TRANSPORT

The University of Houston Department of Chemical and Biomolecular Engineering

Fall 2012

Professor Wins $2.1M R01 Award for Cancer Research

Navin Varadarajan, assistant professor of chemical and biomolecular engineering, won a grant worth approximately $2.1 million from the National Institutes of Health and its National Cancer Institute to study the best ways to modify human immune cells to fight against cancer.

In immunotherapy, human immune cells are modified and trained to fight hard-to-treat tumors. Varadarajan's research focuses on engineered T cells, immune cells that recognize and attack disease cells. One immunotherapy approach involves modifying naturally occurring T cells to fight cancer cells. Known as chimeric antigen receptor T cells, or CAR T cells, these cells have proven effective in combating some cancers that are particularly difficult to treat.

CAR T cell therapy, in combination with other immunotherapy techniques, has achieved impressive clinical successes in fighting B-cell lymphomas that are otherwise considered untreatable outside of stem cell transplantation.

The properties of CAR T cells that are responsible for their clinical success are unknown. To address this, Varadarajan will use a novel research tool of his own design to study individual CAR T cells. The tool, dubbed the nanowell array, is a polymer slide containing tens of thousands of individual chambers, each 125 picoliters. At this size, the chambers are the perfect size to isolate and study individual cells. Varadarajan will expose CAR T cells used to fight these lymphomas to a nanowell array. The individual cells trapped in the array's chambers will then be studied in order to determine their individual properties relating to their ability to fight cancer, such as their ability to kill tumor cells and what molecules they produce in order to communicate with other immune cells.

Cells from the same batches will also be infused into patients, allowing researchers to correlate CAR T cell properties with clinical outcomes over the course of months, effectively allowing them to identify which modified T cells are most effective at fighting cancer.

Three to six months after infusion, Varadarajan and his collaborators will take blood from their patients and isolate their CAR T cells. Once again using the nanowell array, Varadarajan will isolate and study these cells, most of which will be several generations removed from the cells the patients originally received. He will then determine how well those daughter cells maintain the properties that make them effective cancer fighters, thus enabling researchers to design better treatment regimens.

Varadarajan's collaborators on this project include Laurence Cooper, a physician and researcher at the University of Texas MD Anderson Cancer Center; Badrinath Roysam, electrical and computer engineering department chairman at the Cullen College, and Peng Qiu, an assistant professor of bioinformatics and computational biology at MD Anderson.

Three CAREER Awards in 2012

Three faculty members in the UH department of Chemical and Biomolecular Engineering have received National Science Foundation CAREER Awards this year. The latest winner, assistant professor Jeffrey Rimer, is one of six Cullen College of Engineering faculty members who have received the honor in 2012.

Jeffrey Rimer received a five-year, $400,000 grant to expand his efforts to improve zeolites, a class of catalysts used in the petroleum and chemical industries to create a range of different products, from ion-exchange additives in detergents to gasoline and alternative fuels.

Zeolites are nanoporous materials with small channels that span their entire structure. Molecules enter the channels, react within the zeolite and then exit, transformed into something new. As a rule of thumb, the shorter the channel, the better. In longer channels, residue from the reactions is more likely to build up in the pores, limiting zeolite efficiency. In addition, shorter channels increase the product yield.

Rimer has developed and recently filed a patent for a method to produce ultra-thin zeolites. During the synthesis of commercial-grade zeolites, the individual crystals grow through the attachment of growth units to the zeolite surface. Rimer has discovered certain molecules that attach to specific zeolite surfaces and block growth units from attaching, thereby tailoring the size and shape of zeolite crystals.

While the modified zeolites retain the same basic shape, through this process they can measure as thick as 100 nanometers, about 10-times thinner than unmodified zeolites. With his earlier research to validate the approach of using zeolite modifiers, funded by an NSF BRIGE Grant, Rimer worked primarily with commercially available molecules. The CAREER award will allow him to create entirely new molecules to tailor the growth of specific zeolites. In doing so, he aims to develop a rational system for creating such molecules for any targeted zeolite.

This award will be used to strengthen outreach initiatives at the K-12, undergraduate, and graduate levels to promote engineering education and research. Rimer has partnered with KIPP Houston High School (a minority institution ranked 16th in national college readiness) to establish a dynamic program for student and teacher (NSF-RET) research at the University of Houston, guest lectures on engineering topics to KIPP AP Chemistry students, lesson plans that integrate results of Rimer's research, and an annual seminar to promote increased interest in STEM.

Assistant professors Gila Stein and Jacinta Conrad also received 2012 CAREER Awards.

Researchers Create Beneficial Proteins in Infection Process

Balakrishnan Ramesh, a Ph.D. student, and post-doctoral researcher Victor Sendra, working with their faculty mentors, associate professor Patrick Cirino and assistant professor Navin Varadarajan, both in the UH Department of Chemical and Biomolecular Engineering, recently authored a paper published by the Journal of Biological Chemistry, outlining their work on a class of proteins known as autotransporters.

Bacteria produce autotransporters and then move them to their outer surface, where they're involved in a number of processes, including recognizing other bacteria and infecting human cells. Working outside the cell, the research team used well-known recombinant DNA techniques to engineer a piece of DNA to create mutated autotransporter proteins that are actually beneficial, with possible uses including vaccine development and degrading or consuming pollutants. They then inserted this DNA into bacteria, where it produced the recombinant proteins.

The mutated autotransporters, however, are far more intricate than naturally occurring ones, requiring complex disulfide chemical bonds to maintain their proper shape. This research team, however, has engineered disulfide-utilizing autotransporters that have moved to the bacteria's outer surface, a feat achieved by adjusting where exactly on the protein the genetic modification appears. Their findings have been confirmed through multiple screening tools, including microscopy and flow cytometry.

The funding for this study was provided by The Welch Foundation.

Catalysis Research Could Lower Biofuel Costs

Lars Grabow, assistant professor of chemical and biomolecular engineering, was awarded a two-year, $100,000 grant from the American Chemical Society's Petroleum Research Fund to study ways to make biofuels competitive with oil-based fuels like gasoline and diesel.

Grabow will examine catalysts that remove sulfur from crude oil through a process known as hydrodesulfurization (HDS). He will use what he learns to help create new catalysts for the production of transportation fuels, including biofuels.

Typically, sulfur is removed from crude oil by injecting it with high-pressure hydrogen and then exposing it to metal sulfide catalysts. While HDS is generally well understood, Grabow will seek to gain new insights into this process by using an electronic structure method to simulate it down to the behavior of individual electrons.

He will then use what he learns to devise principles for the removal of oxygen, or hydrodeoxygenation (HDO) from pyrolized biomass, a mixture of solids and liquids that results from heating biofuel crops, such as algae.

The presence of oxygen in biomass dramatically lowers its heating value, Grabow said, resulting in less powerful fuels. Removing this oxygen is essential for biofuels to be competitive with petroleum-based fuels.

While it took decades to develop the ideal catalysts used in HDS today, Grabow's research could cut down the development time for HDO catalysts to just a few years.

Colloid Discovery Could Lead to New Adhesives, Drilling Fluids

Jacinta Conrad, assistant professor of chemical and biomolecular engineering, along with Melissa Spannuth, a former post-doctoral researcher, recently discovered that a model colloid-polymer suspension will turn from liquid to gel when placed in a confined space. They published a paper on their findings in the July 13 issue of Physical Review Letters.

Conrad conducted this work with a model suspension of solid particles and polymer chains – a simple system used to conduct basic research in this area. In such systems, each sphere has an area surrounding it that excludes other particles. Thanks to entropy, though, the polymer chains force these spheres together into take on a crystalline structure, giving the polymers as much room as possible to move within the crystals themselves.

Covering the suspension with a glass plate placed at an angle changes these interactions. Just as each sphere has an area of exclusion, the glass plate itself has a zone where neither the spheres nor the polymer chains can enter. This forces the spheres together more quickly, resulting not in a crystal, but a disordered gel.

Conrad noted that more study of this phenomenon is needed, especially on colloid systems consisting of different materials. If this property transfers, though, it could be used to create novel glues and adhesives, or in any situation where turning a liquid into a solid would be valuable, such as in wellbores.

UH Chem-E Car Team Places Fifth

at National Competition

The University of Houston Chem-E Car team competed at the 2012 AIChE National Competition recently, taking fifth place, the highest that UH has achieved at the national level.

Students representing UH were An Dinh (team lead), Edward McDowell, Joshua Dillon, Rishabh Mahajan, Sheli Wilson, Stephen Havard, and Tanya Rogers. Their 29-pound car was dubbed the "Zombie Cougalac." The team was advised by Professor Micky Fleischer.

Chemical engineering student teams from around the country were challenged to design and construct a size-limited car that is powered by a controlled chemical reaction. The car's performance was evaluated by its ability to travel a specified distance of 21 meters with a load measuring 300 milliliters. Distance and load parameters were given to the teams an hour before the competition.

Since the UH team's second-place win in the regional competition in April, the entire car was rebuilt to make it more competitive at the national level. The team converted all of the car's materials to either stainless or aluminum for chemical compatibility. As a commitment to US manufacturing, the team sourced parts and supplies produced domestically.

Student PROFILE

Christopher Lovero will graduate this semester with a degree in chemical engineering. During his academic career at the University of Houston, he held three internships; served as an officer in the UH chapter of the Society of Hispanic Professional Engineers (SHPE); and most recently, was chosen as the 2012 UH Homecoming King.

As a freshman, Lovero joined the Program for Mastery in Engineering Studies (PROMES), an engineering excellence program that gives students opportunities in recruitment, advising, workshops, scholarships and jobs. Through the community activities of UH SHPE and PROMES, Lovero volunteered much of his time to promote UH engineering. His inspiration to excel often came from meeting others who are driven to make their future better.

Lovero's internships took him to the Valero McKee Refinery, working in process engineering; Total Petrochemicals in Port Arthur, Tx., and Enterprise Products, a midstream services company in downtown Houston, where he has accepted a full-time offer upon graduation.

During his last semester as an undergraduate, Lovero decided to run for homecoming as a proud representative of PROMES, and was announced as the Homecoming King on November 10. "I wanted to show everyone that there are true leaders at Cullen College who are making good things happen, who are going to lead in the workforce," he said.

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To ensure that your information is included on the Chemical Engineering Alumni database please contact Nicolette Solano at Nsolano2@uh.edu and provide her with your current physical address, email address and telephone numbers.

Announcements

Chemical Engineering Certificates

Process design and chemical companies are seeking advanced/professional training for their employees to sustain the knowledge necessary to compete with the increasing demands of complex engineering and management.

The UH Executive Certificates of Chemical Engineering were created out of necessity for industry and as widespread applications for engineers through the chemical engineering field.

- Process Engineering and Modeling
- Advanced Topics in Process Analysis
- Chemical Engineering in Safety, Operations and Management

www.chee.uh.edu/certificates

The **UH Department of Chemical & Biomolecular Engineering Annual Report 2012** is now available online at www.chee.uh.edu/annual-report/2012

Nicolette Solano recently joined the department as the Administrative Assistant to the Chair.

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