CONFERENCE 2017
WATER, ENERGY & FOOD NEXUS
WELCOME FROM THE DEAN

On behalf of Texas A&M University at Qatar, it is my pleasure to welcome you to the Qatar Fertiliser Company (QAFCO) – Texas A&M University at Qatar Conference 2017. This annual event is hosted by Texas A&M at Qatar and presented in collaboration with QAFCO. QAFCO has been a steadfast and dynamic partner to Texas A&M at Qatar through the years, and I thank QAFCO for its unwavering belief in the strength of our academic and research programs, our faculty, and our current and former students.

This important conference highlights the pressing need for policy makers, industry and academia to work together to develop new knowledge and create scientific solutions that have direct impact on the world around us. This year, we focus on the water, food and energy nexus, essential for sustainable development and human well-being. Global studies foresee that demand for fresh water, food, and energy will continue to increase through the next several decades owing to population growth, economic development, cultural and technological changes, and climate change. This nexus is even more critical for areas such as the Middle East and Qatar, where fresh water is scarce and a substantial amount of oil and gas revenue is consumed to generate energy for seawater desalination for irrigation and for potable use. There are many such synergies and trade-offs between water and energy use and food production. The keynote lecture and all invited talks will assist on the recognition of these synergies and the approaches to balance the trade-offs. Thus, the global and local communities will jointly ensure water, energy, and food security for future generations. I thank our speakers for sharing their expertise with the professionals participating in this influential gathering of industry practitioners and academic scholars. Best wishes for a productive conference and many thanks to QAFCO for their support and partnership in this meeting of international experts.

Dr. César O. Malavé
Dean,
Texas A&M University at Qatar
WELCOME FROM THE ORGANIZING COMMITTEE

On behalf of the Science Program and the Chemical Engineering Program at Texas A&M University at Qatar, we are pleased to welcome you to the annual QAFCO – Texas A&M University at Qatar Conference 2017.

We are very proud of our partnership with QAFCO, which has generously supported us since 2007 in hosting the first conference series in Qatar. This series has attracted an impressive list of world-renowned scientists through the years, including 96 invited speakers from 19 countries. In addition, the list of speakers in previous years has included two Nobel laureates, Dr. Robert H. Grubbs and Dr. Ei-Chi Negishi, and a holder of the US. National Medal of Science, Dr. Paul Alivisatos.

The theme for this year’s edition is Water, Food and Energy Nexus. We are glad to have Dr. Michael Ladisch, professor at Purdue University in the United States, as keynote speaker of the 2017 edition of the conference. In addition, we have 15 distinguished invited speakers from the United States, Europe, Asia and the Middle East.

We hope this conference will be an outlet for the exchange of scientific knowledge, sharing ideas, discussing future collaborations and building new projects. Your presence at this conference reaffirms our pursuits of cutting-edge chemistry and chemical engineering research in Qatar and the region. We wish you a very productive time at this event.

Dr. Hassan S. Bazzi
Co-chair
Assistant Dean for Research

Dr. Ioannis Economou
Co-chair
Professor, Chemical Engineering Program

Dr. Konstantinos E. Kakosimos
Co-chair
Assistant Professor, Chemical Engineering Program

Dr. Sherzod Madrahimov
Co-chair
Assistant Professor, Science Program
# QAFCO – Texas A&M University at Qatar Conference 2017

## Water, Energy and Food Nexus

**Thursday, 12 January 2017**

Hamad bin Khalifa Student Center, Education City, Doha Qatar

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<td>8:00–8:45 a.m.</td>
<td>Registration and Light Breakfast</td>
<td>Noon – 1:30 pm</td>
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<td>Dr. Hassan S. Bazzi, Assistant Dean for Research, Texas A&amp;M University at Qatar</td>
<td>Lunch</td>
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<td>8:45–8:55 a.m.</td>
<td>Dr. César O. Malavé, Dean, Texas A&amp;M University at Qatar</td>
<td>1:30 – 2:30 pm</td>
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<td>Mr. Abdulrahman M. Al-Suwaidi, CEO, Qatar Fertiliser Company (QAFCO)</td>
<td>2:30 – 3:00 pm</td>
<td>Dr. David Allen, University of Texas at Austin, USA</td>
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<td>9:00–9:05 a.m.</td>
<td>Keynote Lecture (Ballroom, Chair: Dr. Konstantinos E. Kakosimos)</td>
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<td>Mr. Michael Ladisch, Purdue University, USA</td>
<td>3:00 – 4:00 p</td>
<td>“Chemistry in Nanopores: Fine-tuning Chemical Interactions for CO₂ Capture, Water Treatment, and Catalysis”</td>
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<td>9:05–10:10 a.m.</td>
<td>Renewable Resources at the Water-Food-Energy Nexus</td>
<td>4:00 – 4:30 pm</td>
<td>Dr. Rabi Mohtar, Texas A&amp;M University, USA</td>
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<td>Mr. Fahad Al-Attiya</td>
<td>“Water, Energy, Food Nexus: A Road Map for Sustainability”</td>
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<td>10:10–10:30 a.m.</td>
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### Session I

**Chair:** Dr. Sherzod Madrahimov (Room 1)

- **10:30–11:00 a.m.**
  - Dr. Theodor Agapie, California Institute of Technology, USA
  - "Conversions of CO and N₂ with Molybdenum Complexes"

### Session II

**Chair:** Dr. Ioannis Economou (Room 2)

- **11:00–11:30 a.m.**
  - Dr. Rakesh Agrawal, Purdue University, USA
  - "Solar Energy to Fuels, Chemicals and Electricity"

### Session III

- **11:30 a.m.–noon**
  - Dr. Boon Siang, National University of Singapore, Singapore
  - "Developing Catalysts for the Electrochemical Reduction of Carbon Dioxide and the Hydrogen Evolution Reaction"
  - Dr. Rabi Mohtar, Texas A&M University, USA
  - "Water, Energy, Food Nexus: A Road Map for Sustainability"
## Session II

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<td>1:30 a.m.–2:00 p.m.</td>
<td>Dr. Hongcai “Joe” Zhou Texas A&amp;M University, USA  &quot;Tuning the Synthesis of Metal-organic Frameworks (MOFs) through Thermodynamic and Kinetic Analysis&quot;</td>
<td>Dr. Angel Irabien University of Cantabria, Spain  &quot;Carbon Dioxide Utilization: Capture and Electrochemical Reduction to Useful Products&quot;</td>
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<tr>
<td>2:00 p.m.–2:30 p.m.</td>
<td>Dr. Omar K. Farha Northwestern University, USA  &quot;Functional Metal organic Framework Materials&quot;</td>
<td>Dr. Daniel Schwartz University of Washington, USA  &quot;Probing the Nonlinear Dynamics of a Battery to Gain New Diagnostic Insights&quot;</td>
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## Session III

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<td>3:00 p.m.–3:30 p.m.</td>
<td>Dr. Cristiane Sanchez Farinas Brazilian Agricultural Research Corporation, Brazil  &quot;Enzymatic Conversion of Lignocellulosic Biomass as a Platform to Obtain Fuels, Chemicals, and High-value Products&quot;</td>
<td>Dr. Gerasimos Lyberatos National Technical University of Athens, Greece  &quot;Wastes and Biomass Valorization for Biofuels, Energy, and Biopolymer Production&quot;</td>
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<td>3:30 p.m.–4:00 p.m.</td>
<td>Dr. Pance Naumov New York University Abu Dhabi, UAE  &quot;Dynamic Molecular Single Crystals&quot;</td>
<td>Dr. Keat Teong Lee Universiti Sains Malaysia, Malaysia  &quot;Microalgae: A Third-generation Biomass for Biofuel Production&quot;</td>
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Abstract

There are numerous dimensions that will define solutions to sustainably address basic needs of a growing global population: water, food, and energy. The challenges presented by climate change and population growth coincide with the emergence of science and technology that will help to provide solutions by enhancing the production of food and providing sources of energy that are both renewable and carbon efficient. In this context, the study of renewable resources—solar, wind, water, and biomass—becomes a critical element of transitioning current practices to a sustainable global economy that benefits people living in diverse geographical areas. In particular, the development of agricultural and bio-manufacturing biotechnologies will help to address needs for food and fuels by providing more efficient ways of growing crops, improving post-harvest technology and food security, and enabling bioprocess engineering that transforms non-edible components from agricultural production into value-added biofuels and bio-products with reduced carbon footprints.

This presentation will give an overview of how renewable resources, when grown and processed in a sustainable manner, might provide these and other benefits. This keynote address will also attempt to make connections between how fundamental advances in science, engineering, and technology—when coupled to successful translation of discoveries to tangible products—could begin to enable evolutionary changes in how we produce or use water, food, and energy. The important role of higher education in providing interdisciplinary experiences in solving problems based on teamwork of technical subject-matter experts will also be illustrated. Examples will be taken from advances in plant genotyping and phenotyping, mechanisms of biocatalytic plant cell wall deconstruction, and application of engineering for translating advances to scalable solutions for a world with nine billion people in it.

Biography

Michael R. Ladisch is director of the Laboratory of Renewable Resources Engineering (LORRE) and Distinguished Professor of Agricultural and Biological Engineering with a joint appointment in the Weldon School of Biomedical Engineering. He was CTO at Mascoma Corp. from 2007 to 2013 and serves on the scientific advisory board of Agrivida. His B.S. from Drexel University and M.S. and Ph.D. from Purdue University are in chemical engineering. Ladisch’s research addresses transformation of renewable resources into biofuels and bioproducts, protein bioseparations, and food pathogen detection. He is an author of two textbooks, numerous journal papers, and 20 patents. Ladisch was elected to the U.S. National Academy of Engineering in 1999, named as one of 100 engineers of the modern era by AIChE in 2008, received the Charles D. Scott Award in 2009, and elected a fellow of ACS and AAAS in 2011 and the National Academy of Inventors in 2014. He has recently joined the board of the newly formed Foundation for Food and Agriculture Research.
Abstract
The chemistry of small molecules carbon dioxide (CO$_2$), carbon monoxide (CO), and dinitrogen (N$_2$) is of interest in the context of renewable energy storage and conversion and sustainable production of food. With the rise of atmospheric CO$_2$ levels and geopolitical constraints on the availability of reduced carbon reserves, the generation of liquid fuels from oxygenated C$_1$ feedstocks is desirable using carbon-neutral sources of energy. Formation of deoxygenated C$_{2+}$ products from CO$_2$ is rare and occurs via initial conversion to CO. While many homo- and heterogeneous catalysts convert CO$_2$ to CO and their mechanisms are currently a topic of significant interest, examples of deoxygenative coupling of CO to C$_{2+}$ products are sparse and the mechanism is largely unknown. The conversion of N$_2$ to ammonia (NH$_3$) as fertilizer is also a major environmental and socioeconomic issue given the projected growth of world population. The H$_2$ used in the Haber-Bosch process for the production of NH$_3$ is derived from fossil fuels, connecting the industrial conversion of N$_2$ to NH$_3$ to the challenges of CO$_2$ and CO generation and conversion.

Biography
Theodor Agapie is a professor of chemistry at the California Institute of Technology. Originally from Bucharest, Romania, Agapie received his B.S. degree from Massachusetts Institute of Technology in 2001 and his Ph.D. from California Institute of Technology in 2007. He was a Miller Postdoctoral Fellow at University of California, Berkeley. Agapie returned to Caltech in 2009 to start his independent career as assistant professor of chemistry. He has been professor of chemistry since 2014. His research focuses on synthetic inorganic and organometallic chemistry on topics related to energy conversion, catalysis, and upgrading readily available chemical precursors.

"Conversions of CO and N$_2$ with Molybdenum Complexes"
Abstract

Currently, more than 80 percent of the world’s energy needs are met by burning fossil fuels such as natural gas. The supply of these fuels is limited and will eventually run out. Combustion of fossil fuels also generates carbon dioxide, which is a suspected accelerant of global warming and a regulatory burden for industrial emitters. One solution for reducing atmospheric CO\(_2\) levels is carbon capture and sequestration. Another alternative is to electrochemically reduce the emitted CO\(_2\) into carboxylic acids, hydrocarbons or alcohols, which are useful chemical feedstocks and fuels. Water can also be reduced to hydrogen gas, which can be used as a carbon-free fuel. If the energy used for these processes is generated from a renewable source such as solar or wind, we can envisage a chemical production cycle that is closed-loop with net-zero carbon emission.

In this talk, we will present issues related to the electroreduction of CO\(_2\) to C\(_2\) and C\(_3\) molecules, as well as water electrolysis. We will first discuss factors that gave Cu\(_2\)O-derived Cu catalysts the ability to selectively reduce CO\(_2\) to ethylene. We will show that this ability can be correlated to the crystallite sizes of the Cu\(_2\)O-derived Cu particles. We shall also present a new class of CO\(_2\) reduction catalysts made from Cu and Zn, which is highly selective towards the formation of ethanol. A two-site mechanism to rationalize the selectively is proposed.

Finally, we show an operando Raman spectroscopy study of amorphous MoS\(_x\) films during the hydrogen evolution reaction. This investigation allowed us to directly identify sulfur atoms in MoS\(_x\) as the catalytically active sites for proton reduction.

Biography

Boon Siang Yeo studied chemistry at the National University of Singapore (NUS), where he received his B.Sc. (Hons) and M.Sc. degrees. He obtained his Ph.D. from ETH Zurich and did postdoctoral research at the Lawrence Berkeley National Laboratory. Boon Siang joined the NUS in 2012 as an assistant professor in the Department of Chemistry. He is also an adjunct assistant professor in the Solar Energy Research Institute of Singapore. His work focuses on developing efficient electrocatalysts for important sustainable energy conversion reactions, such as the reduction of carbon dioxide to liquid fuels.
Dr. Cafer T. Yavuz
KAIST (Korea Advanced Institute of Science and Technology)

Abstract
Nanopores (< 100 nm) in porous polymers offer confined spaces with vast contact surfaces and tunable functionalities. We have developed a family of nanoporous covalent organic polymers (COPs) through scalable, catalyst-free conditions that feature a wide range of functional groups available for chemical interactions. In particular, azo (N=N) groups were shown to selectively separate CO\textsubscript{2} from N\textsubscript{2} by the discovery of an N\textsubscript{2}-phobic mechanism. By varying chain length of a covalently tethered amine within a nanopore, we optimized CO\textsubscript{2} binding energy, leading to new CO\textsubscript{2}-sorbent designs. Charged organic molecules are captured by a size and charge dependent separation using fluorinated porous networks. This unique interaction of fluorine with charged species enables considerable promise in water treatment technologies. Nanopores with heterocyclic pore-wall chemistries (e.g., benzoxazoles) enable catalytic, oxidative, metal-free coupling of amines. Another, highly charged COP system converts epoxides and CO\textsubscript{2} into cyclic carbonates with unprecedented selectivity and conversion at near ambient conditions. When the nanopores are loaded with nanoparticles, the porous host and the reactive nanocrystal display a symbiotic action. A poisoned Pd nanoparticle in a sulfur COP catalyzes acetylene reduction into ethylene with exceptional yields. Caged cobalt oxide within an amide porous polymer is found to be as active as a Pd in CO oxidation. Finally, nanoscale iron particles remain highly reactive if concealed within the confined spaces of porous polymers.

Biography
Cafer T. Yavuz received his B.S. degree in chemistry from the Middle East Technical University in Ankara, Turkey. He completed the four-year program in only three years being the first in the honor program’s and second in the chemistry department’s 40-year history. When he was in high school, he attended the 29th and 30th International Chemistry Olympiads representing Turkey twice and won silver and a bronze medals in Canada and Australia, respectively. He was admitted to Rice University in 2001 with a Welch scholarship and received his master’s and Ph.D. under the supervision of Dr. Vicki L. Colvin. His research focused on production of magnetic nanocrystals and their use in arsenic removal. His paper in Science magazine was named Forbes magazine’s “Top 5 nanotech breakthroughs of 2006” and was covered in more than 80 media outlets, such as The New York Times, BBC, The Houston Chronicle, and The Guardian. His work was selected among the “Six Ideas That Will Change The World” by Esquire magazine (December 2007). He worked as a postdoctoral scholar at the University of California, Santa Barbara, with Dr. Galen Stucky on CO\textsubscript{2} sequestration, conversion, and co-activation with methane (CH\textsubscript{4}) until his appointment as an assistant professor in the Graduate School of Energy, Environment, Water, and Sustainability (EEWS), KAIST, South Korea in June 2010. He is the first Turkish faculty member (tenure track) appointed to a Korean university. He was promoted to associate professor in September 2013 and jointly appointed to the Department of Chemistry. He is an editorial board member at Chem, a new chemistry journal by Cell Press. He is also associate editor for RSC Advances of the Royal Society of Chemistry.
As an emerging class of highly ordered porous materials, metal-organic frameworks (MOFs) have attracted a great deal of attention in the past two decades. The modular nature empowers MOFs with extraordinary flexibility such as designable topology, adjustable porosity, tunable surface properties, and variable surface functionalities within a single material, which enables potential MOF applications in many areas, including gas storage, separation, catalysis, and biomedical applications. Two prerequisites for these applications are functionality and stability. Thus, functionalization of exceptionally stable MOFs that have the most upsides in applications becomes a sought-after goal. MOF synthetic work has relied almost exclusively on the “one-pot” approach initially. In the past few years, attentions have been focused on the labile nature of the metal-carboxylate bonds. Recent work in stepwise MOF synthesis has led to a new synthetic toolbox. Using existing coordination assemblies including preformed clusters, metal-organic polyhedron (MOPs) and MOFs as starting materials — through bridging ligand exchange or metal metathesis — new MOPs and MOFs that are otherwise difficult or unforeseeable to obtain are now readily accessible. The key is to systematically analyze the kinetics and thermodynamics (K&T) of ligand exchange and metathesis reactions and apply K&T control. For instance, for high-valent MOFs, the inertness of the metal-carboxylate bonds is a double-edged sword: The MOFs are difficult to make but they are generally exceptionally stable. This has posed a synthetic challenge for the preparation of high-valent MOFs, which may have the most application potential. By judicious K&T control, we have developed the following synthetic methods: (1) Kinetically tuned dimensional augmentation, in which a robust cluster with terminal carboxylate groups has been extended to 3D-rameworks by systematically tuning the kinetics of the synthetic procedure; (2) post-synthetic metathesis and oxidation, where redox chemistry has been applied to tune the kinetics of the synthetic procedure; and (3) sequential linker installation, through which up to three different linkers can be installed sequentially to obtained mixed linker MOFs with crystallographically ordered structure.
Abstract

Metal-organic frameworks (MOFs) are an emerging class of solid-state materials built up from metal-based nodes and organic linkers. They exhibit permanent porosity and unprecedented surface areas which can be readily tuned through coordination chemistry at the inorganic node and/or organic chemistry at the linkers. The high porosities, tunability, and stability are highly attractive for many applications. This talk will address new advances in the synthesis and activity of MOF materials developed at Northwestern University for relevant applications.

Biography

Omar K. Farha is a research professor of chemistry at Northwestern University, Distinguished Adjunct Professor at King Abdulaziz University, president of NuMat Technologies, and associate editor of ACS Applied Materials and Interfaces. His research accomplishments have been recognized by several awards and honors, including the Royal Society of Chemistry Environment, Sustainability, and Energy Division Early Career Award; American Chemical Society Satinder Ahuja Award for Young Investigators in Separation Science; and an award established by the Department of Chemistry at Northwestern University in his honor: the Omar Farha Award for Research Leadership. His current research spans diverse areas of chemistry and materials science ranging from energy to defense-related challenges. Farha has more than 250 peer-reviewed publications, holds 10 patents, and was named a “Highly Cited Researcher” by Thomson Reuters in 2014, 2015, and 2016.
Abstract

The conversion of lignocellulosic biomass into fuels, chemicals, and high-value products using the biochemical route has been considered the most sustainable alternative for the implementation of this process. Thus, enzymatic conversion of the polysaccharides present in lignocellulosic biomass will certainly be a key technology in future biorefineries. In fact, the first industrial-scale cellulosic ethanol plants that have started operating worldwide apply the enzymatic hydrolysis process to convert biomass into simple sugars. However, several technological challenges still need to be addressed in order to obtain commercially competitive products. One such challenge is the need to use high loadings of solids in the hydrolysis reactors. In addition to the associated difficulties from the process engineering perspective, the presence of inhibitors of the biochemical reactions can negatively affect the efficiency of both the enzymatic hydrolysis and the alcoholic fermentation. These inhibitors, together with the residual lignin, also have impact on the enzyme loading required to convert cellulose into glucose, which in turn has a major influence on the economics of the process. The use of on-site enzyme production within the ethanol mills is a potential approach to reduce the costs associated with enzymes. Besides, this strategy allows the production of an enzymatic cocktail tailored to degrade each specific biomass. This presentation will discuss some of the current challenges and perspectives regarding the enzymatic hydrolysis step for processing lignocellulosic biomass within the biorefinery concept. Recent results of process configuration strategies for biomass conversion using biochemical technologies to obtain biofuels as well as high-value products such as nanocellulose and on-site production of enzymes using sugarcane biomass as feedstock will be presented.

Biography

Cristiane Farinas holds a B.Sc. degree from the Federal University of São Carlos (UFSCar, Brazil), and a master's (2001) and doctoral degree (2004) from State University of Campinas (UNICAMP, Brazil), all in chemical engineering. She held a postdoctoral position in the Chemical Engineering Program at Federal University of Rio de Janeiro (COPPE-UFRJ, Brazil) in 2006, all in the area of bioprocess engineering. She is currently a researcher at EMBRAPA – the Brazilian Agricultural Research Corporation (Ministry of Agriculture, Livestock, and Food Supply). Farinas has been working on research projects in the bioenergy area, focusing on the development of bioprocesses for enzyme production for application in the biofuels sector. Her interests are in chemical and biochemical technologies for biomass conversion within the biorefinery concept. She has been carrying teaching activities in the Graduate Program in Chemical Engineering from UFSCar, where she ministers graduate courses and supervises master's and doctorate students and postdoc fellows.
Abstract

Elastic materials that are capable of stimuli-responsive mechanical reconfiguration are indispensable for fabrication of mechanically tunable elements for actuation and energy harvesting, including flexible electronics, artificial muscles, and microfluidic elements. The advanced materials that will qualify for these applications in the future must fulfill an extended list of requirements, including reversibility, rapid and controllable mechanical response that is proportional to the applied stimulus, and extended lifetime without fatigue. Elastic properties are counterintuitive for single crystals of molecular materials, which are normally perceived as stiff and brittle entities. The growing realization that bending, curling, twisting, jumping, and other mechanical effects of single crystals are surprisingly common has inspired researchers to control crystal motility for actuation. However, new mechanically responsive crystals are reported at a greater rate than their quantitative photophysical characterization; quantitative and measurable parameters that determine the mechanical response have yet to be established.

We have recently developed an overarching model for mechanical effects in crystals that aids our understanding of their relation to macroscopic measurables. The model can be used for quantification and for benchmarking of the performance of different mechanical effects. The results provide a basis for direct correlations with the molecular and crystal structure.

Biography

After acquiring his Ph.D. in chemistry and materials science from Tokyo Institute of Technology in 2004, Panče Naumov continued his research as an independent research fellow of the National Institute for Materials Science in Japan. There he established a new laboratory for the study of solid phenomena, while simultaneously performing research at two Japanese synchrotrons. In 2007, he was appointed an associate professor at Osaka University, where he established a second, new laboratory for solid-state chemistry, and led a small but very active research group. In 2012 he became an associate professor at New York University’s new campus in Abu Dhabi (NYUAD). The research in Naumov’s group at NYUAD is in the domain of structural and solid-state chemistry, nanoscience, and photochemistry. In the past few years, he has focused on the development of new, frontier, diffraction-based methods for the study of reaction mechanisms in the solid state. His publication portfolio includes more than 160 publications that have been cited more than 2,500 times, with an h-index of 25. He serves as a member of the review panels with the National Science Foundation (NSF), European Research Council (ERC), The Petroleum Fund of the American Chemical Society (ACS), and the Ministry of Education and Science of the Russian Federation. He is active reviewer for more than 40 journals published by the Nature Publishing Group, the American Chemical Society, Wiley-VCH, the Royal Society of Chemistry, Elsevier, and other publishers.
Abstract

In the long run, it is likely that all the basic human needs will be met by renewable sources such as solar energy. However, there are several challenges associated with harness, storage and use of solar energy to meet our daily needs for food, chemicals, heat, electricity, and transportation. In a sustainable future, all these usage must coexist.

We will first present some results from our energy systems modeling highlighting the synergistic interactions that exist for transportation sector and production of chemicals. This will be followed by a discussion and analysis of candidate processes to produce hydrogen from solar energy, our modeling results for energy storage at giga Watt-hour levels, and uninterrupted around the clock electricity production using new solar thermal power cycles with internal hydrogen circulation. Such cycles have a potential to not only supply solar thermal electricity at an unprecedented efficiency during the period while solar energy is available but have a potential to supply around the clock electricity with efficiencies similar to that from batteries storage.

However, here energy is stored at a much higher density. We will then discuss our vision of how to use solar thermal processes to meet demand for water, chemicals and food.

Biography

Rakesh Agrawal is the Winthrop E. Stone Distinguished Professor in the School of Chemical Engineering at Purdue University. He is an expert in energy-related areas involving the conversion of biomass to liquid fuels, processes associated with low-cost solar cells, energy systems analysis, and high-efficiency separations processes. He is a member of the National Academy of Engineering, and a fellow of the American Academy of Arts and Sciences and the National Academy of Inventors. He received the National Medal of Technology from President Barack Obama in 2011, holds 121 U.S. patents and nearly 500 non-U.S. patents, has been author of 163 technical papers, and has given more than 200 invited talks.
“Water-Energy-Food Nexus: A Road Map for Sustainability”

Dr. Rabi Mohtar
Texas A&M University, USA

Abstract

Global shifts in risks and changes associated with water, energy, and food securities will be presented. Special attention will be paid to the interconnectedness of the portfolio of these primary resources. The water-energy-food nexus builds on integrated resources management, and will be introduced as a holistic transdisciplinary and inclusive multistakeholder platform for primary resource allocation and management. The nexus platform allows for the identification of local and site-specific tradeoffs and hotspots that facilitate dialogue among stakeholders. From among those hotspots, the role of local and site-specific knowledge will be explored. Localization of resources using the nexus platform will be highlighted with a focus on better utilization of local resources and improved understating of the impacts of reuse and resource efficiencies. Various success stories of Nexus implementation will be presented. The talk will conclude with recommendations for future action.

Biography

Rabi Mohtar is a TEES Endowed Professor at Texas A&M University in College Station, Texas, USA. Mohtar pioneered the development of a conceptual and modeling framework linking the water-energy-food (WEF) nexus with science and policy. He designed and evaluated international sustainable water management programs addressing population growth and water shortage conditions in arid climates. He has been named the 2015 Ven Te Chow Memorial Lecturer, distinguished alumnus of American University of Beirut (2013), and recipient of the Kishida International Award (2010). Mohtar is a member of the International Steering Committee of the World Water Forum and serves on the advisory council to the World Water Council.

Climate change is one the main drivers in the development of mitigation alternatives to the carbon dioxide accumulation in the atmosphere. Carbon dioxide capture and storage and carbon dioxide capture and utilization require the development of novel processes able to connect human demands with the use of natural resources. Carbon dioxide capture and the electrochemical transformation of carbon dioxide into formic, acid, carbon monoxide, methanol, or methane using renewable energies allows to store the intermittent energies as useful products. New processes for carbon capture have been studied at a laboratory scale, including the coupling of ionic liquids and membrane materials in non-dispersive absorption processes. Some examples – including the study of different ionic liquids and membrane materials – show the availability of innovative technologies to be applied to the carbon capture. The electrochemical reduction of carbon dioxide is a complex process in which the selection of the catalyst plays an important role. In laboratory studies the viability to develop technical processes to obtain formic acid has been shown using different forms of tin (Sn) from flat plates to microparticles or nanoparticles based catalysts. High productivities and faradaic efficiencies have been leading to a promising process to obtain formic acid from carbon dioxide and renewable energy. Electrocatalysts based on copper have been able to produce carbon monoxide, methanol, and methane, and show promising possibilities to the process intensification.

**Biography**

Since 2005, Angel Irabien has been professor and head of the research unit SOSPROCAN with 23 researchers, coordinating the following research topics: Carbon capture and utilization, waste minimization, circular economy and sustainability, life cycle assessment of processes and products. In the past 10 years he has been invited to many international congresses and as member of many scientific committees, keynote lectures and plenary lectures. Also in the past 10 years, more than 100 of his papers have been published in Q1 scientific journals and more than 20 international, national and regional research projects have been carried out. A recent research stay as academic visitor in the Department of Engineering Science (University of Oxford) has been used to develop new tools for the assessment of sustainable products and technologies.
Abstract

The State of Texas has extensive fuel, electricity, and agricultural production. All of these systems rely on water resources, and the spatial and temporal variations in water availability in Texas can be extreme. The robustness and resiliency of coupled and interdependent natural gas infrastructures, infrastructures needed to provide electrical energy, and the interaction of these fuel and electricity infrastructures with water systems, agricultural activity, and air quality can be assessed using coupled systems of state of the science modeling tools. This presentation will describe several case studies of this type of systems modeling, including the response of the systems to extreme drought and the response to environmental policy interventions. While these analyses of the Texas food-energy-water systems are inherently regional, the methods used to construct the necessary modeling systems can be applied to many regions.

Biography

David Allen is the Gertz Regents Professor of Chemical Engineering and director of the Center for Energy and Environmental Resources at the University of Texas at Austin. He is the author of seven books and more than 200 papers, primarily in the areas of urban air quality, the engineering of sustainable systems, and the development of materials for environmental and engineering education. The quality of his work has been recognized with multiple awards; he has served on a variety of governmental advisory panels and from 2012 to 2015 chaired the U.S. Environmental Protection Agency’s Science Advisory Board. Allen received his B.S. in chemical engineering, with distinction, from Cornell University in 1979. His M.S. and Ph.D. degrees in chemical engineering were awarded by the California Institute of Technology in 1981 and 1983. He has held visiting faculty appointments at the California Institute of Technology, the University of California, Santa Barbara, and the U.S. Department of Energy.
Abstract

Organic waste (such as agroindustrial waste) and biomass may be converted to useful biofuels such as bioethanol, biogas, and biodiesel through appropriate biotechnological processes. Anaerobic digestion is a mature technology, widely used for biogas generation from various types of biomass. Typical CSTR-type digesters are routinely used, despite the fact that they require long retention times. High-rate digesters are able to produce large quantities of biogas with a small retention time. A novel such digester, the periodic anaerobic baffled reactor (PABR), has been used to this end. Its design, operation and effectiveness for the treatment of specific agroindustrial wastes are presented. Hydrogen represents for many the fuel of the future. A hydrolytic bioreactor may generate hydrogen, while at the same time, carbohydrates (and other biological macromolecules) are converted to a mixture of fatty acids and alcohols. The hydrogen yield and the mixture composition highly depend on the bioreactor operating conditions. The liquid effluent from a hydrogen producing bioreactor may then be exploited in two different ways (a) production of biogas (methane and CO₂) through anaerobic digestion or (b) production of biopolymers through an SBR operation. Biopolymers represent a sustainable alternative to conventional polymers. Such two-stage processes have been developed successfully for sweet sorgum extract, olive-mill wastewater, dairy wastewater, and glycerol, generated as a byproduct of the biodiesel industry. An alternative to a two-stage process for waste and biomass valorization is the use of a microbial fuel cell to generate directly electrical energy from waste in an environmentally friendly manner. Microbial fuel cells may be used to generate electricity effectively even from municipal wastewaters. Recent developments in the use of dual-chamber and single-chamber microbial fuel cells for the simultaneous wastewater treatment and electricity generation are presented.

Biography

Gerasimos Lyberatos is currently professor in the School of Chemical Engineering, National Technical university of Athens (since July 2011). He obtained his B.S. at MIT (USA) and his M.S. and Ph.D. at Caltech (USA) and served as assistant and associate Professor at the University of Florida. In 1990 he joined the University of Patras as an associate professor and in 1993 became a professor. His research interests are in biochemical engineering and environmental technologies. He has more than 160 publications in international refereed journals and given more than 250 participations in international conferences. Lyberatos is editor of the Journal of Hazardous Materials (Elsevier) and associate editor of Waste and Biomass Valorization (Springer).
Battery use is growing rapidly in consumer electronics, vehicles, and grid applications. In nearly all applications, there is a desire to operate the battery aggressively (i.e., faster charging, deeper discharging, etc.) without compromising safety or cycle life. Unfortunately, most batteries are operated conservatively owing to poor diagnostic insight into the internal states of the battery. We describe the use of moderate amplitude current perturbations to drive batteries into the weakly nonlinear regime, where the fundamental and higher harmonic response of the voltage provides new insights into battery states. Experiments and simulations are combined to illustrate the physics and chemistry that is accessible with this form of nonlinear electrochemical impedance spectroscopy.

As with nonlinear optical techniques, we show that the second harmonic response is sensitive to symmetry breaking in the charge transfer reaction at either electrode, with the frequency of symmetry-breaking being characteristic of the positive or negative electrodes. Our long-term goal is to combine this physics-rich probing of batteries with statistical predictors to estimate the state of health and remaining usable life of a battery, opening new avenues for more aggressive battery management.

Biography

Daniel T. Schwartz is Boeing-Sutter Professor of Chemical Engineering and director of the Clean Energy Institute at the University of Washington. He earned his Ph.D. in chemical engineering at the University of California, Davis, in 1989 and then did a postdoc at the U.S. Department of Energy’s Lawrence Berkeley National Laboratory. In 1991, Daniel joined the University of Washington, where he founded the Electrochemical Materials and Interfaces Laboratory. His students use electrochemical engineering principles to understand, design, and improve a wide range of electrochemical materials and devices. Select honors include the University of Washington Marsha Landolt Distinguished Graduate Mentor Award and Electrochemical Society recognition as Fellow and the Henry B. Linford awardee. He is an elected member of the Washington State Academy of Sciences.
Dr. Keat Teong Lee
Universiti Sains Malaysia, Malaysia

**Abstract**

Ever since after the industrialization revolution in Europe, the use of fossil-based fuel has been escalating in tandem with the increase in world population and improved standard of living. Unfortunately, the use of fossil-based fuel can cause negative effect on the earth’s ecosystem, society, and economy at large. In addition to that, fossil-based fuel are generally categorized as non-renewable source as the rate of usage far exceeds the rate of formation and thus will be depleted in the future. These factors have made conventional fossil-based fuel no longer sustainable to meet the world’s increasing energy demand. In addition, it has been well established that one of the main causes of global warming is the emissions of greenhouse gasses from combustion of fossil fuels in vehicles, factories, and power plants. In order to replace fossil-based fuels, the production of biofuels has therefore gained much attention recently as an immediate and potential alternative. Biofuels can be defined as solid, liquid, or gaseous fuels that are derived from biological processes rather than geological processes that take a very long time. One of the readily available feedstocks for biofuels are crops that contain sugar, starch, or oil. However, as the world confronts food shortages due increasing world population, scientists around the globe are scrambling to develop biofuels from non-edible feedstocks that may be more sustainable in the long run. Recently, microalgae has emerged as a third-generation biomass feedstock for biofuel production due to its fast growth rate and ability to accumulate high quantity of lipid and carbohydrate inside their cells for biodiesel and bioethanol production, respectively. However, several recent life cycle assessment studies have revealed that enormous energy input is required to cultivate microalgae and also for the harvesting and drying processes. The energy required (in the form of electricity) is normally generated from burning coal or natural gas that emits substantial amount of CO\textsubscript{2} to the atmosphere and this could entirely eliminate all the positive effect of culturing microalgae for CO\textsubscript{2} bio-fixation and biofuel production. Thus, in my presentation, I will cover some of the development being carried out to reduce the energy requirements for conversion of microalgae to biofuels.

**Biography**

Lee Keat Teong obtained his Ph.D in chemical engineering from Universiti Sains Malaysia (USM) in 2004. He is currently a professor in the School of Chemical Engineering and director of the Research Creativity and Management Office at USM. Lee has been co-author of one book, eight book chapters, 28 review papers, and more than 100 research papers in peer-reviewed international journals. He is currently the co-editor for *Energy Conversion and Management* (Elsevier), and an editorial board member for *Bioresource Technology* (Elsevier) and *Energy Science and Engineering* (Wiley). He has also won numerous awards, including Young Scientist Award 2011 by The International Forum on Industrial Bioprocess and 2012 Top Research Scientists Malaysia by the Academy Sciences of Malaysia. Currently he is working on the production of biofuels (biodiesel and bioethanol) from biomass (including macro and microalgae) using various technologies. Apart from that, he also has special interest on the social and sustainability aspects of biofuels.
Abstract

Qatar, like its sisters in the GCC, is a country born with multiple disabilities. First and foremost is the lack of fundamental resources such as water and food. The endowment of hydrocarbon resources and the influx of liquidity into the economies of these small city states has led them to make choices that were at the time seen to lead to a path of development and greater prosperity, but they are also unsustainable and risk-prone. What followed were economic models that are catastrophic in every sense of the word, if one measures its resilience against the inherent risks that surrounds the availability and access to such fundamental resources. The talk will assess the current economic model in light of these circumstances and offer an alternative pathway that aims to maintain control and resilience against a changing world.

Biography

Following his schooling in Qatar, Fahad Al-Attiya joined the Qatar Armed Forces as an officer cadet at which time he was accepted to and educated at the Royal Military Academy, Sandhurst, in the UK. After Sandhurst, he served with the elite Grenadier Guards in the UK and then with the Special Forces in Qatar. In 2007 he joined the office of the Heir Apparent at the Emiri Diwan as Legal Counsel for His Highness the Emir. He is also on the Legislation Council of Qatar. In November 2008 the Heir Apparent directed Al-Attiya to chair and lead the Qatar National Food Security Program, a cooperative effort virtually unprecedented in Qatar's history. Under Al-Attiya's leadership, the QNFSP developed a Master Plan that will become a model for sustainable, environmentally friendly agriculture in arid regions, and represent a unique challenge to the popular conceptions of food security being achieved in dry land countries.

Al-Attiya is currently serving as a Legal Council for His Highness the Emir.