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Analysis of secondary organic aerosol using a Micro-Orifice Volatilization Impactor (MOVI) coupled to an ion trap mass spectrometer with atmospheric pressure chemical ionization (APCI-IT/MS)

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We describe the development and characterization of a Micro-Orifice Volatilization Impactor (MOVI) which is coupled to an ion trap mass spectrometer with atmospheric pressure chemical ionization (APCI-IT/MS), and its application in laboratory and field measurements. The MOVI-APCI-IT/MS allows the quantification of organic acids and other oxidation products of volatile organic compounds (VOCs) in secondary organic aerosols (SOA) on a semi-continuous basis. Furthermore, the vapor pressure and saturation concentration of the particle components can be estimated.

The MOVI was first described in 2010 by Yatavelli and Thornton (Yatavelli and Thornton, 2010). It is a single stage, multi-nozzle impactor with 100 nozzles, each having a diameter of 150 μm. At a flow-rate of 10 L·min^{-1} air is drawn through the MOVI and particles are collected on a deposition plate. The cut-point diameter (d_{50}, diameter of 50% collection efficiency) is at 130 nm. A low pressure-drop of only 5.3% of atmospheric pressure behind the nozzles allows collecting not only low-volatile but even semi-volatile compounds, which are an important part of SOA. After collecting particles hydrocarbon-free synthetic air is led over the collection surface into the APCI-IT/MS and the collection surface is heated up to 120 ˚C in less than 200 s, volatilizing the sampled SOA. The vaporized compounds are transferred into the ion source and subsequently analyzed by mass spectrometry. Due to the soft ionization at atmospheric pressure the obtained mass spectra show only low fragmentations and can easily be interpreted.

In laboratory experiments the MOVI-APCI-IT/MS was used for the chemical analysis of SOA generated from α-pinene-ozonolysis in a smog chamber. The limit of detection was found at 7.3 ng for pinic acid. The vapor pressure $log\ p^0$ and the saturation concentration C^*_{25} for pinic acid were calculated from the desorption temperature using the method presented by Faulhaber et al. (Faulhaber et al., 2009). Furthermore, in summer 2011 the MOVI-APCI-IT/MS was successfully tested in field measurements during the „Bio-hydro-atmosphere interactions of Energy, Aerosols, Carbon, H_2O, Organics and Nitrogen – Rocky Mountain Biogenic Aerosol Study" (BEACHON-RoMBAS) in a ponderosa pine woodland in the southern Rocky Mountains of North America. The study was focused on understanding the formation, growth and properties of biogenic organic aerosol. We measured the composition of the aerosol particles and determined the concentration of pinic acid and isobaric substances. By means of intercomparison studies with other instruments like an aerosol mass spectrometer (AMS) and a MOVI coupled to a chemical ionization mass spectrometer (CIMS) we could validate our measurements.

References:

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