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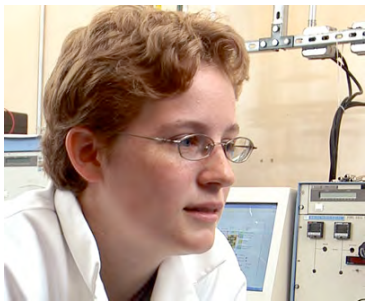
The Monthly Newsletter of Rensselaer Polytechnic Institute's School of Science

Accelerated B.S./Ph.D. Program

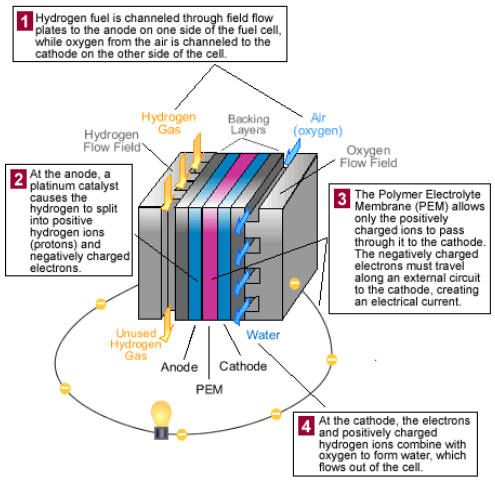
Jordan Mader



This month, Jordan Mader, a Chemistry Graduate Student, who was in the first group of students selected to be in the Accelerated B.S./Ph.D. program is highlighted. (In the January 2009) issue of Science News Amanda Lund, the other person in the first group was featured. Jordan's research is with Professor Brian Benicewicz, formerly of Rensselaer and currently at South Carolina.

Jordan's research focuses on blending the chemistry of low temperature, water-based fuel cells with the high temperature, acid-based PBI fuel cell chemistry. To this end, she has been developing sulfonated PBI polymers. Investigations of these chemistries includes homopolymers, random copolymers, and block copolymers. Each polymer subset has been characterized for polymer properties such as mechanical integrity, proton conductivity, acid uptake and retention, molecular weight, and fuel cell performance under varying conditions. Thus far, these polymers show great promise as high temperature fuel cell membranes.

Over the past several years, there has been great interest in developing forms of alternative energy that are both environmentally friendly and reduce the dependency on dwindling oil sources. Fuel cells have developed as an attractive alternative to traditional power generating devices. A fuel cell is an electrochemical device that converts hydrogen (H_2) and oxygen (O_2) to electricity and water (H_2O) (see figure below).



http://www.nersc.gov/news/science/Fuel_cell.gif

There is great interest in the class of polymer-based proton exchange membrane fuel cells (PEMFC), which work by using a polymer membrane to conduct protons (H^+) during the chemical reaction that takes place inside a fuel cell. Recently, there has been a major emphasis on the development of high-temperature (>100°C) PEM fuel cells. The benefits of operating fuel cells at higher temperatures include: the reduction or elimination of humidification requirements, increased tolerance to fuel impurities (e.g., CO), wider fuel choices, lower fuel reforming costs, improved electrode kinetics, higher conductivities, and smaller heat exchangers or radiators. Traditional polymer fuel cell membranes that rely on water for proton conduction require complicated or expensive water management systems for operation at 80°C or higher. Initial work on PBI-phosphoric acid based membranes using the commercially available PBI polymer has shown that many of the requirements for high-temperature operation could be satisfied by this membrane system. Since these early reports in the literature, much work has been done to more fully evaluate and develop fuel cell membranes based on PBI polymers.

Typically, PBI-based fuel cells use phosphoric acid (PA) as an electrolyte, because of its high proton conductivity and thermal stability. It has been reported that these membranes exhibit high ionic conductivities at high temperatures, low gas permeability, excellent chemical and thermal stability in the fuel cell environment, and nearly zero water drag coefficient. Furthermore, PBI polymer is commercially available; it is well-characterized and methods of synthesis have been developed thoroughly. However, some of the perceived problems with using PBI for fuel cell membranes include: the low molecular weights, low phosphoric acid loading, phosphoric acid retention, and membrane durability. Improvements in these properties are the focus of much research, which should lead to improved membranes that satisfy the extensive needs of a commercially viable fuel cell membrane.

A new process for synthesizing high molecular weight polybenzimidazoles and membrane casting was developed at Rensselaer Polytechnic Institute (RPI) in conjunction with the group that now constitutes BASF Fuel Cells. Collaboration between the two groups began in late 1998. This new method, termed “the PPA process”, uses polyphosphoric acid (PPA) as the polycondensation agent, polymerization solvent, and membrane casting solvent. PBIs were synthesized mostly from 3,3’,4,4’-tetraaminobiphenyl (TAB) and various dicarboxylic acids, although many combinations of tetraamines and diacids are possible. After

polymerization, the PBI solutions in PPA were cast and the PPA hydrolyzed in-situ to phosphoric acid (PA). Under appropriate conditions, a sol-gel transition occurred to produce a film with a combination of desirable physicochemical properties not obtainable from conventional imbibing processes. These membranes had high PA-doping levels, good mechanical properties, excellent conductivities, and excellent long-term stabilities, even when operating at temperatures over 150°C. A critical part of the process is the sol-gel transition that occurs for many heteroaromatic polymers. The sol-gel transition is induced by a change in the nature of the solvent, when PPA (a good solvent for many PBI polymers) is converted to PA (a poor solvent) via a simple hydrolysis reaction following absorption of water during a post-casting process.

Darrin Fresh Water Institute Offers a Semester of Study for Undergraduates at Lake George

Rensselaer plans to provide a unique opportunity to undergraduates with interdisciplinary research and education in the environmental sciences by leveraging the world class resources of The Margaret A. and David M. Darrin '40 Fresh Water Institute (DFWI) on Lake George, Bolton Landing, NY. With the 7,500 sq. ft. teaching/research facility, and the Education Center, the Darrin Fresh Water Institute is well poised to offer an intensive, highly focused semester of integrated classroom and fieldwork in the Fall 2009. The program of study advances Rensselaer's goal of immersing students in the process of actually doing science with the aim of developing the critical thinking, analytical, and communication skills necessary to pursue their career objectives. This program is a full residential emersion experience, the first of its kind at Rensselaer.

The Semester of Study at the Darrin Fresh Water Institute is based on and conciliate with the goals of The Rensselaer Plan and the Undergraduate Plan. We anticipate that the Semester of Study will increase the national/international reputation of Rensselaer and the Darrin Fresh Water Institute in environmental research, education, and training.

The general program of study is based on a semester of 16 credit hours. While course offerings may change in subsequent years to reflect the interests and expertise of participating faculty, the Fall 2009 curriculum will include the following:

- Freshwater Ecology with lab (4 credits, Boylen) BIOL 4700
- Applied Environmental Microbiology with lab (4 credits, Nierzwicki-Bauer) BIOL 4680
- Out-of-Classroom Experience (3 credits, STSS-4800) BIOL 2930
- Independent Research/Culminating Experience (4 credits) BIOL 2900
- Seminar Series in the Environmental Sciences (1 credit) BIOL 4940

Connecting the program's diverse educational activities will be a holistic, systems-based approach to understanding the complex inter-relationships between the environment and human activities. Participating undergraduates will experience a unique, rigorous training program in freshwater ecology and environmental science, as expected for a research university with the resources available at Darrin Fresh Water Institute and a history of educational leadership. The seminar series, featuring external scientists of national prominence, will not only enhance the student experience, it will also strengthen relationships with other institutions and further the reputation of the Darrin Fresh Water Institute and Rensselaer. These more personal one-on-one relationships will translate into more effective recruitment of undergraduate and graduate students, development of new research collaborations centered at Lake George, and raise national awareness of the Darrin Fresh Water Institute.

Awards

The Research and Development program progress was highlighted in the Department of Energy's Solid State Lighting Program. **Christian Wetzel,** Future Chips Constellation Professor of Physics, gave an invited presentation entitled **'Closing the "Green Gap" in LED Materials'**. Co-authors on the paper are
Christian Wetzel and Theeradetch Detchprohm (both RPI), and D. Hanser and E. Preble (Kyma Technologies, Inc. Raleigh NC). The paper reports on progress in the research contract with
PI C. Wetzel (80%) and Co-PI E.F. Schubert (RPI) (20%).

Following this presentation, Wetzel accepted an award on behalf of Rensselaer Polytechnic Institute.

"Illuminating Ideas"
Presented to
Rensselaer Polytechnic Institute
For Significant Achievements
In Solid-State Lighting R&D
2008"
State Lighting R&D 2008"

For more information on the Rensselaer Solid State Lighting Program see:

http://www.netl.doe.gov/ssl/highlights_RPI.html

Also presented at this Workshop was a paper entitled: "Commercialization in the Global Context" by

Susan Walsh Sanderson & Kenneth L. Simon*s, Rensselaer Polytechnic Institute,* "Results of a recently completed study analyzing patents filed and acquired in solid-state lighting projects internationally"

Faculty News and Notes

Ingrid Wilke, Department of Physics, Applied Physics and Astronomy, was promoted to Associate Professor with Tenure in 2008. Dr. Wilke's major research effort has been in experimental ultrafast optical physics and physics of materials especially in the THz region. She focused on the study of narrow band gap semiconductors (InN) as THz-radiation source, the investigation of dielectric properties of biological tissue in the THz-frequency range, and the creation of nanopores in the membranes of living cells by focused femtosecond laser beams. Her group reported from Rensselaer the first observation of optically excited THz radiation from an InN thin film with a GaN buffer film on a sapphire substrate. The radiation from the InN surface resulting from the transient photocarrier current is about one order of magnitude stronger than that from InN/GaN interface. The result is an important experiment in photonics. The significance of this work is that the InN is a small bandgap material that means it can emit light in longer wavelengths possibly from deep ultraviolet to near infrared as well as to be used as THz emitters and radiation modulators.

Martin Hardwick has been appointed Acting Head of the Computer Science Department. Martin replaces **Jeff Trinkle**, who is stepping down as head of the department after many years of service to concentrate on his research.

Russ Ferland, Assistant Professor of Biology, has received a Basil O/Connor Starter Scholar Research Award from the March of Dimes entitled The Functional Role of the Joubert Syndrome Causing Gene, AHI1, in Brain Development.

Ferland presented a seminar on "The Role of AHI1 in the Neurodevelopmental Disorder, Joubert Syndrome" at Neurology Grand Rounds at the University of Rochester on November 7, 2008".

Ferland also presented "Defects in Primary Cilia and Vesicular Trafficking in the Neurodevelopmental Disorder, Joubert Syndrome" at the Neuroscience Program seminar at Upstate Medical University in Syracuse, NY on November 11, 2008, and "Abnormalities in the formation of primary cilia in the neurodevelopmental disorder Joubert Syndrome," for the Interdepartmental Neuroscience Program at Georgetown University in Washington, D.C., on December 16th, 2008.

Blanca Barquera, Assistant Professor of Biology, has had a paper entitled "The electron transfer pathway of the Na+-pumping NADH:quinone oxidoreductase from Vibrio cholerae" accepted in the Journal of Biological Chemistry. Co-authors are Oscar Juarez and Joel E. Morgan.

Fern Finger, Assistant Professor of Biology gave a seminar "Septin functions in *C. elegans* axonal dynamics" on December 10th, 2008 in Piscataway, NJ that was jointly sponsored by the Department of Pathology and Laboratory Medicine at the Robert Wood Johnson Medical School, and by the Department of Genetics at Rutgers University.

Chapter 14, "Septins and Human Disease" of the book "The Septins", editors Peter A. Hall, S.E. HIlary Russell, and John R. Pringle, recently published by John Wiley & Sons, Ltd. (2008), was co-authored by **Fern Finger**, Assistant Professor of Biology and Peter A. Hall, F.R.C. Path., Musgrave Professor of Pathology, Centre for Cancer Research and Cell Biology, Queens University, Belfast, Northern Ireland.

Three RPI Faculty, Dr. Janet Paluh (Biology), Dr. Ravi Kane (Chemical and Biological Engineering) and Dr. Badri Roysam (Departments of Electrical, Computer and Systems Engineering and Biomedical Engineering) are participating in a NYSTEM Planning Grant for Retinal Stem Cell therapies. The Planning Grant is spearheaded by Dr. Sally Temple of the New York Neural Stem Cell Institute, who recently received the prestigious MacArthur award for her work on neuronal stem cells.

B. M. Glasheen, A. Kabra, A. Page-McCaw. Distinct functions for the catalytic and hemopexin domains of a Drosophila matrix metalloproteinase. Proceedings of the National Academy of Sciences USA (in press). The 2nd author is an undergraduate, currently a senior in the Accelerated Physician-Scientist program.

* *This newsletter is prepared monthly and distributed to School of Science faculty, staff, students and alumni to highlight accomplishments and events within the school. Please submit news items for the next newsletter to Samuel Wait, Associate Dean of Science, at waitsc@rpi.edu.*