Hygroscopic properties of urban aerosol particles: Results from IMPACT study in Tokyo

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INTRODUCTION

Hygroscopic properties of aerosol particles control their optical properties and cloud condensation nuclei activity, and thus relate to radiative balance on the earth. Although hygroscopicity of major water-soluble inorganic salts has been evaluated by a number of studies, little is known about possible perturbations of liquid water content by the presence of organics and water-insoluble inorganics (e.g., elemental carbon) in atmospheric inorganic salt particles. In this study, hygroscopic properties of organic-inorganic mixed particles were investigated based on field measure-ments in Tokyo, with the application of a hygroscopicity tandem differential mobility analyzer (HTDMA) [Mochida et al., 2004].

EXPERIMENTS

Hygroscopic growth factor (HGF) measurements of urban aerosol particles were carried out using the HTDMA at Research Center for Advanced Science and Technology, the University Tokyo (Kobama, Meguro-ku) from July 21 to August 15 and from November 10 to 17, 2004. Aerodyne Aerosol Mass Spectrometer (AMS) was deployed for the measurement of chemical composition of aerosol particles. A cloud condensation nuclei (CCN) counter was op-erated to determine the CCN activity of particles classified by the HTDMA.

RESULTS AND DISCUSSION

Time series of HGFs for 100 and 200 nm particles were obtained under RH conditions of 85% and 90%. The distributions of HGF values changed significantly with time, which was in accordance with the change in chemical composition of particles. RH dependences of HGFs in humidification and dehumidification branches, which corre-spond to equilibrium and meta-stable states, respectively, were also obtained. A clear histeresis was observed, imply-ing that the liquid water content of particles is controlled by the history of RH in the atmosphere.

Liquid water volume of aerosol particles (Vwtotal) was derived from the HGF on the assumption that the volume of chemical components is additive. Liquid water volume expected from inorganic components (Vw_inorg) was on the other hand predicted using a thermodynamic model (AIM, http://www. hpc1.uea. ac.uk/˜e770/aim.html) [Clegg et al., 1998]. The difference in water volumes estimated from two different calculations, delta_Vw = Vw_total - Vw_inorg, was in some cases positive, which suggests an increase in the amount of liquid water by association of organics with inor-ganic salts.

CCN activity of particles positively correlates to the particle hygroscopicity at 83% and 90% RH (Figure 1). The observed relationship between hygroscopicity and CCN activity of aerosol particles was not fully explained by a core-shell model with the inorganic salt solution shell. This result suggests that factors characteristic to organics (e.g., partial dissolution and reduction in surface tension) affect the CCN activity of urban aerosol particles.

CONCLUSIONS

Perturbation of liquid water content by organic components is suggested from simultaneous measurements of hygroscopic growth factors and chemical compositions of urban aerosol particles in Tokyo. A model to predict CCN activity of particles based on the aqueous solution of inorganic salts is not sufficient to predict the measured CCN activity. Factors characteristic to organics are likely to be responsible for the CCN activity of organic-inorganic mixed particles.

REFERENCES

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