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A combined particle trap/HTDMA hygroscopicity study of mixed inorganic/organic aerosol particles

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Abstract. Atmospheric aerosols are often mixtures of inorganic and organic material. Organics can represent a large fraction of the total aerosol mass and are comprised of water-soluble and insoluble compounds. Increasing attention was paid in the last decade to the capability of mixed inorganic/organic aerosol particles to take up water (hygroscopicity). We performed hygroscopicity measurements of internally mixed particles containing ammonium sulfate and carboxylic acids (citric, glutaric, adipic acid) in parallel with an electrodynamic balance (EDB) and a hygroscopicity tandem differential mobility analyzer (HTDMA). The organic compounds were chosen to represent three distinct physical states. During hygroscopicity cycles covering hydration and dehydration measured by the EDB and the HTDMA, pure citric acid remained always liquid, adipic acid remained always solid, while glutaric acid could be either. We show that the hygroscopicity of mixtures of the above compounds is well described by the Zdanovskii-Stokes-Robinson (ZSR) relationship as long as the two-component particle is completely liquid in the ammonium sulfate/glutaric acid system; deviations up to 10% in mass growth factor (corresponding to deviations up to 3.5% in size growth factor) are observed for the ammonium sulfate/citric acid 1:1 mixture at 80% RH. We observe even more significant discrepancies compared to what is expected from bulk thermodynamics when a solid component is present. We explain this in terms of a complex morphology resulting from the crystallization process leading to veins, pores, and grain boundaries which allow for water sorption in excess of bulk thermodynamic predictions caused by the inverse Kelvin effect on concave surfaces.

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