FALL 2014



CHEMICAL AND BIOMOLECULAR ENGINEERING A. JAMES CLARK SCHOOL of ENGINEERING

chbe.umd.edu

Room to Move

Can spacing layers of graphite make sodium-ion batteries a reality?

INSIDE: CELL GELS | ANTIFUNGAL INTRABODIES | CATALYSTS & ORGANIC ELECTRODES | UNIT OPS

chair'sm ssage



THIS SEMESTER,

I'm teaching the first course in our senior design sequence, for the first time. As in every semester, I spend the first two weeks trying to learn everyone's name, usually as I hand back graded assignments. And as in every semester I've been at the University of Maryland, I think to myself: Wow, it's like the United Nations in this classroom! And that's a good thing.

At last count, our undergraduate student body in ChBE is composed of 96% citizens or permanent residents. But many of those students and their families have immigrated here, and many have parents, grandparents or great grandparents who immigrated, reflecting the diversity of regions that our students come from. We also have F-1 students who came from places far and wide, like Cameroon and China, just to study here. Thanks to the wonderful international community within the beltway, I like to tell our students that they can be as Cameroonian or Chinese as they want to be, even if they are from someplace else. The number of our American students who study abroad, or who are trying to fit foreign language study or the international engineering minor into their curriculum, has steadily increased. One of our seniors, **Lisa Wiest**, spent a year in Korea, and now that she's back she spends time socializing with Korean students, friends, and professors in a whole new way. For us faculty members, international sabbaticals—or more routinely, conference calls at odd hours—with foreign collaborators have been the norm for a while.

Many of our alumni—both U.S. citizens and those who have returned home—are now living abroad, so there are ChBE Terps all around the world! If you're one of those Terps and would like to share your experience with our current students, let me know! Sure, the world is getting smaller every day, but there's nothing like your story to bring it home to our students.

Go Terps!

Stalg. La

Sheryl H. Ehrman Keystone Professor and Chair sehrman@umd.edu

IN THIS ISSUE:

- 2 CHAIR'S MESSAGE
- 3 COVER STORY
- 4 RESEARCH NEWS
- 6 FACULTY NEWS
- 8 UNIT OPS UPGRADES
- 9 STUDENT NEWS AND RESEARCH



ON THE COVER:

ChBE researchers and their colleagues modified graphite to create a sodiumion battery anode. Sodium-ion batteries could be an inexpensive alternative to lithium-ion, but getting them to work has been challenging. After the oxidation and reduction of graphite, the distance between its layers is expanded so sodium atoms can shuffle in and out and provide reversible charge capacity. The expanded graphite looks more disordered than pristine graphite after the treatment-the layers are no longer perfectly parallel to each other. Although they bend and distort, the overall layered structure is still retained. For the full story, see page 3.



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Room To Move

SPACING GRAPHITE LAYERS MAKES A BETTER BATTERY ANODE

As the demand for rechargeable lithium-ion (Li-ion) batteries has grown, the battery industry has found itself facing a problem of supply and demand. Lithium is not an abundant element, and most lithium deposits are found in only a handful of countries. Both problems make its long-term availability and cost uncertain.

In a paper published in the June 4 issue of *Nature Communications*, Department of Chemical and Biomolecular Engineering (ChBE) professor **Chunsheng Wang** and Department of Materials Science and Engineering professor **John Cumings** explain how a modified version of a Li-ion battery anode could allow manufacturers to replace the lithium with a more common element.

Sodium (Na), an earth-abundant and inexpensive element, shares many properties with lithium, but so far has not been able to replace it. The best strategies for creating Li-ion batteries often can't be adapted for use in Na-ion batteries, rendering them a laboratory curiosity and keeping them out of the market.

The main problem is the atom's size. Sodium ions are larger than lithium ions, which limits the kinds of materials that can be used in a Na-ion battery anode, the component into which the positively charged ions flow. Graphite (a form of pure carbon) is among the most superior options, and is also the most common in Li-ion batteries. When creating graphite anodes, lithium ions are easily electrochemically intercalated (embedded) into its layered structure, but for sodium ions it's a tight squeeze, and the result is a battery with sluggish performance and low capacity.

The solution, Wang and Cumings have discovered, is to increase the space between the individual layers of carbon that make up the graphite. Their team starts with graphite oxide, a common industrial material formed by exposing graphite to an aggressively corrosive solution that stuffs oxygen between its layers. The oxygen atoms bond with each carbon layer, pushing and holding them apart. However, the resulting material is inevitably "overstuffed," leaving no room for sodium ions to get in. To make the material suitable for use in Na-ion batteries, some of the oxygen must be removed.

The solution to this second problem was developed by the paper's first author, ChBE graduate student **Yang Wen**. Wen heats the expanded, oxidized graphite to high temperatures and floods it with argon gas, causing it to decompose. In this process, oxygen bonded to carbon breaks away in the form of either



YANG WEN (LEFT) & PROFESSOR CHUNSHENG WANG

carbon monoxide (CO) or carbon dioxide (CO_2) gas, which is caught up and removed by the argon gas flow. Wen's key discovery is the precise combination of temperature and duration for the reaction. Her technique ensures that enough oxygen atoms have been removed to let the sodium ions in, but enough are left behind to prevent the expanded graphite from collapsing. The process may be likened to jacking up every floor of a multi-storey building to accommodate taller tenants, and then removing excess scaffolding until only the required support beams remain.

After testing the material both in experimental batteries and in a transmission electron microscope for realtime observations, the team found that Na-ion battery anodes manufactured with the expanded graphite had good energy density and retained 73 percent capacity after 2000 charge/discharge cycles.

"Expanded graphite is already commercially available," explains Wang, "but industry uses a different method to make it. If they follow Yang's procedure, they can use it to make expanded graphite suitable for sodium-ion batteries." However, he adds, "they won't be as powerful as lithium-ion batteries. You'll need more of them to get the same amount of power, but the cost is so much lower it will make up for it."

Cumings agrees. "Sodium-ion batteries are also heavier, so for now they're not suitable for most vehicles and airplanes. But for something like building or grid-level power storage–where they're just going to sit there– the fact that you get more kilowatt hours per dollar becomes a strong selling point."

In addition to Wang, Cumings and Wen, the research team included **Kai He** (Brookhaven National Lab), **Yujie Zhu** (ChBE), **Fudong Han** (ChBE), and **Yunhua Xu** (ChBE). Co-authors **Isamu Matsuda** and **Yoshitaka Ishii** (both University of Illinois) verified the team's reduction process.

The expanded graphite project was supported by Nanostructures for Electrical Energy Storage, the University of Maryland's Energy Frontier Research Center funded by the U.S. Department of Energy; the Maryland NanoCenter; and the University of Maryland Energy Research Center.

For More Information:

Yang Wen, Kai He, Yujie Zhu, Fudong Han, Yunhua Xu, Isamu Matsuda, Yoshitaka Ishii, John Cumings & Chunsheng Wang. Expanded graphite as superior anode for sodium-ion batteries. *Nature Communications* 5, 4033. Published online 4 June 2014. DOI: 10.1038/ncomms5033.

researchnews

Hydrophobically Modified Polymers Create "Cell Gels"

NEW TECHNIQUE COULD BE USED IN TISSUE ENGINEERING, 3D CELL CULTURE.

MULTIPLE HYDROPHOBIC "TAILS" (RED) ARE ATTACHED TO EACH POLYMER BACKBONE (PURPLE)—IN THIS EXPERIMENT, HM-CHITOSAN OR HM-ALGINATE. IN THEIR EFFORTS TO AVOID WATER, THE FREE ENDS OF THE TAILS "PLUG INTO" CELL MEMBRANES (GREEN), LINKING THE CELLS AND POLYMER CHAINS TOGETHER AND FORMING A GEL. WHEN ALPHA-CD IS ADDED, THE TAILS RELEASE AND PLUG INTO IT INSTEAD, AND THE GEL BECOMES A LIQUID AGAIN.



Modified polymers that instinctively "plug into" cell membranes, forming a structure that can also be pulled apart without damaging the cells, could lead to new approaches in tissue engineering, according to research published by current and former University of Maryland students and faculty. The paper, "Reversible gelation of cells using self-assembling hydrophobically-modified biopolymers: Towards self-assembly of tissue," was published in *Biomaterials Science* and highlighted on the journal's blog.

"Typically, cells are embedded in a biocompatible hydrogel scaffold network, where they grow over time," explains co-author and ChBE professor **Srinivasa Raghavan**. "In our case, cells are active components of the network–they *are* the structure rather than residents inside one."

Raghavan and his co-authors, including ChBE graduate students **Vishal Javvaji** and **Hyuntaek Oh**, former group member **Matthew Dowling** (Ph.D. '10, bioengineering), and Associate Professor **Ian White** (Fischell Department of Bioengineering) found that adding modified forms of natural biopolymers such as chitosan and alginate to a liquid suspension of cells transformed it into an elastic gel. The gelling did not occur when unmodified biopolymers were used.

The team grafted fatty hydrophobic (naturally repelled by water) "tails" onto the chainlike "backbone" of the bipolymers. In their quest to find a "dry dock," the tails embed themselves in the cells' bilayer membranes, whose interiors are also hydrophobic. Since there are multiple hydrophobic tails attached to each bipolymer chain, they are able to bond with additional cells, creating a threedimensional network in which the cells serve as junctions. The result is a gel that immobilizes the cells, but does not harm them.

Adding another material, a soluble barrel-shaped molecule called α -cyclodextrin (alpha-CD), reverses the effect. Alpha-CD

is capable of attracting and bonding with the hydrophobes on the bipolymers, but cannot interact with the cells' hydrophobic membranes. As the gel is exposed to an excess of alpha-CDs with competing bonding sites, the bipolymers detach from the cells and bond with the alpha-CD instead. When the cells are released from their network, the gel reverts to a liquid suspension. The reversal process does not harm the cells either.

The results were demonstrated with hydrophobically modified versions of alginate and chitosan, which are biocompatible and already used in biological studies; and with blood, endothelial, and breast cancer cells.

Raghavan says this discovery is not necessarily better than current tissue engineering techniques, but presents an alternative approach to explore. He and his co-authors believe the technique could also serve as a platform for applications such as 3-D cell culture, injectable cellular therapies, tissue sealants, and blood clotting.

For More Information:

Vishal Javvaji, Matthew B. Dowling, Hyuntaek Oh, Ian M. White and Srinivasa R. Raghavan. Reversible gelation of cells using self-assembling hydrophobically-modified biopolymers: towards self-assembly of tissue. *Biomater. Sci.*, 2014, 2, 1016-1023. DOI: 10.1039/C4BM00017J

researchnews

Fighting Fungus with Engineered Intrabodies

RALPH E. POWE JR. FACULTY AWARD SUPPORTS KARLSSON'S DEVELOPMENT OF NEW EXPERIMENTAL TOOL.

Bacterial infections are not the only drugresistant illnesses. Candidiasis, typically caused by the *C. albicans* fungus, is one of the most common hospital-acquired bloodstream infections. Also known as a yeast infection, localized candidiasis of the skin, mouth, nails and other parts of the body are often easily treated. In immunocompromised patients, however, the infection may spread throughout the body, evolving into a life-threatening form of sepsis called candidemia. *C. albicans*' combination of natural and increasingly acquired drug-resistance has led the CDC to declare the fungus a "serious threat" to human health.¹

Assistant Professor **Amy Karlsson** is developing a new process that more accurately simulates the effect of antifungal drugs on their targets, which she believes will convert more discoveries in the lab into products on the shelf. Karlsson recently received a Ralph E. Powe Junior Faculty Enhancement Award from Oak Ridge National Laboratory to support the project.

In the search for new antifungal drugs, researchers try to identify the proteins and cellular functions that affect a fungus' virulence and health, as well as the genes responsible for controlling them. Drugs are then designed to attack these targets. Although many targets have been discovered, very few new antifungal agents have been successful. Karlsson and her research group believe this is because the way in which the targets are disabled in the lab is unrelated to the way antifungal drugs do so in the body.

Potential targets are typically identified using a procedure known as gene knockout, in which a gene is removed to determine what effect it has on an organism's behavior. If removing a gene from *C. albicans* eliminates the production of a protein responsible for virulence, that protein is identified as a possible drug target.

"When a gene knockout is used, the protein encoded by the gene is also eliminated," Karlsson explains. "But when an antifungal drug is used to inhibit a protein target, it doesn't remove the protein from the cell. It binds to the protein and disrupts its cellular function. Knocking out the gene tells us what to attack, but not how."

The Karlsson Group's novel approach is to focus on the proteins instead of the encoding genes that produce them. The team's strategy is to mimic the behavior of antifungal drugs by using engineered antibodies that disrupt the function of potential antifungal drug targets at the protein level.

After engineering an antibody that binds to the target protein, Karlsson and her team need to get it into the *C. albicans* cells. Drug delivery is difficult under normal circumstances, and this simulated drug delivery is even more challenging because antibodies are not naturally evolved to work within cells. Karlsson and her group are addressing this problem by evolving intrabodies, antibodies capable of functioning inside of a cell, in the lab.



AMY KARLSSON

They then prompt *C. albicans* to produce these intrabodies on its own, bypassing the need to develop a drug delivery system to get the intrabodies into cells.

"Our intrabodies disable both the target protein and the activities it performs, so we can identify exactly what that protein does and which of its parts enable the pathogen to survive and to affect us," Karlsson explains. "If we used gene knockouts, we probably wouldn't be able to observe that." And, she adds, the technique can be used to study proteins in any type of cell, making it an efficient and effective tool for biomolecular research.

"This project will develop a powerful new drug target validation tool for *C. albicans* and provide biochemical information that will guide drug design," says Karlsson. "We may even identify engineered antibodies that could serve as therapeutics themselves."

¹ Centers for Disease Control and Prevention (2013). Antibiotic Resistance Threats in the United States, 2013. Retrieved September 18, 2013, from www.cdc.gov/ drugresistance/threat-report-2013.



INTRABODIES WILL BE ISOLATED AND EXPRESSED IN C. ALBICANS TO IDENTIFY PROTEINS THAT MAY BE SUCCESSFUL THERAPEUTIC TARGETS.

facultyn≡ws



JEFFERY KLAUDA



GANESH SRIRAM

Klauda, Sriram Promoted

The A. James Clark School of Engineering and the Department of Chemical and Biomolecular Engineering (ChBE) extend their congratulations to **Jeffery Klauda** and **Ganesh Sriram**, who were promoted to the rank of Associate Professor with tenure, effective July 1 and August 23, respectively.

"Ganesh and Jeff have contributed enormously to the department through their scholarship, dedication to teaching, and service," says ChBE professor and chair **Sheryl Ehrman**. "I look forward to seeing what the next stage of their careers will bring!"

Klauda, who joined ChBE in Fall 2007, uses molecular simulations and thermodynamic modeling to describe the function, dynamics, and physical properties of cellular membranes and gas hydrates. His work, conducted in the Laboratory of Molecular & Thermodynamic Modeling, has diverse applications in biology and energy, from explaining how cells transport cholesterol and other molecules, to exploring whether certain mutations in cell membranes cause the early onset of cataracts, to using gas hydrates as a natural energy source and storage medium for carbon dioxide and hydrogen.

In 2012, he received a National Science Foundation (NSF) CAREER Award for his proposal to use the first all-atom technique to predict the structural transitions that occur in a class of proteins called secondary active transporters (SATs) as they interact with cell membranes. A paper on the work, which could help explain why and how drug-resistant cells expel antibiotics, was featured on the cover of the *Journal of Molecular Biology*.

Both graduate and undergraduate members of Klauda's group have received recognition for their research, including the Clark School's Dean's M.S. Research Award, Society of Chemical Industry-sponsored summer internships at top companies, travel and poster awards, and conference invitations.

Klauda received his Ph.D. in Chemical Engineering from the University of Delaware in 2003. To learn more about his work, visit: chbe.umd.edu/~jbklauda

Sriram, who joined the department in Spring 2008, is the director of the Metabolic Engineering Laboratory, which specializes in systems biology, metabolic flux analysis and gene regulatory network analysis, especially of eukaryotes. The group's work has many potential applications in commodity fields such as food, fiber, biofuels, therapeutics, and renewable feedstocks, with an emphasis on sustainable resources.

During his time at the Clark School, Sriram has led a collaboration to investigate carbon-concentrating mechanisms that make algal photosynthesis more efficient; has been part of a collaboration that received a \$3.2 million grant from the NSF to engineer poplar trees into high-yield crops for biofuels; was the co-PI on a project that received a \$1.9 million grant from the NSF to acquire a superconducting nuclear magnetic resonance (NMR) spectrometer for solving complex problems in biology and medicine; was named the 2011 Maryland Outstanding Young Engineer by the Maryland Science Center; and edited a book on plant metabolism. Outside of the lab, he is a Keystone Professor in the Clark School's program of excellence in early engineering education and part of ongoing efforts to improve student retention.

Sriram's growing roster of past and present laboratory personnel, ranging from high school interns to postdoctoral research associates, have received numerous awards and fellowships for their research from federal agencies such as the NSF and the National Institute of Standards and Technology (NIST), professional societies, institutes, and the University of Maryland.

Sriram received his Ph.D. in Chemical Engineering from Iowa State University in 2004. To learn more about his work, visit: **openwetware.org/wiki/Sriram_Lab**

6

Anisimov Elected to AIChE Fellowship

The Department of Chemical and Biomolecular Engineering (ChBE) is pleased to announce Professor **Mikhail Anisimov**'s election to Fellowship in the American Institute of Chemical Engineers (AIChE).

Anisimov's research interests include critical phenomena and phase transitions in supercooled water, fluids, fluid mixtures, liquid crystals, and surfactant and polymer solutions. He also studies the applications of photon-correlation spectroscopy and highresolution adibatic calorimetry to soft condensed-matter materials. He has co-authored major works that have affected engineers across a number of fields, including a theorybased calculation for the critical parameters of aqueous solutions of sodium chloride and a new international formulation of thermal conductivity of water and steam, which were adopted as international standards by the International Association for the Properties of Water and Steam (IAPWS). The 2012

International Symposium on Mesoscale and Fluctuation Dynamics was held in his honor.

Anisimov came to the University of Maryland in 1994 as a visiting professor at the Institute for Physical Science and Technology (IPST), and became a research scientist and affiliate professor in 1996. He has been a jointly appointed to ChBE and IPST since 2002, and is an affiliate of the Department of Chemistry & Biochemistry and the Chemical Physics Program. He has also served as a Distinguished Visiting Professor at the Petroleum Institute in Abu Dhabi, UAE. In 2007, he received the Clark School's Poole & Kent Teaching Award for Senior Faculty.

Anisimov is the author or co-author of over 200 publications, including books, chapters, refereed journal articles, and reviews. He is an elected fellow of the American Association for the Advancement of Science, the American Physical Society, the International Academy of Refrigeration, and the Newtonian Society. He is also an elected member of the New York Academy of Sciences, the Russian Academy of Engineering, the Russian Academy of Natural Sciences, and the Washington, D.C. Cosmos Club.



Ehrman Appointed Fulbright Ambassador

ChBE professor and chair **Sheryl Ehrman** has been named a Fulbright Ambassador, an official representative of the outreach branch of the U.S. Department of State's prestigious Fulbright Program. The highly competitive program awards merit-based grants to American professors and other professionals who wish to study, conduct research, teach, or lecture abroad. Fulbright Ambassadors are former Fulbright Scholars who travel to campuses and events to spread awareness of the program, its benefits, and how to apply.

Ehrman has already given presentations at Jackson State University in Jackson, Miss., and at the University of Maryland, and hopes to visit several more schools in the upcoming year. She has two specific goals in mind.

"I'm trying to focus on campuses that haven't had many Fulbright applicants or recipients, in order to encourage faculty who might not normally apply," she says. "I'm also hoping to increase applications from faculty in STEM [Science, Technology, Engineering and Math] fields, which is also a goal of the Council for International Exchange of Scholars. I think STEM faculty at the University of Maryland have done reasonably well at securing grants from the Fulbright program, but there's still a perception that Fulbrights are mainly for faculty in the arts, humanities and social sciences."

During her own year as a Fulbright Scholar, Ehrman was a Visiting Associate Professor at the Indian Institute of Technology, Bombay (IITB), one of the most selective STEM institutions in India. There, she collaborated with Professor **Chandra Venkataraman** and her research group on experimental studies of liposome leakage during aerosolization, which has applications in the formulation of vaccines for delivery via the lungs rather than by injection. In the years since, Venkataraman and her students have visited Ehrman's labs at the Clark School, and Ehrman has formally promoted engineering student and faculty participation in study abroad programs.

To learn more, visit: www.cies.org



educationnews

Unit Ops: Upgrades and Acquisitions

Life is tough on a Unit Ops Lab. An integral part of every chemical and biomolecular engineering major's undergraduate education, it's the site of countless experiments run over and over by thousands of students for decades.

ChBE's Unit Operations Lab is no exception. But thanks to the generosity of alumni, friends and corporate donors, and the dedication of ChBE faculty and staff, it's undergoing a steady transformation.

"We've put a lot of effort into upgrading and modernizing the lab in the past year and a half," says ChBE professor and chair Sheryl Ehrman, "so we can expose the students to current measurement techniques, as well as industry-standard software and instrumentation for data collection and process automation and control."

Improvements include:

- A new membrane separation unit that allows students to work with Lab View and collect far more data via computer than could be collected manually.
- A new computer-controlled heat exchanger with two attachments that allow students to study either a shell and tube exchanger or a vessel heated by a jacket or coil, with or without stirring. Students are able to experiment with a variety of parameters.
- Upgraded absorption column and fluid flow experiments that now incorporate orifice and ventur meters.
- Upgrading the distillation unit to improve control of reflux and make sample collection easier.

The fuel cell station is also being updated, and plans are in the works to install a closed-system gas absorber that has its own temperature and humidity controls, rather than being tied to the building's.

Lecturer Dr. Audaldo (Aldo) Ponce joined the department in March 2013 to lead the latest improvement efforts and

maintain the lab on a permanent basis going forward. He works closely with Assistant Professor Amy Karlsson, his co-instructor for CHBE 437: Chemical Engineering Laboratory, the primary course taught in the Unit Ops Lab.

Ponce's next goal is to acquire new experiment stations and additional versions of the existing ones.

"Right now we don't have enough equipment for all of the students," he explains. "In each section of the course, we'd like to decrease the number of students per station to give them a more direct experience with the equipment. We'd also like to incorporate some process control equipment, because it will give them the opportunity to experience what they will see in industry. Currently, they are learning that in the classroom only-they know the theory but not the practice."

The changes aren't limited to equipment and software. Karlsson and Ponce have also retooled CHBE 437's syllabus to include more time on technical communication.

"I wanted students to not only get more practice writing experimental plans and lab reports, but to get a better understanding of how to write well," says Karlsson. "We now include a lecture on how to prepare a report in the style of a scientific paper, and we have the students conduct peer reviews. Our goal is to help them understand that it's not only important to be able to do the work but to communicate what they've done to others."

LEFT: SENIOR KATIE POHIDA WORKS WITH THE NEW GAS MEMBRANE SEPARATION STATION, RIGHT: DR. ALDO PONCE AND PROFESSOR AMY KARLSSON AT THE FLUID FLOW STATION

GENEROUS SUPPORT

2009: ChBE and the (then) College of Chemical & Life Sciences shared a bequest from the estate of Mrs. Virginia Murray, made in honor of her late husband, alumnus Guy Edward Murray (B.S. '36, chemistry). The Murrays designated their gift for the purchase of new equipment. See: ter.ps/murraygift. ChBE also received a bequest from the estate of alumnus James Blakeley Lowe (B.S. '63).

2012: A gift from the Dominion Foundation

funded the purchase of a new heat exchanger and a new gas membrane separation station. The Foundation is part of Dominion Resources, one of the nation's largest producers and suppliers of electricity and natural gas. See: ter.ps/dominiongift

2013-2014: Darryll Pines, dean of the A. James Clark School of Engineering, provided funding to support ongoing renovations.

YOU CAN HELP!

Help us continue the Unit Ops upgrades by supporting the Chemical and Biomolecular Engineering Gift Fund. Donations can be made securely online at ter.ps/unitops. For more information, or to inquire about donating by check, contact Heather Medina, A. James Clark School of Engineering Assistant Director of Development, at 301-405-3303 or hmedina@umd.edu. Your generosity will enable our students to gain important practical experience on industry equipment.



studentnews

Wells Fellowships Support Development of New Battery and Catalyst Technologies

ChBE graduate students **Laleh Emdadi** and **Chao Luo** have received the University of Maryland Energy Research Center's first Harry K. Wells Graduate Fellowships. The \$20,000 awards, made possible by a \$400,000 endowment from **Harry K. Wells** (B.S '43, mechanical engineering), support research in the field of sustainable energy generation or storage.

LALEH EMDADI: FAST, HIGH-YIELD CATALYSTS

Emdadi, advised by Assistant Professor **Dongxia Liu**, is searching for ways to improve the cascade reactions that convert biomass (plant matter) into the commodity chemicals used to make biofuels and other biomaterials. Cascade reactions are ordered, consecutive series of reactions, each facilitated by an inorganic or organic catalyst. This process, Emdadi explains, is complicated, expensive, and wastes energy because each reaction in the cascade requires its own cycle of separation and purification, and often its own type of catalyst.

"Instead of using these multi-step reactions," she says, "we are designing a catalyst that is able to handle the whole cascade reaction at once."

Emdadi's catalyst is made from a very thin, plate-like zeolite. Zeolites are microporous aluminosilicate minerals that are already used in industry as catalysts and in separation processes. Emdadi and Liu are using their zeolites to build a novel catalyst structure in a way Liu compares to building a tower with bricks. The new catalyst will perform all of the reactions necessary to convert cellulose (the high-energy ingredient extracted from biomass to create fuels) into 5-(ethoxymethyl)furfural (EMF), which is used in the synthesis of biodiesel. Its advantages include enhanced mass transport, a high yield of desired products, and few unwanted byproducts. These attributes allow it to produce more EMF at a higher rate than traditional zeolite catalysts.

CHAO LUO: ORGANIC BATTERY ELECTRODES

Like many researchers, Luo, advised by Associate Professor **Chunsheng Wang**, is concerned about the future of rechargeable lithium-ion (Li-ion) batteries, due to their reliance on non-abundant materials, high cost, and a recycling process that consumes large amounts of energy and releases carbon dioxide.

"Next generation batteries should not only have high power and energy densities, but also be made from renewable and recyclable materials," says Luo. "Organic materials derived from biomasses are the best candidates for lightweight, flexible, transparent batteries because of their sustainability, environmental benignity and low cost." Luo would like to develop organic electrodes for Li-ion and sodium-ion (Na-ion) batteries. If commercialized, Na-ion batteries would provide a cheaper alternative to Li-ion technology.

Research on organic battery electrodes is still in its early stages, but Luo is excited about the possibilities—his project is currently unique on campus. The Wells Fellowship, he says, will enable him to synthesize several organic electrode compounds that he will test for electrochemical performance, and to acquire the detailed results he needs to pursue grants for further research and development.

In Luo's preliminary work, he used organic croconic acid disodium salt as a main component of an organic electrode for Li-ion and Na-ion batteries. His results demonstrated that using nanoscale salt particles coated with graphene oxide significantly enhanced the electrode's performance in both types of batteries. The results have been published in *Nano Letters* and the *Journal of Power Sources*.



LALEH EMDADI



ELECTRON MICROSCOPY IMAGE OF EMDADI'S MORDENITE FRAMEWORK INVERTED ZEOLITE.



CHAO LUO

See our back cover for an image of Chao Luo's organic nanowires!

studentn≡ws





TEAM THIRSTY TURTLES' CURRENT LINEUP, FRONT ROW (L-R): KELSEY FRANEY, AMANDA MERLOCK, KATIE POHIDA. MIDDLE ROW (L-R): RICHARD GRAVER, BRANDON HURN, KYLE LUDWIG. TOP ROW (L-R): MARK ADAMS, DAVID SHOEMAKER, ISAAC ZAYDENS. NOT PICTURED: JOSH CONDON, SARAH DE LEON (ECE), AND BEN GELINAS. THE TEAM IS ADVISED BY ASSOCIATE PROFESSOR CHUNSHENG WANG.

Chem-E Car Team Fundraising for Nationals

introducing After а new car and overcoming a course hazard at the American Institute of Chemical Engineers' mid-Atlan-Chem-E Car Competition, tic Team Thirsty Turtles is preparing for the nationals, to be held AIChE's annual meeting at this fall in Atlanta. Launch UMD, new crowdfunding program, wants to help them get there.

While the team is hard at work improving its fourth and newest car, *Testudo Mobile*, it's getting a boost in publicity and fundraising assistance from Launch UMD, a selective, Kickstarter-like program dedicated to helping University of Maryland students, faculty and staff pursue their passions.

The team has worked tirelessly to research, design and build the chemical reaction-powered vehicle, which must carry a cargo and travel a specified distance—both of which are only revealed at the competition. Each team must carefully calculate the duration of the reaction required to perform the task, taking variables like weight, mechanical properties, and flooring into account.

Although the team has sponsors, traveling to competitions is a major expense, and members have had to choose who gets to go while still leaving enough in their budget to upgrade *Testudo Mobile*. Since each one of them specializes in a particular aspect of the car, it's a strategic advantage to have as many of them in the "pit crew" as possible. Sending even a core team consumes most of the budget, leaving little to use for upgrades based on what they learned from the regionals.

Regardless of these challenges, team member and ChBE senior **Katie Pohida** feels working on *Testudo Mobile* and its predecessors has been about much more than winning. "Chem-E Car is about forming friendships, communicating with professors, networking with professionals, and learning what it takes to be an engineer in the real world," she says. "It's given us the chance to test our knowledge, and the AIChE competitions have given us the opportunity to attend seminars and meet students from around the nation."

But winning *would* be nice, Team Leader and ChBE senior **Brandon Hurn** admits. He believes *Testudo Mobile* will get the job done at the finals, and hopes working with Launch UMD will improve the team's chances.

"Whether it's construction materials, drivetrain components, or sending a hardworking student to the conference," he says, "we will use every donation to help our team win first place, and to do it in style!"

Team Thirsty Turtles' crowdfunding campaign runs through October 22 at **www.launch.umd.edu**. You can support the team at any time by visiting **ter.ps/chemecar**.

Learn more about how *Testudo Mobile* works and the contentious 2014 regional competition at **ter.ps/chemecarsp14**.

GIBBONS: ENGAGED FACULTY AWARD

William Gibbons (Ph.D.

'14) received the Clark School's ENGAGED Faculty Award for excellence in teaching. He was nominated for the honor by an undergraduate student enrolled in his Spring 2014 section of



WILL GIBBONS

Thermodynamics II. Gibbons was cited for being approachable and accessible, having high expectations of his students, providing advice and support on academic and extracurricular activities, and taking a genuine interest in and concern for his students, especially outside of class.

Over the course of his academic career, Gibbons was well-known for his dedication in the classroom and his outreach efforts. In 2013, he received ChBE's Teaching Assistant Award for his work as Professor **Richard V. Calabrese**'s lead TA in ENCH 422 and 424, Transport Processes I and II.

Full story: ter.ps/wgengaged

ZAYDENS NAMED MERRILL SCHOLAR

ChBE senior Issac Zaydens

was named a 2014-2015 Merrill Presidential Scholar. The award honors the University of Maryland's most successful rising seniors and their mentors from both the University faculty and their K-12 education. Each year,



ISAAC ZAYDENS

scholars and their mentors are recognized in a special ceremony, and teachers and faculty participate in a workshop designed to strengthen relationships between the university and K-12 schools.

Zaydens has been an anchoring member of ChBE's Chem-E car team, and has served as an officer in its student chapter of the AIChE. His past honors include an internship in Air Products' Hyco Product Engineering division in Allentown, Pa., arranged through the competitive SCI Scholars Program.

Full story: ter.ps/izmerrill

Students Win NSF Graduate Research Fellowship, Two Honorable Mentions

Sudabeh (Sudi) Jawahery (B.S. '14) was awarded a 2014 Graduate Research Fellowship from the National Science Foundation (NSF). **Lauren Dorsey** (B.S. '14) and ChBE graduate student **Svetlana Ikonomova** received Honorable Mentions.

The NSF's Graduate Research Fellowship Program is designed to ensure the diversity and quantity of the nation's scientists, mathematicians, and engineers by supporting outstanding students attending accredited U.S. colleges or universities. NSF Graduate Research Fellowships are among the most prestigious and selective in the country, and Honorable Mentions are considered an achievement in their own right.

Jawahery was a member of Fischell Department of Bioengineering Assistant Professor **Silvina Matysiak**'s Biomolecular Modeling Group, where she used molecular modeling techniques to study neurodegenerative disorders. In one of her projects, she studied the toxicity of the huntingtin protein, which forms aggregates (large clusters) that, in the pathology Huntington's disease, interfere with neuron function. Her work focused on discovering potentially toxic interactions between the mutant segment of the huntingtin protein and the lipid bilayers in cell membranes, which could play a role in mediating aggregate formation. This fall, Jawahery joined the doctoral program in chemical engineering at the University of California, Berkeley.

Ikonomova, advised by Assistant Professor **Amy Karlsson**, received an Honorable Mention for her work in developing a diagnostic array that can detect and identify different species of fungal pathogens, particularly *Candida albicans*, the cause of common health complaints including vaginal yeast infections and diaper rash. In immunocompromised patients, however, it is difficult to treat and even fatal. Ikonomova uses single-chain variable antibody fragments, which she engineers for improved affinity, to try to capture *Candida* fungal cells. *(See related story, p. 5.)*

Dorsey, a member of Associate Professor **Ganesh Sriram**'s Metabolic Engineering Laboratory, used metabolic flux analysis and isotopic labeling experiments to track how and where nitrogen, a key nutrient, is metabolized in plants. The subject of her studies was poplar, a tree being considered for use as a renewable biofuel crop. What she learned could explain how plant metabolism can be optimized to produce products such as biofuel precursors, and how their growth can be increased in nitrogen-deficient conditions. In her senior year, she and ChBE graduate student **Xiaofeng Zhang** examined evidence that a light-capturing protein, not poplar's bark storage protein, is responsible for storing nitrogen at the suspension cell level. This fall, Dorsey began doctoral studies in chemical and biomolecular engineering at the University of Delaware, where she hopes to continue her work in this area.

To learn more about the NSF Graduate Fellowship Research Program, visit www.nsfgrfp.org.



A. JAMES CLARK SCHOOL OF ENGINEERING

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WHAT'S THIS? Graduate student Chao Luo, a member of Associate Professor Chunsheng Wang's research group, hopes to turn organic nanowires like these into cheaper, more environmentally-friendly electrodes for lithium-ion batteries. His work is supported by one of the University of Maryland Energy Research Center's first two Wells Fellowships. Graduate student Laleh Emdadi, a member of Assistant Professor Dongxia Liu's research group, received the other. She is currently developing a novel, high-performance catalyst. For the story, see page 9. **COLUMNS** is published for alumni and friends of The Department of Chemical and Biomolecular Engineering at the A. James Clark School of Engineering. Your alumni news and comments are welcome. Please send them to:

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AICHE: BAGELS & GRITS 5, CHEM-E CAR, & MORE!

The Department of Chemical and Biomolecular Engineering at the A. James Clark School of Engineering, **UNIVERSITY OF MARYLAND** invites you to join us at the annual meeting of the AIChE in Atlanta, GA for:

Our Bagels and Grits Breakfast!

Meet our faculty and students. Learn more about our programs and our **current faculty search**. No RSVP required—see you there!

Monday, Nov. 17, 7:00-8:30 a.m., Location: TBA See our web site or visit us at AIChE for the most up-to-date info.

Chem-E Car Finals!

Cheer on our team, the Thirsty Turtles! (See page 10.) See the AIChE web site for more information.

Where else will we be at AiChE? Visit chbe.umd.edu/aiche for more information!