

University of Michigan
DEPARTMENT OF CHEMISTRY

ANALYTICAL CHEMISTRY

Graduate Program



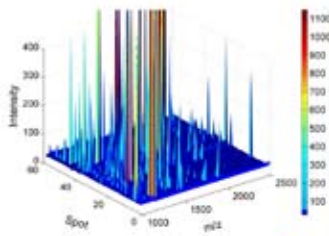
The Department of Chemistry at the University of Michigan has a rich tradition of excellence in the field of Analytical Chemistry. Hobart H. Willard made this department his home from 1903-1951, and ushered in the era of instrumental analysis in modern analytical chemistry. Philip J. Elving, a renowned electroanalytical chemist, maintained Michigan's stature in the field during the period of 1952-1984, with pioneering research and influential editorial work. Thanks to the solid foundation that Willard and Elving provided, the graduate analytical chemistry program at Michigan continues to flourish in 21st century. Particular areas of expertise are in Separations, Microfluidics, In Vivo Measurements, Electrochemistry, Chemical and Biosensors, Mass Spectrometry and Spectroscopy. Examples of research projects in these areas are highlighted below.

Separations

Chemical separations remain a core tool in the arsenal of analytical chemists involved in anything from biological research to pharmaceutical industry to environmental analysis.

The continued evolution of separation methods

such as chromatography and electrophoresis is driven by the need for analysis of complex mixtures on smaller scale in shorter times. At Michigan, we have research aimed at developing new instrumentation, methods, and applications of electrophoresis and chromatography. A particular emphasis is on miniaturizing separation methods so that analysis can be performed on extremely small samples including single cells, i.e., "lab-on-a-chip" systems. Studies to increase the speed of separation analysis to sub-second levels for rapid, high-throughput analysis and interfacing separations to a variety of spectroscopic detectors are ongoing. Applications to

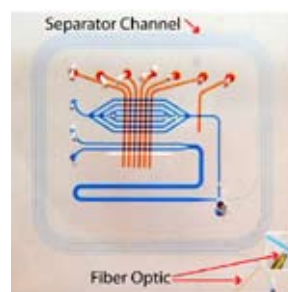


LC-MS analysis of brain tissue (Kennedy)

a variety of topics including metabolomics, proteomics, glycomics, neuroscience, and pharmaceuticals are being explored.

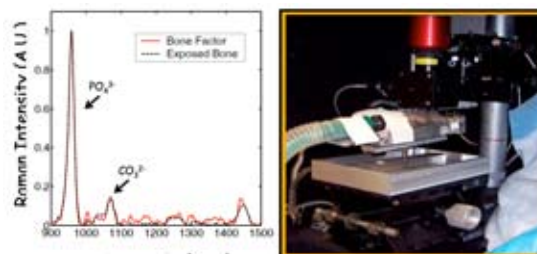
Microfluidics

Use of microfabrication techniques to create fluidic networks for performing chemical analysis promises to revolutionize chemical instrumentation. The University of Michigan has a large concentration of microfluidics researchers investigating all aspects of this exciting new field including fabrication methods, properties of microfluidics, and developing new chemical instrumentation. Students can participate in this research as well as the *Microfluidics in Biomedical Sciences Training Program* which offers numerous training, course, and seminar opportunities within a community of engineering, physics, biomedical, and chemistry researchers.



Capillary-PDMS Microfluidic Chip (Kennedy)

In Vivo Measurements

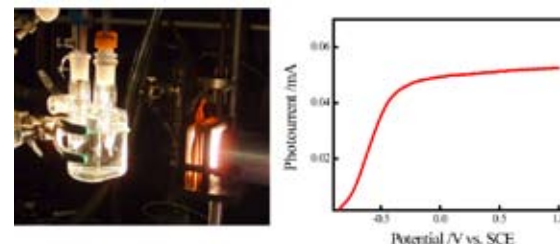


Raman spectroscopic analysis of mammalian musculoskeletal tissue integrity (Morris)

An exciting frontier for chemical measurement science is to monitor molecules in living systems. At the University of Michigan, we have several groups who are investigating different aspects of this frontier with a variety of techniques. Topics include developing more biocompatible implantable sensors for chronic measurements, sampling and rapid separation methods to monitor brain chemistry in living subjects, developing nanoscopic sensors for monitoring the chemical environment in living cells, and developing spectroscopic tools for non-invasive investigation of bone and soft tissues.

Electrochemistry

Charged interfaces are at the heart of many chemical sensing modalities and energy conversion/storage technologies. The University of Michigan Chemistry Department has a long tradition in the development and application of electroanalytical methods such as voltammetry, chronoamperometry,

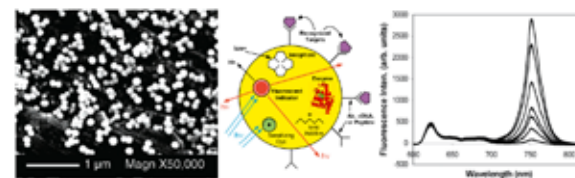


Photoelectrochemical response of n-GaP(111) in 1M H₂SO₄ (Maldonado)

potentiometry, and AC impedance for studying the fundamental and practical aspects of charged interfaces. Coupled with complementary spectroscopic and scanning probe analyses, electroanalytical techniques provide detailed kinetic and thermodynamic information on interfacial chemical processes. Current work is directed towards studying and controlling the electrochemical properties of novel electrochemical sensor architectures, the corrosion stability of chemically modified semiconductor photoelectrodes in aqueous solutions, and the activity of heterogeneous electrocatalysts for fuel-forming electrochemical reactions.

Chemical and Biosensors

The ability to monitor concentrations of key chemicals/biochemical species in complex environmental or physiological matrices via electrochemical or optical transducers requires the design of chemically selective coatings or interfaces. Our analytical program has active research efforts on a number of fronts relative to modern chemical sensor technol-



Fluorescent indicator-dye embedded PEBBLE nanoparticle sensor for in vitro and in vivo monitoring of intracellular and extracellular oxygen (Kopelman)

ogy. These include the development of microarray sensors for gas phase monitoring based on resistance changes of surface modified gold nanoparticles and conducting polymer films, use of metal ion-ligand complexes in polymeric films to create anion and gas sensors, design of nanoparticle optical sensors for intracellular measurements, and the use of surface immobilized biocatalysts to prepare a new generation of biosensors.

Mass Spectrometry

The Nobel Prize winning volatilization/ionization techniques of electrospray ionization and matrix-assisted laser desorption/ionization (MALDI) allow mass spectrometric analysis of a tremendous range of small and large molecules, including biomacromolecules. At Michigan, state-of-the-art mass analyzers such as linear ion trap, orbitrap, and Fourier transform ion cyclotron resonance (FT-ICR) are utilized for highly complex, omic-type biological analyses, including metabolomics, proteomics, peptidomics, and glycomics. Researchers are developing improved sample preparation, fractionation, separation, and clean-up strategies as well as novel tandem mass spectrometric and bioinformatics solutions. Application areas of current interest include diabetes and cancer research, neurochemistry, nucleic acid structural analysis, and cell signaling pathways.



Fourier transform ion cyclotron resonance mass spectrometer (Hakansson)

Spectroscopy

Vibrational spectroscopy can elucidate molecular structures because vibrational spectra are fingerprints of molecules. At the University of Michigan, advanced vibrational spectroscopic and imaging techniques including Raman spectroscopy and imaging, sum frequency generation spectroscopy and imaging, four-wave mixing spectroscopy and CARS imaging are used to investigate a variety of chemical, biochemical, and biophysical problems. Raman spectroscopy and imaging are applied to examine problems at scales ranging from single molecules to tissue specimens, with the princi-

pal focus on musculoskeletal tissue. Various nonlinear spectroscopic tools are used to investigate molecular structures of interfacial biological and polymer molecules to understand molecular mechanisms of membrane protein and peptide functions, biocompatibility, marine biofouling, and polymer adhesion. Multi-dimensional NMR techniques are used to investigate the role of non-soluble and non-crystalline amyloid peptides in aging-related diseases and the toxicity of antimicrobial peptides to biological cell membranes. Polymorphism of pharmaceutical drugs, high-resolution structures of bone and synthetic nanocomposites, and membrane interaction of nanomedicines are also investigated using solid-state NMR techniques.



Bruker 900 MHz spectrometer (Ramamoorthy)

Further Information

For more information about specific research interests see www.umich.edu/~michchem or contact a faculty member directly:

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How to Apply

Application to the Chemistry Graduate Program at the University of Michigan is online at www.umich.edu/~michchem/graduate/

For questions regarding admission, see www.umich.edu/~michchem or contact the department by

Website:	www.umich.edu/~michchem
Email:	ChemAdmissions@umich.edu
Phone:	toll free 888-999-2436 or 734-764-7278
Fax:	734-647-4865

cover: Depiction of implantable sensor catheter in an artery (Meyerhoff)

Chemistry at the University of Michigan

Analytical Chemistry

