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A thermal desorption mass spectrometer for freshly nucleated secondary aerosol particles

A. Held and S.G. Gonser
Bayreuth Center of Ecology and Environmental Research (BayCEER), University of Bayreuth, Bayreuth, Germany

Secondary aerosol formation in the atmosphere is observed in a large variety of locations worldwide, introducing new particles to the atmosphere which can grow to sizes relevant for health and climate effects of aerosols. The chemical reactions leading to atmospheric secondary aerosol formation are not yet fully understood. At the same time, analyzing the chemical composition of freshly nucleated particles is still a challenging task.
We are currently finishing the development of a field portable aerosol mass spectrometer for nucleation particles with diameters smaller than 30 nm. This instrument consists of a custom-built aerosol sizing and collection unit coupled to a time-of-flight mass spectrometer (TOF-MS). The aerosol sizing and collection unit is composed of three major parts: (1) a unipolar corona aerosol charger, (2) a radial differential mobility analyzer (rDMA) for aerosol size separation, and (3) an electrostatic precipitator for aerosol collection. After collection, the aerosol sample is thermally desorbed, and the resulting gas sample is transferred to the TOF-MS for chemical analysis.
The unipolar charger is based on corona discharge from carbon fibres (e.g. Han et al., 2008). This design allows efficient charging at voltages below 2 kV, thus eliminating the potential for ozone production which would interfere with the collected aerosol. With the current configuration the extrinsic charging efficiency for 20 nm particles is 32 %. The compact radial DMA similar to the design of Zhang et al. (1995) is optimized for a diameter range from 1 nm to 100 nm. Preliminary tests show that monodisperse aerosol samples (geometric standard deviation of 1.09) at 10 nm, 20 nm, and 30 nm can easily be separated from the ambient polydisperse aerosol population. Finally, the size-segregated aerosol sample is collected on a high-voltage biased metal filament. The collected sample is protected from contamination using a He sheath counterflow. Resistive heating of the filament allows temperature-controlled desorption of compounds of different volatility.
We will present preliminary characterization experiments of the aerosol sizing and collection unit coupled to the mass spectrometer. Funding by the German Research Foundation (DFG) under grant DFG HE5214/3-1 is gratefully acknowledged.

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