

# Glassy and Ultraviscous Aerosol

## Supervisors

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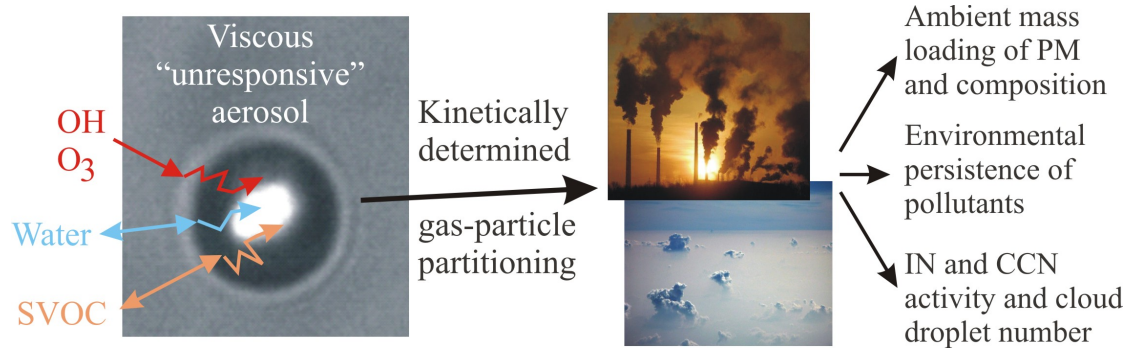
## Project description

Aerosols play significant roles in the atmosphere, influencing the formation and lifetimes of clouds, impacting on visibility and air quality, and affecting human health. It is most frequently assumed that the composition of the condensed fraction of the aerosol is governed by thermodynamic principles with the proportions of semi-volatile organic components and water in the gas and particulate phases at equilibrium. Recently, however, it has been shown that secondary organic aerosol (SOA) can exist in amorphous, viscous and even glassy phases, suggesting that ambient aerosol does not achieve equilibrium on an instantaneous timescale. Thus, the partitioning of water, semi-volatile organic components and chemical oxidants between the gas and particle phases will be kinetically determined, influencing the activity of SOA as cloud condensation nuclei and ice nuclei, the persistence of organic components in the condensed phase and impacting on their oxidative lifetimes (Fig. 1). Indeed, the timescale required for SOA composition to equilibrate has been shown to depend strongly on the ambient organic mass loading, particle size and the diffusion constant of species within the aerosol condensed phase; equilibration timescales can even exceed days for aerosols at low mass loading in remote rural environments.

We will investigate the kinetic factors that inhibit changes in aerosol composition, develop a framework for incorporating slow kinetics in simulations of chamber and ambient aerosol, and establish the atmospheric conditions under which aerosol is likely to persist at disequilibrium. Using novel instruments to study individual aerosol particles, we will study the time response of particle size to changes in the relative humidity, simulating the response of organic aerosol to changes in environmental conditions in the atmosphere. From the rate of water condensation or evaporation from a particle, we will infer the diffusion constant of water in surrogates for atmospheric aerosol. We will also measure the viscosity of aerosol particles directly by controlling the coalescence of pairs of particles using optical tweezers and monitoring the timescale for the particle to return to a spherical shape. Through collaboration with researchers at the University of Manchester and ETH-Zurich, we will develop and refine tools for predicting the viscosity of aerosol and the compositional dependence of the diffusion constant of water, based on our laboratory data. These tools will then permit accurate evaluation of the timescale for aerosol particle equilibration in the atmosphere and shed light on the importance of thermodynamic and kinetic factors in regulating aerosols.

U.K. Krieger, C. Marcolli and J.P. Reid, 'Exploring the Complexity of Aerosol Particle Properties and Processes using Single Particle Techniques', *Chemical Society Reviews* 41 (19) (2012) 6631 - 6662.

D.L. Bones, J.P. Reid, D.M. Lienhard, and U.K. Krieger, 'Comparing the mechanism of water condensation and evaporation in glassy aerosol', Proceedings of the National Academy of Sciences 109 (29) (2012) 11613-11618



Kinetically limited aerosol processes through slow diffusion in a particle bulk can have widespread consequences on ambient aerosol.