Title of Research Project: Hydrophilic-Hydrophobic Phase-separated Nanocomposite Electrolytes

Faculty Name: John A. Staser

Department or School: Dept. of Chemical and Biomolecular Engineering

Brief Description of Project: Polymer electrolytes are essential components for a host of electrochemical energy conversion devices, including fuel cells and technologically advanced electrolyzers. They are gaining attention as separators for flexible, lightweight electrochemical capacitors. Unfortunately, standard proton exchange membranes (PEMs) are too expensive for widespread commercial application, and alternative configurations like anion exchange membranes (AEMs) possess poor mechanical stability and ion conductivity. Our group’s recent work has focused on developing graphene oxide nanocomposites that are cost-effective and possess high mechanical stability and ionic conductivity. The novel approach we will take for this Apprenticeship Pilot Program is quaternization of hyperbranched polymers (i.e., to impart ionic conductivity to traditionally non-conductive polymers) with subsequent chemical functionalization of graphene oxide. The quaternized hyperbranched functional groups on the graphene oxide sheets will modify graphene oxide in two ways: 1) it will enhance its hydrophilicity and 2) will increase ionic conductivity. The increased hydrophilicity, however, may be detrimental to electrochemical system performance (i.e., increased fuel crossover, representing wasted resources), and so we will further modify the nanocomposites by functionalization with hydrophobic (i.e., silane) groups. These hybrid hydrophilic-hydrophobic materials represent a novel approach toward synthesizing polymer electrolytes, and could advance the state-of-the-art toward commercialization.

The undergraduate student will gain hands-on experience in polymerization and functionalization of polymers, in nanomaterials synthesis, and in materials characterization (thermogravimetric analysis, transmission electron microscopy, etc.) along with building electrochemical test cells for performance evaluation.

Student's Role in Project and Benefit to Student:

The student will, after an initial training period, take the lead on quaternizing the hyperbranched polymers, synthesizing the chemically functionalized hydrophilic-hydrophobic graphene oxide-based nanocomposites, and characterizing the novel materials through physical analysis and electrochemical evaluation. The student will learn, in addition to hands-on knowledge, fundamentals of materials processing and electrochemical engineering. For example, the student will learn to evaluate the functionality of the novel nanocomposite electrolyte by quantitative analysis of fuel cell performance, directly comparing results to those obtained from commercial membranes. Such analytical experience should help the student develop skills necessary for a career in science and engineering (beyond what he/she learns in the classroom) and would make the student more competitive should they wish to enter graduate school. He/she will be able to work alongside graduate students and postdoctoral researchers at the Center for Electrochemical Engineering Research at Ohio University, gaining additional knowledge by observing other ongoing research projects.
One additional benefit to the student is the ability to work in the lab semi-autonomously. After an initial training period, the student will be able to work when his/her schedule permits, so long as either the PI or the postdoctoral researcher is present in the lab. Instead of the student being given “tasks” at the start of each week, the student will work under the knowledge that they need to reach certain research goals. Guidance will be provided to help the student reach those goals, of course, and he/she will be encouraged to ask questions of anyone in the PI’s group. On the other hand, the student will be given the opportunity to partially direct their research project, and will be given the freedom to make mistakes. Mistakes made during the semester will serve as another learning experience.

Finally, the student will benefit by learning about laboratory safety. In addition to the Chemical Hygiene Safety Training required by Environmental Health and Safety, the Center for Electrochemical Engineering Research (in which the PI’s lab is located) has its own comprehensive safety training that all researchers must attend. The emphasis on safety in the PI’s lab will help the student get ahead of his/her peers, many of whom have never worked in a laboratory setting where safety is considered paramount, and will be attractive to any future employer.

**Desired Qualifications for Apprentice (e.g. course background, skills, computer expertise, interest, etc.):**

The student apprentice should have completed the chemistry courses required for chemical engineering, as well as mass and energy balances (introductory chemical engineering courses, CHE 2000 and CHE 2010).

The student should have fundamental computer skills, including knowledge of Microsoft Excel.

The student should be able to work in a team environment, and also be able to work semi-autonomously to achieve his/her research goals.

The student should be interested in materials science research related to electrochemical energy conversion and storage.
UNDERGRADUATE RESEARCH APPRENTICESHIP PROPOSAL
2015-16

Faculty Member: John A. Staser
Department or School: Dept. of Chemical and Biomolecular Engineering
Campus Address: 159 Stocker
Phone: 593-1443
Email: staser@ohio.edu

Choose one funding option:

____ Hire a student to work for 25 hours a week for 12 weeks during the summer term.

____ Hire a student to work for 10 hours a week for the 30 weeks of the 2015-16 academic year.

____X____ Hire a student to work for 10 hours a week for the 15 weeks of one semester, either Fall 2015 or Spring 2016. Indicate which term: ___Spring 2016___________

Faculty Signature: 

Department Chair/School Director Signature: 

Submit this form along with a current CV directly to the Honors Tutorial College, 35 Park Place, no later than 5:00 p.m., Friday, January 23, 2015. We cannot accept late applications.
John A. Staser, Ph.D.
Assistant Professor
Department of Chemical and Biomolecular Engineering
Center for Electrochemical Engineering Research
Ohio University
staser@ohio.edu

PROFESSIONAL PREPARATION
Undergraduate: Case Western Reserve University Chemical Engineering BS 2005
Graduate: University of South Carolina Chemical Engineering PhD 2009
Postdoc: University of South Carolina and Benedict College 2009

APPOINTMENTS
• Assistant Professor, Chemical and Biomolecular Engineering, Ohio University, Athens, OH 08/2013 - Present
• Assistant Professor, Chemical Engineering, University of Puerto Rico – Mayagüez, PR 08/2012-05/2013
• Advisor/Consultant, Chemical Engineering, University of South Carolina, Columbia, SC 01/2012-08/2012
• Consultant, Bioproduct Stewardship Program, San Juan, PR 03/2012-08/2013
• Director/Engineer, Antilles Renewable Energy, Bayamon, PR/NuVant Systems, Crown Point, IN 05/2011-10/2011
• Project Engineer, Giner Electrochemical Systems, Newton, MA 01/2010-05/2011
• Postdoctoral Associate, Chemical Engineering, University of South Carolina, Columbia, SC 05/2009-12/2009
• Postdoctoral Associate, Department of Chemistry, Benedict College, Columbia, SC 05/2009-12/2009
• Adjunct Faculty, Engineering Technology, Midlands Tech. Coll., Columbia, SC 12/2008-03/2009
• GSRP Fellow, Electrochemistry Branch, NASA Glenn Res. Cent., Cleveland, OH 07/2007-07/2008
• Co-op, DuPont Fuel Cells, Wilmington, DE 01/2003-01/2004

PEER-REVIEWED PUBLICATIONS

BOOKS AND CHAPTERS

SYNERGISTIC ACTIVITIES
- Member of the Electrochemical Society and the American Institute of Chemical Engineers; ECS Interface Advisory Board; IE&EE division representative to ECS membership committee
- Secretary/Treasurer of IE&EE division of ECS
- ECS IE&EE division conference student outreach program
- Secretary for the Fundamentals of Electrochemistry group, American Institute of Chemical Engineers
- Reviewer for International Journal of Hydrogen Energy, and Journal of the Electrochemical Society
- Student outreach leader at Trimble Local School District
COLLABORATORS & OTHER AFFILIATIONS
Brian C. Benicewicz (University of South Carolina); MVS Chandrashekhar (University of South Carolina); Kevin Daniels (Naval Research Laboratory); Maximilian B. Gorensek (University of South Carolina); Alexander Gulledge (University of South Carolina); Peter Harrington (Ohio University); Jai Vishnuvarman Jayakumar (aeSolutions); Chang-Hee Kim (Green Technology Center Korea); C.K. Mittelsteadt (Giner Inc.); Simon G. Stone (Giner Inc.); T.S. Sudarshan (University of South Carolina); Ricky Valentin (University of Puerto Rico); John Weidner (University of South Carolina); Chris Williams (University of South Carolina)

Graduate Advisor and Postdoctoral Sponsor: Prof. John Weidner (University of South Carolina)

Thesis Advisor and Postgraduate-Scholar Sponsor: Christian Arroyo Torres (graduate student, OHIO, 2014-present)
Allen Rodriguez (graduate student, OHIO, 2014-present)
Omar Movil (postdoctoral scholar, OHIO, 2014-present)