The Self-Similar Cluster Size Distribution in Random Coagulation and Breakup

RUBEN D. COHEN

Department of Mechanical Engineering & Materials Science, Rice University, Houston, Texas 77251

Received April 24, 1991; accepted August 2, 1991

A self-preserving size distribution profile is developed based on a recent model for the evolution of the cluster sizes in rapidly stirred suspensions where both coagulation and breakup occur concomitantly and randomly (Cohen, R. D., *J. Chem. Soc. Faraday Trans.* **86,** 2133 (1990); **87,** 1163 (1991)). An important finding, among others, is that the nature of the size distribution formed by random coagulation and breakup is, as might be expected, markedly different from that involving pure Brownian coagulation.

NOMENCLATURE

- A defined in Eq. [3]
- c number concentration of clusters (Eq. [12a])
- c_o number concentration of primary particles (Eq. [12b])
- i cluster size or number of primary particles in a cluster
- i_{max} maximum cluster size (satisfies Eq. [23])
- i_{min} minimum cluster size (Eq. [20])
- N total number of clusters in the system (Eq. [4])
- N_i total number of clusters of size i in the system
- N_o total number of primary particles in the system (Eq. [5])
- $p(i)$ size distribution probability (defined in Eq. [6])
- $p_B(i)$ size distribution probability for pure Brownian coagulation
- Z size distribution characteristic at steady-state (Eq. [9b])
- μ size distribution characteristic at any evolutionary stage (satisfies Eq. [2])
- ξ reduced independent parameter in pure Brownian coagulation (Eq. [10])
- ζ reduced independent parameter in random coagulation–breakup processes (Eq. [17])
- ζ_{max} maximum or leading limit of ζ (Eq. [26])
- ζ_{min} minimum or trailing limit of ζ (Eq. [21])
- $\zeta_{max\infty}$ maximum limit of ζ at steady-state (Eq. [28])
- $\zeta_{min\infty}$ minimum limit of ζ at steady-state (Eq. [27])
- $\forall$ total volume of the system

INTRODUCTION AND BACKGROUND

It is evident from the ever-increasing amount of literature covering this area, that the formation and evolution of aggregates and drops in dispersions is an important subject in many science and engineering fields. Basically, the phenomenon can be classified into three conceptually distinct categories: (i) pure coagulation, (ii) pure breakup or fragmentation, and (iii) simultaneous coagulation and breakup.

The amount of work done on Brownian coagulation is overwhelming. This ranges from solutions of the Smoluchowski Equation to investigations concerning the structural and fractal properties of the aggregates produced,

0021-9797/92 $3.00