Hysteresis in Water Content of Ultrafine Glassy Organic Aerosol Particles

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Abstract

Water content of aerosol particles is atmospherically important. Water content of organic aerosol particles has been estimated by assuming thermodynamic equilibrium. Here, we discovered that the hysteresis phenomenon occurred to water content of glassy ultrafine organic aerosol particles, demonstrating that thermodynamically non-equilibrium states need to be considered. Hygroscopic growth for monodisperse ultrafine particles (sucrose and glucose) was investigated for the temperature range from 252 K to 296 K. Hysteresis was not observable at 296 K, consistent with literature data. However, hysteresis in water content was observed at sub-273 K. The lowest relative humidity (RH), at which hygroscopic growth of particles did not depend on exposure history to water vapor, was defined as equilibrium RH. Equilibrium RH for 100 nm particles was approximately the same as the glass transition points, demonstrating that water diffusion in a highly viscous matrix of organic aerosols was the key for the phenomenon. Employment of a kinetic multi-layer model quantitatively predicted equilibrium RH as a function of temperature, exposure time, and the particle size. Considering the temperature and RH range of Earth's atmosphere, we hypothesize that hysteresis in water content for organic aerosols ubiquitously occurs in the upper troposphere, impacting chemical aging and cloud formation processes.

Early Career Scientist

NO, I am not an early career scientist.