Laboratory characterization of a size-resolved CPC battery to infer the composition of freshly formed atmospheric nuclei

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Keywords: CPC calibration, heterogeneous nucleation, particle activation.
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Atmospheric particle nucleation is an important environmental nano-scale process, with climate models indicating that nearly half of the global cloud condensation nuclei (CCN) may be formed from freshly nucleated particles. However, our understanding of atmospheric nucleation and its influence on climate is limited since few direct measurements have been made of either the nucleation rate or the chemical composition of the freshly formed clusters, both of which are necessary to constrain the mechanism and develop a nucleation model. In our study, we have developed an instrument to infer the size-resolved composition of freshly formed atmospheric particles, addressing a key knowledge gap in the composition of nucleated aerosol below 3 nm. This size-resolved condensation particle counter battery (SR-CPCb), is an extension of the CPCb concept [1] developed and used to infer the composition of nucleation mode particles between 2 and 9 nm [2]. In the SR-CPCb, the CPCb measurement principle has been extended down to 1 nm by combining a conventional nanoparticle mobility classifier with a CPCb composed of CPCs designed for the detection of sub 2 nm aerosol [3-7]. By sampling mobility-classified particles, the size resolved CPCb (SR-CPCb) eliminates the strong dependence of CPC response on particle size and charge below 2 nm [4-10]. Therefore, any measured differences in CPC response are then attributed solely to composition-specific interactions between the particle and the various working fluids.

The SR-CPCb is composed of a nanoparticle mobility spectrometer that has been optimized for the sampling and mobility classification of sub 3 nm particles [9]. The particle detector is composed of a CPCb containing the following CPCs with their accompanying working fluids: a Particle Size Magnifier [3] (diethylene glycol), a DEG-UCPC [5] (diethylene glycol), a TSI 3786 UCPC (water), a TSI 3025A UCPC [5] (butanol), and a pulse height UCPC [6] (butanol). The experimental schematic for determining the size, charge, and composition dependent particle detection efficiencies of the CPCb is described in [10]. The following methods were used to generate challenge aerosols for the characterization of the CPCb: (1) electrospray generation of molecular ion mobility standards, (2) evaporation of solid sodium chloride via tube furnace, (3) evaporation of ammonium sulfate via tube furnace, (4) tungsten oxide formation via a wire generator, and (5) candle aerosol generation. Presented results will include the particle composition dependent response of the SR-CPCb and size-dependent transmission efficiencies associated with the nanoparticle mobility spectrometer.

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This work was supported by the US Department of Energy (DOE) Atmospheric System Research Program (Office of Science, OBER) under contract DE-AC02-98CH10886, US DOE Grant Number DE-FG-02-05ER63997, the Academy of Finland (project nos. 1251427, 1139656, 141451, 133872), the Finnish Center of Excellence (project no. 1118615), and the European Research Council (ATMNUCLE).