Synchrotron FTIR Imaging at SRC

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The first instrument coupling infrared light to a microscope for imaging microtomed tissue sections was reported by Blout & Mellors 1949 and Fraser, 1950. Sixty years later, the first wide-field imaging FTIR microscope [IRENI] was commissioned at SRC, enabling the highest spatial resolution images [Nasse et al. Nat. Meth]. In the past year, yet another breakthrough occurred with the first FTIR tomographic imaging. My research efforts in the imaging of biological samples has benefitted dramatically from the advances implemented at SRC [Kastyak et al, Neuroimage 2012; Hirschmugl & Gough, Applied Spec 2012, Liao et al Analyst 2013]. In this talk, I will present a few of our results from FTIR mapping conducted on the earlier single pixel, raster-scan microscopes, and contrast them with the latest results obtained at IRENI.

Our research focus is spectroscopic characterization of tissues and small organisms at biologically relevant length and time scales, to achieve a better understanding of the molecular basis of differences in health and disease. Applications range from imaging of brain tissue taken from post-mortem human brain cases of Alzheimer's Disease and from transgenic mouse models of this disease, to 2D images and 3D tomography of the nutrient composition in sea ice diatoms. At IRENI (InfraRed ENvironmental Imaging, Synchrotron Radiation Center, Univ. Wisconsin-Madison), twelve synchrotron beams are imaged onto a FPA to create spectrochemical images with an effective geometric pixel resolution of 0.54×0.54 μm^2, an increase of two orders of magnitude over standard thermal source systems, permitting analysis at sub-cellular dimensions.

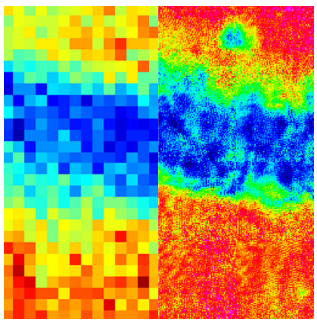

Fig. 1 — FTIR image of neurons (blue) & grey matter (yellow-red). Left: 5.5μm pixels (thermal source) Right: 0.54 μm pixels IRENI. Kastyak et al, Neuroimage 2012

The enhanced speed of data acquisition facilitated by the brilliance at IRENI, plus FPA multiplexing, has enabled the first ever IR tomography experiments. We are using FTIR TOMO, pioneered by Hirschmugl and Martin in 2012 (Nat. Meth 2013), to do 3D FTIR tomography of sea ice diatoms from arctic waters. Algal diatoms are a primary nutrient source for the marine ecosystem, particularly in the early spring, and are likely being affected by the recent rapid changes in the arctic environment. Here, our long term goals are to understand the effects of nutrient and light stress on biomass composition.

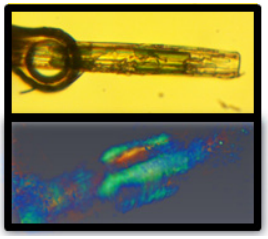

Fig. 2 TOP: Photomicrograph of sea ice diatom. Green center shows chloroplasts in cell body. BOTTOM: tilted 3D TOMO FTIR of diatom processed for protein (green) & lipid (red).
A. Ciapala,; C. Liao, P. Trokajlo; CJ Mundy, J. Seldmair, C. Hirschmugl and K M Gough, 2013