To Develop A Portable Mid-Infrared Spectrometer With An Integrated Biosensor For Pathogen Detection

Dr.Joseph Irudayaraj, Project Leader

Cooperators: Dr.Lisa Mauer,

Graduate Student:
Sandeep P Ravindranath

Goals: Brief description

- Develop FTIR and Raman libraries for pathogenic bacteria and characterize them based on their unique fingerprints.
- Functionalize the gold sensors with specific antibodies to develop a biosensor capable of detecting the specific bacteria when exposed to test sample.
- Develop a portable mid-IR spectrometer with an enhanced capability to detect pathogenic bacteria at extremely low cell count.

Statement of Problem: The advancements in miniaturized instrumentation has accelerated development of biosensors capable of integrating biorecognition and spectroscopy with specifications capable of supporting pathogen detection and address safety concerns in the food supply. The ideal method for the detection of pathogens would require minimum sample preparation, would analyze samples directly, and would be rapid, automated, non-invasive, quantitative and relatively inexpensive. FTIR and Raman spectroscopies are particularly attractive as they possess inherent molecular selectivity, and can perform both qualitative and quantitative analysis of chemical and biological species. The FTIR spectra of intact cells reflect the vibrational or rotational motions of specific functional groups or bonds in biochemical components such as proteins, lipids, and carbohydrates within cell membranes. Therefore, each species or strain can produce unique fingerprint-like IR spectra, over the entire mid-infrared (mid-IR) spectral region of 4000–650 cm^{-1}. The integration of the biosensor to the FTIR is extremely essential as it enhances the sensitivity of this spectroscopic approach. Detection of even an extremely weak signal from a biosensor is enough to suggest that the biosensor has formed an association with the specific bacteria that is being tested upon. Thus by coupling this biosensor module with a spectroscopic technique, we can reduce the detection limits of the instrument by several orders of magnitude. This approach of pathogen detection satisfies most of the expected properties of rapid detection methods. But the large size of an FTIR or a Raman spectrometer makes it limited to lab-scale experiments due to which samples from the site of inspection needs to be carefully extracted and transported to the closest testing lab. This necessitates a device that can be taken to the site of inspection and capable of producing instantaneous results.

Current Activities: Characteristic FTIR and Raman libraries of both common and rare pathogens are being developed. Multivariate Statistical analysis methods are being developed to analyze the bacterial spectra and methods to integrate this technology into a portable device. Biosensors with functionalized antibodies that have specificity towards pathogenic bacteria are being developed.