**FALL 2015** 



# CHEMICAL AND BIOMOLECULAR ENGINEERING

A. JAMES CLARK SCHOOL of ENGINEERING

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## Roll On!

UMD hosts AIChE's Mid Atlantic Student Conference and Chem-E Car Competition

INSIDE: TRACKING FRACKING | CHBE STARTUPS | MICRODEVICE MODELS | HONORS & AWARDS

### chair'sm≡ssage



#### WHAT IS MPACT?

We define that here in the A. James Clark School of Engineering as "transforming fearless ideas into new innovations that will benefit millions." Some of these could be direct; for example, a blood clotting bandage developed based on research done in a ChBE lab that recently received FDA approval (see p. 13). This transformation could be indirect, such as an idea nucleated within a new battery

research center co-founded by a ChBE faculty member and an Army Research Laboratory scientist (see p. 2) that could be the next big thing in energy storage.

Every day brings something new. However, none of our students or professors know whether this might be the day the idea that benefits millions will be discovered when they walk into the lab and start up a new process, hit "run" on a new simulation, or put pencil to paper to work out a new theory. But we know we want to try because we're engineers, and we live to solve problems. Maybe the new thing is the idea itself. Or maybe the new thing is a small part of a larger idea, requiring contributions from many others before a single person will benefit. Maybe the new thing is a Chem-E Car design that leads to second place in regionals amidst tough competition (see p. 4), but more importantly, leads to all team members benefiting from this valuable hands-on experience.

As engineers, we approach these never-been-tried-before things with a solid grounding in mathematics, chemistry and physics. We do them at a campus that has an incredible system in place for translating ideas into real processes and products that do improve lives. And our undergrads, graduate students and postdocs are there every step of the way, developing skills that they will take with them into the next phase of their careers.

I hope you enjoy reading about all of our stories of Mpact in this issue! I look forward to sharing many more. Go Terps!

Lalg. Lo

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

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#### ON THE COVER:

This little Chem-E Car, *Shelldon*, looks a lot like its predecessor, *Testudo Mobile*, but "under the hood"—or in this case, shell—it's powered by a reaction that is unique among its rivals. *Shelldon* debuted at the 2015 Mid-Atlantic AIChE Student Conference, hosted at UMD by Department of Chemical and Biomolecular Engineering students.

For the full story, see page 4.

### PARTN RSHIPS

### High Energy at Extreme Battery Center's First Meeting

UMD, ARMY RESEARCH LAB AND NIST LAUNCH CENTER FOR RESEARCH IN ADVANCED BATTERY MATERIALS

The Center for Research in Extreme Batteries (CREB), founded by members of the University of Maryland (UMD) and the U.S. Army Research Laboratory (ARL), hosted its first official meeting in May 2015. The event drew experts from throughout the Mid-Atlantic who discussed their efforts to develop batteries for use in some of the most challenging environments in the world–and beyond.

Launched in late 2014, CREB grew out of a partnership between Department of Chemical and Biomolecular Engineering (ChBE) associate professor **Chunsheng Wang** and ARL senior chemist **Kang Xu**. After a series of successful projects and publications, the pair proposed a center to promote open access to facilities and collaborative research in advanced battery materials, technologies and characterization techniques. The National Institute of Standards and Technology (NIST) joined UMD and ARL's efforts to make CREB a reality.

"The center's focus is university and national lab research that includes industry manufacturing for beyond state-of-the-art lithium-ion technologies," says **Cynthia Lundgren**, chief of ARL's electrochemistry program.

Originally conceptualized with the mission to solve practical battery problems faced by U.S. ground forces, CREB has already exceeded its founders' expectations, says Professor **Eric Wachsman**, director of the University of Maryland Energy Research Center and a member of CREB's steering committee. After the center's announcement and launch, he says, "interest was overwhelming." CREB was contacted by scientists throughout the region, and from fields they had not originally expected. This enthusiasm helped the new center refine its goals.

"The battery community tends to be focused on making cheaper batteries for automotive applications," says Wachsman, who

develops solid oxide fuel cells, "and there's a big need for that. But in developing these new batteries, we discover all kinds of chemistries that are really high performance, but not necessarily low cost. For a car, cost is the most important thing. But when it comes to the Department of Defense, NASA and biomedical applications, the primary factor is the battery's performance. Can it take radiation in space? Can it survive extreme heat and cold? Can it take a bullet? Can it be implanted in a body? Those environments are extreme, and that's why we developed this center for research in extreme performance, environments, and applications. That







THE CENTER FOR RESEARCH IN EXTREME BATTERIES' STEERING COMMITTEE. LEFT TO RIGHT: DAVID JACOBSON (NIST), CHUNSHENG WANG (UMD), KANG XU (ARL), CYNTHIA LUNDGREN (ARL), JOSEPH DURA, (NIST), ERIC WACHSMAN (UMD) AND WILLIAM ACKER (NEW YORK BATTERY AND ENERGY STORAGE TECHNOLOGY CONSORTIUM). PHOTO AND PHOTOS BELOW COURTESY OF DOUG LAFON, ARL.

is an area that has been overlooked by the vast majority of battery centers."

In addition to presenting research, attendees of CREB's first official meeting discussed how to recruit new participants, define membership, establish a framework for research funding and operational support, and increase awareness of the center in industry, government and academic institutions.

"The meeting brought scientists and engineers from UMD, industry, the military, and national labs together to discuss how we can coordinate our efforts to solve critical problems in lithium-ion batteries," says Wang, who is also a member of the center's steering committee. "CREB has already accelerated my own group's research in nanostructured electrodes, which has resulted in several key advancements in battery technology. I'm looking forward to new partnerships."

Funding has been approved for a stateof-the-art dry room that has been proposed to be the center's core facility. New equipment, including an electrochemical *in-situ* atomic force microscope with confocal Raman capability, is also in procurement.

### **COV**ERstory



CHERYL TEICH

### Undergraduates Host AIChE Mid-Atlantic Student Conference

Chem-E Car Shelldon heads to nationals!



In a dramatic finish, Carnegie Mellon literally inched out the University of Maryland in the 2015 Chem-E Car Competition, held at the American Institute of Chemical Engineers (AIChE) Mid-Atlantic Student Conference. The Terps' second place finish still qualifies them for the national competition, to be held at the annual meeting of the AIChE in November.

Chem-E Car was just one of the activities at the conference, which was organized by UMD's student chapter of the AIChE and hosted on the College Park campus in April. More than 300 students and their advisors attended from universities in Delaware, Maryland, New Jersey, New York, Pennsylvania, and Virginia.

#### **KEYNOTE & BANQUET ADDRESSES**

**Steven Chalk** (B.S. '83), Deputy Assistant Secretary for Department of Energy's Office of Energy Efficiency and Renewable Energy, presented the conference's keynote address. Chalk oversees the nation's "clean energy portfolio," including wind, solar, geothermal, hydropower, biomass, and hydrogen technologies. He has also worked to integrate renewable technologies into the U.S.'s electric grid, implemented \$17 billion in research grants, and supported the creation of new clean energy tax programs.

AIChE President and Fellow **Cheryl Teich** spoke at the conference's banquet and awards ceremony. She currently serves as the Process Engineering and Reaction Engineering Leader at the Dow Chemical Company. Teich considers herself an "expert generalist" in process development, scale up, reaction engineering, and problem solving. Her career has focused on process development and scale up of specialty materials.

"One of my favorite parts of the conference was Cheryl Teich describing the football inflation scandal ["Deflategate"], in demonstrative fashion, as an example of gauge versus absolute pressure units confusion," said ChBE professor and chair **Sheryl Ehrman**.

#### CHEM-E CAR COMPETITION RESULTS

Fifteen cars from thirteen schools competed in this year's Chem-E Car Competition, which challenges students to design and construct small, chemically powered model vehicles. The cars must carry a specified cargo over a distance only revealed at the competition, and stop as close to a finish line as possible. Any kind of chemical reaction may be used. Each team must carefully calculate the duration of the reaction required when they are told how far their vehicle must travel. This year, AIChE officials announced a target distance of 22 meters (72.18 feet) and a payload of 300 mL (10.14 ounces) of water.

**Team Thirsty Turtles** fielded its fifth Chem-E car, *Shelldon. Shelldon* proved to be the most consistent and reliable car overall,



but was a mere five centimeters (1.9 inches) farther from the finish line than Carnegie Mellon's vehicle after the teams' second runs.Virginia Tech placed third, the City College of New York placed fourth, and Johns Hopkins University rounded out the top five teams, which are now qualified to compete at the national level.

"With global investment in clean energy approaching \$1 trillion in a few years, I highly encourage engineering graduates to consider a career path in researching and deploying energy efficiency and renewable energy technologies. There are lots of interesting problems to be solved involving fluid dynamics, electrochemistry, thermodynamics, heat transfer and more."

#### -Steven Chalk (B.S. '83)

"We are very pleased," says team member and then-AIChE student chapter president Katie Pohida (B.S. '15). "Even though another team came in first, our car performed almost perfectly." Shelldon, she explains, is powered by a reaction that had never been used in a Chem-E Car before. "Most teams use some form of a pressure timed reaction or the iodine clock reaction. [Ours] is unique because it continually oscillates, giving us another avenue in timing the car. Counting oscillations gives us the ability to target any distance the judges may give us. Our reaction team and their leader, Alyssa Brown, spent countless hours trying to perfect the color, period of oscillation, and clarity of the solution.

Our reaction is very sensitive to changes in concentration, so they definitely need to be exact when measuring chemicals."

Team Thirsty Turtles is sponsored by BASF, W.L. Gore & Associates, W.R. Grace, and the generous donors who participated in the team's recent Launch UMD crowdfunding campaign, which raised \$5,900 from 96 people over 30 days.

#### PROFESSIONAL WORKSHOPS

The conference offered four professional workshops designed to help students prepare for careers in chemical engineering. Session topics included understanding corporate culture, process simulations in the real world, interviewing strategies, membership in AIChE after graduation, consulting, careers in national agencies, and how to host forums and dinners. A special researchoriented session and laboratory tours were presented by ChBE assistant professors **Amy Karlsson** and **Dongxia Liu**.

#### RESEARCH

The conference hosted undergraduate research poster and paper competitions that attracted more than 50 total entries. Major **Steve Winter** (United States Military Academy) and Assistant Professor **Mary Staehle** (Rowan University) judged the posters. Paper presentations were judged by members of the National Capital Section of the AIChE, including Dr. **Milind B. Ajinkya**, Dr. **Cynthia DeBisschop**, Dr. **Marshall Lih**, Dr. **Treniece Terry**, ChBE associate professor Dr. **Nam Sun Wang**, and Dr. **Robert Wellek**.

#### FUN

Other activities included ChemE Jeopardy, which the University of Maryland won, qualifying them to compete at the national conference; and a Student Bash. The conference concluded with a banquet and awards ceremony.

### researchMpact

### Emissions from Natural Gas Wells May Travel Far Downwind

Emissions linked to hydraulic fracturing, the method of drilling for natural gas commonly known as "fracking," can be detected hundreds of miles away in states that forbid or strictly control the practice, according to a paper published in the journal *Atmospheric Environment*. The study, conducted at the University of Maryland, is among the latest data presented in the ongoing debate over fracking's long-term effects on the environment.

The team used years' worth of hourly measurements from photochemical assessment monitoring stations in the Baltimore, Md., and Washington, D.C., areas to identify the sources of organic carbons in the region's air. Starting in 2010, the data didn't seem to make sense.

"While there's been an overall decline in non-methane organic carbons and improvement in air quality since 1996, the atmospheric concentration of ethane, one of the components of natural gas, rose 30 percent between 2010 and 2013," says ChBE professor and chair **Sheryl Ehrman**, the paper's corresponding author.

Methane accounts for 80–95 percent of the makeup of natural gas, and it is thought to have a global warming potential roughly 30 times greater than that of carbon dioxide. Until recently,

however, monitoring it has not been a priority. Ehrman and her team could not acquire enough long-term methane data for the study, so they instead tracked other "tracer species" (molecules) such as ethane, the second most abundant compound in natural gas, and indicative of emis-

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sions associated with natural gas drilling, production, and transport.

Preliminary research revealed that there was nothing happening in Maryland that could account for the steep increase. Maryland does not currently permit fracking. After running a wind rose analysis—a tool used by meteorologists to track wind direction, distribution and speed in a specified area—they felt even more confident that Maryland was receiving the tail end of emissions originating in Pennsylvania, West Virginia, and Ohio.

"Two thirds of the time the Baltimore region was downwind of the Marcellus shale play," Ehrman says.

"The question you start to ask yourself is, if ethane levels are going up this much, and it's only a small percentage of all natural gas, how much methane and other, more reactive emissions are escaping from these wells?" says ChBE Ph.D. student **Tim Vinciguerra**, the paper's lead author. "Following the fracturing process, the well undergoes completion venting to clear out fluid and debris before production. A substantial amount of hydrocarbons are emitted as a result of this flowback procedure."

And harmful emissions don't necessarily have to come from the well to be a



SHERYL EHRMAN'S AIR QUALITY STUDENTS. FRONT ROW, LEFT TO RIGHT: TIM VINCIGUERRA, ALEXA CHITTAMS, RAHMA ZAKARIA, CINDI M'BAGUI MATSANGA. BACK ROW, LEFT TO RIGHT: DR. EHRMAN, THOMAS DESKIN, VITOR GONCALVES.

#### WHAT IS MPACT?

ENGINEERS HAVE THE UNIQUE CAPABILITY TO INNOVATE AND DESIGN NOVEL PRODUCTS AND FIND NOVEL SOLUTIONS THAT CAN IMPROVE MILLIONS OF LIVES. AT THE CLARK SCHOOL WE PLACE A SPECIAL EMPHASIS ON TRANSFORMING FEARLESS IDEAS INTO NEW INNOVATIONS THAT BENEFIT MILLIONS. THIS IS WHAT WE CALL "MPACT."

byproduct of fracking, he adds. "The diesel engines running the trucks and drilling equipment over long periods of time emit additional pollutants such as nitrogen oxides, particulate matter, sulfur dioxide, and larger hydrocarbons that also affect air quality."

"We've seen a statistically significant difference in the air quality on the days the wind passed over areas heavy in natural gas production versus the wind coming from areas with no known production," says Ehrman Group member **Alexa Chittams**, a Department of Electrical and Computer Engineering junior currently performing detailed wind trajectory analyses that could provide additional evidence that the ethane in Maryland came from neighboring states. "This suggests that areas of natural gas production contributed to the trends in ethane increase."

"What these results mean to me is that we've got strong indications that it's a regional issue," says Ehrman. "What we want to do is bring this to people's attention, advocate for long-term methane monitoring, and promote regional cooperation in monitoring and reducing emissions from natural gas production."

These new findings on natural gas emissions are also consistent with established findings by University of Maryland scientists showing that westerly winds can carry power plant emissions and other pollution from states like Ohio, West Virginia, and Pennsylvania to the Washington, D.C., region and elsewhere along the East Coast.

This work was funded by the National Science Foundation, the Maryland Department of the Environment, and NASA.

#### For More Information:

Timothy Vinciguerra *et al.* Regional Air Quality Impacts of Hydraulic Fracturing and Shale Natural Gas Activity: Evidence from Ambient VOC Observations. *Atmospheric Environment*, 110 (April): 144-150 (2015).

### researchnews

### Edible Materials Could Help Break Up Oil Slicks

#### RAGHAVAN GROUP'S EFFORTS PART OF GULF OF MEXICO RESEARCH INITIATIVE

There are currently no "ideal" options for cleaning up an oil spill. Chemical dispersants, such as the COREXIT 9500A used after the *Deepwater Horizon* event in 2010, contain ingredients whose longterm effects on the environment and on marine life are unclear or unknown. The decision to use them is a controversial one: breaking spills into small droplets using even more things that shouldn't be in the ocean is problematic, but surface slicks and oil washing up on shores is probably worse.

Members of ChBE's Complex Fluids and Nanomaterials Group are conducting fundamental research on nontoxic materials that may one day be used to create safer dispersants. Results published in *Langmuir* describe a new food-grade emulsifier that creates smaller droplets of crude oil in seawater and keeps them apart longer than COREXIT 9500A. The ongoing project is funded by the Gulf of Mexico Research Initiative (GoMRI).

The key ingredients in dispersants are molecules called surfactants or emulsifiers, which enable the mixing of typically unblendable substances such as oil and water. These are used to create many household products including paint, cosmetics, ice cream, and salad dressing. Attacking an oil spill with dispersants is like shaking a bottle of salad dressing on an immense scale, then adding an ingredient to prevent the oil from coalescing and rising to the top of the bottle for as long as possible. The goal is to sink the oil and distribute it as widely as possible, in the smallest droplets possible. Dispersants can also be deployed underwater at leaking wells to prevent oil from reaching the surface.

In theory, this should make it easier for ocean dwelling, oil-consuming bacteria to remove spilled oil. But far below the waves, fish and crustaceans-including those we eatwill absorb or consume the droplets too.

It is for that reason Professor **Srinivasa Raghavan**, the director of the Complex Fluids and Nanomaterials Group, has partnered with Professor **Vijay John** and his research group at Tulane University to explore whether each component of an oil dispersant can be made from nontoxic, biodegradable materials while offering performance equal to or better than current commercial products. It won't change the oil in any way, but it

would make using dispersants a little safer. The team combined two surfactants to create a new emulsifier that is effective on mixtures of crude oil and seawater. One of these materials is lecithin, a natural phospholipid (a type of fat) found in soybeans, certain seeds, and eggs. The other is a polysorbate (a combination of natural sugar alcohol and fatty acids) called Tween 80<sup>®</sup>, which makes products like ice cream smoother. Both are amphiphiles, meaning their molecules are attracted to water on one end and fats and oils on the other. While neither is an effective emulsifier on its own, they make a great team in a 60/40 lecithin/Tween 80 blend.

When exposed to a mixture of seawater and crude oil, lecithin's and Tween 80's amphiphilic ("fat-loving") ends attach themselves to the oil. As these connections are made, the oil is broken into droplets coated with a thin film of densely packed surfactant molecules whose hydrophillic ("water-loving") ends face the seawater. The lechithin maintains a particularly strong grip on the oil, while the Tween 80's large hydrophilic ends block the droplets' ability to merge with each other or back into the slick.

A comparison of the new lecithin/ Tween 80 blend with the Corexit 9500A used in the Gulf of Mexico spill shows that the former leads to smaller oil droplets that remain stable and prevent coalescence for a



STABLE EMULSION USING FOOD-GRADE AMPHIPHILES

much longer period of time. The size and stability of crude oil droplets are believed to be important to their dispersion and eventual degradation in the ocean, a process that could take years.

"The rate at which the oil degrades varies enormously, depending on factors such as water temperature, oxygen levels, and the physical and chemical nature of the oil," explains graduate student **Jasmin Athas** (Department of Chemistry and Biochemistry), the paper's first author and a member of Raghavan's group. "The more resistant the oil droplets are to coalescence, the better. The fact that they are stabilized by a material that the bacteria might also eat is a bonus."

Athas stresses that the current work is a proof of concept, the first step in designing a new dispersant. In the next phase of the research, the group will explore replacing another key ingredient, the solvent, which is the liquid medium that holds the emulsifier so that it can be sprayed as evenly as possible over an oil spill.

#### For More Information:

Jasmin C. Athas *et al.* An Effective Dispersant for Oil Spills Based on Food-Grade Amphiphiles. *Langmuir* 30, 9285-9294 (2014).

### researchnews New Models Will Improve Design of Biomedical Devices

Researchers who study artificial capsules in microcapillary (pipe-like) and microfluidic (channel-like) devices now have easier ways to characterize their behavior thanks to a new pair of methodologies developed by ChBE professor **Panos Dimitrakopoulos**.

The study of these tiny, fluid-filled membranes and their behavior in viscous flows has steadily increased due to their versatility in engineering, pharmaceutical, agricultural, and biomedical applications, and in the fabrication of microparticles with desirable properties.

"The ability to determine the elastic properties of the membranes of artificial capsules is essential to improving the design of the devices in which they are utilized," explains Dimitrakopoulos.

For example, researchers designing drug delivery systems need to know under what conditions the capsule's membrane will rupture and release its cargo due to excessive deformation as it is pushed through small capillaries.

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The elasticity of a capsule membrane is characterized by its shear modulus (the resistance to a change in its shape but not its surface area) and its area-dilatation modulus capsule deforms, and calculating the former typically requires knowing the latter. This results in researchers having to use multiple devices and perform a significant amount of testing in order to separate shear from areadilatation effects and calculate the value of the individual moduli.

Dimitrakopoulos' first methodology explains how to derive both the shear and area-dilatation moduli of a capsule in a single experiment conducted in a microfluidic device. The capsule is placed at the intersection of two channels in what is known as a "four-roll mill" device. As liquid flows through, it diverts around the capsule, splitting and turning left and right into perpendicular channels. These multidirectional flows both deform the capsule and create a "stagnation point" at the center of the intersection, holding it in place. The flow strength is increased to create greater distortions of the capsule's width and length that can be recorded visually by a camera. The value of both elastic moduli can then be derived by comparing these lengths with computational results obtained by Dimitrakopoulos' group.

The second methodology describes how to determine a membrane's shear

modulus, independent of its areadilatation modulus, by flowing a capsule through a microcapillary device that suddenly narrows to a diameter comparable in size. The capsule's length is measured from photos that capture it at its maximum defor-



A MODEL SHOWING THE DISTORTION OF A CAPSULE AS IT SQUEEZES THROUGH A MICROCAPILLARY DEVICE. MEASUREMENTS USED TO DETERMINE ITS SHEAR MODULUS ARE TAKEN AT ITS GREATEST DISTORTION/ELONGATION, WHICH OCCURS AS IT PASSES THROUGH THE BOTTLENECK.

(the resistance to an increase in its surface area without changing its shape). Acquiring this information from a tiny capsule inside a microscale device isn't easy. Shear and area-dilatation occur simultaneously as a

mation as it is forced to squeeze through this bottleneck. In its computational investigation, Dimitrakopoulos' group showed that the capsule's maximum elongation is characterized by local shape-changing under a



ABOVE: A DIAGRAM OF THE PLANAR EXTENSIONAL FLUID FLOW IN A MICROFLUIDIC DEVICE THAT HOLDS AND DEFORMS A CAPSULE AT ITS CENTER. BELOW: A MODEL OF THE STEADY-STATE LAMELLAR SHAPE OF A CAPSULE WITH LOW MEMBRANE HARDNESS WHILE IN THE MICROFLUIDIC DEVICE.

constant surface area, and therefore depends only on the membrane's shear modulus. Comparing experimental measurements of the capsule's maximum elongation with computational results derived for the same microdevice, the membrane's shear modulus can be determined without the need to know its area-dilatation modulus.

The new techniques are the latest developments in Dimitrakopoulos' ongoing computational studies, which include the behavior of artificial capsules and red blood cells in microfluidic devices, the microcirculation of the human body and in disease states.

#### For More Information:

P. Dimitrakopoulos, "Effects of membrane stiffness and scaling analysis for capsules in planar extensional flows," *J. Fluid Mech.,* 745, 487-508 (2014).

P. Dimitrakopoulos and S. Kuriakose, "Determining a membrane's shear modulus, independent of its area-dilatation modulus, via capsule flow in a converging microcapillary," *Soft Matter*, 11, 2782-2793 (2015).

### facultyn≡ws

### Anisimov Wins Touloukian and USM Regents Awards

In 2015 ChBE professor **Mikhail Anisimov** received both the Yeram S. Touloukian Award from the American Society of Mechanical Engineers' (ASME) Heat Transfer Division and the University System of Maryland's Board of Regents Faculty Award for Scholarship, Research, or Creative Activity.

The Touloukian Award, established in 1988, recognizes "outstanding technical contributions in the field of thermophysical properties" and has become the most prestigious international honor of its kind. The ASME cited Anisimov "for the performance of crucial experiments and introduction of new concepts: isomorphism, non-asymptotic critical behavior, complete scaling, and competing length scales, for deepening the understanding of phase behavior, criticality, and thermophysical properties of complex fluids, liquid crystals, polymer solutions, supercooled water, and crude oils." The award included a bronze



UMD PRESIDENT **WALLACE LOH** (LEFT) PRESENTS **MIKHAIL ANISIMOV** WITH THE REGENTS AWARD.

medal and travel expenses paid to attend a presentation ceremony.

Established in 1995, the Board of Regents Faculty Awards represent the highest honors given to professors throughout the university system. Candidates are reviewed and selected by the Council of University System Faculty and approved by the board in five categories: excellence in teaching; scholarship, research, or creative activities; public service; mentoring; and collaboration. Honorees receive a \$1000 cash prize and a plaque.

Anisimov's research interests include critical phenomena and phase transitions in supercooled water, fluids, fluid mixtures, liquid crystals, and surfactant and polymer solutions. He has co-authored major works including a theory-based calculation for the critical parameters of aqueous solutions of sodium chloride and a new international formulation of the thermal conductivity of water and steam. He is an elected Fellow of multiple societies, including the AIChE, AAAS, and APS; and an elected member of the New York Academy of Sciences, the Russian Academy of Natural Sciences.

### Choi Patents Plastic-Producing Particles

A three-dimensional silica particle and its accompanying reaction engineering process, both invented by ChBE professor **Kyu Yong Choi**, are poised to boost the efficiency and lower the cost of producing some of the world's most important commodity plastics. The system received U.S. Patent 8,940,655 earlier this year.

Silica, a porous material with an extremely high surface area, is ideal for use as an inert, flat substrate (surface) on which to perform high-activity catalytic reactions. These reactions are used to create polymers such as polyethylene and polypropylene, but according to Choi, they are currently highly inefficient. Reactions end prematurely, wasting up to 90 percent of the catalyst.

Choi and his team have created a new, three dimensional, ultraporous silica nanoparticle that allows 80-90 percent of the catalyst to react, resulting in less waste and a higher product yield. Known as "pseudo inverse opal silica" (PIOS) for its similarity in structure and color to the gem, the particle takes the form of something like empty eggshells clumped together in a sphere, forming a ball made out of tiny, empty balls.

The PIOS particles provide about the same amount of surface area and pores as their two dimensional counterparts, but their open structure allows both catalysts and reactants to get to their reaction sites quickly and easily, instead of being limited to squeezing and in out of tiny pores. The open regions also allow the product of the reactions, the polymer, to "get out of the way" and expose new reaction sites. The initial reaction rate is extremely high, and more than twice as much polymer is produced than in current industry-standard reactions.



A 3D PSEUDO-INVERSE OPAL SILICA (PIOS) MICROPARTICLE PRODUCED IN CHOI'S POLYMER REACTION ENGINEERING LAB. A PIOS IS A SPHERICAL ARRANGEMENT OF HOLLOW SILICA SUBPARTICLES THAT EXHIBITS A HUGE SURFACE AREA AND A WIDE-OPEN AND INTERCONNECTED INTERNAL STRUCTURE. THESE NOVEL PARTICLES HAVE APPLICATIONS IN CO<sub>2</sub> CAPTURE, SUPPORTED CATALYSIS, CHEMO-SENSING, AND MORE. SEE **GO.UMD.EDU/PIOS** TO LEARN HOW THESE UNIQUE PARTICLES ARE MADE.

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### alumninews



LAUREN DORSEY



MERON TESFAYE



NICHOLAS YARAGHI

### Two ChBE Alumnae Win NSF Graduate Research Fellowships

#### ALUMNUS RECEIVES HONORABLE MENTION

Department of Chemical and Biomolecular Engineering (ChBE) alumnae **Lauren Dorsey** (B.S. '14) and **Meron Tesfaye** (B.S. '13) were awarded Graduate Research Fellowships from the National Science Foundation (NSF). ChBE alumnus **Nicholas Yaraghi** (B.S. '13) received an Honorable Mention.

NSF Graduate Research Fellowships, which are among the most prestigious academic awards in the nation, provide three years of support that may be used over a five-year period. For each year of support, the NSF provides a stipend of \$30,000 to the fellow and a cost-of-education allowance of \$10,500 to the degree-granting institution. Honorable Mentions are granted to meritorious applicants who do not receive fellowship awards as an acknowledgement of significant national academic achievement.

Dorsey is starting her second year of Ph.D. studies in the University of Delaware's Department of Chemical and Biomolecular Engineering, where she works in Professor **Wilfred Chen**'s protein engineering lab. Her current work focuses on engineering a synthetic consortial biofilm. Outside of the lab, she is an active member of the department's Chemical Engineering Graduate Student Club.

"It means a lot that [ChBE] at the University of Maryland was so supportive through the [NSF] application process, and especially now that I've graduated," she says.

Tesfaye is currently a third year chemical engineering Ph.D. student in Professor **Adam Weber**'s research group at the University of California, Berkeley and Lawrence Berkeley National Lab. Weber is a member of the Berkeley Energy Storage and Conversion for Transportation and Renewables (BESTAR) Program, an umbrella organization that addresses the technological barriers to making clean energy technologies widely available. Tesfaye's contributions toward this goal focus on understanding transport resistances in the catalyst layer of fuel cells. Currently, she is studying gas transport through ultrathin nafion membranes and the effect of humidity on them. Her previous projects include hydrogen production of algae, TiO<sub>2</sub> thin films for solar applications, and process optimization in plasticizer synthesis.

Yaraghi is currently a third year Ph.D. student in the Department of Chemical and Environmental Engineering at the University of California, Riverside. He works in Professor **David Kisailus**' Biomimetics and Nanostructured Materials Lab, where he is studying the structure-mechanical property relationships of damage-tolerant composite materials found in the dactyl club (feeding appendage) of the beautiful-but-infamous mantis shrimp, which can smash its shelled prey and even break aquarium glass. Yaraghi is investigating how these clubs form in nature in order to design bio-inspired, impactresistant synthetic composite materials. He was also recently awarded a National Defense Science & Engineering Graduate Fellowship through the Department of Defense. In 2014, he won a Best Poster Award at the Materials Research Society (MRS) Spring Meeting & Exhibit. After completing his doctorate, he would like to pursue a career in academia or at a national laboratory.

### **G**ENEROSITY

### Alumnus Creates New Scholarship

THE DR. JAIME A. VALENCIA '74 CHEMICAL ENGINEERING ENDOWED SCHOLARSHIP FUND SUPPORTS CHBE STUDENTS AT THE CLARK SCHOOL



In 1970, a University of Maryland scholarship made it possible for **Jaime Valencia** (B.S. '74) to travel from Arequipa, Peru to College Park to study chemical engineering. Despite a heavy course load, doing his first semester's homework "with a dictionary in one hand," and working part time, he loved his time at Maryland.

The education and mentorship Valencia received helped him launch a successful career as an inventor, entre-

preneur, and leader in the oil and gas industry. Inspired by his experiences and supported by matching funds from the ExxonMobil Corporation, Valencia has established an endowed scholarship fund which he hopes will help the next generation of UMD undergraduates get a professional education in ChBE.

Valencia was a curious child who was always interested in technology and would take apart toys to see how they worked. His love of chemistry, physics, math and the development of new technologies made chemical engineering a perfect career choice.

Today, he leads Technology Development and Commercialization efforts at ExxonMobil Upstream Research and is a member of the Clark School's Board of Visitors. He lives in the Houston, Texas area with his wife, daughter and son.

"I was very fortunate to have had great opportunities in the oil and gas field, in which the identification of a need, thermodynamic analysis, some creative thinking, and process simulation led to my developing some novel technologies," he says.

Among those technologies are the Controlled Freeze Zone<sup>™</sup>, a cryogenic process for the removal and geosequestration of CO<sub>2</sub> and

other contaminants in natural gas; flue gas desulfurization technologies; and a modeling system used to analyze process plant data. He was also the cofounder of a process technology company that was later acquired by a global oil company.

While earning his B.S. and a minor in nuclear engineering, Valencia took advantage of what was at the time a rare opportunity: access to the university's mainframe computer. Engineering students were issued \$50 accounts that they could use to pay for time on a terminal. The department chair, Professor **Joseph M. Marchello**, received an account containing \$1500 in credit.

"He wasn't interested in using the computer, so when I asked him if I could use his account, he said, 'You can have it,'' Valencia recalls. "I was in paradise. I taught myself computer programming and played with it quite a bit. I used to do my homework and generate graphs with it...that was unheard of. Back

#### ABOUT THE FUND

The Dr. Jaime A. Valencia '74 Chemical Engineering Endowed Scholarship Fund was established by a gift from its namesake and a matching gift from the ExxonMobil Corporation. Students majoring in ChBE with a GPE of 3.0 or higher are eligible for this merit-based, \$1000 scholarship. Each academic year, the Clark School will select a recipient, who may continue to receive the scholarship in subsequent years if he or she maintains a GPA of at least 3.0. The first scholarship will be awarded in the 2015-2016 school year.

To learn more about establishing scholarships, contact **Heather Medina**, A. James Clark School of Engineering Assistant Director of Development, at **301-405-3303** or **hmedina@umd.edu**.

### ter.ps/supportchbe

Gifts of any amount can be made to the Chemical & Biomolecular Engineering Fund, which supports the educational and research needs of our students and faculty.

then, access to the mainframe was difficult and not many people used the computer for much of anything."

His new skills got the attention of his physical chemistry professor, **John "Jack" Moore**, who asked him to write a spectral de-convolution program for his plasma generator. Although Valencia initially had no idea what that meant, he managed to do it and the instrumentation ultimately became part of a space probe that gathered information about the sun. Moore would later suggest actually insist—that Valencia apply to MIT for graduate school. Valencia received his Sc.D. from MIT in 1978.

Technology and analytical tools, he says, are among the things that have changed most since he was a student. His enthusiasm and

> willingness to embrace, guide, and even invent those changes have fueled his career.

Asked what advice he has for engineers interested in entrepreneurship, Valencia says, "Having your own business will involve hard and long work, but if you are passionate about it you will not notice it....One must have a clear goal and a road map to get there...and must adjust it according to the 'road' and 'weather' conditions."

ABOVE: JAIME VALENCIA IN 1974. BELOW: OUTSIDE OF WORK, VALENCIA'S FAVORITE HOBBIES ARE FOLLOWING FORMULA 1 GRAND PRIX RACING AND DRIVING SPORTS CARS, INCLUDING HIS OWN PORSCHE AND FERRARI. HERE, HE'S TESTING A LAMBORGHINI GALLARDO AT A TRACK NEAR HOUSTON.



### Image: Imag



Making a great catch like the astonishing three-fingered touchdown reception by New York Giants receiver **Odell Beckham Jr.** in 2014 requires exceptional timing, skill, strength, hand-eye coordination...and sticky gloves. But there's a catch to the catch those gloves quickly wear out. **Grip Boost LLC**, a company formed by UMD alumni, has created an inexpensive, quick-drying gel that keeps football gloves ready for the next great play. Grip Boost<sup>™</sup> is the first NCAAcompliant product on the market to restore old gloves to like-new condition without leaving residue on the ball.

Football players often wear gloves coated with a tacky polymer that helps keep the ball from slipping through their hands, but the stickiness doesn't last very long.

"Depending on your position and the game, they could last anywhere from a few weeks to only a few plays before the [original] coating wears down," says former UMD and Baltimore Ravens tight end **Matt Furstenburg** (B.S. '12), one of Grip Boost's cofounders. New gloves retail from \$20 to over \$80 a pair. That's not a problem for a professional or Division I college team, but it's a major expense for youth league and high school players, who typically have to buy their own non-essential equipment. Furstenburg saw an opportunity to create an affordable product that could make the gloves last longer.

He partnered with cofounder **Harry Geller**, an entrepreneur-in-residence at UMD's Robert H. Smith School of Business. The Maryland Technology Enterprise Institute connected the pair with their future cofounders, all members of ChBE professor **Srinivasa Raghavan**'s research group.

Raghavan's group has extensive experience developing products made with strategically modified chitosan, a natural biopolymer with high adhesive and tack properties. Because it is non-toxic and adheres to skin, tissue and cells, the group has used it to develop blood-clotting bandages, foams and surgical sprays (see story at right).

### Grip Boost is Catching On!

"We found it sticks to footballs pretty well, too," says cofounder **Chanda Arya** (Ph.D. '14), one of Raghavan's former students. Arya, along with fellow cofounders and lab-mates **Kevin Diehn** (M.S. '14) and **Zachary Rom** (B.S. '15), took up the challenge of creating a chitosan-based product that did not leave residue on the ball, did not exceed the tackiness of existing gloves, and could be used quickly and easily. The team verified Grip Boost met the first two requirements using friction coefficient, tack and residue tests, and addressed the third by making the modified chitosan highly soluble in alcohol.

The result was a quick-drying, easy to use, clear gel. Players apply a small amount to their gloved hands and rub them together. When the alcohol evaporates 15–20 seconds later, a thin, tacky film is left behind, restoring the gloves to their original condition. A two-ounce bottle of Grip Boost contains about 60 applications.



### FDA Clears Blood Clotting Pad Developed in ChBE for Sale

A fast-acting, blood-clotting bandage developed in ChBE professor Srinivasa Raghavan's Complex Fluids and Nanomaterials lab has been cleared for sale by the U.S. Food and Drug Administration (FDA). The product, called the Hemogrip<sup>™</sup> Patch, is made by **Remedium** 

> Technologies, a startup company launched by its inventor, alumnus Matthew Dowling (Ph.D. '10, bioengineering). Raghavan, who serves as Remedium's scientific advisor, was Dowling's Ph.D. advisor.

Hemogrip's patented, life-saving technology is based on modified chitosan, a biopolymer derived from chitin, which is found in the exoskeletons of shrimp, crabs, and other crustaceans. Chitosan is a unique natural material because it is biocompatible, anti-microbial, and highly durable under a wide range of environmental conditions.

When applied to wounds, Hemogrip almost immediately creates a three-dimensional nanoscale mesh that coagulates blood and stops hemorrhaging. Despite its effective Velcro-like interactions with tissue, it is gentle enough to be removed from the patient without causing further injury. The pad is designed to be used by surgeons, soldiers, first responders, or even unskilled helpers in locations ranging from the operating room to the battlefield.

Dowling says that what makes his product stand out from similar ones is its improved physical properties, which allow it to hold together under higher blood pressure flows.

More importantly, he adds, clearing the Hemogrip Patch for sale represents a regulatory milestone that paves the way for Remdium to seek FDA approval for and commercialize a suite of unique products based on the same technology. These include a sprayable foam that expands into large and deep body cavity wounds, where direct pressure cannot be applied.

People with shellfish allergies have nothing to fear from Hemogrip, Dowling says, because process of converting chitin into modified chitosan removes protein impurities responsible for allergic reactions. Past clinical studies of chitosan-based bandages on patients with known shellfish allergies have demonstrated their safety.

"Remedium is an excellent example of how the University of Maryland's unique entrepreneurship programs support the transformation of research into real products that impact lives and bolster the economy," says Professor Patrick O'Shea, UMD's Vice President and Chief Research Officer. "Our programs are open to all students and faculty members who are excited about learning how to create a clear business plan, navigate the patent and licensing processes with ease, and launch a successful startup company."

Learn more:

go.umd.edu/hemogripfoam remediumtechnologies.com go.umd.edu/hemogripcen

The company is now focused on marketing, sales, and scale-up. Sales have risen 50 percent per quarter, and are currently at 400-500 bottles a month.

Remedium

Hemogrip"

CHNOLOGIES

INSTRUCTIONS FOR USE

apply new bandage

CAUTIONS/WARNINGS

. Apply dressing directly over actively bleeding wour Apply pressure to backing for at least 2 minute required) for dressing to adhere and bleeding

3. Apply outer bandage wrap (not included) to 4. If bandage fails to adhere, remove, wipe wo

5. Remove dressing within 24 hours with sali

Do not use if seal is broken and/or contents

over eyes. Use promptly after opening. Contains chitos

Use prompty and opening, contains and for external use only, do not implant. Not for eat. Single use only. Do not re-sterilize.

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Success, however, came with its own challenges. "We were struggling to meet demand," says Arya. "We realized we needed to make our modified chitosan differently. No one had made it on a commercial scale before, so we had to develop our own alternative scalable chemistries. Once we did that, our manufacturing capacity shot up. Our next goal is to lower the cost of the product and make the production process more environmentally friendly."

Aiding the effort is ChBE alumnus Alex Langrock (B.S. '10 and Ph.D. '14), who was recently brought on board to help with scale up, process optimization, and quality control.

Grip Boost has continued to apply for technology commercialization grants, and hopes to explore retail sales in 2016. The product is currently available through Amazon.com and gripboost.com

x 3" diagonal

Hemostat Bandage

(7 cm x 7 cm)

### studentn≡ws

### Nguyen: NOAA Hollings Scholarship



The National Oceanic and Atmospheric Administration (NOAA) awarded ChBE junior Catherine Nguyen a Hollings Scholarship. Nguyen will receive two years of academic support totaling \$16,000, a ten-week, full time paid internship after her junior year, and travel funds to attend NOAA Scholarship Program conferences. The NOAA internship will provide handson training in the administration's

CATHERINE NGUYEN

technology, research, policy, management, and education activities. Nguyen is one of eight UMD students and only 150 nationwide to join the Hollings Scholarship's 2015-2017 cohort.

Nguyen's search for undergraduate research opportunities in biomedical technology led her to a job in ChBE professor **Srinivasa Raghavan**'s Complex Fluids and Nanomaterials Group the summer after her freshman year. She was paired with a mentor, graduate student **Jasmin Athas**, to work on two ongoing projects. In the first, she's assisting in the development of a "smart" gel which folds into three-dimensional shapes in the presence of an enzyme and has potential applications in biosensing and drug delivery. In the other, she's part of a team studying and developing alternatives to the dispersants used to break up oil slicks such as COREXIT 9500A, which was implemented after the Deepwater Horizon event in 2010. (*See related story, p. 7.*)

It was the second project that sparked her interest in the impact of chemicals on human and environmental health.

"I had not realized that the dispersant used to clean up the oil spill could be more harmful than the oil spill alone," she says. "I also learned about studies showing that [it] is toxic to marine life. I applied for the NOAA Hollings Scholarship because I wanted to do more research on the toxicity of dispersants."

Nguyen chose to major in chemical and biomolecular engineering not only for its diverse career options, but also to enrich her journey to become a "physician-scientist." After earning her bachelor's degree, she would like to join an M.D./ Ph.D. program in which she can combine her love of science, technology, math, and medicine.

"I am a pre-med student but I chose the unconventional major because I wanted to understand more about technology being developed that could be used to improve human health," she explains.

Outside of class, Nguyen is a member of the ChBE's student chapter of AIChE, OXE (the chemical engineering honor society), the Primannum Honor Society, Engineers Without Borders' Compone, Peru project team, and UMD Club Tennis. She is a guided study session leader for Physics 161: Mechanics and Particle Dynamics, and was recently invited to join the Clark School's Research, Instruction, Service, and Entrepreneurship (RISE) program.

### Gastfriend Named 2015 Goldwater Scholar



ChBE senior **Benjamin Gastfriend** is one of four University of Maryland students who were awarded scholarships by the Barry M. Goldwater Scholarship and Excellence in Education Foundation. He is among the 260 Barry Goldwater Scholars selected from 1,206 students nominated nationally this year.

Gastfriend is a member of ChBE associate professor **Ganesh Sriram**'s Metabolic Engineering Laboratory,

BEN GASTFRIEND

which focuses on engineering the metabolism of microorganisms to produce biofuels and other chemicals.

At the beginning of his sophomore year in 2013, Gastfriend was searching for a meaningful research experience that would compliment his coursework. He decided to apply to Sriram's group after taking Biology for Engineers, which sparked his interest in the intersection of chemical engineering and biological systems. It was his first research experience, and it's had a substantial effect on his education and identity as an emerging scientist.

"[It's] been one of the most enriching parts of my academic experience at Maryland," he says, adding that his positive experience has inspired him to pursue a Ph.D. in chemical engineering.

Gastfriend is performing isotope-assisted metabolic flux analysis to create a genome-scale metabolic model of *Saccharophagus* 

### honors&AWARDS DISSERTATIONS

Congratulations to the following students, who have all demonstrated outstanding scholarship, research skills, and service.

#### DEPARTMENT/CLARK SCHOOL

Outstanding Junior Award and Women in Engineering Service Award: **Emily Fraik** 

Outstanding Senior Award: Isaac Zaydens

David Arthur Berman Memorial Award: Beth Sheil

Chairman's Award: Amanda Merlock

Outstanding Student Service Award: Amanda Filie

ChBE Undergraduate Research Awards: Christopher Boughter, Benjamin Gastfriend and Jacob Piekarz

Outstanding GA: Tao Gao

#### UNIVERSITY AWARDS

Hulka Fellowship and Kokes Fellowship: Yiquing Wu

Wells Fellowship: Mann Saxbodin

Wylie Fellowship: Chao Luo

#### LEARN MORE

Citations and additional information are available at: go.umd.edu/chbeawards15

#### 2014: MAY

**Szu Ting Chou:** "Development and Biophysical Characterization of HK Polymer for SiRNA Delivery to Tumor in a Mouse Model." (Advisors: Mixon and Seog)

William Gibbons: "Electrospun Ceria Based Fibers for Energy Conversion Applications." (Advisor: Jackson)

**Hyuntaek Oh:** "Photoresponsive Systems Based on Self Assembly." (Advisor: Raghavan)

**Curtisha Travis:** "Model Analysis of Atomic Layer Deposition Growth Kinetics and Multiscale Process Dynamics." (Advisor: Adomaitis)

#### 2014: DECEMBER

**Chandameny Arya:** "Bio-Inspired Polymer Microparticles for Targeted Recognition and Response." (Advisor: Raghavan)

#### 2015: MAY

Xiaofeng Zhang: "Quantitative Studies of Nitrogen Metabolism in Plant Cells Using Isotope-assisted Instationary Metabolic Flux Analysis and Mathematical Modeling." (Advisor: Sriram)



### awardnews

#### THERE'S MORE ONLINE!

We're proud to say that we have so many great stories about students who have been honored for their research, service and academic performance that we couldn't fit them all in one newsletter. We hope you'll take a moment to visit our web site to "meet" these aspiring engineers:

#### "Building Flexible Electronics"

Maria Kaplan received a summer undergraduate research fellowship from NIST. At NIST's Material Measurement Laboratory, she explored materials and techniques used to fabricate organic semiconductor films. go.umd.edu/kaplannist

#### "Molecular Dynamics Simulations of Protein Binding"

Viviana Monje-Galvan received the Chemical Society of Washington's travel award to support her trip to the 249th National Meeting of ACS, where she presented her molecular dynamics simulations of model cell membranes and peptide interactions. go.umd.edu/mgprotein

"Electrochemical Society Wins 2nd Student Chapter Award" go.umd.edu/ ecs2ndaward

"Hurn Wins ExxonMobil/AIChE-NCS Award" go.umd.edu/hurnexxonmobil

*degradans*, a marine bacterium found in the Chesapeake Bay. Microbes like *S. degradans* are becoming increasingly important to our efforts to replace petroleum-based products with those made from sustainable and more environmentally friendly resources.

*S. degradans* is particularly effective at breaking down cellulose and other components of plant biomass into ethanol, a key step in the production of biofuels. It also has the ability to produce a carbon storage molecule called poly-3-hydroxybutyrate that can be processed for use as a biodegradable plastic.

"[Our work] will ultimately allow us to identify the optimal conditions for the production of useful products, or allow us to propose strategies for altering the bacterium's genome to facilitate enhanced production of those products," Gastfriend explains.

In late 2014, he received a Grant-in-Aid-of-Research from

Sigma Xi, the Scientific Research Society, which helped fund another study in which he performed metabolic flux analysis on carbon-13-labeled switchgrass, a plant used in the production of biofuels. Sriram notes that these prestigious, highly competitive awards are typically won by graduate students.

"It will be hard to come across another student and researcher as outstanding as Ben," says Sriram. "His performance in classes is unprecedentedly brilliant. He is creative and industrious, conducts comprehensive literature reviews, performs experiments and computation impeccably well, draws impressive insights from his results, and writes up his work in detail—all with little to no supervision. Even when he first interviewed with me as a sophomore, he showed an astounding grasp of core research methodology that is typically senior- or graduate- level material."



The Department of Chemical and Biomolecular Engineering University of Maryland 4418 Stadium Dr. College Park, MD 20742-2111 Nonprofit Org. U.S. Postage PAID Permit No. 10 College Park, MD

WHAT'S THIS? Each of these little beads is a colony of *Candida albicans* yeast cells grown in Assistant Professor **Amy Karlsson**'s lab. Her group is engineering antimicrobial peptides to fight *C. albicans* infections and evaluating their antifungal activity. After the cells are mixed with the engineered peptides, they are put on agar plates and the survivors grow to form colonies. The colonies are counted to help determine the percentage of cells that are killed by each peptide and the minimum concentration of peptide required to completely prevent cell growth. **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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Department Chair: Dr. Sheryl Ehrman Editor/Designer: Faye Levine

### AICHE: BAGELS & GRITS 6, 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 Salt Lake City, Utah for:

#### **Our Bagels and Grits Breakfast!**

Meet our faculty and students and learn more about our academic programs. No RSVP required—see you there!

Monday, Nov. 9, 7:00-8:30 a.m., Location: TBA See our web site or visit us at AIChE for the most up-to-date info.

> Cheer on our team, the Thirsty Turtles! (See page 4.) See the AIChE web site for more information.

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