B27 An Analysis of Organic and Inorganic Gunshot Residues (OGSR and IGSR) Via Electrochemical Methods With Screen-Printed Carbon Electrodes and Nanoparticle Modifications

Colby E. Ott, MS, Shippensburg, PA 17257; Pedro Calderón-Arce, MS, University of Costa Rica, San Jose 11501-2060, COSTA RICA; Korina Menking-Hoggatt, MS, Morgantown, WV 26501; Courtney H. Vander Pyl, MS, Department of Forensic and Investigative Science, Morgantown, WV 26506; Ana L. Alvarado-Gámez, PhD, University of Costa Rica, San Jose 11501-2060, COSTA RICA; Tatiana Trejos, PhD, West Virginia University, Morgantown, WV 26506; Luis E. Arroyo, PhD, West Virginia University, Morgantown, WV 26506-6121*

Learning Overview: After attending this presentation, attendees will be able to understand the use of alternative analytical tools to detect Gunshot Residues (GSR) and to explain the advantages associated with electrochemical methods to improve detection capability, uncertainty, and speed of analysis.

Impact on the Forensic Science Community: This presentation will impact the forensic science community through the implementation of a rapid and comprehensive voltammetric GSR method for the dual detection of IGSR and OGSR. Practitioners will find a simple yet powerful technique that could offer timely investigative leads and speed up forensic investigations.

Following the discharge of a firearm, the compounds present in the propellant and primer, as well as residues from the cartridge and bullet, are expelled from the firearm under high pressure and heat. These compounds, globally termed GSRs, are then deposited in the vicinity of the shooting, including the hands and clothing of individuals. The detection of GSR can be a critical piece of evidence during a shooting incident and can provide valuable leads to investigators. However, the current analysis methods either lack sensitivity (as in color testing), take hours per sample (as in using Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy (SEM/EDS)), or are limited to detection of only the inorganic or the organic markers.

Electrochemistry improves upon these weaknesses by offering the simultaneous analysis of both IGSR and OGSR signatures, reducing run times to a few minutes per sample, offering qualitative and quantitative information, and providing lab-based and portable field testing. In this study, the analysis of OGSR and IGSR was performed using both Square-Wave Voltammetry (SWV) and differential pulse voltammetry in acetate buffer pH 4.5. A pre-concentration potential was applied before the analysis of the sample to improve the signal. The electroanalytical method was performed first using disposable carbon electrodes for the analysis of inorganics (lead, antimony, and copper) and organics (2,4-Dinitrotoluene [DNT], Diphenylamine [DPA], Nitroglycerin [NG], Methyl Centralite [MC], and Ethyl Centralite [EC]). The use of gold nanomaterials for the modification of electrode surfaces was investigated for the deposition of gold (Au) onto the working electrode (Screen-Printed Carbon Electrodes [SPCE]/Au). The use of bismuth films was also explored. Comparison of the performance of bare carbon, bismuth film, and gold surface working electrodes is presented in this study.

The following limits of detection were determined through statistical analysis of calibration curves as three times the standard deviation in the y-intercept divided by the mean in µg/mL: 0.09 (lead), 0.25 (antimony), 0.04 (copper), 1.28 (DNT), 1.17 (DPA), 0.52 (NG), 0.68 (EC), and 5.34 (MC). Analysis of GSR via gold deposition onto the SPCE working electrode resulted in improved limits of detection (in µg/mL) of 0.012 (lead), 0.011 (antimony), 0.013 (NG), and 0.007 (DNT). The limit of quantitation for the organic compounds using the SPCE/Au was below 0.050µg/mL with the relative standard deviation for repeatability and reproducibility below 2%.

A validation set of 180 samples collected from the hands of shooters (n=80, diverse ammunition and firearm) and non-shooters (n=100) were run to assess the performance of the method, with overall accuracy better than 84%. Accuracy was estimated based on the number of true positives, true negatives, false positives, and false negatives.

This work demonstrated the ability of simultaneous detection of both OGSR and IGSR using electrochemical methods. Excellent improvements in sensitivity were shown for OGSR when utilizing a gold surface on the carbon working electrode. The sensitivity for OGSR is highly desirable due to the higher informative value of these compounds in associating a suspect to a shooting incident.

Gunshot Residue, Electrochemistry, Screen-Printed Carbon Electrodes

*Presenting Author