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Surface-Enhanced Raman Scattering Optical Fibers as Chemical Sensors

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Introduction & Background

In this project, a surface-enhanced Raman scattering (SERS) based optical fiber sensor is designed to monitor pH in real time. SERS spectra of reporter molecules adsorbed on the fiber are used to deliver information on the chemical composition of the environment.

Raman Spectroscopy. Raman spectroscopy is a vibrational spectroscopy that results from an inelastic energy exchange between an incident photon and matter (Figure 1). The energies of inelastically scattered photons can be used to measure characteristic vibrational frequencies of molecules $\nu_{\text{Raman}}$. While researchers have long recognized the potential analytical applications of Raman spectroscopy, the small Raman cross section ($10^{-20} - 10^{-19}$ cm$^2$) has limited sensitivity.

Surface-Enhanced Raman Scattering (SERS). In 1977, two independent groups reported the SERS phenomenon that was first observed by Fleischmann and coworkers in 1974. For molecules adsorbed on roughened metal surfaces, the Raman scattering cross section $\sigma_{\text{Raman}}$ is enhanced as much as 15 orders of magnitude, enabling detection and identification of single molecules. Both electromagnetic enhancement (EEM) and chemical enhancement (CE) mechanisms have been proposed to explain the SERS phenomenon (Figure 2).

![Electromagnetic SERS Enhancement by Metal Nanoparticles](image)

Methods

![Fabrication of SERS-Active Optical Fiber](image)

Experimental Results

![SERS Spectra of Crystal Violet Molecules Adsorbed on Gold-Coated Optical Fiber Sensor](image)

![Far-Field SERS Spectra of 4-MPy Adsorbed on Gold-Coated Optical Fiber at Varied pH](image)

![pH Calibration Curve](image)

Conclusions & Future Work

The self-assembled gold monolayer is grown on the surface of the optical fiber, and can be used to detect SERS of reporter molecules. 4-Mercaptopyrididine (4-MPy) has been shown to be SERS active and its spectrum changes based on its protonation state. Therefore, 4-MPy can be used to sense changes in pH. In our group, this has been shown by collecting spectra at varying pH by focusing laser light onto the gold coated fiber when 4-MPy is adsorbed. Moving forward, the spectra will be obtained through the fiber sensor and used to monitor pH in real time.

Acknowledgements

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References