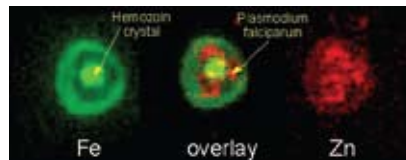




The University of Michigan at Ann Arbor is among the leading academic institutions in the USA with programs of recognized national and international reputation for excellence. As one of the first universities in the country to have a chemistry department, Michigan has a longstanding tradition of achievement in the molecular sciences. This continuing commitment to quality and innovation is reflected in multi-faceted research activities covering all areas of modern chemistry. The graduate program leading to the Ph.D. degree in Chemistry is designed to develop students into world class researchers and educators. Organized and informal research groups create stimulating learning environments in the areas of Analytical, Biological, Inorganic, Materials, Organic and Physical Chemistry.

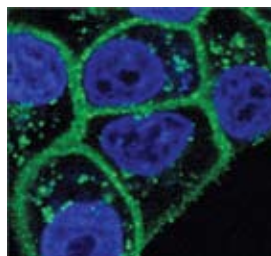
At Michigan the vision for the future is not confined by the traditions of the past. As the questions chemists ask become more complex, our vision must focus beyond fundamental chemical sciences into the interface with other disciplines. Joint studies are offered in many areas such as medicinal chemistry, macromolecular science, applied physics, and biophysics. This approach enhances the critical skills you will need to succeed in industry or academia in our increasingly complex and interdependent world. Laboratory rotations in the first year provide a jump-start on research and allow students to explore their individual areas of interest before committing to a research lab and a dissertation topic. A dynamic Future Faculty Program funded by the US Department of Education develops scientists into scholars and educators. The department prides itself on strong connections with industry. Graduates of the U of M Chemistry Department are in leading positions in industry and academia throughout the country.



X-ray fluorescence nanoprobe image of the distribution of Fe and Zn in a red blood cell infected with *Plasmodium falciparum*.

Analytical Chemistry

Development of revolutionary techniques and their application to real-world analytical problems are the research domains of the Analytical Chemistry group at Michigan. Faculty and students work closely with biomedical and industrial scientists and engineers to tackle difficult analytical challenges. Novel non-electrophoresis based immunoassays are being developed for environmental monitoring and detection of bacteria and viruses. Innovative chemical sensors based on metal ion complexes, nanodevices, or even RNA molecules are used to detect anions, cations, gases, radicals, and metabolites. In vivo sampling methods are used in conjunction with LC/MS to discover novel neurotransmitters. Cutting-edge mass spectrometry tools are developed for the identification and characterization of protein posttranslational modifications, to map macromolecular contact surfaces, and to identify protein biomarkers in the proteome of cancer cells. Spectroscopic imaging is applied to chemical and biomedical problems, including the normal and pathologic development of bone tissue and the role of trace metal ions in normal and pathogenic cellular function.



PAMAM dendrimers with folic acid targeting ligands bind to KB cells (green fluorescence). The cell nuclei have been stained with DAPI (blue fluorescence).

Chemical Biology

Chemical Biology is an exciting multidisciplinary approach to studying the fundamental chemical principles that govern all biological systems. At Michigan,

many research groups use combinations of physical, chemical, biochemical and genetic approaches to study biological catalysis by proteins and by RNA enzymes. These studies include the posttranslational modification of proteins, the generation of free radicals, the reduction of sulfate, and the cleavage of RNA. The relationship between biomolecular structure and function is investigated using x-ray crystallography and NMR spectroscopy. Micro- and nano-scale devices are being developed for the detection of minute amounts of clinically relevant biomarkers and pathogens. State-of-the-art microscopy allows for the imaging and manipulation of single molecules in vitro and in living cells. The broad role of metal ions in biology is investigated in research focusing on the enzymatic, spectroscopic and structural characterization of metal sites in proteins, nucleic acids and whole cells. The importance of RNA biochemistry is becoming increasingly evident. Research at Michigan is at the forefront of this effort studying ribozyme catalysis, RNA structure and dynamics, and the molecular level dissection of the role of proteins required for ribosome assembly and RNA transcription. Efforts to interpret experimental results at a more microscopic level are fueled by the development of theoretical models that range from atomic level detail to coarse-grained molecular representations.



Dinitrogen bound intermediate of the active site of nitrogenase from DFT calculations

Inorganic Chemistry

The breadth of research at the University of Michigan reflects the highly interdisciplinary character of modern Inorganic Chemistry. Inorganic Chemistry at the University of Michigan flourishes in the areas of metals in biology (Bioinorganic Chemistry), catalysis for transformation of organic molecules (Organometallic Chemistry) and Medicinal Chemistry. Organometallic Chemistry at UM explores functionalization of C-H bonds using main group

and transition metal compounds and synthesis of chiral heterocycles. Bioorganometallic Chemistry unites organometallic and bioorganic chemistry. Interdisciplinary research in Bioinorganic Chemistry spans several areas including iron-sulfur clusters in electron transfer and catalysis; photo system II and high-valent manganese chemistry; the biological role of nitric oxide as a signaling and regulating molecule; the distribution and catalytic function of zinc in biology; to protein design for heavy metal sensors. Research in Medicinal Chemistry focuses on the therapeutic uses of nanoparticles - and on the critical aspects of nanoparticle toxicity.



STM image of a nanopatterned surface decorated with clusters of aromatic rings spaced by alkane chains

Materials Chemistry

The diversity of research programs in materials chemistry at Michigan creates an extraordinary opportunity for stimulating graduate research at the interface of materials science and analytical, inorganic, organic, and physical chemistry. The broad scope of the Materials chemistry research at Michigan also benefits from collaborations with the nearby Medical and Engineering campuses. Highlights of ongoing research projects include: the development of smart nanoparticles for biomedical sensing, imaging and therapy; The synthesis of amphiphilic polymers that interact with cell membranes to understand polymer-lipid interactions and create antimicrobials, polymeric drug carriers, and membrane probes; The development of new electrochemical and optical anion and gas selective sensors using various metal-ligand complexes as anion/gas recognition agents within thin polymeric films; The development and application of transition metal oxides, nitrides, and oxynitride semiconductors as photoelectrodes in regenerative and photosynthetic electrochemical

cells; The use of ultrafast time-resolved fluorescence and absorption measurements to probe the kinetics of fast energy redistribution processes that occur in branched macromolecular structures; Computational modeling of molecular and nano scale conductivity.



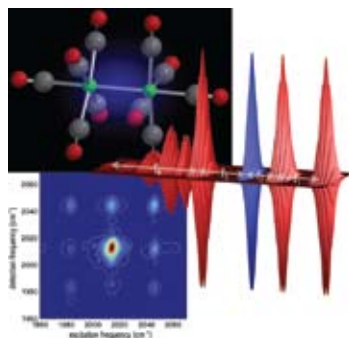
Nickel-catalyzed coupling of an aldehyde, alkyne and enone via redox isomerization (Montgomery).

Organic Chemistry

Michigan offers a diverse selection of research opportunities in Organic synthesis with particular strengths in Organometallic Chemistry, Organic Chemistry, Bioorganic Chemistry, and Organic Materials. Whether students are interested in the use of transition metals in reaction discovery, synthetic methodology development, and mechanistic chemistry, or on applying organic chemical principles to solve problems focused on human health, there is a broad spectrum of available research projects. Highlights of ongoing research projects include: Discovering methods to transform inert carbon-hydrogen bonds into new functional groups; Exploring the reductive coupling of aldehydes and alkynes or enones and alkynes; Developing strategies for reprogramming gene expression using small molecules, both natural products and 'designer' molecules; Identifying novel molecular targets and small molecules for the treatment of autoimmune diseases and cancer; Developing novel routes for the efficient production of new members of conjugated oligomers and polymers with planar structural constraints, such as fused oligothiophenes. A highly collaborative atmosphere spanning the department and university allows students to tackle important problems in Chemical Biology, Medicinal Chemistry, and Materials Science, further strengthening the breadth of Organic Chemistry research at Michigan.

Physical Chemistry

Physical Chemistry aims to provide fundamental explanations of complex chemical systems thus placing Chemistry in its key role as the Central Science on a firm theoretical foundation. At Michigan experimental and theoretical groups collaborate to span a wide range of research interests including single molecule spectroscopy, atomic scale imaging, solid state NMR, X-ray spectroscopies, femtosecond dynamics, multi-dimensional spectroscopy, ultrafast optics, materials science, surface characterization and nanotechnology. Advances in these areas require development and implementation of state-of-the-art experimental and theoretical techniques. Concentrated efforts in surface and nano-science emphasize development of a molecular level understanding of interfaces related to catalysis, electronic devices and materials, biological systems and drug delivery. Spectroscopic methods from NMR to X-ray provide a real time window into structure and dynamics of fundamental chemical and biological systems. Computational methods and theoretical approaches are applied to the understanding of quantum dynamics, electronic structure, biological function, electron and energy transport and the interpretation of single-molecule, nonlinear and multidimensional spectroscopies.



2D IR spectra Two-dimensional infrared spectrum of dimanganese decacarbonyl, $Mn_2(CO)_{10}$, in cyclohexane. Using femtosecond laser pulses, the Kubarych group applies transient multidimensional spectroscopy to the study of condensed phase chemical dynamics including biological and photocatalytic reactions.

University of Michigan and Ann Arbor

The University of Michigan offers a rich intellectual environment. The many institutes, laboratories, collections, museums, centers, and libraries provide excellent facilities in a wide range of academic endeavors. Ranked second nationwide in overall

research funding, the University provides extensive opportunities for research collaborations outside chemistry, enhanced by top-ranked programs in chemical biology, medicine, engineering, physics, biophysics, applied physics, biology, biochemistry, mathematics, and computer science.

The University is located in Ann Arbor, a city of 110,000 residents, which combines the comfort and charm of a college town with the vivid cultural life of a large city, including live music, theater, dance, fine dining, a top-ranked college sports program, and outdoor cafes. In addition, Ann Arbor is conveniently located within 20 minutes of the Detroit airport, and within a modest four to five hour drive of Chicago and Toronto.

Further Information

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

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

1988 Willard H. Dow Chemistry Laboratory



Atrium of the Chemistry Laboratory

Chemistry

at the
University of
Michigan

