.

In case of *antisolvent crystallization* an antisolvent is mixed with the solution. While the addition of antisolvent decreases the overall concentration, the solubility in the mixed solvent is also decreased. If the solubility decrease due to the antisolvent is larger than the concentration decrease due to dilution, supersaturation is created and crystallization can occur. A continuous antisolvent crystallization would have a solution and an antisolvent feed flow and a suspension outflow.

For *reactive crystallization* two solutions each containing one of the reagents are mixed. The reagents react to form a solute with a lower solubility so that the solute concentration is higher than the solubility and crystallization occurs. A reactive crystallization could be performed for instance by adding a high pH solution to a low pH solution of a compound: the change in pH upon mixing the solutions reduces the solubility of the compound and crystallization can occur. A continuous reactive crystallization would have two solution feeds and a suspension outflow. Reactive crystallization is a combination of chemical reaction and crystallization. The reaction rate and solute generation rate (reaction product) defines the solute concentration, and at the solution temperature, the supersaturation ratio would be determined. Although the reactive crystallization normally runs at steady state, any temperature change or disturbance in any reagent flow (concentration) could disturb the crystallization phenomena, including the nucleation rate and crystal growth. Yazdanpanah *et al.*