Hygroscopicity of sub 30nm SOA particles during CLOUD 10

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The impact of aerosol particles on the atmosphere and climate depends strongly on their ability to take up water vapour (hygroscopicity) and act as cloud condensation nuclei. The hygroscopicity is determined by the composition and the size of the particles. Direct measurements of the chemical composition of sub 30 nm particles is quite challenging. Thus, size resolved hygroscopicity measurements may give valuable insides into the composition of these particles and how this may change growing from 10 to 30nm.

Sulfuric acid, ammonia and oxidised organic vapours play an important role in new particle formation of secondary organic aerosol (SOA) and growth of those particles. The CLOUD chamber at CERN was designed to study new particle formation and the early stages of particle growth (Kirkby et al., 2011). During the CLOUD 10 campaign a range of different conditions were studied aiming at mimicking atmospheric relevant processes as best as possible and at the same time deciphering the influence of the different factors on hygroscopicity (see Table 1 for details). Ozone concentration and relative humidity (RH) in the chamber were held constant. Photo-oxidation (OH radicals) was induced by UV lights which also influenced the H_2SO_4 production from SO_2.

Table 1. Range of experimental conditions

condition	range
organic precursors	α-pinene
	α-pinene + Δ-3-carene
	isoprene
[H_2SO_4]	$10^4 - 5 \cdot 10^7$ /cm^3
[NO_x]	$0 - 15$ ppb
[NH_3]	$0 - 3$ ppb
temperature	-25ºC – 25ºC

The hygroscopic growth factor at 90% RH was measured with a custom built Hygroscopicity Tandem Differential Mobility Analyser (nanoHTDMA) for particles of sizes from 10 to 25nm (Keskinen, 2011). Then the hygroscopicity parameter κ was calculated based on the method by Petters and Kreidenweis (2007). As the κ values for pure H_2SO_4 and α-pinene derived SOA are known, the volume fractions of organics and H_2SO_4 in the particles can be calculated with the simple Zdanovskii–Stokes–Robinson (ZSR) mixing rule.

Higher gas phase H_2SO_4 concentrations increased the hygroscopicity of the particles while higher organic precursor concentrations in the gas phase decreased it (see Fig 1). Only a small effect of the particle size was observed between 15 and 25nm. The impact of NO_x in the system was also investigated. NO_x can influence the composition of the particles directly through the oxidation pathway of the organics and indirectly by lowering the H_2SO_4 concentration.
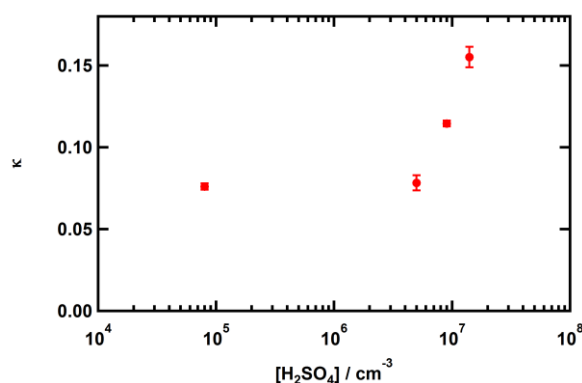

Figure 1. Average hygroscopicity parameter κ vs gas phase H_2SO_4 concentration for experiments with 1.3 ppb α-pinene+Δ-3-carene precursor mix (error bars are standard deviation from averaging).

References:
Keskinen, H. et al. (2011), *Aerosol Sci. Technol.*, **45**, 1441–1447, 2011.
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