E28 Detection, Identification, and Characterization of Gunshot Residue (GSR) Using Raman Spectroscopy

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Learning Overview: After attending this presentation, attendees will have a better understanding of recent advancements of the application of Raman spectroscopy for GSR analysis, identification, and discrimination. The implementation of advanced statistics to differentiate experimental Raman spectra collected from non-equivalent GSR samples will be discussed.[1]

Impact on the Forensic Science Community: This presentation will impact the forensic science community by addressing the accuracy and effectiveness of shooting incident investigations.

Raman spectroscopy has numerous applications in forensic chemistry.[2] Raman spectroscopy 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. 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] This is contrary to current GSR elemental analysis methods which rely solely on the detection of the heavy metals (lead, barium, and antimony).

Raman microspectroscopic mapping and multivariate analysis was recently utilized for the detection of GSR on adhesive tape. The study included a validation of the reproducibility/ruggedness and specificity of the approach.[4] Raman mapping for GSR detection was performed on an independent Raman microscope, not used to generate the training set. These independent spectra were classified against the original training dataset using Support Vector Machine Discriminant Analysis (SVMDA). The resulting classification rates of 100% illustrate the reproducibility of the technique, its independence upon a specific instrument, and provide an external validation for the approach. Additionally, the same procedure for GSR collection (tape lifting) was performed to collect samples from environmental sources, which could potentially provide false-positive assignments for current GSR analysis techniques. Thus, particles associated with automotive mechanics were collected. Automotive brake and tire materials are often composed of the heavy metals lead, barium, and antimony, which are the key elements targeted by current GSR detection technique. It was determined that Raman spectroscopic analysis was not susceptible to misclassifications from these samples.

Results from these validation experiments illustrate the great potential of Raman microspectroscopic mapping used with tape lifting as a viable complimentary tool to current methodologies for GSR detection. Furthermore, current methodologies are not well-developed for automated Organic GSR (OGSR) detection. A new two-step method for the detection and identification of OGSR was also developed.[5] This method utilizes highly sensitive fluorescence hyperspectral imaging of a sample area to detect potential GSR particles, followed by confirmatory identification of the detected particles using Raman microspectroscopy.

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Reference(s):

1. Lednev I.K., Bueno J. *Ammunition and weapon type identification based on spectroscopic gunshot residue analysis.* USA patent US 9,518,808 B2 2016.
2. Mistek, E., Fikiet M.A., Khandasammy S.R., Lednev I.K. Toward Locard's Exchange Principle: Recent developments in forensic trace evidence analysis. *Anal Chem*. 2019;91:637-654.
3. Doty K.C., Lednev I.K. Raman spectroscopy for forensic purposes: Recent applications for serology and gunshot residue analysis. *Trends Anal Chem*. 2018;103:215-222.
4. Bueno J., Halamkova L., Rzhevskii A., Lednev I.K. Raman microspectroscopic mapping as a tool for detection of gunshot residue on adhesive tape. *Anal Bioanal Chem*. 2018;410:7295-7303.
5. Khandasammy S.R., Rzhevskii A., Lednev, I.K. A novel two-step method for the detection of organic gunshot residue for forensic purposes: Fast fluorescence imaging followed by Raman microspectroscopic identification. [under revision in *Anal Chem* 2019].

Raman Spectroscopy, Gunshot Residue, Statistics