A171 Attenuated Total Reflectance-FTIR Spectroscopy for Gunshot Residue Analysis: Potential for Ammunition Determination

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The goal of this presentation is to describe the development of a novel and alternative method for Gunshot Residue (GSR) analysis.[1] After attending this presentation, attendees will have a better understanding of the application of Attenuated Total Refectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR) for GSR analysis, identification, and discrimination. The implementation of advanced statistics to differentiate experimental spectra collected from non-equivalent GSR samples will be discussed.

This presentation will impact the forensic science community by potentially greatly impacting the accuracy and effectiveness of shooting incident investigations.

The successful application of Raman micro-spectroscopy combined with advanced statistics for the analysis and differentiation of GSR particles originating from two different calibers (0.38 inch and 9mm) of ammunition was reported last year.[2] For that research, only light-colored (tan) GSR particles were selected for analysis, due to strong fluorescence interferences resulting from the analysis of darker-colored GSR particles. The conclusion was that the technique has the potential to provide a strong chemical and statistical link between GSR samples and specific firearm-ammunition combinations, as well as the ability to exclude a specific firearm-ammunition combination from generating the unknown GSR sample. Reported Raman spectra were found to have contributions from both organic and inorganic components of GSR; however, the method did not rely upon the detection of these heavy metals, illustrating its potential as a novel alternative to current GSR analysis techniques.

This is a report on the application of ATR-FTIR spectroscopy combined with advanced statistics for GSR analysis. Evidentiary analysis by FTIR is fast, user-friendly, relatively inexpensive, and non-destructive. Little sample preparation or sample quantity is required, and the resulting FTIR spectra offer a molecular fingerprint for the compound in question. Additionally, the technique offers a combination of unique features such as portability, database-search functionality, and multivariate analysis capabilities. Applications of FTIR to forensic chemistry include identification of paint, explosives, smokeless gunpowder propellant, and illicit drugs. Previous investigations of GSR by FTIR were focused on qualitative chemical composition and shooting distance determinations. In the present study, FTIR spectra were collected from *individual* GSR particles originating from three different firearm-ammunition combinations. Preliminary results indicate that the new technique is more comprehensive than all currently accepted and innovative methods of GSR identification. Successful differentiation of FTIR spectra from three firearm-ammunition combinations (0.38 inch, 0.40 inch, and 9mm calibers) was achieved. Informative FTIR spectra could be collected from *all particles* regardless of their color, fluorescence contribution, and morphology, representing significant improvements relative to the reported earlier Raman-based approach.[2] In this work, informative FTIR spectra were collected from previously unanalyzable firearm discharge samples, consisting of exclusively dark particles (0.40 inch). Principal Component Analysis (PCA) revealed grouping, by data collected from the same caliber. Projection to Latent Structures Discriminant Analysis (PLS-DA), also known as Partial Least Squares Discriminant Analysis, was able to differentiate GSR data from the three firearm-ammunition combinations (calibers) at a rate of 100% for the internal validation and 93.3% for the external validation. These results are supported by Leave-One-Out (LOO) cross validation.

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.

References:

[1]Bueno, J.; Sikirzhytski, V. and Lednev, I.K. Attenuated Total Reflectance-FT-IR Spectroscopy for Gunshot Residue Analysis: Potential for Ammunition Determination. Analyt Chem, 2013. Published on Web. DOI: 10.1021/ac4011843.

1. Bueno, J.; Sikirzhytski, V. and Lednev, I.K. Raman Spectroscopic Analysis of Gunshot Residue Offering Great Potential for Caliber Differentiation. Analyt Chem, 2012, 84, 4334-4339. (Made a journal cover, C&E News, and Canada Discovery Channel — Daily Planet program).

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Gunshot Residue, Trace Evidence, Vibrational Spectroscopy

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