E18 Raman Microspectroscopy and Advanced Statistics for Detection and Characterization of Gunshot Residue (GSR)

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After attending this presentation, attendees will have a better understanding of the recent advancements of the application of Raman microspectroscopy for GSR analysis, identification, and discrimination. This presentation will describe the development of a novel and alternative method for GSR detection and analysis.[1] The implementation of advanced statistics to differentiate experimental Raman spectra collected from non-equivalent GSR samples will be discussed.

This presentation will impact the forensic science community by demonstrating whether this method can already be used for practical purposes. This research has the potential to greatly impact the accuracy and effectiveness of shooting incident investigations. This study has generated significant interest among the scientific community and practitioners. *Journal of Analytical Chemistry*, the top journal in the field in the world, highlighted the article on the journal cover. *Chemical & Engineering News*, the top news magazine of the American Chemical Society, released press coverage. Canada Discovery Channel made a piece on the daily *Planet* program about this discovery. Several emails have been received from police detectives.

Raman spectroscopy has numerous applications in forensic chemistry.[2] Raman analysis is a technique that can obtain confirmatory class identification of analytes through low intensity laser light scattering. The technique is non-destructive, rapid, sensitive, and requires little or no sample preparation. Furthermore, portable Raman spectrometers are readily available, allowing for crime scene accessibility. Raman spectroscopy offers several advantages over the current methodology for GSR analysis. The technique has been shown to detect components from both the organic and inorganic constituents of GSR on adhesive tape.[3,4] This is contrary to current GSR elemental analysis methods, which rely solely on the detection of the heavy metals (lead, barium, and antimony). This is problematic since environmental concerns have led to the increased popularity in heavy metal-free or "green" ammunition. It has been found that in the absence of heavy metals, current elemental analysis techniques are severely hindered when making accurate identification of GSR samples. Additionally, the probability of environmental and manufacturing particles assigned (incorrectly) as being GSR has increased with the onset of "green" ammunition. Until recently, the application of Raman spectroscopy for GSR analysis was largely unexplored, although this approach is not dependent on detecting metals, and is more capable of differentiating environmental contaminants and GSR. Therefore, a Raman spectroscopic method displays numerous advantages in specificity when compared to current techniques.

The firearm discharge process could be considered analogous to a complex chemical reaction. Therefore, the chemical composition of the products (GSR particles) is directly related to the chemical nature of the reagents (firearm-ammunition combination) and the conditions of the reaction. Preliminary results reveal that Raman data collected from GSR particles originating from different firearm-ammunition discharges were successfully classified according to caliber. Using a 785-nm Raman excitation, 0.38-inch and 9mm caliber firearm discharge samples were probed. Resulting data was treated with statistical methods (performed using MATLAB® with the PLS_Toolbox), such as Principle Component Analysis (PCA) and Support Vector Machines (SVM). The results demonstrate a high probability of this method to correctly classify data from the two examined calibers. Preliminary results illustrate that the variations between non-equivalent GSR samples can be detected through this method. Since GSR is often collected from a suspect, the application of this method to forensic investigations would provide a link between GSR collected from the shooter and the crime scene.

This emerging technique illustrates the possibility for an on-scene, non-destructive identification and chemical characterization method for GSR. This method has the potential to greatly impact the forensic science community by increasing the accuracy (and discriminatory power) of GSR detection. The most direct application for this research is a method to exclude a specific firearm-ammunition combination as producing an evidentiary GSR sample. The comparison of a laboratory-generated GSR sample discharge and an evidentiary GSR sample can be made without extensive preliminary studies.

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Gunshot Residue, Raman Spectroscopy, Chemometrics