“To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...”
Division of Chemical, Bioengineering, Environmental, and Transport Systems

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Chemical Process Systems
1401 Catalysis
Robert McCabe

1417 Molecular Separations
Angela Lueking

1403 Process Systems, Reaction Engineering, & Molecular Thermodynamics
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7644 Electrochemical Systems
Carole Read

Chemical Process Systems Cluster
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Engineering Biology & Health
1491 Cellular & Biochemical Engineering
Steven Peretti

5345 Engineering of Biomedical Systems
Michele Grimm

7236 Biophotonics
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7909 Biosensing
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5342 Disability & Rehabilitation Engineering
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1440 Environmental Engineering
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1179 Biological & Environmental Interactions of Nanoscale Materials
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Transport Phenomena
1407 Combustion & Fire Systems
Song-Chang Kong

1443 Fluid Dynamics
Ronald Joslin

1415 Particulate & Multiphase Processes
Susan Muller

1406 Thermal Transport Processes
José Lage

Transport Phenomena Cluster
Shahab Shojaei-Zadeh

Division Experts and AAAS Science & Technology Policy Fellows
Multiple Programs Expert
Geoffrey Prentice

Engineering of Biomedical Systems Expert
Carol Lucas

AAAS S&T Policy Fellow
Gregory Meyer
Clean Energy Topics in CPS

- Investments in fundamental engineering science research including:
  - solar energy OPVs, solar fuels
  - biofuels and bioenergy
  - energy storage—batteries and flow batteries
  - fuel cells
  - energy efficiency
  - energy materials and manufacturing
Chemical Process Systems

Catalysis
- Heterogeneous catalysis related to sustainability and chemical processes
- Heterogeneous catalyst design, synthesis, and characterization
- Basic understanding of catalytic reactions, kinetics, and mechanisms

Molecular Separations
- Methods and mechanisms for purification of gases, chemicals, or water
- Mass separation agents or processes
- Field (flow, magnetic, electrical) induced separations

Process Systems, Reaction Eng. & Mol. Thermodynamics
- Chemical Reaction Engineering
- Process Design, Optimization and Control
- Reactive Polymer Processing
- Molecular Thermodynamics for Chemical Processing and Materials

Electrochemical Systems
- Electrochemical Energy Systems
- Organic Photovoltaics
Directions for Catalysis Study:

• Basic understanding of catalytic mechanisms via kinetic studies, computational methods, and characterization techniques.

• Discovery, design, and synthesis of catalysts specifically tailored to lower activation barriers and promote high rates and desired selectivity.

• Scalable, economical, and durable catalyst formulations and synthesis methods targeted at applications of both long-term commercial and societal importance.
Artificial Leaf Platform; remarkable CO2 conversion performance

Dichalcogenide nanoflakes reduce CO2 to CO electrochemically in an ionic liquid medium concurrently with an artificial leaf platform that oxidizes H2O to O2

Partial support under NSF CBET - 1512647

Program Goals:

• Support fundamental engineering research that will enable innovative processes for the sustainable production of electricity, fuels, and chemicals and for energy storage.

• Stress molecular level understanding of phenomena that directly impacts key barriers to improved system level performance (e.g. energy efficiency, product yield, process intensification)

• Proposed research should be inspired by the need for economic and impactful conversion processes.
Electrochemical Systems FY18 Themes

Electrochemical Energy Systems:
• Energy storage for renewable electricity production & transport
• Solar fuels: Photocatalytic or photoelectrochemical processes for the splitting of water into H2 gas, or for the reduction of CO2 to liquid or gaseous fuels
• Fuel Cells and Electrochemical chemicals

Organic Photovoltaics (OPVs):
• Fundamental research on innovative processes for the fabrication and theory-based characterization of future organic PV devices
• Devices of interest include polymer and small molecule OPVs for electricity generation
CAREER: Novel redox-active electrolyte additives to enhance efficiency and direct product selectivity in electroreduction reactions

Bryan McCloskey, University of California-Berkeley, CBET-1653430 (Start Date: July 2017)

Overall goal: Improve desirable product selectivity during O\textsubscript{2} and CO\textsubscript{2} reduction

**Approach:** Identify and incorporate electrolyte additives to promote desired reactions

Preliminary research indicates that adding soluble redox-active molecules to the electrolyte can dramatically influence product distributions in Li-air batteries and during CO\textsubscript{2} reduction. We will specifically pursue the use of N-heterocycles to promote desired reactions in these systems, stressing elucidation of reaction mechanisms to understand how to appropriately design electrolytes that improve each systems’ performance.

Challenge: Reduced oxygen species degrade electrolyte
Challenge: Poor product selectivity and energy efficiency
The Molecular Separations program supports research focused on **novel methods and materials** for separation processes, such as those central to the chemical, biochemical, bioprocessing, materials, energy, and pharmaceutical industries.

A **fundamental understanding** of the interfacial, transport, and thermodynamic behavior of multiphase chemical systems as well as **quantitative descriptions of processing characteristics** in the process-oriented industries is critical for efficient resource management and effective environmental protection.

A snapshot of proposals submitted since July 2017
Areas of emphasis (FY18):

- Design of scalable mass separating agents and/or a mechanistic understanding of the interfacial thermodynamics and transport phenomena that relate to purification of gases, chemicals, or water

- Design or improvement of mass separation agents or processes that are based upon, and advance, transport principles

- Downstream purification of biologically derived chemicals for increased throughput

- Field (flow, magnetic, electrical) induced separations and other innovative approaches that address a significant reduction in energy and/or materials requirements in the process industries
Process Systems, Reaction Engineering and Molecular Thermodynamics (PRM)

Program supports research and education projects related to:

1. Interactions between chemical reactions and transport phenomena in reactive systems, and the use of this information in the design of complex chemical and biochemical reactors (Reaction Engineering)
   a. Reactive processing of polymers, ceramics, and thin films
   b. Electrochemical and photochemical processes of engineering significance or with commercial potential

2. Design and optimization of complex chemical processes (Design)

3. Dynamic modeling and control of process systems and individual process units (Control)

4. New materials and processes based on utilizing Molecular Simulation and Statistical Thermodynamics (Molecular Thermodynamics)
NSF-DOE Workshop: Modular Manufacturing

Investments in fundamental engineering science research including:
- process intensification
- modular reactors
- energy efficiency
- systems controls

Molecular-level Science and Engineering

Module-level Integration

Pilot Scale

Plant Scale

NSF Funded Projects

http://www.efrc.udel.edu/2017NSFWorkshop/

Projects funded by Mission-Oriented Agencies (e.g., DOE)
Advice... Talk to a friendly program officer

Determining program fit takes homework

• Write up a 1-pager
  • Have your overview paragraph,
  • Intellectual merit paragraph
  • Broader impacts paragraph

• Make clear what is your transformative feature of your research and why

• Email 1-pager to program officer and ask for input

• In the end, it is your choice where to submit
Moved to Alexandria, Virginia 😞
Contacts and Thank you for Serving as a Reviewer!

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Chemical Process Systems Cluster

Chemical processes are critical in the production of chemicals, materials, clean water, energy, pharmaceuticals, and other commodities. The Chemical Process Systems (CPS) Cluster has four programs that support fundamental science and engineering research for the development of novel materials, mechanisms, and/or tools to improve the efficiency, resource utilization, and/or intensification of chemical processes. This cluster supports research seeking innovations in catalytic design, reaction engineering, multiphase chemical separations processes, molecular thermodynamics, process control and design, and sustainable energy conversion.

The overarching goal of the CPS programs is to support basic research that improves the overall efficiency and product yields of chemical processes while reducing the size and complexity of process equipment and minimizing emissions.