Chemical Properties of Combustion Aerosols: An Overview

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Keywords: fine particle matter, organic carbon, black carbon, organic markers
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A wide variety of pyrogenic and anthropogenic sources emit fine aerosols to the atmosphere. The physical and chemical properties of these aerosols are of interest due to their influence on climate, human health, and visibility.

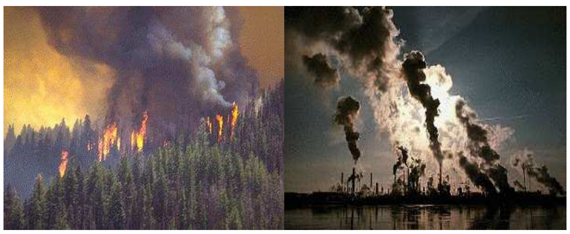

Figure 1. Two combustion source types: Biomass burning and industrial-based.

Aerosol chemical composition is remarkably complex. Combustion aerosols can comprise tens of thousands of organic compounds, refractory carbon, metals, cations, anions, salts, and other inorganic phases and substituents [*Hays et al.*, 2004]. Aerosol organic matter normally contains semivolatile material that partitions between the gas-, liquid-, and particle-phases, a process controlled by dynamic equilibrium or interfacial mass transfer considerations. Volatile and semivolatile gas-phase organic matter can undergo photo-oxidation in the atmosphere, creating particle nuclei or growing particles further via condensation. This diverse chemistry and processing of combustion emissions aerosols produces distinct particle morphology and nanostructure that is heterogeneous, which in turn contributes to the optical properties, aerodynamic nature, and thus fate and transport of these aerosols [*Hays and VanderWal*, 2007].

Exhaustive determination of the complex chemical nature of combustion aerosols requires utilizing a series of advanced analytical techniques. *The focus of this talk is the analytical measurements that have evolved in the aerosol and combustion science community for reliably measuring chemical composition.* The use of both real-time and laboratory-based instrumentation will be covered. What will be shown is how real-time particle instrumentation has improved our ability to monitor: (i) transient combustion events; (ii) single black carbon (BC) particles; (iii) the extent of volatile organic mass coating BC, and (iv) organic composition at low aerosol mass. Photoacoustic spectroscopy, laser incandescence methods, and mass spectroscopy-based applications central to aerosol investigations are topics of interest.

In addition, the benefits and disadvantages of off-line laboratory techniques will be considered with regard to combustion aerosol composition. The use of X-ray fluorescence spectroscopy (XRF) and inductively coupled plasma-mass spectroscopy (ICP-MS) for metals will be included together with the high-vacuum electron microscopy techniques that are capable of not only measuring heterogeneous micro- and nano-structure (Figure 2) but of also detecting metal inclusions in combustion soot mixtures.

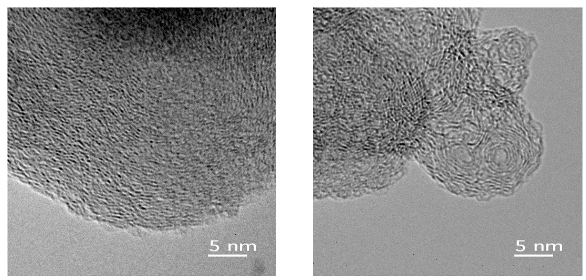

Figure 2. High-resolution transmission electron microscopy (HR-TEM) of oil boiler soot (left) and aircraft engine soot (right).

Finally, the application of liquid and gas chromatography (LC and GC) for the identification of novel organic markers in biomass burning and anthropogenic aerosols will explored. In specific, the use of two dimensional GC methods and hyphenated MS techniques for identifying organic nitrogen compounds will be further considered [*Ma and Hays*, 2008; *Samy et al.*, 2011]. The effects of sampling methods on detection limits and organic analyte concentration measurements will be discussed as well.

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