E101 Chemical Characterization of Tattoo Inks to Aid in the Identification of Highly Decomposed Remains

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After attending this presentation, attendees will understand the chemical composition of common tattoo inks and the ways in which the ink composition can be used for identification of decomposed remains.

This presentation will impact the forensic science community by describing analytical methods that can be used to determine the elemental and organic composition in common tattoo inks and by demonstrating the identification of ink components in decomposed tissue samples.

The popularity of tattoos is increasing, with recent figures estimating that 24% of the population in the United States currently has at least one tattoo. The depth to which the inks are injected into the skin causes tattoos to remain intact even after extensive tissue damage. Due to the relative permanence of the ink, tattoos are often used to identify victims of mass disasters, based on visual assessment of the tattoo; however, for remains that are in an advanced state of decomposition or that are otherwise severely degraded, visualization of tattoos in this manner is limited.

The purpose of this initial work was to investigate the detection of tattoos based on the elemental and organic composition of the inks. As these inks are not heavily regulated, the first step was to chemically characterize a set of common tattoo inks, then to demonstrate the presence of these components in decomposed tissue samples. A total of 30 tattoo inks were included in this initial study. Inks were blotted onto separate filter papers and dried in a desiccator for 24 hours prior to analysis. Each ink was analyzed by Attenuated Total Reflectance/Fourier Transform Infrared (ATR/FTIR) spectroscopy to determine the organic composition and by X-Ray Fluorescence (XRF) spectroscopy to determine the elemental composition.

The IR and XRF spectra were first assessed visually to determine the possible pigments present in the inks. For example, the IR spectra of two blue inks indicated the presence of N-Cu-N absorptions at 1,088 cm^{-1} and C-N-C absorptions at 781cm^{-1} and 756cm^{-1}. The XRF spectra of the same two inks indicated the presence of copper and titanium. The IR absorptions combined with the presence of copper indicated copper phthalocyanine as the major pigment in the inks. Titanium is used as a whitening agent and, hence, further distinction of the inks was possible with the lighter blue ink containing a significantly higher intensity of titanium.

Principal Components Analysis (PCA) and Hierarchical Cluster Analysis (HCA) were then applied to the spectral data to more readily visualize similarities and differences among the inks based on both the elemental and organic composition. The XRF and IR spectral data were combined and PCA was initially applied. Inks of similar color were positioned closely on the scores plot and distinctly from other inks using the first four principal components, which accounted for 80% of the total variance in the data set; however, the lighter-colored inks that essentially differed only in the titanium concentration were not readily differentiated using PCA. Using HCA, similar groups of inks were observed as in PCA, although the lighter-colored inks were more readily distinguished.

Following characterization of the tattoo inks, the detection of ink components in decomposed tissue samples was investigated. In this initial study, only elemental composition was investigated and Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM/EDS) was used due to the imaging capabilities offered in addition to the elemental composition analysis. A subset of red, blue, and black inks was analyzed using SEM/EDS and the elemental composition of the inks was compared to that generated previously using XRF spectroscopy. After demonstrating correspondence between the two techniques, SEM/EDS was used to analyze tissue samples that had been tattooed with red ink and allowed to decompose. After 19 days, the carcass was in a state of advanced decomposition, with skin discoloration preventing visualization of the tattooed area. Nonetheless, iron, silicon, and magnesium, previously identified in red ink, were detected at significant levels in the tissue samples. Although preliminary in nature, these results demonstrate potential for the detection of ink components in decomposed tissue samples.

Tattoo Inks, Chemical Characterization, Decomposition