B159 Characterization of Hair Dyes Using Ultra High-Performance Liquid Chromatography Electrospray Ionization Time-of-Flight Mass Spectrometry (UHPLC-ESI-TOF/MS) for the Forensic Analysis of Dyed Hair

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After attending this presentation, attendees will learn about the process and chemicals used to dye human hair and options for analysis of dyed hair. The attendees will be exposed to the idea of using HPLC with MS detection to analyze dyed hair for forensic purposes.

The presentation will impact the forensic science community by suggesting a technique that brings additional support to hair evidence when an association can be made between a person and the crime scene based on dyed hair. This technique involves dye extraction from hair using typical solvents followed by LC analysis with MS detection.

Forensic analysis of questioned hair typically entails microscopic comparison with known hair collected from the suspect or from the victim possibly followed by mitochondrial DNA analysis if the investigation microscopic comparison does not result in an exclusion. The microscopic comparison is a quick yet notoriously unreliable technique, which requires an extremely well-trained investigator. Many convictions obtained using hair evidence were later reversed based on DNA evidence, emphasizing an unacceptable rate of false positives.

Mitochondrial DNA analysis can reduce the probability of false positives to a very low, yet still unacceptable, value. Unlike nuclear DNA analysis, mitochondrial DNA analysis cannot individualize the evidence to a single suspect/victim with sufficient confidence. When both the questioned and the known hairs were dyed, the analysis of hair color can further increase the evidentiary power of hair. This is especially important when any other type of evidence linking the victim/suspect to the crime scene is missing.

Eighty percent of commercial hair formulations are permanent, oxidative dyes. They consist of a mixture of small precursors known as primary intermediates and coupling molecules that enter the hair fiber and react under oxidative conditions to form larger dye molecules. The size of the dyes prevents them from leaving the hair and they become deposited in the hair cortex to produce long-lasting color. Booster dyes are sometimes added to commercial formulations to tune the resulting hair color. Depending on the composition of the precursors and their relative amounts in a dye kit, different hair colors can be achieved.

This study seeks to examine, characterize, and identify dyes extracted from human hair via instrumental analysis for the purpose of determining common origin. UHPLC-ESI-TOF/MS was used to identify the components of permanent hair dyes. A UHPLC separation of dyed hair sample extracts was indicative of a small collection of predicted oxidation dye products, though with very low intensities. Dyes formed from oxidation reactions are more difficult to extract and detect than additive or booster dyes found in the same dye kit. Dye signals can vary in intensity among different permanent dye formulations of similar colors, even when they contain similar precursor molecules. Extraction method studies determined the heated methanol extraction procedure provided better extraction of oxidation dyes than a sodium hydroxide hair digestion. It was also determined that there is no direct correlation between the length of a hair sample and the intensity of detected dyes, limiting the forensic value of quantitative dye measurements.

Hair, Liquid Chromatography, Mass Spectrometry

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