On the Unification of Three Theories for the Kinetics of Crystal Nucleation

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Over the past fifty years a theory for crystal growth and nucleation, where a Fokker-Planck equation is coupled with a mass balance equation, has been used by several groups for the study of the kinetics of nucleation from the bulk solution. Another recent approach to the same problem defined a logistic differential equation which gave an expression for the number of critical nuclei formed as a function of time. Both of the theories lead to results for the kinetics of nucleation that agree with experimental reports. We show here that the two methods actually yield identical expressions for the nucleation rate. A third description is provided via the so called JMAK equation. We find that this famous formula, under certain conditions, predicts the same kinetic behavior as found using the other two methods. We then conjecture for there being a type of universality for the kinetics of crystal nucleation. Further, it is proposed that these models give a kinetic description for two-step and homogeneous nucleation. This result motivates a description of the induction period in terms of the behavior of the nucleation rate for nuclei generated by the two-step mechanism.