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Hygroscopicity and timescale of equilibration for aerosol mixtures of ammonium sulphate/adipic acid

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The hygroscopic properties of aerosol particles can be measured with a hygroscopicity tandem differential mobility analyzer (HTDMA). The effect of water vapour equilibration times on the measurements of aerosol hygroscopicity is a recent topic. It has been discussed whether organic/inorganic aerosol mixtures show kinetic limitations of water uptake in the submicrometer size. To study this effect, chambers of different residence times were installed between the humidifier and the second DMA in the HTDMA. The hygroscopic growth factor (GF) is defined as the measured mobility diameter (D) at a set RH divided by the measured dry mobility diameter (D0) at 10%RH or lower. D0=50, 100 and 250 nm particles, composed of a mixtures of ammonium sulphate (AS) and adipic acid (AA) were investigated. A mixture in the ratio 1:3 of AS:AA by weight showed an increasing GF with increasing residence time, until equilibrium was reached after about 10 s.

Several processes to explain this phenomenon have been proposed such as: liquid/solid phase diffusion or film forming limitations, crystal dissolution or formation of hydrates. If the equilibration time would solely depend on the mass accommodation coefficient, then a lower limit for the coefficient can be calculated. Presently it has not been possible to detect any difference in equilibration times between the three different sizes mentioned above, which would indicate a surface rather than a volume based limitation.

As a conclusion, this work indicates that the measured GF of mixed aerosol particles can be underestimated if not sufficient residence time is ensured for the determination of the GF. Therefore, the residence time of the particles in the controlled RH should be specified for HTDMA and similar measurements.