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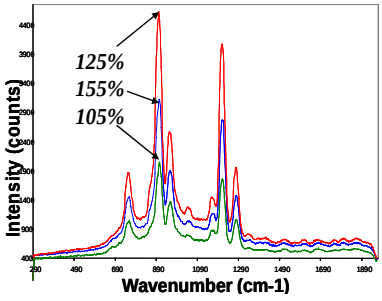
*The **Sepaniak Research Group** contributes innovative research in the three broad areas of chemical analysis listed below. Themes that permeate our efforts include molecular recognition in analysis and the use of micro- and nano-technology and materials in the development of a wide range of new analytical techniques.*

Microscale Chemical Separations. Our separations research program is dedicated to the development of capillary electrokinetic separation techniques for chemical analysis. Fundamental work focuses on studies involving highly ordered assemblies as selective reagents for capillary electrophoresis (CE) separations. These additives have included macrocyclic compounds such as cyclodextrins (CDs) and calixarenes, micelles, and soluble (entangled) polymers and are employed in electrophoretic or electrochromatographic modes. An important goal of our work is to study molecular recognition as it applies to CE separations. Often we employ lab-on-a-chip μ-fluidic separation devices (see figure at right) fabricated from polymeric materials such as polydimethylsiloxane (PDMS). The development of new and improved optical detection methods is also a focus of our efforts (see below). Our separations work is applied to samples of environmental, forensic, biological, and industrial significance.

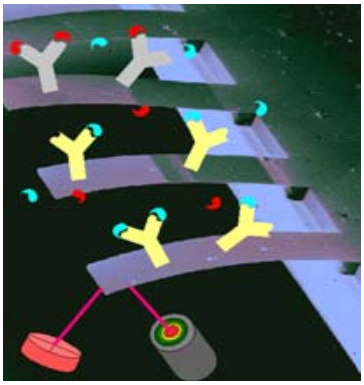
Lab-on-a-chip μ-fluidic device



SERS spectra optimized by physically manipulating, via stretching, the plasmon resonance of a Ag- PDMS nanocomposite

Optical Spectroscopy. Sensitive methods of detection for CE and lab-on-a-chip devices are being developed based on laser optical methods. The inherent sensitivity of laser induced fluorescence detection has been exploited for a wide variety of applications (naturally fluorescent drugs, toxins, labeled DNA and proteins, metal complexes, etc.). A major effort involves exploiting the potential for high sensitivity and exceptional selectivity of surface enhanced Raman scattering (SERS) for detection in microscale separations and environmental analyses. Approaches have included the use of novel metal-PDMS nanocomposities for integrated μ-fluidics and SERS detection. Methods to improve the questionable reproducibility and dynamic range of SERS are being pursued and involve unique lithographically-prepared and nanocomposite substrates (see figure at left) to increase sensitivity and dynamic range, sample translation to improve reproducibility, and applications in separations, high throughput screening, and sensing.

Chemical Sensing. Methods to impart selectivity to micro-electro-mechanical sensors (MEMS) are being developed. Methods of depositing and immobilizing polysiloxane phases, chelating resins and imprinted sol gels, and macrocylic reagents on micro-dimension cantilever-based MEMS are being developed. The macrocycle compounds developed and characterized through molecular recognition studies serve as tunably selective sequestering phases when immobilized on the planar substrate. These various phases are used to increase response factors and add chemical specificity to analyte-induced surface stresses that cause the cantilevers to bend. Methods of developing nano-structured surface features enhance the response characteristics of the sensors by orders of magnitude. Applications for these novel sensing technologies abound in the environmental, homeland security, and medical fields. For example, chiral discrimination has been achieved by immobilizing antibodies on μ-cantilevers (see figure at right). The response signatures from arrays of differentially functionalized cantilevers are being used with data mining techniques to identify analytes. The coupling of these arrays with chemical separation techniques is also underway. Another sensing project involves the development of new technique termed magnetically assisted transport evanescence field fluoroimmunoassays (MATEFF) wherein functionalized magnetic beads are used to harvest analyte and deliver it to a highly localized field for sensing by optical means.



μ-cantilevers coated with the enantio-selective antibodies responding (bending) to amino acids; deflections measured by reflecting diode laser beam onto position sensitive detector