

ANALYTICAL SEMINAR

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“Expanding the Reach of IR Chemical Imaging: Into Aqueous Environments and Below the Surface”

Infrared (IR) absorption spectroscopy offers a uniquely powerful combination for chemical imaging: it is label-free, chemically specific through vibrational fingerprinting, and absolutely quantitative via the Beer-Lambert law — without internal references or calibration standards. However, two fundamental barriers have prevented IR from reaching its full potential. First, strong water absorption at 1650 cm^{-1} directly overlaps the amide I peak of proteins, overwhelming biological signals in aqueous environments. Second, photothermal AFM-IR microscopy, despite its nanometer spatial resolution, has been treated as a surface-only technique with no rigorous quantification of how deep it actually probes. This seminar presents two recent approaches that independently remove each barrier. The first introduces solvent absorption compensation (SAC) IR microscopy, in which a rotating polarizer pair pre-compensates water absorption at each wavenumber before light enters the sample, enabling quantitative tracking of protein, lipid, and nucleic acid dynamics in live cells on a benchtop instrument. The second establishes that AFM-IR probing depth scales empirically as $(f - b)^{-3/2}$ with laser repetition rate — a finding that departs significantly from classical thermal diffusion theory — and uses this calibrated depth sensitivity to achieve the first 3D tomographic reconstruction of buried nanostructures with nanometer resolution. Together, these advances expand IR chemical imaging into aqueous biological environments and below the sample surface, moving the field toward a truly quantitative chemical microscope.