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Influence of surface coating of aerosol particles on their hygroscopic properties

P. Villani (1), D. Picard (1), K. Sellegri (1), P.Laj (1) and M. Kulmala (2)

(1) OPGC-LaMP, CNRS-University of Clermont-Ferrand, France, (2) Department of Physical Sciences, University of Helsinki, Helsinki, Finland, ,(p.villani@opgc.univ-bpclermont.fr / Fax: +33 473 405136 / Phone: +33 473 407678)

The hygroscopic properties of aerosol particles are often related to their content of soluble material, on the basis of the Köhler theory. Recent studies, however, seem to indicate that the role of aerosol particle surface properties has been underestimated. The hygroscopic properties of aerosol particles are classically studied using aerosol classifiers in tandem, separated by a humidifier (HTDMA, Humidity Tandem Differential Mobility Analyzer). However, it is not yet known how the surface of the particles influences their growth rate when they are exposed to a humid environment. Theoretical calculations of sub-saturation growth mainly involves the solubility of the particle bulk, the role of the particle surface being taken into account through the surface tension of the solute, and through the accommodation coefficient of water on the hydrated surface. Surface tensions and accommodation coefficients are poorly documented and it is still an open question whether this theoretical approach is accurate or not.

In order to study these surface effects, the VHTDMA newly developed is aiming to modify the surface of particles by gently heating them, and then measuring their hygroscopic properties before and after surface treatment. The instrument is composed of two DMAs and CPCs, separated by an oven and a hydration device in series. A complete study of an aerosol size consists in measuring the size change obtained after slight heating (up to 110C) (Volatility-Scan), then the size-change due to exposure to a humid flow (90%) (Humidity-Scan), and finally the size change due to heating followed by humidifying (Volatility-Humidity-Scan).

The VHTDMA has been operated for the first time during the BACCI/QUEST campaign that took place in April 2005 in Hyytiälä, Finland. Results show that, under some conditions that might be linked to nucleation events, the hygroscopic properties of aerosol particles significantly change when the particles surface is modified by heating. The hygroscopic change is either positive (thermally conditioned particles more hygroscopic than original particles) or negative. Thermal conditioning can also lead to two different hygroscopic modes not visible with single hydration. These preliminary results indicate that the surface property is a key parameter, yet underestimated, driving the hygroscopic behavior of the particles. The use of Köhler theory to may lead to erroneous prediction of CCN number concentration.