Polymer Science and Engineering at CWRU

Department Of Macromolecular Science and Engineering
Kent Hale Smith Building
Overview

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

Active Areas of Research:


- 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

Prof. Michael Hore

Arriving
July 2014
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)
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

Casey Johnson (UG)
Eric Giles (UG)
Ben Beck (Graduate)
Sarah Biggar (High School)
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.

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.
Responsive Polymers

Integrated Failure Indication; Tamper-Evident Packaging

Gas Sensor Materials
- [4·Eu^{3+}]
- [3·La^{3+}]
- [1·Zn^{2+}]

Shape Memory Polymers
Stable Temporary Shape

Shear Thinning: Thixotropic

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
Modeling, Simulation & Processing

Multiscale computational simulations of nanocomposites

- 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

Dynamics of mixing in the channel above as portrayed in ten consecutive cross sections down the channel. 2000 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.

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

Sampling device Rotational rheometer

Polymer blends compatibilized with nanoclays

Sampling sections along extruder

- 0.2 μm
- 2.0 μm
- 200 nm
- 0.2 μm
- 200 nm

Extrude
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
Bayer Material Science
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
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)

Number of layers = 2^{n+1}

n = number of multipliers

Thousands of layers
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