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Viscosity of α-pinene secondary organic material and implications for particle growth and reactivity

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Secondary organic particles are abundant in the troposphere, and may play an important role in climate, air quality, and health. Viscosity is a physical property of particles that is poorly understood and may influence particle sizes and concentrations in the troposphere, as well as reaction rates with various atmospheric oxidants. In order to predict the effects of particle viscosity on various atmospheric processes, the viscosities must be quantified.

A major obstacle to measuring viscosities of atmospheric or environmental chamber samples is the small sample volumes (typically on the order of milligrams after long collection times). The minimum sample volumes required for current microviscometry techniques are on the order of 10's of μL's. Those techniques, however, are limited to measuring viscosities <0.1 Pa s, in the low viscosity liquid regime. The viscometers currently available to measure higher viscosities require much greater sample volumes, which are not realistically achievable in any atmospheric sampling or chamber experiments.

Presented here are two novel approaches to measuring the viscosity of environmental chamber and atmospheric samples, which are capable of measuring a wide range of viscosities using significantly less than 1mg of material, and applicable across the ambient tropospheric RH range.

The first is a bead-mobility technique, where small ($\sim$1μm), insoluble beads are observed as they circulate within 20-50 μm particles. The second is a poke-flow technique, whereby 20-70 μm particles are poked with a needle, and the flow rate of these particles after poking is used to determine viscosity. These techniques not only provide visual evidence that the water-soluble fraction of atmospheric samples behave as semi-solids or solids, but also quantitative information as to their viscosities.