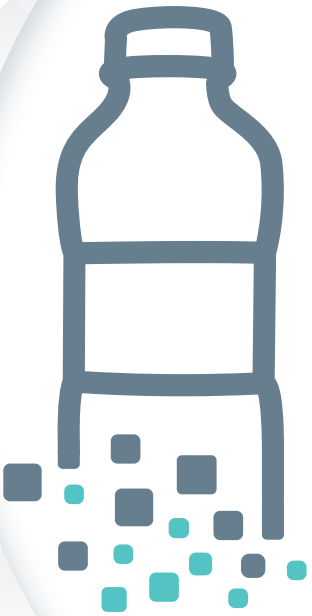

GLOBAL SYMPOSIUM ON WASTE PLASTIC

Ecosystem Impacts, Remediation and Waste Management

SEPTEMBER 19-20, 2019

University of Kentucky Gatton Student Center, Lexington, KY

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TIPS FOR A SUCCESSFUL MEETING

Say **hello** to everyone.
You might make someone's day.

Introduce yourself to people you don't know.
They may be your next good friends.

Stop and **smile**.
You will brighten the room considerably.

Be **understanding**.
Everybody makes mistakes.

Help those with less experience.
We were all novices at some point.

Respect others.
We all have something valuable to contribute.

Value staff and volunteers.
They are here for you.

Be **kind**.
You will never like everybody, but you can be cordial to all.

Enjoy the meeting!
You can have fun while sharing,learning and networking.

Abstracts appear as submitted by their authors. Neither the American Institute of Chemical Engineers (AIChE) and its entities, nor the employers affiliated with the authors or presenting speakers, are responsible for the content of the abstracts.

WELCOME ADDRESS

Greetings!

Dear Colleagues:

Welcome to the 2019 Global Symposium on Waste Plastic – Ecosystem Impacts, Remediation and Waste management, and to Lexington, Kentucky.

This year's symposium focuses on key themes in plastic manufacturing, recycle, reuse and disposal. The program features speakers from leading companies, prominent universities, and various government entities. Together, they will discuss and share ideas, innovations and achievements for managing the waste plastic accumulation challenges faced by both developing and developed countries. Through engaging with speakers and other participants, we hope you will leave the 2019 Global Symposium on Waste Plastic with an enriched outlook on the most current research and industry-oriented efforts in waste plastic management.

The keynote speakers at the beginning of each day will set the stage for the overarching themes of the conference, which the invited speakers and presenters in the technical sessions that follow will explore in depth. Regular networking breaks will facilitate discussions between the speakers and audience.

This conference would not be possible without the dedication and contributions from many of our colleagues. We acknowledge the efforts of our Technical Co-chairs and Organizing Committee, and the leadership of the Session Chairs. We extend additional thanks to all of our invited and selected presenters, corporate sponsors, academic and government supporters, without whom the conference would not be possible. Finally, we would like to thank you for coming and taking part in this conference and wish you a pleasant stay in Lexington and an enriching experience at the 2019 Global Symposium on Waste Plastic.

Sincerely,

Conference Chairs

Dr. Jeffrey Seay
PJC Board of Trustees Engineering Associate Professor
Chemical Engineering, Paducah Campus
University of Kentucky, Kentucky, USA
Jeffrey.Seay@uky.edu

Dr. Nien-Hwa Linda Wang
Maxine Spence Nicholas Professor
Chemical Engineering
Purdue University, Indiana, USA
wangn@ecn.purdue.edu

CONFERENCE ORGANIZERS

Conference Co-Chairs

Jeffrey Seay, *University of Kentucky, USA*
Nien-Hwa Linda Wang, *Purdue Univeristy, USA*

Steering Committee

Ed Daniels, *REMADE Institute, USA*
Betsy Beymer-Farris, *University of Kentucky, USA*
Grace Wan-Ting Chen, *University of Massachusetts Lowell, USA*
Peter Clarke, *XSeriCon, Hong Kong*
Martin Geithmann, *Plastic Technologies, Inc., USA*
Jiří Jaromír Klemeš, *Brno University of Technology, Czechia*
Prasenjit Mondal, *Indian Institute of Technology - Roorkee, India*
Ignasi Palou-Rivera, *RAPID, USA*
Robert Peters, *University of Alabama at Birmingham, USA*

Organizers

The 2019 Global Symposium on Waste Plastic is organized by the American Institute of Chemical Engineers (AIChE) Institute for Sustainability (IfS).

AIChE The Global Home of Chemical Engineers

institute for sustainability An AIChE Technological Community

PROGRAM OVERVIEW

Wednesday, September 18, 2019	
07:30 PM – 08:30 PM	Bourbon Dinner

Thursday, September 19, 2019	
07:00 AM – 09:00 AM	Registration
09:00 AM – 09:15 AM	**Opening Ceremony**
09:15 AM – 10:00 AM	**Keynote Presentation**
10:00 AM – 10:20 AM	Coffee Break
10:20 AM – 12:20 PM	**Session 1 – Waste Management and Circular Economy**
12:20 PM – 01:30 PM	Lunch
01:30 PM – 03:30 PM	**Session 2 – Ecosystem Impacts and Remediation Strategies**
03:30 PM – 03:50 PM	Coffee Break
03:50 PM – 04:05 PM	**Special Guest Talk**
04:05 PM – 04:30 PM	**Rapid Fire Session**
04:30 PM – 06:00 PM	**Poster Session & Welcome Reception**

Friday, September 20, 2019	
07:30 AM – 09:15 AM	Registration
09:15 AM – 10:00 AM	**Keynote Presentation**
10:00 AM – 10:20 AM	Coffee Break
10:20 AM – 12:20 PM	**Session 3 – Reuse and Recycle of Waste Plastic**
12:20 PM – 01:30 PM	Lunch
01:30 PM – 03:30 PM	**Session 4 – Industry Panel**
03:30 PM – 04:00 PM	**Closing Ceremony**

TECHNICAL PROGRAM

Thursday, September 19, 2019		
07:00 AM – 09:00 AM	Registration	
09:00 AM – 09:25 AM	**Opening Ceremony**	
09:25 AM – 10:00 AM	**Plenary Talk: James Drummond, Lexmark, USA**	
10:00 AM – 10:20 AM	Coffee Break	
10:20 AM – 12:20 PM	**Session 1 – Waste Management and Circular Economy**	
10:20 AM – 10:45 AM	Invited Talk: End of Life Considerations for Plastics Recyclability and Benign Degradation	Meltem Urgun Demirtas, Argonne National Laboratory, USA
10:45 AM – 11:00 AM	582847: The Use of Supercritical Water for the Liquefaction of Polypropylene into Oil	Wan-Ting (Grace) Chen, University of Massachusetts Lowell, USA
11:00 AM – 11:15 AM	584189: Determining Waste Plastic Generation in Developing Cities Via Geographical Analysis	Chandni Joshi, University of Kentucky, USA
11:15 AM – 11:30 AM	581004: Integrated Framework of Plastic Footprint Toward Regional Circular Economy	Yee Van Fan, Brno University of Technology, Czech Republic
11:30 AM – 11:45 AM	582700: Health Risk Assessment of Plastic Waste in the Frame of the Circular Economy	Dimosthenis Sarigiannis, Aristotle University of Thessaloniki, Greece
11:45 AM – 12:00 PM	584591: The Plastic Pileup in Thailand: Illuminating Local Voices and Perspectives on the Causes and Grassroots Solutions	Olivia Meyer, University of Kentucky, USA
12:00 PM – 01:30 PM	Lunch	
01:30 PM – 03:30 PM	**Session 2 – Ecosystem Impacts and Remediation Strategies**	
01:30 PM – 01:55 PM	Invited Talk: Polymer Characterization of Plastic Debris from the Central Pacific	Kathryn Beers, National Institute of Standards and Technology (NIST), USA
01:55 PM – 02:20 PM	Invited Talk: Waste Valorization: an Approach to Advanced Functional Materials	Ramaswamy Nagarajan, University of Massachusetts Lowell, USA
02:20 PM – 02:35 PM	582712: Plastic Pollution in the Oceans	Robert W. Peters, University of Alabama at Birmingham, USA
02:35 PM – 02:50 PM	582542: Plastic Derived Fuel Oil (PDFO) Vs Conventional Diesel: A Qualitative and Quantitative Analysis in a Developing Country Context	Ronald Kizza, Makerere University, Uganda
02:50 PM – 03:05 PM	582551: Permanent Disposal of Plastic Waste By Carbon Sequestration	Ian MacKay, Yankee Scientific, Inc., USA
03:05 PM – 03:20 PM	582368: Electrospinnig of Recycled High Impact Polystyrene Nanofibers for Oil Spill Removal	Ahmed Mohamed Hassan Ahmed, Bureau Veritas SA, Alexandria University, Saudi Arabia
03:20 PM – 03:35 PM	584197: Recycling of PET through the Manufacturing of Carbon Nanofibers	Efstratios Svinterikos, United Arab Emirates University, United Arab Emirates
03:35 PM – 03:50 PM	Coffee Break	
03:50 PM – 04:05 PM	**Special Guest Talk: Maya Meena's Last Straw. Maya Meena Zachry, Dixie Magnet Elementary School, USA**	
04:05 PM – 04:30 PM	**Rapid Fire Session**	
04:30 PM – 06:00 PM	**Poster Session & Welcome Reception**	

Friday, September 20, 2019		
07:30 AM – 09:15 AM	Registration	
09:15 AM – 10:00 AM	**Plenary Talk: Mary Ellen Ternes, Earth & Water Law, LLC, USA: The Basel Convention, Plastic Waste and the Circular Plastic Economy**	
10:00 AM – 10:20 AM	Coffee Break	
10:20 AM – 12:20 PM	**Session 3 – Reuse and Recycle of Waste Plastic**	
10:20 AM – 10:45 AM	Invited Talk: Chemical Recycling of Polyethylene Waste By Oxidative Degradation	Jennifer Le Roy, BioCellection Inc., USA
10:45 AM – 11:10 AM	Invited Talk: Catalytic Upcycling of Polyolefins	Cynthia Jenks, Argonne National Laboratory, USA
11:10 AM – 11:25 AM	582673: Chemical Recycling of Waste PET with Super-Acid Catalysts	Maria Coleman, University of Toledo, USA
11:25 AM – 11:40 AM	584835: Plastic As an Enabler in Waste Plastic-Biomass Pellets Production	Stas Zinchik, Michigan Technological University, USA
11:40 AM – 11:55 AM	581492: Combining Reclaimed PET with Bio-Based Monomers Enables Plastics Upcycling	Scott Nicholson, National Renewable Energy Laboratory, USA
12:00 PM – 01:30 PM	Lunch	
01:30 PM – 03:30 PM	**Session 4 – Industry Panel**	
	Session Chairs: Wan-Ting (Grace) Chen, University of Massachusetts Lowell, USA and Martin Geithmann, Plastic Technologies, Inc., USA	
	David Butler, Alltech, USA	
	Ed Daniels, REMADE Institute, USA	
	James Drummond, Lexmark, Inc., USA	
	Sandeep Kulkarni, KoolEarth Solutions Inc., USA	
	Janna Norton, Alltech, USA	
	Ignasi Palou-Rivera, RAPID, USA	
	David Wagger, The Institute of Scrap Recycling Industries (ISRI), USA	
03:30 PM – 04:00 PM	**Closing Ceremony**	

Posters

1. 582706: A Study of the Physical Properties of Plastic Derived Fuel Oil Produced from Waste Plastic. Shelby Browning, University of Kentucky, USA
2. 584137: Characterization of Microplastics in Precipitation. Bekah Anderson, Montana State University, USA
3. 584186: Development and Analysis of a Waste Plastic Generation Profile for Kampala, Uganda. Rana Turkmani, University of Kentucky, USA
4. 584190: Emissions Analysis of Plastic Derived Fuel Oil Using Trash to Tank Process, Brett Quigley, University of Kentucky, USA
5. 584796: Waste Control Using Blockchain Technology. Neha Gupta, WVU, USA
6. 584835: Plastic As an Enabler in Waste Plastic-Biomass Pellets Production. Stas Zinchik, Michigan Technological University, USA
7. 584837: Removal of Chlorine from Plastic Waste Blends. Shreyas Kolapkar and Stas Zinchik, Michigan Technological University, USA

8. 584886: Circularity, Cost and Life Cycle Impact: Accounting for Trade-Offs in Choosing Plastic Grocery Bags and Waste Management Strategies. Vyom Thakker, The Ohio State University, USA
9. 584943: Using Life Cycle Thinking to Understand the End-of-Life Impacts of Sugarcane Bagasse and Bioplastics. Dennis Newby, University of Kentucky, USA
10. 584966: Understanding Slow Pyrolysis of Plastic. Wenqi Li, University of Kentucky, USA
11. 584971: Upcycling of Polyethylene Terephthalate Using Petase and Deep Eutectic Solvents. Jameson Hunter, University of Kentucky, USA
12. 585017: Solar Thermal Depolymerization Process. Yu Miao, Baylor University, USA

Plenary Speaker Biographies

James Drummond

James P. Drummond obtained his BS in Mechanical Engineering from Virginia Polytechnic Institute in 1994, and he obtained a Ph.D. in Materials Science and Engineering from the University of Cincinnati in 1999. His focus on polymer materials brought him to Lexmark International where he is currently a Senior Materials Engineer, and Corporate team lead for polymer materials. As a member of the Lexmark Global Sustainability Council he has helped the company focus on plastic material recovery and reuse, resulting in products with some of the highest post-consumer plastic content in the industry. This focus has also led him to help develop international recycling standards like EPEAT, and work with global organization like the Ellen MacArthur foundation to help build a more "Circular" Economy for plastics.

Mary Ellen Ternes

Mary Ellen Ternes is a partner in the Oklahoma City office of D.C. based Earth & Water Law, LLC. Ms. Ternes represents manufacturing, recycling and other industrial and municipal clients, with in-depth experience in air, solid and hazardous waste, wastewater, drinking water program permitting, compliance, recycling and reuse, with particular emphasis in developing efficient regulatory strategies for complex and high profile processes and industries, enforcement defense, risk management, due diligence, voluntary cleanup practices as well as federal and state rulemaking, administrative proceedings and litigation.

Her relevant legal experience includes representation of:

- Hazardous waste fuel blender with permitting and scope of "legitimate recycling," "continued use," "product," "waste," "treatment" and "disposal," and permitting boundary for "storage" versus "treatment";
- Chemical manufacturer and scope of RCRA exempt "closed-loop recycling," "continued use" and "beneficial use" for chemical reaction intermediates, unreacted residues, by-products including process residues, off-spec products, container wash water and unused products;
- Plastic recycler and scope of "beneficial use" for wash water sediments;
- Manufacturer of consumer products from plastics and other resins in California Proposition 65 compliance, managing product issues arising with international imports and chemical constituent concentrations requiring Prop65 warning including phthalates and other chemicals;
- Scrap recycling facilities regarding business strategies for collection, sorting, and recovery given scope of solid and hazardous waste regulation, and definitions of "waste," "product," "recovery," "treatment," "storage" and "speculative accumulation."
- Cement manufacturer in permitting authorizing use of high BTU hazardous waste derived fuels under air and waste programs; prevailing in permit challenge by environmental activist;
- Automobile manufacturer, working with industry trade group, to resolve recycling interpretation and RCRA compliance approach for ongoing solvent use and reuse, resulting in EPA RCRA Online No. 14632 guidance document;
- Commercial solvent recycler with development of national solvent "continued-use" program and compliance demonstration across EPA Regions and state delegated programs;
- Battery recycler regarding scope of scrap metal exemption and "legitimate recycling";

- Thermal treater of oil impacted soils with application of "treatment" versus "incineration" to thermal soil desorption system;
- Hazardous waste recycler using thermal treatment process and defense in enforcement actions involving disputes regarding "legitimate recycling," "toxics along for the ride," and Boiler and Industrial Furnace (BIF) permitting versus hazardous waste incineration ("Subpart O) permitting;
- Used tire recycler regarding "treatment," "incineration," "waste" and "product," in permitting pyrolytic thermal treatment process producing commercial fuel oil product from pyrolysis of used tires;
- Chemical manufacturer in permitting and business strategies for patented process producing diesel fuel from captured methane from landfill gas emissions.

Ternes began her career as an On-Scene Coordinator for the U.S. EPA Region 6 in Superfund emergency response and RCRA hazardous waste incinerator permitting, then left EPA to join industry, managing environmental compliance for a commercial hazardous waste incineration company, negotiating air, hazardous waste, and toxic substances treatment and disposal permits, demonstrating compliance and conducting audits. During law school, she was a law clerk for the U.S. EPA Office of General Counsel Air and Radiation Division.

Ternes is a Fellow and Life Member of the American Institute of Chemical Engineers where she serves as Chair of the Public Affairs and Information Committee's Legal Developments Subcommittee, having just completed the PAIC Climate Change Policy Review Project as chair of the PAIC Climate Change Task Force. Ternes is also a Fellow of the American College of Environmental Lawyers, where she serves as Chair of the Outreach Committee and Strategic Planning Task Force. Ternes also serves the American Bar Association (ABA) Business Law Section as Chair of the Environmental Committee, and the ABA Section of Environment, Energy and Resources (SEER) as Liaison for Sections, Divisions and Forums. In her past service, Ternes founded and chaired AIChE's Chemical Engineering and the Law Forum, co-chaired the AIChE's 2010 Spring Conference, and chaired AIChE's Environmental Division Sections for Climate Change, and Legislation and Regulatory. Ms. Ternes has also chaired the ABA's SEER Committees for Air Quality, and Climate Change, Sustainable Development and Ecosystems, and Ethics, in addition to chairing both the ABA SEER's Year-in-Review annual publication (2013-2017), and the 2004 Annual Conference on Environmental Law. Ternes is a frequent speaker and author, contributing to the ABA's Clean Air Act Handbook (Chapter 6: New Source Review, 2d, 3d and 4th ed.), and CRC's Air Pollution Control Handbook (2d ed.), as well as serving on the Editorial Board for ABA SEER's *Natural Resources & Environment* (NR&E) and AIChE's *Environmental Progress and Sustainable Energy*, while contributing regularly to both ABA SEER's *NR&E* and *Trends,* as well as AIChE's *Chemical Engineering Progress* (CEP). She is listed in Chambers USA Guide to America's Leading Lawyers for Business; The Best Lawyers in America©, Oklahoma Super Lawyers and the International Who's Who of Environment Lawyers.

Ternes received her J.D. (high honors) from the University of Arkansas at Little Rock (1995) and her B.E. (ChE) from Vanderbilt University (1984). Ternes maintains a national environmental practice focusing on federal regulatory programs, including those delegated to approved states for implementation, and is admitted to practice law in Oklahoma, Arkansas, South Carolina, District of Columbia.

INVITED SPEAKER BIOGRAPHIES

Invited Speaker Biographies

Kathryn Beers

Kathryn L. Beers is currently the Group Leader in the Materials Science and Engineering Division of Polymers and Complex Fluids at the National Institute of Standards and Technology and has been at NIST since 2000 when she first joined as a National Research Council Postdoctoral Fellow in the Polymers Division. She is a member of the AIChE, American Chemical Society, Materials Research Society and Sigma Xi. Her research interests include advances in polymer synthesis and reaction monitoring, macromolecular separations, integrated and high throughput measurements of polymeric materials, microreactors and microfluidics, degradable and renewable polymeric materials and sustainable materials. She has recently engaged in new programs at NIST in plastics recycling and the circular economy.

Cynthia Jenks

Dr. Cynthia Jenks leads the Division of Chemical Sciences and Engineering at Argonne National Laboratory. Research in the division spans from fundamental chemical science through applied engineering research and development She co-leads Argonne's efforts aimed at addressing the challenges of plastic upcycling and will chair the upcoming Department of Energy Basic Research Needs Workshop on Transformative Manufacturing. Before joining Argonne in 2017, Dr. Jenks served as assistant director for scientific planning and as director of the Chemical and Biological Sciences Division at Ames Laboratory. Prior to that, she was a staff scientist and postdoctoral fellow at Ames Laboratory. Dr. Jenks holds Ph.D., and M.Phil. degrees in chemistry from Columbia University, a M.S. degree in chemical engineering, also from Columbia University, and a bachelor's in chemical engineering from the University of California, Los Angeles. She is a Fellow of the American Association for the Advancement of Science.

Ramaswamy Nagarajan

Ramaswamy Nagarajan is an associate professor at the University of Massachusetts, Lowell and has a science and engineering background with bachelor degrees in chemistry and rubber technology and a doctoral degree in polymer science from the University Massachusetts. His research interest is in the development of "greener"/sustainable routes to advanced functional materials (polymers, additives and surfactants). Working at the interface of science and engineering his research group has been involved in translating fundamental research into engineering applications for advancing technology in new and emerging areas. He is the Co-editor of Journal of Renewable Materials and has published 52 papers in peer-reviewed journals and holds 14 U. S. patents.

Jennifer Le Roy

Jennifer is the director of research and development at BioCellection Inc., a chemical recycling company that upcycles plastic waste. Biocollection's aim is to protect our environment through creating innovative recycling processes for currently unrecyclable post-consumer waste plastics by converting this waste into virgin quality building blocks for sustainable supply chains. Our

innovations unlock the potential of using plastic waste to replace fossil fuel as a resource for creating new materials.

Meltem Urgun-Demirtas

Meltem Urgun-Demirtas is the Group Leader of the Bioprocesses and Reactive Separations in the Applied Materials Division of Argonne National Laboratory. The group focuses on re-engineering of plant flow diagram to develop innovative technologies for industrial applications as well as development and application of intensified reactor and separation technologies for bioenergy and bioproducts production, water treatment, and manufacturing. She is also a Fellow at the Northwestern and Argonne Institute of Science and Engineering. Dr. Urgun-Demirtas has over 20 years of experience in the design and operation of chemical and bioprocesses, development and scale up of new technologies from bench- to pilot- and field-scale, techno-economic analysis and modeling of processes. Currently, she serves as Argonne's Program Manager for Bioenergy Technologies Office of DOE which includes sustainability analysis of feedstock and development of new technologies and materials for production of biofuels and bioproducts. Most recently, Urgun-Demirtas has been working on the development of new plastics to increase polymer recyclability and generate benign degradation products at the end of their life.

Industry Panel Speaker Biographies

David Butler

David Butler is head of sustainability at Alltech. In this role, he helps set the company's sustainability commitments and goals. He also ensures that Alltech continually finds innovative ways to be more sustainable across the more than 120 countries in which it operates.

Butler previously worked in the Kentucky Department for Environmental Protection on the cleanup of hazardous waste sites. He also runs a renewable energy and sustainability podcast called Clean Power Planet, and he founded a solar energy activism community called Solar Kentucky.

Prior to his role as head of sustainability, he was the digital marketing manager at Alltech for more than 9 years. He built the company's online visibility through search engine optimization, social media interaction and content marketing.

Butler received bachelor's degrees in economics and environmental geoscience from the University of Kentucky. He also received a master's degree in geochemistry from the University of Kentucky. His graduate research focused on bioremediation of chlorinated solvents in wetland soils.

INVITED SPEAKER BIOGRAPHIES

Ed Daniels

Ed has been with the REMADE Institute since December 2017. Prior to joining REMADE, Ed was with Argonne National Laboratory for 32 years. During his career at Argonne, his research focused on the development of sustainable manufacturing processes, in collaboration with the iron and steel, aluminum, chemicals, automotive and recycling industries. His last assignment at Argonne was as the Deputy Associate Laboratory Director for the Energy and Global Security Directorate. The research activities of the directorate included nuclear engineering, decision and information sciences, national security, transportation technology, industrial process engineering research and renewable energy. Prior to that assignment, he served as the Division Director for the Energy Systems Division, growing the Division to one of the largest at Argonne. During his career at Argonne, Ed established one of the first collaborative research and development agreements (CRADA) at Argonne and within the national laboratory complex. He subsequently led a number of other CRADA's including a 10-year $20 million CRADA on automotive materials recycling with the Vehicle Recycling Partnership (Ford, GM and Chrysler) and the American Plastics Council. He holds 14 patents and has authored more than 125 papers on energy and sustainable technology. His work has been recognized through numerous awards including the University of Chicago Distinguished Performance Award and the Intellectual Law Property Association of Chicago Inventor of the Year Award.

James Drummond

James P. Drummond obtained his BS in Mechanical Engineering from Virginia Polytechnic Institute in 1994, and he obtained a Ph.D. in Materials Science and Engineering from the University of Cincinnati in 1999. His focus on polymer materials brought him to Lexmark International where he is currently a Senior Materials Engineer, and Corporate team lead for polymer materials. As a member of the Lexmark Global Sustainability Council he has helped the company focus on plastic material recovery and reuse, resulting in products with some of the highest post-consumer plastic content in the industry. This focus has also led him to help develop international recycling standards like EPEAT, and work with global organization like the Ellen MacArthur foundation to help build a more "Circular" Economy for plastics.

Sandeep Kulkarni

Dr. Sandeep Kulkarni is the founder and President of KoolEarth Solutions Inc., a technical consulting and business development company focused on helping small as well as large companies develop and commercialize new sustainable packaging solutions as well as to improve the sustainability footprint of existing packaging and to reduce/eliminate packaging waste. He is also a member of a team that recently launched Ubuntoo (www.ubuntoo.com), a unique website and collaboration platform for solutions to address plastic waste and plastic litter. Sandeep has over 20 years of industry experience working for several large packaging companies, such as International Paper, Neenah Paper and Georgia Pacific. Most recently he worked for PepsiCo, in the area of sustainable beverage packaging. Sandeep has 7 granted patents as well as several publications in industry journals. He has also served on conference advisory boards and has delivered several invited presentations, at international conferences, on the topics of sustainability

and sustainable packaging. Sandeep serves as an Adjunct Professor at The Packaging School (affiliated with Clemson University) as well as the North Carolina State University.

Janna Norton

Janna Norton currently serves Alltech as the business manager for the research division, assisting in the oversight of day-to-day administrative and management activities for the department. Norton joined Alltech's research team in 2001 and has held various administrative positions throughout the years. Along with business management duties, Janna oversees university relations and education outreach, coordination of the research internship program, recruitment, university collaboration and alliance development, in conjunction with overseeing Kentucky "agriscience" education outreach programs for K-12 students. Norton earned a bachelor's degree in journalism at Eastern Kentucky University and a master's in library science at the University of Kentucky.

Ignasi Palou-Rivera

Ignasi Palou-Rivera is the Technology Platform Director of the RAPID Manufacturing Institute, a part of the American Institute of Chemical Engineers (AIChE) in partnership with the US Department of Energy (DOE). The RAPID Institute focuses in the promotion of modular chemical process intensification (MCPI) with the goal of reducing the capital and energy intensity of the US process industries. Ignasi holds a Ph.D. in Chemical Engineering from the University of Wisconsin-Madison, and an Engineer Degree from the Universitat Politècnica de Catalunya in Barcelona. His technical background spans the areas of process modeling and optimization, techno-economic, life-cycle and sustainability analysis of fuels and chemicals, and R&D management. Defore joining RAPID, he had been a part of several industrial and academic organizations such as LanzaTech, Argonne National Laboratory, BP Refining Technology, and Aspentech. Ignasi is a Senior Member of AIChE, and has been heavily involved in volunteer positions with CAST Division (Computing & Systems Technology Division) as well as being the current Chair of the Sustainable Engineering Forum (SEF).

David Wagger

Dr. David Wagger is Chief Scientist and Director of Environmental Management at the Institute of Scrap Recycling Industries (ISRI) in Washington, DC. He has 25 years of experience in environmental engineering, policy, regulation, and science, including 14 years at ISRI. He assists members with environmental compliance and management and represents ISRI and the recycling industry on federal and state environmental regulatory matters and on external panels and working groups on R&D, science, and sustainability. Dr. Wagger holds a B.S. and a Ph.D. in chemical engineering from, respectively, the University of California, Berkeley, and the Massachusetts Institute of Technology where he was a Fannie and John Hertz Foundation Fellow.

Plenary Talk Abstracts

Plenary Talk: The Basel Convention, Plastic Waste and the Circular Plastic Economy.

Mary Ellen Ternes
Earth & Water Law, LLC, Oklahoma City, OK

On May 10, 2019, at the 14th meeting of the Basel Convention Conference of the Parties (COP), participating nations agreed to add "plastic waste" to the list of "other wastes," effective January 1, 2021. The addition of "plastic waste" to the Basel Convention means that the global trade in plastic waste will be regulated subject to the Convention's protections requiring legitimate recycling, and a new Partnership in Plastic Waste will begin work on solutions. And even though the United States has never ratified the Basel Convention, the United States is directly impacted, as countries are now turning away U.S. shipments of plastic waste and sending it back.

With this global circular plastic economy, the flow of new plastic into commerce will be affected, impacting manufacturers and consumers alike. The global effort to adapt to a cradle-to-cradle plastic economy necessarily contemplates collective engagement by government, manufacturers, consumers and recyclers alike in order to fundamentally reform the global commerce of plastic, from historically contemplated abandonment to continuing use.

Implications reach beyond the consumer plastic industry. For example, as plastic demand declines, ethylene demand may also decline, impacting hydrocarbon markets and ultimately oil and gas production and investment. Also, EPA and state regulations governing solid waste recycling may provide assistance or challenges, depending upon governmental response to recycling approaches.
The 2019 Global Symposium on Waste Plastic will provide an excellent opportunity explore implications and solutions.

Special Guest Talk: Maya Meena's Last Straw.

Maya Meena Zachry
Maya Meena Zachry, Dixie Magnet Elementary School, Lexington, KY

Plastic pollution is a well discussed concern as a major environmental crisis. The disastrous effects of it are already seen far and wide, drawing attention to the gravity of the situation. This alarm has directed academics, scientists, researchers and innovators alike to dedicate research and development helping manage and mitigate the environmental impacts of plastic pollution. Common perception is that such responsibility largely falls on the aforementioned parties to solve our predicament of the indestructible plastic. Another common view is that protecting and healing the earth is overwhelming and unachievable therefore an impossible undertaking by a 'non green' person. Maya Meena's Last Straw was founded in 2018 by a 3year old who passionately believes that we do not need millions doing things perfectly, we just need millions doing SOMETHING. Maya Meena's Last Straw proposes the simplicity of beginning with the plastic straw. In this presentation, Maya Meena aims to stage her oath to our Plastic Warriors committed to finding solutions, mitigating processes or innovation to manage our plastic waste that she will aid them in the means of making better choices every day so that everyday people like her and families like hers can take steps to "turn off the faucet as tightly as we can" so the true work of

healing our earth can take place. Highlights of steps she has personally taken in reducing plastic waste as well as the barriers keeping her from them will be shared.

Session 1: Waste Management and Circular Economy

Invited Talk: End of Life Considerations for Plastics Recyclability and Benign Degradation.

Meltem Urgun-Demirtas
Applied Materials Division, Argonne National Laboratory, Lemont, IL

Currently employed standards for plastics biodegradation have major limitations that impair detailed mechanisms involved in degradation pathways. There is a need for further improvement of the current conceptual understanding of the end of life of plastics and highlighting existing knowledge gaps. Detailed knowledge of plastics degradation behavior is important not only to aid in understanding the fate of plastics but also to help develop materials and application strategies that increase plastics recovery and help inform most appropriate end-of life options to minimize environmental concerns. The main mechanisms underlying the fundamental steps in depolymerization of plastics need to be elucidated. This knowledge is crucial for biodegradable plastic producers to produce and offer consumers more responsible choice plastics and refine their processes, where end-of-life considerations such as monomer recovery or biodegradation will be an integral part of new industry practice.

The Use of Supercritical Water for the Liquefaction of Polypropylene into Oil.

Wan-Ting (Grace) Chen[1]*, Jin Kai*[2]*, and Nien-Hwa Linda Wang*[3]
(1)Plastics Engineering, University of Massachusetts Lowell, Lowell, MA, (2)Purdue University, West Lafayette, IN, (3)School of Chemical Engineering, Purdue University, West Lafayette, IN

About five billion tons of plastic waste have accumulated in landfills and the natural environment over the past 50 years. Polypropylene (PP) waste accounts for about 23% of the total plastic waste. Converting PP waste into useful products can reduce the accumulated waste and associated risks to the environment and human health. In this study, model PP was converted into oil using supercritical water at 380-500°C and 23 MPa over a reaction time of 0.5-6 hr. Up to 91 wt.% of model PP was converted into oil at 425°C with a 2-4 hr reaction time or at 450°C with a 0.5-1 hr reaction time. Higher reaction temperatures (>450°C) or longer reaction times (>4 hr) led to more gas products. The oil products consisted of olefins, paraffins, cyclics, and aromatics. About 80-90 wt.% of the oil components had the same boiling point range as naphtha (25-200°C) and heating values of 48-49 MJ/kg. Reaction pathways for converting model PP into oil under the tested conditions were proposed. Preliminary analyses indicate that this conversion process is net-energy positive and potentially has a higher energy efficiency and lower greenhouse gas emissions than incineration and mechanical recycling. The oil derived from PP has potential to be used as gasoline blendstocks or feedstocks for other chemicals.

Determining Waste Plastic Generation in Developing Cities Via Geographical Analysis.

Chandni Joshi[1]*, Rana Turkmani*[2]*, and Jeffrey R. Seay*[3]

(1)Chemical Engineering, University of Kentucky College of Engineering, Paducah, KY, (2)Chemical Engineering, University of Kentucky, Paducah, KY, (3)Chemical and Materials Engineering, University of Kentucky, Paducah, KY

With recent global attention on waste plastic generation and its accumulation on land and in oceans, several solutions for combating waste plastic accumulation have emerged. Viable solutions include ocean-cleanup efforts, reduction of waste plastic on land by recycling or incinerating, utilization of waste plastic for construction of homes, roads, and consumer goods like shoes or blankets, and complete removal of plastic from the ecosystem via pyrolysis. These solutions are altering human perception of waste plastic from garbage to a valuable resource.

However, the potential and feasibility of implementing these solutions is limited in developing countries due to lack of data on the amount of plastic waste generated in a location, such as for a city or village. Often, insufficient capital and infrastructure hinder proper collection and management of waste plastic in these regions. Thus, a tool is needed for estimating waste plastic generation in places where data is not readily available. This study performs this analysis by correlating geographical information, such as residential and commercial density, size and location of buildings to population density and income level – factors directly correlated to waste plastic generation. A case study was performed in Kampala, Uganda for development of a metric that estimates waste plastic generation by analyzing the geographical overview of the city's neighborhoods via QGIS, an open-sourced special analysis tool. Initially, input data were provided for the city's plastic generation, population density and income level for each neighborhood. In return, the metric estimates waste plastic generation for similar Sub-Saharan African cities.

Integrated Framework of Plastic Footprint Toward Regional Circular Economy.

Yee Van Fan[1]*, Jiří Jaromír Klemeš*[1]*, and Chew Tin Lee*[2]
(1)SPIL, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic, (2)Universiti Teknologi Malaysia, Johor Bahru, Malaysia

The plastics frequently have a short retention time (user phase) and improper disposal, not complying with the circular economy. Recycling is a promoted practice. However, the implementation is costly and requires advanced technologies due to the sensitiveness to composition (type), colour and contaminants. Some amount of plastic waste is claimed to be recycled by exporting into the developing countries. Energy recovery can be a viable solution despite some barriers, e.g. off-gas cleaning, the capacity of infrastructure, investment cost. The accounting methodology in assessing the footprint has a direct impact on the decision making. A comprehensive and consistent quantitative framework still needs more development. This study aims to highlight the critical issues in assessing Plastic Footprint and propose an integrated framework to facilitate plastic waste allocation for recovery. The Plastic Footprint introduced by Boucher et al. at the International Union for Conservation of Nature, focuses on leakage and litter, can be a basis for the integrated framework development. This work suggests the integration of plastic footprint with Energy and GHG Footprints to prevent the possibility of footprints shifting as well as to facilitate the plastic waste allocation better. The novel approach is supported by a graphical visualisation. This framework is also enabling the footprints comparison among different materials e.g. paper, glass and metal. The circular economy is not confined to a country border. The

plastic waste import and export activities could be complementary when sharing resources, treatment facility, capacity and infrastructure, supply chain and the demand for recovered products are optimised.

Health Risk Assessment of Plastic Waste in the Frame of the Circular Economy.

***Dimosthenis Sarigiannis**, Antonis Gypakis, Alberto Gotti, and Spyros Karakitsios*
Environmental Engineering Laboratory, Department of Chemical Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece

In this study we have developed an innovative tool for integrated health risk assessment of plastic waste. The INTEGRA LCA software couples the integrated external and internal exposure assessment capabilities of the INTEGRA computational platform with life cycle impact assessment. The integrated software platform allowed us to perform a first-of-its-kind analysis of adverse health outcomes attributable to chronic exposure to persistent organic pollutants associated with plastic material use and disposal.Our analysis focused on plastic waste generated in the two main metropolitan centers in Greece, Athens and Thessaloniki.

The coupled integrated exposure and life cycle assessment methodology developed in this study and translated into the INTEGRA LCA platform is a significant step towards the direction of comprehensive, precise and transparent estimation potential health risks associated with use, management and disposal of plastics in urban settings. Our first results in the two major Greek metropolitan centers indicate the need to optimize the management of plastic waste in the country and to enhance the awareness of consumers with regard to the long-term adverse health effects of chronic exposure to plastic components. The incorporation of life cycle analysis produces different conclusions than a simple environmental impact assessment based only on estimated or measured emissions. Taking into account the overall life cycle of both the waste streams and of the technological systems and facilities envisaged under the plausible scenarios analyzed herein, alters the relative attractiveness of the solutions considered and enhances the robustness of the health impact assessment.

The Plastic Pileup in Thailand: Illuminating Local Voices and Perspectives on the Causes and Grassroots Solutions.

Olivia Meyer
Department of Geography, University of Kentucky, Lexington, KY

Plastic waste is accumulating at an unprecedented rate and threatens human and ecosystem health around the world. The plastic waste issue is especially pervasive in Thailand, one of the six most significant contributors to marine plastic pollution (Jambeck et al., 2015). While international media covers Thailand's ranking and the plastic-induced deaths of megafauna on its shores, Thai regulatory institutions, grassroots environmental organizations, and residents living and working near plastic waste sites are left out of these discourses. Recognizing the importance of Thai knowledges and experiences has the potential to improve how we respond to the plastic waste issue, but not enough is known about their perspectives. As attention centers on this country, we have yet to hear from the voices of Thai people. This research involves a qualitative ethnographic study of Thai people's lived experience with and perspectives on the sources and effects of plastic waste, the power relationships underlying discourses that inform the issue, and Thai responses and agency. Through discourse analysis of ten in-

depth semi-structured interviews, I engage with those involved in plastic waste governance, production, recycling, and environmental activism in the Bangkok metropolitan area. Preliminary findings suggest that those in power are reticent to alleviate the plastic pileup through measures that would challenge plastic production. These groups contest Thailand's ranking in the Jambeck et al. study while grassroots organizers call for western-derived solutions and regulatory measures. These proposed solutions must be considered in the local context.

Session 2: Ecosystem Impacts and Remediation Strategies

Invited Talk: Polymer Characterization of Plastic Debris from the Central Pacific.

Kathryn L. Beers
National Institute of Standards and Technology, Gaithersburg, MD

Identification of ocean debris is one focus area of an emerging Circular Economy program at the National Institute of Standards and Technology (NIST) that includes a new network of academic centers dedicated to plastics recycling technology and training. This talk will provide a brief overview of NIST's role and capabilities, and then focus on early work facilitating the development of PCA tools for FT-IR through more explicit identification of samples via high throughput, multi-detection size exclusion chromatography. Results of preliminary investigations of surface degradation and other possible marine exposure effects will also be presented.

Invited Talk: Waste Valorization: an Approach to Advanced Functional Materials.

Ramaswamy Nagarajan[1], *Zhiyu Xia*[1], *Shiran Yu*[2], *Sourabh Kulkarni*[3], *Ravi Mosurkal*[4], *and Jayant Kumar*[5]
(1)Plastics Engineering, University of Massachusetts Lowell, Lowell, MA, (2)Plastics Engineering, UMass Lowell, Lowell, MA, (3)Mechanical Engineering, University of Massachusetts Lowell, Lowell, MA, (4)CCDC SC, Natick, MA, (5)Physics and Applied Physics, University of Massachusetts Lowell, Lowell, MA

Advanced functional materials development is increasingly driven by new requirements as well as sustainability considerations. Waste co-products can serve as sustainable and cost-effective feedstock for the production of the next generation of safer advanced functional materials. This concept is illustrated with two classes of waste co-products that can be efficiently converted into advanced functional additives.

The development of non-halogenated flame retardant materials (FR) using co-products obtained from the food industry will be presented. It has been demonstrated that combinations of naturally occurring phenols and phytic acid can be utilized to yield additives that have excellent char forming and fire retardant properties.

Biobased and bio-inspired surfactants are the second class of materials that will be discussed. Non-ionic surfactants such as nonylphenol ethoxylates (NPE), are being phased out due to their aquatic toxicity. A new class of surfactants based on polysaccharides obtained predominantly from fruit waste has been developed recently. These surfactants derived from waste exhibit surface activity similar to that of NPE.

These two examples demonstrate the possibility of utilizing co-products to develop advanced functional materials that serve as sustainable alternatives to toxic materials such as halogenated flame-retardants and toxic surfactants. The benefits for the pursuit of materials research using waste feedstock transcends sustainability considerations and often opens exciting possibilities, making it worthwhile from a scientific and commercial perspective.

Plastic Pollution in the Oceans.

Taniya Sultana, A.B.M. Tausif Ullah Chy, Mary Claire Nabors, Mukti Patel, and ***Robert W. Peters***
Civil, Construction, and Environmental Engineering, University of Alabama at Birmingham, Birmingham, AL

During this past spring semester, we had a new course offered on "Environmental Disasters – Lessons Learned". The graduate students selected the topic of plastic pollution in the oceans for their class project.

The threat to marine life in the oceans comes in various forms such as dumping of waste, over exploitation and harvesting, pollution, invasive species, land reclamation, dredging, and global climate change. One particular type of human impact that represents major threat to marine life is the pollution by plastic debris. Plastic has become one of the most common forms of pollution in the ocean and is causing problems to become more and more severe each day, impacting both the natural environment and human life.

Plastic pollution has negative impact on our oceans and the health of wildlife, causes harm to the creatures that live in the ocean (from coral reefs to turtles gagging on straws, to whales and seabirds). These creatures starve because their bellies become jammed with plastic. Another recent concern regarding plastic pollution is the impact on food webs and marine ecosystems. The concentrated toxins of plastic materials might be delivered to animals via ingestion and transferred to their food webs. At least 26 species of cetaceans have been documented to ingest plastic debris.

This paper/presentation addresses how plastics end up in oceans, a brief history of plastic production and pollution, ecological effects of plastic pollution in the oceans, environmental impacts, health impacts, economic implications, ethical risks and concerns, and a discussion of lessons learned.

Plastic Derived Fuel Oil (PDFO) Vs Conventional Diesel: A Qualitative and Quantitative Analysis in a Developing Country Context.

Ronald Kizza[1]*, Jeffrey R. Seay*[2]*, Noble Banadda*[3]*, and Shelby Browning*[4]
(1)Department of Agricultural and Bio-Systems Engineering, Makerere University, Kampala, Uganda, (2)Chemical and Materials Engineering, University of Kentucky, Paducah, KY, (3)Makerere University, Kampala, Uganda, (4)Chemical Engineering, University of Kentucky College of Engineering, Paducah, KY

Due to depleting fossil fuel sources, Plastic Derived Fuel Oil (PDFO) has gained so much attention over the past decade as an alternative to Conventional fossil diesel. Although several researchers have reported the properties of PDFO and recommended its usage in diesel engines, no study has done a detailed qualitative and quantitative comparison with conventional diesel. This study aims to qualitatively and quantitatively assess PDFO produced from pyrolysis of waste plastic based on standard

recommended tests for a diesel in a developing country. Waste polyethylene (HDPE and LDPE), Polypropylene (PP) and Polystyrene (PS) were pyrolyzed independently in a 3T UKATS processor designed and fabricated for developing countries to produce PDFO. The produced PDFO and conventional diesel (bought from a gas station) were analyzed for distillation test, density, flash point, marker concentration, copper strip corrosion, energy content, and viscosity, and then compared with the standards. The energy recovery potential of PDFO was computed based on the Non-Recyclable Plastic (NRP) collected and dumped at the landfill whereas for conventional diesel, it was based on the production data from the Ministry of Energy and Mineral Development. Results of the qualitative analysis indicate that PDFO is a potential substitute for conventional diesel and can be used as a stand-alone fuel or as a blend. The energy recovery calculations reveal that Uganda produces waste plastic that can be converted into energy enough to serve the entire population of Kampala city.

Permanent Disposal of Plastic Waste By Carbon Sequestration.

*Eric Guyer and **Ian MacKay***
Yankee Scientific, Inc., Medfield, MA

Carbon capture and sequestration is a technically feasible and economically attractive answer to the unsolved and growing problem of the responsible management of low-grade, post-consumer plastic waste in a world increasingly focused on the environmental impacts of carbon in the atmosphere. While reduced use and recycling of plastic can contribute to limiting the impact of plastic production and use on the environment, new solutions to the problem of accumulating plastic waste are needed. Solutions for plastic waste disposal must be scalable to the magnitude of the problem and will be acceptable, in the future, only if they do not contribute carbon emissions to the atmosphere. This paper presents the technology and economic rationale for deployment of processing plants that convert plastic waste to carbon dioxide for permanent sequestration in deep geologic structures. Carbon capture and storage technology has been actively pursued in connection with power generation around the world but has met economic challenges in that application. The paper discusses how and why these developments in carbon capture technology present a sustainable, affordable, and conclusive answer to the problem of plastic waste management.

Electrospinnig of Recycled High Impact Polystyrene Nanofibers for Oil Spill Removal.

Ahmed Mohamed Hassan Ahmed
Commodities, Bureau Veritas SA, Jubail, Saudi Arabia; Materials Science, Alexandria University, Alexnadria, Egypt

The conventional techniques used for oil spill decontamination have many disadvantages as high operating cost, generation of secondary pollutant and complex operation techniques. Clean up and recovery processes from an oil spill are difficult and depend upon many factors, including the type and the viscosity of the oil spilled, the temperature and the type of water. Electrospun nanofibers have started to show great attention in the last three decades, they are characterized by high surface area to volume ratio and better mechanical properties. Oil sorbent nanofibers were prepared from recycled high impact polystyrene (HIPS) by the electrospinning process. The fibers surface morphology, crystallinity, hydrophobicity, and the sorption capacity over potable water and sea water were studied.

The results revealed that the contact angle of HIPS fibrous sorbent reached 153 degrees and the sorption capacity for crude oil, gas oil and motor oil were 50, 62, 125 g/g, respectively. The sorption capacity is higher than regular general purpose polystyrene (PS) nanofibers making it a highly promising material for oily water purification.

Recycling of PET through the Manufacturing of Carbon Nanofibers.

Efstratios Svinterikos[1]*, Ioannis Zuburtikudis*[2]*, and Mohamed Al Marzouqi*[1]
(1)Chemical and Petroleum Engineering, United Arab Emirates University, Al Ain, United Arab Emirates,
(2)Chemical Engineering, Abu Dhabi University, Abu Dhabi, United Arab Emirates

Poly(ethylene terephthalate) is one of the most widely used commodity plastics and the main material for the manufacture of water bottles. Hence, the development of alternative uses of waste PET will have a positive impact on growing environmental concerns.

Our strategy consists of combining recycled PET with lignin for the manufacture of carbon nanofibers. Lignin and PET are miscible and can be blended by dissolving them in the same solvent, as it is demonstrated in our published work. Using the electrospinning technique, the blend is spun into fibrous mats of controllable average fiber diameters in the submicron- or nano-scale. The presence of PET is crucial for the formation of fibers, as lignin alone cannot be electrospun successfully. Finally, the electrospun lignin/PET nanofibers are thermally treated under inert atmosphere at elevated temperatures (>800 ^{o}C) for transforming them into carbon nanofibers.

Various important features of the carbon fibrous mats, such as the morphology and the porosity, are determined by the average fiber diameter of the precursor electrospun mats, as well as by the relative percentage of PET in the blend. Carbon nanofibers of minimum average diameter (close to 100 nm) can be prepared successfully only when the PET percentage is as low as 10 % w/w. When the percentage of PET is much higher, then it is not feasible to produce carbon nanofibers. However, a higher percentage of PET (around 50 %w/w) leads to much higher microporosity, as the PET disintegrates during carbonization leaving empty molecular space inside the carbon nanofibers.

Session 3: Reuse and Recycle of Waste Plastic

Invited Talk: Chemical Recycling of Polyethylene Waste By Oxidative Degradation.

Jennifer Le Roy
BioCellection, MENLO PARK, CA

Today, only 9% of plastic packaging gets recycled worldwide. The rest goes to landfills, incinerators, and oceans. At BioCellection, we aim to protect our environment through creating innovative recycling processes for currently unrecyclable post-consumer waste plastics by converting this waste into virgin quality building blocks for sustainable supply chains. Our process is developed for polyethylene, which is over a third of all plastics produced globally. We are currently focused on LDPE and HDPE flexible plastics - think grocery bags, bubble wraps, trash bags, retail packaging, food wraps, etc.

We have developed a thermal oxidation chemical recycling process that enables polymers to be broken into lower molecular weight species with oxygenated terminals, forming valuable organic acid compounds that can be harvested, purified, and used to make products. Compounds created from our process include succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, and azelaic acid. These are the first chemical intermediates made from post-consumer waste! Today's intermediates are produced using petroleum, and they're essential in the production of performance materials, solvents, coatings, and more. Our innovation unlocks the potential of using plastic waste to replace fossil fuel as a resource for sustainable supply chains.

Invited Talk: Catalytic Upcycling of Polyolefins.

Cynthia Jenks
Chemical Sciences and Engineering, Argonne National Laboratory, Lemont, IL

With the majority of plastics used to date being single-use and because of the lengthy time for their natural degradation, new pathways are needed to efficiently and economically re-use these materials. Chemical transformation of waste plastic to create higher value products, known as upcycling, is an emerging area of research. Low-density polyethylene recycling, for example, is extremely limited at this time, and the potential of upcycling these materials could be part a multi-pronged solution for handling existing waste and moving away from single-use plastics. Here, we discuss pathways to catalytically deconstruct waste plastics with a focus on retaining their inherent chemical and energy value. We consider the advantages and disadvantages of this approach compared to recycling and converting back to monomers or syngas. As part of a multi-institutional collaboration, Argonne National Laboratory is designing new, cooperative catalysts to *selectively*, rather than randomly, cleave polyolefins. A key advantage of this approach is that relatively uniform macromolecules can be produced avoiding the formation of light alkanes through excessive hydrogenolysis.

Chemical Recycling of Waste PET with Super-Acid Catalysts.

Hossein Abedsoltan, Hatim Alsenani, and ***Maria R. Coleman***
Chemical Engineering, University of Toledo, Toledo, OH

This study focused on developing and applying novel super-acid catalysts to chemical recycling of waste polyethylene terephthalate (PET). Acid hydrolysis reaction of PET produces terephthalic acid (TPA) and ethylene glycol (EG). The effect of 8M H_2SO_4 as acid catalyst at 150 ^oC was measured to establish a baseline reaction kinetics. The goal of this work is to develop recoverable catalysts with increased activity in hydrolysis of PET to avoid the highly corrosive environment acid environment. Superacid catalysts prepared with $AlCl_3$ and H_2SO_4 or poly(styrene sulfonate) (PSSA) were prepared and characterized for acid hydrolysis of PET at 150 ^oC. The impact of catalyst type, composition and concentration on PET conversion and TPA yield were monitored. The recovered TPA was characterized with FTIR and NMR to compare with commercial TPA . The PSSA based acid/super-acid catalysts can be recovered for reuse thereby avoiding the acid disposal issue in usage of homogeneous acid catalysts.

Combining Reclaimed PET with Bio-Based Monomers Enables Plastics Upcycling.

Scott Nicholson
Strategic Energy Analysis Center, National Renewable Energy Laboratory, Golden, CO

Less than 30% of PET plastic is recycled in the United States.[1] The low reclamation rate may be due to mechanical recycling accounting for the majority of commercial PET recycling. Mechanical recycling yields a lower-quality recycled plastic than the process of chemically recycling back to the monomer phase, which can be energetically and economically expensive. In this work, recently published in *Joule*, reclaimed PET bottles are chemically recycled and converted into higher-value fiberglass-reinforced plastics (FRPs).[2] This presentation will focus on the supply-chain level energy and greenhouse gas emissions intensities associated with this novel upcycling route. The Materials Flows through Industry supply chain analysis tool, developed at NREL, is used to estimate these impacts.[3] Depending on the extent and speed of adoption, this strategy for plastic upcycling could lead to significant energy usage and emissions reductions over the traditional FRP supply chain. Overall, this approach could provide an economic incentive for plastics recycling and renewable feedstock use through the creation of higher-value FRPs.

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A Study of the Physical Properties of Plastic Derived Fuel Oil Produced from Waste Plastic.

Shelby Browning[1], Ronald Kizza[2], Brett Quigley[3], Chandni Joshi[1], and Jeffrey R. Seay, Ph.D., P.E.[4]
(1)Chemical Engineering, University of Kentucky College of Engineering, Paducah, KY, (2)Department of Agricultural and Bio-Systems Engineering, Makerere University, Kampala, Uganda, (3)University of Kentucky, Paducah, KY, (4)Chemical and Materials Engineering, University of Kentucky, Paducah, KY

Plastic waste around the globe has become a massively detrimental issue that can lead to health complications and environmental destruction. Studies and prior experimentation suggest that thermally decomposing plastic will cause the carbon bonds to break apart and form a fuel oil similar in composition to diesel. Using a low-cost and simple processor called the Trash-to-Tank (3T) processor developed by the University of Kentucky Appropriate Technology and Sustainability (UKATS) Research Team, waste plastic can be converted into fuel, known as Plastic Derived Fuel Oil (PDFO) and sold as a diesel alternative.

The 3T processor has been specifically designed to be appropriate for underdeveloped regions where access to sophisticated literature are often lacking. Currently, the UKATS Research Team is conducting a pilot study in Uganda to assess the performance of the 3T process. In order to ensure that the fuel meet all appropriate regulatory requirements for use as a motor vehicle fuel in Uganda, emissions testing has been commissioned from the Ugandan Bureau of Standards. The laboratory results for the PDFO will be presented and compared with traditional number 2 fuel oil. The 3T process has been implemented in Uganda and has the potential to provide a low cost way for rural communities in developing regions to take ownership of the waste plastic problem in their communities. This process is part of the establishment of locally managed decentralized circular economies in underdeveloped regions and further can give women and other people living in poorer regions the ability to become entrepreneurs.

Characterization of Microplastics in Precipitation.

Bekah Anderson
Montana State University, Bozeman, MT

The modern lifestyle is consumed by plastic. From disposable bottles to packaging to modern appliances, plastic is nearly impossible to avoid. A rapidly growing area of research is focused on microplastics, which are small plastic particles either directly produced to be small or are derived from the weathering of larger plastic pieces. Extensive research has been conducted on the characterization of marine microplastics, but relatively less is known about freshwater systems and especially transport throughout the water cycle. Due to the ubiquitous nature of plastic, there are likely microplastics in precipitation and they can be found in remote environments. This research project aims to characterize microplastics presence in Montana precipitation. To complete this task, precipitation samples (i.e. rain, snow, hail) were taken, filtered, and observed using epifluorescence microscopy to count and categorize plastic particles. Raman spectroscopy was employed to chemically identify unknown polymers. Thus far, preliminary results have shown plastic particles in precipitation. The findings of this research project will further inform the prevalence of microplastics and their role in environmental contamination. As society

moves further towards sustainability and environmental responsibility, it is imperative that we actively work to understand and resolve the implications of our plastics use.

Development and Analysis of a Waste Plastic Generation Profile for Kampala, Uganda.

Rana Turkmani[1]*, Chandni Joshi*[2]*, and Jeffrey R. Seay, Ph.D., P.E.*[3]
(1)Chemical Engineering, University of Kentucky, Paducah, KY, (2)Chemical Engineering, University of Kentucky College of Engineering, Paducah, KY, (3)Chemical and Materials Engineering, University of Kentucky, Paducah, KY

Pollution is a significant global challenge. Municipal solid waste accumulates on land in many areas globally due to lack of appropriate disposal methods, capital and infrastructure for managing waste. In some rural areas, waste management solutions are nonexistent, meaning waste piles around residential locations. One sustainable solution to this problem considers complete elimination of plastic from the ecosystem. This solution is termed as Trash to Tank (3T), a process which converts waste plastic types (polystyrene, polypropylene, low-density polyethylene, and high-density polyethylene) into Plastic Derived Fuel Oil (PDFO) via pyrolysis. The fuel produced is similar in composition to diesel and kerosene.

A country suitable for use of 3T is Uganda, lacking sufficient capital and infrastructure to manage all of its waste. In order to optimize the utilization of 3T process, reduce waste plastic accumulation on land and in the natural waterways of Uganda (River Nile and Lake Victoria), a waste plastic generation profile must be developed and analyzed. This study accomplishes this for a small subset of Uganda, the capital city of Kampala. Through partnership with Kampala Capital City Authority (KCCA), a local waste management municipality, existent waste plastic generation was determined for the city. This information was correlated with available data on population density and geographical analysis of income level via ArcGIS (a spatial analysis tool) to understand the impact of population and income on waste generation. The results of this study reveal the interplay of these factors for waste plastic management in Kampala and similar sub-Saharan African cities.

Emissions Analysis of Plastic Derived Fuel Oil Using Trash to Tank Process.

Brett Quigley[1]*, Chandni Joshi*[2]*, and Jeffrey R. Seay*[3]
(1)Mechanical Engineering, University of Kentucky College of Engineering, Paducah, Paducah, KY, (2)Chemical Engineering, University of Kentucky College of Engineering, Paducah, KY, (3)Chemical and Materials Engineering, University of Kentucky, Paducah, KY

Plastic is ubiquitous in our environment. Along with it comes significant waste plastic generation, which is an imminent threat to both terrestrial and marine ecosystems. A potential solution for completely eliminating waste plastic from the environment is a process called Trash to Tank (3T), which converts waste plastic to a fuel similar in composition to diesel and kerosene via thermal decomposition in the absence of oxygen. This fuel is termed as Plastic Derived Fuel Oil (PDFO) in this research study.

In this analysis, an appropriate technology based 3T process, which utilizes an InStove Rocket Stove and fabricated stainless steel retort were used to perform slow-pyrolysis (temperature of 250-400°C) of plastic types, high-density polyethylene, low-density polyethylene, polystyrene and polypropylene to PDFO. However, for PDFO to be widely used as a diesel or kerosene substitute, or as a blend for

petrodiesel, its emissions must be tested. Therefore, utilizing a diesel engine and a Bacharach combustion analyzer, the nitrogen oxide, sulfur oxide and carbon monoxide emissions of the various PDFOs were analyzed. The results of this study are presented in this research project.

Understanding Slow Pyrolysis of Plastic.

Wenqi Li, Yuxuan Zhang, and Jian Shi
Biosystems and Agricultural Engineering, University of Kentucky, Lexington, KY

Plastic pollution is a growing environmental concern worldwide. Recently, there are growing interests to convert plastic into varieties of advance materials with tailorable properties through slow-pyrolysis. However, unlike fast pyrolysis of plastic which has been extensively investigated, the process of plastic slow pyrolysis is so far not well understood. Therefore, in the present study, slow pyrolysis of plastic was investigated with a commercial pyrolyzer – GC/MS system. The overall product distributions, including gas, volatile and solid products were tracked at different heating rates (2, 20, 40℃/min) and different temperature regions (100-200℃, 200-300℃ and 300-600℃). Solid residues were further characterized for potential material application to determine the morphology, pore structure, conductivity, interfacial chemistry, and mechanical properties using SEM/in-situ TEM, XRD, BET, FT-IR/Raman, XPS and solid phase NMR.

Circularity, Cost and Life Cycle Impact: Accounting for Trade-Offs in Choosing Plastic Grocery Bags and Waste Management Strategies.

Vyom Thakker[1] *and Bhavik R. Bakshi*[2]
(1)Department of Chemical and Biomolecular Engineering, The Ohio State University, Columbus, OH,
(2)William G. Lowrie Department of Chemical and Biomolecular Engineering, The Ohio State University, Columbus, OH

With the onus of waste mitigation and elimination of oceanic plastics, it is essential to establish Circular Economy for Plastics. This work aims to develop a theoretical framework for the assessment and design of alternative plastic products while accounting for Circularity, Impact and Costs. A holistic network is developed to link various modules in life-cycles of five different types of plastic bags that can be used by a household. A Multi-objective non-linear optimization problem is solved to find the globally optimal pathway in this network. Optimization criteria include - Degree of Circularity, Global Warming Potential and Cost. A novel metric captures the restored value in down-scaling of waste plastic and loss of natural capital due to littering, thereby describing the economic circularity of the network. Decision variables are the fraction of each bag type used, preferred collection method and waste management strategies.

Two stake holders are considered for the objectives, namely - Individual Households and Society, corresponding to Bag costs and Life-Cycle Costs respectively. Pareto fronts for three objectives are plotted and an optimal set of decisions is proposed, which, from Societal perspective is the uptake of reusable low-density polyethylene (LDPE) bags and single-use high-density polyethylene (HDPE) bags, with curbside collection and combination of recycling and incineration. Whereas, the decisions from perspective of consumers shift towards using a fraction of bags which are biodegradable (poly-lactic acid - PLA), and partial waste management by composting. Numerous additional insights are obtained from the study, including sensitivity of results towards re-usability of bags.

Upcycling of Polyethylene Terephthalate Using Petase and Deep Eutectic Solvents.

Jameson Hunter
Biosystems and Agricultural Engineering, University of Kentucky, Lexington, KY

Plastics are becoming a major waste product across the world. The United States has stopped much of its recycling of plastic due to the cost, and as a result are sending it to the landfills. One solution to this problem is to change the way that plastic is recycled. Plastic upcycling involves depolymerizing plastic into its monomers for reuse and it has the potential to create a new market in recycling.

Polyethylene terephthalate or PET is a thermoplastic polyester that is relatively chemically inert and resistant to microbial degradation. Currently, the most common method of depolymerizing PET is with expensive, environmentally harmful chemicals. However, there has been a recent discovery of a microbe that has evolved in a high PET environment and is able to degrade and metabolize PET through the use of its PETase enzyme. Deep Eutectic Solvents (DES) are a type of ionic liquid that incorporates one or two solid compounds to give a eutectic with a melting point lower than either of the original compounds often resulting in a liquid at room temperature. DES has low volatility, a wide temperature range, and has been shown to be able to solubilize PET. Using DES as a solvent in a PETase and PET reaction has the potential to become a cheaper alternative to the current PET upcycling methods. However, testing needs to be done for biocompatibility between different DES and PETase as well as which compatible DES has the highest rate of solubility of PET.

Solar Thermal Depolymerization Process.

Yu Miao
School of Engineering and Computer Science, Baylor University, Waco, TX

Plastic pollution has become one of the most pressing environmental issues, as rapidly increasing the production of disposable plastic products overwhelms the world's ability to deal with them. Conventional thermal depolymerization process still depends on the non-renewable fossil fuels. Therefore, a depolymerization process driven by a renewable energy source (such as solar thermal energy) will become the best solution.

The proposed work will focus on the development of solar thermal depolymerization reaction set-up. The novel concept is proposed to enhance or maintain the overall efficiency of the depolymerization process without using any of fossil energy resources. The primary objective of the work proposed here is to demonstrate the feasibility of solar thermal depolymerization process with a conversion of 60~70%. The set-up includes heliostat, two-stage depolymerization reactors, heat recuperator, and distillation column. The feedstock polymers are firstly ground into small chunks and mixed with a homogeneous catalyst (Y-zeolite or $MgCO_3$) and water. It is then fed into the first stage depolymerization reactor, and the temperature and pressure are controlled at 375°C and 225bar respectively to create supercritical water. The products of this process include slurry with polymer and catalyst, which is sent to a second-stage reactor which is located inside the heliostat. The solar energy generates heat and the reaction temperature keeps at 460~500°C, breaking down the longer hydrocarbon chains. The product then flows through a heat recuperator and recycle the heat for the first stage reactor. Finally, the shorter hydrocarbons are sorted through distillation, generating oil and ethylene.

Using Life Cycle Thinking to Understand the End-of-Life Impacts of Sugarcane Bagasse and Bioplastics.

Dennis Newby
Civil Engineering, University of Kentucky, Lexington, KY

In 2018, the Government of Belize introduced an implementation Strategy and Action Plan to phase-out plastics as well as Styrofoam and to transition to green products like bioplastics. Bioplastics are plastics derived from plants, one of which is sugarcane bagasse (a byproduct from sugar production) plastics. Given that Belize agriculture exports consists of 60% sugarcane, bagasse is produced in excess. In this study, we will investigate the environmental impacts of replacing petroleum single-use plastics with sugarcane bagasse plastics as well as using anaerobic digestion to manage bioplastic waste. We propose to use life cycle assessment (LCA) to assist Belize with strategies for eliminating single-use plastics and methods for managing the bioplastic waste via anaerobic digestion. By using LCA, we will evaluate the environmental impact of using the bioplastics as an alternative in addition to the impacts of utilizing anaerobic digestion as a waste mitigation technique. We will consider the end-of-life cycle processes of the bagasse such as the collection, transportation, and disposal in addition to the offsets such as energy, fertilizer and biochar to analyze its environmental impact. Through analyzing these processes, we will be able to evaluate the environmental impacts of replacing single-use plastics with bagasse plastics and management of the bagasse plastic after use. Anaerobic digestion of bioplastics could lead to many different applications where the energy produced could make sugar production self-sustaining, biochar could be used for buffer zones to stop river pollution and fertilizer could enhance soil quality.

PRESENTATION INSTRUCTIONS

Oral Presentations

Please check the Technical Program for your scheduled presentation time - speaking slots are 15 minutes (including Q&A) for selected speakers, 45 minutes for Plenary and 25 minutes for Invited speakers (please check the schedule). Presentations should be in PowerPoint format (any aspect ratio) and should be uploaded to the projection computer at least 15 minutes prior to the start of your session. You may email your presentation to lucya@aiche.org ahead of time and bring it on a flash drive as a backup.

Poster Presentations

Poster Session

- The Poster Session and Welcome Reception will be held on Thursday, September 19 from (4:30-6:00 PM) directly after the Rapid Fire Session (4:05-4:30 PM). Please put your posters up as soon as you arrive on Thursday morning.
- Poster presenting authors are responsible for printing, setting up and taking down their poster; mounting supplies will be provided.
- The poster board surface will be 30x40 in, portrait or landscape – please do not print your poster any bigger.

Rapid Fire Poster Session

- All Poster presenters should plan to participate in the Rapid Fire Session, where the author will display one slide (PPT, 16:9, no animations) and in 2-5 minutes present the key information about their poster to the conference audience. You may use your Poster as the slide. The Rapid Fire presentation is meant to be an abstract rather than a comprehensive explanation of your work. The complete explanation should be reserved for the poster session.
- Poster authors taking part in the Rapid Fire session must send their slide by 9AM September 19 to lucya@aiche.org or notify Lucy Alexander if you do not wish to participate.

CODE OF CONDUCT

Code of Conduct

AIChE's volunteers are the core of the Institute and make all of its programs, conferences and educational efforts possible. These offerings provide excellent opportunities for AIChE members and meeting attendees to gain greater technical expertise, grow their networks, and enhance their careers. AIChE events provide engineers, scientists, and students a platform to present, discuss, publish and exhibit their discoveries and technical advances.

At all times, volunteers and meeting attendees should act in accordance with AIChE's Code of Ethics, upholding and advancing the integrity, honor and dignity of the chemical engineering profession. AIChE's Board of Directors has developed these guidelines to foster a positive environment of trust, respect, open communications, and ethical behavior. These guidelines apply to meetings, conferences, workshops, courses and other events organized by AIChE or any of its entities and also to volunteers who conduct other business and affairs on behalf of AIChE.

SPECIFICALLY:

1. Volunteers and meeting attendees should understand and support AIChE's Code of Ethics.
2. Volunteers and meeting attendees should contribute to a collegial, inclusive, positive and respectful environment for fellow volunteers and attendees, and other stakeholders, including AIChE staff.
3. Volunteers and meeting attendees should avoid making inappropriate statements or taking inappropriate action based on race, gender, age, religion, ethnicity, nationality, sexual orientation, gender expression, gender identity, marital status, political affiliation, presence of disabilities, or educational background. We should show consistent respect for colleagues, regardless of discipline, employment status, and organizations for which they work, whether industry, academia, or government.
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Any violations of the foregoing should be reported to the President or the Executive Director of the Institute.

DISCOVER MORE IN GREEN ENGINEERING THROUGH AIChE® PROGRAMMING

Attend a conference in a new place, participate in a meeting that unites around cutting-edge topics and meet like-minded professionals from around the world.

Enterprise + Infrastructure Resilience Conference

ENTERPRISE AND INFRASTRUCTURE RESILIENCE NEW

August 12-13 | Cincinnati, OH

Explore multifaceted resilience strategies for the modern enterprise that address dependence on external systems, such as the environment, stakeholders, shareholders, and society.

GLOBAL SYMPOSIUM ON WASTE PLASTIC

GLOBAL SYMPOSIUM ON WASTE PLASTIC NEW

September 19-20 | Lexington, KY

Join the discussion with engineers, scientists and other stakeholders on innovations for managing the universal waste plastic accumulation challenges facing both developing and developed countries.

Competitive Energy Systems Symposium MIDDLE EAST

COMPETITIVE ENERGY SYSTEMS SYMPOSIUM NEW

September 24 | Manama, Bahrain

Your expertise is needed at this critical event addressing the challenges of staying competitive in a changing climate through innovation within the energy sector.

BIOENERGY SUSTAINABILITY CONFERENCE

2019 BIOENERGY SUSTAINABILITY CONFERENCE

October 21-23 | Nashville, TN

Share your research and make an impact by collaborating with other researchers to disseminate the latest innovative concepts, methods, and results in the various domains of bioenergy sustainability.

19AIChE Annual Meeting, Orlando, FL

2019 AIChE ANNUAL MEETING

November 10-15 | Orlando, FL

In addition to programming from 22 of AIChE's Divisions and Forums, the meeting will feature innovative Topical Conferences on Concentrated Solar Energy for Power Generation and Chemical Processing, Innovations of Green Process Engineering for Sustainable Energy and Environment, and more.

ENGINEERING SUSTAINABLE DEVELOPMENT

ENGINEERING SUSTAINABLE DEVELOPMENT 2019 NEW

December 12-13 | Seoul, South Korea

Engineers, scientists and policy makers will gather to discuss technical and engineering challenges of addressing the 2030 Agenda for Sustainable Development and the 17 Sustainable Development Goals (SDGs).

SOLAR ENERGY SYSTEMS CONFERENCE

SOLAR ENERGY SYSTEMS NEW

December 12-13 | Waco, TX

This 2-day symposium will focus on solar energy innovation, challenges and opportunities for engineers and other stakeholders.

LEARN MORE AT aiche.org/events2019

AIChE The Global Home of Chemical Engineers

Center for Energy Initiatives An AIChE Technological Community

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Event details including dates and locations are subject to change, please check website for most current information.

POLYMERS & TEXTILES CONFERENCE

NOVEMBER 6-8, 2019
ALUMNI HALL, UNIVERSITY OF MASSACHUSETTS LOWELL, MA

UMASS LOWELL 125 YEARS PROUD 1894 - 2019

Join us for the **Polymers & Textiles Conference** which will cover manufacturing and innovations, advancements in materials and fibers, workforce development, advanced textiles applications, business developments for advanced materials and products and aspects of sustainability.

This is the event for you to interact with chemical engineers, researchers, chemists, and more who specialize in polymers and textiles.

SESSION TOPICS

- Manufacturing and Innovation
- Advancements in Materials and Fibers
- Workforce Development
- Advanced Textiles Applications/Smart and Connected
- Business Development for Advanced Materials and Products
- Sustainability in Smart Fabrics
- Evolving Design Processes

CONFERENCE CHAIRS

Jess Jur
North Carolina State University

Ram Nagarajan
University of Massachusetts, Lowell

Yolita Wildman
Flex, Textiles Program Management

Yuly Fuentes
Massachusetts Institute of Technology

Submit an abstract, register and learn more about Polymers & Textiles 2019 aiche.org/polymers

Interested in sponsoring and/or exhibiting at this event? Contact sales@aiche.org

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ECCP
Engineering Cosmetics & Consumer Products

SAVE THE DATE

NOVEMBER 9-10, 2019 • HYATT REGENCY • ORLANDO, FL

The Conference on Engineering Cosmetics and Consumer Products (ECCP) will discuss research and development as well as process engineering, product engineering, innovation, and packaging.

Session topics include:

- Process Engineering
- Product Engineering
- Package Engineering
- Open Innovation
- Regulatory Issues, Safety, Compliance
- Sustainability

Academic, clinical, and industrial researchers are invited to submit their own discoveries. You can also share this invitation with colleagues who might be interested in collaborating. This conference provides a perfect opportunity to share, network, and learn.

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SPACE TRAVEL STAR TECH

ADAPTIVE RESEARCH AND TECHNOLOGIES FROM CHEMICAL AND BIOLOGICAL ENGINEERING

November 18-20, 2019
Hyatt Regency Boston, MA
aiche.org/startech

Participate in the **2nd Space Travel: Adaptive Research and Technologies from Biological and Chemical Engineering (STAR Tech)**, an event that brings together experts from industry and academia to discuss space travel technology and capabilities needs, in an effort to accelerate the development of commercial and non-commercial space exploration.

SESSION TOPICS

- **Brewing** - This topic area will focus on how to develop fermentation for the production of useful molecules to support a sustainable presence on Earth and in space.
- **Fueling** - Focus on how to develop chemical and material technologies for efficient and reliable processing of fuel and energy storage.
- **Nourishing** - Focus on sustainable strategies of producing nutritious and palatable foods with the dual purpose of supporting food security on Earth and optimal crew health in space.
- **Building** - Focus on developing new chemical, biological, and material science approaches to building components and techniques, for feasible survival in space and sustainable survival on Earth.
- **Reclaiming** - Focus on chemical, biological, and material technologies that optimize resource utilization through reuse and reprocessing of existing “waste” streams.

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NASA

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aiche.org/startech

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FOOD-ENERGY-WATER NEXUS

DECEMBER 5-6, 2019 | NYIT AUDITORIUM ON BROADWAY | NEW YORK, NY

You're invited to present your work at the **Food-Energy-Water Nexus** this December in New York City. Your expertise is needed for collaboration in addressing the critical concerns of how we provide and maintain the food, energy and water supplies in urban environments as the population continues to increase.

TOPICS INCLUDE

- Impact of Climate Change on the Food-Energy-Water Nexus
- Food-Energy-Water Nexus Data and the Data Science Community
- Policy for the Resilience of FEW Impacts
- Innovative Solutions
- Transforming Urban Infrastructure to Support Food Scarcity
- Forecasting Energy Needs for Increasing Populations
- Hydrofracking and Its Impacts on the FEW Nexus
- Food Waste as an Energy Source in Urban Environments

CONFERENCE CHAIRS

David Nadler
NYIT, Chair

Ziqian Dong
NYIT, Co-Chair

Submit an abstract, register and learn more about Food-Energy-Water Nexus
aiche.org/few19

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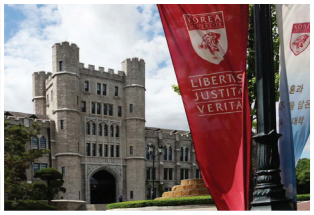
ENGINEERING SUSTAINABLE DEVELOPMENT

DECEMBER 12-13, 2019
KOREA UNIVERSITY, SEOUL, SOUTH KOREA

You're invited to the **Engineering Sustainable Development** conference, taking place this December 12-13, where engineers, scientists and policy makers will gather at the Korea University in Seoul to discuss technical and engineering challenges of addressing the 2030 Agenda for Sustainable Development and the 17 Sustainable Development Goals (SDGs).

KEY DATES

June 12 ..... Call for Abstracts Opens
August 1..... Registration Opens
September 12..... Call for Abstracts Close
September 26..... Acceptance Notifications
October 12..... Early Bird Registration Ends
December 12-13..... Conference

Submit an abstract, register and learn more about EngSD 2019
aiche.org/engSD

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Technical & Engineering Challenges of Addressing Sustainable Development

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APRU

SPS SUSTAINABLE PACKAGING SYMPOSIUM

December 16-18, 2019
University of California, Santa Barbara, CA

Participate in the Sustainable Packaging Symposium – to discuss Innovative Technologies and Life Cycle Approaches for Packaging Sustainability in a Circular Economy World in a format where attendees will have ample opportunities to network and foster innovation.

SESSION TOPICS

- Packaging Sustainability Today – Drivers and Trends
- Packaging Sustainability and Life Cycle Approaches
- Innovative Technologies
- Research in Packaging Sustainability
- Role of Global Standards and Policy to Foster Packaging Sustainability
- Circular Economy World for Packaging
- Future of Packaging Sustainability – Balancing the Needs and Wants of All Stakeholders

Submit an abstract, register and learn more about SPS
aiche.org/sps

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