E23 A Universal Method for Biological Stain Characterization Using Raman Spectroscopy: From Body Fluid Identification to Phenotype Profiling

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After attending this presentation, attendees will better understand the potential forensic application of Raman spectroscopy. The implementation of advanced statistics for the analysis of spectroscopic data and the evaluation of the accuracy and reliability of the conclusions made will be discussed.

This presentation will impact the forensic science community by demonstrating the accuracy and effectiveness of biological stain analysis for forensic purposes.

This presentation will report on the development of a novel, non-destructive, and confirmatory method for characterizing biological stains. The all-in-one method has a capability to identify the body fluid, determine human or animal origin, time since deposition, phenotype profile, race and sex, specifically.

Traces of body fluids discovered at a crime scene are a potential source of DNA, which is a major individual evidence in the modern forensic investigation. The application of Raman spectroscopy for non-destructive, confirmatory identification of biological stains at a crime scene, including dry traces of sweat, vaginal fluid, semen, saliva, and blood, have recently been reported.[1] The method allowed for differentiating animal and human blood as well menstrual and peripheral blood.[2,3] Most recently, the method was further developed for determining the time since deposition for bloodstains for up to two years.[4] The theory behind Raman spectroscopy is based on the inelastic scattering of low-intensity, non-destructive laser light by a solid, liquid, or gas sample. Very little or no sample preparation is needed, and the required amount of material tested with a Raman microscope can be as low as several picograms or femtoliters. A typical Raman spectrum consists of several narrow bands and provides a unique vibrational signature of the material. Typically, non-resonance Raman spectroscopy is not destructive for the sample. A portable Raman spectrometer is now a reality that should allow the identification at the crime scene.

It would be of great help for criminal investigations to develop a phenotype profiling immediately at a crime scene based on a rapid analysis of biological stains. With this goal in mind, the possibility of race differentiation based on Raman spectroscopy of blood traces has been investigated.[5] Specifically, advanced statistical analysis of spectroscopic data was used to discriminate between Caucasian (CA) and African American (AA) donors based on dry peripheral blood traces. Spectra were collected from 20 donors varying in gender and age. Support Vector Machines-Discriminant Analysis (SVM-DA) was used for differentiation of the two races. An outer subject-wise Cross-Validation (CV) method evaluated the performance of the SVM classifier for each individual donor from the training dataset. The performance of SVM-DA, evaluated by the Area Under the Curve (AUC) metric, demonstrated 83% probability of correct classification for both races, and a specificity and sensitivity of 80%. This initial work was followed by further proof-of-concept studies demonstrating the differentiation of donor's sex based on bloodstains and saliva traces, as well race differentiation based on traces of semen.[6-8] Overall, the developed method has great potential for crime scene investigation, providing rapid and reliable results with no sample preparation, destruction, or consumption.

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