Aerosol mass spectrometry of refractory black carbon containing particles

T.B. Onasch[1,2], E.C. Fortner[1], P. Massoli[1], L.R. Williams[1], A.T. Lambe[1,2], A.M. Trimborn[3], J. T. Jayne[1], P. Davidovits[2], and D.R. Worsnop[2]

[1]Center for Aerosol and Cloud Chemistry, Aerodyne Research, Inc., Billerica, MA, 01821, USA
[2]Department of Chemistry, Boston College, Chestnut Hill, MA, 02467, USA
[3]Aeromegt GmbH, Hilden, 40723, Germany
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Presenting author email: onasch@aerodyne.com

The soot particle aerosol mass spectrometer (SP-AMS) instrument, recently developed by Aerodyne Research, Inc., combines the ability to measure the mass and chemical composition of size-resolved particulate matter, including refractory black carbon components (Onasch et al. 2012). This instrument was developed to address the issue that refractory black carbon-containing particles formed in incomplete combustion processes are strong light-absorbers with significant climate forcing impacts and potential health effects. The complex nature of these particles makes their characterization (microphysical, chemical and optical) challenging. The SP-AMS technique represents a new method for characterizing and quantifying the chemical and physical properties of particulate refractory black carbon. Using the SP-AMS, we have participated in a growing number of laboratory studies and field campaigns to characterize refractory black carbon-containing particles from a range of sources and over a range of atmospheric aging. We will present selected highlights from these studies.

The SP-AMS is equipped with an intracavity Nd:YAG CW laser vaporizer (1064 nm). Only light absorbing particles, such as refractory black carbon containing particles, will vaporize in the laser beam. Both the nonrefractory and refractory components are vaporized. Particulate vapors are ionized by electron ionization (70 eV) and detected with high resolution time-of-flight mass spectrometry. The SP-AMS can be operated with or without a resistively heated (600^{o}C) tungsten vaporizer; with both vaporizers, the SP-AMS measures all refractory and non-refractory particles.

Laboratory results have focused on characterizing the chemical and physical properties of laboratory-based flame soot and manufactured refractory black carbon particles as a function of coating with organic compounds and sulfuric acid and thermal denuding (Eben S. Cross et al. 2010). These studies have provided the foundation for using the SP-AMS instrument to constrain measurements of the optical properties of ambient soot particles, specifically relating to the absorption enhancement due to atmospheric aging.

In addition, we are characterizing the carbon ion distributions generated by different refractory black carbon particle types. These mass spectral signatures may provide unique information on different types of refractory black carbon sources. Figure 1 shows five carbon ion mass spectra for laboratory and field measured rBC particle types and illustrates a trend towards larger carbon clusters.

The field measurements conducted include biomass burning (FLAME3), flare emissions (Fortner et al. 2012) internal combustion engine sources (Massoli et al. 2012; Cross et al. 2012; NYC, MIT Engine Lab, and Caldecott Tunnel), and urban environments (Cappa et al. 2012; CalNex 2010 and ClearfLo 2012). Mass spectral features and size distribution results for several field deployments will be presented with emphasis on source characterization and the characterization of the chemical and physical changes that rBC particles undergo as a function of atmospheric aging.

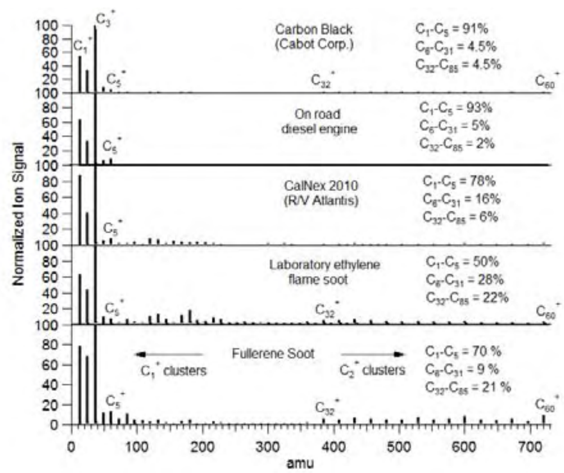

Figure 1. Refractory black carbon mass spectra for laboratory and field particulate sources.

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Cappa, C. D., et al. (2012) *Science* 337 (6098) (August 30): 1078–1081.

Cross, E. S., et al. (2012) *Journal of Engineering for Gas Turbines and Power* 134 (7): 072801.

Cross, E. S., et al. (2010) *Aerosol Science and Technology* 44 (8) (June 30): 592–611.

Fortner, E. C., et al. (2012) *Industrial & Engineering Chemistry Research* 51 (39) (May 3): 12586–12592.

Massoli, P., et al. (2012) *Aerosol Science and Technology* 46 (11) (November): 1201–1218.

Onasch, T. B., et al. (2012) *Aerosol Science and Technology* 46 (7) (July): 804–817.