Message from the Director

Thermodynamics is a cornerstone of the chemical sciences and chemical engineering. The modern production of chemicals, pharmaceuticals, and fuels relies on the understanding and prediction of the thermophysical properties of chemical species and mixtures that govern phase equilibria, separations, yields and selectivities in chemical processes.

Today, thermodynamics also provides the principal framework for soft matter engineering, including structured and complex fluids, bio-inspired materials and materials formed by self-assembly. The applications of soft materials are ubiquitous, spanning consumer products to agrochemicals, but they are also at the heart of emerging frontiers in biotechnology, energy and nanotechnology. To serve these needs, the Center for Molecular and Engineering Thermodynamics (CMET) serves as a focal point for research in thermodynamics and its broad scientific and engineering applications.

I am pleased to present this report, which describes the research and education activities of CMET over the past year. During this period, CMET expanded through the addition of five new faculty members from the departments of Materials Science and Engineering and Chemical Engineering. They are Kristi Kiick, Darrin Pochan, Michael Mackay, Thomas Epps and Christopher Roberts. Their research and expertise, detailed in the pages that follow, reflect the growing breadth and impact of CMET. The Center also welcomed a new Administrative Assistant, Cinda Younce.

CMET represents an internationally recognized community of talented faculty, students and postdocs at Delaware with unique expertise and resources. This report will give you a sense of the breadth of cutting edge research initiatives, discoveries, inventions, and innovations in the center. We welcome you to join us, whether it’s as a collaborator, student or research sponsor.

Eric M. Furst
Director, CMET
The Center for Molecular & Engineering Thermodynamics

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Content Manager: Cinda Younce
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Electric field assembly of colloidal crystals viewed through cross-polarizers.
Sponsoring CMET

CMET welcomes industrially supported grant and contract research, collaborative projects with industrial scientists and engineers, and industrial sabbaticals and exchanges of research personnel. Sponsored CMET projects have access to state of the art facilities, including many novel experiments, unique equipment and computational resources, as well as the complementary expertise of the CMET faculty and researchers.

Sponsored research enhances the education of our students and enables you to build relationships with talented engineers and scientists in training. Other benefits include:

- Rapid access to research discoveries.
- Expertise and resources to understand and solve short, medium and long-term research and development challenges.

Several levels of commitment are available, depending on your organization’s current and future needs.

OPEN INNOVATION: Research focused on emerging areas or underlying engineering science. Research projects are typically a 3-4 year commitment that support graduate research in the center, contributions to the science and engineering literature and the development of intellectual property.

SHORT TERM GRANT: A 1-2 year project with support for a postdoctoral researcher and faculty participation. Such projects are in-depth, often to understand underlying fundamental phenomena in an engineering problem or study the feasibility of a novel concept, and may include the development of new experiments or experimental techniques.

FACULTY ENGAGEMENT: CMET can facilitate connections with faculty experts to arrange off-campus visits. CMET will also coordinate visits to the University of Delaware campus to discuss topics jointly with several faculty, enabling immediate access to multiple perspectives and expertise.

CONTRACT RESEARCH: Suitable for short-term characterization and analysis using the research resources of the CMET faculty. The project scope is limited.

CENTER AFFILIATES: Annual CMET contributions and gifts-in-kind, typically $10,000 or more to the Center or contributions to individual faculty totaling $25,000 or more, are used to support the general research and teaching missions, including graduate research, student participation at national and international research conferences, seed grants for exploratory research, new equipment purchases and equipment maintenance and upgrades.

CMET will coordinate collaborative research, visiting scientist and material transfer agreements with conguizant University offices.
Douglas J. Doren

RESEARCH INTERESTS
Theoretical and computational exploration of new chemical reactions for semiconductors, photocatalysis, selective oxidation and polymerization reactions, and first-principles calculations of solvation energies

RECENT AWARDS, HONORS, AND ACCOMPLISHMENTS
• Chair, Search Committee, Chaired Professorship in Energy (2009–2010)
• R&D Task Force, Delaware Health Sciences Alliance (2008–present)
• Steering Committee, Delaware Valley Institute for Clinical and Translational Science (2008–present)
• Organizer, Nobel Prize Symposium (2007–present)
• Associate Director, Center for Catalytic Science and Technology (1996–present)

RECENT PUBLICATIONS
• W. Liu, R.H. Wood, D.J. Doren, “Sodium Chloride in Supercritical Water as a Function of Density: Potentials of Mean Force and an Equation for the Dissociation Constant from 723 to 1073 K and from 0 to 0.9 g/cm3,” J. Phys. Chem. B. 112, 7289 (2008).

• Associate Dean for Research, College of Arts & Sciences
• Interim Associate Dean for the Natural Sciences, College of Arts & Sciences
• Professor of Chemistry and Biochemistry

EDUCATION
• Ph.D.–Harvard University (1986)
• AM–Harvard University (1981)
• BS–University of California, Berkeley (1979)

CONTACT
P: (302) 831–2793
E: doren@udel.edu
www.udel.edu/doren
Thomas H. Epps, III

RESEARCH INTERESTS
Self-assembling polymers, nanostructured materials, fuel cell and battery membranes, nanotemplates, and solution-assembling materials for drug delivery

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
- Presidential Early Career Award for Scientists & Engineers–Department of Defense, 2009
- Air Force Young Investigator Award, 2009
- College of Engineering Outstanding Junior Faculty, University of Delaware, 2009
- Invited Lecturer “Manipulating Ordering in Block Copolymer Systems Using Interface Modifications”, Gordon Research Conference (GRC), Polymers East, South Hadley, MA, June 2009
- Invited Panelist - ACCESS Alumni Panel Massachusetts Institute of Technology (MIT) (Chemical Engineering), Cambridge, MA, October 24, 2009
- National Science Foundation (NSF) CAREER Award, 2007

RECENT PUBLICATIONS

Assistant Professor of Chemical Engineering

EDUCATION
- MS–Massachusetts Institute of Technology (1999)
- BS–Massachusetts Institute of Technology (1998)

CONTACT
P: (302) 831-0215
E: thepps@udel.edu
www.che.udel.edu/research_groups/epps
Eric M. Furst

RESEARCH INTERESTS
Colloids and polymers, microrheology, interfacial phenomena, directed assembly of nanomaterials, electrokinetics

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
• European Union Erasmus Mundus Scholar, 2009
• Society of Rheology Publications Award, 2008
• Outstanding Junior Faculty Member for the College of Engineering, 2007
• Keynote Lecture “Microrheology and rapid screening of therapeutic hydrogelators,” Joint meeting of the Belgian Group of Rheology and Dutch Rheological Society, Rotterdam, The Netherlands, April 2009
• Keynote Lecture “Microrheology of hydrogelation and its application to high-throughput screening,” EU SoftComp Annual Meeting, Venice, Italy, May 2009

RECENT PUBLICATIONS
Kristi L. Kiick

RESEARCH INTERESTS
Polymer chemistry; biomaterials; biopolymers, hydrogels, drug delivery

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
• Etter Memorial Lectureship in Chemistry, 2010
• ACS POLY Division Program Chair, 2009–2011
• 2008 NIH Advisory Workshop: Multivalency

RECENT PUBLICATIONS
Abraham M. Lenhoff

RESEARCH INTERESTS
Separations processes, protein biophysics and bioengineering, colloid and interface science, transport phenomena

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
• American Chemical Society Award in Separations Science and Technology, 2009
• Alan S. Michaels Award for the Recovery of Biological Products, 2009
• College of Engineering Excellence in Teaching Award, University of Delaware, 2009

RECENT PUBLICATIONS
Michael E. Mackay

RESEARCH INTERESTS
Nanoparticle dispersion and segregation, rheology, organic photovoltaics, polymer physics

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
- Invited Lecturer “Polymer and Nanoparticle Self-Assembly,” Ventura Gordon Conference, 2009
- AIChE Session Organizer in Novel Flows, 2007
- ACS Session Organizer in Polymeric Nanoparticles and Nanostructures, 2007
- Society of Rheology Publication Award, 2001

RECENT PUBLICATIONS
Darrin J. Pochan

RESEARCH INTERESTS
Polymer physics, self-assembly, biopolymers, peptides, hydrogels, block copolymers, inorganic/organic hybrid materials

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
• Associate Editor for North America, Soft Matter
• American Physical Society Program Chair, Division of Polymer Physics, American Physical Society national meeting, 2011, Dallas, TX
• Materials Research Society Spring 2010 meeting co-chair, 2010
• John H. Dillon medal, Division of Polymer Physics, American Physical Society, 2007
• College of Engineering Outstanding Young Faculty Award, University of Delaware, 2006
• Keynote Lecture, Polymeric and Self-Assembling Hydrogels: From Fundamental Understanding to Applications in Biology and Medicine, Manchester, United Kingdom, September, 2009

RECENT PUBLICATIONS
Christopher J. Roberts

RESEARCH INTERESTS
Protein biophysics and biotechnology; biopharmaceutical stability; statistical mechanics and thermodynamics; molecular modeling

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS

• Nominated for University Excellence-in-Teaching Award, University of Delaware, 2009
• Top Reviewer Award (one of 24), J. Pharm. Sci., 2008
• College of Engineering Excellence in Teaching Award, University of Delaware, 2008
• AAPS New Investigator Grant in Pharmaceutics and Pharmaceutical Technologies, 2005

RECENT PUBLICATIONS

Stanley I. Sandler

RESEARCH INTERESTS
Thermophysical properties and phase equilibria, basic theory, experimental measurements, and supercomputer simulation

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
- Honorary Professorial Fellow, University of Melbourne (Australia), 2004-2009
- ExxonMobil Professor, National University of Singapore, 2006-2009
- Fellow, Institute of Chemical Engineers (Britain), 2004
- Founders Award, American Institute of Chemical Engineers, 2004

RECENT PUBLICATIONS

EDUCATION
- Ph.D.–University of Minnesota (1966)
- BS–City College of New York (1962)

CONTACT
P: (302) 831-2945
E: sandler@udel.edu
www.che.udel.edu/sandler
Krzysztof Szalewicz

RESEARCH INTERESTS
Theory of intermolecular forces, simulations of condensed phases, spectroscopy of van der Waals molecules, explicitly-correlated methods of molecular structure calculations

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
- College of Arts & Sciences Outstanding Scholar Award, 2004

RECENT PUBLICATIONS

EDUCATION
- D.Sc.–University of Warsaw (1984)
- Ph.D.–University of Warsaw (1977)
- MS–University of Warsaw (1973)

CONTACT
P: (302) 831-6579
E: szalewic@udel.edu
www.physics.udel.edu/~szalewic
Norman J. Wagner

RESEARCH INTERESTS
Nanoscience and nanotechnology, colloid, polymer & surfactant science, complex fluids, rheology, nonequilibrium thermodynamics, directed self-assembly, transport phenomena, molecular simulation and multiscale modeling

RECENT AWARDS, HONORS AND ACCOMPLISHMENTS
• Executive Committee, Neutron Scattering Society of America, 2009 – present
• Executive Committee, Society of Rheology, 10/07-present
• Chair, Department of Chemical Engineering, 7/07-present
• 2005 American Chemical Society Delaware Section Award, January 2006

RECENT PUBLICATIONS
Optical trapping and confocal microscopy in the Furst laboratory.
CMET Degrees Awarded

Recent CMET alumni have taken positions in industry, national laboratories, and academia. Below is a list of alumni who graduated in 2009, their advisor while they were at UD, and their current employer.

**MS**

- **Kate Hollabaugh**
  - **MS | Wagner**
  - **Dow Chemical**

- **Elizabeth Minich**
  - **MS | Pochan**
  - **Icon Clinical Research**

- **Frances Spinelli**
  - **MS | Furst**
  - **Millenium Pharmaceuticals**

**PhD**

- **Monica Branco**
  - **PhD | Wagner**
  - **National Institutes of Health**

- **Manoj Charati**
  - **PhD | Kiick**
  - **Post-doctoral Researcher, University of Pennsylvania**

- **Honggang Cui**
  - **PhD | Pochan**
  - **Post-doctoral Researcher, Northwestern University**

- **Kelly Hales**
  - **PhD | Pochan**
  - **Avon Central Research & Development**

- **Matt Helgeson**
  - **PhD | Wagner**
  - **Post-doctoral researcher, Massachusetts Institute of Technology**

- **Ji Yeon Huh**
  - **PhD | Furst**
  - **Post-doctoral Researcher, NIST**

- **Rohan Hule**
  - **PhD | Pochan**
  - **Post-doctoral Researcher, California Institute of Technology**

- **Ann Kim**
  - **PhD | Kiick**
  - **Post-doctoral Researcher, Univ. of Calif. Los Angeles**

- **Vahik Krikorian**
  - **PhD | Pochan**
  - **Post-doctoral Researcher, MIT**

- **Matthew Lamm**
  - **PhD | Pochan**
  - **Merck Central Research & Development**

- **Travis Larson**
  - **PhD | Furst**
  - **Dow Chemical**
Directed self-assembly of colloidal dicolloids.
# PHD Candidates

In 2009, 65 graduate students in the center were pursuing advanced degrees in Chemical Engineering, Materials Science and Engineering, Physics and Chemistry. Below is a list of 2009 students, their advisor, and project title.

<table>
<thead>
<tr>
<th>Name</th>
<th>Advisor</th>
<th>Project Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Julie Albert</td>
<td>Epps</td>
<td>Self-assembled block copolymer thin films</td>
</tr>
<tr>
<td>Aysegul Altunbas</td>
<td>Pochan</td>
<td>Peptide hydrogels as tissue regeneration and drug delivery scaffolds</td>
</tr>
<tr>
<td>Chisom Amaechi</td>
<td>Epps</td>
<td>Nanoparticle behavior in polymer blends for organic photovoltaics applications</td>
</tr>
<tr>
<td>Aaron Baldwin</td>
<td>Kiick</td>
<td>PEG-Heparin hydrogels</td>
</tr>
<tr>
<td>Peter Beltramo</td>
<td>Furst</td>
<td>Polarization of nanoparticles electric fields during directed self-assembly</td>
</tr>
<tr>
<td>Nandita Bhagwat</td>
<td>Kiick</td>
<td>Peptide-scaffolding of electroactive groups</td>
</tr>
<tr>
<td>Marco Blanco</td>
<td>Roberts</td>
<td>Molecular modeling of Protein folding and aggregation</td>
</tr>
<tr>
<td>Brian Bowes</td>
<td>Lenhoff</td>
<td>Protein transport and adsorption in polymer-modified ion-exchange media</td>
</tr>
<tr>
<td>Rebecca Brummitt</td>
<td>Roberts</td>
<td>Mechanisms and predictive approaches to antibody aggregation</td>
</tr>
<tr>
<td>Yingchao Chen</td>
<td>Pochan</td>
<td>Charged block copolymer self-assembly</td>
</tr>
<tr>
<td>Christopher Gillespie</td>
<td>Lenhoff</td>
<td>Protein interactions in solutions</td>
</tr>
<tr>
<td>Mingxing Gong</td>
<td>Doren</td>
<td>Electronic properties of organic molecules on semiconductor surfaces</td>
</tr>
<tr>
<td>Na Guo</td>
<td>Doren</td>
<td>Silicon surface chemistry and catalysis for biofuel production</td>
</tr>
<tr>
<td>Brett Guralnick</td>
<td>Mackay</td>
<td>Hybrid organic-inorganic solar cells</td>
</tr>
<tr>
<td>Dennis Kalman</td>
<td>Wagner</td>
<td>Structure and rheology of shear thickening fluids</td>
</tr>
<tr>
<td>Kelley Kearns</td>
<td>Lenhoff</td>
<td>Membrane Protein Purification and Crystallization and Characterization of Protein-Detergent Complexes</td>
</tr>
<tr>
<td>Urzula Gora</td>
<td>Szalewicz</td>
<td>Three-body potential for water</td>
</tr>
<tr>
<td>Sarah Grieshaber</td>
<td>Kiick</td>
<td>Peptide-polymer block copolymers</td>
</tr>
</tbody>
</table>
PHD CANDIDATES

Jai Kelkar
Epps
Targeted drug delivery and biopolymers and bioresponsive polymeric vesicles for drug delivery

Elizabeth Kelley
Epps
Use of novel biomaterials for targeted drug delivery and bioresponsive polymeric vesicles

Don Kessler
Wagner
Field responsive materials using shear thickening fluid composites

Jon Kiel
Mackay
Self assembly for photovoltaic devices

Jung Min Kim
Wagner
Microstructure and rheology of colloidal and nanoparticle gels and glasses

Harun Koku
Lenhoff
Analysis of Transport in Ion-Exchange Media

Ohm-Divyam
Krishna
Kiick
Collagen-containing assembled materials

Wei-Fan Kuan
Epps
Nanoporous network and their applications in alternative energy

Pushkar Lele
Furst
Directed self-assembly in electrical and optical fields

Eric Levenson
Kiick
Immunology of multivalent oligonucleotide-modified polymers

Rachael Lewus
Lenhoff
Interactions and phase behavior of monoclonal antibodies

Linqing Li
Kiick
Hydrophilic elastomeric polypeptide hydrogels

Shuang Liu
Kiick
Multivalent glycopolymers

Particle hydrodynamic interactions near solid interfaces are studied using holographic optical tweezers.
Sarah Mastroianni
Epps
Nanostructured photovoltaic materials using conjugated block copolymer assemblies

Ronald Maurer
Roberts
Rational strategies for aggregate dissociation and refolding

Michael Mayeda
Epps
Nanoporous network polymers functionalized with catalytic particles to convert ammonia to hydrogen and nitrogen gas for a potential hydrogen economy

Chris McGann
Kiick
Polypeptide-heparin elastomeric hydrogels

Jason McMullan
Wagner
Directed self-assembly of two-dimensional colloidal arrays

Manish Mittal
Furst
Interactions of colloids in AC electric fields

Mark Panczyk
Wagner & Furst
Directed assembly of anisotropic particles in AC electric fields; Assembly of anisotropic particles in electric fields

Bum Jun Park
Furst
Colloidal interactions and mechanics at the oil-water interface

Leigh Quang
Lenhoff
Thermodynamic Modeling of Protein Phase Behavior

Obaidur Rahaman
Doren
Models of proteins and metal ions for simulations of binding energies

Fazle Rob
Szalewicz
Linear-scaling dispersion energy

Christina Russo
Epps
Targeted drug release and the use of surfactants in pharmaceutical applications

Anvar Samadzoda
Lenhoff
Characterizing interactions between surfactants and membrane proteins, with special emphasis on protein-detergent complexes of GPCRs

Sameer Sathaye
Pochan
Peptide hybrid materials
<table>
<thead>
<tr>
<th>Name</th>
<th>Advisor(s)</th>
<th>Research Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heather Schmidt</td>
<td>Doren</td>
<td>Materials for solar fuel production</td>
</tr>
<tr>
<td>Kelly Schultz</td>
<td>Furst</td>
<td>High throughput microrheology of biomaterial hydrogelators</td>
</tr>
<tr>
<td>Jon Seppala</td>
<td>Mackay</td>
<td>Influence of nanoparticles on polymer properties</td>
</tr>
<tr>
<td>Mikhil Sharma</td>
<td>Pochan</td>
<td>Nanoparticle-soft matter hybrid materials</td>
</tr>
<tr>
<td>Hao Shen</td>
<td>Mackay</td>
<td>Multilayer thin films of polymers and nanoparticles for application in solar cells</td>
</tr>
<tr>
<td>Indira Sriram</td>
<td>Furst</td>
<td>Active and non-linear microrheology</td>
</tr>
<tr>
<td>Carrie Street</td>
<td>Wagner</td>
<td>Microstructure and rheology of crystallized surfactant solutions</td>
</tr>
<tr>
<td>Ayben Top</td>
<td>Kiick</td>
<td>Polypeptide conjugation and assembly</td>
</tr>
<tr>
<td>Steven Traylor</td>
<td>Lenhoff</td>
<td>Chromatographic Separation of Proteins</td>
</tr>
<tr>
<td>Erica Tseng</td>
<td>Mackay</td>
<td>Rough coatings for photovoltaic devices</td>
</tr>
<tr>
<td>Maeva Turreau</td>
<td>Epps</td>
<td>Creating a nanoporous capture device using block copolymer network templates that will capture and concentrate metabolites to help in the analysis of downstream rivers</td>
</tr>
<tr>
<td>Jeong Jae Wie</td>
<td>Wagner &amp; Mackay</td>
<td>Non-Einstein phenomenon in polymer nanocomposites</td>
</tr>
<tr>
<td>Charles Woods</td>
<td>Roberts</td>
<td>Multi-scale modeling of colloidal phase behavior</td>
</tr>
<tr>
<td>Conqi Yan</td>
<td>Pochan</td>
<td>Peptide hydrogel nanostructure and flow properties</td>
</tr>
<tr>
<td>Na Young Kim</td>
<td>Roberts</td>
<td>Structure and mechanisms of protein aggregation and phase behavior</td>
</tr>
<tr>
<td>Wen-Shiue Young</td>
<td>Epps</td>
<td>Multi-component block copolymer network structures and applying them to energy storage systems</td>
</tr>
<tr>
<td>Wenluan Zhang</td>
<td>Mackay</td>
<td>Organic-inorganic solar cells based on silicon</td>
</tr>
<tr>
<td>Sheng Zhong</td>
<td>Pochan</td>
<td>Charged block copolymer self-assembly</td>
</tr>
<tr>
<td>Jiahua Zhu</td>
<td>Pochan</td>
<td>Charged block copolymer self-assembly</td>
</tr>
<tr>
<td>Adil Zuber</td>
<td>Furst</td>
<td>Non-linear microrheology</td>
</tr>
</tbody>
</table>
Postdoctoral Researchers and Fellows

Postdoctoral Researchers and Fellows, working closely with their faculty advisors, are an integral part of the research teams of the Center. Below is a list of the 2009 Postdoctoral Researchers and Fellows, their advisor, and project title.

- **Wojciech Cencek Szalewicz**
  - Advisor: Wagner
  - Project: Ultra-accurate calculations for He2 linearly scaling TD-DFT

- **Rich Dombrowski Wagner**
  - Project: Engineered crystal products

- **Aaron Eberle Wagner**
  - Project: Structure and rheology of thermoreversible sticky spheres

- **Katie Garber Kiick**
  - Project: Multivalent scaffolds

- **Anna Greene Kiick**
  - Project: Peptide-modified polymeric delivery vehicles

- **Alexander Grunberger Roberts**
  - Project: Investigating thin films of nanoparticle-laden block copolymer composties and their self assembly

- **Jennifer Kelly Epps**
  - Project: Investigating thin films of nanoparticle-laden block copolymer composties and their self assembly

Ballistic performance of shear-thickening fluid (STF) impregnated fabric.
Basavaraja Madivala
Wagner
Structure and rheology of suspensions of vesicles and anisotropic articles

Atsushi Mahara
Kiick
Senior Scientist, National Cardiovascular Research Institute, Osaka, Japan

Armin Opitz
Wagner
Antisense nanoparticles for MRI imaging of oncogene expression

Jong Keun Park
Epps
Conducting polymers for lithium battery and photovoltaic applications

Konrad Patkowski
Szalewicz
Potential for Ar2 third-order induction energy with response effects

Rafal Podeszwa
Szalewicz
Dispersionless density-functional theory

Venkat Pradmanabhan
Mackay
DFT calculations of nanoparticles in thin polymer films and in the bulk

Raghunath Roy
Epps
Collaborative block copolymer based drug delivery project

Erinc Sahin
Roberts
Engineering protein aggregation resistance; aggregation of biopharmaceuticals

Tom Smart
Epps
Block copolymers in solution

Prachi Thereja
Wagner
Rheology and microstructure of surfactant solutions

Kathleen Zetune
Wagner
Puncture resistant textiles and composites
Research Grants

DuPont Young Professor Award
DuPont Company (6/03–5/11)
K. L. Kiick

Development of Flexible Extremities Protection Utilizing Shear Thickening Fluid/Fabric Composites
Army Research Office (7/04–6/09)
N. J. Wagner, G. Gillespie

Nanoscale Engineering and Manufacture Effected through Molecular Architecture and Structure
National Science Foundation—NIRT (2005–2010)
M. E. Mackay, D. Tomanek, C. Hawker, K. Wooley

Advanced Biomaterials via Peptide Self-Assembly
National Institutes of Health (1/05–1/10)
D. J. Pochan

COBRE: Membrane Protein Production and Characterization
National Institutes of Health (6/05–5/10)
A. M. Lenhoff

Nanoscale Directed Self-Assembly in Electrical and Optical Fields
National Science Foundation (8/05–7/09)
N. J. Wagner, E. Kaler, E. Furst, Velev, Brady

Collaborative Research: The Thermodynamics of Protein separations
National Science Foundation (9/05–8/10)
A. M. Lenhoff

Effect of Nanoparticles on the Flow Properties of Polymers
BASF—Germany (2006–2010)
M. E. Mackay

Materials World Network: Heating Polymers: The Self Assembly Approach
National Science Foundation (2006–2010)
S. Rowan, M. E. Mackay

Aggregation of Protein Therapeutics: Mechanisms, Stability, and Interdiction
National Institutes of Health Biotechnology Research Partnership (9/06–8/11)

High-Precision Calculations of Density and Dielectric Viral Coefficients for Helium for New Pressure and Temperature Standards
National Institute of Standards and Technology (10/06–9/09)
K. Szalewicz
RESEARCH GRANTS

InSPACE-2: Structural and Rheological Transitions of Field-Responsive Fluids in Microgravity  
**NASA (1/07–1/10)**  
E. M. Furst

Optical Trapping for Directed Self-Assembly  
**Sandia National Laboratories (3/07–2/10)**  
E. M. Furst

Controlling Block Copolymer Interactions Using Tapering Between Blocks to Stabilize Networks  
**National Science Foundation Career Award (3/07–2/12)**  
T. H. Epps

 Templating Ion-Conducting Network Membranes Using Tapered Block Copolymers  
**American Chemical Society Petroleum Research Fund (9/07–8/09)**  
T. H. Epps

Collaborative Research: Active and Non-Linear Microheology  
**National Science Foundation (9/07–8/10)**  
E. M. Furst, T. Squires

Microstructure in Gelling Systems  
**International Fine Particles Research Institute (IFPRI) (9/07–8/10)**  
E. M. Furst, M. Solomon

Center for Neutron Science  
**National Institute of Standards and Technology (9/07–8/12)**  
N. J. Wagner

Small Angle Neutron Scattering on Polymers and Complex Fluids  
**Department of Commerce SANS (9/07–8/12)**  

Neutron Science at the University of Delaware and National Institute of Standards and Technology  
**Department of Commerce (10/07–9/12)**  
D. J. Pochan

Nanoparticles Stabilize Thin Polymer Films: A Fundamental Study to Understand the Phenomenon  
M. E. Mackay

Controlled Release of Low Molecular Weight Heparin for Anticoagulation Therapy  
**Nemours Foundation (1/08–12/09)**  
K. L. Kiick

Molecular Design of Responsive Biomaterials (COBRE)  
**National Institutes of Health (4/08–3/13)**  
Development of Density Functional Theory for Intermolecular Interactions

**Department of Defense (ARL) (5/08–7/09)**

K. Szalewicz

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Indirect Reinforcement of Nanocomposites

**Army Research Office (2009–2012)**

M. E. Mackay

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REU: Undergraduate Research in Energy and Sustainability Engineering

**National Science Foundation REU (6/08–5/11)**

T. H. Epps, J. Lauterbach

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Fundamental Understanding of Weld-Line Formation

**Dow Chemical (2009–2010)**

A. Beris, N. J. Wagner, M. E. Mackay

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Photophysical Studies of Conjugated Chromophores on Peptide Templates

**National Science Foundation (6/08–5/11)**

K. L. Kiick, L. Rothberg

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Ion-Conducting Network Membranes Using Tapered Block Copolymers


T. H. Epps

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Two-Dimensional Combinatorial Methods for Polymeric Film Coatings

**National Institute of Standards and Technology (9/08–8/10)**

T. H. Epps

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Theoretical Studies of Intermolecular Forces

**National Science Foundation (3/09–2/12)**

K. Szalewicz

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Protein Adsorption and Transport in Chromatographic Bioprocessing

**National Science Foundation (9/08–11/09)**

A. M. Lenhoff

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Multifunctional Biomaterials from Collagen-Containing Multiblock Polymers

**National Science Foundation (5/09–4/12)**

K. L. Kiick

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Molecular Design of Advanced Biomaterials

**National Institutes of Health (9/08–9/13)**

T. Beebe, K. L. Kiick

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IDEA Network of Biomedical Research Excellence

**National Institutes of Health (5/09–4/14)**

D. Weir, K. L. Kiick

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First- Principle Predictions of Crystal Structure of Energetic Material

**Department of Defense (10/08–9/11)**

K. Szalewicz

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Peptide-Based Nanostructure for Multifunctional Composite Materials

**Army Research Laboratory (6/09–5/10)**

D. J. Pochan
Electron Transport Membranes Using Nanostructured Block Copolymers

**University of Delaware Research Foundation** (6/09–5/11)

T. H. Epps

Towards a General Design Approach to Arrest Non-Native Aggregation of Multi-Domain Proteins

**National Science Foundation** (6/09–5/12)

C. J. Roberts, E. J. Fernandez, A. S. Robinson

A Novel Approach to Calculations of Intermolecular Forces Between Large Energetic Molecules

**Department of Defense Army Research Office** (8/09–7/12)

K. Szalewicz

Block Copolymer Self-Assembly

**National Science Foundation** (8/09–7/13)

D. J. Pochan, 1 co PI

Effect of Natural Organic Matter on Bioavailability and Mobilization of Metals

**National Institutes of Health** (9/09–8/11)

D. DiTorom, D. Doren, R. Carbonaro

Electron Transport Membranes Using Nanostructured Block Copolymers

**National Science Foundation CBET** (9/09–8/12)

T. H. Epps, M. Jeffries-El

MRI: Acquisition of a Facility for Computational Approaches to Molecular-Scale Problems

**National Science Foundation MRI** (9/09–8/12)

D. Doren, D. Vlachos, M. Taufer, S. Patel

Directed Self-Assembly of Nanodispersions

**Department of Energy** (9/09–8/12)

E. M. Furst

Interactions and Self-Assembly of Anisotropic Colloidal Particles in Electric Fields

**National Science Foundation** (9/09–9/12)

E. M. Furst

Structure, Stability, and Mechanisms of Nonnative Protein Aggregate & Microparticle Formation

**National Science Foundation** (9/09–9/12)

C. J. Roberts

Rational Design of Innovative Catalytic Technologies for Biomass Derivative Utilization

**Department of Energy EFRC** (9/09–8/14)

D. Vlachos, D. Doren

Ion-Conducting Network Membranes Using Tapered Block Copolymers

**Presidential Early Career Award for Scientists and Engineers—Department of Defense** (9/09–8/14)

T. H. Epps

Understanding and Overcoming Efficiency Limits in Organic Photovoltaics

**University of Delaware Research Foundation** (2010–2013)

M. Doty, M. E. Mackay
Facilities & Resources

Department of Chemical Engineering
College of Engineering
Complex Fluids Laboratories

• TA Instruments AR2000, AR-G2 and ARES rheometers with multiple geometries, solvent traps and sample temperature control.

• Rheo-SALS combined rheology and small-angle light scattering

• Brookhaven ZetaPals dynamic light scattering instrument

• UV/vis spectrophotometers (Spectronic 2000, Bausch & Lomb; Lambda 4B, Perkin-Elmer)

• Anton Paar DMA 35 and DMA 60 digital densimeters

• Capillary rheometer (Instron)

• Capillary viscometer (Cannon)

• Holographic optical tweezers—Zeiss Axio Observer microscope equipped for bright field microscopy; Phantom v5.1 high speed digital camera (1000fps at 1000×1000 resolution, 2GB).

• Time-shared optical tweezers and active microrheology—Zeiss Axiovert 200 microscope equipped for simultaneous bright field or video-rate confocal imaging; Yokogawa Nipkow disk confocal and 100mW 3-line Ar+ excitation laser; Stanford Photonics XR-Mega 10 Gen III 10 bit intensified digital ccd camera; PI-FOC microscope objective nanopositioner for high-speed 3D confocal microscopy; 300kHz acousto-optic deflector (AOD) and analog amplifier; quadrant photo-diode detector and 10mW HeNe laser for high resolution particle tracking; high numerical aperture (NA) objectives (Two 63× NA 1.2 C-Apo, 63× NA 1.4 Plan-Apo and one 100× NA 1.3 Plan-Apo)

• Diffusing wave spectroscopy—2W etalon equipped Argon ion laser (488nm), dual PMT detection, Brookhaven BI-9000 high speed correlator.

• Dynamic light scattering—two Brookhaven DLS instruments with goniometers. Scattering at multiple wavelengths with 2W Argon ion laser (488 nm) or 50 mW He-Ne laser (633 nm); thermostated sample cells, two BI 9000 correlators, and a differential refractometer

• Video-rate confocal imaging: Yokogawa Nipkow disk confocal and 100mW 3-line Ar+ excitation laser; Stanford Photonics XR-Mega 10 Gen III 10 bit intensified digital ccd camera; PI-FOC microscope objective nanopositioner for high-speed 3D confocal microscopy.

• Multiple particle tracking microrheology: Zeiss Axiovert 200 microscope equipped for bright field and epifluorescence; Phantom v5.1 high speed digital camera (1000fps at 1000×1000 resolution, 4GB).
Macromolecular Characterization Shared Facility

- Brookhaven Instruments BI-200SM dynamic/static light scattering instrument
- Microcal VP-DSC for calorimetric characterization of protein and peptide solutions

Materials Science and Engineering Department Central Facilities

- Digital Instruments Nanoscope III atomic force microscope
- NEXUS 670 FTIR
- Waters Alliance gel permeation chromatography system – both organic and aqueous polymer analysis
- VAC DRI-TRAIN HE-493 glovebox
- Nikon Microphot-SA optical microscope (transmission and reflective modes)
- Oxygen plasma chamber for inorganic wafer/disk cleaning/oxidation
- Bruker Tensor 27 FTIR spectroscopy
- Contact angle goniometry
- PerkinElmer Diamond DSC; PerkinElmer Pyris 1 TGA
- FEI Vitribot for cryoTEM sample preparation
- Leica CPC vitrification instrument
- Standard sampe preparation equipment
- (Leica cryoultramicrotome, carbon evaporators, gold sputtering and evaporators)
- Rigaku 36-kW rotating-anode x-ray source
- Bruker small- and wide-angle x-ray scattering camera with 2-D CCD array x-ray detector

College of Engineering Electron Microscopy and X-ray Scattering Laboratory

- Technai 12 120kV TEM with Gatan 626 cryotransfer stage, Gatan CCD for low dose cryoTEM imaging
- JEOL FEG2010 TEM with Gatan 626 cryotransfer stage and imaging filter, CCD (electron energy filtering)
- JEOL 2000FX TEM with Gatan 626 cryotransfer stage
- JEOL JSM 7400F Field Emission Scanning Electron Microscope
- JEOL JSM 5300LV Low Voltae Scanning Electron Microscope
Center for Molecular & Engineering Thermodynamics | 2010

Institution Facilities

Delaware Biotechnology Institute (DBI)

The DBI is a government-academia-industry partnership. The Institute provides a set of core facilities with state-of-the-art instrumentation and to make these core facilities available to the University and other institutes in the region.

Bioimaging. Dr. Kirk Czymmek, Director

The DBI bioimaging center is staffed by Dr. Czymmek and two full-time bioimaging technicians. Instrumentation available in this facility includes:

- Zeiss CEM TEM
- Hitachi S4700 FESEM
- Zeiss LSM510 NLO multiphoton confocal microscope
- Digital Nanoscope III AFM
- Compound microscope
- Microtome tools
- Amersham Pharmacia MD Typhoon Phosphorimager and Fluoroimager

Custom Microarray Facility

Ms. Diane York, Coordinator

- Affymetrix Gene Chip instrument system,
- Packard Bioscience Multiprobe II HTEX liquid handling robot
- Genomic Solutions Flexys colony picking robot
- GeneMachines OmniGrid microarraying robot
- Microarray slide scanner

Protein Production Core Facility

Dr. Yu Sung, Director

- Instrument acquisition funded by NCRR COBRE
- New Brunswick Scientific BioFlo 4500 fermentor (30L capacity – bacteria and yeast)
- New Brunswick Celligen bioreactor (10L capacity – insect and mammalian cell)
- Avestin EmulsiFlex cell homogenizer
- Amersham Akta Explorer 100 fast protein liquid chromatography

Protein Biophysics Shared Instrumentation Facility

Mr. Robert Pekala, Building Manager

- Aviv Instruments Model 215 circular dichroism spectrometer
- Perkin Elmer/Wallac Victor and Fusion fluorescence/absorbance/polarization multi-well plate readers
• Applied Photophysics stopped-flow device with fluorescence and absorbance detection
• Beckman-Coulter analytical ultracentrifuge

COMMON EQUIPMENT

Mr. Robert Pekala, Building Manager

• 2 Autoclaves, 2 freezer farms, 2 glassware washers, 4 tabletop centrifuges
• 4 Mammalian cell culture incubators and 6 Class II Biosafety hoods
• 3 New Brunswick C-25 floor platform shakers and 1 New Brunswick C-24 benchtop platform shaker
• Two cold rooms
• 5 Beckman Coulter Optima and 2 Beckman Coulter Avanti superspeed centrifuges
• 2 Beckman Coulter DU 7400 diode array spectrophotometers
• Beckman Coulter DU 640 UV/Vis spectrophotometer
• Beckman Coulter CEQ 2000XL DNA analysis system
• 2 Alpha Innotech 2200 gel documentation systems and 2 Spectroline transilluminators
• Beckman Coulter LS6500 liquid scintillation counter
• Barnstead Nanopure Diamond water purification units in each lab
Recent Seminars

To enhance the quality of our students’ educational experience and our own range of knowledge, CMET hosts a Seminar Series, which brings scientists and engineers to campus from institutions around the world.

Jeff Fowler
*Research Scientist, Technology and Projects*
Syngenta Crop Protection
“Some Colloidal Science Challenges in the Agrochemical Industry”

Ramón Castañeda-Priego
*University of Guanajuato, Mexico*
“Thermodynamics, Structure and Effective Interactions in Charge-Stabilized Colloidal Suspensions”

Jan Mewis
*Professor Emeritus, Katholieke University of Leuven, Belgium*
“Some Rheological Features of Clay/Polymer Nanocomposites”

Nicos S. Martys
*National Institute of Standards and Technology*
“Contact and Stress Anisotropies in Start-Up Flow of Colloidal Suspensions”

Student Awards & Fellowships

Ohm Krishna
*Kiick*
ACS Excellence in Graduate Polymer Research symposium

Armin Opitz
*Wagner*
Pigford Fellowship

Mark Panczyk
*Furst*
American Chemical Society’s Division of Colloid & Surface Chemistry, Outstanding Poster Contribution

Kelly Schultz
*Furst*
ACS Excellence in Graduate Polymer Research symposium

Visit our website to learn about our upcoming seminars!

[www.che.udel.edu/cmet/seminars.html](http://www.che.udel.edu/cmet/seminars.html)
Your gifts are used for many worthwhile purposes, including support of our research and educational programs. To make a donation, please visit **UD Connection** (www.udconnection.com) and click **Donate Today**. If you wish to designate your gift to CMET, select *other* from the list provided, then specify *Center for Molecular & Engineering Thermodynamics*. 

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