Off-Line Analysis of the Hygroscopicity of Water-Soluble Particulate Matter in the Urban Air of Nagoya

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Atmospheric aerosol particles are involved in the cloud formation process in the atmosphere by acting as cloud condensation nuclei (CCN). Whether the particles act as CCN are governed by the chemical composition as well as the size and the condition of the water-vapor supersaturation. The presence of water-soluble matter (WSM) in the particles is essential for the CCN activation. Because the composition of water-soluble fraction is complex in terms of the water-soluble organic matter (WSOM), it is difficult to understand the relationship between the composition of aerosol particles and their CCN activity. In this study, we investigated the hygroscopicity of the WSM and the WSOM in urban aerosols over Nagoya, based on the collection of aerosol samples on filters and the analysis of the CCN activity of the water soluble components in the laboratory. The relationship between the O/C ratio of the WSOM and their hygroscopicity was also examined.

Atmospheric aerosol particles with aerodynamic diameters smaller than 0.95 μm ($PM_{0.95}$) were collected on filters in the Higashiyama Campus, Nagoya University, Nagoya, Japan, from 11 to 31, August 2013. Ten aerosol samples were collected, and aerosol components on the filters were extracted with water. Particles were generated by atomizing an extract solution, and they were classified by size using a differential mobility analyzer (DMA). Whereas the classified particles were counted using a condensation particle counter (CPC), CCN-active particles among the classified particles were counted using a CCN counter (CCNC). Four different water-vapor supersaturation (SS) conditions of 0.13%, 0.27%, 0.47%, 0.90% were applied to investigate the CCN activity of the particles. Activation diameters were determined from size-resolved CCN fractions, and then the hygroscopicity parameter $\kappa$of WSM (κ_{WSM}) were calculated. The mass concentrations of WSOM in the sampled atmospheric aerosols were obtained from the analysis of WSOC using a total organic carbon analyzer and the OM/OC ratios derived from the mass spectra collected using a high resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS). The hygroscopic parameter $\kappa$of the WSOM (κ_{WSOM}) was calculated using the κvalue of the generated particles and the chemical composition data. Two different methods, i.e., a regression-extrapolation method and a Zdanovskii, Stokes, and Robinson (ZSR) method for respective samples, were used to obtain the κ_{WSOM} values.

The κ_{WSM} ranged from 0.34 to 0.51 with a mean of 0.44. The κ_{WSOM} calculated from the regression-extrapolation method were in the range from 0.23 to 0.28 for four respective SS conditions. From the ZSR method for respective samples, the κ_{WSOM} were calculated to be on average 0.16 - 0.28. Whereas no clear relationship was observed for the κ_{WSOM} derived from the regression-extrapolation method and the SS conditions, the higher the SS condition was, the higher the κ_{WSOM} derived from the ZSR method for respective sample was. Further investigation about the cause of the difference of the κ_{WSOM} derived from these two methods is necessary. In the analysis of the studied ten aerosol samples, no clear relationship between the O/C ratio and the κ_{WSOM} was found (r: -0.21).

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