Hygroscopic characterization of individual cloud condensation nuclei with atomic force microscope

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Majority of atmospheric aerosols takes up water and can eventually act as cloud condensation nuclei (CCN). How these particles interact with water therefore, regulates the climate and hydrological cycle. The hygroscopicity parameter κ is a single parameter that represents hygroscopicity of aerosol particles (Petters and Kreidenweis., 2007). In order to physically derive κ, it is necessary to obtain precise measure of the relative humidity, dry CCN size, hygroscopic growth factor (gf) and surface tension of the solution/air interface. Previously, κ of a given aerosol population has been derived using a hygroscopic tandem differential mobility analyzer (HTDMA).Although HTDMA has been widely accepted as a powerful tool to measure aerosol hygroscopic behavior, the measurement reflects an overall average of numerous particles and does not necessarily preserve extremes of the distribution. Therefore, it is also important to carefully examine particle hygroscopic growth at an individual particle level (Morris et al., 2016). Another limitation is that, previous works mainly assumed the surface tension of pure water or bulk solution, since there was no conventional method for directly measuring the surface tension of the droplets. Here, we present our attempts to combine methods to directly measure the surface tension and gf of a single droplet by atomic force microscopy (AFM), which in principle allow us to directly derive κ of individual particles. In this study, we measured gf and surface tension of sodium chloride (NaCl). The gf (80% RH) derived in this experiment (1.73±0.35) coincides with the value of the previous work (Morris et al., 2016) within the standard deviation. In terms of the surface tension, the retention force required for deriving the surface tension was found to be 19±3 nN, which is slightly smaller than the reported value of 30 nN (Morris et al., 2015), the difference can be attributed to the different shape of the cantilever used in both studies. Hygroscopicity parameter κ was derived from gf, dry particle diameter and surface tension obtained in this experiment and found to be 1.10. The fact that current value coincided with the values obtained in the previous study (Koehler et al., 2006; Clegg and Wexler., 1998), supports the validity and potential of this new method. In the future, other substances having various surface activities and mixing states (mineral salt and organic species) will be tested using this method, and further applied to actual atmospheric aerosol particles.

