Macromolecular science and engineering is the study of the synthesis, structure, processing, and properties of polymers. These giant molecules are the basis of synthetic materials including plastics, fibers, rubber, films, paints, membranes, and adhesives. Research is constantly expanding these applications through the development of new high performance polymers, e.g. for engineering composites, electronic, optical, and biomedical uses. In addition, most biological systems are composed of macromolecules—proteins (e.g. silk, wool, tendon), carbohydrates (e.g. cellulose) and nucleic acids (RNA and DNA) are polymers and are studied by the same methods that are applied to synthetic polymers.

Production of polymers and their components is central to the chemical industry, and statistics show that over 75 percent of all chemists and chemical engineers in industry are involved with some aspect of polymers. Despite this, formal education in this area is offered by only a few universities in this country, resulting in a continued strong demand for our graduates upon completion of their BS, MS, or PhD degrees.

Mission
To educate students who will excel and lead in the development of polymeric materials and the application of structure-property relationships. The department seeks to prepare students for either professional employment or advanced education, primarily in this or related science or engineering disciplines, but also in professional schools of business, law or medicine. Undergraduate students are offered opportunities for significant research experience, capitalizing on the strength of our graduate program.

Research
The research activities of the department span the entire scope of macromolecular science and polymer technology.

Synthesis
New types of macromolecules are being made in the department’s synthesis laboratories. The emphasis is on creating polymers with novel functional properties such as photoconductivity, selective permeation, and biocompatibility, and in producing new materials which behave like classical polymers without being linked together by covalent bonds.

Physical Characterization
This is the broad area of polymer analysis, which seeks to relate the structure of the polymer at the molecular level to the bulk properties that determine its actual or potential applications. This includes characterization of polymers by infrared, Raman, and NMR and mass spectroscopy, thermal and rheological analysis, determination of structure and morphology by x-ray diffraction, electron microscopy, and atomic force microscopy, permeability and free volume, and investigation of molecular weights and conformation by light scattering.

Mechanical Behavior and Analysis
Polymeric materials are known for their unusual mechanical capabilities, usually exploited as components of structural systems. Analysis includes the study of viscoelastic behavior, yielding and fracture phenomena and a variety of novel irreversible deformation processes.

Processing
A major concern of industry is the efficient and large scale production of polymer materials for commercial applications. Research in this area is focusing on reactive processing, multi-layer processing and polymer mixing, i.e., compounding and blends. The integration of sensors and processing equipment, and methods for examining changes in structure and composition during processing steps are growing areas of inquiry. Both laboratory and simulation research are brought to bear on these critical issues.

Materials Development and Design
Often, newly conceived products require the development of polymeric materials with certain specific properties or design characteristics. Materials can be tailor-made by designing synthesis and processing conditions to yield the best performance under specified conditions. Examples might be the design of photoluminescent and semi-conducting polymers for use in optoelectronic devices, polymers that are stable at high temperatures for fire-retardant construction materials, high temperature polymer electrolytes for use in advanced fuel cells, low density thermal insulating polymer composite materials, advanced polymeric optical devices, and biocompatible polymers for use in prosthetic implants, reconstructive medicine and drug-delivery vehicles.

Biopolymers
Living systems are composed primarily of macromolecules, and research is in progress on several projects of medical relevance. The department has a long-standing interest in the hierarchical structure and properties of the components of connective tissues (e.g., skin, cartilage, and bone). The department is also engaged in the development of new biocompatible polymers for applications in human health.

Faculty
Gary Wnek, PhD
(University of Massachusetts, Amherst)
The Joseph F. Toot, Jr. Professor and Chair
Polymeric biomaterials for drug delivery and regenerative medicine; nano- and micro-fiber fabrication; bio-mimicking approaches for polymer flammability mitigation; polymer packaging systems design; polyelectrolyte gels and elastomers; physiologically-mimicking macromolecular constructs with attention to primitive motile and irritable systems
Eric Baer, DEng
(Johns Hopkins University)

Director, Centered for Layered Polymeric Systems (CLiPS) and Herbert Henry Dow Professor of Science and Engineering

Multilayered and ultrathin polymer films and devices. Irreversible microdeformation mechanisms; pressure effects on morphology and mechanical properties; relationships between hierarchical structure and mechanical function; mechanical properties of soft connective tissue; polymer composites and blends; polymerization and crystallization on crystalline surfaces; viscoelastic properties of polymer melts; damage and fracture analysis of polymers and their composites. Structure-property relationships in biological systems

Michael Hore, PhD
(University of Pennsylvania)

Associate Professor

Polymer physics; neutron scattering; polymer nanocomposites; grafted polymers and brushes; theory and modeling; self-consistent field theory; structure-property relationships; reconfigurable materials.

Hatsuo Ishida, PhD
(Case Western Reserve University)

Professor

Processing of polymers and composite materials; structural analysis of surfaces and interfaces; molecular spectroscopy of synthetic polymers

João Maia, PhD
(University of Wales Aberystwyth, U.K.)

Associate Professor

Polymer rheology: extensional rheology and rheometry; micro- and nano-rheology; bio-rheology: food rheology and processing; rheology for macromolecular technology: development and optimization of polymer blends and composites; viscoelasticity of micro- and nano-layered polymer films; on- and in-line monitoring of extrusion-based processes; micro-processing; environmental rheology and processing

Ica Manas-Zloczower, DSc
(Israel Institute of Technology)

Professor

Structure and micromechanics of fine particle clusters; interfacial engineering strategies for advanced materials processing; dispersive mixing mechanisms and modeling; design and mixing optimization studies for polymer processing equipment through flow simulations

Svetlana Morozova
(University of Massachusetts, Amherst)

Assistant Professor

Polymer dynamics

Valentin Rodionov, PhD
(Scripps Res. Institute)

Assistant Professor

Organic polymer chemistry; synthesis of novel macromolecular structures and architectures; catalysis

Lei Zhu, PhD
(University of Akron)

Professor

Nanoscale structure and morphology of crystalline/liquid crystalline polymers and block copolymers; ferroelectric and dielectric polymers for electric energy storage; polymer/inorganic hybrid nanocomposites; biodegradable polymers for diagnostic and drug delivery

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Secondary Faculty

James M. Anderson, PhD
(Ohio State University, M.D.)

Professor of Macromolecular Science, Pathology, and Biomedical Engineering

Biocompatibility, inflammation, foreign body reaction to medical devices, prostheses, and biomaterials

Donald Feke, PhD
(Princeton University)

Professor of Chemical Engineering and Macromolecular Science

Fine-particle processing, colloidal phenomena, dispersive mixing, and acoustic separation methods

Roger French, PhD
(Massachusetts Institute of Technology)

F. Alex Nason Professor of Materials Science

Optical materials and elements, optical properties and electronic structure of materials, and electrodynamic van der Waals-London dispersion interactions

John Protasiewicz, PhD
(Cornell University)

Professor of Chemistry

Inorganic, organic, main group, materials, polymer, catalysis, organometallic chemistry, and X-ray crystallography

Charles Rosenblatt, PhD
(Harvard University)

Professor of Physics

Experimental condensed matter physics and liquid crystal physics

Kenneth Singer, PhD
(University of Pennsylvania)

Professor of Physics

Modern optics and condensed matter experiment and nonlinear optics

Philip Taylor, PhD
(Cambridge University, England)

Perkins Professor of Physics

Phase transitions and equations of state for crystalline polymers; piezoelectricity and pyroelectricity

Horst von Recum, PhD
(University of Utah, Salt Lake City)

Assistant Professor of Biomedical Engineering

Novel platforms for the delivery of molecules and cells and the use of novel stimuli-responsive polymers for use in gene and drug delivery

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Adjunct Faculty

Thomas Chapin, PhD
(University of Connecticut)

Vice President, UL Laboratories

Polymer Flammability
Lashanda Korley, PhD
(Massachusetts Institute of Technology)
*Distinguished Professor, Materials Science & Engineering and Chemical & Biomolecular Engineering, University of Delaware*
Hierarchical peptide polymer hybrids; new fiber manufacturing strategies for functional material development; responsive composites; interplay of covalent and non-covalent interactions

Jon Pokorski, PhD
(Northwestern University)
*Associate Professor, Nanoengineering, University of California San Diego*
Biomaterials for delivery of therapeutic proteins; protein-polymer conjugates; drug-delivery; biopolymer catalysts; self-assembling peptides; affinity-based delivery of therapeutics; layered polymeric delivery systems

Stuart Rowan, PhD
(University of Glasgow)
*Professor, The Institute for Molecular Professor for Molecular Engineering, Innovation and Enterprise, University of Chicago*
Supramolecular chemistry; synthesis of metallosupramolecular and stimuli-responsive polymers; isolation and utilization of cellulose nanocrystals in biomimetic and porous systems; reversible covalent chemistry

Christoph Weder, DrScNat
(ETH Zurich Switzerland)
*Professor of Polymer Chemistry and Materials and Director, Adolphe Merkle Institute of the University of Fribourg, Switzerland*
Design, synthesis and investigation of structure-property relationships of novel functional polymers: polymers with unusual optic and/or electronic properties; (semi)conducting conjugated polymers; stimuli-responsive polymers; biomimetic materials, polymer nanocomposites, supramolecular chemistry

**CWRU/Brazil Dual PhD Degree Adjunct Professors**

Rosario Elida Suman Bretas, PhD
(Federal University of Sao Carlos)
*Professor*
Department of Materials Engineering

Veronica Maria de Araujo Calado, PhD
(Federal University of Rio de Janeiro)
*Professor*

Sebastiao Vicente Canevarolo Junior, PhD
(Federal University of Sao Carlos)
*Professor*
Center for Exact and Technology, Dept of Materials Engineering

Leonardo Bresciani Canto, PhD
(Federal University of Sao Carlos)
*Professor*
Department of Materials Engineering

Marcio da Silveira Carvalho, PhD
(Pontificial Catholic University of Rio de Janeiro)
*Professor*
Department of Mechanical Engineering

Osvaldo de Lazaro Casagrande Junior, PhD
(Federal University of Rio Grande do Sul)
*Professor*
Department of Organic Chemistry

Jose Roberto Moraes d’Almeida, PhD
(Federal University of Rio de Janeiro)
*Professor*
Department of Chemical Engineering

Griselda Barrera Galland, PhD
(Federal University of Rio Grande do Sul)
*Professor*
Institute of Chemistry

Aurora Perez Gramatges, PhD
(Pontifical Catholic University of Rio de Janeiro)
*Professor*
Department of Chemistry

Elizabete Fernandes Lucas, PhD
(Federal University of Rio de Janeiro)
*Professor*
Institute of Macromolecules

Raquel Santos Maurer, PhD
(Federal University of Rio Grande do Sul)
*Professor*
Department of Chemical Engineering

Paulo de Souza Mendes, PhD
(Pontifical Catholic University of Rio de Janeiro)
*Professor*
Department of Mechanical Engineering

Monica Feijo Naccache, PhD
(Pontifical Catholic University of Rio de Janeiro)
*Professor*
Department of Mechanical Engineering

Sidnei Paciornik, PhD
(Pontifical Catholic University of Rio de Janeiro)
*Professor*
Department of Materials Engineering

Luiz Antonio Pessan, PhD
(Federal University of Sao Carlos)
*Professor*
Department of Materials Engineering

Cesar Liberato Petzhold, PhD
(Federal University of Rio Grande do Sul)
*Professor*
Institute of Chemistry

Joao Henrique Zimnoc Dos Santos, PhD
(Federal University of Rio Grande do Sul)
*Professor*
Institute of Chemistry

Paulo Henrique Schneider, PhD
(Federal University of Rio Grande do Sul)
*Professor*
Institute of Chemistry
Determination of the solid state structure and morphology of polymers. X-ray analysis of the structure of thermotropic copolyesters, copolyimides, polyurethanes, polysaccharides; supramolecular assemblies, fluoropolymers; molecular modeling of semi-crystalline and liquid crystalline polymers; rheological properties of polysaccharides and glycoproteins.

Alexander M. Jamieson, DPhil
(University of Oxford, England)
Professor
Quasielastic laser light scattering; relaxation and transport of macromolecules in solution and bulk; structure-function relationships of biological macromolecules.

David A. Schiraldi, Ph.D.
(University of Oregon)
Professor
Polymers and their properties, including Aerogel composites, structure-property relationships, transport phenomena and packaging materials, condensation polymers, bio-based polymer synthesis, polymer flammability and sustainable FR agents, polymer blends and complex polymer systems.

Peter A. Asseff, Professor of Organic Chemistry Emeritus
Composites, including Aerogel composites, structure-property relationships, transport phenomena and packaging materials, condensation polymers, bio-based polymer synthesis, polymer flammability and sustainable FR agents, polymer blends and complex polymer systems.