

RESEARCH CLUSTER E: Polymers for Renewable Energy

Faculty Participants: Bryan Coughlin and S. "Thai" Thayumanavan (co-leaders)
with 24 other principal researchers from large multi-investigator energy research initiatives

UMass Amherst is home to two major national research centers for renewable energy—the U.S. Department of Energy-funded "Polymer-Based Materials for Harvesting Solar Energy" Energy Frontier Research Center (PHaSE EFRC)—as well as an Army Research Office-funded project on Development of Enabling Chemical Technologies for Power from Green Sources (ChemEnergy), in total involving 26 UMass researchers from four departments. Cluster E leverages millions of dollars of federal research efforts and specialized laboratory facilities in these centers by providing an industry R&D conduit to polymer-related fundamental research on advanced materials for fuel cells, photovoltaic devices and related energy technologies.

PHaSE focuses on organic photovoltaic strategies using polymers, large conjugated oligomers, organic-inorganic composite materials, and nanoparticle quantum dot hybrids. PHaSE research includes: synthesis of conjugated homopolymers, dendrimers, block copolymers, and segmented structures exhibiting control over component energy levels using electron withdrawing/donating functionalities; preparation of p-type conjugated polymers with affinity for the surface of n-type nanoparticles and nanorods for effective dispersion of particles/rods and controlled aggregation of electron/hole carriers; assembly and morphology of photovoltaic materials through templated nanoscopic ordering of polymers, chromophore stacking in crystalline and partly crystalline materials, and control of heterojunction domain size for creation of charge pairs with optimum morphologies for charge separation and subsequent transport; and characterization studies involving the photophysics of charge transport and energy transfer within nanostructured photovoltaic composite films.

ChemEnergy research focuses on chemistry- and materials-related research for military applications: biomimetic and biological materials for energy, proton transport materials for fuel cell applications, and materials for photovoltaics applications. Projects include work on bio-inspired proton exchange membranes, biohybrid materials for hydrogen production catalysis, dendron-rod-coil architectures for photoinduced electron transfer in polymers, and studies of triazole polymers for anhydrous proton conducting properties in fuel cell membranes. This Center also focuses on the bases for charge transfer and transport in polymeric materials spanning the molecular to the macroscopic scale of supramolecular assemblies, for impacts in innovative materials for fuel cells, batteries, and solar cells. The researchers in the Center, synthesize and characterize organic materials featuring novel charge conduction architectures and pathways involving site-to-site jumps along well-defined scaffolds, with the aim of both identifying optimal chemistries and dynamics for facile charge transfer and fabricating ideal scaffolds for stable and rapid charge conduction. The center develops chemical methods for precise placement of functional groups on molecular, supramolecular and macromolecular scaffolds, thereby tuning distances and orientations of donor-acceptor pairs. Researchers study these molecules and materials for charge transfer and transport using a variety of techniques, including single molecule methods, to develop a structure-function correlation that will inspire future energy materials design. This Army program has also contributed to the establishment of a Charge Transport/Renewable Energy Equipment Facility for use by the broader Cluster E research community and participating member companies



Photovoltaic cell fabrication and analysis unit and the impedance spectroscopy unit for proton conductivity measurement, part of the UMass Amherst "Charge Transport Laboratory."

Cluster E Membership Opportunity:

Companies supporting Cluster E research are able to directly connect with UMass Amherst's leading scientific innovators and nationally-funded energy research initiatives involving polymers while at the same time collectively sponsoring small, focused projects that provide insights into next-generation materials for clean energy harvesting, conversion and storage. The following project areas are currently being emphasized in Cluster E pre-commercial consortium-based research:

- **Materials for PEM fuel cell membranes.** Through the design and fabrication of conducting nanochannels in polymer films, we are developing and characterizing a class of comb-type organized supramolecular polymer assemblies containing amphoteric proton transfer functionalities. We are also studying and characterizing the conduction mechanism of anhydrous proton-conducting triazole-functionalized polysiloxanes.
- **Novel polymers for enhanced charge transport in organic photovoltaic cells.** Synthesis of novel conjugated polymers, block copolymers with linear and branched architectures, hybrid materials for enhancing photovoltaic efficiencies. We are studying these new materials as components of nanoscopic assemblies for achieving bulk heterojunction structures.

Cluster E Investigator Community:

- **Chemical Engineering:** Dimitrios Maroudas, Peter Monson.
- **Chemistry:** Scott Auerbach, Michael Barnes, Jeanne Hardy, Kevin Kittilstved, Paul Lahti, Michael Maroney, Ricardo Metz, Vincent Rotello, S. "Thai" Thayumanavan, D. "DV" Venkataraman.
- **Physics:** Anthony Dinsmore, Chris Santangelo, Mark Tuominen.
- **Polymer Science & Engineering:** Alex Briseno, Kenneth Carter, E. Bryan Coughlin, Alfred Crosby, Todd Emrick, Gregory Grason, Ryan Hayward, Thomas Russell, James Watkins.

Contact Information:

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