

happen when the solution is in the unsaturated region, and that spontaneous nucleation will occur when the cooling exceeds the metastable zone width and should principally be avoided. There have however been many successful crystallisations of *inorganic* compounds that utilize spontaneous nucleation as the means of initiating nucleation, *e.g.* pigments, iron oxides, inorganic salts *etc.* In crystallisation of inorganic materials, water is largely used as the sole solvent; dissociation reactions, ionic interactions and pH play a major role in determining the solubility of a particular inorganic species in aqueous solution, as most inorganic materials are ionic.¹⁴⁶ Precipitation is perhaps a better phrase for inorganic crystallisations. The subtle differences between precipitation and crystallisation have been well explained.² The former is generally initiated at high supersaturation, resulting in fast nucleation and a large number of very small primary crystals. Agglomeration often occurs soon after nucleation and aging or maturation then follows covering all irreversible changes that take place in a precipitation after its formation.² Unlike crystallisation of organic species where a wide range of solvents or/and solvent mixtures can be used, increasing the varieties of interactions between solutes and solvents and complicating the process operation, control and prediction, the formation of hydrates (water molecules constitute part of the crystal structure) results in perhaps the most complications in unseeded crystallisation of inorganics, *e.g.* some compounds form several hydrates with varying water contents. As a result, there are neither issues of morphology nor of size distribution, while yield is the main focus, *e.g.* iron oxides, which were one of the first industrial inorganic compounds I was involved with. Seeded precipitations are occasionally operated, but rather crude methods of seeding are practised, *e.g.* bag loads of product crystals are dumped into crystallisers *via* a manhole.

When nuclei collide with the walls of the crystalliser and with other nuclei, this could lead to breakage of nuclei that could act as seeds for additional nucleation. The prerequisite for this to happen would be that a sufficient number of nuclei of reasonably larger sizes would be available in the vessel, however, sizes of nuclei were small from spontaneous nucleation in this case.

It should be stressed that while spontaneous nucleation has been used in both batch and continuous crystallisations, spontaneous nucleation as the means of generating nuclei seldom works in tubular continuous crystallisers for organic compounds, as encrustation occurs, leading to blockage^{16,66} (see Section 3.5 for more details).

3.5.1.2 Seeded Cases

Any crystallisation textbook would tell you that within the metastable zone, nucleation may or may not take place, but what does it mean in reality? It is very rare, or we can use the word “certain” again, for homogeneous primary nucleation to take place within the metastable zone. This