C14 Microscopy of Soot Particles

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After attending this presentation, attendees will understand the basics of soot particle formation including the three most common forms: char, cenisphere, and aciniform. They will be shown what these forms look like and how microscopy might be used tell them apart.

This presentation will impact the forensic community by increasing the general knowledge of how microscopic level soot particles may be similar or different when generated by different combustion sources. These differences may be useful when investigating potential criminal arsons and in environmental forensic investigations of potential industrial contamination and the sources of darkening agents.

Soot is generated during the incomplete combustion of organic materials. Individual soot particles show different characteristics depending on the nature of the fuel and the parameters of combustion. The particle characteristics of the two most common forms of soot, char soot and aciniform soot, can be used to distinguish between different sources. Commercial varieties of soot like carbon black, lampblack, and coke have distinctive characteristics that often allow them to be distinguished from the non-commercial forms of soot. The ASTM Standard Practice D6602-03b provides a basis for investigations involving soot particles. Using this Practice, polarized light microscopy (PLM) can be used to differentiate between soot particles and other dark particles that may be present in a sample. PLM and scanning electron microscopy equipped with energy dispersive x-ray spectroscopy (SEM- EDS) can be used to differentiate certain forms of coal and coke from other particles of char. Because aciniform soot particles are composed of aggregates of primary particles in the nanometer range, transmission electron microscopy (TEM-EDS) is used to confirm its presence and provide diagnostic characterization. Aciniform soot particles can be classified according to their morphology (shape and appearance of the primary particles and aggregates), their elemental composition, and primary particle size distribution. TEM is also useful in looking at turbostratic layering, an attribute of the internal structure of some primary aciniform particles.

A number of reference samples of soot or similar black carbon materials were obtained and characterized. Standard reference petroleum coke obtained from the National Institute for Standards and Technology (NIST) – (SRM 2718) was found to have similar characteristics to standard reference bituminous coal (NIST-SMR 2693) when analyzed by PLM. They could be differentiated based on elemental composition differences as determined by SEM-EDS. Additional work was also done on reference samples of coal (anthracite, bituminous, lignite) and peat obtained from the American Coal Foundation, Washington, DC. Reference ASTM carbon blacks (grades N134, N220, N326, N330, and N660) were compared with NIST standard reference Diesel Particulate Matter (SRM 2975) using the TEM-EDS procedures described in the ASTM Standard D6602-03b. Commercial carbon black and diesel soot are both composed of aciniform carbon particles. They both show turbostratic layering in their primary particles. Carbon blacks have average primary particle diameters (related to the specific grade) with fairly tight standard deviations. Diesel soot particles can have average primary particle diameters that are similar to carbon black but have larger standard deviations. This presentation will also include illustrations of microscopic characterizations of soot particles that were used in a number of investigations including those concerning California wildfires, industrial combustion sources, candles in residences, and a site of a suspected arson.

Soot, Microscopy, Aciniform

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