Single Particle Characterization using a Light Scattering Module coupled to an Aerodyne Aerosol Mass Spectrometer

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INTRODUCTION

The Aerodyne aerosol mass spectrometer (AMS) measures, in real time, the non-refractory organic and inorganic mass composition and vacuum aerodynamic diameter of submicron aerosol particles (*Jayne et al.*, 2000). To extend the capability of the AMS as a stand-alone instrument, a light scattering module (LS) has been developed and incorporated into the AMS (now called LS-AMS) (*Cross et al.*, 2007). With the LS-AMS the magnitude of the scattered light signal (R_{LS}) and vacuum aerodynamic diameter (d_{va}) are determined for every particle (refractory and non-refractory) with a size greater than the light scattering detection limit (~180nm). By measuring the scattered light from a wide range of aerosol particles of known size, shape, and refractive index a single calibration curve, valid for atmospherically important aerosol particles, has been obtained. This calibration curve relates the magnitude of the scattered light signal (R_{LS}) to the optical diameter of the particles. The combination of the optical and aerodynamic diameters, allows one to calculate the particle density (or effective density) via equation 1:

$$\rho_p = d_{va}/d_o * \rho_0. \quad (1)$$

With particle densities obtained on a single particle basis, the mixing state of the ambient aerosol particle distribution can be determined (*Cross et al.*, 2007).

In the original version of the AMS (denoted Q-AMS) the ions are detected with a calibrated quadrupole mass spectrometer. Because the quadrupole measures only one single m/z per particle event, single particle mass fractions must be averaged to obtain an estimate of the full chemical composition of single particles. Field results obtained with the Q-AMS equipped with a light scattering module have been reported (*Cross et al.*, 2007).

Recently, the quadrupole mass spectrometer has been replaced by a time of flight mass spectrometer (ToF). The ToF provides the complete mass spectrum for each single particle event. Thus the ToFAMS can quantitatively measure single particle chemical composition for ambient aerosol particles (*Drewnick et al.*, 2005).

The light scattering module has now been added to the ToFAMS as shown in Figure 1, and the combined unit has been deployed during the MILAGRO, 2006 field study in Mexico City.

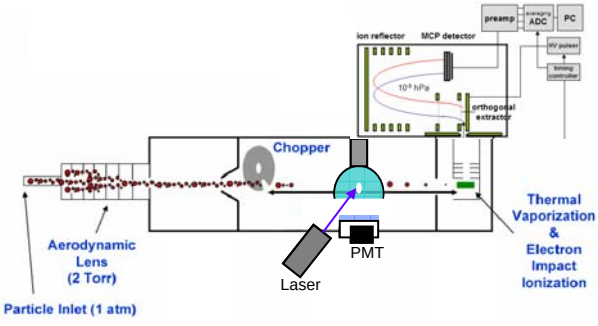

Figure 1. LS-ToFAMS Instrument

The scattered light signals are used to trigger the acquisition of single particle mass spectra, enabling a more efficient operation of the AMS as a single particle detector. The combination of optically-derived and chemically-derived densities is used to differentiate between internal and external mixtures of aerosol particles. In several cases, the optical scattering unit detected two distinct particles within the same detection cycle, one with purely organic components and the other purely inorganic.

REFERENCES

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