Low Temperature Plasma Ionization Mass Spectrometry for Real-Time Analysis of Size-Selected Organic Aerosol Particles

Sandra E. Spencer, Gary L. Glish

Ambient aerosol particle composition has been shown to be influenced by particle diameter. Though methods for real-time analysis of gas phase neutrals have been developed, current techniques for analysis of aerosol particles typically involve collection of particles on a filter prior to analysis, preventing real-time analysis. It has been shown that different results are obtained when a sample is collected on a filter prior to analysis or analyzed in real-time. Mass spectrometry is ideal for real-time aerosol analysis due to its speed, sensitivity, and specificity. Low temperature plasma ionization (LTPI) is an ionization technique that eliminates the requirement for sampling aerosols onto a filter. By coupling LTPI with a differential mobility analyzer (DMA), size-selected aerosols can be analyzed in real-time.

Aerosols were generated by pyrolysis of a natural polymer, ethyl cellulose. The denuder used to remove gaseous neutrals was coated in XAD according to the Environmental Protection Agency guidelines. The pyrolysate was directed through a transfer line to a cylindrical DMA. By scanning the voltage on the DMA electrode, a range of size-selected aerosol particles were transmitted through the device. The size-selected aerosol was either sent to a condensation particle counter (CPC) to measure the particle size distribution or to a 3D quadrupole ion trap mass spectrometer for LTPI of the particles in the pyrolysate.

To ensure that LTPI generates ions from compounds in the particle phase of the aerosol, a tetrafluoroethylene (TFE) coated quartz filter was placed in-line with the aerosol produced from the pyrolysis of ethyl cellulose. TFE is known to minimally adsorb gasses, but the filter is rated to remove 96.4% of the particles in the aerosols. With the filter in-line, the analyte signal was reduced to nearly background level, suggesting that the compounds ionized by LTPI are from the aerosol particles rather than gaseous neutrals. The overall ion intensity decreased after the pyrolysate was passed through a denuder to remove gaseous neutrals in the ethyl cellulose pyrolysate. However, the ion distribution with and without the denuder was similar. The decrease in signal intensity is likely due to diffusion of particles to the walls of the denuder.

The pyrolysate was directed through a cylindrical DMA to generate a size-selected beam of aerosol particles. As the DMA voltage is scanned, various ions corresponding to the analyte are observed. Analyte ions of \( m/z \) 199 and 201 are the most abundant analyte ions when the DMA is transmitting particles of approximately 90 nm. However, when particles of approximately 220 nm are being transmitted through the DMA, the analyte ion of \( m/z \) 183 is the dominant ion in the mass spectrum.

Analysis of size-selected aerosols in real time using a differential mobility analyzer and low temperature plasma ionization mass spectrometry.