FALL 2013

COLUMNS

CHEMICAL AND BIOMOLECULAR ENGINEERING
A. JAMES CLARK SCHOOL *of* ENGINEERING

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A NEWSLETTER FOR ALUMNI AND FRIENDS OF THE DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING AT THE A. JAMES CLARK SCHOOL OF ENGINEERING, UNIVERSITY OF MARYLAND.

IN THIS ISSUE:

FACULTY SEARCH

We are conducting an **open-rank search** for the first Robert Franklin and Frances Riggs Wright Distinguished Chair in Chemical Engineering.

See the Chair's Message on page 2 to learn more!

Anisimov Elected to Russian Academies of Engineering and Natural Sciences

Department of Chemical and Biomolecular Engineering (ChBE) and Institute for Physical Science and Technology professor **Mikhail Anisimov** has been elected as a foreign member of both the Russian Academy of Engineering and the Russian Academy of Natural Sciences.

The Russian Academy of Engineering unites leading Russian and foreign scientists, engineers, scientific research organizations, higher educational institutions and enterprises. Anisimov was honored by the academy for his substantial contributions to the thermodynamics of phase transitions in simple and complex fluids, both theoretically and experimentally; for his role as a bridge between Russian and American traditions in thermodynamics; and for his "outstanding creativity, energy, and purposefulness." The Russian Academy of Natural Sciences is one of academia's largest and most authoritative organizations that supports education and applied scientific research. It inducted Anisimov for his contributions to and international collaborations in petroleum science and technology.


ANISIMOV (STANDING) WITH STUDENTS

"This is an incredible achievement, and I am very pleased to congratulate Mikhail on this honor and recognition," says **Darryll Pines**, dean of the A. James Clark School of Engineering.

Anisimov, who specializes in mesoscopic and nanoscale thermodynamics, critical phenomena, and phase transitions in soft matter, received his Ph.D. in Physical Chemistry and Chemical Physics from Moscow State University in 1969, and a D.Sc. in Molecular and Thermal Physics from the Kurchatov Institute of Atomic Energy, Russia, in 1974. Prior to joining the University of Maryland, his academic appointments included serving as professor and chair of the Moscow State Academy of Oil and Gas' Department of Physics and department head of the Russian Academy of Sciences' Institute for Oil and Gas Research. He is the author or co-author of over 200 publications, and is an elected fellow of the American Association for the Advancement of Science, the American Institute of Chemical Engineers, the American Physical Society, the International Academy of Refrigeration, and the Newtonian Society. He is also a member of the New York Academy of Sciences and the Washington, D.C. Cosmos Club.

"It gives me great pleasure to congratulate Mikhail on this most significant distinction," says ChBE professor and chair **Sheryl Ehrman**.

chair's MESSAGE

SHERYL EHRMAN

NUMBERS, NUMBERS, NUMBERS… SOMETIMES IT'S POSSIBLE TO GET BURIED IN NUMBERS.

As a campus, we're starting the strategic planning process to develop our next five year plan, and at the department level, we just revisited our metrics this past summer. Our number of incoming freshman this fall is 24% higher than last August and we have a strong class of internal and external transfer students. Our number of Ph.D. students is on the rise. We have added three new faculty members (for our most recent, Professor **Michael Zachariah**, see p. 4) and two new staff members in the past three years. **We are searching again—an open rank search, allowing us to recruit the first faculty member to hold the Robert Franklin and Frances Riggs Wright Distinguished Chair in Chemical Engineering.** For more information about the search, please visit **chbe.umd.edu/employment**

The story of the origin of this generous gift will be in the Spring newsletter, but if you can't wait, you can read about it at: **ter.ps/balfour**

But numbers only tell part of the story. We are so proud of Professor **Mikhail Anisimov**, elected this year as a foreign member of both the Russian Academy of Engineering and the Russian Academy of Natural Sciences. It seems every week I hear from alumni who are also doing amazing things. Two weeks ago I heard from **Mark Davis** (B.S. '06) who is working at a small winery in California and will be bottling his first personal vintage this year. Last week, it was **Jason Repac** (B.S. '04), who is heading up the start-up and commissioning of a new facility for DuPont that will be manufacturing organic light emitting diodes. Alumni, please feel free to check in. I would love to hear from you!

Even as we go to press with this issue, we've received more good news. The Fall 2013 ARPA-E awards were just announced, and Professors **Chunsheng Wang** and **Eric Wachsman** are leads on two battery-related Phase I projects (see **ter.ps/batteryarpae** for the story). I wonder what next week will bring?

Bar charts only go so far. People, and their ideas, go farther!

Go Terps!

Sheryl H. Ehrman
Keystone Professor and Chair

researchNEWS

"GENTLE DELIVERY" KITS COULD HELP BRING GENE THERAPIES TO MARKET

Imagine if you could "turn off" the genes that instruct cells to grow into tumors or tell your immune system to attack your own body, or if you could tell immune cells to fight a disease they're ignoring. That is the promise of a potential gene therapy called RNA interference (RNAi), and a Clark School-based startup is commercializing a product that could bring it a step closer to clinical reality.

A nucleotide like DNA, but usually single-stranded, RNA is involved in the expression, coding, decoding, and regulation of genes. One type of RNA, called "silencing" (siRNA), is capable of disabling certain genetic-level activity. Controlling the silencing process could enable us to treat diseases caused by malfunctioning genes.

Currently, the use of siRNA is restricted to laboratory studies. Its therapeutic potential is overshadowed by the difficulty of delivering it to malfunctioning cells, which see it as a threat to their molecular machinery, and have lines of defenses to keep it out.

In order to circumvent those defenses, cells are subjected to chemical treatments or electrocution to produce pores in their membranes through which the siRNA can pass. This process kills many of the cells in an experiment–a reasonable loss in a Petri dish, but too dangerous for clinical use.

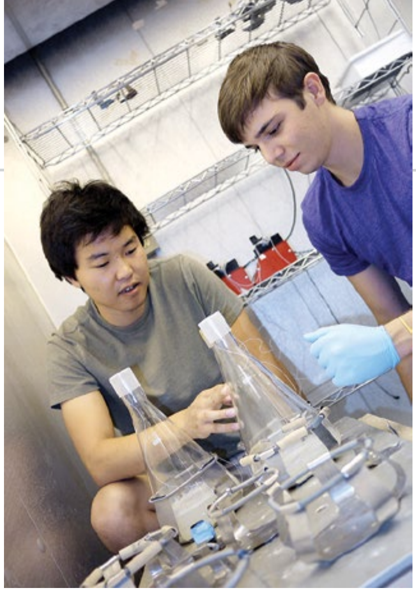
Department of Chemical and Biomolecular Engineering (ChBE) graduate students **Chanda Arya** and **Kevin Diehn**, advised by ChBE professor **Srinivasa Raghavan**, want to commercialize a non-cytotoxic, "gentle" siRNA delivery technique developed at the National Institutes of Health (NIH). Their startup company, Birich Technologies, has exclusively licensed the technology, which is based around a modified protein called a chemokine.

Cells send out chemokine as a distress call when under attack. Immune cells respond by following the trail of protein molecules to its source, internalizing it along the way–"like Pac Man eating a line of power pellets," Diehn says. The NIH's chemokine has been engineered to bind to siRNA. When an immune cell willingly consumes it using its natural mechanisms, the siRNA is taken in as well and gets to work, without damaging the cellular membrane.

Supported by a $149,251 Maryland Industrial Partnerships (MIPS) grant, Birich and Department of Cell Biology and Molecular Genetics professor **Jonathan Dinman** are currently developing the processes necessary to mass-produce the NIH's chemokine from genetically-modified yeast and to stabilize it for distribution and storage.

In the next phase of the project, they will distribute sample chemokine kits to scientists using siRNA to study immune system diseases. While gathering feedback, they plan to produce a "library" of chemokines, which will enable targeting of a variety of immune cells. If the chemokines' efficacy is validated by successful research, it would pave the way for Birich to launch a retail product and could ultimately become a part of FDA approved genetic therapies.

The entire project, from the marketing plan to product development, is something Arya and Diehn do outside of their Ph.D. research. They say the support they have received from Raghavan, ChBE, and the Clark School's Maryland Technology



CHBE GRADUATE STUDENTS AND BIRICH TECHNOLOGIES CO-FOUNDERS **CHANDA ARYA** (LEFT) AND **KEVIN DIEHN** (RIGHT) USE GENETICALLY MODIFIED YEAST TO PRODUCE AN siRNA BINDING PROTEIN.

Enterprise Institute, which awarded them the MIPS grant, has made it all possible.

"We've been able to pursue entrepreneurship thanks to the support and freedom given to us by the UMD community," says Diehn. "Ultimately, the best way to learn something is by experiencing it firsthand."

"PSEUDO INVERSE OPAL" PARTICLE BOOSTS PLASTICS PRODUCTION

A technique that uses a unique particle to boost the chemical reactions that generate commercial polymers could greatly improve the manufacturing common plastics. The patent-pending process was created in the ChBE's Polymer Reaction Engineering Laboratory, directed by Professor **Kyu Yong Choi**.

Silica is a porous material with an extremely high surface area, which makes it ideal for use as an inert, flat substrate (surface) on which to perform high-activity heterogeneous catalytic reactions. In this process the catalyst, which coats the surface of the silica, reacts with a second material to produce a third. Silica's pores provide a large number of sites at which these reactions can occur. When silica is used to create a class of polymers called polyolefins, its pores swell with the new material and they fracture, exposing even more reaction sites, until the silica disintegrates and the reactions end. The technique is used to produce the most important commodity polymers, plastics like polyethylene and polypropylene, but it's not efficient.

"The fragmentation is very irregular and hard to predict," Choi explains. "Sometimes it's incomplete, and you have big pieces of unfragmented silica with a lot of precious catalyst buried inside, wasted. Typically less than 10% of a catalyst is used in these reactions."

But if a new, three-dimensional silica particle developed by his research group is used, Choi says, 80-90% of the catalyst is able to react, increasing product yield and reducing costs.

Choi's group developed a polymerization technique that allowed them to create hollow, spherical polymer particles as large as 100 microns in diameter that contain many nano-sized grains of the same type of polymer—small balls inside of a larger one, or as Choi likes to describe it, something like a pomegranate. This structure serves as the template for the new silica substrate.

To make the 3D substrate, the group creates the same particles, but fills the empty spaces between the nanograins inside with a silica precursor, a material that can be converted to pure silica using a chemical reaction. An acid treatment applied to the polymer particles triggers the reaction, resulting in a silica/polymer composite inside the big, outer sphere. Finally, the particles are put in a furnace. The polymer burns away in a process called calcination, but a pure silica glass remains in the form of the space the precursor had filled—a three-dimensional negative or "inverse" of the original polymer particle.

The result, says Choi, are novel ultraporous silica nanoparticles, each a cluster of empty eggshells in the approximate shape of the original outer polymer ball. This structure has its own outer shell where the precursor had coated the inside of the outer polymer ball, so thin that the tiny hollow balls inside are visible under a scanning electron microscope. Choi calls these particles pseudo inverse opal silica (PIOS)—they are similar in structure and color as opals—and he says they hold the key to enhanced polymer reaction engineering.

Choi explains that while the particles provide about the same amount of surface area and pores as their 2D counterparts, their "wide open structure" allows both catalysts and reactants to get to them quickly and easily, instead of being limited to squeezing and in out of only 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.

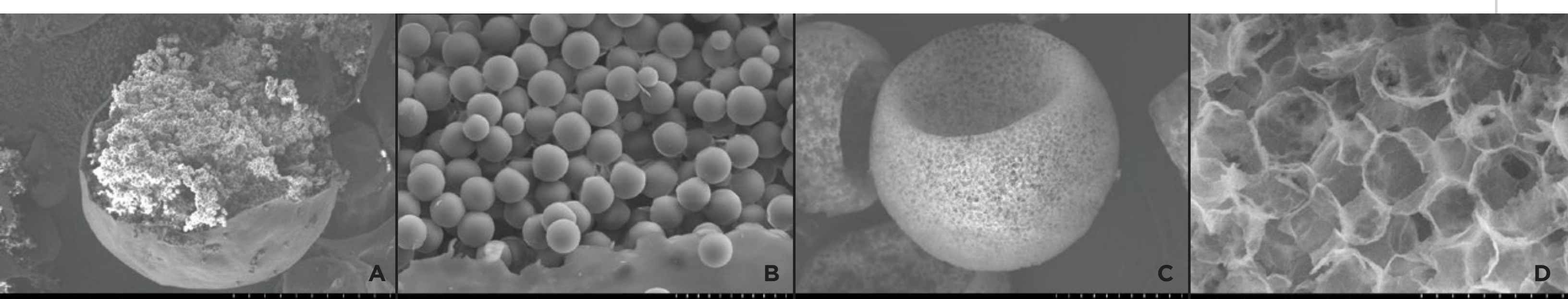
"Not only that," Choi adds, "but you could also copolymerize your polymer with a bulky, large molecule co-reactant that would normally be very hard to get into the small pores in conventional silica. The PIOS' larger openings give you the possibility of making a polymer with better structure and properties."

Going forward, Choi and his group are hoping to license the technology through the University's of Maryland's Office of Technology Commercialization. They are currently studying the use of PIOSes to manufacture additional kinds of polymers.

For more information, see:

Kyu Yong Choi, Carla V. Luciani, Laleh Emdadi, Sang Yool Lee, In Hak Baick, and Jong Sung Lim. "Spherical Pseudo-Inverse Opal Silica with Pomegranate-Like Polymer Microparticles as Templates." Macromolecular Materials and Engineering, 297(10): 1021-1027 (2012).

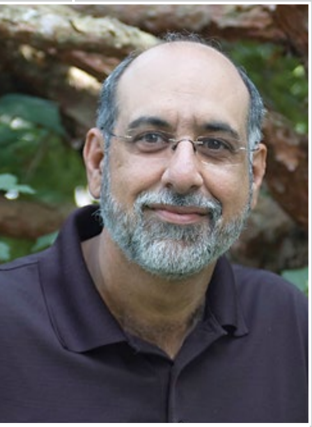
Sang Yool Lee and Kyu Yong Choi. "Polymerization of Ethylene over rac-Et(1-indenyl)2ZrCl$_2$/MAO Catalyst Supported on Pseudo-Inverse Opal Silica Particles." Ind. Eng. Chem. Res., 2012, 51 (29): 9742–9749 (2012).



(A) A POMEGRANATE-LIKE POLYMER PARTICLE THAT HAS SPLIT OPEN; **(B)** SUBPARTICLES, OR NANO-GRAINS, INSIDE THE POMEGRANATE-LIKE PARTICLE; **(C)** A SILICA PIOS PARTICLE AFTER THE POLYMER HAS BEEN REMOVED, AND **(D)** THE CLUSTER OF EGGSHELL-LIKE STRUCTURES INSIDE OF A PIOS PARTICLE.

ZACHARIAH JOINS FACULTY

The Department of Chemical and Biomolecular engineering (ChBE) is pleased to welcome Professor **Michael R. Zachariah** to its faculty. He will hold a joint appointment in the Department of Chemistry and Biochemistry.



MICHAEL R. ZACHARIAH

Zachariah earned his Ph.D. in chemical engineering from the University of California, Los Angeles in 1986. Prior to joining the University of Maryland faculty in 2003 with appointments in the Department of Mechanical Engineering and the Department of Chemistry & Biochemistry, he was a professor at the University of Minnesota and the leader of the Reacting Flows Group at the National Institute of Standards and Technology (NIST).

"We're very excited to have Professor Zachariah join the department," says ChBE professor and chair **Sheryl Ehrman**. "He is a wonderful educator and an internationally recognized innovator in the field of aerosol science and technology."

Zachariah's notable accomplishments include his pioneering development of new characterization tools for studying nanoparticles, and of a one-of-a-kind mass spectrometer for the study of ultra-fast condensed state reactions. His research group, the UMCP/NIST Co-Laboratory for Nanoparticle Based Manufacturing and Metrology, currently focuses on the development of analytic tools, dubbed "Nanolytics," used to probe the behavior and function of nanoparticles and nanowires; and on the use of aerosol-based synthesis of new materials with applications in the fields of energy and medicine, including targeted cancer therapies.

Zachariah has taught courses on a variety of topics including nanoparticle and aerosol dynamics, reaction engineering, microelectronics processing, physical measurements, particle engineering, and combustion.

His honors include a Sinclair Award from the American Association for Aerosol Research for sustained excellence in aerosol research and technology; the Clark School's 2011 Senior Faculty Outstanding Research Award; and a Bronze Medal from the United States Department of Commerce for superior federal research.

ADOMAITIS TEACHES SOLAR ENERGY COURSE AT PEKING U.

In July 2013, ChBE professor and associate chair **Ray Adomaitis** taught a course on solar energy at Peking University (PKU). ENCH 468L: Photovoltaics is part of a new exchange program between the University of Maryland and PKU.

Six Clark School students from multiple engineering departments, including ChBE junior **Hannah Shockley**, traveled to China with Adomaitis. Twenty more students from PKU, Hong Kong, Chile, Australia, Toronto, the University of Delaware, and the University of Pittsburgh joined them in class. The course covered the device physics and manufacturing processes of crystalline and thin-film photovoltaic cells, how solar solutions fit into an energy infrastructure, and the computational skills necessary to quantify solar cell efficiency.

"I found the course to be a rewarding and unique educational experience for both myself and the students," says Adomaitis. "The location at PKU allowed me to put fundamental solar energy concepts into a wider international context."

"[It] was truly an enlightening experience that opened my eyes to many ideologies that I will cherish for the rest of my life," says senior electrical and computer engineering major **David Daniel**, who took the course. "[It] enabled me to completely escape my comfort zone…The most important thing I gained from this trip was learning how to develop relationships with people whose backgrounds are completely different than mine…I was able to enjoy the things that I appreciate in the USA from a different perspective."

"[This] was one of the best experiences I have ever had in my life," says classmate **Kevin Diep**, a senior majoring in mechanical engineering. He enjoyed the group's three-day tour of Beijing as well as the class, describing Adomaitis' presentation of the material as "engaging and passionate." His favorite part of the trip, however, was the opportunity to meet and learn with other engineering students from around the world, making new friends in the process. "I flew halfway around the world expecting China, and got the whole world instead…I would highly recommend other students attend Peking University."

PROFESSOR **RAY ADOMAITIS** (SECOND FROM LEFT) WITH CLARK SCHOOL STUDENTS ON THE PKU CAMPUS.

BON VOYAGE!

We recently said goodbye to longtime faculty member and friend Professor **William Weigand**, who retired on June 30. We wish him the best and soon expect to see him embark on his next career as a full-time ski bum. See you on the slopes, Bill!

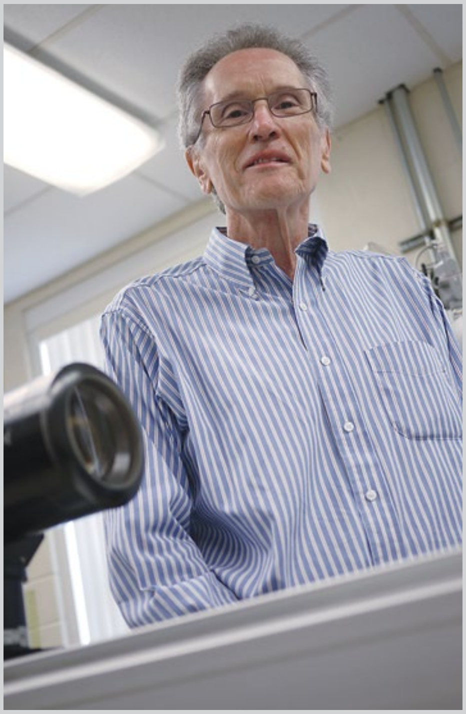
The Mixmaster

The A. James Clark School of Engineering is well known for supporting entrepreneurship and cultivating startup companies founded by its faculty and students, but did you know that some of its notable faculty have long-standing relationships with industry? Rather than launching their own companies, these professors have dedicated their careers to enhancing the quality, safety and efficiency of the processes used to manufacture products we use every day. ChBE professor **Richard V. Calabrese** is among them.

Calabrese is one of the people responsible for making your toothpaste the right consistency, your skin cream smooth, and your laundry detergent more concentrated. He's also one of the people who estimated the flow of oil coming from the Deepwater Horizon spill and one of five experts the Department of Energy asked for advice on handling Cold War-era radioactive and chemical waste at its Hanford, Wash. site.

What do toothpaste and toxic waste have in common? Multiphase flow.

Multiphase flow is the methodology used to describe what happens when two or more materials are brought together, and one may or may not dissolve in the other: oil in water, pigment and acrylic in water-based paint, or scrubbing particles in toothpaste or skin care products. It sounds simple, but it's not, especially in manufacturing situations in which a consistent dispersion throughout a large volume of material is essential. No one wants a bottle of pills in which the amount of medication varies from one to the next, or the drug particles are too large for the body to properly absorb.



"You can make whipped cream and mayonnaise in your kitchen blender," says Calabrese, "but when you have to replicate the results in a room-sized vat, it's a whole different game. How do you predict what will happen when all you have is data from the blender?"

Over the years, Calabrese has worked with companies whose products are used everywhere, including Bristol Myers Squibb, Chevron, Dow Chemical, DuPont, Ely Lily, Merck, Pfizer, and Proctor & Gamble. Many of them are current or former members of the High-Shear Mixing Research Program, a consortium he has directed since the 1990s.

He's also helped local companies. Martek Biosciences, producer of microalgal omega-3 DHA nutritional supplements and one of the Maryland Technology Enterprise Institute's biggest success stories, turned to Calabrese when they needed to scale up operations for commercial production.

Martek was culturing its product-producing microalgae at the University of Maryland's Bioprocess Scale-up Facility, but their attempts to provide oxygen to large batches of the tiny organisms was too rough—they were not growing. Calabrese and his students devised a protocol that bubbled oxygen in without killing the algae or stunting their growth, and helped establish a manufacturing process for Martek that the company still uses today.

Does he ever feel like he's missing out by not working in currently buzzworthy fields, like nanotechnology or drug delivery? No, he says. After all, as those tiny products are ready to be manufactured on a large scale, more people are talking to him about it.

MORE ABOUT MARTEK:
ter.ps/rvcmartek

SOLVING TOXIC PROBLEMS:
ter.ps/rvccleanup

DID YOU KNOW...?

Professor Calabrese served as Acting Chair of the Department of Chemical Engineering from 1992-1994.

He was a Fulbright Senior Scholar to the UK (1991-1992), a DuPont Visiting Scientist (2000-2001), and an Adviser to the DOE's Assistant Secretary for Fossil Energy (2009-2010).

He has won the A. James Clark School of Engineering's Outstanding Teaching Award for Junior Faculty and its Poole & Kent Teaching Award for Senior Faculty.

He currently serves as the chair of the American Institute of Chemical Engineers' (AIChE) Chemical Technology Operating Council, which manages the group's programming and knowledge dissemination activities. He also a serves on the board of the AIChE's Center for Energy Initiatives, which seeks to unite energy professionals for the purpose of identifying, formulating, advocating, launching and implementing new projects that address the nation's energy needs. He is currently working to develop a Center of Excellence within the AIChE, called Nuclean, on nuclear waste cleanup. He is a founding member and past president of AIChE's North American Mixing Forum (NAMF) and is an elected Fellow of the AIChE.

Martek, the Maryland company Calabrese assisted, is the producer of life'sDHA™, the leading sustainable and vegetarian source of algal DHA (docosahexaenoic acid)—important for brain, heart and eye health—for use in infant formula, foods and beverages, dietary supplements and animal feeds. Martek was later acquired by Royal DSM for €790 million.

Members of Calabrese's research group have won three of the six North American Mixing Forum Student Paper Awards for their work on liquid-liquid dispersions. Two other group members have been finalists.

SOLAR TEAM DISTILLS MOST AND PUREST WATER AT INTERNATIONAL COMPETITION

"Millions of people die every year simply due to the fact that they don't have access to clean water, something we take for granted here in the United States," says Clark School senior **Sahson Raissi** (Department of Civil and Environmental Engineering [CEE]).

Solar distillation units, which collect clean water evaporated from a dirty or salty source, are easy to build and offer a valuable solution to the problem, particularly for people in developing nations. At its most basic, a solar still is simply a basin used to hold the undrinkable water, fitted with a cover on which to gather condensation.

The system, however, has its drawbacks. "The challenge with this technology is that it is relatively a slow process," Raissi explains. "You have to wait a while for the sun to use its energy to evaporate water that basically starts out around room temperature."

Raissi, along with four classmates from CEE and ChBE, took on the annual Environmental Design Contest's challenge to design and build a more efficient solar still. Their prototype, which produced the most and purest water in the competition, earned them the Judges' Choice Award and United States Bureau of Reclamation's Renewable Energy Application Demonstration Award. Representatives from the Bureau were so impressed by the design of the still they asked to put in on display at their facility, and invited team members to apply for internships.

Sponsored by New Mexico State University's WERC Consortium for environmental education and technology development and the Institute of Electrical and Electronics Engineers (IEEE), the annual Environmental Design Contest invites students from around the world to undertake one of several tasks focused on addressing a real-world problem. Each team prepares four presentations: one written, one oral, a poster, and a bench-scale model. A panel of environmental science and engineering professionals serve as judges.

Team captain and CEE junior **Krishna Trehan** was searching for a way to apply what he'd learned in class to an environmental design project. After discovering the competition, he assembled a team including Raissi, junior **Merily Horwat** (CEE), junior **April Tressler** (CEE), and junior **Ryan Smith** (ChBE). The undergraduates then recruited ChBE professor and chair **Sheryl Ehrman** and CEE director of undergraduate student services **Alan P. Santos** as their advisors, entered the contest, and got down to business.

Smith says the team's strategy focused on optimizing the parameters they believed would maximize the still's efficiency. "We wanted to follow three simple ideas," he explains. "Minimize the amount of air within our unit, maximize the contact between the dirty water and our aluminum basin, and maximize the surface area to allow for more sun exposure."

The team believes its makeup was as important as its technical strategy: Horwat, Raissi and Trehan specialize in environmental engineering; Smith is a chemical engineer; and Tressler is a structural engineer.

"Every step of the design process was understood and developed by at least one person," says Tressler. "The civil engineers with the environmental focus knew the standards that had to be achieved by the water produced by the still. The chemical engineer knew the concepts and theorems that applied to water evaporation and the transfer of heat….[and I was] able to develop a physical design that satisfied all the previous criteria."

THE TEAM WITH THEIR SOLAR DISTILLATION UNIT. PHOTO BY ALAN P. SANTOS.

The interdisciplinary mix also served them well in the competition, she adds. "At least one person from the team was able to answer any questions that were asked by the judges…Our team had knowledge of every aspect of solar distillation and was very well prepared."

The team is already planning for next year's entry. "We were all so excited after we won two awards that we immediately started improving our design on the car ride back to the hotel from the contest venue!" says Trehan.

Team members describe the contest as "an amazing experience," and say they particularly enjoyed meeting their competitors, some of whom congratulated them after the awards ceremony for turning in such a strong performance–the first from the University of Maryland at the competition since 1995.

"But the absolutely greatest feeling was that we were able to represent the University of Maryland the best way we could," Trehan adds. "We all love this school and wanted to make it proud."

The Solar Distillation team would like to thank its sponsors, including the Bechtel Corporation, CEE, ChBE, Professor **Ashwani Gupta** and the University of Maryland Combustion Lab, and Clark School dean **Darryll Pines**; as well as the team members' families, friends, and advisors.

CHEM-E CAR TEAM HEADS TO NATIONAL COMPETITION AGAIN!

Team Thirsty Turtles took fourth place in the American Institute of Chemical Engineers' (AIChE) mid-Atlantic regional Chem-E Car Competition, held at Rutgers University in Newark, N.J. in April. The top-5 finish earned them a spot at the national competition, to be held at AIChE's annual meeting this fall in San Francisco.

The contest challenges teams of students to design and construct a small, chemically powered model vehicle. 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 to power the cars, which are not remote-controlled. Each team must carefully calculate the duration of the reaction required when they are told how far their vehicle must travel.

AIChE officials announced a target distance of 20 meters (65.6 feet) and a payload of 200 grams at the finals. Team Thirsty Turtles' nickel-metal hydride battery-powered car, *The Pride of Maryland II*, traveled 16.81 meters (55.15 feet).

The Pride of Maryland was improved and rebuilt for this year's competition. One of the major changes included the switch from a zinc-air battery, which had previously powered the car and its predecessor, *Raphael*.

"[The new battery] was made [by] extracting the cells from a used Prius battery and soaking them in 6 molar potassium hydroxide solution, which acts as the electrolyte," explains team member and ChBE junior **Yousif Alsaid**, adding that the car's electrical system also received an upgrade, a robust circuit that allows the team to control the power that goes to the wheels from the battery via a digital indicator.

At first, everything went smoothly, and after its first run, the Thirsty Turtles were in second place, thanks to trial runs that allowed them to accurately predict their required reaction times. "[We] got a deviation as small as +/- 0.5 seconds for each test, which was pretty amazing," recalls Alsaid.

But halfway through its second run, he says, *The Pride of Maryland* surprised them. "The car slowed down dramatically, apparently for no reason, and stopped short of our first run's distance. We were pretty upset, seeing as all our calculations and tests were spot-on. We eventually passed it off as being due to the unevenness of the floor."

On examining the video footage, however, the real culprit was discovered. "The indicator that was supposed to set the power output to 65% had changed to 60% on its own halfway through the run! This had never happened before in any of our tests in the lab and we suspect it may have been due to the shaking of the car interfering with the internal wiring."

Despite the problem, says Alsaid, "we are very happy with our performance and proud of every member who contributed

THE CHEM-E CAR TEAM WITH *THE PRIDE OF MARYLAND II.*

to securing us a place in the national competition. More importantly, we have learned what does and does not work through days of trial and error that eventually paid off, [and] this is an educational experience above anything else. We have set the bar high and hope to perform even better during nationals!"

Team Thirsty Turtles includes ChBE majors **Yousif Alsaid** (junior), **Richard Graver** (junior), **Nicholas Lepak** (B.S. '13), **Amy Nutis** (B.S. '13), **Leonard Pagliaro** (senior), **Katherine Pohida** (junior), **David Shoemaker** (junior), **David "Trae" Vanaskey** (junior), and **Isaac Zaydens** (junior); and electrical engineering major **Matthew Ford** (B.S. '13). The team is advised by ChBE associate professor **Chunsheng Wang** and sponsored by the W.R. Grace Foundation.

CHBE UNDERGRADS WIN PRESTIGIOUS INDUSTRIAL INTERNSHIPS FROM SCI PROGRAM

Five ChBE undergraduates spent their summers in internships at top companies through a program offered by the Society of Chemical Industry (SCI), the America International Group (AIG), the American Chemical Society (ACS), and the American Institute of Chemical Engineers (AIChE).

Lauren Dorsey, **Boheng Ma**, **Zachary Rom**, **Yoon Shin**, and **Isaac Zaydens** were selected from a nationwide field of "exceptional sophomores and juniors" majoring in chemistry and chemical engineering to receive five of the thirty-seven positions offered by the SCI Scholars program. SCI Scholars receive $6000–$10,000 for a ten-week industrial internship and $1000 in discretionary funding.

Dorsey, a junior, joined DuPont's Research and Development Division as a laboratory assistant in Newark, Del., adding to her substantial research experience. In addition to being a current member of ChBE assistant professor **Ganesh Sriram**'s Metabolic Engineering Laboratory, where she studies the metabolic pathways of nitrogen in poplar trees, in 2012 she was a research intern at the University of Virginia, where she studied the production of renewable commodity chemicals from biomass.

"I [hadn't] worked in industry before and [was] excited to see how it compares with my research experience in an academic setting," she says, adding that the experience provided her with insight she'll need as she makes decisions about her future. Dorsey plans to pursue a Ph.D. in renewable energy, and would ultimately like to join a company in which she can explore making traditional energy sources more sustainable or create renewable energy technologies.

Ma, a junior, also headed to DuPont, to a position as an associate investigator in the company's Department of Materials Science and Engineering in Wilmington, Del. There,

continues on page 8

SCI INTERNSHIPS continued from page 7

he was part of a team working with photovoltaics. Ma is preparing for a career in the energy industry. He has previously worked at the UMD Sustainability Office, where he collected and analyzed greenhouse gas data, and is a member of a Gemstone team utilizing piezoelectric materials to harness and store vibrational energy from wind.

"I specifically want to…[develop] innovative and sustainable solutions to provide reliable energy sources for future generations," he says. He was excited about his SCI internship because it gave him the opportunity to apply his classroom knowledge to a project that would teach him about the design, manufacture, and testing of solar photovoltaic cells. After graduation, Ma plans to work in industry before returning to school for a M.B.A or Ph.D.

Rom, a junior, served as an Integrated Supply Chain Intern at Honeywell PMT's division of Performance Materials and Technologies in Chesterfield, Va. Rom chose to become a chemical engineer because of his interest in a career in either the pharmaceutical or healthcare industries. During his sophomore year, he got his start in lab work and the research process in Fischell Department of Bioengineering professor **John Fisher**'s Tissue Engineering & Biomaterials Laboratory, where he studied chondrocyte adhesion to hydrogels. In the summer of 2012, he was an intern at the National Eye Institute (part of the National Institutes of Health), where he helped develop an image processing algorithm to noninvasively measure antioxidant concentrations in the retinas. He is weighing whether to pursue a career in industry or medicine. Outside of class and the lab, he plays hockey and golf, and is an avid snowboarder.

Shin, a junior who traveled to Freemont, Ca. for an internship at Air Liquide, describes living and working in the San Francisco Bay area as "an unforgettable experience." While he's been active in research since his freshman year, the SCI internship was his first industrial experience.

"[Working] at Air Liquide allow[ed] me to test the waters and get a feel for what it's like to be a working engineer," he says, adding he learned from the professionals he met that long hours and a willingness to relocate would probably be required to advance his career in industry–something that has prompted him to think about how he can balance his desire to explore the world with his interest in having a family-oriented life.

"[It's] giving me a lot of insight into what I want to do after graduation," he adds. "Everyone should try a similar experience at least once before graduating."

Zaydens, a sophomore, headed to Allentown, Pa. to work in the Global Engineering and Manufacturing department of Air Products' Hyco Product Engineering division. Zaydens chose to major in chemical engineering because it combined his three favorite subjects–chemistry, physics, and mathematics–and offered a broad range of career options. The SCI internship provided him with his first opportunity to apply what he's learned in class to real-world problems. Like many of his classmates, he used the internship experience to help him make decisions about his future career path. Outside of class, Zaydens is a member of the University of Maryland Chem-E Car team, whose chemical reaction-powered model vehicle is headed to the national competition this fall *(see related story, p. 6)*. Zaydens also serves as the treasurer of the Clark School's student chapter of the American Institute of Chemical Engineers.

ChBE and the Clark School extend their congratulations to all of these excellent young engineers!

36 CLARK SCHOOL STUDENTS IN NIST SUMMER RESEARCH PROGRAM

The A. James Clark School of Engineering is proud to announce that 36 of its students were accepted into the National Institute of Standards and Technology's (NIST) Summer Undergraduate Research Fellowship (SURF) program in Gaithersburg, Md.

The NIST SURF program allows students majoring in engineering, science and mathematics to work side by side with leading researchers, use cutting-edge technology and gain valuable hands-on research experience in NIST's six laboratories: the Material Measurement Laboratory; Physical Measurement Laboratory; Engineering Laboratory; Information Technology Laboratory; Center for Nanoscale Science and Technology; and the NIST Center for Neutron Research.

More than 600 student applications from 136 schools were received for the summer 2013 program. Of the approximately 190 students accepted into the program, 43 attend the University of Maryland—a record high. Of those, 36 were Clark School students representing seven of its eight departments, including ChBE students **Shir Boger**, **Anita Kundu**, and **Charles Onyenemezu**.

Boger worked in the Materials Measurement Lab, under the guidance of Dr. **Richard Cavicchi**. "This summer at NIST [was] a great experience," he says. "Working with 150 other undergraduate interns has given me the opportunity to meet so many interesting people with a variety of backgrounds. I have learned so many new applications while still applying things that I learned in my chemical engineering classes. My project at NIST was very interesting and has made me reconsider my future plans."

TO LEARN MORE, VISIT: www.nist.gov/surfgaithersburg

YOUNG ECS CHAPTER EMPHASIZES OUTREACH, WINS CHAPTER AWARD

Although not quite two years old, the University of Maryland student chapter of the Electrochemical Society (ECS) already has a busy schedule and a reputation for outreach and energy-related advocacy. This summer, their efforts earned them the ECS's first Outstanding Student Chapter Award.

ChBE/Department of Materials Science and Engineering (MSE) professor and University of Maryland Research Center director **Eric Wachsman**, who serves as the group's advisor, is proud of its progress.

"Within one year of formation [it] was already extremely active and growing in membership," he says. "[Its members] are actively engaged in research, yet find the time to reach out to the D.C. regional community."

"The wonderful thing about ECS is the interdisciplinary nature of the society," says chapter vice president and ChBE graduate student **Will Gibbons**. "It fosters an environment which promotes interaction with researchers from many different backgrounds, and I think that's part of the value of the student chapter at UMD. We have students from chemical engineering, materials science, and chemistry, which really

MEMBERS OF ECS AT CONGRESSIONAL VISITS DAY. LEFT TO RIGHT: MATERIALS SCIENCE AND ENGINEERING GRADUATE STUDENTS **COLIN GORE** AND **AMY MARQUARDT**; SENATOR **BARBARA BOXER** (D-CALIFORNIA), **HANNA NILSSON** (GRADUATE STUDENT, MATERIALS), AND ECS VICE PRESIDENT AND CHBE GRADUATE STUDENT **WILL GIBBONS**. *PHOTO COURTESY OF THE OFFICE OF SENATOR BARBARA BOXER.*

Massachusetts Institute of Technology professor **Donald R. Sadoway** and U.S. Department of Energy Hydrogen Production Technology Development Manager **Eric Miller**.

helps members broaden their network outside of their departments. We're very honored by the recognition of our accomplishments."

Here are just a few of the chapter's notable activities from the past year:

"Getting Juice from Juice." In February 2013, the chapter headed to the National Institute of Standards and Technology, where they hosted a session of the Adventure in Science Program. The program gets scientists and kids aged 8–15 together for presentations and activities designed to inspire and entertain. In addition to Gibbons, graduate students **Colin Gore** (MSE), **Amy Marquardt** (MSE), and **Chris Pellegrinelli** (MSE) led the students through a hands-on project in which they were able to use anthocyanin, a pigment molecule found in blackberry juice, and electrically conductive glass slides to fabricate their own dye-sensitized solar cells, which they then tested under different lighting conditions.

Science, Engineering, and Technology Congressional Visits Day. In March 2013, ten chapter members traveled to Capitol Hill, where they discussed the benefits of the "innovation ecosystem" created through a combination of federal and private scientific research programs, and the importance of stable and predictable federal funding in the face of the Sequester. The group met with Senators **Mark Udall** (D-Co.), **Tom Harkin** (D-Ia.), **Chuck Grassley** (R-Ia.), **Elizabeth Warren** (D-Mass.), **Ben Cardin** (D-Md.), **Barbara Mikulski** (D-Md.), and **Pat Toomey** (R-Pa.), all of whom are members of committees focusing on commerce, science and transportation, energy and natural resources, and related appropriations.

Energy Seminars by Distinguished Guests. The chapter has hosted or co-sponsored prominent speakers such as

IAPWS ADOPTS GUIDELINE AUTHORED BY ALUMNA, FACULTY

The International Association for the Properties of Water and Steam (IAPWS) has adopted a theory-based calculation for the critical parameters of aqueous solutions of sodium chloride, first-authored by ChBE alumna **Daphne A. Fuentevilla** (Ph.D. '12), as its new international guideline. The formulation, published in the *International Journal of Thermophysics*, was ratified by the member nations of the IAPWS in January 2013.

IAWPS publishes internationally accepted formulations for water and aqueous solutions that can be used to calculate thermodynamic and transport properties, viscosity, and thermal conductivity over a large range of temperatures and pressures. Fuentevilla's work is the latest in a series of contributions to the IAPWS's efforts from the joint research group led by her advisor, Professor **Mikhail Anisimov**, and Distinguished University Professor Emeritus **Jan Sengers**.

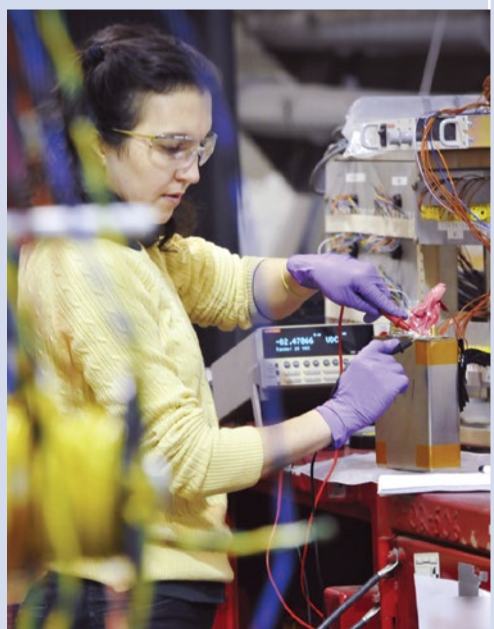
Fuentevilla, who conducted the research while a doctoral student, studied the critical points of water–temperatures, pressures and densities at and beyond which multiple phases of water (such as fluid and vapor) cease to exist and becomes what is known as a supercritical fluid. Near these critical points, water possesses unusual thermodynamic properties, and even small changes in temperature and pressure can measurably alter them. When impurities are introduced–intentionally or naturally–the critical points shift. Industrial engineers who use supercritical fluids take advantage of their properties, and need accurate equations describing these parameters in order to efficiently and successfully manage their processes.

In the study, Fuentevilla set out to refine what is known about the critical points of high-temperature, high-pressure, aqueous solutions of sodium chloride—salt water. Salt water, she says, should serve as a good model for the behavior of other solutions, because it has been well studied, allowing researchers to access a large body of experimental data.

Fuentevila attended the University of Maryland with the support of a Department of Defense SMART Scholarship, which provides tuition and a stipend for science, technology, engineering, and mathematics students in exchange for civilian service with the DOD. She is currently a chemical engineer and power system specialist at the Naval Surface Warfare Center, Carderock Division, where she has worked with batteries, capacitors, fuel cells, and alternative energy systems for the Navy since 2004. She provides technical expertise in lithium battery safety and supports Navy and Marine Corps program offices with system safety and platform integration of power systems. Most recently she provided technical support to the National Transportation Safety Board for their investigation into lithium battery failures in the 787 Dreamliner aircraft.

For more information, see:

D.A. Fuentevilla, J.V. Sengers, and M.A. Anisimov. "Critical Locus of Aqueous Solutions of Sodium Chloride Revisited." Int J Thermophys33(6):943-958 (2012)



DAPHNE FUENTEVILLA
COURTESY OF NSWCCD

COMPANY FOUNDED IN CLARK SCHOOL AWARDED $500K TO TEST HEMORRHAGE-HALTING FOAM

Story courtesy of and based on the original by Mtech.

RAGHAVAN & DOWLING

Remedium Technologies Inc., a medical device company founded by Clark School alumni and faculty developing innovative products to control severe hemorrhaging, was awarded a $500,000 Small Business Innovation Research (SBIR) grant from the National Science Foundation (NSF). The award will fund testing of the company's sprayable foam, which is designed to rapidly halt bleeding caused by large and deep traumatic injuries.

In collaboration with Massachusetts General Hospital and the University of Maryland, Remedium will complete pre-clinical trials to evaluate the safety and efficacy of Hemogrip™ in controlling non-compressible hemorrhaging, bleeding that cannot be slowed or stopped using direct pressure. Hemogrip is a high-pressure, sprayable foam that can expand into an injured body cavity, adhering to tissue and stopping bleeding within minutes. There are currently no hemostatic products available for the treatment of non-compressible wounds, which account for 85 percent of hemorrhage-related deaths.

The grant will also support additional product research by ChBE's Complex Fluids and Nanomaterials Group, directed by Remedium co-founder Professor **Srinivasa Raghavan**.

"Remedium is honored to be recognized for its product development progress with this important Phase II funding from the National Science Foundation," says **Matthew Dowling** (Ph.D. '10), CEO and co-founder of Remedium. "We are enthusiastic in approaching pre-clinical trials with a product we see as critical in addressing one of the biggest unmet needs in trauma medicine today."

Hemogrip's life-saving technology is based on chitosan—a natural biopolymer found in the exoskeleton of shrimp, crabs, and other crustaceans. Chitosan is unique as a natural material because it is biocompatible, anti-microbial, and highly durable under a wide range of environmental conditions. When applied to wounds, Hemogrip creates a nanoscale, three-dimensional mesh, rapidly coagulating blood and staunching blood loss.

The Hemogrip foam is dispensed from a handheld, lightweight canister. It can be removed quickly and easily without damaging tissue, and since it is based on chitosan—the second most abundant biopolymer on earth—it is also inexpensive.

Remedium was previously awarded a $150,000 SBIR Phase I grant from the NSF, two Maryland Industrial Partnerships (MIPS) grants totaling $206,000, a $140,000 Maryland Proof of Concept Alliance grant, a $75,000 Maryland Technology Development Corporation Maryland Technology Transfer Fund grant, and a $200,000 Maryland Biotechnology Center Translational Research Award. In 2009, it received the University of Maryland's Outstanding Invention of the Year Award in the Life Sciences division from the Office of Technology Commercialization.

The young company has been highly successful in business plan competitions, winning first prize and $25,000 in the Oak Ridge National Laboratory's 2010 Global Venture Challenge; the "Most Promising Security Idea" award and $10,000 in the 2009 4th Annual Global Security Challenge; $8000 in the Maryland Technology Enterprise Institute's 2007 $50K Business Plan Competition; and $5,000 in the Invest Maryland Challenge.

Remedium has six patents pending related to the Hemogrip platform. Its products, which also include surgical sprays and bandages, are designed to be used by surgeons, soldiers, EMTs, or even unskilled helpers, in locations ranging from the operating room to the battlefield to emergency situations.

NSF PROGRAM HELPS POSTDOC PREPARE FOR INDUSTRIAL TRANSLATION

Research results often don't find their way into the "real world" of consumers and industry. The National Science Foundation (NSF), one of the largest sponsors of fundamental research, hopes to change that by recruiting senior graduate students and postdoctoral researchers into its Innovation Corps (I-Corps) program.

Applicants to the I-Corps program must be affiliated with NSF-funded, basic-research projects identified as having the potential for near-term application in the commercial world. Participants receive a $50,000 grant and entrepreneurship training designed to help them formulate a business plan and pitch their products to industry.

Deepa Subramanian (Ph.D. '12), a member of ChBE professors **Mikhail Anisimov** and **Jan Sengers**' Mesoscopic Fluctuations and Critical Phenomena group, was the first participant from ChBE to be selected for the I-Corps program.

DEEPA SUBRAMANIAN

Subramanian's project grew out of Anisimov's 2010 grant for a study titled "Mesoscale Structures in Aqueous Solutions"—a name that may not seem to have much of a commercial ring to it. Anisimov and his team have been modeling and documenting the behavior of molecules called small alcohols, which are used as co-solvents and surfactants in industry. When placed in water, these alcohols naturally hydrogen bond with water to form more complex, nanoscale structures. But when the group added a hydrophobic element to the solution, the small alcohols instead went through a cycle of forming and reforming larger, mesoscale hydrophobic molecules with a spherical core-and-shell-like structure. These behaviors, at both length scales, change the thermodynamic properties of the solution. Understanding how and why is important to anyone using these types of solutions in industrial processes.

CHBE DEPARTMENT AWARDS WINNERS. LEFT TO RIGHT: **LAUREN DORSEY**, **HUBERT HUANG**, **MICHAEL HARRIS**, AND **EITAN LEFKOWITZ**. FAR RIGHT: CHBE PROFESSOR AND CHAIR **SHERYL EHRMAN**. NOT PICTURED: **LISA LIU** AND **CASEY SMITH**.

Subramanian discovered that the mesoscale molecules had properties with commercial potential: they had the ability to stabilize colloids and emulsions—products that are dispersions of one material in another, like paint or salad dressing. Colloid-based products are everywhere, and keeping their ingredients from separating is essential. Several stabilization techniques already exist—including adding polymers, viscosity modifiers, and salt-based surfactants—but Subramanian says her molecules have certain advantages.

"We use a simple agitator-driven mixing process as opposed to using complex, energy-intensive milling machines," she says. "The resulting colloidal solutions have been observed to be stable for over three years." Products that last longer, she says, could lead substantial savings in energy and manufacturing costs.

With Anisimov and **Craig Dye**, the director of the Maryland Technology Institute's Ventures Accelerator program, as her support team, Subramanian worked her way through I-Corps' intensive eight-week program. In the initial stages, she was also aided by students from the Robert H. Smith School of Business who were part of a course on technology commercialization.

I-Corps required her to discuss her product with at least 100 people whose company might benefit from it. She says that while the interviews were grueling, they taught her how to present her research in terms of what she could do for others.

She learned her technology could work best in the agrochemical industry, which makes products such as pesticides and herbicides. While companies expressed interest in her colloid stabilizers, they also provided some important feedback: They want to see a product, but Subramanian was pitching an active component that could be used in many products. She realized she would need to partner with a smaller business to produce a specific, targeted product ready to sell to industry.

The University of Maryland's Office of Technology Commercialization hopes to help her do that. It filed a provisional patent on her technology, and is pursuing licensing opportunities while waiting for the final patent to be granted.

This fall, Subramanian headed to Yale University's Department of Chemical and Environmental Engineering to start a new postdoctoral research project.

inBRIEF

Chia-Ying "Winnie" Chiang (Ph.D. '12), formerly advised by ChBE professor and chair **Sheryl Ehrman**, joined the National Taiwan University of Science and Technology in Taipei, Taiwan, as an assistant professor.

Darryll Williams (M.S. '01, Ph.D. '04) was appointed Associate Dean for Recruitment, Retention, and Community Engagement and Director of the Center for STEM Diversity at Tufts University, after a three-year rotator position at the NSF. At UMD Williams was co-advised by **Sheryl Ehrman** and former ChBE professor **Tracey Holoman**.

honors&AWARDS 2012–2013

Congratulations to the following students, who were recognized at the Clark School's and department's 2012-2013 Honors and Awards Ceremony. They have all demonstrated outstanding academic and research performance, and have made contributions to the Department and field. Complete citations are available at: **ter.ps/chbeawards13**

DEPARTMENT AWARDS

- Outstanding Junior Award: **Hubert Huang**
- Outstanding Senior Award: **Michael Harris**
- David Arthur Berman Memorial Award: **Lauren Dorsey**
- Chairman's Award: **Lisa Liu**
- Outstanding Student Service Award: **Eitan Lefkowitz**
- Graduate Teaching Assistant Awards: **Chanda Arya, Laleh Emdadi**, and **Will Gibbons**

CLARK SCHOOL HONORS & AWARDS

- Outstanding Engineering Co-op/Intern Award: Casey Smith
- Student Address, May 2013 Commencement Ceremony: Juan Quintero-Moreno

recent DISSERTATIONS

MAY 2013

Pushkar Pendse: "Investigation of Lactose Permease as a Structural and Functional Model for Membrane Proteins." Advisor: **Jeffery Klauda**

Yanting Luo: "Synthesis of Novel Alkaline Polymer Electrolyte for Alkaline Fuel Cell Applications." Advisor: **Chunsheng Wang**

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ABOUT THE COVER IMAGE

THE BLUE IMAGE USED ON THE COVERS, PRODUCED BY SCANNING ELECTRON MICROSCOPY, SHOWS POLYETHYLENE (PLASTIC) NANOFIBRILS GROWING AS A RESULT OF ETHYLENE'S INTERACTION WITH A HIGH ACTIVITY METALLOCENE CATALYST ON THE EXTERIOR AND INTERIOR SURFACES OF A SILICA NANOTUBE 200 NM IN DIAMETER. THE POLYETHYLENE PRODUCED AT THE ACTIVE CATALYTIC SITES FORM FIBRILS APPROXIMATELY 30NM IN LENGTH THAT GROW AS ETHYLENE CONTINUES TO POLYMERIZE. PROFESSOR KYU YONG CHOI'S POLYMER REACTION LABORATORY SPECIALIZES IN ADVANCED AND EFFICIENT PRODUCTION TECHNIQUES FOR GENERATING COMMERCIAL POLYMERS. FOR MORE INFORMATION ABOUT THEIR LATEST TECHNIQUE, SEE P. 3.

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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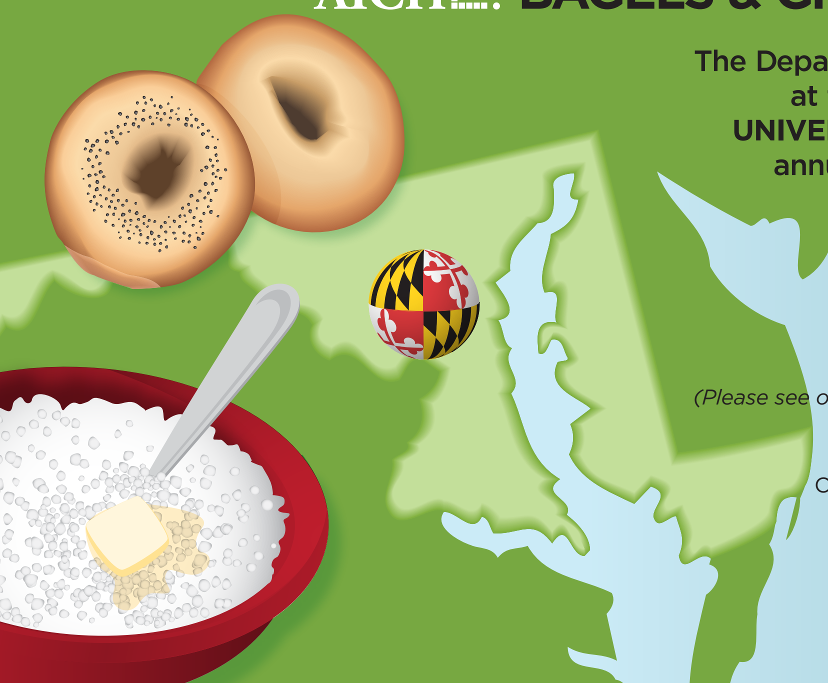
Department Chair: Dr. Sheryl Ehrman
Editor: Faye Levine

AICHE: BAGELS & GRITS 4, 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 San Francisco, CA for:

OUR BAGELS AND GRITS BREAKFAST!

TALK TO US IN PERSON ABOUT OUR CURRENT FACULTY SEARCH!
Meet our faculty and students and learn more about our programs.
No RSVP required—see you there!

Monday, Nov. 4, 7:00–8:30 a.m., Location: TBA
(Please see our web site or visit us at AIChE for the most up-to-date information.)

CHEM-E CAR FINALS!

Cheer on our team, Thirsty Turtles, at the finals! *(See related story, p. 6)*

See the AIChE web site for more information.

WHERE ELSE WILL WE BE AT AICHE?

VISIT www.chbe.umd.edu/aiche FOR MORE INFO!