Hygroscopicity of nucleated nanoparticles in the presence of sulfuric acid and organics

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Atmospheric aerosols are emitted from natural and anthropogenic sources (i.e., primary aerosols) and are generated by gas-to-particle conversion processes (i.e., secondary aerosols). They influence Earth's climate change either by scattering and absorbing incoming sunlight or by acting as cloud condensation nuclei for cloud formation. In addition, they can cause adverse human heath effect and participate in various heterogeneous reactions with vapours in the atmosphere. Especially, hygroscopicity, the ability of water uptake by particles, is important properties to indirectly estimate chemical composition in particles. In this study, we focus on hygroscopicity of nucleated nanoparticles (10, 15, and 20 nm) produced by CLOUD (Cosmic Leaving Outdoor Droplets) experiments at CERN (Kirkby et al 2011).

A nano-tandem differential mobility analyzer (nano-TDMA) was applied to measure hygroscopicity of nanoparticles in the presence of sulfuric acid and organics during CLOUD 7 experiment. Generated particles inside CLOUD chamber were dried and then particles having certain size were selected with differential mobility analyzer (DMA). The selected particles were introduced into aerosol humidifier. Relative humidity in the humidifier was around 90%. Size distibution of humidified particles were determined with another DMA and condensation particle counter (CPC; TSI 3785).

In this way, we can determine hygroscopic growth factor (HGF) that is the ratio of geometric mean diameter (GMD) of size dependent nanoparticles at humidified condition to that at dry condition. And hygroscopic parameter κ can be derived from Petters and Kreidenweis (2007) with following equation:

$$\kappa = \left(HGF^3 - 1\right)\cdot\left[\frac{1}{S}\cdot\exp\left(\frac{4\sigma_w M_w}{RT\rho_w d_{dry} HGF}\right) - 1\right]$$

where S, σ_w, M_w, ρ_w, R, and T are saturation ratio, water surface tension at room temperature, molecular weight of water, density of liquid water, ideal gas constant, and room temperature, respectively. Also the organic volume fraction (ε_o) in the selected nanoparticles was calculated assuming two compounds consisting of organic and inorganic sulfates (Keskinen et al 2012)

$$\varepsilon_O = \frac{\kappa - \kappa_i}{\kappa_o - \kappa_i}$$

where κ is measured values, κ_o, κ_i are the hygroscopicity parameter for organic and inorganic sulfate, respectively.

The hygroscopicity of nanoparticles in the presence of sulfuric acid and organics with OH scavenger was smaller than those without OH scavenger in the chamber regardless of experimental conditions. It indicates that hygroscopicity of nanoparticles is enhanced by OH oxidant.

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