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Humidity dependence of extinction coefficients of secondary organic aerosols and its relation with chemical properties

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Atmospheric aerosols scatter and absorb solar radiation, thereby influencing the Earth's radiation balance. Light extinction is the sum of scattering and absorption. The aerosol extinction coefficient depends on chemical composition, particle size, shape and mixing sate in addition to wavelength of light. The uptake of water by aerosol particles can change extinction coefficients by changing size and refractive index of particles. Therefore, the detailed understanding of the relative humidity (RH) dependence of the extinction coefficients is important to estimate the impact of aerosols on radiation balance. However, the RH dependence of optical properties for secondary organic aerosol (SOA) has not been studied in detail.

In this work, we have determined the RH dependence of extinction coefficients of the SOAs generated during (1) the photooxidation of toluene in the presence of NO_x and (2) the ozonolysis of α-pinene. The SOAs were generated in a 6 m_3 teflon coated stainless-steel chamber in the absence of seed particles. The RH dependence of aerosol extinction coefficients at 532 nm was measured using a custom-made cavity ring-down spectrometer (CRDS). The CRDS has two measurement cells, in which the RH were controlled at $<$10% and 80%, respectively. The size distributions and chemical compositions of the SOAs were also measured using a scanning mobility particle sizer (SMPS, TSI) and a time of flight aerosol mass spectrometer (ToF-AMS, Aerodyne), respectively.

The ratio of extinction coefficients measured under high RH condition (RH=80%) to those measured under dry condition, F(RH), were compared with the relative abundance of the ion signal m/z=44 measured by the ToF-AMS to total organic signal, f_{44}. The f_{44} factor is known as a maker of oxygenated species such as organic di-acids, poly-acids, oxo-acids, hydroxy-acids, and acyl peroxides. Small RH dependence of extinction coefficients was found for the α-pinene-SOA with F(RH) of about 1.05, but the F(RH) values for the toluene-SOA were increase up to 1.4-1.6 with increasing the f_{44}. Interestingly, the relationship between F(RH) and f_{44} for the toluene-SOAs did not depend on the initial NO_x concentrations. Our results suggest that the increase in hygroscopicity due to oxidation of the SOAs mainly contributes to the observed RH dependence of extinction coefficients for the toluene-SOA.

Keywords: Secondary organic aerosol (SOA), Optical property, Humidity dependence, Chemical property, Climate change