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Surface tensions, viscosities, and diffusion constants in mixed component single aerosol particles

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Surface tension and viscosity are important aerosol properties but are challenging to measure on individual particles owing to their small size and mass. Aerosol viscosity impacts semivolatile partitioning from the aerosol phase, molecular diffusion in the bulk of the particle, and reaction kinetics. Aerosol surface tension impacts how particles activate to serve as cloud condensation nuclei. Knowledge of these properties and how they change under different conditions hinders accurate modelling of aerosol physical state and atmospheric impacts. We present measurements made using holographic optical tweezers to directly determine the viscosity and surface tension of optically trapped droplets containing ∼1-4 picolitres of material (corresponding to radii of ∼5-10 micrometres). Two droplets are captured in the experimental setup, equilibrated to a relative humidity, and coalesced through manipulation of the relative trap positions. The moment of coalescence is captured using camera imaging as well as from elastically backscattered light connected to an oscilloscope. For lower viscosity droplets, the relaxation in droplet shape to a sphere follows the form of a damped oscillator and gives the surface tension and viscosity. For high viscosity droplets, the relaxation results in a slow merging of the two droplets to form a sphere and the timescale of that process permits determination of viscosity. We show that droplet viscosity and surface tension can be quantitatively determined to within <10% of the expected value for low viscosity droplets and to better than 1 order of magnitude for high viscosity droplets. Examples illustrating how properties such as surface tension can change in response to environmental conditions will be discussed. Finally, a study of the relationship between viscosity, diffusion constants, vapour pressures, and reactive uptake coefficients for a mixed component aerosol undergoing oxidation and volatilisation will be discussed.