B216 A Quantitative Trace Elemental Analysis of Aluminum Materials for Forensic Discrimination

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Learning Overview: After attending this presentation, attendees will understand how trace elemental analysis of aluminum (Al) materials by Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) can be used for source discrimination of Al samples.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing a method to measure the trace elemental composition of Al samples, which can be used to discriminate among various sources of aluminum.

Hypothesis Statement: Quantitative measurement of trace elemental concentrations in Al materials by ICP/MS can discriminate between sources and provide valuable information regarding the exclusion or potential association of two compared samples.

Al is commonly used as a metallic fuel in the chemical mixtures of Improvised Explosive Devices (IEDs) to increase the heat of explosion. Various types of A1-rich products, including foil, paste, powder, cans, spray paint, pyrotechnics, and binary exploding targets are easily accessible to the general public and can provide the starting material for production of IEDs. Al powder from these sources can be produced inexpensively using simple, available techniques. This research developed a method to accurately and precisely measure the trace elemental concentrations of Al materials and aims to evaluate its discrimination potential for various sources of Al through the comparison of their trace elemental profiles.

Koons et al. measured trace element compositions for 30 rolls of Al foil and determined that there were quantifiable differences among rolls from 12 discrete manufacturers.[1] In addition to being able to differentiate between manufacturers, different lots from the same manufacturer also displayed distinct compositions. This study builds on these initial results and develops a more robust determination of the discriminatory power of comparisons of Al trace element compositions. This will be achieved through increased sampling, sample diversity, and more sensitive instrumentation. The total number of samples included in the present study is larger (~350 sources, currently) and sample variability is greater in terms of source material and region. The instrumentation allows for greater precision and lower detection limits, potentially yielding additional elements for comparison.

Concentrations of trace elements are determined from solutions using High-Resolution-Inductively-Coupled Plasma-Mass Spectrometry (HR-ICP-MS). For sample types that necessitate separation, the Al component is isolated from the other components of the product. Approximately 50mg of purified Al is dissolved using high-purity hydrochloric and nitric acids. Three aliquots of these concentrated sample digestions are removed and diluted to ~500ppm of dissolved Al for analysis on a HR-ICP-MS. Measurements were obtained using external calibration and internal standardization. The calibration standards reflect a wide range of elemental concentrations that may be observed in Al samples. A multielement internal standard is used in order to correct for instrumental drift, signal suppression, and matrix effects resulting from the high Al matrix of the samples. National Institute of Standards and Technology (NIST) and International Analytical Reference Materials (IARM) Al alloy reference materials are used as external standards and are regularly measured to verify the accuracy of the method. Quantitative data for all analyte elements certified in the external reference materials are collected; non-certified analytes are also measured, though the accuracy of these measurements cannot be verified.

An initial test was conducted to determine the homogeneity within a roll of Al foil for the measured element concentrations. This test provides a means to assess the degree of sampling necessary for Al foil rolls measured in this study. Three samples were taken across the width of a roll at approximately every ten feet for the entire length of the roll (250ft), totaling 78 samples from a single roll of Al foil. These samples were digested and analyzed according to the established procedure.

Statistical analysis will be used in order to determine which elements will have the greatest effect on the discriminating power (which is equal to one minus the random match probability) when attempting to distinguish between Al sources. Within- and between-source distributions of trace elemental concentrations will be used to develop criteria to compare Al samples from two sources: one from the Al material recovered from a crime scene and the other from a specified known Al source. Further, a method to assess the evidential support for an association between materials recovered from a crime scene and a specified Al source versus an alternative source will be explored.

Reference(s):

1. Koons, R.D., Peters, C.A., and Merrill, R.A. Forensic Comparison of Household Aluminum Foils Using Elemental Composition by Inductively Coupled Plasma-Atomic Emission Spectrometry. *Journal of Forensic Sciences,* 38, no. 2 (1993): 302-315. doi: 10.1520/JFS13409J.

Trace Elements, Aluminum, ICP/MS

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