

SERS for Biomedical and Forensic Applications: Monitoring in vitro Processes of Bacteria, Human Body Fluids, and Cancer Cells.

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Surface enhanced Raman spectroscopy excited at 785 nm is found to be a sensitive probe of the metabolic products of bacterial and human cells. The applications discussed here are the first examples of the use of SERS in the field of metabolomics. Cells removed from the human body undergo characteristic *in vitro* robust biological activity whose detection can be exploited for a number of biomedical and forensic applications. This optical methodology is fast, label free, portable, inherently multiplexing, easy-to-use and relatively inexpensive. In particular, the purine degradation products resulting from energy depletion in bacterial cells provides a unique SERS signature that can be both species and strain specific.¹ An *in situ* grown, Au nanoparticle covered SiO₂ substrate resulting from a metal ion doped sol-gel process results in strong reproducible SERS spectra for these types of molecules.² This methodology is being developed for diagnosing blood and urinary track infections. Antibiotic specific bacterial identification can be accomplished with this technique when this SERS acquisition is coupled to a library and statistical analysis procedure.³

We report the first 785 nm excited SERS spectra of human blood and red blood cells (RBCs).⁴ The SERS spectrum of fresh blood is just that of blood plasma. The SERS spectrum of red blood cells is exclusively due to hemoglobin. The nature of the SERS spectrum of whole human blood changes dramatically over the course of ~ 24 hours. The spectrum of stored blood becomes nearly dominated by hypoxanthine, a metabolite of pure degradation, over this period of time due to its release into blood serum from blood particles (white blood cells and/or platelets). The SERS spectrum of RBCs may be exploited for malaria detection and studies of anti-malarial drug interactions.

Tumor cells are well-known to exhibit high metabolic rates compared to normal, non-pathogenic cells. Again, characteristic SERS vibrational signatures due to molecules like adenine, hypoxanthine and NADH appear over the course of several hours from single cancer cells. Thus SERS may provide a procedure for *in vitro* single cell cancer detection as well as fundamental studies of the effects of genetic or proteomic manipulation for cancer therapy efficacy evaluation.

Finally, the use of SERS for trace detection and identification of human body fluids such as blood, semen, vaginal fluid and saliva will be described. The effects of human cell metabolism in these *in vitro* fluids can be observed and provide a novel methodology for ultrasensitive forensic identification at crime scenes.

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