D70 Exploration of Isotope Ratio Mass Spectrometry as a Method for Thread Analysis

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The goal of this presentation is to present Isotope Ratio Mass Spectrometry (IRMS) as a prospective method in thread analysis, its use beyond the differentiation of white cotton threads, and the effect several factors have on the isotope ratios of threads.

This presentation will impact the forensic science community by demonstrating the potential of using IRMS for the analysis of various threads.

Clothing threads can be used as crime scene evidence if there are techniques that can compare the threads to their sources. Current methods use infrared spectroscopy and microscopy to analyze color, chemical composition, and a cross section of threads for comparison to the thread source. Different white cotton threads cannot be differentiated if they have similar color and composition, assuming that no biological evidence exists. IRMS is promising as it has been shown to be able to detect significant differences in carbon, oxygen, and hydrogen isotope ratios of white cotton threads from different sources. These differences in isotope ratios result from the cotton crop sources undergoing varying degrees of fractionation as a result of their unique environments; but it is not yet fully known what other factors affect isotope ratios of clothing threads.

The goal of this research is to investigate the potential of this method for other natural threads and determine the extent to which isotope ratios are impacted by factors such as dyeing, sweating, bleaching, and thread location throughout an article of clothing. Samples were collected from various t-shirts, silk fabrics, and jeans. Two used multicolored cotton shirts from different manufacturers were used in order to study commercial dyeing and a new, white cotton shirt was used to study household dye and the effects of bleaching it. Another new white cotton shirt was also used to explore how the combined effects of sweating and bleaching influence the isotope ratios of cotton threads. Four silk fabrics with different stitching were acquired to expand this study to other natural threads. The shades of blue in three different pairs of jeans were also studied to investigate homogeneity of jean threads and the effect the amount of dye has on isotope ratios.

These clothing samples were acquired and combusted in either an Elemental Analyzer (EA) or high Temperature Combustion/Elemental Analyzer (TC/EA). A continuous flow isotope ratio mass spectrometer was used to analyze carbon isotopes in carbon dioxide gas, which is formed in the EA, and oxygen and hydrogen isotopes in carbon monoxide and hydrogen gas formed in the TC/EA. The differentiability of isotope ratios of two threads was determined using two-sample t-tests with a 95% confidence level. Visualization of the comparison between different threads using all three isotope ratios is achieved through three-dimensional trivariate plots.

Threads of different color in the multicolored shirts varied in their differentiability. It was determined that for one of the shirts, fewer than half could be differentiated using IRMS, while for the other, nearly all colors could be differentiated from each other. The multicolored shirts also showed differences in isotope ratios between different panels. For the dyed white cotton shirts, the threads showed no significant change in their isotope ratios from the undyed source. This implies that the differentiability among colors found in the multicolored shirt is likely due to cotton of different sources. When the dyed threads are bleached, the threads are differentiable from both the dyed and undyed threads, indicating that bleach changes the chemical composition of the threads instead of reversing them to their original, undyed states. Sweat can also significantly change the isotope ratios of cotton threads and make the altered threads differentiable from the original. Silk threads with different stitching are found to have significantly different isotope ratios and thus are differentiable from each other. White threads in one pair of jeans were found to be differentiable from the dyed threads using carbon isotope ratios. These findings enhance IRMS analysis for cotton threads by elucidating the effects of dyeing and bleaching on their isotope ratios and expand the scope of this method to other natural threads.

Isotope Ratio, Mass Spectrometry, Thread Analysis

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