Polymer Science and Engineering at CWRU

Department Of Macromolecular Science and Engineering

Kent Hale Smith Building

CASE WESTERN RESERVE UNIVERSITY EST. 1826

think beyond the possible

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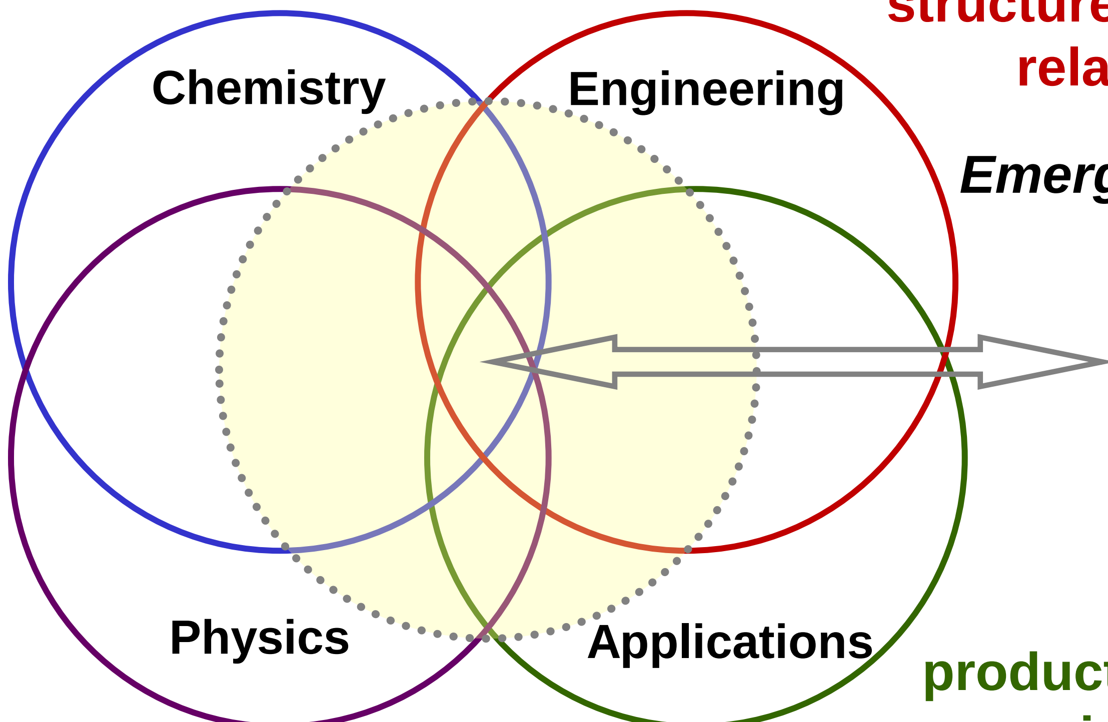
Macromolecular Science & Engineering

Polymer Science and Engineering

molecular design
methodology development
synthesis
characterization

polymer analysis & testing
processing & rheology
structure/property relationships



Emerging areas:

bio
nano
medical
energy

optics
electronics
modeling/theory
characterization

product design
commercialization
entrepreneurship
industry partnerships

Overview

Faculty: 414 Full Time (new hires in 2007, 2008, 2009(2), 2012(2), 2014); 4 Active Emeritus

Active Areas of Research:

Polymer Synthesis, Self-Assembly, Processing & Rheology, Fuel Cells, Optoelectronic Materials, Biomaterials, Simulations, Nanocomposites, Polymer Characterization, Transport Phenomena, Performance Polymers, Failure Mechanics

- First Ph.D. Programs in Polymer Science and Engineering in U.S.
- First ABET-accredited B.S. degree program
- Total BS graduates 295: Currently 81 students
- Total MS Graduates 375 Currently 10 students
- Total PhD graduates 471: Currently 75 students
- Postdocs: 25 currently
- Ranked in Top Polymer Programs in the US for the last 30 years

http://polymers.case.edu

Faculty

Prof. David Schiraldi
Chairman

Prof. Rigoberto Advincula

Prof. Eric Baer

Prof. Liming Dai

Prof. Hatsuo Ishida

Prof. Alex Jamieson

Prof. LaShanda Korley

Prof. Joao Maia

Prof. Ica Manas-Zloczower

Prof. Jon Pokorski

Prof. Stuart Rowan

Prof. Gary Wnek

Prof. Lei Zhu

Arriving July 2014

Prof. Michael Hore

The Undergraduate Program

Mission: To educate and train undergraduate students in the diverse range of Science and Engineering disciplines (and beyond) which will position them to make an impact in the both the Industrial and Academic field of ***Polymer Science and Engineering*** in the US and beyond.

Philosophies:

- **To make an impact in today's polymer community students need to understand a range a fundamental disciplines: Engineering, Chemistry, Physics, Biology**

Undergraduate Degree Tracks
Polymer Science and Engineering: Polymer Engineering Track
Polymer Science and Engineering: Biomaterials Track

- **Research and Hands-on Experience Enhances Classroom Education**

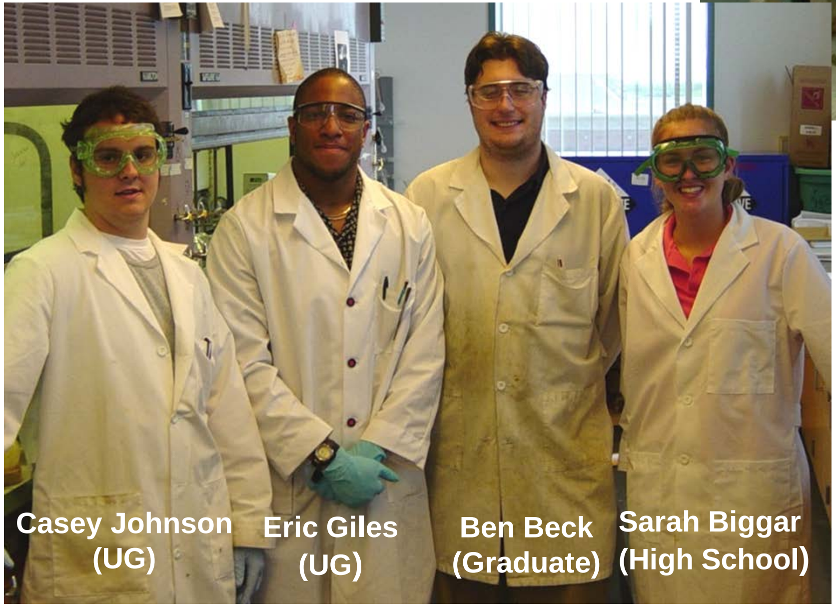
Undergraduate Research Activities
Freshman Research Program (EMAC 125)
Research in Sophomore and Junior Year (EMAC 325)
Senior Project
BS/MS and Coop Programs
NSF and Industry Funded Summer Research Program (20-25 students/year)

Macromolecular Science & Engineering

Undergraduate Research

Summer Research Program

NSF REU and Industry Funded Program (20-25 students/year)

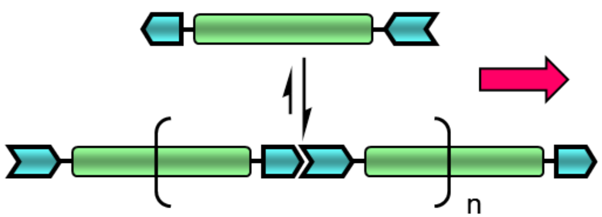


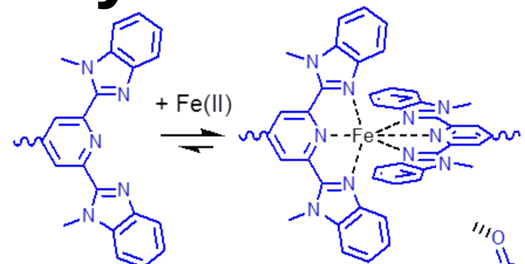
Work in Research Teams

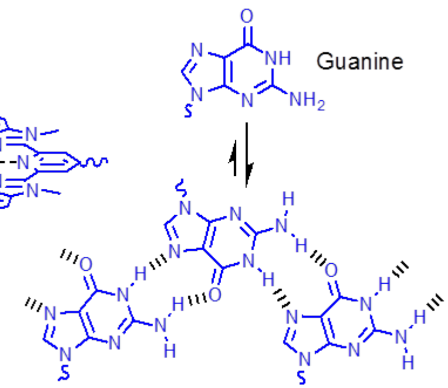
Graduate Student
Senior/Junior Undergraduate
Freshman/Sophomore Undergraduate
High School Student

Macromolecular Science & Engineering

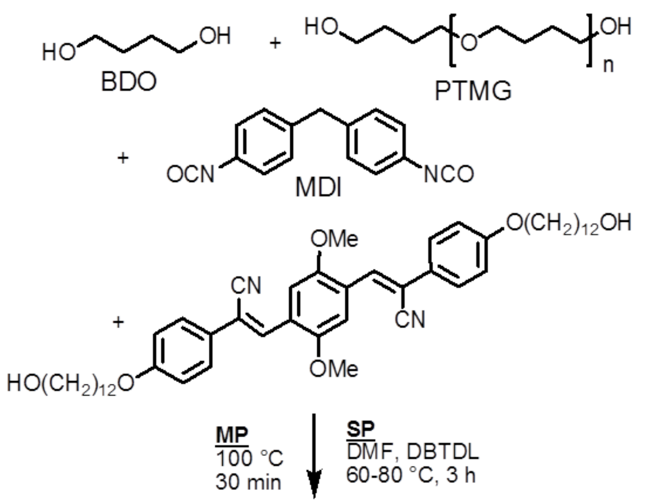
Synthesis





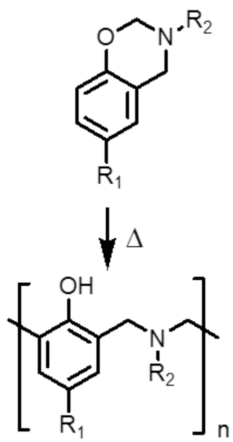


Self-Assembly and Supramolecular Polymerization: The utilization of non-covalent interactions, e.g. hydrogen bonding, metal/ligand coordination, to organize small molecules into polymeric architectures

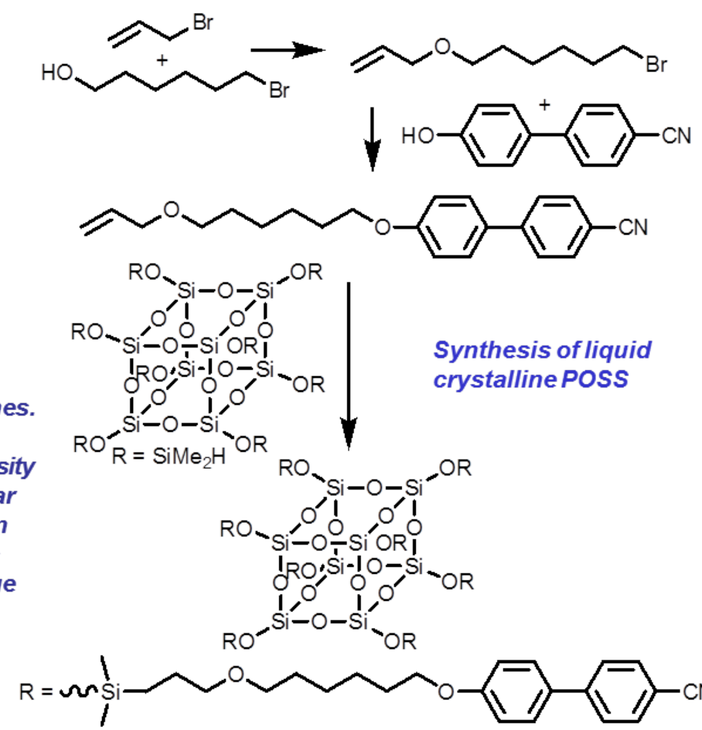


mechano-responsive thermoplatsic polyurethanes

Synthesis of thermoplastic polyurethanes with built-in photoluminescent sensor molecules. These materials are part of a study that explores and exploits a new approach for the design of mechano-responsive polymers



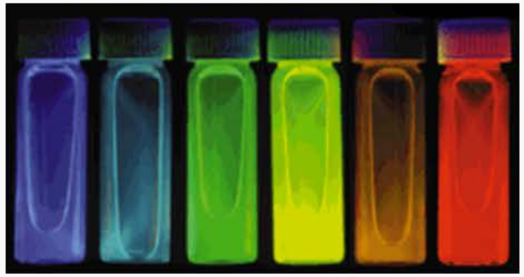
Synthesis of polybenzoxazines. Key attributes of these polymers: low crosslink density but high modulus, high char yield, low water absorption despite many hydrophilic groups, near-zero shrinkage during polymerization

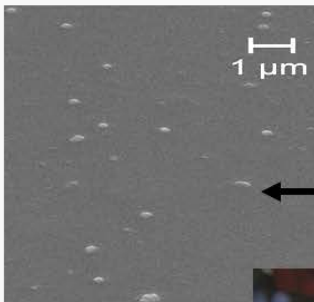


Synthesis of liquid crystalline POSS

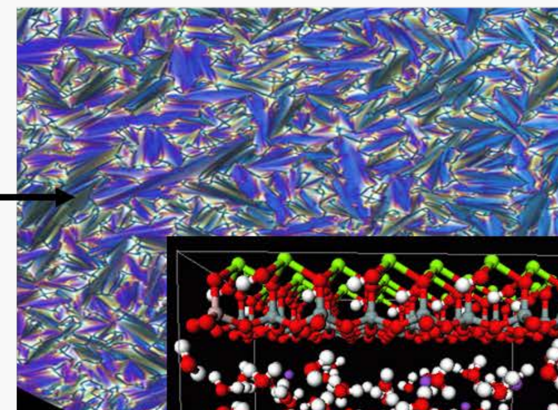
Nanoscience and Technology

10 nm

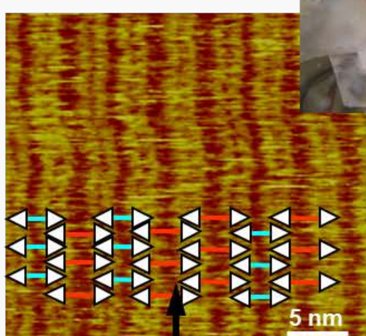




Optical
Nanoparticles

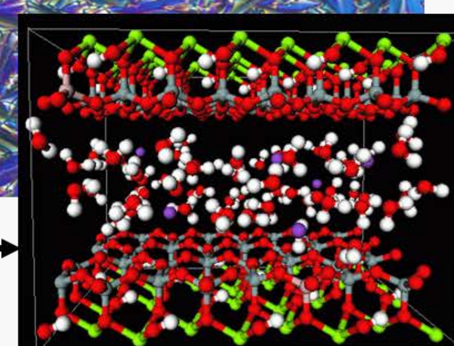


Liquid
Crystalline
Nanomaterials



Electrospun
Nanofibers

Nanoscaffolds by
Self-Assembly



Nano-composites:
Improved Mechanical
Properties

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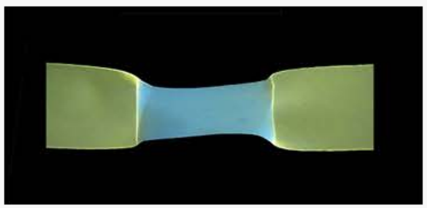
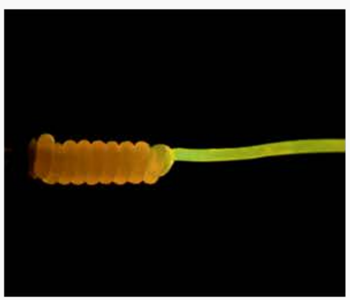
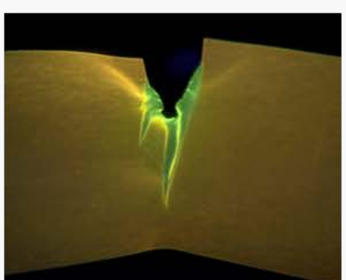
Responsive Polymers

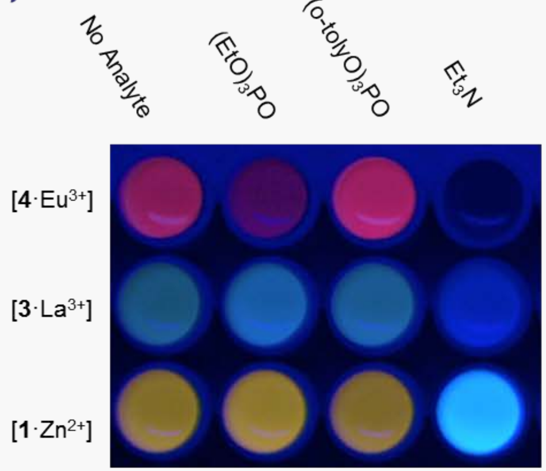
Integrated Failure Indication; Tamper-Evident Packaging







Gas Sensor Materials



Shear Thinning: Thixotropic

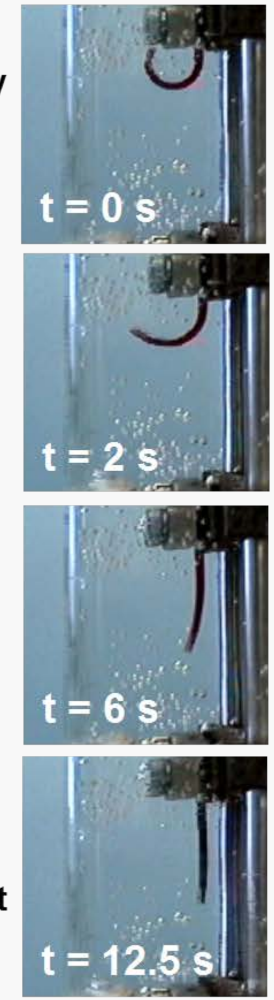
Shape Memory Polymers

Stable Temporary Shape

Heat

↓

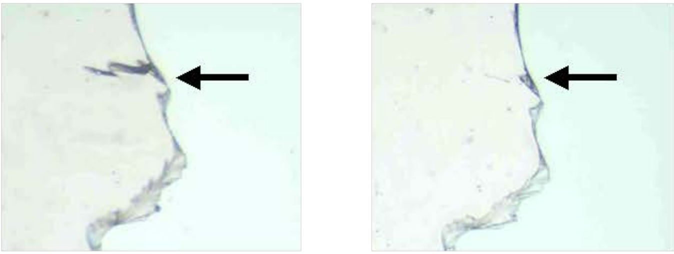
Permanent Shape



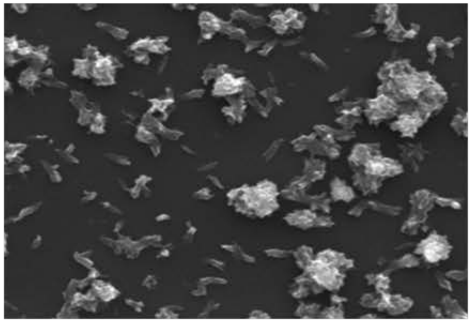
Biomaterials and Biomimetics

Biomimetic Materials (Touch-Responsive Sea Cucumber)

Polymeric Actuators

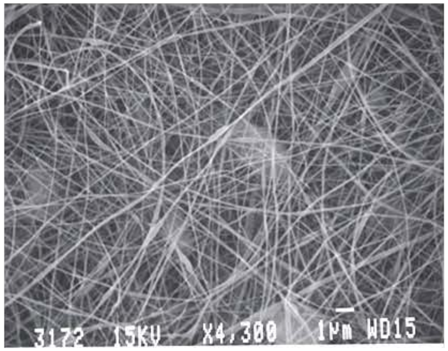


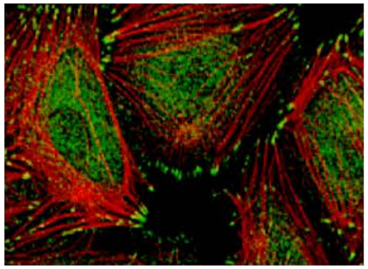
Materials Based on DNA (Next Generation of Tailored Biomaterials with Self-Healing Properties)



Polymers for Biomineralization

Electrospun Scaffolds for Tissue Engineering





New Polymers to Control Cell Adhesion on the Surface of an Implant

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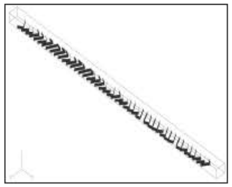
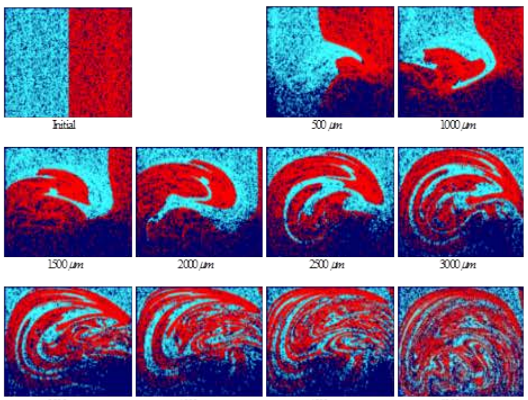
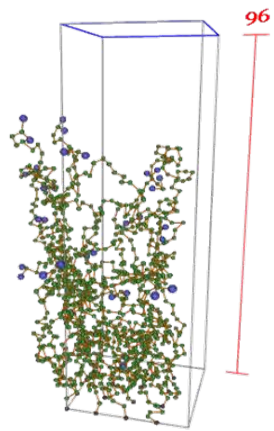
Modeling, Simulation & Processing



Microfluidic device using a fractal patterning for enhanced mixing



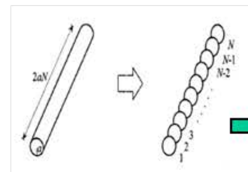
Dynamics of mixing in the channel above as portrayed in ten consecutive cross sections down the channel. 26000 particles were used in the simulation.



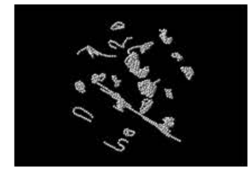
Snapshot of Monte Carlo simulation of polymer brush end-functionalized with divalent ligands interacting with approaching surface decorated with receptor sites.

Multiscale computational simulations of nanocomposites

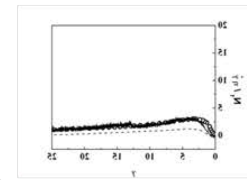
(L/D=20, D=50 nm, ϕ=1%; η_m=1000 Pa.s, =10 s^{-1}, E=6/600 GPa)

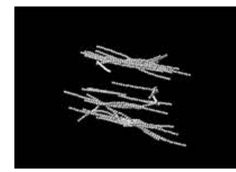


- Intra-fiber interactions
- van der Waals interactions
- Hydrodynamic interactions
- Collision potential

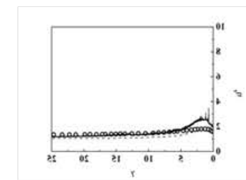


6 GPa
Small flocculation & isolated fibres



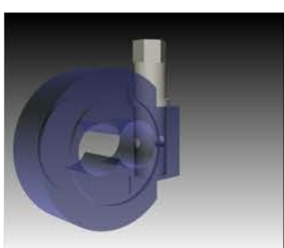


600 GPa
Large flocculation/alignment in the flow direction/percolation

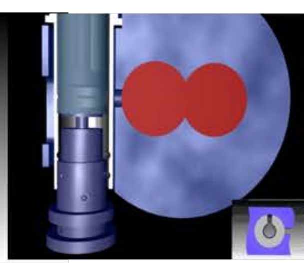


Polymer blending and compounding / On-line monitoring and control of extrusion

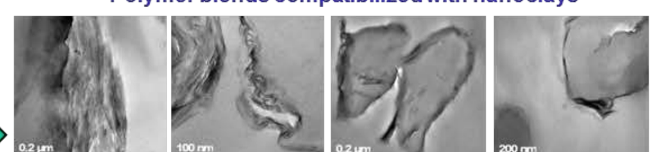
Sampling device

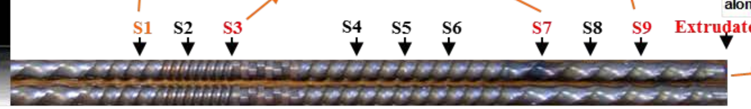


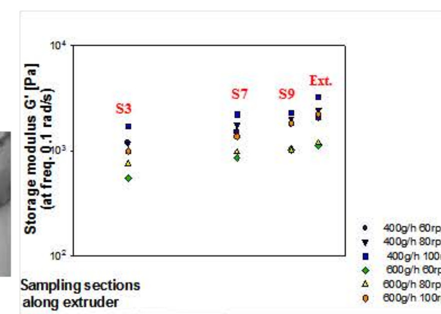
Rotational rheometer



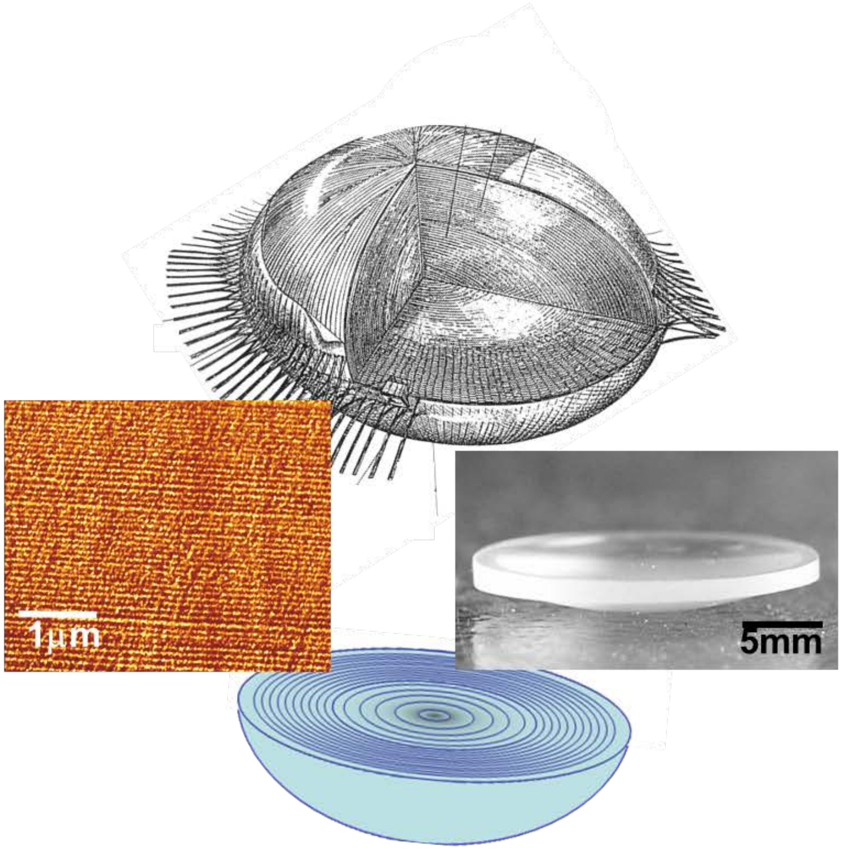
Polymer blends compatibilized with nanoclays



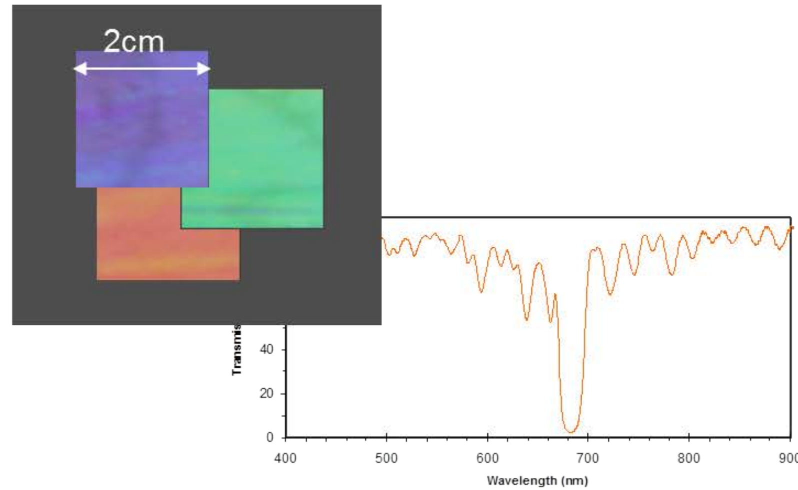




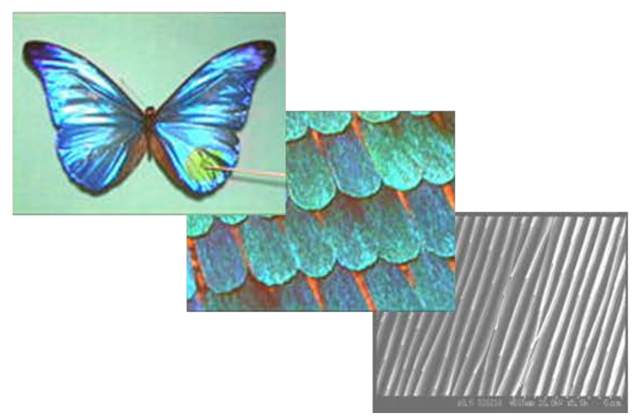
Bioinspiration



A synthetic lens mimics the layered structure and gradient refractive index of the biological lens.



1-Dimensional photonic crystals with narrow reflection bandgap are comprised of may alternating layers of PS and PMMA. They mimic the iridescence of the butterfly wing.



Industry Connections

Extensive Collaboration with Industry

Biopolymers
Materials Development and Design
Mechanical Behavior and Analysis
Physical Characterization
Processing
Rheology
Synthesis

Product Improvement and Enhancement
New Product Development
Technology Commercialization

Partners:
Dow
DuPont
Sumitomo-Bakelite Co. Ltd.
3M
BayerMaterialScience
Toyobo Co Ltd.
Kimberly-Clark Co.
Infoscitex
Philip Morris
Goodyear
Boston Scientific
DuPont-Teijin Films
Seksui Chemicals
Aerovox
Alcan
Layered Technologies
Chevron
INVISTA
Voith Fabrics
Hybrid Plastics
Petrobras

Characterization

The Department is fully equipped with state-of-the-art instruments all aspects of polymer characterization

NMR (solution and solid-state),
X-Ray Diffraction
Mechanical Testing
Thermal Analysis (DSC, TGA, DMTA)
Spectroscopy
GPC
Rheology
Gas Diffusion
Microscopy (Optical, Electron and Atomic Force)
MALDI-MS
Positron Annihilation
Light Scattering
Computer Modeling

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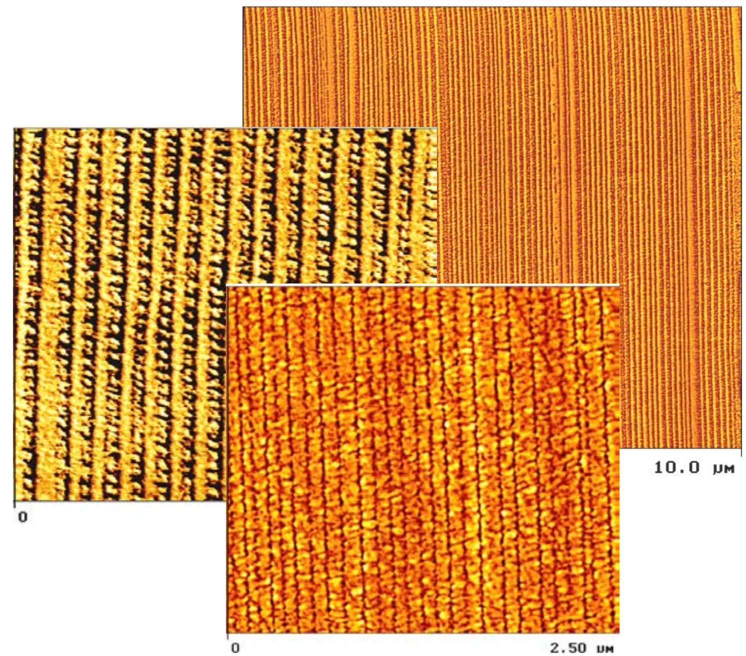
Macromolecular Science & Engineering

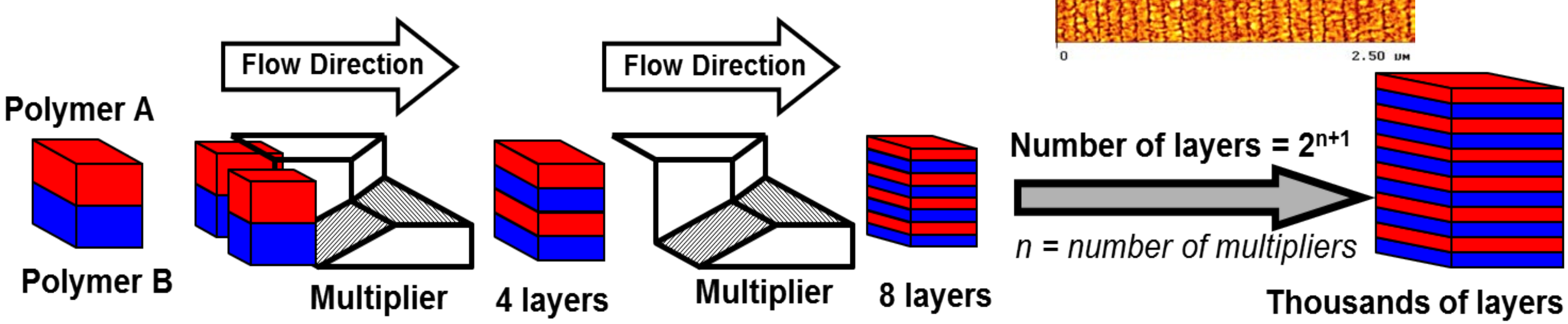
CLiPS

NSF Science and Technology Center for Layered Polymeric Systems

Director: Prof Eric Baer

A multidisciplinary science and education center enabled by a unique microlayer and nanolayer coextrusion technology (forced-assembly)





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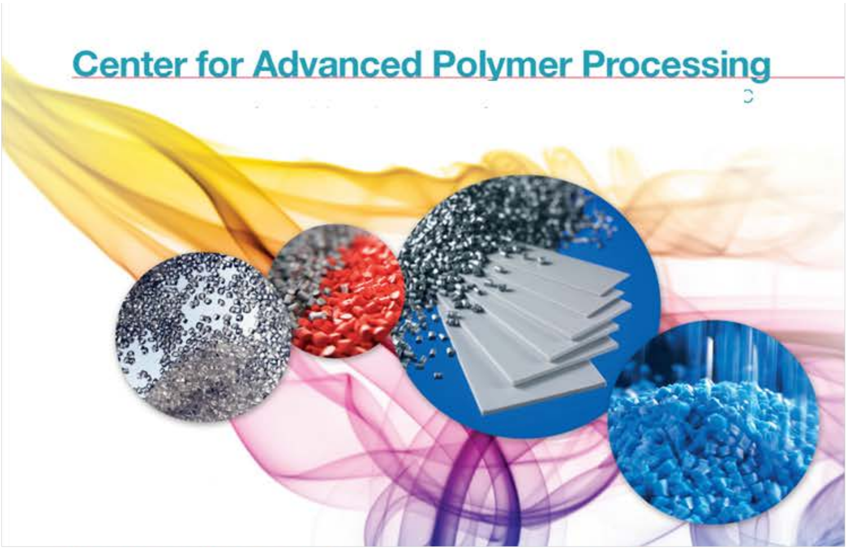
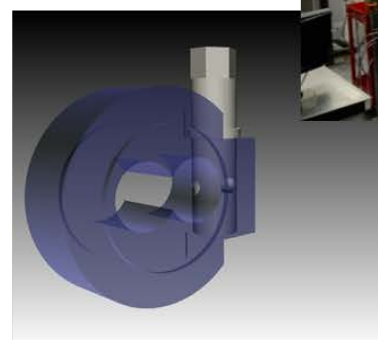
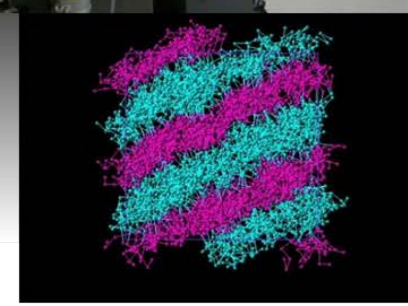


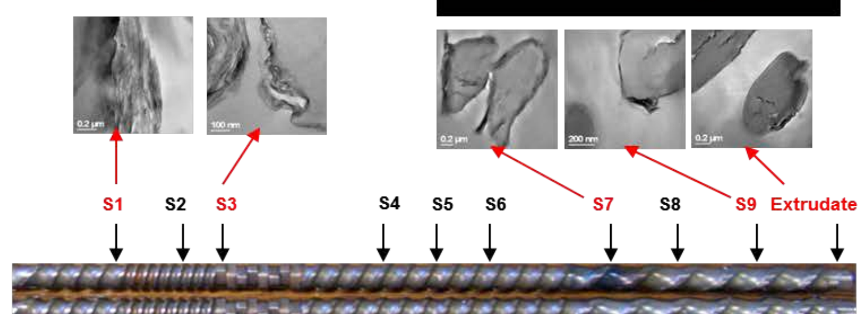
Supporting and promoting excellence in polymeric materials science and engineering

RESEARCH TOOLS

- Develop state-of-the-art *on-line sensors* that allow multiple rheological, physical, chemical and morphological quantities to be measured along the screw axis of twin-screw extruders;
- Combine with *advanced computational multiscale simulation capabilities* to build physical-chemical-structural models of said systems and processes under realistic conditions;
- Implement new R&D *modular co-extrusion and nano-layering line* with single and twin-screw extruders;
- Use these tools in an integrated way to develop *new advanced and functional multiphase complex materials* or optimize the performance of existing ones.







Case Macro
Ready for its next 50 years