University of Michigan

DEPARTMENT OF CHEMISTRY

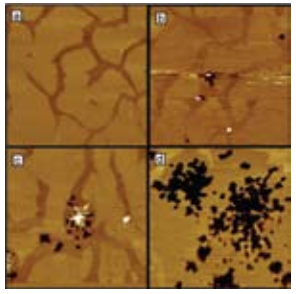
MATERIALS CHEMISTRY

Graduate Program

The diversity of research programs in Materials Chemistry at the University of Michigan creates an extraordinary opportunity for stimulating graduate research at the interface of materials science and analytical, inorganic, organic, and physical chemistry. Particular areas of expertise are in Materials Synthesis, Materials in Biology and Medicine, Materials in Sensors, Materials in Energy Conversion and Storage, Spectroscopy of Materials, and Theoretical Description of Materials Properties. Selections of research projects in these areas are highlighted below.

Materials Synthesis

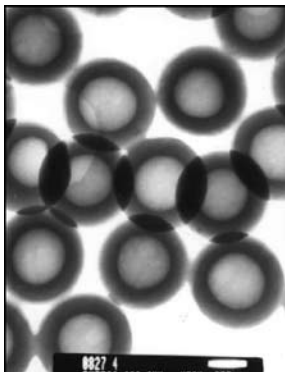
Materials science is driven by the synthesis of new materials with functional properties. Highlights of materials synthesis research at Michigan include: (1) The development of living polymerization methods towards new conjugated polymers for optoelectronic applications. (2) Design of new polymeric systems for controlling pharmaceutical crystallization and elucidating mechanisms of form selection.



AFM height images of supported DMPC bilayer during phase transition before and after addition of 25 nM G7 PAMAM dendrimers. Defects (black areas) caused by dendrimers are approximately 5 nm deep. Scan size 1 μm (Banaszak Holl).

Materials in Biology and Medicine

Non-natural materials can be utilized to probe, monitor, or modify biological processes. Highlights of ongoing research projects include: (1) Synthetic and biophysical studies on polymeric platforms for targeted drug-delivery and gene-delivery applications with a special emphasis on understanding the role of multivalency and membrane translocation events. (2) The synthesis of engineered multifunctional nanoplatforms containing various combinations of drugs, enzymes, antibodies, polymers, dyes, magnetic oxides, metallic coatings, and silica for applications such as medical-imaging contrast agents for targeted MRI of brain-tumors and drug-delivery agents for side-effect free chemotherapy, radiation therapy or photodynamic therapy of cancer. (3) The design and synthesis of amphiphilic polymers that can actively interact with cell membranes to understand polymer-lipid interactions as well as to create antimicrobials, polymeric drug carriers, and membrane probes.



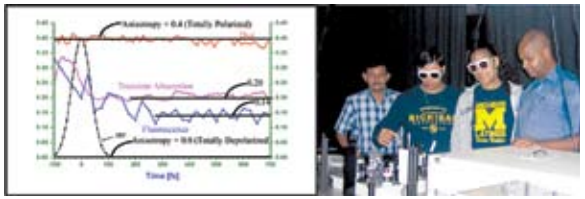
Hollow organically modified silica nano-bottles, with hydrophobic outer shell and hydrophilic inner shell. These nanoparticles can be used in photoacoustic in vivo oxygen imaging (Kopelman).

Materials in Sensors

Chemical and biological sensors provide critical information on the environmental surroundings in real-time. Highlights of sensor research at Michigan include: (1) The design of new molecules that induce hydrogelation in the presence of an analyte for use in breath analysis and environmental sensing. (2) 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. (3) The development of integrated microanalytical systems for complex vapor-mixture analysis and the implementation of sensor-based systems for environmental monitoring applications.

Materials in Energy Conversion and Storage

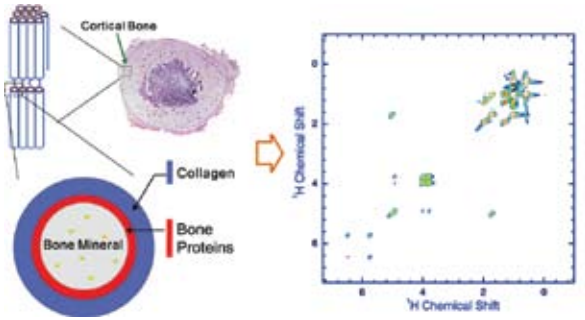
The increasing need for renewable energy has placed energy production, storage, and transport at the forefront of materials research at the University of Michigan. Highlights of ongoing research projects include: (1) Synthesis of coordination polymers with high intrinsic microporosity for use in gas storage. (2) Derivatization of gallium phosphide surfaces for chemical/electrical passivation and improved electrocatalysis. (3) The development and application of transition metal oxides, nitrides, and oxynitride semiconductors as photoelectrodes in regenerative and photosynthetic electrochemical cells. (4) The synthesis of hybrid organic-inorganic layered materials as high-capacity battery electrodes and new superconducting materials.



Time-resolved fluorescence anisotropy and transient absorption anisotropy of metal-chromophore assemblies (Goodson).

Spectroscopy of Materials

Modern spectroscopies provide insight into the electronic, structural, and interfacial properties of materials. Highlights of ongoing research projects include: (1) Ultra-fast time-resolved fluorescence and absorption measurements focused on probing the kinetics of fast energy redistribution processes that occur in branched macromolecular structures.

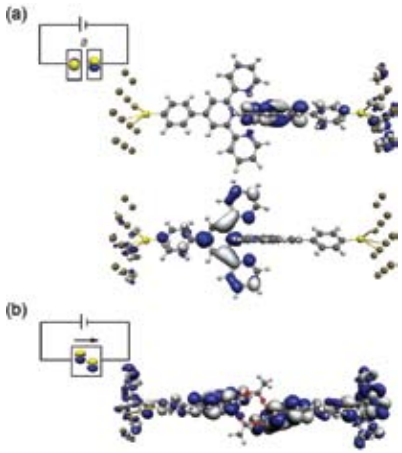


Bone, like other tissues in our body, is undergoing a continuous rebuilding process. Solid-state NMR spectroscopy is used to understand the function of the lipids and bone proteins in this dynamic process (Ramamoorthy).

(2) State-of-the-art techniques including sum frequency generation vibrational spectroscopy and atomic force microscopy are being used to understand molecular surface/interface structures of polymers and proteins. (3) New and cutting edge solid-state NMR spectroscopic methods, including specifically constructed multiple radio-frequency pulses, magic-angle spinning, multiple resonance schemes, and sensitivity enhancement procedures, are being used to study the structure and properties of molecules in single crystalline, liquid crystalline, polycrystalline, and amorphous phases.

Theoretical Description of Materials Properties

Computational quantum chemistry can provide microscopic insight that is difficult to obtain by other tools. At Michigan, charge transport through nanostructures is being investigated by implementing state-of-the-art calculations of molecular conductance. Some recent projects include: (1) spin-dependent transmission in ligated porphyrin molecules, (2) transport in chemical sensors, and (3) hydrogen uptake in metal organic frameworks.



Computational modeling supports the hypothesis that Co(II) acetate-mediated stacking is responsible for experimentally observed conductivities (Dunietz).

Life in Ann Arbor

The University of Michigan offers a rich intellectual environment. Opportunities for research and collaboration in materials chemistry are enhanced by top-ranked programs in engineering and medicine. The University is located in Ann Arbor, a small city of 110,000, combining the comfort and charm of a college town with the vivid cultural life of a large city.

Further Information

For more information about specific research interests, go to: www.umich.edu/~michchem. Please feel free to contact faculty directly.

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How to Apply

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

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

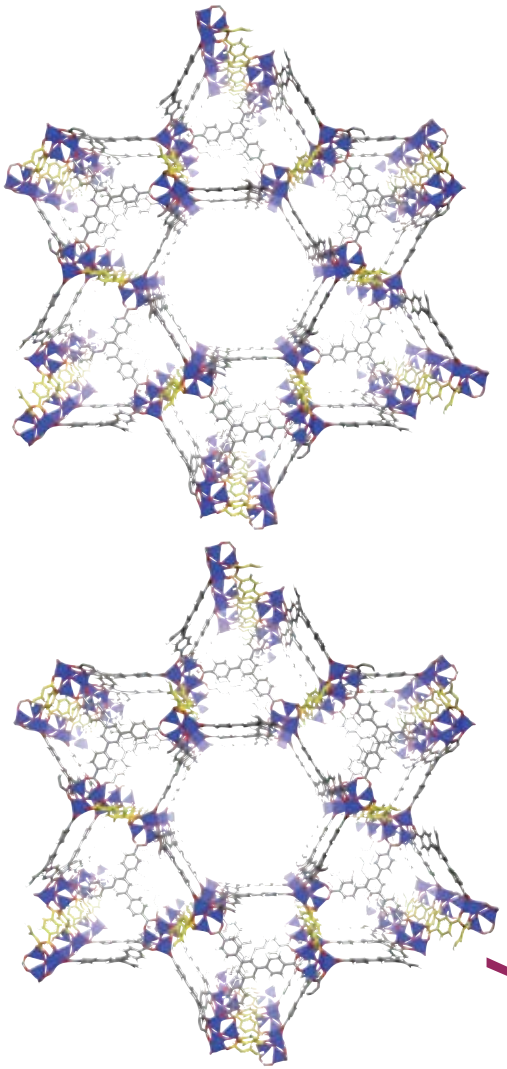
Website:	www.umich.edu/~michchem
Email:	ChemAdmissions@umich.edu
Phone:	toll free 888-999-2436 or 734-764-7278
Fax:	734-647-4865

Cover: Crystal structure of UMCM-1 (University of Michigan Crystalline Material-1), a mesoporous material possessing unprecedented levels of microporosity (Matzger).

2008

Chemistry at the University of Michigan

Materials Chemistry



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