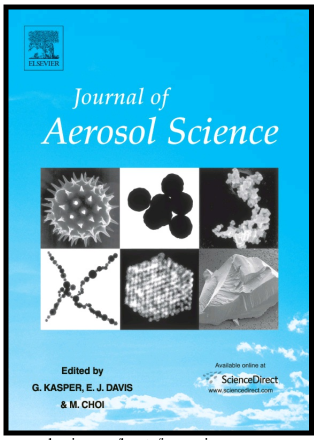
Author's Accepted Manuscript



www.elsevier.com/locate/jaerosci

On the growth rate of particle surface area for Brownian coagulation

Xie Mingliang

PII: S0021-8502(17)30008-3
DOI: http://dx.doi.org/10.1016/j.jaerosci.2017.07.009
Reference: AS5149

To appear in: *Journal of Aerosol Science*

Received date: 6 January 2017
Revised date: 2 March 2017
Accepted date: 28 July 2017

Cite this article as: Xie Mingliang, On the growth rate of particle surface area fo Brownian coagulation, *Journal of Aerosol Science* http://dx.doi.org/10.1016/j.jaerosci.2017.07.009

On the growth rate of particle surface area for Brownian coagulation

Xie Mingliang

State Key Laboratory of Coal Combustion, School of Energy and Power Engineering, Huazhong University of Science and Technology, Wuhan 430074, China

mlxie@mail.hust.edu.cn

Abstract
The surface area of fine particles corresponds to the Gibbs free energy, and the particle number density corresponds to the entropy of particle system. In this study, the growth rate of particle surface area is given quantitatively for Brownian coagulation both in the free molecule and continuum regime based on the moment method. The results show that the relative growth rate for particle surface area is one-thirds of that for particle number density. The relationships together with the second law of thermodynamics form a kind of physical constraints for Brownian coagulation, which will be helpful to understand the population balance equation from point of view of thermodynamics.

Keywords: surface area; growth rate; Brownian coagulation; moment method; Gibbs free energy; entropy

Introduction

Aerosols are unstable with respect to coagulation. Particle collision and coagulation lead to a reduction in the total number of particles and an increase in the average size. The reduction in surface area that accompanies coalescence corresponds to a reduction in the surface free energy under conditions of constant temperature and pressure (Friedlander, 2000). From a macroscopic perspective, in classical thermodynamics the entropy is interpreted as a state function of a thermodynamic system, which is proportional to the total number of particles. Therefore, the reduction in the total number of particles corresponds to a reduction in the entropy of particle system. Following the second law of thermodynamics, there is a qualitative relationship between surface free energy and entropy. In this study, the relationship of relative growth rate between particle surface area and particle number density is given quantitatively for Brownian coagulation at long time, which can be considered as a constraint condition for Brownian coagulation in thermodynamically.

The mathematical modeling

In the classical theory of coagulation, coalescence occurs instantaneously after two particle particles collide, and a new sphere is formed, which means

$$\upsilon = \upsilon_1 + \upsilon_2 \tag{1}$$

where υ is particle volume, and the change of particle surface area between before and