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EVOLUTION OF NUMBER CONCENTRATION OF NANO- PARTICLES UNDERGOING BROWNIAN COAGULATION IN THE TRANSITION REGIME*

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Abstract: Evolution of number concentration of nanoparticles undergoing Brownian coagulation in the transition regime is studied theoretically and numerically. The results show that the curves of particle size distribution move toward the area with large particle diameters, the curve peak becomes lower and the range that particle diameters cover becomes wider as time elapses. In the process of coagulation the particles with small diameter disappear gradually and the particle size distribution remains a log-normal distribution. The change rate of the particle size distribution is more appreciable at the initial stage than that at the final stage. The initial Knudsen number has a significant effect on the coagulation rate which increases with decreasing the initial Knudsen number. The larger the initial geometric standard deviation is, the smaller the curve peak is, and the wider the area that curves cover is. The initial geometric standard deviation has a significant effect on the particle size distribution which can remain a self-preserving state when the initial geometric standard deviation is smaller than 2. With the increase of the diversity of initial particle size, the particle size distribution does not obey the log-normal distribution any more as time elapses.

Key words: nanoparticles, Brownian coagulation, number concentration, numerical simulation

Introduction

Numerous applications of two-phase flow carrying nanoparticles can be found in the field of engineering, for example, the system of an air cleaner, ejector scrubbers, air-spray systems, vehicle exhaust plumes and at the outflow of combustion products. In many of these processes the distribution of the dispersed particle is a controlling factor in the efficiency and the stability of the process. Brownian coagulation is an important phenomenon for nanoparticles because it results in a decrease in number concentration and an increase in particle size, while many properties of natural or man-made nanoparticles depend on their size distribution. Brownian coagulation was described theoretically by Smoluchowski who put forward a scheme to calculate discretized particles. After that, Muller derived an integro-differential equation, i.e., the Particle General Dynamic Equation (PGDE) to describe the evolution of number concentration of particles. It is, however, difficult to solve the PGDE as long as the Brownian coagulation is involved because of the complexity of the PGDE[1]. Fortunately, the solution of the PGDE in a specific particle size regime, i.e., the free molecule regime or the continuum regime, can be obtained by using the moment method, for example, Pratsinis's Moment Method (PMM)[2], the Quadrature Method Of Moments (QMOM)[3] and the Sectional Method (SM)[4]. Furthermore, Yu et al.[5,6] put forward a new approach, i.e., the Taylor- series Expansion Method Of Moments (TEMOM), to solve the PGDE undergoing Brownian coagulation. Liu and Lin[7], Gan et al.[8] performed numerical simulation of

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