14.3 Understanding EFC from a Melt Crystallization Point of View

It is useful to understand eutectic freeze crystallization from a melt crystallization point of view, since melt crystallization forms an important "subclass" of crystallization that has a number of specialized applications. There is no real theoretical basis for the distinction between solution crystallization and melt crystallization, but historically, the very different industrial techniques used for melt crystallization have justified it being considered as a separate class of crystallization method.[25]

A melt is the common name given to a liquid or a liquid mixture at a temperature near its freezing point. Eutectic freeze crystallization is classified as a melt crystallization for two main reasons: firstly, the crystallizing phase is the solvent itself and secondly, (and this follows from the first reason) the operating temperature is close to the melting temperature of the main component.

Since eutectic freeze crystallization is dominated by ice crystallization, it has been classified as a melt crystallization problem. However, because of the simultaneous crystallization of salt, EFC also exhibits solution crystallization characteristics. This will be explained in more detail in a later part of this chapter, under Section 14.6: Coupled heat and mass transfer problem.

14.4 Defining Supersaturation in Eutectic Freeze Crystallization

Table 14.3 summarizes some expressions used to describe supersaturation for different crystallization methods.

Table 14.3 Summary of expressions for supersaturation, as well as expressions used in practice for cooling, melt and evaporative crystallization. Note that practical expressions usually are not consistent with the thermodynamic ones. c is the actual concentration in the solution and c_{eq} the equilibrium concentration (kg solute/kg solution or kg solute/kg solvent or kg solute/kg mixed solvent in the case of anti-solvent crystallization); similarly, T and T^* (K) are the actual and the equilibrium temperatures.[26]

Thermodynamic expression	Practical expressions	Crystallization method	Restriction
$(\Delta h_f/T^*)(T-T^*)$ (J mol^{-1})	$\Delta T = T^* - T$(K)	Cooling, melt	P constant, low supersaturation
RT ln S_{cm} RT ln S_c (J mol^{-1})	$\Delta c = c - c_{eq}$ (g solute /g solution) or (g solute/g solvent)	Evaporative	T, P constant, low supersaturation.T, P constant, low supersaturation, single solute