Advantages of Synchrotron IR Spectromicroscopy

- Diffraction limited spot size (2-10 μm)
- Large signal-to-noise ratios
- High spectral resolution
- Non-invasive (non-ionizing and label free)
- Hyperspectral imaging of living cells

Synchrotron infrared (IR) radiation is 1000 times brighter than a conventional blackbody source. When combined with a microscope, this increased brightness provides diffraction-limited spatial resolution with high signal-to-noise ratios. Because IR is non-ionizing and requires no external labeling, it can be used to chemically image single living cells non-invasively.

Real-Time Biochemistry of Living Cells

Synchrotron radiation-based Fourier transform infrared (SR-FTIR) microscopy is a label-free non-invasive molecular technique that couples the high brightness of synchrotron radiation with the high throughput and vast analytical capabilities of FTIR spectrometers. With a synchrotron source, FTIR microscopes are capable of diffraction-limited chemical imaging with signal-to-noise-ratios 100-1000 times greater than standard blackbody sources. This enhancement of spatial resolution and signal levels enables investigations of sophisticated microbial biochemistry for a broad range of innovative applications.

Infrared spectromicroscopy for linking microbial stress-adaptive responses to genomic properties

Determining transient chemical properties of the cellular environment can elucidate the paths through which a microbial system adapts to changes in its hostile environment. Understanding such paths will enable us to better utilize sophistications of microbes for a broad range of biotechnology applications. We have investigated how obligate anaerobe Desulfovibrio vulgaris cells survive short-term exposure to air by using SR-FTIR to monitor hydrogen bonding changes in cellular water.
Circumventing water absorption barrier for studying microbes in aqueous environments

Microbes often form structured dynamic communities of aggregated cells enclosed in a self-produced polymeric matrix that adheres to both inert and living surfaces in aqueous environments. Aqueous environments hinder SR-FTIR’s sensitivity of bacterial activity. The recent development of in situ open-channel microfluidic culturing systems (team with the Microfluidics Systems Group at Lawrence Livermore National Laboratory) circumvents this water-absorption barrier, enables real-time chemical imaging of bacterial activities in biofilms, and offers opportunities to facilitate comprehensive understanding of the structural and functional dynamics in a wide range of microbial systems.

Open-channel microfluidics and SR-FTIR for studying biofilm dynamics

Bacterial biofilms are structured dynamic communities of aggregated cells enclosed in a self-produced polymeric matrix that adheres to both inert and living surfaces in aqueous environments. Many biofilm processes important in pathogenesis and ecology are initiated in confined microscopic spaces. Here we used our microfluidic SR-FTIR microscopy platform to compare the dynamics of biofilm formation in microchannels (higher nutrient supplies/mass exchange) with microwells (lower nutrient supplies/waste removal). We first monitored the SR-FTIR signal at a fixed location (a) over a 9-hour period, then used the mapping mode to obtain chemical images of biofilms in each microstructure by collecting full SR-FTIR spectra at each position.