D32 Forty Years of Squinting — Environmental Forensic Microscopy: 1974–2014

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After attending this presentation, attendees will better understand how different types of microscopes can be used in environmental/industrial investigations.

This presentation will impact the forensic science community by providing illustrations of how environmental forensic microscopy has been used to solve contamination and other questions by one investigator and his team over the past 40 years.

During the first 40 years of my career, I have had the opportunity to use various microscopes and forensic techniques to solve a number of interesting environmental/industrial questions involving product identification, indoor air quality concerns, outdoor darkening agents including various types of soot, lead particles, asbestos, and glass fibers, ceramic whiskers, corrosion debris, and particles from the World Trade Center disaster of September 11, 2001. The sampling and analysis methods I have used over the years in environmental forensic investigations were drawn primarily from the criminal forensics, industrial hygiene, and environmental monitoring areas. Combining various aspects of these disciplines allowed me to generate a procedure that fit the varied and sometimes very complex environmental/industrial situations.

Some investigations required only a light microscope but many of the microscopic analyses in environmental forensic investigations were accomplished utilizing a combination of visible light, infrared light, and electron microscopy. The light microscopy was usually performed initially with a stereo-binocular microscope followed by Polarized Light Microscopy (PLM) but may have involved Phase Contrast (PCM), darkfield, or fluorescence microscopy. Infrared microscopy was done using Fourier Transform Infrared (FTIR) microspectroscopy. FTIR is very useful when identifying organic molecules such as plastics and polymers. Scanning Electron Microscopy (SEM) was used in some studies because it allows the analyst to see particles that are smaller than can be seen with light microscopy and when equipped with an X-ray analysis unit, allows the analyst to determine the elemental composition of the particles. Transmission Electron Microscopy (TEM) also allows the analyst to see particles that are smaller than can be seen with light microscopy and when equipped with electron diffraction capabilities and an X-ray analysis unit, allows the analyst to determine the crystal structure and elemental composition of the particles.

One environmental method, American Society for Testing and Materials (ASTM) Practice D6602, provides a list of different types of microscopes used to investigate particles: a stereo-binocular microscope, capable of 1-60x magnification; a polarized light microscope, equipped with objectives in the 4-100x range of magnification (for a total magnification between 40x and 1000x); a transmission electron microscope equipped with a suitable camera; and a scanning electron microscope equipped with Energy or Wavelength Dispersive Analysis Equipment (EDS or WDS). A TEM equipped with Selected Area Electron Diffraction (SAED) and EDS is sometimes referred to as an Analytical Electron Microscope (AEM).

The capabilities of the various microscopy tools will be illustrated through short presentations of several investigations including: the source of asbestos fibers in a kitchen faucet filter; the composition of many building products studied during a case working for the Attorney General for the State of Maryland; characterization of dust that was generated by the World Trade Center tragedy of September 11, 2001; a spot called Ralph on a carpet in a South Carolina courthouse that kept growing larger; particles in home dust that were reported to be evidence of an alien visitor; and, the sources of black, white, and yellow deposits on automobiles.

Microscopy, Environmental, Historical Uses