

Direct Measurements of Water Transport Kinetics and Viscosity of Glassy Organic Aerosol

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Quantifying the interactions between glassy aerosol and water vapour is crucial for understanding the formation of cloud condensation nuclei and ice nuclei in the atmosphere, and the partitioning of semi-volatile species between the particle and gas phases. A glassy aerosol is defined as a non-crystalline material and a disordered amorphous solid. Often, the Stokes-Einstein equation is assumed to relate molecular diffusion constants and viscosity and, at the viscosities typical of glasses (where timescales to reach equilibrium can be up to weeks (Shiraiwa et al., 2012)) suggest that the composition of atmospheric particles may be governed by kinetic rather than thermodynamic factors. We will assess the validity of the Stokes-Einstein equation through direct measurements of the relative humidity (RH) dependence of the viscosity of organic aerosol and the timescale for water transport during condensation and evaporation.

Measurements of the water transport in organic aerosol were made on single particles using the aerosol optical tweezers technique (Bones et al.). The response in size of an individual aerosol droplet (3 - 6 μ m radius) to stepwise changes in RH was measured. The water activity dependence of the diffusion constant of water can be determined from measurements made over transitions between many pairs of RH values.

The viscosity of an aerosol droplet can be inferred from measurements of the timescale for the binary coalescence of two individual trapped aerosol particles using holographic optical tweezers (viscosities measured over a range of 12 orders of magnitude (Power et al., 2014)) (Figure 1).

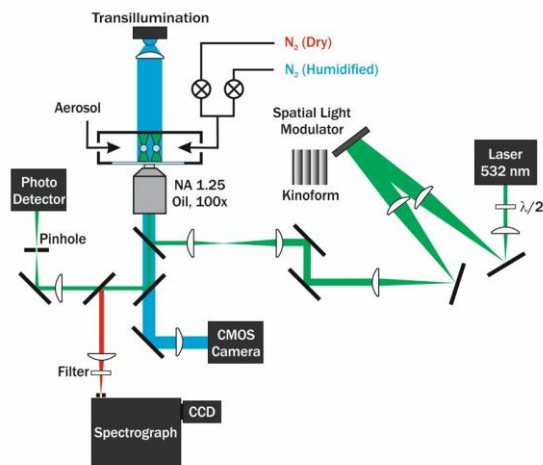


Figure 1. Experimental setup of aerosol optical tweezers used to monitor the coalescence of two trapped droplets.

A comparison of the diffusion constants of water and the viscosity of the organic particle at the same water activity will be used to illustrate the significant errors in assuming the validity of the Stokes-Einstein equation.

Measurements will be presented for a range of binary component aerosol containing organic compounds with a broad range of chemical functionalities and for more complex multicomponent aerosol (Figure 2).

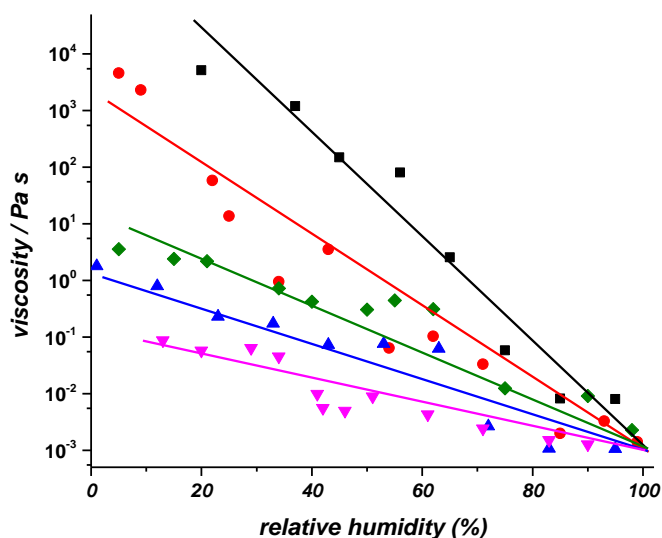


Figure 2. Viscosity of various sugars as a function of relative humidity. Black (sorbitol), red (erythritol), green (1,2,6-hexanetriol), blue (1,2,4-butanetriol) and purple (1,4-butanediol) shown.

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