UH Energy
UNIVERSITY OF HOUSTON

2025 UH ENERGY SYMPOSIUM

PLASTICS CIRCULARITY

UNIVERSITY OF HOUSTON

APRIL 17, 2025

Shell Polymers

LyondellBasell

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Welcome

Debalina Sengupta

Chief Operating Officer
Energy Transition Institute
Assistant Vice President
Division of Energy and Innovation
Symposium Chair

It is my pleasure to welcome you to the 2025 UH Energy Symposium on Plastics Circularity at - **The Energy University®**. This year's one-day event gathers industry, government, and academia leaders to discuss one of the most pressing and challenging needs of our times - plastics circularity. Attendees can explore technology showcases, art, and poster competitions, contributing to a circular economy. Overall, this program aims to set the stage for action-oriented and definitive learning experiences that will shape the future of plastics circularity.

Agenda

Registration & Welcome 7:30 AM
Opening Keynote: Torkel Rhenman, *LyondellBasell* 8:10 AM - 9:00 AM
Poster Pitches 9:00 AM - 9:30 AM
Session One: Standards, Policy, Business Models 9:30 AM - 11:15 AM
Lunch, Poster Competition, Tech Showcase and Sponsor Messages 11:15 AM - 12:15 PM
Lunch Keynote: Senami Akle, *Logitech* 12:15 PM - 1:00 PM
Session Two: Science, Technology, Case Studies 1:15 PM - 3:00 PM
Art Show 3:00 PM - 3:30 PM
Expert Panel Discussion: 3:30 PM - 5:00 PM
Awards, Reception and Networking 5:00 PM - 6:30 PM

Organizing Committee Members

Megan Robertson Neal R. Amundson Professor, William A. Brookshire Department of Chemical and Biomolecular Engineering
Tracy Hester Instructional Professor of Law, University of Houston Law Center
Greg Bean Executive Director, Gutierrez Energy Management Institute, C.T. Bauer College of Business
Joseph Powell Aspire Shell Endowed Chair and Executive Director for Energy Transition Institute, Professor, William A. Brookshire Department of Chemical and Biomolecular Engineering

LyondellBasell Opening Keynote Speaker

LyondellBasell is one of the world's largest plastics, chemicals and refining companies. In his role as EVP, Torkel has manufacturing and commercial responsibility for the APS compounding and related business segments.

Torkel Rhenman
Executive Vice President, APS
LYONDELLBASELL

Torkel joined LyondellBasell in 2019 as Executive Vice President, Intermediates and Derivatives (I&D) and gained responsibility for the Refining business segment in 2020. Prior to joining the company, he served as CEO of Lhoist Group, a leading global mining and lime manufacturing company.

He also spent 26 years with DuPont serving in various commercial, manufacturing and management positions including global business director roles in DuPont Dow Elastomers and DuPont Packaging and Industrial Polymers.

In 2008, he was appointed CEO of Solae LLC, a specialty food ingredient joint venture between DuPont and the U.S. agribusiness group Bunge. Torkel holds a Master of Chemical Engineering degree from the Royal Institute of Technology, Stockholm, Sweden. He serves on the board of directors for CoorsTek. He also is a delegate to the University of Houston Energy Advisory Board and serves on the American Cancer Society's CEOs Against Cancer - Greater Houston Chapter.

Lunch Keynote Speaker

Senami Akle
Director, Head of Design for Sustainability,
Logitech

Senami is an accomplished professional with a diverse background spanning industries such as consumer electronics, food and technology. Recognized for her pioneering work in innovation and sustainability, she has played integral roles in product innovation and design for sustainability, always with a steadfast commitment to environmental improvement. Presently, Senami serves as the Director and Head of Design for Sustainability at Logitech, where she champions the integration of sustainable practices into the company's core product portfolios and operations.

She firmly believes that innovation lies at the heart of effecting positive change, whether in product design, company culture, or societal progress. It is this belief that drives her to always push for new solutions that are both beneficial to people and the planet.

As a human centered leader, Senami advocates for the power of collaboration in unlocking innovative solutions and catalyzing meaningful impact. "There is only so much one person can achieve; true collaboration is the cornerstone of innovation and the key to affecting the transformative change needed to design a positive future." Born of French-Beninese heritage and residing in Switzerland, Senami pursued her academic journey at Ecole Polytechnique Paris and UC Berkeley, focusing on environmental engineering. Additionally, she successfully completed an MBA course specializing in innovation and entrepreneurship.

Session 1 - Standards, Policy, and Business Models

Mary Ellen Ternes, Partner, Earth and Water Law LLC

Mary Ellen is a senior environmental attorney with a background in chemical engineering and prior experience at the USEPA and in industry. She has spent the past 30 years representing a broad range of commercial, industrial, and municipal clients in environmental regulatory and litigation matters. She is a Fellow at the American Institute of Chemical Engineers and American College of Environmental Lawyers. She is Senior Fellow for Law and Policy at the Global Council for Science and Environment and serves on the National Academy of Sciences, Engineering and Medicine: Roundtable on Plastic Pollution.

Scott Trenor, Technical Director, Association of Plastic Recyclers (APR)

Scott is leading efforts on APR programs in design for recycling, recyclability testing protocols and global harmonization of packaging design protocols. Scott had over 20 years of experience prior to joining APR, including serving as the Principal Scientist & Global Sustainability Lead in plastics additives at Milliken & Company. He was also a Senior Scientist at Kraton Polymers.

Ganesh Nagarajan, Senior Director, Plastics, WM

Ganesh has over 30 years of experience in the plastics industry, having worked across the value chain—from film converting to resin production to waste management. Throughout his career, he has held various roles, including product development, sales and marketing, and business management, across diverse geographies, including the Americas and Asia.

Scott Coye-Huhn,Vice President, Energy, Biomaterials, and Circularity (EBC) Division, SCS Global Services

Scott has been in the renewables space for over 20 years acting primarily in regulatory compliance and general counsel roles. The EBC division houses SCS's low carbon fuels programs, along with its biomaterials and circularity programs. Beyond regulatory compliance, Scott's career includes several years in environmental litigation, legislative and community advocacy, and economic development.

Session 2 - Science, Technology, and Case Studies

Wei Cai, Chief Technology Officer, Technip Energies

Wei serves on the Executive Committee for Technip Energies. In this role, she shapes their technology strategy to support business growth and leads their Technology and Innovation organization to drive technology execution. Wei also champions external collaborations and alliances to build the technology ecosystem for the company.

Michelle E. Seitz, Program Director, NIST Circular Economy Program – Plastics, National Institute of Standards and Technology

Before joining NIST, Michelle was an AAAS Science and Technology Policy Fellow at the U.S. Department of Energy. She supported AMMTO's Circular Economy pillar with a focus on advancing plastics circularity via program, strategy, and technology development. Prior, she was a Senior Scientist at DSM's Material Science Center in the Netherlands where she worked on research and development of plastic materials.

Katrina Knauer, Chief Technology Officer, BOTTLE Consortium, National Renewable Energy Laboratory

Katrina is a polymer scientist and chemical engineer who is driven by a steadfast commitment to addressing the pressing issue of plastic waste. She had a post-doctoral experience with BASF, specializing in plastics recycling. Katrina ventured into entrepreneurship with Novoloop Inc., a groundbreaking startup dedicated to chemical recycling of plastic film.

Kathryn J Wright, Vice President, R&D, Kraton Corporation

Kathryn joined Kraton in 2002 and is currently the Vice President of R&D for its Polymers business segment. Her expertise is in new product development for consumer, medical and automotive applications. She is process driven while focusing on people development to equip the next generation of innovators for Kraton.

Expert Panel - Path Forward for Plastics Circularity

Moderator: Celeste Schurman, Producer, Houston Matters, Houston Public Media

Helmut Brenner, Environmental Social Governance Manager, Shell USGC Chemicals Products and US Polymers Businesses

Helmut Brenner is the Environmental Social Governance Manager for the Shell USGC Chemicals & Products and US Polymers Businesses. Areas of responsibility include ESG Risk Management for sustainable chemistry, local impact, stakeholder engagement; Sustainable Products Assurance with 3rd party certifications, bio and recycled products; Portfolio Decarbonization and voluntary carbon markets; Public Outreach, Policy, Advocacy, Communication, and Education.

Jace Tunnell, Director of Community Engagement, Harte Research Institute, Texas A&M Corpus Christi

Jace is the founder of Nurdle Patrol, a citizen science project that tracks plastic pellet concentrations internationally. He also directs and produces “Beachcombing,” a video series about items washing up along the Gulf of Mexico to help promote awareness on Gulf processes and interesting creatures in the ocean.

Meltem Urgun Demirtas, Department Manager – Sustainable Materials and Processes, Argonne National Laboratory

Meltem has over 25 years of experience designing and operating chemical and bioprocesses, developing and scaling new technologies from bench-to-pilot and field-scale, techno-economic analysis, and process modeling. Currently, she serves as Argonne’s Program Manager at the Bioenergy Technologies Office of DOE.

Andrew Oliver, Technology Manager Sustainable Feedstocks, The Dow Chemical Company

Andrew’s career has spanned 16 years and multiple roles in engineering, operations, and leadership across major chemical and energy sectors in Texas. In 2022, he was named Technology Manager for Sustainable Feedstocks in North America where he spearheaded technical trials and compliance initiatives for advanced recycling and partnerships focused on circular and bio-based feedstocks, with a focus on technical solutions to progress Dow product sustainability.

Keynote Speaker Abstracts

Speaker Name: Torkel Rhenman
Affiliated Organization: LyondellBasell
Title of Talk: Unlocking the Circular Potential of Plastics

Abstract:
The global transition to a circular plastics economy demands innovative approaches that bridge multiple industries and stakeholders. The comprehensive strategy by LYB demonstrates how integrated technologies and strategic partnerships can unlock value across automotive, packaging, and other industries. By implementing an integrated hub model, LYB is systematically addressing key circular plastics economy challenges: building scale, reducing costs, and capturing maximum value throughout the plastics lifecycle. Concrete examples underscore its approach. The MoReTech chemical recycling facility in Cologne showcases the technological capabilities in processing complex plastic waste streams. Through a partnership at the Cyclyx Circularity Center in Houston, LYB exemplifies its strategy of accessing diverse, low-cost waste feedstock streams. The Circluen portfolio of sustainable solutions from LYB illustrates its innovative approach, delivering materials based on recycled and renewable feedstocks. This presentation will provide insights for a diverse audience—including OEMs, converters, brand owners, consumers and academic researchers—demonstrating how innovative recycling technologies can transform plastic waste into valuable resources.

Speaker Name: Senami Akle
Affiliated Organization: Logitech
Title of Talk: Innovating for Plastics Circularity

Abstract:
Explore the future of circularity in this engaging session, centered on how recycled plastics play a key role in driving innovation. Unlocking the circular economy is key to minimizing waste and maximizing resources. But how can businesses take actionable steps to make this a reality? This session will outline Logitech's approach to using recycled plastics through innovative practices and sustainable design principles. The company will showcase how choosing to use recycled plastics as their primary material has revolutionized their mice, keyboard, and headset categories, serving as a driving force for innovation. Motivated by data and amplified by creativity, Logitech takes you behind the scenes of their Design for Sustainability program. Showing that it's possible to design with less, design smarter, and design for progress to achieve business success.

Logitech's Head of Design for Sustainability will walk you through key considerations in product development, leading to innovation across multiple areas. The company will share how they are activating simple and convenient ways for consumers to recycle, and giving refurbished devices a second chance. Above all, you will learn how Logitech is scaling to maximize positive impact with their recycled, Next Life Plastics program. Join this session to gain practical insights and tools for driving circular innovation within your organization. Whether you are a policymaker, solutions provider, researcher or student, let's collaborate and redefine the way we drive action for a circular economy.

Session One Abstracts

Speaker Name: Mary Ellen Ternes
Affiliated Organization: Earth & Water Law, LLC
Title of Talk: Legal Landscape for Plastic Circularity

Abstract:
The legal landscape for plastic circularity is currently quite dynamic but therein lies great opportunity to mitigate material risk from plastic pollution litigation through better implementation of plastic circularity. Plastic circularity is impacted by state and federal environmental regulations governing energy production, chemical and other manufacturing, and recycling and waste management including municipal and biosolids application. Implementation of plastic circularity is challenged by a general lack of mandatory requirements and standards, as well as lack of sufficient infrastructure, financial benefit and government incentives supporting such efforts. New to this landscape is uncertainty arising from the recent change in political administrations. This uncertainty extends to the scope and implementation of existing regulation, fate of recently adopted and proposed future regulation, resolution of tension between shifts in federal policy and opposing state authority in the context of international policy developments, funding for research regarding science supporting plastic circularity and infrastructure for plastic waste management supporting plastic circularity, and availability of governmental resources, including staff, to oversee regulatory administration. Also trending in this landscape is increasing plastic litigation seeking relief from damages caused by plastic pollution, which could potentially be mitigated through efficient implementation of plastic circularity. This presentation will review these issues in context while providing references for further review.

Speaker Name: Scott Trenor
Affiliated Organization: Association of Plastic Recyclers
Title of Talk: Recycling of Plastic Packaging: Current and Potential Future States

Abstract:
Plastic packaging is ubiquitous in our modern society, serving as the primary materials for delivering products to the consumer. While these materials offer numerous advantages such as durability, cost-effectiveness, safety and versatility, their end-of-life situation leaves much to desire. We will explore hurdles and approaches to increase the recyclability of plastic packaging, how APR approaches design for packaging and how that design may apply to recycling processes under development and new materials.

Speaker Name: Ganesh Nagarajan
Affiliated Organization: WM
Title of Talk: Enabling and Advancing Plastics Circularity: How WM is Shaping the Future Through Innovation and Collaboration

Abstract:
WM is in a unique position as the largest solid waste company in North America – we are able to hold the title of the largest landfill company and the largest recycling company on North America. WM's sustainability goals are built on three key pillars. Material is repurposed, Energy is renewable, Communities are thriving. As part of our vision to enable a future where materials are repurposed, WM has set a goal to increase recovery of recyclable materials by 60% to 25 million tons annually by 2030, including an interim milestone of a 25% increase in recovery of recyclable materials by 2025. To achieve this, WM plans to invest more than $1.4 billion in approximately 40 new and upgraded state-of-the-art recycling facilities from 2022 through 2026, which is expected to generate an additional 2.8 million tons of recycling capacity per year. These facilities are designed with advanced technology such as optical scanners, intelligent sorting equipment, volumetric scanners, cameras, fire suppression technology and more. These new and upgraded facilities are anticipated to increase the quantity and quality of the material we recycle and expand recycling access to new markets.

Speaker Name: Scott Coye-Huhn
Affiliated Organization: SCS Global Services
Title of Talk: Lower Carbon Chemicals and Packaging: A Certification Standard for Defossilizing the Chemicals Industry

Abstract:
Biobased and recycled raw materials, including carbon dioxide will be key to defossilizing the chemicals and plastics sectors. SCS Standards, the official standards development body for SCS Global Services, has developed a certification standard so companies can make robust audited claims about reducing the carbon footprint of their products. The standard provides a cradle to gate carbon intensity calculation for the real world, based on ISO 14067 and Together for Sustainability (TfS) Guidance, with a unique approach to an updating baseline that drives increased reductions over time.

The standard incorporates reduction methods such as bio and recycled content, renewable energy, carbon capture and storage and efficiency improvements. There is flexibility to allow companies to sell products with a carbon intensity tailored to the needs of individual customers. The Standard, SCS-115 has been developed with input from the chemicals industry, start-ups, and NGOs.
The following topics, in addition to those mentioned above, will be covered: Carbon intensity calculation methodology; Allocation of carbon emissions to products based on mass balance principles; On-Site and off-site product carbon intensity reduction; Compensating for emissions of the supply chain;
Coprocessing; CO2 uptake from the air during biomass growth; Alignment of biobased or recycled content and GHG emissions savings; Potential use for compliance with Extended Producer Responsibility.

Session Two Abstracts

Speaker Name: Wei Cai
Affiliated Organization: Technip Energies
Title of Talk: Circularity at Technip Energies

Abstract:
The presentation Circularity at Technip Energies explores the company's initiatives and technologies aimed at enhancing circularity within its operations. It covers various aspects such as proprietary technologies for plastic recycling, execution of circularity projects, instilling circular design in engineering projects, and methodologies for waste segregation and recycling. The presentation highlights key technologies like Alterra for converting solid plastic waste into pyrolysis oil, Anellotech's PlasTCat® for
r-BTX production, and Technip Energies' proprietary Pure.rOil™ for pyrolysis oil purification. Additionally, it discusses the SYNOVA + Pure.rGas™ technology for producing olefinic gas from plastic waste. The presentation aims to provide a comprehensive overview of Technip Energies' efforts towards achieving a sustainable and circular economy.

Speaker Name: Michelle Seitz
Affiliated Organization: National Institute of Standards and Technology
Title of Talk: Improving Measurements and Data to Enable Plastics Circularity

Abstract:
NIST's work related to advancing measurements and data to enable plastic circularity. Several vignettes will be shared including work to expand mass spectrometry libraries coverage of plastics-related compounds, advances in time-gated Raman spectroscopy, coupled rheological-spectroscopy approaches for understanding how blends effect crystallization behavior during flow, and efforts related to advancing separations of mixed plastics.

Speaker Name: Katrina Knauer
Affiliated Organization: National Renewable Energy Laboratory
Title of Talk: Addressing plastic waste today while developing recyclable-by-design materials for the future

Abstract:
The plastic pollution crisis is also an energy challenge, with plastic production projected to consume 20% of global fossil fuels by 2050. Current polymerization processes offer little room for efficiency gains, while large-scale recycling is limited to mechanical methods with diminishing returns due to contamination and polymer degradation. To strengthen America's energy security and global competitiveness, the U.S. plastic industry must embrace system-wide innovation—integrating a bio- and waste-based supply chain with a circular plastic economy driven by advanced recycling technologies. The Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment (BOTTLE™) Consortium, a U.S. Department of Energy multi-organization initiative, is spearheading this effort. BOTTLE develops low-energy chemical recycling strategies to recover plastic waste and designs next-generation, recyclable-by-design (RBD) polymers. This talk will showcase flagship BOTTLE technologies in plastic deconstruction, waste upcycling, and RBD polymers—offering practical solutions to reduce waste, boost energy efficiency, and position the U.S. as a leader in sustainable manufacturing.

Speaker Name: Kathryn Wright
Affiliated Organization: Kraton Corporation
Title of Talk: Styrenic Block Copolymers Are Enabling a Circular Economy

Abstract:
Styrenic block copolymer (SBC) innovations improve the sustainability profile of many applications including asphalt roads, adhesives, consumer and medical goods including upcycling and reuse of mixed waste streams. The versatile design space for SBCs makes them an ideal category of thermoplastic elastomers to enable a circular economy by lowering the carbon footprint of end-use products, increasing recyclability, and enabling new product designs for end-of-life recyclability consideration. Case studies highlighting the use of SBCs for improved circularity will be described.

Expert Panel Abstracts

Speaker Name: Helmut Brenner
Affiliated Organization: Shell Polymers
Title of Talk: Path Forward for Plastic Circularity

Abstract:
Structural shifts in customer and investor priorities have driven governments, institutions, brands, and industry partners to increasingly demand higher levels of corporate responsibility and sustainability from the companies they transact with and invest in. Towards this end Shell has the ambition to demonstrate differentiated, industry leading ESG performance across a range of legacy and emerging industry issues in the communities and areas where we currently operate and plan to grow over the next 30 years. Whilst this societal shift is inevitable, there exist significant gaps in supporting policy, regulation and education. These are both sources of threat and opportunity for business with ambition to thrive during the energy transition and the new circular economy.

Speaker Name: Jace Tunnell
Affiliated Organization: Harte Research Institute for Gulf of Mexico Studies at Texas A&M University Corpus Christi
Title of Talk: Plastic Accumulation Along Texas Beaches

Abstract:
A citizen science program called Nurdle Patrol has recorded plastic pellet concentrations along beaches, lake shorelines, riverbanks, and railroads from volunteers conducting 10-minute surveys. Over 10,000 volunteers have collected over 20,000 surveys at over 9,000 sites across the United States, Mexico, and 24 other countries to help identify possible sources of the plastic pellets (nurdles). Nurdles are small plastic pellets that are the basis of almost everything plastic. Nurdles look like food to animals causing possible intestinal blockage and/or starvation if eaten, and they absorb harmful chemicals in the environment that are known to have negative impacts on fish and wildlife. In addition to Nurdle Patrol, weekly beach surveys are conducted to see what is washing up along our shorelines to educate the public about the amazing place we live. Jace Tunnell will present about Nurdle Patrol efforts and some of the odd and interesting things he has found over the years in his beach surveys, including over 40 messages in a bottle, finding a prosthetic leg, illegal fishing gear, creepy dolls, and much more. The overall message is that plastic in the ocean has real consequences for marine life in and out of the ocean.

Speaker Name: Meltem Urgun-Demirtas
Affiliated Organization: Argonne National Laboratory
Title of Talk: The Importance of Analysis in Formulating Circular Plastics

Abstract:
As industry moves towards the production of environmentally friendly circular plastics, analysis becomes crucial to formulate new polymer chemistries, identify opportunities for technology improvement, and provide research and development guidance under a systemic and dynamic framework. Multiple analysis tools are needed to accelerate circular plastics production. For example, the utilization of AI/ML is crucial to determine how polymer properties impact their interaction with receiving environments and understand their environmental fate and effects. The end-of-life analysis provides an evaluation of potential environmental concerns, and indicates where options exist, those that are more environmentally compatible, i.e., less harmful to humans and the receiving environment. A combined materials flow and life cycle analysis is another crucial tool for understanding how the new circular plastics influence the supply chain and downstream markets. The systematic approach should provide a guiding framework for a consistent and transparent evaluation with large-scale implications across value and supply chains and identify the conflicting priorities (e.g., tradeoffs between plastics circularity and environmental indicators) and unintended consequences from the circular strategy implementation.

Speaker Name: Andrew Oliver
Affiliated Organization: Dow Inc.
Title of Talk: Expert Panel: Path Forward for Plastics Circularity

Abstract:
Dow is committed to using a scientific and collaboration approach to drive innovation, sustainability, and inclusivity. With the ambition to be the world's most innovative materials science company, Dow aims to create significant impacts through its three core sustainability goals: protecting the climate, transforming waste, and closing the loop. Protecting the Climate: Dow plans to reduce its net annual carbon emissions by 15% (5 million metric tons) by 2030 compared to 2020 levels and achieve carbon neutrality by 2050 (scopes 1, 2, and 3, plus product benefits).

Transforming Waste: By 2030, Dow will commercialize 3 million metric tons of circular and renewable solutions annually by transforming plastic waste and alternative feedstocks. The company is expanding efforts to collect, reuse, and recycle waste while growing its portfolio to meet demand.
Closing the Loop: Dow aims for 100% of its products sold in packaging applications to be reusable or recyclable by 2035, thus eliminating plastic waste. Key initiatives include investments in technologies and infrastructure for global recycling, and partnerships. Dow is a founding member of the Alliance to End Plastic Waste which has collaboratively committed $1.5 billion over 5 years to manage waste and promote post-use solutions. Through efforts like partnering with Mura Technology, Circulus, Xycle, and Refinity, Dow is advancing the circular economy and promoting innovative technologies. These endeavors showcase Dow's dedication to sustainability and impactful collaboration.

Poster Abstracts

Poster Session Coordinator: Dr. Sribala Gorugantu
Assistant Professor and Presidential Frontier Faculty Fellow
William A. Brookshire Department of Chemical and Biomolecular Engineering
University of Houston

#01
Title: Enhancing Properties of Sustainable Thermoplastic Elastomers through Incorporating Ionic Interactions
Authors: Josiah Hanson, Megan L. Robertson
UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Biobased Polymers
Abstract:
Thermoplastic elastomers (TPEs) are widely used in electronics, clothing, adhesives and automotive components due to their high processability and flexibility. ABA triblock copolymers, in which A represents glassy end-blocks and B a rubbery midblock, are commercially available TPEs that most commonly use polystyrene end-blocks and polydiene mid-blocks which are derived from petroleum, whose manufacturing and disposal have undesired environmental impacts, motivating the development of TPEs from sustainable sources. Vegetable oils and their fatty acid derivatives are attractive alternatives to petroleum due to their abundance, low cost, biodegradability, and low toxicity. However, polymers with bulky constituents, like long alkyl side-chains of fatty acid-derived polymers, typically exhibit poor mechanical performance due to lack of entanglements in the rubbery matrix. To improve the mechanical properties, transient networks were incorporated into the fatty-acid derived midblock through either hydrogen bonding or ionic interactions. ABA triblock copolymers with either poly(n-butyl acrylate-co-acrylic acid) or poly(lauryl methacrylate-co-methacrylic acid) midblocks, derivable from corn stover and vegetable oils respectively, were synthesized in order to probe universal relationships among mechanical properties and rheological properties across the material systems. The comonomer acid groups were neutralized to obtain ionic interactions in the midblock. The glassy endblocks were poly(methyl methacrylate). Samples had varying acid content, ion content, and neutralizing cations used. The midblock chain dynamics were probed with rheology showing increased relaxation times with increasing ion content, and tensile testing showed up to 17- fold enhancement in strength. The presence of ionic aggregates was confirmed with small-angle X-ray scattering, and model fitting was used to extract structural information of the ionic aggregates formed in the midblocks of these materials. Surprisingly, this revealed that both the number and size of ionic aggregates remained constant with increasing acid and ion content. Therefore, there is some other aspect of the ionic aggregates and how they interact with the polymer chain dynamics that is governing the mechanical properties. Moving forward, the midblock relaxation processes of the midblock under shear are being investigated further, along with the mobility of ions since it may impact how effectively ionic aggregates can act as crosslinks and thus be controlling for the mechanical properties that have been observed.

#02
Title: Sustainable Epoxy Resins Derived from Para-Phenolic Acids
Author(s): Rosalie S. Berg , Megan L. Robertson, Venkatesh Balan
Faculty Advisor Name: Megan L. Robertson, Venkatesh Balan
UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Biobased Polymers
Abstract:
Composites made of epoxy resins are high strength, yet lightweight alternatives to traditional metal components used in automotive, wind, and electronics industries. Traditionally, epoxy resins are produced from petroleum-derived bisphenol A (BPA), which is epoxidized and cured with an amine or anhydride hardener. Unfortunately, BPA-based epoxy resins are derived from a non-sustainable resource and are not easily recycled, and BPA itself is a known endocrine disruptor. Lignin, a polyphenolic component of biomass, offers potential as a more sustainable and less toxic replacement for BPA in epoxy resins. In this project, lignin-based para-phenolic acids (syringic, vanillic, and 4-hydroxybenzoic acids) were epoxidized using a two-stage allylation-epoxidation procedure and then reacted with an anhydride curing agent to form epoxy resins. Epoxidation of allylated syringic acid with a peracid produced a hydroxylated side-product with an oxidized aromatic ring, which was not observed in the vanillic or 4-hydroxybenzoic acid systems. The amount of this side product increased with increasing reaction time; however, its presence did not impact the resin properties. We have examined the curing behavior of epoxidized para-phenolic acids with an anhydride curing agent and studied the thermal and mechanical properties of the cured resins. Increasing number of methoxy groups on monomer results in lower cross-link density of the fully cured resins and higher glassy modulus. Understanding how the chemical structure of the lignin-derived monomer impacts epoxy resin properties can help produce targeted epoxy resins with superior properties to petroleum-derived resins.

#03
Title: Functionalization and Repurposing of Polyolefins to Polyurethanes
Authors: Ronard Herrera, Megan L. Robertson, Ramanan Krishnamoorti
Faculty Advisor Name: Megan L. Robertson, Ramanan Krishnamoorti
UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Upcycling
Abstract:
By 2050, plastic waste is expected to accumulate to a staggering amount, where polyolefins (POs) are the primary source of this waste. In the U.S., only 4% of plastics are recycled, the rest are landfilled or incinerated. Momentum has therefore shifted towards looking for a solution to address polyolefin waste in order to move to a circular economy. Post-use modification has shown promising results in upcycling polyolefins, removing limitations of inertness, and improving the final physical properties of the recycled material while extending its useful lifetime. Specifically, the functionalization of POs with hydroxyl groups provides new opportunities in the development of thermoset polyurethanes (PUs), which have not yet been explored. Thermoset PUs, known for their long-lasting properties, are frequently used in foams, elastomers, and film production. This provides the opportunity to upcycle POs to durable, value-added products with long lifetimes. In this work, polypropylene (PP) was functionalized and upcycled to thermoset PUs. First, a PP-based polyol was synthesized through hydroxylation of maleic anhydride-grafted PP and subsequently cured with a diisocyanate to form a thermoset PU. The crystal structure (unit cell and lamellar structure) and crystallization and nucleation kinetics of the PP were preserved in the PU, indicating the formation of a urethane network did not impact the PP crystallization process. At room temperature, the PU showed high modulus due to the presence of crystallization; upon increasing the temperature above the melting temperature, the modulus decreased to a rubbery plateau, consistent with the formation of a network. The resulting PU showed higher glass transition temperature and lower degree of crystallinity than its PP predecessor due to the crosslinked nature of the polymer. The presence of PP crystallization in the PU led to a higher modulus than that of traditional polyester or polyether PUs, with a trade-off in diminished ductility. The mechanical integrity of the PU was maintained through several reprocessing cycles due to the melt processability enabled by the presence of a urethane exchange catalyst. This functionalization and upcycling route thus offers a promising alternative to repurposing PP waste, in which the creation of melt-processable thermoset polymers opens new applications for the materials.

#04

Title: Microplastic Detection in Complex Environmental Matrices: Comparative Study of Thermal Degradation Methods

Author(s): Amna Afzal, Jagos Radovic, Thomas Malloy, Qi Fu

Faculty Advisor Name: Qi Fu

UH Department/College/School: Department of Earth and Atmospheric Sciences

Aspects of Plastics Circularity: Environmental

Abstract:

Microplastics (MPs) are widely recognized contaminants in aquatic and terrestrial environments, yet standardized protocols for their detection, quantification, and characterization across different matrices remain incomplete. Detecting and analyzing MPs in complex environmental samples often requires extensive sample workup, which can affect the reliability of results through sample loss and introduction of allochthonous contamination, in addition to reducing the analytical throughput and efficiency. To address these challenges, this study explores thermal degradation techniques—Rock-Eval and Pyrolysis Gas Chromatography-Mass Spectrometry (Pyrolysis GC-MS)—as methods for detecting and characterizing MPs without the need for sample preparation. The goal is to determine the minimum detection and identification thresholds for MPs in complex environmental matrices using these approaches. To assess the effectiveness of both methods, polystyrene and polyethylene microplastics were spiked into soil, sediment, and sand matrices at concentrations ranging from 0.00034% to 4.2%. Both Pyrolysis GC-MS and Rock-Eval were used to analyze the samples, with lower concentrations tested more cautiously on Pyrolysis GC-MS to prevent instrument contamination. The results show distinct differences in the sensitivity and accuracy of the two methods. While both techniques successfully identified MPs, pyrolysis GC-MS demonstrated greater sensitivity, detecting MPs at concentrations as low as 0.00034%. In contrast, Rock-Eval was more effective at higher concentrations (1% to 4.2%), showing a linear increase in Total Organic Carbon (TOC) with increasing MP content. These findings highlight the limitations of Rock-Eval for low-level detection and emphasize the precision and reliability of pyrolysis GC-MS in identifying MPs, even at trace levels. This study underscores the importance of method selection for microplastic analysis and supports the use of pyrolysis GC-MS in developing standardized protocols for environmental monitoring. The findings contribute to improving the accuracy and comparability of microplastic research across various environmental matrices. Future work involves further testing of different MP polymers with more complex matrices to yield better results.

#05
Title: Repurposing Decommissioned Wind Turbine Blades as Highway Overhead Sign Structure
Author(s): Nagesh Ramaswamy, Bhupendra Joshi, Gangbing Song, Y. L. Mo.
Faculty Advisor Name: Y. L. Mo
UH Department/College/School: Department of Civil and Environmental Engineering

Aspects of Plastics Circularity: Upcycling
Abstract:
Wind energy's rapid growth has led to a significant challenge with decommissioned wind turbine blades (DWTBs), whose complex composite materials are difficult to recycle, and these DWTBs often end up in landfills. This research proposes a sustainable solution by repurposing DWTBs as structural components for Highway Overhead Sign Structures (OSSs). The high strength-to-weight ratio and durability of DWTBs offer substantial economic, environmental, and structural benefits. Economic analysis shows a 73% reduction in raw material costs for OSS, with significant savings in steel and concrete. Environmentally, repurposing DWTBs will reduce CO2 emissions by 242 tons per 40-foot span structure, supporting global net-zero goals. The feasibility is validated through technical assessments, design adaptations, regulatory considerations, and experimental demonstration. By integrating DWTBs into infrastructure projects, this study advances circular economy practices and provides a viable solution for managing wind turbine blade waste, conservation of resources, and ultimately contributing to sustainable infrastructure development.

#06
Title: Pyrolytic Deconstruction of Mixed Plastic Wastes into Value-Added Chemicals
Author(s): Sadashiva K. Patil
Faculty Advisor Name: Sribala Gorugantu
UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Advanced Recycling
Abstract:
Plastic waste generation poses a significant challenge from industrial, environmental, and societal perspectives. Although polyolefins, like HDPE and LDPE, are currently being recycled through mechanical recycling methods, a vast majority of them end up in landfills due to improper sorting and contamination. Catalytic pyrolysis offers a promising approach to recovering carbon from complex waste streams, such as municipal solid waste and medical waste. However, the heterogeneous nature of these feedstocks can lead to uneven decomposition, incomplete conversion, and the formation of by-products such as char. Catalytic upgrading is further complicated by heteroatom-containing groups (e.g., –OH, –COOH, –HCN), which can deactivate catalysts through coke formation and acidic site poisoning. It is imperative to deconvolute the effects of feedstock composition on the pyrolytic reaction mechanism to enable catalyst and reactor design.

This study investigates the primary and secondary reaction kinetics of mixed plastic model compounds to unravel key reaction pathways leading to the formation of high-value chemicals. A two-stage micropyrolysis reactor is employed to ensure operation in the kinetic regime and minimize transport limitations. Coupled with GC×GC and TOF-MS, this setup enables tracking the temporal evolution of the products and comprehensive analysis of product distribution, including CO_2, C_2–C_4 olefins, light oxygenates, and aromatic hydrocarbons. By integrating experimental insights with data-driven modeling, this work will provide a framework for optimizing reactor conditions and catalyst design, paving the way for more efficient plastic waste valorization.

#07
Title: Low-Temperature Chemical Recycling of Polymers Through Catalytic Solvolysis
Author(s): Vera E. Alato
Faculty Advisor Name: Sribala Gorugantu
UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Circularity: Chemical Recycling
Abstract:
Depolymerization of semi-crystalline polymers, such as polyesters and polyamides, via solvolysis with glycol or methanol presents a viable chemical recycling route for monomer recovery at relatively low temperatures. These polymers exhibit spherulitic morphology, characterized by radially growing crystallites that form compact, spherical structures. The interplay between structural and morphological features, such as crystallinity and molecular weight distribution, influences the reactivity of ester and amide bond linkages at temperatures above their glass transition (Tg) but below their melting point. While both heterogeneous and homogeneous catalysts have been investigated for PET depolymerization, uncertainties remain regarding reaction mechanisms and intra-particle transport limitations that affect solvolysis efficiency.

This study aims to elucidate the structure-property relationships governing depolymerization kinetics to mitigate transport limitations and enhance process efficiency. Key parameters—including particle size, crystallinity, initial molecular weight, and solvent-to-polymer ratio—will be systematically evaluated under varying temperature and pressure conditions to optimize solvolysis. Additionally, non-thermal methods such as sonication will be explored to improve catalyst-polymer interactions, thereby enhancing depolymerization rates and reducing energy input. This research will establish a systematic framework for selective depolymerization of multilayer polymer materials, including textiles and electronic shredded waste, which contain complex matrices of PET, polyamides, polyurethanes, and natural fibers such as cotton.

#10
Title: Determination of Phthalate Emissions in Houston air and dust using Comprehensive two-dimensional Gas Chromatography
Author(s): Fnu Anshika, Bernhard Rappenglueck
Faculty Advisor Name: Bernhard Rappenglueck
UH Department/College/School: Department of Earth and Atmospheric Sciences

Aspects of Plastics Circularity: Life Cycle Assessment/Techno Economic Assessment
Abstract:
Phthalates are semi-volatile organic compounds that are used as plastic additives which get released from plastics throughout their lifecycle. They are known as endocrine disruptors and have adverse impact on neural and reproductive system. This research focuses on developing a method for analysis of phthalates using comprehensive two-dimensional gas chromatography with mass spectrometer (GCxGC/MS) and its distribution in Houston. Multiple combinations of detectors have been tested to develop a method which performs best across all the detectors. The combinations that have been tested are GC-MS, GCxGC/MS, GC-MSMS, gas chromatography with flame ionization detector (GC-FID), GCxGC/FID. The samples will be collected in dust phase, gas-phase and particulate phase. The sampling is currently being conducted across various location in Houston such as traffic signals and highways. This study will be able to provide a comprehensive view over phthalates and improve the understanding of distribution of traditional phthalates and their replacements.

#11
Title: Enhancing Physical Properties of Polypropylene Films with Cellulose Nanocrystals
Author(s): Diana Cousins, Ibrahim Kamara, Francisco Gomez, Megan L. Robertson, Alamgir Karim
Faculty Advisor Name: Alamgir Karim
UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Polymer Science
Abstract:
Only 2% of plastic films and flexible packaging are recycled, presenting a significant challenge in sustainable waste management. A notable obstacle lies in the recycling of multilayer films, where each layer possesses distinct compositions and functionalities. Integrating nanomaterials into polymer films has emerged as a promising strategy to enhance their properties. By bolstering film functionality, the required layers in multilayer films can be reduced, facilitating their recyclability. Cellulose nanocrystals (CNCs) represent a class of biobased nanoparticles renowned for their ability to confer desirable properties to nanocomposite films. However, the integration of CNCs into non-polar materials poses a significant challenge due to their unfavorable surface energies. This study addresses this by employing a grafting-to approach to attach polypropylene (PP) chains onto CNCs to improve their dispersion in a PP matrix. Adding grafted CNCs to PP thin films greatly enhanced Young's modulus, especially when the CNCs were confined to lie in plane, resulting in a remarkable 762% increase at a film thickness of 16 nm. An increase in PP crystallinity was also observed, due to the CNCs' role as nucleating agents. Additionally, the influence of undercooling on PP crystallization in the films was observed to be significant. This research sheds light on the potential of grafting polyolefins to CNCs as a means to enhance film properties and address challenges associated with multilayer film recyclability.

#12
Title: Dynamic Pricing and Cost-Sharing Optimization in a Dual-Channel E-Waste Recycling System for a Circular Economy
Author(s): Chuyue Wang
Faculty Advisor Name: Jian Shi
UH Department/College/School: Industrial Engineering

Aspects of Plastics Circularity: Life Cycle Assessment/Techno Economic Assessment
Abstract:
This study develops a dynamic pricing strategy for a dual-channel e-waste recycling system to enhance the efficiency of closed-loop supply chains within the circular economy. By integrating manufacturer-led and recycled material market channels, we establish a cost-sharing mechanism that optimally distributes green service and recycling costs among stakeholders. Using a Stackelberg game-based model, we analyze pricing and profit distribution dynamics, ensuring financial sustainability and market stability. Results show that the dual-channel mechanism improves profitability, price stability, and recycling efficiency, providing strategic insights for policymakers and industry leaders in sustainable e-waste management.

#13

Title: Battery Recycling for Conservation: A Quantitative Evaluation of Mining Substitution and Habitat Protection

Author(s): Chuyue Wang

Faculty Advisor Name: Jian Shi

UH Department/College/School: Industrial Engineering

Aspects of Plastics Circularity: Life Cycle Assessment/Techno Economic Assessment

Abstract:

Battery recycling is essential for the circular economy, not only recovering valuable materials but also reducing the environmental damage caused by mining. This study analyzes how recycling lithium-ion and nickel-metal hydride batteries from electronic devices can lower the demand for cobalt, nickel, lithium, and rare earth metals, thereby reducing deforestation, pollution, and habitat destruction in key mining regions such as the Congo Basin, Indonesian rainforests, and South American salt flats. By quantifying metal recovery rates and mining reduction, we estimate the positive impact on biodiversity conservation, particularly for endangered species like gorillas, rare birds, and flamingos, whose habitats are threatened by resource extraction. The results highlight the direct link between e-waste recycling and wildlife protection, emphasizing that a closed-loop recycling system not only conserves critical raw materials but also serves as a practical strategy for species conservation and ecosystem restoration.

#14

Title: Lignin Valorization with Earth-Abundant Metal Catalysts

Author(s): Robert Comito, Simran, Zipeng Gu, Qingqing Dong, Tayann Cobo, Pratyush Naik, Maxym Tansky

Faculty Advisor Name: Robert Comito

UH Department/College/School: Natural Sciences and Mathematics

Aspects of Plastics Circularity: Chemical Recycling

Abstract:

Lignin is the most underutilized fraction of biomass. Although it is produced in large quantities as a byproduct of paper production and other biomass industries, lignin has few applications beyond low-grade fillers and incineration as a fuel. Nevertheless, the selective depolymerization of lignin could provide valuable commodity chemicals. Vanadium catalysts show promise in this reaction, but show low productivity and are therefore not economical. This project uses electronically coupled divanadium catalysts to promote improved activity and selectivity by vanadium in this reaction. We show that analogous comparison of monovanadium and divanadium catalysts validate our hypothesis that cooperation between vanadium centers improves activity. The poster describes our preliminary studies on lignin model compounds as well as extracted lignin. It will also cover extensive mechanistic analysis using the oxidative cleavage of diols as a probe of redox cooperation.

#15
Title: Location-Based Multi-Period Pricing for Plastic Recycling
Author(s): Xiaohang Zhu, Haowei Yang
Faculty Advisor Name: Meng Li
UH Department/College/School: Decision and Information Science, C. T. Bauer College of Business

Aspects of Plastics Circularity: Advanced Recycling
Abstract:
This study introduces a dynamic, multi-period, location-based pricing model for incentivizing plastic recycling, focusing on customer behavior and efficient logistics management. Recognizing the dual benefit of economic gain and environmental sustainability, our research addresses key challenges in traditional recycling methods, which typically involve static pricing structures that fail to adapt to changing environmental and operational conditions. By introducing dynamic, location-specific pricing, we explore whether companies can significantly influence customer recycling decisions and improve overall efficiency. The study specifically utilizes gas station network within Houston as strategically positioned collection points. These gas stations serve dual roles: collection points for recyclables and temporary storage locations. Given the limited storage capacity at each station, our model incorporates inventory management and customer incentivization through price adjustments, aimed at optimizing collection volumes and distribution across multiple locations. A mixed-integer nonlinear programming (MILNP) model was developed and subsequently linearized to facilitate computational tractability. Our case study, which considers multiple customer zones and collection centers over a monthly planning horizon, demonstrates that location-based pricing can significantly enhance revenue and efficiency compared to uniform pricing. Results indicate that strategic location-based pricing effectively directs consumer choices, maximizes revenue, reduces unsatisfied demand, and ensures compliance with regulatory constraints.

#16
Title: The state-of-the-art RDF conversion using dual-chamber pyrolysis/gasification
Author(s): Seyedborhan Mousavi, Joseph Powell
Faculty Advisor Name: Joseph Powell
UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Chemical Recycling
Abstract:
The growing challenge of municipal solid waste (MSW) management and the increasing demand for sustainable energy solutions necessitate efficient conversion technologies. Refuse-derived fuel (RDF), derived from processed MSW—including plastics and bio-waste—presents a promising feedstock for thermochemical conversion into valuable fuels and chemicals. Gasification and pyrolysis have emerged as viable pathways to extract energy-rich syngas, biofuels, and platform chemicals while mitigating environmental pollution and landfill dependency. This presentation explores the state-of-the-art in RDF conversion, with a particular focus on advancements in dual-chamber pyrolysis-gasification systems. A critical assessment of recent studies highlights key operational parameters influencing efficiency, emissions, and product composition. Additionally, economic and environmental perspectives are examined to assess the feasibility of RDF valorization as a sustainable alternative to fossil-based energy. By consolidating recent developments, this presentation provides insights into optimizing RDF utilization for energy and chemical production, supporting the transition toward circular waste management and renewable resources.

#17
Title: Novel Method for Ethylene Production by Gas Phase Oxidative Dehydrogenation of Ethane
Author(s): Syed Ahsan Imam, Vemuri Balakotaiah, Praveen Bollini
Faculty Advisor Name: Vemuri Balakotaiah, Praveen Bollini
UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Chemical Reaction Engineering
Poster Abstract:
Ethylene is an indispensable chemical commodity to produce a variety of important products including polyethylene, ethylene oxide, vinyl chloride and various others. Surge in ethylene production has been reported by 6.2% from 2021 to 2023 and the global economic market is projected to approximately 7% compound annual growth rate. Steam cracking is being employed in the industry for the production of ethylene with naphtha (derived from crude oil source) or ethane (derived from natural gas source) as the feedstock and being of endothermic nature, it requires elevated temperature input typically 750-900 deg C (tube temperature can rise to 1100 deg C) requiring 16 GJ/ton (ethane feed) and 23 GJ/ton (naphtha feed) energy requirement and accounting for 260 Mt/yr of CO2 emissions. This high temperature requirement can adversely affect the life of reactor tubes and requires shutdown for coke removal. Ethane partial oxidation or oxidative dehydrogenation of ethane (ODHE) has surfaced as a potential alternative considering lower reaction temperature requirement (because of exothermic nature), high conversion, and decrease in coke formation compared to ethane cracking; however, it has not been commercially implemented yet. Several catalysts have been reported and summarized in the literature; however, little work has been presented in the past incorporating (non-catalytic) homogenous chemistry which can be an emergent competing alternative to the aforementioned. Considering promising performance of homogeneous chemistry, it makes things holistically viable by reducing the overall complexity of modelling followed by scale-up of the process in comparison to heterogenous chemistry or when both are combined under specific conditions. The influence of homogeneous chemistry plays a pivotal role even with a catalytic system when high temperature operation is anticipated and may stand out under certain process conditions; therefore, it is utmost necessary to corroborate such behavior independently. The intent of present work focuses on presenting 7 reaction/8 species based global kinetic model for homogeneous (non-catalytic) ODHE which aims towards ease in deciphering reaction pathway, reactor bifurcation, and potential scale-up analysis. The process also proceeds with nearly CO2 free manufacturing. With the traditional industrial cracking, almost 70% of ethylene cost is attributed to the energy requirement, utilizing the exothermic energy to operate reactor auto-thermally (without any heat input) under Lumped Thermal Reactor configuration leveraging thermal back-mixing and considering industrial perspective in mind, space times milli-second order is desired to comply with reactor volume constraint and ethylene yield between 45~48% with ~58% conversion and ~83% ethylene selectivity is predicted.

#18

Title: Optimization of Catalytic Reactor Design for Carbon Efficient Olefins Production from Natural Gas

Author(s): Dhagash M. Pandit, Praveen Bollini, Vemuri Balakotaiah

Faculty Advisor Name: Praveen Bollini, Vemuri Balakotaiah

UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Chemical Reaction Engineering

Abstract:

Ethylene is an essential building block of the petrochemical industry and is used to produce a variety of chemical intermediates and polymers. Conventional ethylene production relies on ethane steam cracking which is energy intensive due to its endothermicity. Oxidative dehydrogenation of ethane (ODHE) and Oxidative coupling of methane (OCM) are attractive routes to produce ethylene from ethane and methane respectively which are the main constituents of natural gas. Since shale gas revolution, researchers have extensively studied these partial oxidation processes; significant body of work is present in the literature to develop a stable and active catalyst that maximizes the ethylene selectivity. However, both the processes are limited to commercialization due to heat management (exothermicity) concerns, maintaining optimum temperature such that catalyst deactivation and reactor runaway is avoided. Autothermal operation (no external heat input) is a potential solution which utilizes heat generated by the reaction to drive the reaction forward along with higher productivity and lower energy consumption. In this work, we demonstrate the feasibility to carry out these partial oxidation reactions in an autothermal monolith reactor through comprehensive bifurcation analysis. We use a multi-scale reduced order model that accounts for pore diffusion to analyze the ignition-extinction behavior during (ODHE) in a monolith reactor coated with a MoVTeNbOx (M1) catalyst. We determine the optimal catalyst layer thickness and monolith substrate properties so as to maximize the region of autothermal operation (or per pass conversion of ethane) as well as selectivity to ethylene. Our modeling results indicate that metallic monoliths with intermediate length, high substrate conductivity and high cell density (or small hydraulic radius) are optimal to approach the so called “homogeneous lumped thermal reactor (LTR) limit” which leads to the best reactor performance (92% ethylene selectivity at 25% ethane conversion). It is also shown that operation of the reactor in the external mass or heat transfer controlled regime with strong interphase gradients can lower ethylene selectivity. We also report the feasibility of carrying out ODHE at high pressure (5 bar) with fixed linear velocity and examine the impact of feed dilution on reactor performance and compare the same with that obtained in the steam cracking of ethane. We compare OCM (La2O3/CaO-catalyst) and ODHE (M1-catalyst) from a kinetics perspective, highlighting the impact of back-mixing and operating temperature on ethylene yield. Our modelling results provide critical insights for designing a CO2-free reactor to produce ethylene, the world's largest-volume chemical.

#19

Title: Design and Synthesis of Arylated Iminopyridyl Nickel(II) Complexes for Olefin Polymerization: Investigating the Impact of Organoboron/Nickel Ion-Pair Activation on Polymer Architecture.

Author(s): Muhammad Arslan, Hasaan Rauf, Yu-Sheng Liu, Eva Harth

Faculty Advisor Name: Eva Harth

UH Department/College/School: Department of Chemistry, College of NSM

Aspects of Plastics Circularity: Polymer Science

Abstract:

While research on Ni-catalyzed olefin polymerization has primarily focused on ligand design, the role of ion-pair interactions in defining the polymer micro- and macrostructures remains largely unexplored. This phenomenon is well-explored in early transition metal systems, yet the counterion effect in late-transition [N, N]-chelated Ni(II) complexes has remained elusive due to the lack of thermodynamically stable complexes. We have developed air- and moisture-stable carbyl iminopyridyl Ni(II) precatalysts to investigate the influence of inner- and outer-sphere Ni ion-pair interactions. This poster presentation will demonstrate how inner-sphere organoboron counterions enable access to higher molecular weight homo- and co-polymers while also having a role in regulating polyethylene branch density and distribution. The activation mechanism via organoboron cocatalysts is investigated in contrast to conventional organoaluminum cocatalysts. Additionally, introducing a phenyl substituent on the bridging carbon (tether carbon) of the ligand acts as a rotational barrier, which influences the formation of higher molecular weight polymers compared to methyl-substituted analogs. Through this new activation method controlled short-chain branching incorporation is achieved even under high ethylene pressure, circumventing the need for elaborate ligand modifications, low monomer pressures, or α-olefin copolymerization. DFT calculations provide further insights into ion-pair interactions and the controlled chain-walking mechanism. This study demonstrates how ion-pair interactions and ligand architecture can be leveraged to precisely modulate polyolefin molecular weights and microstructures within the iminopyridyl Ni(II) system.

#20

Title: Advancing Polar Polyolefin Block Copolymer Synthesis: A Continuous Flow Approach Utilizing Coordination-Insertion and Free Radical Polymerizations

Author(s): Stephen Don Sarkar, Huong Dau, Eva Harth

Faculty Advisor Name: Eva Harth

UH Department/College/School: Department of Chemistry, College of NSM

Aspects of Plastics Circularity: Polymer Science

Abstract:

Polar polyolefin block copolymers, comprising polyethylene and polyacrylate segments, have earned significant attention due to their enhanced physical and chemical properties. Recent advancements in continuous flow synthesis have enabled precise control over polymerization reactions, leading to excellent reproducibility. In this study, we developed a continuous flow system that integrates two distinct polymerization processes to synthesize polyethylene-polyacrylate diblock copolymers. At first, the polyethylene segment was synthesized using a gas-liquid droplet flow, where gaseous ethylene monomer underwent living coordination-insertion polymerization in the presence of a Pd(II) diimine complex. Here, the gaseous phase facilitated the formation of a heterogeneous droplet flow and served as the monomer source for the polymerization reaction. A systematic kinetic investigation examined the influence of residence time on the molecular weight (Mn) to assess the living nature of the polymerization process. Subsequent addition of acrylate into the flow system triggered a switch in the polymerization mechanism by forming a Pd-acrylate macrochelate, which retarded the ethylene polymerization. Blue light irradiation generated a radical macroinitiator from this macrochelate through the Pd-carbon bond homolysis. The resulting macroinitiator underwent free radical polymerization in a second tubular reactor containing excess acrylate monomers, forming the polyacrylate segment as the second block. The generation of the radical macroinitiator for the radical pathway was validated by performing a radical trapping experiment. This methodology enabled the synthesis of polyethylene-polyacrylate block copolymers with a broad range of molecular weight compositions. Additionally, various polar polyethylene block copolymers were prepared by involving different acrylate monomers. This study successfully demonstrated the synthesis of polar polyethylene block copolymers in a flow reactor, integrating monomers with differing physicochemical properties through two distinct polymerization methods utilizing a metal complex.

#21

Title: Recycling of Nitrile Butadiene Rubber Waste from Oil & Industry

Authors(s): Amarsinh Pramod Ghatge, R. S. Tarade, K. Surve, N. Thumuluri, A. A. Cherian, M. R. Kaitha, R. Krishnamoorti, A. K. Bhowmick, J. Yun, A. Zolfaghari, M. Marya, H. Tu

Faculty Advisor Name: Anil Bhowmick

UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Polymer Science

Abstract:

Nitrile Butadiene Rubber (NBR) is widely used in the oil and gas industry due to its excellent resistance to oils, fuels, and chemicals. However, the disposal of NBR waste presents significant environmental and economic challenges. This study investigates the devulcanization and recycling of NBR waste through a combination of mechanical and chemical methods, optimizing its reuse in industrial applications.

In this investigation, waste nitrile rubber was recycled by 1) treating the rubber at high pressure and high temperature in carbon dioxide with and without devulcanizing agents and 2) treating the rubber having devulcanizing agent in a Twin-Screw extruder under high pressure and high temperature in the presence and absence of nitrogen environment. The results indicated that waste rubber could be devulcanized using both these techniques. The tensile strength of the waste rubber decreased from 12.90 MPa to 4.02 MPa, the elongation at break was reduced to 12% and the sol fraction increased by 40% when the rubber was treated at 175 oC, 1450 psi and 6 hrs in a Parr reactor. Horikx's plot of sol fraction vs cross linking density also proved efficiency of this technique for devulcanization. The waste rubber could be turned into fine powder using the shear extrusion technique. The results indicated that extrusion of the rubber in presence of nitrogen enhanced swelling in toluene and hence decrosslinking, thus improving the recyclability of NBR. The number of extrusions passes significantly influenced the material's swelling properties, with increased passes in nitrogen, yielding better devulcanization. Optical microscopy highlighted variations in particle size and geometry, suggesting differential breakdown during processing. These particles were incorporated in virgin nitrile rubber compounds and were found to be effective for partial replacement. This study demonstrates a viable approach to recycling NBR waste, offering insights into optimizing devulcanization processes for industrial applications. Future work will focus on refining process parameters to enhance recyclability and scalability. By addressing the challenges of NBR disposal, this research contributes to the advancement of sustainable materials management in the oil and gas industry.

#22

Title: Forced Dynamic Operation of Propylene Oxidation to Acrolein on Multicomponent Metal Oxides for Process Flexibility

Author(s): Mohammad Moniruzzaman, Kai Wu

Faculty Advisor Name: Lars C. Grabow, Michael P. Harold

UH Department/College/School: William A. Brookshire Department of Chemical and Biomolecular Engineering

Aspects of Plastics Circularity: Process Improvement

Abstract:

Selective oxidation of propylene to acrolein using multicomponent metal oxide catalysts is the first step for the commercial synthesis of acrylic acid, a key component in acrylate-based polymers. Conventionally, the process is carried out under steady-state conditions in fixed-bed or fluidized-bed reactors. Lattice oxygen of the catalyst is thought to be incorporated in acrolein/acrylic acid via Mars-Van Krevelen mechanism, which is a surface redox cycle involving oxidation of the catalyst by gas phase oxygen and reduction of the lattice oxygen by reducing agent/s. In contrast, electrophilic surface oxygen species have been proposed to participate in the formation of some of the byproducts, including COx, acetaldehyde, acetic acid, and formaldehyde. Therefore, decoupling the oxidation and reduction stages of the catalyst has the potential to improve the selectivity of acrolein/acrylic acid. In addition to the kinetics of product formation, oxygen storage and mobility in the bulk of the catalyst play a significant role in the dynamic operations enhancement. In this study, we investigated both steady state and forced dynamic operation (FDO) of a laboratory fixed-bed reactor with a structured catalyst to identify conditions of acrolein selectivity/yield enhancement in FDO over steady state operation. Kinetic results revealed that oxidation of the catalyst is rate limiting at temperatures below 380 °C. Interestingly, below this temperature level, feed composition modulation has also been found to markedly improve propylene conversion and acrolein selectivity compared to steady-state counterparts. We have demonstrated that the improved catalytic activity is due to the periodic feed composition sustaining a higher oxidation state of the catalyst.

#23

Title: Investigations of Nickel Catalysts for Improved Synthesis of Non-Alternating Polyketones

Author(s): Dibyajyoti Panja, Yashmeen
Faculty Advisor Name: Brad P. Carrow
UH Department/College/School: Department of Chemistry

Aspects of Plastics Circularity: Polymer Science

Abstract:
Chemical recycling is a collection of emerging innovative technologies to transform plastic waste into base chemicals, monomers and feedstocks. Depolymerization of polyolefins to monomers, however, is energetically costly as a consequence of the thermodynamically strong carbon-carbon bonds in these materials. Development of alternative approaches to the chemical recycling of waste polyolefins is therefore desirable. Non-alternating copolymerization of ethylene and carbon monoxide (E/CO) has emerged as an interesting area of polymer synthesis in this regard because the resulting long-spaced polyketones have microstructures similar to polyethylene but periodic ketones in the polymer backbone can be targeted for mild (photo)chemical scission of the polymer backbone and/or further derivatization into new materials in the context of chemical recycling. Nickel-based complexes have recently emerged as leading catalysts for the synthesis of high molecular weight E/CO-copolymers. However, systematic knowledge about how catalyst structure biases the copolymerization toward non-alternating microstructures is currently limited, and catalyst deactivation side reactions limit reaction productivity below practical thresholds. We have experimentally and computationally examined how the catalyst structure affects both the selectivity for desired non-alternating versus alternating copolymerization as well as the relative rates of propagation versus catalyst deactivation. These data will help guide the rational evolution of new catalytic polymerizations with increased selectivity and productivity to advance long-spaced polyketone materials as viable substitutes for commodity polyolefins with improved capacity for chemical recycling.

#24

Title: Toward Functional Ultra-High Molecular Weight Polyethylenes (f-UHMWPE) by Design of Nickel Based Olefin Polymerization Catalysts

Author(s): Dibyajyoti Panja, Anthony R. Scavuzzo

Faculty Advisor Name: Brad P. Carrow

UH Department/College/School: Department of Chemistry

Aspects of Plastics Circularity: Polymer Science

Abstract:

Molecular weight is one of the key parameters governing polyolefin properties. For example, increased molecular weights in block copolymers has been correlated to improved compatibilization in polymer blending. Ultra-high molecular weight materials, such as ultra-high molecular weight polyethylene (UHMWPE), can also engender characteristics unique from lesser molecular weight congeners, such as high impact resistance, high abrasive resistance, and self-lubrication. We describe here efforts to synthesize UHMWPE in a manner potentially amenable to preparation of functional derivatives that could be useful in applications such as graft copolymer synthesis or reactive compatibilization to facilitate blended plastics recycling. In that regard, late transition metal catalysts such as those based on nickel, have shown the most promise for copolymerizations of ethylene with comonomers possessing reactive functional groups. Access to functionalized UHMWPE (f-UHMWPE) materials would be desirable to probe the effects of extreme molecular weight on compatibilization efficiency. Building on the recent discovery by Brookhart and Daugulis at the University of Houston that simple nickel(II) halide salts coordinated by a trialkylphosphine can generate highly active catalysts in the presence of an alkylaluminum activator for the synthesis of UHMWPE, we have systematically examined the effect of the phosphine ligand structure on the resulting catalyst activity, polymer branching and molecular weight using experimental and computational approaches. Significant improvements have been observed in each of these parameters as compared to the initially reported catalysts. Efforts to develop a single component catalyst that does not require alkylaluminum additives will also be discussed, which are an important step toward copolymerizations of ethylene with polar comonomers to access f-UHMWPE variants.

#25

Title: Life-cycle Analysis of Recycled Plastics and Biochemicals with the GREET Model

Author(s): Michael Wang, Pahola Thathiana Benavides, Ulises R Gracida-Alvarez

Organization: Systems Assessment Center, Energy Systems and Infrastructure Analysis Division, Argonne National Laboratory

UH Department/College/School: Energy Transition Institute (Michael Wang, Distinguished Senior Scholar)

Aspects of Plastics Circularity: Advanced recycling, Life cycle assessment/Techno economic assessment

Abstract:

Petroleum and natural gas are used not only to produce fuels but also to produce chemicals and plastics. These fossil energy sources can be augmented by biobased and waste feedstocks which foster domestic energy and chemical industries and enhance the environmental sustainability of chemical products. This study explores two case studies using the R&D Greenhouse Gases Regulated Emissions and Energy Use in Technologies (GREET) Model to assess the greenhouse gas (GHG) emissions of chemical products. The first case evaluates the GHG emissions of adipic acid (AA) produced from sugars derived through three different pretreatment techniques using corn stover as feedstock. The findings reveal that biobased AA can reduce GHG emissions by up to 80% compared to fossil-based AA. The second case evaluates the GHG emissions of diesel and high-density polyethylene (HDPE) produced from post-use plastic (PUP) via pyrolysis. Results show that PUP-based diesel can achieve up to a 28% reduction in GHG emissions compared to conventional diesel. Similarly, PUP-based HDPE presents up to a 23% reduction in GHG emissions compared to conventional HDPE.

Art Show

Art Show Coordinator: Beatrix Madersbacher Eide
Sustainability Coordinator
Office of Sustainability, Facilities Planning and Construction
University of Houston

#01
Name: Raizelle Le
UH Department/College/School: NSM - Chemistry
Title of Artwork: Just a Plastic Bag
Materials used: Plastic grocery bags, crochet hook
Idea of Artwork:
A grocery bag or backpack (to be determined) will be crocheted out of yarn made from plastic grocery bags. Supporting pieces may also be made from the same plastic bag yarn material. A design will be incorporated, depending on the colors and types of plastic bags that can be acquired, and it should be practical to use and easy to hold and carry. A piece that could be used in everyday life is intended to be created.
Description of Artwork:
The artwork will be a crocheted bag, clearly made out of grocery bags. The construction of the piece will be sturdy using tighter stitching (half double crochets if possible). The size of it will be approximately 2 feet by 1 foot, which is the size of a large tote bag. Different colors and types of plastic bags can be used to achieve a colorful look or design, to emphasize that products made from recycled items do not have to be ugly and boring. The bag will have a wider handle for easier grip, and the bottom will use thicker plastic to make it sturdier. It will be a functional piece that is easy to store, carry, and hold items in without them falling out. The piece will include customizable aspects such as plastic crocheted charms and the designs using different colors and types of bags. The overall look of the artwork should be well put together and show that plastic can create good quality items.
Context of Artwork:
The point of the piece is to give new life to "trash." The main visual in the piece is a reusable crocheted bag, made from single-use plastic grocery bags. Plastic bags can often be seen floating in the street, and they are barely used once before becoming too damaged and needing to be thrown away. By creating a stronger, sturdier, reusable bag from these single-use plastic bags, it is intended to demonstrate that what was once "plastic trash" can become sustainable and useful in everyday life. Not only can the plastic be repurposed in this way, but the process is not particularly difficult. Lowering waste and promoting sustainability do not have to be challenging. Simply by using what already exists, items can be created that are not only personalized but also encourage the reduction of overconsumption and plastic bag pollution.

#02
Name: Angela Sanchez
UH Department/College/School: Cullen College of Engineering
Title of Artwork: Wings of Circularity
Materials intended to use: Plastic bottles, hot glue, plastic wrap, paint, plastic bags, metal wire (structure)
Idea of Artwork:
When talking about circularity, its about giving new life to something that looks like it would otherwise be waste. I got the idea from a Harry Potter movie, where Hawkes is reborn from his ashes. So I wanted to touch on the new life from recycled plastic while also touching on overconsumption of plastics.
Description of Artwork:
A phoenix rising from plastic waste, symbolizing the rebirth of plastics through recycling and innovation.
Context of Artwork:
Like the legendary phoenix that rises from its own ashes, plastics have the potential for rebirth. Too often, we see plastic as disposable, a material meant to be used once and discarded. But what if, instead, we saw it as part of a continuous cycle—one that transforms waste into opportunity? "Wings of Circularity" represents this transformation, symbolizing the power of innovation, responsibility, and circularity in the way we approach plastics. The base of the sculpture, composed of discarded plastic waste, serves as a stark reminder of our current challenges. Yet, as the phoenix emerges, its form is reimagined wings crafted from repurposed materials, soaring toward a future where plastics are not pollutants, but valuable resources given a second life. This sculpture is a call to action. It challenges industries, engineers, and individuals to rethink how we use and manage plastics, pushing for sustainable solutions that bridge the energy industry with circularity. Through technology, recycling, and conscious effort, we can break free from the linear “take-make-waste” model and embrace a future where plastics are reborn, just like the phoenix. The future of plastics is not in landfills—it is in innovation, renewal, and responsibility.

#03
Name: Christina Leen
UH Department/College/School: Cullen College of Engineering
Title of Artwork: Breathless: Drowning in a World of Plastic
Materials intended to use: Acrylic Paint, paint brushes, canvas
Idea of Artwork:
As an acrylic painter, talent will be used to showcase a woman drowning in an ocean surrounded by trash. A detailed description can be seen.
Description of Artwork:
"Breathless: Drowning in a World of Plastic" is an acrylic painting that tells a harsh truth. A woman fights to stay above water, her face barely breaking the surface as plastic waste pulls her under. Bottles, bags, and debris wrap around her limbs, trapping her in a sea that should bring life but now suffocates.
The deep blues of the ocean mix with unnatural colors of pollution, making the water feel heavy and unwelcoming. Thick brushstrokes create movement, showing the struggle, the desperation. Light flickers across the surface, hinting at hope, but the weight of waste is relentless.
Context of Artwork:
This piece is more than just paint on canvas, it’s a statement. A reminder that we are drowning in plastic, and if we don’t act, we won’t just watch the ocean disappear beneath waste... we’ll be swallowed by it too.

#04
Name: Tiffany Colston
UH Department/College/School: Civil Engineering Cullen College of Engineering
Title of Artwork: You are what you eat
Materials intended to use: Aluminium cans, plastic water bottles, plastic bags, wrappers, plastic utensils, wire, hot glue, and many other plastic materials found
Idea of Artwork:
The aim of the project is to create a 3D representation of the human digestive system using only recycled plastics and discarded materials. From the front, the sculpture will be seen as a realistic anatomical model, but as perspectives shift, it will be revealed that the interior is entirely composed of various plastic waste. This contrast is designed to highlight the infiltration of microplastics into the human body, emphasizing the hidden dangers of plastic pollution and its impact on human health.
Description of Artwork:
Ingested is a 3D mixed-media sculpture replicating the human digestive system, constructed entirely from recycled plastics collected across my university's campus. Reinforced for structural stability, the sculpture stands at 3x3 feet, featuring a colour palette of whites, beige, deep reds, and other organic tones reflective of the human digestive tract.
At first glance, the sculpture appears as a traditional anatomical model, but as viewers move around it, they uncover its true composition—an intricate, chaotic mass of discarded plastics. These plastics, once used and forgotten, now form the system responsible for processing our consumption. This shift in perspective reflects a deeper reality: the infiltration of plastic waste into our environment, food systems, and ultimately, our bodies. By utilizing materials found in everyday life—fragments of packaging, bottle caps, wrappers, and plastic bags—the sculpture highlights the pervasiveness of plastic pollution. It underscores how synthetic waste, once thought to be disposable, never truly disappears but instead cycles back into human consumption. Ingested serves as both a visual metaphor and a call to action, urging viewers to confront the unseen health risks posed by microplastics and reconsider society's reliance on plastic before its impact becomes irreversible.
Context of Artwork:
Ingested highlights the growing crisis of plastic pollution and its hidden impact on human health. While plastic waste is often linked to environmental harm, its infiltration into our food systems and bodies remains largely unnoticed. This sculpture challenges viewers to confront the uncomfortable reality that microplastics, from the plastics we discard daily, are now present in our agriculture, water, and digestive systems.
Plastics have entered the human digestive system through contaminated food, water, packaging, and even the air we breathe. Microplastics, tiny plastic particles resulting from plastic waste breakdown, are found in seafood, crops, and drinking water, as well as in packaged and processed foods due to plastic storage and heating. Agriculture, industrial food processing, and airborne particles further contribute to plastic ingestion. The artwork aims to spark reflection, discussion, and action, encouraging individuals to rethink their reliance on plastic, advocate for sustainable alternatives, and push for systemic waste management reforms. As microplastics pose unknown long-term health risks, Ingested serves as both a warning and a call to collective responsibility, urging communities to address this issue.

#05
Name: Patricia Dunn
UH Department/College/School: Cullen College of Engineering - Electrical & Computer Engineering
Title of Artwork: Lost in Plasticity
Materials intended to use: Aluminium cans, plastic water bottles, plastic bags, wrappers, plastic utensils, wire, hot glue, and many other plastic materials found
Idea of Artwork:
A 3D sculpture
Description of Artwork:
A 3D sculpture of a vase and flowers made of Recycled plastic materials, some of which will be collected here on campus or throughout the city. Various flowers inserted into the pot also made from recycled plastic.
Context of Artwork:
There is beauty in what some may consider trash, and that plastic can be recycled into many different things.

#06
Name: Melinda Colmenero
UH Department/College/School: UH Libraries
Title of Artwork: Edible
Materials intended to use: Plastic single use shopping and produce bags
Idea of Artwork:
The idea is to take single-use plastic bags, which are stripped and rolled into yarn. The yarn is then crocheted into a 3D jellyfish and sea turtle.
Description of Artwork:
A jelly fish and sea turtle crocheted out of single use plastic bags. They are stuffed with plastic bags.
Context of Artwork:
Sea turtles and other sea life will mistakenly eat single use plastic bags believing that they are jelly fish. The way the turtle and jellyfish are made shows the dangerous continued use of these plastic bags and the harm it has on sea life. The turtle is made out of plastic shopping bags while the jelly fish is made out of produce bags.

#08
Name: Morgan Turner
UH Department/College/School: C.T. Bauer College of Business
Title of Artwork: Progression
Materials intended to use: Newspaper, magazine clippings, printed photographs, square poster board, glue/adhesives
Idea of Artwork:
This piece uses magazine clippings and photography to create a layered collage that explores the role of plastics in Houston. By combining found images with original photography, the artwork presents both the practical uses of plastics in industries like healthcare and consumer goods, alongside scenes of waste and recycling challenges. The mix of materials reflects the complexity of the issue, while the inclusion of community portraits highlights the people connected to it. This approach creates a visually dynamic composition that encourages reflection on plastic use, waste management, and potential opportunities for improvement.
Description of Artwork:
This collage explores the role of plastics in Houston, depicting both its advantages and challenges. The piece combines images that illustrate the essential role of plastics in industries such as healthcare, public services, and consumer goods, alongside scenes of littered streets and waste management concerns. By presenting these contrasting perspectives, the artwork highlights the complexity of plastic use in modern society.
In addition to focusing on the material itself, this work recognizes the people affected by the plastics industry. The faces of individuals who rely on plastic for daily life, as well as those impacted by waste and recycling limitations, are included to reflect the broader social and environmental aspects of plastic use.
Rather than taking a definitive stance, this artwork encourages viewers to consider the current state of plastic use and disposal in Houston. It invites conversation about potential improvements in recycling, materials, and waste management systems to support a more efficient and sustainable future.
Context of Artwork:
This piece explores the dual nature of plastic—its undeniable role in modern life and its harmful impact on communities. In Houston, plastic is essential in industries such as healthcare, public services, and consumer goods. Yet, the city struggles with inadequate waste management and unequal access to recycling, disproportionately affecting certain neighborhoods. This work is inspired by these disparities, highlighting how plastic waste accumulates in communities that often lack the resources to manage it effectively. Rather than advocating for the complete elimination of plastics, this piece calls for systemic change. We must rethink our relationship with plastic by investing in new materials, technologies, and policies that promote sustainability. Houston's future depends on innovative solutions that balance necessity with responsibility. This artwork serves as both a reflection of our current reality and a vision for a more sustainable, equitable waste management system. Through this, we hope to spark conversation and inspire action toward a cleaner, more just future.

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