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PC6) 전이영역에서의 Brown 응집에 관한 실험적 연구

Experimental Study on Brownian Coagulation in the Transition Regime

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1. INTRODUCTION

Coagulation is a process whereby particles collide with one another due to their relative motion, and adhere to form large particles. Coagulation caused by the random Brownian motion of particles is called Brownian coagulation. Many properties, such as light scattering, electrostatic charges, toxicity, as well as physical processes, including diffusion, condensation and thermophoresis depend strongly on their size distribution. Therefore, Brownian coagulation is substantially important in atmospheric science, combustion technology, inhalation toxicology and nuclear safety analysis.

In this study, the Brownian coagulation rates of polydisperse aerosols in the transition regime were measured experimentally. The experimental coagulation rates took deposition rates (diffusional wall loss rates) into account, because coagulation and diffusion deposition occur simultaneously in a closed chamber. Thus, experiments for the coagulation and deposition were carried out for the accurate measurement of the Brownian coagulation. Additionally, two evaluation methods were used and compared with each other, to obtain accurate coagulation rates in this study.

2. EXPERIMENT

The aerosol coagulation chamber used in our study was a cylindrical acrylic box with a bottom surface diameter of 60-cm and a height of 60-cm. A 10-cm steel fan was installed near the center for stirring within the chamber. Polydisperse oleic acid (liquid particles, 0.887 g/cm^3) and sodium chloride (NaCl, solid particles, 2.16 g/cm^3) aerosols were used for the experiments. The aerosols were produced by a spray-drying type generator, followed by passage through a Kr-85 charge neutralizer. The aerosols generated were introduced into the coagulation chamber, and mechanically stirred for a short time to maintain gentle mixing.

In closed vessels coagulation is always accompanied by deposition. Thus, a deposition experiment was conducted prior to the coagulation experiment under the same experimental conditions. The geometric mean particle diameters were in the range of 25 to 150 nm, and the geometric standard deviations were in the range of 1.55 to 1.65. The different particle diameters were achieved by adjusting the concentration of the solutions differently.

3. RESULTS AND DISCUSSION

The deposition coefficients decreased as the particle diameters increased for particle sizes ranging from 25 to 100 nm. However, the deposition rates of particles did not decreased with an increase in the particle diameters when the particle diameters were larger than 100 nm.

'Figure 1' shows the experimentally determined coagulation coefficients as a function of Kn, together with theoretical expressions given by Dahneke (1983) and Fuchs (1964), and Davies (1979). Dahnekes coagulation rate has been shown to be very close to that of Fuchs (1964) with a relative error of less than 1%. The theoretical values expressed by Dahneke (1983) and Davies (1979) were calculated with monodisperse aerosols. In the present study, however, polydisperse aerosols were used for the experiments on coagulation. Thus, the experimentally obtained Brownian coagulation rates took into account the effects of both the particle size and geometric standard deviation when considering the polydispersity factors (PDF). The coagulation rates for the NaCl and oleic acid particles increased as the Knudsen number (Kn) increased within the range of 0.8 to 3, but those of the aerosol particles did not grow with the increase of Kn when Kn was larger than 3. The experimental results followed the theoretical results of Dahneke and Fuchs, compared to those of Davies.

'Figure 2' shows the development of the particle size distribution observed during the coagulation experiment. The size distribution curves of the 50-nm diameter particles are plotted as a function of the particle size distribution density function. It is seen from 'Figure 2' that the total number concentration and GSD value of polydisperse aerosols decrease but the particle size grows, as time is elapsed.

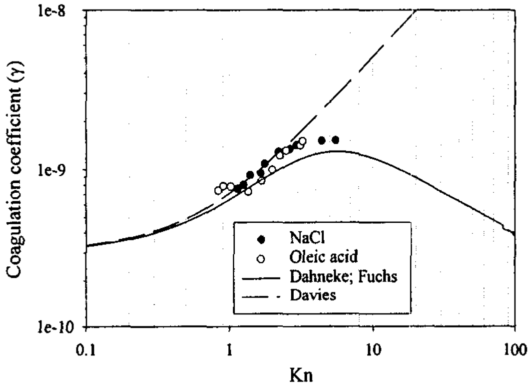

Fig. 1. Coagulation coefficients as a function of Kn.

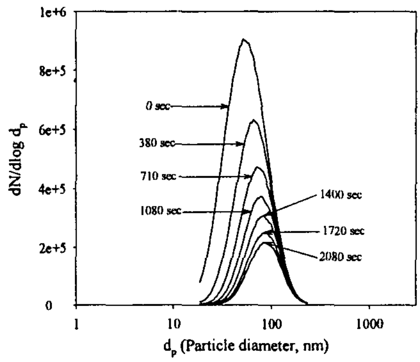

Fig. 2. Development of the particle size distribution for time elapsed.

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