B153 Soil Mineral Analysis by Particle Correlated Raman Spectroscopy (PCRS): Method Optimization

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Learning Overview: After attending this presentation, attendees will understand the value PCRS holds in forensic soil analysis. The optimal soil mineral parameters for automated imaging, Raman analysis, and dispersion will be discussed.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by completing the first steps in achieving the overall aim of developing a robust, automated, and objective analytical method for the analysis and comparison of soil minerals using PCRS.

Soil is a valuable and powerful trace evidence that provides linkages and investigative leads. Criticisms of forensic soil analysis (e.g., subjective, labor-intensive, time-consuming) have resulted in a considerable decline in its use in forensic investigations and created countless missed opportunities within the criminal justice community. Consequently, there is a need for a statistically supported, automated, and objective analytical method for soil analysis. PCRS, also known as particle driven or Morphologically Directed Raman spectroscopy (MDRS), is a novel yet reliable analytical technique that can add significant value to the forensic examination of soil evidence. It has proven easy to use and non-destructive, and its ability to be automated enables a large amount of data to be collected with minimal time required by the criminalist. Resulting data provides qualitative and quantitative information on a sample. PCRS obtains particle images of soil components (i.e., mineral) and produces microscopic morphological characteristics (e.g., circularity, elongation, brightness) and particle size distribution for the particles present. Particles can then be targeted randomly or based on morphological characteristics for Raman analysis to provide secure mineral identification.

The research presented here focuses on PCRS method optimization for soil mineral analysis using traditional figures of merit and response surface modeling of a multi-level experimental design. Laser wavelength, laser power, magnification, grating, and exposure time were examined for chemical identification of minerals via Raman spectroscopy. Particle size, particle destruction, and detector oversaturation influenced the final parameters to be evaluated for spectral analysis. The optimal parameters were determined based on a complex mineral mixture that reflects the diversity of minerals (based on stability, structure, Raman scattering capability, transparency, and fluorescence) that may be found in a single soil sample. The contrast/illumination method, magnification, and targeted morphological analysis were then evaluated to obtain an optimized method for automated imaging and Raman analysis. The effect of field of view and contrast on particle sensitivity and time of acquisition were important factors considered. At this step, final parameters were set for each soil type based on the individual parameters determined necessary for minerals of that given soil type. Now that the optimal method parameters have been determined, they can be applied to the analysis of a range of soil samples to generate a robust PCRS dataset for forensic soil analysis.

Forensic Soil Analysis, Raman Microscopy, Minerals

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