



CEBC



2022
Annual
Report

KU

CENTER FOR
ENVIRONMENTALLY
BENEFICIAL CATALYSIS

The University of Kansas



Aligned with U.N. Sustainable Development Goals

The CEBC completed a year of renewed excitement. Research, education and outreach activities are surging again, bolstered by successes in research grants and the addition of new faculty, staff, industry partners and students. To the delight of everyone, we resumed hosting the Industry and Science Advisory Board meetings in person.

Entering its 20th year, the CEBC mission continues to be strong and vibrant. Its relevance to solving the sustainability grand challenges of our times can be benchmarked in many ways. For example, the CEBC is addressing many of the 2015 United Nations Sustainable Development Goals as highlighted in this report. Two recent National Academies' studies, one on the Chemical Economy and the other on Chemical Engineering, also reinforce the importance of the CEBC's mission. Both reports articulate the urgent need for sustainability-focused research and education in the chemical sciences to accelerate industrial decarbonization. This report features ongoing CEBC programs that address these needs and challenges. These include machine learning-based catalyst discovery for emerging feedstocks and the development of renewable and recyclable plastics.

The impending energy and feedstock transitions toward "net-zero refineries" will cause major industrial shifts. For example, increases in renewable energy generation and storage requirements will demand more of metals such as Co, Ni, Li, Cd and Te. At the same time, the steady growth in electric vehicles will lower petroleum refining output, reducing the demand for catalytic metals such as Pt, Pd, Rh and Ce used in fuels production and passenger vehicles. Another shift, and a potential opportunity, stems from the need for repurposing existing refining infrastructure that may no longer be needed for making fuels. Further, the emergence of hydrogen hubs that produce carbon-free hydrogen and oxygen will spur the distributed manufacturing of green fuels and chemicals.

Going forward, CEBC's decarbonization research efforts will consider such shifts in its sustainability assessments and explore the full range of available feedstocks and metals. Technology development will also consider the possible adaptation of displaced petroleum refining assets where appropriate. Our approach will continue to harness advances in measurements and computations, while also building strengths in biocatalysis for discovery and innovation. We will also educate and train a diverse workforce in new ways to implement the circular economy paradigm. These efforts are strengthened by the addition of new industry partners, faculty and staff featured in this report.

The sustained commitments of our team, industry partners, advisory boards and KU leadership have been instrumental in keeping the CEBC mission at the cutting edge for nearly two decades. This has resulted in strong records of research productivity, workforce training and industry involvement. Thanks to such support, the CEBC is well positioned to be a major player in achieving the goal of industrial decarbonization and sustainability for the benefit of society.

Sincerely,

Dr. Bala Subramaniam
CEBC Director

16 PEACE, JUSTICE
AND STRONG
INSTITUTIONS



Peace, Justice and Strong Institutions

The CEBC introduces the concept of justice into all conversations about DEIB. We aim to be a strong institution built around consciously reducing biases and creating inclusive spaces.

17 PARTNERSHIPS
FOR THE GOALS



Partnerships for the Goals

The CEBC works with industry, other academic institutions, and national laboratories towards a common goal of environmentally beneficial catalysis.

Alignment with U.N. Sustainable Development Goals

In 2015, the United Nations (UN) General Assembly negotiated the adoption of the 2030 Agenda for Sustainable Development with 17 Sustainable Development Goals (SDGs). These goals aim to create a healthier, more equitable society, and improve the global environment by the year 2030. Since these goals were adopted, the United Nations have committed resources and support to missions in water, energy, climate, oceans, urbanization, transport, science, and technology. To achieve these ambitious goals by 2030, broad commitments must be made by stakeholders. The UN SDGs require a sense of urgency and global awareness of primary and secondary environmental and interpersonal impacts. The CEBC has made a commitment to uphold the 17 SDGs in our research, educational programming, and collaborative endeavors.

The CEBC aims to substantially contribute to the progress of the UN Sustainable Development Goals.

We have carefully aligned with each of the 17 SDGs and have outlined them throughout this report.

We will continue to consider multiple scales of impact towards sustainable development as the CEBC grows and changes.



No Poverty

Efforts at the CEBC aim to develop affordable technologies from a variety of feedstocks. This would allow nations to build sustainable manufacturing facilities and provide local employment.



Zero Hunger

CEBC research aims to utilize agricultural waste products as chemical precursors, thereby reducing the use of edible foodstuffs for materials production. CEBC research is also developing green hydrogen technology to make sustainable fertilizers that grow crops to feed the world.



Good Health and Well-Being

Safety, mental health, and well-being are integrated into all research and educational trainings at the CEBC.

Cover photos:

Counterclockwise from top:

Graduate student Hashim Alzahrani

Graduate student Kaihua Zhang

Graduate student Anoop Uchagawakar

Graduate student Zeke Piskulich

Background:

Students discuss their research with

Board members at the Spring 2022

Advisory Boards poster session

Contributors: Ana Chicas-Mosier, Nancy Crisp, Chris Lyon

Designer: Nancy Crisp

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2022 by the numbers

- 35 peer-reviewed publications
- 25 proposal submissions:
13 funded, 8 pending
- 6 active grants of at least \$500,000
- 6 industry partners with >\$721,000
in support for research endeavors



<https://farberlab.ku.edu>

Welcome Rachael Farber New Chemistry Faculty with CEBC

Research Interests: *Research in the Farber group leverages a combination of in situ UHV surface science techniques to determine the atomistic reaction mechanisms driving selective chemical transformations on model nanoparticle and enantioselective catalyst surfaces. The group uses ultra-high vacuum (UHV) surface science techniques to develop a fundamental understanding of the relationship between surface structure, chemical activity, and catalyst stability of oxide-supported metal nanoparticles, and chiral-modified transition metal surfaces.*

Notable: *Anna Louise Hoffman Award for Outstanding Achievement in Graduate Research, Iota Sigma Pi, 2018; Dumbach Award for Excellence in Chemistry, Loyola University Chicago, 2018; Morton M. Traum Surface Science Student Award and Nellie Yeoh Whetten Award, AVS 64th International Symposium and Exhibition, 2017*

Education:

- Postdoctoral Researcher, University of Chicago, Chicago, IL
- Ph.D. Loyola University, Chicago, IL
- B.Sc. Chemistry, Case Western University, Cleveland, OH



New grants funded

NSF CAREER, \$441,172, 2023-2028

Thermal proteome profiling applications for in-situ bioreporting of contaminant degradation in soils

PI: Justin Hutchison, Assistant Professor, KU Department of Civil, Environmental & Architectural Engineering

<https://biocatalytics.ku.edu>

The Hutchison group uses enzymes to catalyze the degradation of anthro-pogenic contaminants for drinking water treatment. As part of the newly awarded NSF CAREER award, the team will use drug discovery techniques applied to environmental systems, such as soil, to identify novel enzymes that can be used to protect drinking water sources. Historically, these techniques have not been applied to environmental systems because of the matrix complexity. To overcome these challenges, the team will apply a newly developed approach to extract enzymes for soil systems paired with modeling and “omics” methods. The grant also supports educational training for junior-level undergraduates and recruitment and retention efforts for Environmental Engineering at KU.

Army Research Office, \$449,374, 2022-2025

U.S. Army Research Office Experimental and Simulation Investigations into Novel Mechanisms for Oxygen Reduction

PI: Kevin Leonard, Associate Professor, KU Department of Chemical and Petroleum Engineering

<https://leonardlab.ku.edu>

Fuel cells generate electricity via the electrochemical oxidation of a fuel (typically hydrogen or methanol) and the electrochemical reduction of oxygen. Fuel cells are crucial Army technologies, because they can power land and air vehicles as well as provide personal power to soldiers. However, the oxygen reduction reaction (ORR), is the half-reaction that limits the overall efficiency of fuel cells due to the complexity of the $4e^-/4H^+$ electrochemical reaction. The last 15 years have not seen a significant advance in the performance of ORR catalysts. Thus, a paradigm shift is necessary in ORR catalyst design.

Prof. Leonard’s mission is to devise sustainable improvements and innovative solutions for fuel and chemical production. He is currently the principal investigator for the NSF Research Traineeship (NRT) grant and co-founder of green-tech start-up Avium LLC, which is in the process of developing a green hydrogen pilot project.

CEBC-affiliated companies at home in Lawrence

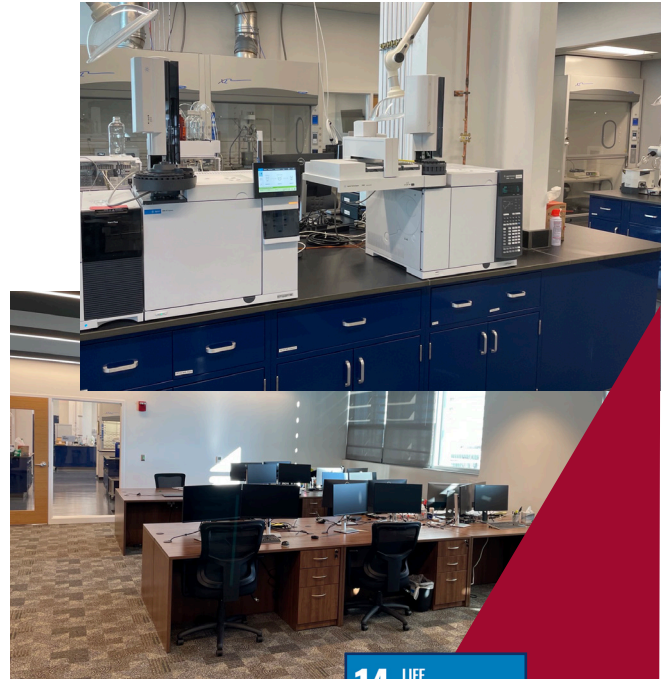
<https://kuinnovationpark.com>

When industry partners locate research facilities near the CEBC, we all benefit from the enhanced collaborative opportunities. The University of Kansas and the City of Lawrence are dedicated to building high-growth, innovation-focused industry clusters. The CEBC welcomes our industry partners to innovate here with us.

ADM expands space at KU campus

adm.com

In 2012, CEBC industry partner company ADM established a lab space in the KU Bioscience & Technology Business Center facility next to the CEBC complex. Ten years later, having outgrown the space, ADM has moved into KU's new Innovation Park Phase III. Located on KU's west campus, the Innovation Park leverages the university's resources and offers highly specialized facilities adjacent to campus. The new space has allowed ADM to triple its facility space, increasing office capacity from four people to 12. The number of walk-in hoods and wet-bench hoods has doubled. Customizable lab benches accommodate analytical equipment. Dedicated spaces for gas tanks, DI water/polishing system, and data closet were built to suit ADM's needs. ADM continues to employ three to four CEBC-affiliated postdoctoral researchers, as well as full-time research employees at the facility.



ADM FACILITIES at INNOVATION PARK, LAWRENCE, KS

Avium LLC is moving on up

aviumenergy.com

In 2018, graduate research at KU led to the launch of start-up business Avium LLC, with facilities in the KU Bioscience & Technology Business Center. By 2022, the company was looking to expand and scale up. Not just any facility could meet their high-power needs, however. Avium needed electrical capacity beyond the norm to scale up the electrolyzers developed to generate hydrogen, and use the technology discovered as part of Joe Barforoush's (BS KU ChemE 2014, PhD KU ChemE 2018) doctoral research. For Avium co-founders Dr. Barforoush and KU professor Dr. Kevin Leonard, the perfect 10,000-square-foot space was available in the Peasley Tech Building in East Lawrence. With funding from Tallgrass Energy, the company was able to adapt existing space to their specialized needs. Avium now employs six people working fulltime to complete their pilot project.



Life Below Water

The CEBC's work on reusable and recyclable plastics aims to reduce the amount of pollution entering waterways.



Life on Land

Science at the CEBC aims to reduce reliance on carbon-intensive fuels which contribute to global warming, habitat loss, and health disparities.

INDUSTRY PARTNERSHIPS

2022 Industry Advisory Board

Company	Board Member
Archer Daniels Midland	Derek Butler, Research Scientist
Chevron Phillips Chemical Chemical Co.	Pasquale Iacono, Research & Process Chemist
Gevo, Inc.	Andrew Ingram, Director of Process Chemistry & Catalysis
Johnson Matthey	Jerry Springs, R&D Director Cathy Tway, Technology & Applications Director
Origin Materials, Inc.	Victor Adamian, Technical Director Bill Gong, Research Scientist
W.R. Grace	Steve Schmidt, Research Fellow

Notable: Dr. Steve Schmidt is the 2023 recipient of the Eugene J. Houdry Award in Applied Catalysis, administered by the North American Catalysis Society to recognize and encourage individual contributions in the field of catalysis.

Jihad Dakka, New CEBC Affiliate Research Scientist

Jihad Dakka has joined the CEBC as an adjunct researcher. Dr. Dakka will work with CEBC and its industry partners, providing his expertise in fundamental concepts focused on transforming and raising the application of oxidation chemistries and acid catalysis. Through research, he works toward innovative technologies and durable solutions to meet the rising demand for energy and to drastically reduce carbon emissions. With 28 years supporting and augmenting the ExxonMobil Research & Engineering R&D pipeline, Dr. Dakka's accomplishments include 158 granted US patents and more than 80 pending patent applications. He has authored 26 high-impact publications. He earned a Doctorate in Industrial Chemical Processes from the Hebrew University of Jerusalem, Israel.



Welcoming Gevo, Inc. to IAB

Gevo is a Colorado-based company with a focus on developing sustainable energy and fuel sources. Gevo uses renewable and sustainable carbon inputs to develop fuels with low- or zero-carbon emissions. Their technology also allows for development of sustainable plastics. Dr. Andrew Ingram, director of process chemistry and catalysis for Gevo, presented an Industry Colloquium at CEBC in the fall. Gevo then committed to future collaboration with the CEBC. Gevo was previously an IAB member company in 2010, while CEBC researchers collaborated on projects for the company.

IAB MEMBERS at SPRING 2022
CEBC ADVISORY BOARDS MEETING



Nine Industry Colloquia presented in 2022

CEBC researchers exchange ideas and discover real-world insights from the CEBC Industry Colloquium Series.

- March 31** Dr. Karl Albrecht (ADM), "Sustainable Material Development in New Monomers, Chemicals and Fuels"
- April 7** Dr. Ben Spry, "On Alkylation and Practical Considerations in Catalysis"
- April 28** Dr. Joe Powell, "Hydrogen and Circularity in Future Energy and Chemicals"
- May 5** Dr. Joe Barforoush (Avium LLC), "A Conversation about Starting a Company"
- October 18** Dr. Andrew Ingram (Gevo), "Sustainable Systems to Produce Net-Zero Carbon Fuels"
- October 25** Dr. Cathy Tway (Johnson Matthey), "Reflections on National Academies' Chemical Economy Report"
- November 8** Dr. Joe Zaher (Danimer Scientific), "Polyhydroxy-alkanoate — A Renewable, Biodegradable Thermoplastic"
- November 28** Dr. Sourav Sengupta (DuPont), "Catalysis — An Indispensable Tool for Sustainable Development"
- December 6** Dr. Matt Wulfers (Phillips 66), "Embracing the Energy Transition: Perspectives from an Integrated Energy Company"

Multi-institution grant reaps notable outcomes

NSF EPSCoR RII Track 2 (R2P), \$4,000,000, 2021-2025

Advanced Manufacturing of Renewable & Recyclable Polymers (R2P)

PI: Bala Subramaniam (KU)

Co-PIs: KU, Alan Allgeier & Donna Ginther; U. Delaware, Marianthi Ierapetritou & Raul Lobo; Pittsburg State U., Tim Dawsey

Plastics are an indispensable part of today's society. Most plastics are made from fossil fuels and only about 10% of plastic waste gets recycled. As a result, plastics exacerbate planetary environmental and health crises.

The goal of the R2P project is to develop novel catalysts and viable processes to (a) transform renewable biorefinery feedstocks into relevant plastics and (b) deconstruct recycled plastics for reuse instead of disposal.

To take on the complexity of this problem, CEBC researchers have teamed up with researchers at the University of Delaware (UD) and Pittsburg State University (PSU). UD brings outstanding and complementary expertise in catalysis and process analysis. The National Institute for Materials Advancement (NIMA) at PSU brings world class expertise in plastics engineering and polymer chemistry.

Furthermore, the project team includes policy experts at both KU's Institute for Policy and Social Research (IPSR) and UD's Biden School for Public Policy, to assess the potential economic and policy implications of a "circular plastics economy".

Now in its second year, the multi-university team has coalesced and made advances in each of the research thrusts. A recent assessment by external program evaluators confirmed that the program benefits from a mixture of new and existing collaborations that span all partner institutions.

The National Science Foundation hopes to see grants funded through this program to sustain these partnerships beyond the life of the grant. And while the R2P team has much more work to do, they're also laying the groundwork to make these collaborations as sustainable as the plastics they're trying to make in the lab.

Notable Outcomes Include:

- Developing an online catalyst research database
- Catalyzed polymer development and subsequent degradation techniques
- Estimating the economic feasibility of bio-based feedstock transition for plastics
- Optimizing experimental conditions for production of desired precursors
- Optimized catalyst production



Growing our Kansas Corn Commission relations

Kansas Corn Commission, \$154,000, 2023-2026

Process Technology and New Products from Corn Oil

PI: Alan Allgeier, Chemical & Petroleum Engineering

Co-PIs: Laurence Weatherley and Bala Subramaniam, Chemical & Petroleum Engineering, and Tom Binder, Adjunct Researcher

The CEBC's relationship with the Kansas Corn Commission began in 2020 with a three-year, \$125,541 project to help ethanol producers target the right chemicals for higher-value ethanol derivatives. The success of that project has spawned new initiatives related to corn oil extraction technology and lipase-catalyzed free-fatty acid development. Modern ethanol plants recover low-value, impure corn oil at the back of the refining section, but CEBC envisions recovering higher value fractionated oil streams for animal nutrition at the front of the plant. The team will extend prior work from the Weatherley group for enhancing mass transfer rates in oil hydrolysis through electrospray technology for this biphasic reaction. CEBC will partner with a Berexco (Wichita, KS) subsidiary, Trenton AgriProducts and Trucent Biorenewables. The team is constructing research equipment and engineering solvent compositions for oil extraction and fractionation.

Pictured above, KU PhD Student Victor Sharma (ChemE) has earned three Kansas Corn Next Generation Scholarships.

Industry, Innovation, and Infrastructure

The CEBC works closely with industry to innovate and identify real-world economically feasible sustainable solutions.



Responsible Consumption and Production

CEBC's research projects aim to develop catalysts and technologies that conserve natural resources and promote a circular economy.



PhD student
KAIHUA ZHANG

Zhang, K. and Caricato, M.
Modeling catalyzed reactions on metal-doped amorphous silicates: the case of niobium-catalyzed ethylene epoxidation
ChemRxiv 2022, 1-21

Dataset helps identify potential catalysts

Current graduate students, Brianna Farris (Chemical Engineering) and Tevin Niang-Trost (Computer Science), co-authored the inaugural paper supported by the NRT grant. Their work demonstrates that with a relatively small hand-curated dataset, their machine learning model can identify outcomes that are well-supported in the literature. The researchers found that simpler models were suitable for binary outcomes at this scale. However, future models will need machine-curated datasets to identify potential catalysts and experimental parameters.

Farris, B. R.; Niang-Trost, T.; Branicky, M. S.; Leonard, K. C.
Evaluation of Machine Learning Models on Electrochemical CO₂ Reduction Using Human Curated Datasets
ACS Sustainable Chem. Eng. 2022, 10 (33), 10933-10943. doi:10.1021/acssuschemeng.2c02941



PhD student
BRIANNA FARRIS

Machine learning explores mysteries of catalysts supported on amorphous silica

Department of Energy Basic Sciences, \$1,600,000, 2018-2022

Ab Initio Machine Learning Algorithms for Modeling Kinetics on Amorphous Catalysts

PI: Marco Caricato, Department of Chemistry

Co-PIs: Brian Laird, Chemistry; Ward Thompson, Chemistry

<https://caricatogroup.ku.edu>

This research is developing a computational framework that combines machine learning, simulation modelling, and molecular dynamics (MD) techniques to predict effective kinetics on heterogeneous, metal-doped amorphous silicate catalysts. Dr. Caricato and PhD student Kaihua Zhang have simulated reaction features in metal-doped amorphous materials. These insights are valuable to understanding the mechanisms underlying catalytic reactions of these compounds. They found that small site models generated similar reactant adsorption and activation energy results to large site models, providing evidence that a more resource-intensive approach may not be necessary. They also found that the same reaction site can host multiple transition state structures but with different energetic barriers. Machine learning can identify features of a reactive event with a relatively small dataset and with data that are comparable to experiments.

Unique traineeship harnesses data revolution

National Science Foundation Research Traineeship (NRT), \$3,000,000, 2019-2024 plus \$315,286 matching from Kansas EPSCoR (Established Program to Stimulate Competitive Research)

Internet of Catalysis—Harnessing Data Science for Catalyst Design, NSF Research Traineeship (NRT) Program

PI: Kevin Leonard, Chemical and Petroleum Engineering

Co-PIs: James Blakemore, Chemistry; Bo Luo, Electrical Engineering & Computer Science; Bala Subramaniam, Chemical & Petroleum Engineering

<https://nrt.ku.edu>

This unique traineeship program is transforming the education and training of masters and doctoral students at the interface between chemistry, engineering, and data science. There is a major unmet need in catalysis research to harness the data revolution to rationally design new catalysts. Trainees work in teams to **Catal**og the literature with data mining, **L**earn from

this knowledge base using machine learning, and use these insights to **S**earch and **T**est new catalysts (**CATALST**).

This revolutionary approach is needed to understand authentic catalytic systems under real conditions, which are vastly complex and data-rich. When fully developed, this model can be applied to any reaction system. The results will enable breakthrough discoveries for the energy, chemical, and data science industries.



PhD student
HASHIM ALZHRANI

Alzahrani, H. and Bravo-Suárez, J.
In Situ Raman Spectroscopy Study of Silver Particle Size Effects on Unpromoted Ag/A-Al₂O₃ During Ethylene Epoxidation with Molecular Oxygen
***J. Catal.* 2023, doi: 10.1016/j.jcat.2023.01.016.**

Cultivating catalysts with promising properties

NSF CAREER, \$500,000, 2019-2024

Spectrokinetic Studies for Understanding Metal-Support Interactions in Catalytic Oxidation of Ethanol NSF Faculty Early Career Development Program
PI: Juan Bravo-Suárez, Associate Professor, KU Department of Chemical and Petroleum Engineering

sites.google.com/site/bravoresearchgroup

In this project, the interactions between gold nanoparticles and metal oxide catalyst supports are studied to design more active and selective catalysts for acetic acid production. A portion of the work funded by this grant was recently published in the *Journal of Catalysis*. The authors presented in situ spectroscopic evidence to clarify the unusually high turnover frequencies of large silver particles sizes (100-170 nm) observed in the industrial silver catalyst for ethylene epoxidation. In this study, current graduate student Hashim Alzahrani prepared unpromoted silver-aluminum oxide catalysts of varying silver sizes. They found that silver particle size impacted the catalyst activity and ethylene oxide selectivity was nearly independent in the 20-170 nm Ag particle size range. However, the main difference between small (<100 nm) and large (>100 nm) silver particles, as evidenced by in situ Raman spectroscopy, was the ability of large silver particles to stabilize a new surface oxygen species most likely by subsurface oxidized silver. These findings provide a new understanding on the role of large silver particles in the epoxidation of ethylene with molecular oxygen.



PhD student STEFFAN GREEN

Ozonolysis produces sweet taste of success

NSF Partnerships for Innovation (PFI), \$707,681, 2019-2024
Technology Development for Valorizing Agricultural Leftovers
PI: Bala Subramaniam

Co-PIs: Tom Binder, KU affiliate researcher; Erik Hagberg, ADM

Using an inventive process based on a prior NSF grant, this research harnesses ozone's unique oxidative potential to selectively extract valuable compounds from agricultural residues. Flavoring agents, including vanilla, are rapidly produced from corn field residues.

PhD student Stef Green has demonstrated a technique for utilizing agricultural leftovers to produce flavoring agents. Their method uses lignin derived from locally sourced corn cobs and stover (husks, tassels, stalks, etc.) and ozone to generate desired flavoring agents. The process breaks the lignin down into desired phenolic aldehydes. The study found that corn cobs produced substantially greater quantities of flavoring agents than corn stover. The inventive process is effective at ambient temperatures and pressures, and is easily scalable for large-scale production of artificial flavoring agents. Preliminary economic analysis shows that the products generate substantial value that enhances practical viability of the technology.

Green, S.; Binder, T.; Hagberg, E.; Subramaniam, B.
Correlation between lignin-carbohydrate complex content in grass lignins and phenolic aldehyde production by rapid spray ozonolysis
***ACS Eng. Au.* 2022, doi: 10.1021/acsengineeringau.2c00041j.**
***jcat.*2023.01.016.**

7 AFFORDABLE AND CLEAN ENERGY



Affordable and Clean Energy
Research into renewable fuel sources with a focus on economic viability are major endeavors of the CEBC.

13 CLIMATE ACTION



Climate Action
Research at the CEBC aims to identify industrial sources of climate change and provide alternative options for future global development.



- **Ph.D. (2020) in Zoology, Oklahoma State University, Stillwater OK USA**
- **B.S. (2015) in Biology, Oklahoma State University, Stillwater OK USA**
- **B.S. (2015) in Psychology with Honors Oklahoma State University, Stillwater OK USA**

Introducing new director of education, outreach and diversity programs

In August 2022, the CEBC welcomed a new Director of Education, Outreach, and Diversity Programs, Dr. Ana Chicas-Mosier (she/her). After completing her Ph.D., she joined Auburn University's Department of Entomology and Plant Pathology as a post-doctoral researcher. While at Auburn, Ana built a strong record of mentorship, developed equity-centered college- and university-level programming, and led professional development sessions for early-career researchers. Through her research, Ana has visited 10 countries and studied honey bees on three continents. Ana's publication and grant record reflect that of an educator, a STEM scientist, and an equity researcher.

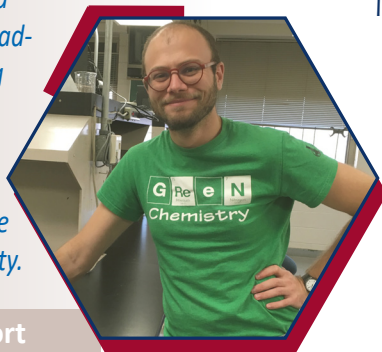
Ana spends her spare time travelling with her spouse, family, and dog, Zucco. She also has two cats, Manxon and Maizey.



Postdoc combines research with teaching

In fall 2022, the CEBC recruited Nakisha Mark for a unique postdoctoral position that integrates teaching and research training. A \$4 million grant from the National Science Foundation Experimental Program to Stimulate Competitive Research (EPSCoR) funds this postdoctoral experience. Nakisha begins a two-year position in January 2023. In addition to her research work, she will gain skills in course development, assessment, and redesign. Collaborative education programming between the EPSCoR grant and the Kansas Corn Commission will also be incorporated.

This is the second grant of this type that the CEBC has been awarded. From 2016 to 2019, Dr. Julian Silverman contributed to lignin research while incorporating sustainability-related exercises in the curriculum for a graduate-level course. After completing the CEBC postdoctoral experience, Dr. Silverman has served as an assistant professor at Manhattan College and at the Fashion Institute of Technology, both in New York City.



ECO-WaTER rises to challenges

NSF RET SITE Award, \$600,000, 2019-2022

Exploring Career Opportunities through Water-Themed Engineering Research (ECO-WaTER)

Investigators: Edward Peltier (PI), Claudia Bode (former CEBC Education Director)

The ECO-WaTER Research Experiences for Teachers (RET) immersed high school science and math teachers in a six-week summer program focused around one unifying theme: water sustainability. Projects have spanned environmental, mechanical, and chemical engineering fields, giving participants the chance to explore grand challenges in engineering, such as the desalination of seawater or oil and gas wastewater cleanup. This grant was CEBC's third NSF RET award.

In the program's final funded year, nine teachers from seven high schools throughout Kansas worked in KU laboratories in Chemical and Petroleum Engineering, Civil and Environmental Engineering, and Mechanical Engineering. Their research projects focused on finding solutions for major water-related challenges facing society today. These topics have both local and global significance.

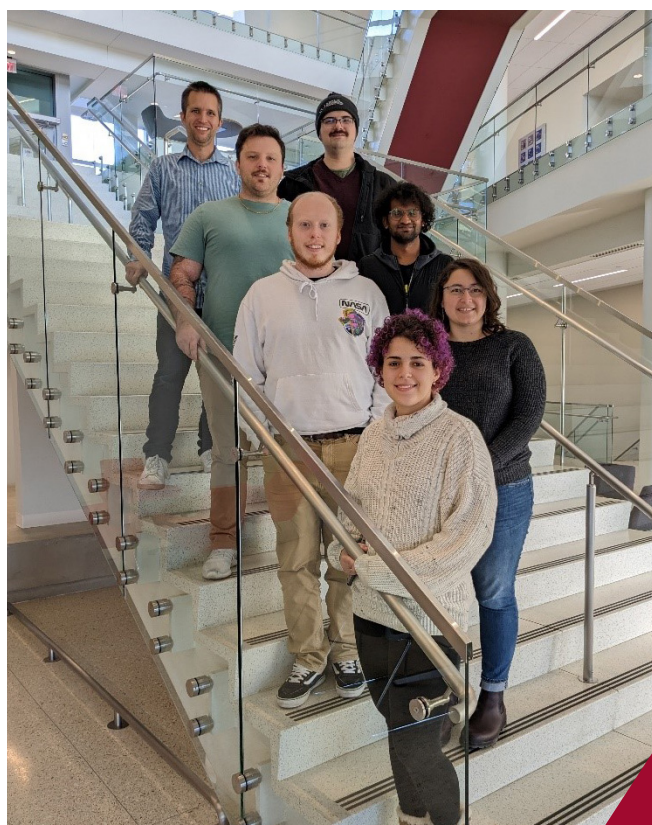
The research projects included:

- Develop nanoparticles to remove oils from wastewater
- Design cooling units to minimize freshwater use at power plants
- Develop ways to reuse wastewater from oil and gas drilling
- Design new electrocatalysts to produce hydrogen from water
- Remove fluorinated chemicals from drinking water

New Education and Equity Strategic Plan

The CEBC continues to increase the prevalence of equity-centered educational programming. The Center aims to increase the frequency of conversations about DEIB and provide clarity on how these efforts impact everyday lives and science. The CEBC's Education and Equity Strategic plan uses often small, but evidence-based, techniques to drive inclusion and belonging. We are building an environment where our trainees can learn professional skills and be better-prepared team members and colleagues for their future endeavors.

- Launched CEBC DEIB webpage for the Center's mission to promote an equitable and inclusive environment. The page includes KU campus equity resources.
- Integrated DEIB into skills training, hosting the DEIB office during grant-supported team-building activities.
- Recruitment at representation-focused conferences such as the Louis Stokes Alliance for Minority Participation, Midwest Regional Center of Excellence and Oklahoma Alliance. Recruitment at these events identifies students whose research overlaps with the CEBC and builds networks with these candidates.
- Working with main campus recruitment and retention organizations such as IHAWKe, CAMP, and the Sloan Foundation and HERS projects. Maintaining these networks promotes collaboration between equity programming.
- Post-doctoral research transition committee provides resources for incoming trainees. Committee members are current postdocs and have the most recent experience with transitioning to KU and Lawrence.
- WinterFLY is an annual orientation held the week before spring classes begin. This event aims to improve team building between graduate student peers and PIs. This year, we hosted the DEIB office, toured the Spencer Art Museum, and had professional development for trainees.
- Boundary Spanning Seminar Series has been integrated into the CEBC's semesterly colloquia. The seminars demonstrate the many career options available to CEBC trainees and allow trainees to interact with current professionals, many of whom are from other universities, in contrast to Industry Colloquia.
- Mental Health moments at the start of every safety meeting emphasize that mental health is a key component of laboratory safety. Covered topics include the importance of sleep, breathing techniques, and identifying microaggressions.
- Incorporating "Science as a Team" into CEBC trainee-centered grants emphasizes the importance of mentorship teams, open lines of communication between colleagues and peers, and defining goals and expectations.



PROF. KEVIN LEONARD (top L) and DR. ANA CHICAS-MOSIER (bottom R) with WinterFLY student participants (from bottom L to top R) MARIA IANC, ALEX ERVIN, STEF GREEN, FELIX SOTVIK, and DARIK ROSSER

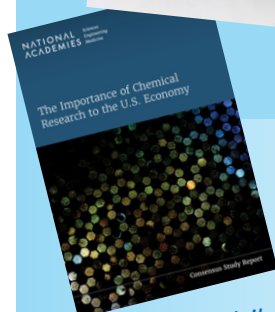
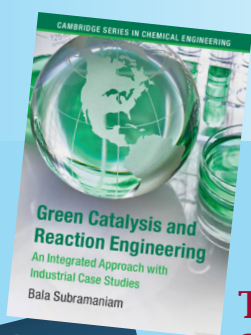
Gender Equality
Our Center recognizes that our research disciplines have had historical gender underrepresentation. The CEBC actively recruits and supports women and gender diverse trainees and faculty.



Reduced Inequalities
The CEBC aims to reduce inequalities on site, at KU, and through environmentally sustainable research. Through DEIB efforts, we promote engagement and discussion around equality and equity and improving workplace conditions.

New textbook highlights Life Cycle Analysis, energy-saving chemical processes

A new textbook by CEBC Director Bala Subramaniam, "Green Catalysis and Reaction Engineering," was published in fall 2022 by Cambridge University Press. The book focuses on the importance of and methods for Life Cycle Analysis (LCA) in developing sustainable chemical technologies. This valuable resource for chemists, engineers and practitioners includes real-world case studies to illustrate the tools to assess the environmental footprint and economics of chemical processes.



National Academies Report: The Importance of Chemical Research to the U.S. Economy

CEBC Director Bala Subramaniam, alongside industry advisory board member Cathy Tway (vice chair of the Study Committee) and others, contributed to a new report on the value of chemical research in the United States.

The report focuses on four topics:

- Outline the role that chemical industry plays in supporting the U.S. economy
- Detail the historical impacts of long-term investment on areas such as security, sustainability, manufacturing, and technology
- Strategize future investments to put the U.S. in a global leadership role in the field
- Identify future areas of development for sustainability and diversity in the workforce



Kevin Leonard

ACS Sustainable Chemistry & Engineering Lectureship Award

Dr. Leonard is honored for his multiple contributions to the field of sustainable chemistry and engineering, including the production, at scale, of clean hydrogen and the development of CO₂-expanded electrolytes that offer potential in the rapidly developing area of synthetic electrochemistry. The recipients of the lectureship awards are chosen from three regions: the Americas, Europe/Middle East/Africa, and Asia/Pacific. The awards honor the scientific accomplishments of scientists working in green chemistry, green engineering, and chemical enterprise sustainability, who have finished their academic studies within the last ten years.



Aaron Teator

3M Non-Tenured Faculty Award

Dr. Teator has been selected to receive a prestigious Non-Tenured Faculty Award (NTFA) from 3M Corporation. This award recognizes outstanding young faculty, nominated by 3M researchers, for their early-career achievements in research. The award provides an unrestricted gift of \$15,000 per year, renewable for up to three years. The award will be used to accelerate the Teator Lab's research activities related to expanding the functional diversity of synthetic macromolecules.

Alan Allgeier, Juan Bravo-Suárez

Great Plains Catalysis Society (GPCS) Elected Officers

Alan Allgeier has been elected as president of the Great Plains Catalysis Society for 2023. Dr. Allgeier previously served on the group's executive committee. He was one of the founding members of this midwest regional chapter of the North American Catalysis Society in 2018.

After serving in various organizational roles for the GPCS, Juan Bravo Suárez was elected to be secretary for the group. He has been active in managing the GPCS Webinar Series since the chapter was formed, and has also helped with the annual Symposium held each fall.



Faculty Presentations

Alan Allgeier

- Great Plains Catalysis Society Fall Symposium Keynote, Ames, IA, August 15

Juan Bravo-Suárez

- Center for Energy Innovation, University of Delaware, February 9
- Gordon Research Conference on Catalysis, New London, NH, June 19-20

Ana Morais

- Great Plains Catalysis Society Webinar Series Presentation, April 22
- AIChE Annual Meeting, Phoenix, AZ, November 13-17
- Presentations at ExxonMobil and 3M

Tim Jackson

- ARCANE Seminar (Plenary), Université Grenoble Alpes, Grenoble, France, May 20
- Seminar, CEA Grenoble, Grenoble, France, June 9
- 16th European Biologic Inorganic Chemistry Conference (Eurobic), Grenoble, France, July 17 – 21

Aaron Scurto

- AIChE Annual Meeting, Phoenix, AZ, November 13-17

Aaron Teator

- ACS Spring National Meeting, San Diego, CA, March 20-24
- Tosoh Polymer Conference, Hollywood, CA, June 8-9
- ACS Fall National Meeting, Chicago, IL, August 21-25
- 3M Non-Tenured Faculty Award Symposium, September

Ward Thompson

- Virtual presentation at Chemical Sciences, Geosciences and Biosciences Group Meeting, Sandia National Laboratories, July 13
- Theory Seminar, Ecole Normale Supérieure, Paris, France, October 14
- Physical Chemistry Seminar, Pennsylvania State University, State College, PA, October 25
- ACS Southwest Regional Meeting, Baton Rouge, LA, November 8

Laurence Weatherley

- Organic Reactions Chemical Society, Jacksonville, FL, October 16-20

Students & Postdocs Conferences Attended

May

- NAM27 North American Catalysis Society Meeting, New York, NY

Students Steffan Green, Simon Velasquez Morales, Bhagysha Patil, Alejandra Torres Velasco and Anoop Uchagawkar; Postdoc Shazia Satter

June

- Gordon Research Conference on Catalysis New London, NH

Student Anoop Uchagawkar

July

- Gordon Research Conference on Green Chemistry Casteldefells, Spain

Student Steffan Green

August

- Great Plains Catalysis Society Symposium Ames, Iowa

Oral Presentations: Students Bhagysha Patil and Anoop Uchagawkar

Posters: Students Hashim Alzahrani, Samir Castilla-Acevedo, Steffan Green, Odri Kingsley Siakpebru, Saabiq Mohammad, Christian Nilles, Matt Stalcup and Alejandra Torres Velasco

October

- Organic Reactions Catalysis Society Jacksonville, FL

Students Samir Castilla-Acevedo and Nan Wang

Postdocs Miriam Basiouny, Bhanupriya Boruah and Shazia Satter

November

- AIChE Annual Meeting Phoenix, AZ

Oral Presentations: Students Alejandra Torres Velasco and Anoop Uchagawkar

Posters: Student Anoop Uchagawkar and Postdocs Shazia Satter and Hongda Zhu



Clean Water and Sanitation

The CEBC's work on reusable and recyclable plastics aims to reduce pollutants in drinking water.



Sustainable Cities and Communities

Sustainability is a core mission of the research and education endeavors of the CEBC. We aim to create a sustainable micro-community with broader global impacts.

Welcome New Postdocs!



Preeti Jain

Ph.D. 2020 in Chemistry, CSIR National Chemical Laboratory, Pune, India; M.Sc. 2013 in Chemistry, Banasthali Vidyapit, Radha Kishnpura, India; B.Sc. 2011 Non-Medical, Government College for Girls, Gurgaon, India

Preeti is currently working on the NSF project on advanced manufacturing of renewable and recyclable polymers through sustainable catalysis. Her research focuses on the development of advanced polymer precursors from bio-based feedstocks. Preeti's past research has included synthesis and characterization of the noble metal-based core-shell bimetallic catalysts, biomass conversion into high-value chemicals, and bimetallic heterogeneous catalyst development for hydrodeoxygenation reactions.



Nakisha Mark

Ph.D. (anticipated Spring 2023) in Chemistry, University of the West Indies, St. Augustine, Trinidad; M.Sc. 2012 in Occupational and Environmental Safety and Health, University of the West Indies, St. Augustine, Trinidad; B.Sc. 2009 in Biology and Chemistry, University of the West Indies, St. Augustine, Trinidad

Nakisha's research utilizes the principles of green chemistry and heterogeneous catalysis to develop chemical compounds that can create multi-linkages in diverse industries. In the classroom she emphasizes that STEM is part of our daily lives and not to be feared. Prior to entering the field of catalysis, Nakisha's research was in agriculture and biomedical waste management. She volunteers at the Caribbean Society of Cosmetic Scientists, where she has hosted virtual career sessions for high school students with the aim of encouraging them into STEM. She has also contributed to uniting cosmetic entrepreneurs in the region through monthly highlights.

Anoop Uchagawkar

Ph.D. 2022 in Chemical Engineering, University of Kansas, Lawrence KS USA; M.S. 2016 in Chemical Engineering, Texas A&M University, College Station TX USA; B.S. 2011 in Chemical Engineering, Maharashtra Institute of Technology, Pune, India

In his recent role as a graduate research assistant, Anoop worked under the guidance of Dr. Bala Subramaniam to develop novel "Molybdenum and Transition Metal-based Bimetallic Mesoporous Silicate Catalysts for Enhancing the Olefin Metathesis Activity for Propylene Production." Developing improved processes with efficient utilization of resources promotes a circular carbon economy. As a postdoctoral researcher, he will be working to develop new catalysts and oxidants for activating light hydrocarbons.

Sandip Singh

Ph.D. 2017 in Chemistry, CSIR National Chemical Laboratory, Pune, India; M.Sc. 2010 in Chemistry, Veer Bahadur Singh Purvanchal University, Jaunpur, India; B.Ed. 2009 in Biological Sciences, Dr. Ram Manohar Lohia Awadh University, Faizabad, India

In Jan 2022, Dr. Sandip Singh joined CEBC as a postdoctoral researcher, working on proprietary projects dealing with the synthesis and characterization of renewable and sustainable plastic precursors. As a postdoctoral transition committee member, he provides resources and insights for incoming post-doctoral researchers. Sandip has served as a postdoc at IIT Indore India, Montana State University, USA, and the University of Gottingen, Germany. One of his many national and international awards and achievements is recognized by the United Nations.

CEBC researchers on the move to PNNL

Three CEBC postdocs have moved to postdoctoral scientist positions at Pacific Northwest National Laboratory (PNNL).

- Dr. Bhanupriya Boruah, CEBC/ADM postdoc August 2021 to November 2022
- Dr. Mi Yeon Byun, CEBC postdoc March 2022 to March 2023
- Dr. Shazia Satter, CEBC/ADM postdoc June 2021 to December 2022

They join Drs. Amy Jystad (PhD Chemistry 2020) and Crystal Shi (PhD Chemical Engineering 2019, CEBC postdoc 2019-2020), who took PNNL positions in 2020.

Front, L to R: SHAZIA SATTER, BHANUPRIYA BORUAH, MI YEON BYUN
Back: SANDIP SINGH



Student Success

Christian Nilles

Advisor, James Blakemore

- Best Poster Presentation Prize, Great Plains Catalysis Society Annual Meeting

Zeke Piskulich

Advisors, Brian Laird & Ward Thompson

- Janukas Dissertation Award, American Physical Society
- KU Chemistry Dept. Argesinger Award

Victor Sharma

Advisor, Alan Allgeier

- Kansas Corn Commission Next Generation Scholarship
- Outstanding Graduate Teaching Assistant award from Dept. of Chemical & Petroleum Engineering

Murilo Toledo Sukeuni

Advisor, Alan Allgeier

- Scholarship to week-long ACS Summer School on Green Chemistry and Sustainable Energy

Kaihua Zhang

Advisor, Marco Caricato

- KU Chemistry Dept. Snyder Chemistry Award

Congratulations, 2022 Graduates!

Julie Leseberg, PhD Chemistry

Advisor, James Blakemore

- Recipient of the Ernest & Marvel Griswold Award in Inorganic Chemistry
- Now a research chemist with Chevron Phillips Chemical in Kingwood, TX

Anoop Uchagawkar, PhD Chemical Engineering

Advisor, Bala Subramaniam

- Graduated with Honors
- Now a postdoctoral researcher at University of Kansas CEBC

Simon Velasquez Morales, PhD Chemical Engineering

Advisor, Alan Allgeier

- Now a senior scientist with AbbVie in Chicago, IL

M.S. Chemical Engineering:

Hashim Alzahrani, Advisor, Juan Bravo-Suárez

- Graduated with Honors
- Now a PhD student at University of Kansas CEBC

Saabiq Mohammad, Advisor, Juan Bravo-Suárez

- Now an Engineering Consultant for Regeneron Pharmaceuticals, Tarrytown, NY

Steffan Green, Advisor, Bala Subramaniam

- Graduated with Honors
- Now a PhD student at University of Kansas CEBC

Brandon Kinn, Advisor, Bala Subramaniam

- Graduated with Honors
- Now a module engineer with Intel Corp. in Hillsboro, OR

Dinu Rajapakse, Advisor, Kevin Leonard

- Now pursuing a career in machine learning in Austin, TX



Where in the **WORLD** are the CEBC alumni?

Kyle Stephens (BS KU ChemE 2017, MS KU ChemE 2019) PhD Material Science 2022, ETH Zürich, now at Paul Scherrer Institut PSI, Switzerland

Priya Srinivasan (PhD KU ChemE 2019) Researcher at Braskem in Philadelphia, PA

David Sconyers (PhD KU Chem 2020) Research Chemist, US ARMY DEVCOM AC - Benet Laboratories, Watervliet, NY

Swarup Maiti (Assoc Researcher 2011-2019) Assoc. Technical Service & Development Scientist, The Dow Chemical Co., Freeport, TX

Jianfeng Wu (CEBC postdoc 2014-2017) Professor of Physical Chemistry, Langzhou University, Langzhou, Gansu, China

Five alumni work for Intel Corp.: **Tim McDonald** (MS KU ChemE 2015), **Dylan Jantz** (PhD KU ChemE 2020), **Pubudu Wimlasiri** (PhD KU Chem 2020), **Ankit Verma** (PhD KU ChemE 2021) and **Brandon Kinn** (BS KU ChemE 2019; MS KU ChemE 2022)

Two alumni are at DOE in Washington, DC: **Kouros Kian** (MBA KU 2015; MS KU ChemE 2017) and **Tomas Green** (BS KU ChemE 2018)

4 QUALITY EDUCATION



Quality Education

The CEBC aims to holistically train our students, employees, and faculty. Technical and research skills, professional development, and transferable knowledge-building are components of this educational program.

8 DECENT WORK AND ECONOMIC GROWTH



Decent Work and Economic Growth

Professional development, transparency, and promoting transferable skills are CEBC missions to provide holistic education for trainees and prepare them for the workforce.

See complete list:
www.cebc.ku.edu/publications

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Inventions & Patents 2004-2022

76 invention disclosures

23 patents issued

2022 activity:

- “Activation of Alkyl Substrates in Condensed Phase with Ozone”
B. Subramaniam, H. Zhu, T. Jackson
- “Methods for the Biocatalytic Production of Acetaldehyde”
A. Allgeier, V. Sharma, T. Binder
- “A Method to Delaminate Polymer Adhesives in Solar Panels Promoted by Sonication in Liquid Carbon Dioxide and Alkanes”
B. Subramaniam, H. Zhu

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