498d Similarity Solution Existence Maps for Binary Rate Processes in Population Balances

R. Bertrum Diemer Jr. and Jon H. Olson

Coagulation is important in aerosol reactors and aggregation is important in crystallization and in various other solids processing unit operations. These coagulation or aggregation processes are analogous to polymerization in their formulation as a binary rate process in population balances for particle size or molecular weight distribution. Under certain conditions, these systems approach time invariant similarity solutions for the distribution shape at long times. Such systems are said to exhibit self-preserving behavior. This paper probes similarity solution existence for a general rate kernel capable of describing the individual terms in commonly encountered collision kernels for coagulation/aggregation (free-molecular, continuum Brownian, laminar shear, turbulent diffusion) as well as the product kernels of the type found in polymerization kinetics. The general kernel can be mapped in a 2-dimensional space in terms of an order parameter and a structure parameter. The Pulvermacher-Ruckenstein analysis is utilized to identify a region of this space where similarity solutions are forbidden. For multi-term compound kernels, it is shown that as long as one term lies outside this region, similarity solutions are possible. This behavior is demonstrated via moment models solved using the MOMIC methodology (method of moments with interpolative closure).