Effect of Charge on Particle Coagulation in the Atmosphere

K. Ghosh[1], S.N. Tripathi[1,2], Manish Joshi[3], Y.S. Mayya[4], Arshad Khan[3] and B.K. Sapra[3]

[1]Department of Civil Engineering, IIT, Kanpur 208 016, India
[2]Centre for Environmental Science and Engineering, IIT, Kanpur 208 016, India
[3]Radiological Physics and Advisory Division, Bhabha Atomic Research Centre, Mumbai 400 085, India
[4]Department of Chemical Engineering, IIT Bombay, Mumbai 400 076, India
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Presenting author email: kghosh@iitk.ac.in

Aerosol particles obtain charge through various processes (natural and man-made). In the atmosphere, galactic cosmic rays play a major role in generation of charged aerosol particles (Laakso *et al.*, 2002). Due to the random interaction between positive and negative ions with aerosols, ambient aerosol particles are generally bipolar charged (Dhanorkar *et al.*, 2001). Charge particles play an important role in global atmospheric electrical circuit and cloud microphysics (Tinsley, 2008). Industrial processes such as atomization of solutions, mechanical dispersion of powders and metal burning etc. generate significant amount of charge on aerosol particles (Kousaka *et al*., 1981; Tsai *et al*., 2005). Coagulation process is one of the important phenomena of aerosol particle growth. Charge on aerosol particles can affect particle coagulation. Several experimental studies have investigated the effect of charge on dynamics of aerosol particles.

A generalized formulation for coagulation of charged particles is presented in this work. The governing equations can be solved numerically (semi-implicit scheme) for a number of discrete size and charge bins. The mechanism gives both volume and charge conserved solution in a computationally efficient way. A new way of handling electrostatic dispersion in dynamic model has been used in this work. The scheme has been tested for charged, nebulized (NaCl) aerosol particles by model studies and also compared with experimental observations. The model simulated results show that charge can significantly affect the coagulation dynamics for particles with level of charge higher than the Boltzmann equilibrium charge limit and size less than 1 µm. For bipolar charge, there was a significant effect on the enhancement of the particle coagulation process. For unipolar charge, electrostatic dispersion was seen to play a very important role in depletion of number concentration. The model was then validated against results of six controlled experiments (electrical low pressure impactor, ELPI, was used for measurement of charge and number size distribution). The model results were found to be in reasonable agreement with experimental results. The developed model is fast (independent of time step) and numerically stable (volume and charged conserved) working model, which can be used for several applications involving coagulation dynamics of charged aerosol particles as well as in atmospheric study.

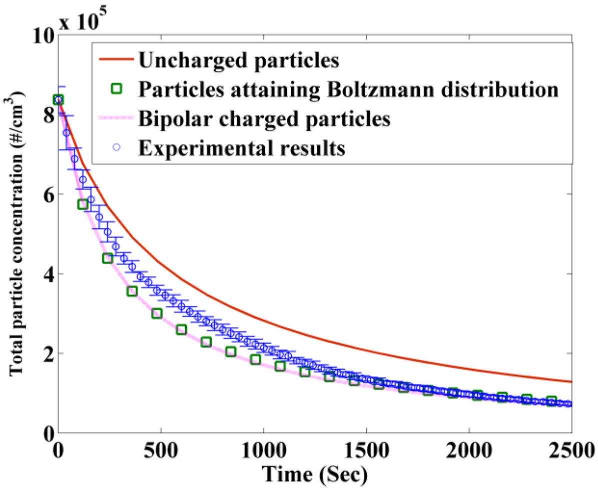

Figure 1. Depletion of number concentration as an effect of charged particle coagulation: theory and experiment

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