Chemical and Biochemical Engineering

Chair

Jun Wang

Undergraduate major: chemical engineering (BSE)

Graduate degrees: MS in chemical and biochemical engineering; PhD in chemical and biochemical engineering

Faculty: https://engineering.uiowa.edu/cbe/people

Website: https://engineering.uiowa.edu/cbe

Facilities

Chemical engineers at the University of Iowa, whether undergraduates or graduate students, benefit from the extensive resources of a top research university. Some of the key facilities and resources available to them include libraries, computing centers, machine and electronics shops, a tool library, prototyping and design studios, chemical analysis and microscopy resources, genetic, cell, and tissue analysis facilities, tutoring and writing centers, and other specialized research infrastructure. These resources are utilized according to each student's customized curriculum and research needs, ensuring they get the most out of their education and training. Specific laboratories maintained by the Department of Chemical and Biochemical Engineering to support undergraduate courses are listed as follows.

Materials Science Laboratory

The Materials Science Laboratory allows students in ENGR:2720 Materials Science to delve deeper into the concepts taught in class. It features tensiometers, hardness testers, an Izod impact tester, a contact angle goniometer, and heat treatment/sintering furnaces to characterize and examine the mechanical properties of a variety of materials. Additionally, students use optical microscopes, metallography specimen kits, and crystallography packages to gain hands-on experience of how material properties are related to their structure.

Chemical Engineering Laboratory

The Chemical Engineering Laboratory provides hands-on learning for undergraduate students in CBE:3150 Thermodynamics/Transport Laboratory and CBE:3155 Chemical Reaction Engineering/Separations Laboratory. The lab is equipped for student experimentation in thermodynamics, fluid flow, heat transfer, mass transfer, chemical reaction engineering, and separations. Much of the lab equipment is made of transparent materials so students can see exactly how things work inside. Additional equipment includes a fluid friction apparatus, a jacketed kettle, and a membrane gas separator. Students use state-of-the-art portable analytical devices in their investigations, including densitometers, polarimeters, and refractometers.

Additionally, a wide array of small equipment is available to support laboratory projects and demonstrations in chemical engineering courses and for use by students performing independent investigations or student groups competing in national chemical engineering contests.

Chemical Process Safety Laboratory

The Chemical Process Safety Laboratory is an integral part of CBE:3125 Chemical Process Safety. Through a series of experiments, students learn about flammability, reactivity, explosions, safety valve design, and electrostatics—all crucial for working safely in the chemical industry. The laboratory is equipped with two MiniFlash automatic flash point testers (closed cup), an advanced reactive system screening tool (ARSST), a minimum ignition energy (MIE) apparatus, a flammability chamber, a modified Hartmann tube, a Hartmann bomb, a liquid conductivity apparatus, a powder chargeability apparatus, a powder volume resistivity apparatus, a Van de Graaff generator, two high impedance electrometers, a field meter, a Faraday cage, and relief sizing software.

Biochemical Engineering Laboratory

The Biochemical Engineering Laboratory is an integral part of CBE:3205 Introduction to Biochemical Engineering. Students use this equipment to perform recombinant DNA experiments and to study the growth and metabolism of microorganisms. The lab is equipped with two controlled New Brunswick BioFlo/CelliGen 115 bioreactors, electrophoresis apparatus, and a thermocycler.

Process Control Laboratory

The Process Control Laboratory is used in CBE:4105 Process Dynamics and Control in Design and CBE:5199 Contemporary Topics: Chemical and Biochemical Engineering. In this lab, students use industrial-grade computer-controlled systems to manage flow, levels, composition, and temperature in pilot-scale devices. Students learn software tools, including DeltaV, a common industrial control system, and LabVIEW, a widely used scientific and engineering measurement and automation system.

Learning modules in the Process Dynamics lab focus on actuators (such as valves and motors), valve positioners, sensors, SCADA (supervisory control and data acquisition) software, distributed control system software, control block diagrams, piping and instrumentation diagrams, mathematical modeling of dynamic systems, and the specification of mathematical transfer functions for chemical, physical, and control operations.

CBE:5199 Contemporary Topics: Chemical and Biochemical Engineering is an introduction to the design and programming of DeltaV-based control systems. Students create a DeltaV operator screen for hardware selected from the process control lab. This allows students to integrate hardware and software and achieve computer control by implementing all project phases: (i) design, (ii) programming, (iii) hardware integration, and (iv) testing and troubleshooting.

Graduate Facilities and Laboratories

The department offers a wide variety of facilities to support and develop research activities.

Air Quality, Climate, Remote Sensing, and Smart Sensing Research Thrusts

The department maintains extensive facilities for computational, field, and laboratory studies of air pollution in the context of climate change. Part of this infrastructure is housed at the Center for Global and Regional Environmental Research (CGRER). The center occupies 5,000 square feet of lab and office space on the fourth floor of the Iowa Advanced Technology Laboratories. CGRER members have dedicated queues and storage within the University of Iowa's extensive High Performance Computing (HPC) facility.

Individual professors maintain a wide variety of air pollution sampling equipment, with a focus on both aerosol and gas-phase physics and chemistry in the context of climate, weather, and human health.

The Atmospheric and Environmental Research (AER) Lab has a diverse research portfolio that encompasses three research themes: development of remote sensing theory and algorithms for characterizing atmospheric (aerosol) particles and surface emissions (especially from fires); development and application of chemistry-aware atmospheric models and observation data to studies in air quality, weather, and climate; and interdisciplinary research via collaborative teamwork in such areas as air quality and public health, irrigation and climate change, environmental monitoring and solutions via community science and engagement.

The Iowa Atmospheric Sensor Development Laboratory (IASDL) is a fully equipped research laboratory dedicated to developing new remote sensing instruments to study the Earth's atmosphere. Focused on laser-based, or lidar, remote sensing, researchers in IASDL develop sensors for use in ground-based, airborne, and spaceborne applications. Advanced technologies and onboard machine learning processing are the basis for creating affordable sensors that produce real-time data products to impact air quality, human health, and decision-making. Researchers in IASDL frequently work with the Operator Performance Laboratory, which is home to several research aircraft, and collaborate with researchers at NASA and other organizations.

Biochemical Engineering

Biochemical engineering laboratories provide facilities for the preparation of biological media and the cultivation of organisms, as well as for the separation and analysis of biomolecules. This equipment includes biological incubators and floor incubator shakers, agitated and airlift bioreactors, light microscopes, autoclaves, Vi-Cell cell counter, thermocycler for polymerase chain reaction (PCR) amplification of DNA, high- and low-speed centrifuges, UV-Vis spectrophotometers, a lyophilizer, biological safety cabinets, and an anaerobic glove box. Phase-contrast and epifluorescence microscopes, gel electrophoresis systems, gas chromatography units with flame ionization and electron capture detectors, and several high-performance liquid chromatography systems with refractive index and photodiode array detectors are available for the characterization of microorganisms and constituent biomolecules.

Through collaborative research agreements, graduate students also have access to specialized facilities for electron microscopy, large-scale fermentation, protein structure, recombinant DNA research, and tissue culture/hybridoma; the Flow Cytometry Facility; and the High Resolution Mass Spectrometry Facility.

Biomedical Engineering

The biomedical engineering laboratories house particle technology equipment including microemulsion equipment for drug encapsulation, sonicators, benchtop scale spray dryers, laser diffraction particle sizer, zetapotentiometer; DNA preparation equipment, gel electrophoresis apparatus; interfacial stress rheometer, surface tensiometer, UV-Vis/fluorescent plate reader, high performance liquid chromatograph, luminometer, lyophilizer, custom-built simulated cough machine, microscopes, incubators, wet chemistry equipment, rotary shakers, incubated plate shakers, autoclave, centrifuges, and laboratory computers. Cell culture and bacterial culture facilities are housed adjacent to the laboratories.

Graduate students also have access to core research facilities, including the Central Microscopy Research Facility, Flow Cytometry Facility, Iowa Institute of Human Genetics, Electron Spin Resonance Facility, Nuclear Magnetic Resonance Facility, High Resolution Mass Spectrometry Facility, and the Center for Gene Therapy.

Computer Facilities

The departmental computer facilities contain a variety of laptops, desktop workstations, and printers. The department is supported by the college's Engineering Technology Center, which maintains a large network of high-performance Linux and Windows workstations along with extensive commercial and public domain software. The department has access to the university's central high-performance research computing facility through ITS–Research Services. The University of Iowa also has access to the ACCESS and Blue Waters national supercomputing resources and is a founding member of the Great Lakes Consortium for Petascale Computing. Locally hosted long-term data storage services are available.

Fundamentals and Applications of Photopolymerization

The Photopolymerization Center was established to advance a fundamental understanding of the kinetics and mechanisms of photopolymerizations. To this end, the center provides unique opportunities for collaborations by industrial and academic investigators to explore photopolymerization processes and develop novel applications based on photopolymerizations.

The center provides equipment and instrumentation for the characterization of photopolymerization systems on the molecular, microscopic, and macroscopic levels. Center researchers pursue an understanding of fundamental photophysical and photochemical processes involved in the photoinitiation reaction, characterization of high-speed propagation and termination kinetics that lead to the polymer structure, and evaluation of material properties through the course of the photopolymerization reaction. Both radical and cationic photopolymerizations are studied with state-of-the-art experimental techniques to elucidate the complex chemical and physical mechanisms that control the initiation, propagation, and termination of the active centers.

Machine Learning and Artificial Intelligence Resources

In addition to specialized software developed and maintained by researchers in the Chemical and Biochemical Engineering department, students, staff, and faculty also make use of the university's High Performance Computing (HPC) resources and the Iowa Institute for Artificial Intelligence (IIAI). HPC

resources include GPU processors that are particularly useful for running machine learning algorithms. The Iowa Institute for Artificial Intelligence helps department researchers transform ideas for machine learning and artificial intelligence applications from concepts to working code.

Electrochemical Engineering

The electrochemical engineering laboratories house facilities for electrocatalyst synthesis and characterization, located in the Iowa Advanced Technology Laboratories (IATL). The equipment includes muffle furnaces and tube furnaces for materials synthesis, optical microscopes for surface characterization, rotating disk electrode (RDE) and rotating ring-disk electrode (RRDE) systems with rotators for electrochemical measurements, flow cells and electrolyzers for device testing, potentiostats/galvanostats (electrochemical workstations), and scanning electrochemical microscope (SECM) for local electrochemical analysis. Three-dimensional printers are available for fabricating customized equipment components and accessories for fluid handling and control. Graduate students also have access to core research facilities, including the Central Microscopy Research Facility, and MATFab Facility.