## C2 Environmental Forensic Microscopy

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The goals of this presentation are to describe to the environmental forensic community the use of light and electron microscopy for the identification of small particles that have been released into the environment. Attendees will gain an understanding of particle collection and analysis techniques where microscopy is used to determine the source of hazardous dust in different environmental settings.

Environmental forensic microscopy is the application of microscopy to the collection, analysis, and identification of small particles and the interpretation of any results as they pertain to environmental investigations and governmental regulations. Collection techniques vary according to the situation presented and range from simple scoop and bag techniques to sophisticated filtering and particle isolation techniques. Airborne particles are usually collected by filtration or impaction, although passive sampling tins are also used. To collect samples of particles from surfaces, scraping, brushing, adhesive tape sampling, wipe sampling, and vacuuming have been employed. When collecting liquid samples for the analysis of suspended particles, consideration must be given to the material used in manufacture of both the sampling container and the filter upon which the particles will ultimately be examined so that no adverse reactions occur between the material and the liquid being sampled. The specific particle collection technique for a particular project is chosen to maximize the probative value of the particles collected and to ensure that a second party preserves portions of any sample collected for analysis. Analysis procedures involve the use of a variety of microscopical tools, including polarized light microscopy with microchemical testing, scanning electron microscopy with X-Ray analysis, transmission electron microscopy with diffraction and X-Ray analysis, infrared microscopy, ultraviolet microscopy, and scanning white light interference microscopy. Identification techniques require the knowledge of trained microscopists utilizing the microscopes to characterize small particles and compare their physical and chemical characteristics to suspect sources.

The forensic environmental microscopist is often called upon to interpret the results of his findings according to applicable environmental or other regulatory law. In many projects, the environmental forensic microscopist must work closely with environmental engineers and practitioners of environmental law to solve complex questions. The following case studies illustrate the range of analytical procedures and variety of information determined during environmental forensic microscopy studies. These projects have been selected from case files compiled over a 12-year period – 1990 to present. Case 1 concerned a surface dust from a residence that was thought to be contaminated with lead-based paint. Paint particles were not detected by scanning electron microscopy, but lead-containing fly ash was found in considerable quantities. Subsequent investigation and sampling of possible sources resulted in matching the fly ash with an outdoor stockpile at an industrial site. Eventually charges were brought against the owner of the site for improper control of environmental emissions. Case 2 involved surface dust samples from residences around a Superfund site that had formerly produced a leadarsenate pesticide. Scanning electron microscopy with X-Ray analysis showed that particles consistent with the pesticide were present in the residential dusts near the former manufacturing plant. The microscopical analyses were used to discriminate between the lead arsenate and other forms of lead present in the dusts such as lead-based paint and to determine the how far the particles had migrated away from the manufacturing plant. Case 3 showed how environmental forensic microscopy is used to investigate indoor environmental questions. A woman complained of allergy-like symptoms in her office in Virginia. The symptoms included irritated eyes, runny nose, and respiratory problems. Examination of dust by polarized light microscopy after collection by micro-vacuuming the woman's work area showed cat hairs in the woman's office. After initially denying it, a co-worker finally admitted to bringing her cat into the workplace when she worked after hours (after the cleaning crew had been through) and letting it run throughout the office complex. Case 4 involved the constituent analyses of bulk asbestos-containing building materials and the matching of results to manufacturers' formulae in environmental cost-recovery litigation being conducted by the Attorney General's Office of the State of Illinois. A number of building products in the state-owned buildings were found to be consistent with products sold by specific manufacturers based on the analyses performed using polarized light microscopy, scanning electron microscopy and transmission electron microscopy. Case 5 involved a sample of water with suspended particulate. The sample was collected from a drainage area outside an industrial complex. The particles were shown to be high in rare earth elements by the x-ray analysis in the scanning electron microscope. The investigation was directed toward a manufacturer of optical glass products in the complex. Case 6 concerned the analysis of a piece of white material that was clogging a drain in a newly renovated building. Light and scanning electron microscopy were used to analyze the material and compare with possible source materials that were being used by various contractors on site. The material was consistent with one of the products being dumped inappropriately into the building drain system. Case 7 is an ongoing investigation using environmental forensic microscopy to investigate dust produced by the collapse of the World Trade Center buildings on September 11, 2001. The characterizations of the dust by polarized light microscopy, scanning electron microscopy and transmission electron microscopy will be useful in determining the extent of the buildings contaminated by the

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tragedy as well as useful in the studies of health effects and cleaning procedures necessary for building recovery.

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