Novel Viscosity Measurement Technique for Atmospheric Aerosols using Fluorescence Lifetime Imaging Microscopy (FLIM)

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Analysis of the phase of atmospheric organic aerosol (OA) has become important in recent years due to the suggestion that secondary organic aerosols (SOAs) can adopt a non-crystalline, amorphous solid or highly viscous liquid state, as opposed to assuming they are a well-mixed liquid (Virtanen, 2012). The presence of such a highly viscous phase will have significant implications for diffusion rates for gases in/out of OA, rates of reaction in the condensed phase, formation rates of OA and other properties such as their ability to act as cloud condensation nuclei.

A quantitative method that can measure viscosity changes of organic aerosol particles is therefore important for a comprehensive understanding of aerosol processes in the atmosphere and currently no method exists to measure directly the viscosity of micrometer size droplets.

Here we present a new technique to quantitatively measure the viscosity of organic aerosol particles in the micron size range using fluorescence dyes called ‘molecular rotors’ combined with fluorescent lifetime imaging microscopy (FLIM). This technique has already been applied successfully to the measurement of viscosity in biological systems (Kuimova, 2012).

This new technique was first tested with sucrose particles with 10 to 100 μm diameters exposed to varying relative humidity. The viscosity increase of sucrose droplets that is expected during a decreasing RH from 90 to 75 % was compared with literature data.

The viscosity change of oleic acid droplets during ozonolysis was also measured online with FLIM (Fig. 1). An increase in viscosity was observed between 100-1000 mPa.s, which can be explained by the formation of oligomers and increased hydrogen-bonding of oxidation products. A size dependence was observed with larger droplets reacting more slowly to the exposure of ozone. This effect was more pronounced when exposed to lower ozone concentrations.

This study was extended to the measurement of the viscosity of the SOA formed from the ozonolysis of α-pinene, when exposed to different ozone concentrations and relative humidity.

Results will also be presented of the first attempts to couple FLIM with optical laser trapping, which allows for a measurement of viscosity changes in a contact-free environment using a suspended aerosol droplet.

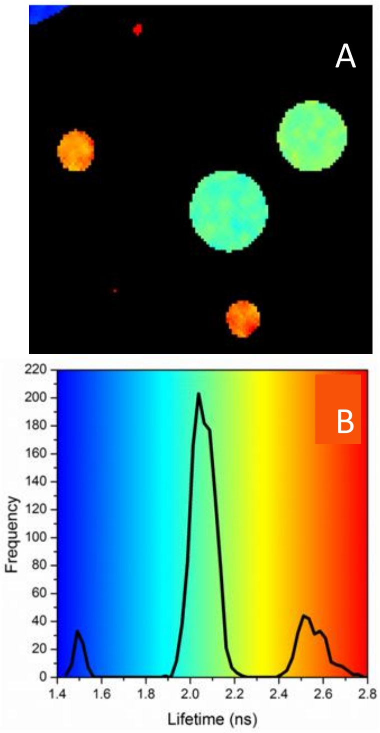

Figure 1. Oleic acid particles (containing the fluorescence molecular rotor BODIPY-C10), exposed to ozone (~1.5 ppm) for 15 mins. (A) Fluorescence Lifetime image. Smaller droplets show a longer lifetime corresponding to a higher viscosity compared to the larger droplets in the same field of view. (B) Lifetime histogram (Hosny, 2013).

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Kuimova, M. (2012) *PCCP* **14**, 12671–12686.
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