B62 A Novel Approach for the Collection and Characterization of Inorganic Gunshot Residue (IGSR) Standards

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Learning Overview: After attending this presentation, attendees will be aware of a novel collection and characterization for authentic IGRS originating from the primer of ammunition.

Impact on the Forensic Science Community: This presentation will impact the forensic science community, which does not have access to an IGSR standard that can be consumed, by attempting to develop one to help advance the discipline of IGSR analysis.

The detection of gunshot residue (GSR) is an important form of trace evidence because it can provide investigative leads, enhance reconstruction, protect citizens from violent criminals, and assist in intelligence operations. Although current methods of Scanning Electron Microscopy/Electron Dispersive X-ray Spectroscopy (SEM/EDS) analysis are scientifically valid, they are time-consuming, typically requiring hours of analysis per sample. Furthermore, studies into new types of rapid instrumentation are slowed by the lack of GSR standard reference materials. A synthetic GSR standard is available for SEM/EDS analysis, but there is no option for a standard that can be manipulated, digested, or deposited onto a substrate. Also, researchers must have firearms and a ballistics lab to test a new method, which can be impossible without access to the proper resources.

A research group at West Virginia University in collaboration with the Sacramento District Attorney's Office–Laboratory of Forensic Services developed a novel method for the collection and characterization of IGSR particles. Ammunition consisting of only a primer and cartridge case was discharged in a controlled environment and suspended in an organic solvent. Then, the particles were collected, stored, and analyzed by three different analytical techniques to characterize the particle's morphology, distribution, and composition of the IGSR standard.

An Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) digestion method was developed and validated for qualitative and quantitative characterization of the IGSR particle suspension. During the preliminary study, the elemental concentration was monitored over three months and an Analysis of Variance (ANOVA) statistical analysis determined the stability of important IGSR markers (e.g., Lead [Pb], Barium [Ba], and Antimony [Sb]) during the time stored. Ruggedness testing was performed to determine the main effects of the digestion method and examined six factors (digestion temperature, digestion time, the time between sample preparation and digestion, the time between digestion and analysis, acid concentration, and analyte concentration) at two levels for 38 different elements. After determining the main effects, the method was validated for the 38 analytes and figures of merit—selectivity, precision, and trueness—were determined.

Since morphology is also a critical aspect of GSR evidence analysis, the standard was assessed to determine if the collection process preserved the spherical morphology and elemental composition typical of GSR particles. The standard was spiked on GSR stubs at multiple time intervals and analyzed by SEM/EDS during the preliminary three-month study. The analysis indicated no degradation of either was observed. To test the homogeneity and reproducibility of the particle deposition, small amounts were spiked onto GSR stubs, and the particles were mapped and counted using an automated GSR recipe and following the American Society for Testing and Materials (ASTM) E1588-17 standard procedure.

Last, laser-induced breakdown spectroscopy was used to test the practical application of the primer standard. The standard was spiked onto GSR stubs and used in a Box-Behnken optimization design and also as a daily Quality Control (QC) sample. The optimized parameters were applied to a micro-chemical mapping method for the detection of IGSR.

A standard such as the one developed can be a powerful tool to greatly enhance the study and interpretation of GSR evidence. For the first time, the forensic community would have access to an IGSR standard of known elemental concentration and number of particles. This study developed a micron-size particle IGSR standard that mimics residues from leaded and non-toxic modern ammunition. The standard is anticipated to strengthen not only future research but also the understanding of the transfer and persistence of GSR by providing ground truth of the number of particles present before activities. A standard can also improve analysis in crime laboratories by providing an option for monitoring the performance of another method of GSR detection besides SEM/EDS analysis. A material such as this can enhance the evidential value of GSR in the long run because the nature of the trace evidence can be evaluated with greater certainty, GSR examiners can provide a clear record of instrument performance, and the community can validate new instrumentation without the challenge of collecting authentic GSR samples.

Gunshot Residue, Standard Development, SEM/EDS

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