B132 Optimization of the Forensic Identification of Blood Using Surface-Enhanced Raman Spectroscopy (SERS)

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Learning Overview: After attending this presentation, attendees will understand the principles of SERS, the characteristic spectroscopic features for blood identification, the wide variety of substrates on which SERS testing can be applied, and the ease of use and practical application for in-field sample analysis.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by presenting a universal technique for the practical application of the identification of blood using SERS. It is recommended that crime scene investigators and detectives become familiar with this technique for the quick and easy use of on-scene sample analysis.

Blood is considered one of the most important forensic evidence found at a crime scene. The use of SERS provides a non-destructive and highly sensitive technique for the confirmation of blood for forensic relevance and can be applied on a portable Raman device for quick sample preparation and processing.

SERS is one of the few confirmatory techniques for blood and the only spectroscopic technique employed for the identification of blood at a crime scene or in the forensic laboratory. This method is able to distinguish between blood from other body fluids by collecting the SERS spectrum on a substrate surface that has been embedded with gold nanoparticles (AuNPs). The AuNPs create an electric field surface enhancement that produces an intense signal, leading to a SERS enhancement. The SERS enhancement allows for sensitive blood detection at dilutions down to 1:10,000, when dried bloodstains are not visible to the naked eye, mimicking a crime scene that has been previously cleaned. A stain transfer method to the SERS substrate was optimized by extracting dried bloodstains with water, saline, and 50% acetic acid solution. Acetic acid proved to be the most efficient in retaining the blood components and releasing the hemoglobin component of blood for detection.

The SERS spectrum of blood is a robust signature of hemoglobin that does not change over time. Characteristic peaks for the identification of blood are 754, 1513, and 1543 cm^{-1}, attributed to a pyrrole ring breathing mode (Nu15) and two C_β-C_β stretches (Nu11, Nu38), respectively. These key SERS peaks, high sensitivity, and signal enhancement by a factor of ten are favorable when compared to normal Raman spectroscopy. A quick and easy procedure for in-field sample analysis for the detection of blood on different substrates has also been developed and applied on a portable Raman device. Various non-porous and porous substrates, including glass, ceramic tile, cotton, denim, fleece, nylon, acetate, wool, and polyester, have yielded strong results for the identification of bloodstains. In addition, testing different commercial and in-house SERS substrates has been effective in the identification of blood.

SERS identification of blood for forensic work is a non-destructive and portable tool that can be applied for quick and easy examination of evidence at a crime scene. The high sensitivity and selectivity of SERS provides a robust spectroscopic signature that aids in the confirmation of blood. It is a more favorable method when compared to alternative presumptive tests for blood and can be applied to stains on a variety of SERS substrates and sample surfaces for universal testing.

SERS, Body Fluid Identification, Forensics