E108 Laser-Induced Breakdown Spectroscopy (LIBS) as a Rapid Detection Technique for Gunshot Residue (GSR)

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Learning Overview: The goal of this presentation is to inform attendees of a rapid technique for the detection of Gunshot Residue (GSR) using LIBS and the performance measures associated with the method.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by informing attendees that LIBS can decrease turnaround time by providing practitioners with a rapid, reliable screening test for GSR detection on hands.

The detection of GSR is crucial during the investigation of firearm-related crimes, and is, therefore, a commonly submitted form of evidence to forensic laboratories. The United States National Crime Victimization Survey (NCVS) most recent data reported 480,000 firearm-related crimes in 2016, and a report by Project FORESIGHT for the 2015-2016 fiscal year found the average turnaround time for GSR to be between 19 and 89 days and cost between $800 to $3,500 per forensic report.[1,2] The current American Society for Testing and Materials (ASTM) standard requires the identification of characteristic elements (typically lead, barium, and antimony) using Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy (SEM/EDS).[3] Although the SEM/EDS method is reliable, it is also costly and time consuming. The goal of this study is to develop a reliable screening method capable of detecting GSR in just a few minutes with minimal destruction of the sample, high specificity, and sensitivity. LIBS is proposed for GSR detection using a universal sampling method compatible with current practice (SEM/EDS). The advantages of this method are the simultaneous multi-element capability, selectivity, sensitivity, versatility, and portability.

A validation set of 296 samples originating from 60 non-shooters and 56 shooters was used to evaluate the accuracy of the method. The non-shooter specimens were collected from at least one of the hands of each individual using the standard carbon adhesive tabs. The sample set from known shooters was collected using four GSR separate stubs from the hands of each individual after firing a pistol or a revolver (right back, right palm, left back, and left palm).

The research presented here developed two different LIBS acquisition methods, one ablating a line of 7mm by 100µm at the GSR stub surface, and another shooting the laser in a 5 by 5 grid of 100µm diameter spots. The grid method allowed for the addition of chemical mapping and spatial information to determine the location of the GSR species on the stub. Both methods left more than 99.9% of the carbon stub intact for further confirmatory testing. Data pre-processing included background subtraction, peak identification, and peak integration. Box plots and principal component analysis were used for exploratory analysis of the data. A positive threshold/result was established when the signal of the analyte was above the limit of detection and exceeded the non-shooter background signal by at least three standard deviations. Alternatively, discriminant analysis was used as a classification tool to group unknowns into shooter or non-shooters categories. The line scanning method showed a true positive rate (sensitivity) of 73%–86%, a true negative rate (specificity) of 97%–100%, and an overall accuracy of 87%–90%, depending on the statistical classification method. The grid method showed a true positive rate (sensitivity) of 73%–100%, a true negative rate (specificity) of 96%–100%, and an overall accuracy of 82%–100%.

The results demonstrated that LIBS is as a rapid, reliable technique with high sensitivity and specificity for GSR detection. The incorporation of a rapid screening method into the current protocol of GSR examination could minimize unnecessary confirmatory analysis of negative samples, reducing costs and offering a more streamlined and efficient management of casework. Moreover, LIBS will provide complementary information to SEM/EDS and increase confidence in the interpretation of the evidence.

Reference(s):

1. *National Crime Victimization Survey*. https://www.bjs.gov/index.cfm?ty=nvat (accessed 12 February 2018).
2. *Project FORESIGHT Annual Report, 2015-2016*. West Virginia University, College of Business and Economics combined with the Forensic Science Initiative. 2016.
3. ASTM E30 Committee, Standard Practice for Gunshot Residue Analysis by Scanning Electron Microscopy/Energy Dispersive X-Ray Spectrometry. In *ASTM E* 1588-16a, ASTM International: West Conshohocken, PA, 2016; pp 1-5.

Gunshot Residue (GSR), Rapid Detection, LIBS