B5 Forensic Studies of Dye and Fiber Degradation During Environmental Exposure by Microspectrophotometry and Capillary Electrophoresis/ Mass Spectrometry

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After attending this presentation, attendees will have a greater understanding about the forensic methods of fiber analysis, as well as the extraneous factors that can complicate forensic comparisons.

This presentation will impact the forensic community and/or humanity by providing a more qualitative and quantitative insight into forensic fiber analysis. Explanations by trace evidence examiners for observed differences in textile fibers as a result of environmental exposure will be more convincing if accompanied by insight into possible chemical or physical mechanisms.

Textile fibers found at crime scenes are rarely found in pristine condition. The degradation of fibers and dyes can complicate the forensic comparison between questioned (evidence) and known (suspect) fibers. The objective of this research is to characterize changes that occur in textile fibers as a result exposure to environmental conditions including laundering and outdoor exposure to sunlight, heat, and moisture. Fabric samples of the most commonly used fiber types (cotton, polyester, nylon and acrylic) have been dyed with the most commonly used dyes (reactive, disperse, acid and basic) and were subjected to a variety of environmental conditions (washing, bleaching, sunlight, heat, accelerated weathering, and natural weathering) and subsequently analyzed to determine the effects of these treatments. Fabric samples were exposed to outdoor weathering (Arizona and Florida) and accelerated outdoor weathering (EMMA and EMMAQUA equivalent to 3, 6, 9 and 12-months in hot-dry and hot-wet environments). Samples were laundered with Tide®, Gain® and Wisk®, each alone, with Clorox® (chlorine bleach), and with Clorox® 2 (peroxide bleach). Small scale investigations on the effect of pool and sea water exposure are also being executed.

Fabric samples were retired from exposure at predetermined time intervals of exposure and analyzed by UV/visible and fluorescence microspectrophotometry. UV/visible and fluorescence microspectrophotometry affords the advantage of producing a distinct spectral fingerprint that can be stored and recalled for further processing. Spectral analysis of the changes in the dyed fiber spectra as a function of the exposure duration is supplemented by further analysis of selected samples using capillary electrophoresis/mass spectrometry. The advantages of CE over other analytical techniques are high separation efficiency, high selectivity, short analysis times/high sample throughput, simplicity and ease of automation, low organic solvent consumption/waste, low sample amounts required (<50 nL injected), and relatively low running costs. The efficiency (expressed as the number of theoretical plates) of CE is around 10^5-10^6 m^{-1}, compared to around 10^5 m^{-1} for HPLC and 10^3 m^{-1} for gas chromatography. In addition, CE capillaries are reusable, inexpensive, and can be used at a higher pH than most silica-based HPLC columns. Adding MS to a CE-DAD system adds qualitative identification capability (molecular mass) to the information gained from CE. Using this system, multiple dye components were analyzed at low concentrations in fiber dye extracts.

Explanations by trace evidence examiners for observed differences in textile fibers as a result of environmental exposure will be more convincing if accompanied by insight into possible chemical or physical mechanisms. A representative sampling of the environmentally exposed samples will be analyzed using automated micro-extraction techniques followed by separation using capillary electrophoresis and analysis of the degraded dyes and deposited chemicals using mass spectrometry. Using these techniques, the level of changes induced by environmental exposure will be assessed, and also insight gained into the chemical natures of the degradation and deposition products. This chemical understanding will also assist in interpretation of spectral data and enhance the forensic significance of the results.

Fiber Analysis, Capillary Electrophoresis/Mass Spectrometry, Microspectrophotometry

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