Detection and quantification of water-based aerosols using active open-path FTIR

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Exposure to airborne particles has an adverse influence on human health. One of the great challenges in aerosol real-time measurements, besides quantification, is to identify their composition. This study suggests using active Open Path Fourier Transfer Infra-Red (OP-FTIR) spectroscopy for quantifying water load in spray cloud as well as solutes load in it.

OP-FTIR operates in the mid-IR range where many organic and inorganic compounds present unique spectral “fingerprints” and hence has great potential for obtaining chemical information of the aerosols. Although a few studies have shown the potential of OP-FTIR for aerosols detection, e.g. measurements of water droplets (Hashmonay & Yost 1999; Wu et al. 2007), It has not been used for investigation of aerosols chemical composition.

Experimental: To minimize wind interference the aerosol cloud was generated within a 20m long polyethylene tunnel open at both ends. A custom agricultural system was used for the dispersion of water-based droplets. In addition to the spectral measurements, off-line measurements of water load in the line of site (LOS) and concentration of the dissolved components in the airborne droplets were conducted. (see figure 1)

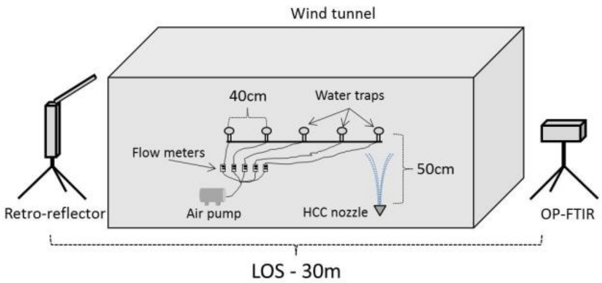

Figure 1: Illustration of the experimental setup inside the spray tunnel.

Three sets of spraying experiments generated different hydrosols clouds: (1) tap water only (with varying loads using different nuzzles), (2) aqueous ammonium sulfate solution (0.35%-3.6%wt) and (3) aqueous ethylene glycol solution (0.47%-2.38%wt).

Results

Experiment 1- Water clouds: The wavelength-dependent extinction coefficient of the droplets was found to be similar for all tested nozzles, resulting a linear relationship between spectrum baseline and water load in the LOS.

Experiment 2 - Cloud of aqueous ammonium sulfate droplets: The ammonium sulfate spectral signature was clearly visible in the signal and a quantitative model was obtained (figure 2).

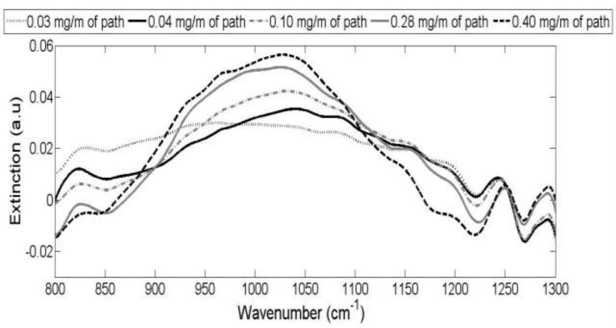

Figure 2: Water-subtracted signals of the ammonium sulfate clouds.

Experiment 3: Cloud of aqueous ethylene glycol droplets. For the semi-volatile ethylene glycol, present in both gas and condense phases, quantification was much more complex and two approaches were developed: (1) using the linear relationship from the first experiment (determination error of 8%), and (2) inverse modeling (determination error of 57%).

Conclusion

This work demonstrates the potential of the OP-FTIR for detecting clouds of water-based aerosols and for quantifying water droplets and solutes present in them at relatively low concentrations.

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