B88 Forensic Textile Dye Analysis by Thermal Desorption Direct Analysis in Real-Time Mass Spectrometry (DART®-MS) and Raman Microscopy

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Learning Overview: After attending this presentation, attendees will better understand how DART®-MS and Raman microscopy can be used for forensic textile dye analysis. The DART®-MS and Raman methods can be used to distinguish among different types of dyes and provide characteristic information for forensic fiber identification.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by comparing the two advanced techniques, DART®-MS and Raman microscopy, for their application on forensic fiber and textile dye analysis, which will hold great potential across a broad range of topics in the analytical chemistry area and will impact the forensic science community, especially the area of forensic fiber analysis.

The Thermal Desorption(TD) -DART®-MS method was developed for the analysis of an array of blue dyes in this study. Past experimentation has shown that the TD-DART®-MS can be used to identify the polymeric backbone structures, and obtain the chemical information, of common textile materials such as cotton, nylon, polyester, cellulose triacetate, poly(propylene), and poly(acrylonitrile).[1] Currently, there are thousands of textile dyes derived from natural sources or made synthetically, and these are classified into different categories according to their application method and chemical composition. The ability to correctly identify an unknown fiber is of great forensic importance, and this evidence is often used to place a suspect's carpet or clothing at a scene.[2-3]

This study was composed of nine blue dyes from four categories (acid, basic, reactive, and vat blues) that are commonly used in manufactured textiles. A TD-DART®-MS method was developed to analyze the dyes, which were applied on an array of common fibers, including silk, cotton, and nylon. The mass spectra were collected, and the multidimensional profiles, including both the physical properties of melting point and chemical information, were analyzed and compared to each other in order to locate identifiable signals. The signals of the dyes were distinguishable from their fiber, and the characteristic ions were unique for each dye structure. The DART®-MS results were compared to those obtained by Raman microscopy with and without Surface-Enhanced Raman Scattering (SERS) by colloidal silver nanoparticles. The benefit of SERS is to limit the excitation depth of the Raman signal from the fibers so that signal due to the dye is enhanced relative to the underlying polymeric fibers. The Raman microscope offers molecular mapping capability that combines the morphological and chemical information of fibers for unequivocal identification fiber origins. The study found that the TD-DART®-MS method requires a single fiber sample size and a sample preparation time of approximately two minutes, but it offers a multidimensional profile within approximately seven minutes. Due to this method being both simple to perform and having high sample throughput potential, this method may significantly contribute to the identification of unknown dyes on fibers in comparison to the traditional, slower methods that require the extraction of dyes or chromatographic separation.

Reference(s):

1. Liang, J., Frazier, J., Benefield, V., Chong, N, Zhang, M. Forensic Fiber Analysis by Thermal Desorption/Pyrolysis-Direct Analysis in Real Time-Mass Spectrometry (TD/Py-DART-MS). *Analytical Chemistry,* 2020, 92(2), 1925-1933.
2. Mather R.R., Wardman R.H. *The Chemistry of Textile Fibres.* Cambridge, UK: RSC Publishing, 2011.
3. Houck M.M. Ways of identifying textile fibers and materials. In: Houck M.M., editor. *Identification of Textile Fibers*: Woodhead Publishing; 2009;6-26.

Textile Dye, DART®-MS, Raman Microscopy