S-1075 Multistate Regional Project

The Science and Engineering for a Biobased Industry and Economy

2022 – 2023 Annual Report

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S1075 Chair for 2022-2023

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Executive Summary

The annual report was compiled from individual station reports submitted by station representatives including outcomes and impacts against the S1075 objectives, outputs, impacts, and target audiences. For a detailed description of each individual objective and task, see the project statement available on the NIMSS database website.

Project Objectives & Tasks

The objectives and tasks of the S1075 project are:

OBJECTIVE A. Develop deployable biomass feedstock and supply knowledge, processes and logistics systems that economically deliver timely and sufficient quantities of biomass with predictable specifications to meet efficient handling, storage and conversion process requirements

Task 1: Identify and evaluate biomass type and availability for selected geographic regions based on economic, agronomic, and climate conditions

Task 2: Characterize feedstock physical and chemical properties throughout the supply chain

Task 3: Develop harvest, pre-processing, handling, densification, storage, and transportation methods for specific biomass feedstock end-users

OBJECTIVE B. Research and develop technically feasible, economically viable and environmentally sustainable technologies to convert biomass resources into chemicals, energy, materials in a biorefinery methodology including developing co-products to enable greater commercialization potential

Task 1: Develop and assess technologies to produce valuable products from lipids and residuals from lipid processing

Task 2: Develop and assess technologies to produce valuable products from cereal grains, other starchy crops and food waste

Task 3: Develop and assess biological conversion technologies to produce valuable products from carbohydrates in cellulosic biomass

Task 4: Develop and assess technologies to produce valuable products from lignin

Task 5: Develop and assess thermochemical conversion technologies to produce valuable products from cellulosic biomass

Task 6: Integrate thermochemical and biological conversion processes to produce valuable products from lignocellulosic biomass

OBJECTIVE C. Perform system analysis to support and inform development of sustainable multiple product streams (chemicals, energy, and materials) and use the insights from the systems analysis to guide research and policy decisions

Task 1: Develop system models and data to assess sustainability of integrated conversion platforms Task 2: Develop integrated system models to configure, analyze and optimize bioenergy and biofuel production systems

Participating Stations and Investigators:

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Outcomes related to Objective A. [Develop deployable biomass feedstock and supply knowledge, processes and logistics systems that economically deliver timely and sufficient quantities of biomass with predictable specifications to meet efficient handling, storage and conversion process requirements]

California

CA station conducted research on biomass conversion and biorefining with cost effectiveness and eco friendliness. The main research activities included production of biodegradable polyester polymers (i.e., polyhydroxyalkonates) from dairy processing wastes and lignocellulosic biomass, designed green deep eutectic solvent systems for improving digestibility of cellulose pulp and lignin valorization, and developed direct laser writing process for transforming lignin into graphene-based materials for energy storage and ultrasensitive sensing applications, biodegradation polymers synthesized from CO2 and algal/vegetable oil.

Variability of bioenergy feedstock properties continues to be a primary challenge to integrated biorefineries in order to achieve continuous operation and meet yield requirements necessary for commercial scale production of biofuels. Development and operation of Integrated biorefinery (IBR) have suffered from failing to account for the complexity and variability of lignocellulosic biomass as well as poor equipment design and flawed integration. Our team is working on a standard QbD approach to better understand and quantify the impacts of feedstock material attributes and process parameters on conversion process quality attributes. The development of prediction models for these conversion process quality attributes contributes to the knowledge basis necessary to support implementation of quality by design into a biorefinery at scale.

Kentucky

The production of cannabidiol (CBD) from the floral material of *Cannabis sativa L.*is of great interest to the hemp industry. The low bulk density oh hemp floral material presents challenges in terms of storage and handling. To improve handling and storage characteristics, both intact (pre-extraction) and supercritical CO_2 extracted hemp floral materials were pelletized. Intact floral material (BaOx) was passed through a hammer mill with a 5 mm screen; while, extracted floral material (Hawaiian Haze) was ball milled through a 60 mesh (250 microns) prior to extraction. Pelletization was conducted using a 3.7 kW pilot scale flat ring pellet mill. Prior to pelletization the floral material was condition to 10, 15, and 20% moisture content (MC). Across all initial MC, extracted floral pellets significantly increased pellet durability by 3%, elevated pellet yield by 4%, and increased bulk density by 14% when compared to intact floral pellets. However, extracted floral pellets required 3.6-fold more kWh/Mg of pellets produced and generated pellets at a 75% decreased rate when compared to intact floral material. The most desirable pellets were those made from the extracted material with 10% MC and the intact material with 15% MC.

Michigan

Michigan State University is developing models for stationary and portable biochar production systems to maximize access to feedstock and minimize transportation costs. This activity is being led by Dr. Raju Pokharel in the Department of Forestry and supported by Dr. Chris Saffron and Dr. Jessica Miesel. In these models, forest biomass serves as the feedstock for slow pyrolysis to make biochar for cropland agriculture. Both Michigan's upper peninsula and lower peninsula are included in the study's geographic scope. Most of the biochar will be land applied in the southern portion of Michigan's lower peninsula, which is the region with the greatest cropland area. Transportation costs of biomass to stationary facilities followed by biochar hauling to agricultural sites are significant. Contrastingly, portable system economics are affected by lower biochar yields after slow pyrolysis. This work is ongoing, with publications expected in 2023-2024.

Minnesota

We have made significant progress in developing deployable biomass feedstock and supply systems that efficiently deliver biomass with predictable specifications to meet the requirements of handling, storage, and conversion processes. Our focus has been on utilizing animal wastewater as a valuable resource for the production of biomass, which can be used as biofuel feedstock and food products.

To achieve this objective, we have adopted a closed loop system approach that combines anaerobic digestion (AD), algae cultivation, and hydroponic cultivation. Through this integrated system, we aim to create a continuous operation that maximizes efficiency and sustainability.

One of our ongoing projects involves demonstrating a complete system that seamlessly integrates all the necessary processes. By doing so, we ensure a smooth and uninterrupted flow of biomass production. Throughout this project, we have encountered and addressed various technical challenges. For example, we have tackled the issue of high salinity, which has the potential to hinder the growth of algae and vegetables within the system. Our efforts have focused on finding effective solutions to mitigate the impact of high salinity on biomass production.

We have conducted extensive data collection to monitor the performance of our system. Specifically, we have gathered information on the reduction of volatile solids and chemical oxygen demand (COD), as well as the production of biogas from liquid swine manure after undergoing mesophilic AD. Furthermore, we have worked on optimizing the nutrient removal process using microalgae, thereby enhancing the overall efficiency of our system.

In addition to the AD component, we have recorded the growth of biomass and the rates of nutrient removal in our hydroponic plants. To evaluate the effectiveness of our system, we have compared the growth rates observed in treated wastewater with those in conventional nutrient-rich solutions.

Montana

MT S U continues to evaluate camelina and other oilseed crops as potential feedstock for biodiesel and aviation fuels. The major work includes: 1) camelina and canola cultivar evaluation for higher oil yield with less nitrogen fertilizer input; 2) genetic modification to improve camelina nitrogen-use-efficiency (NUE).

Camelina is an oilseed bioenergy crop that is under intensive development mainly for sustainable aviation fuel production. However, nitrogen is the biggest energy input and production cost. Nitrogen use efficiency needs to be improved for sustainable feedstock production. Dr. Chen's research group at MT S U is testing camelina germplasm and selecting genotypes that have a high NUE and to identify agronomic traits that contribute to high NUE. Dr. Lu's lab at MT S U is conducting genetic engineering to improve camelina oil yield and NUE. Chen's group are currently also evaluating sugar beet for bioenergy production.

North Dakota

<u>Net-Zero Agriculture: Challenges, Opportunities, and Tools Development</u> – A number of developed

countries like the United States, the United Kingdom, and Canada have made a pact to work towards a "Net-zero" scenario and reduce CO_2 emission by 2050, thereby limiting the global warming level to 1.5°C. Agriculture-related CO_2 emission accounts for 27 % of global greenhouse gas (GHG) emissions due to the vast improvisation and mechanization of farming. In agriculture, livestock alone amounts to approximately 60 % of overall GHG emissions, and the rest is from excessive fossil fuel, fertilizer, and pesticide usage. This research aims to synthesize various challenges and opportunities that may be considered by the farming communities and their trade-offs. Net-zero concepts have huge opportunities for revenue and profit generation in the long run while not so in the immediate application phase. Proper monitoring of carbon footprints and meeting high demands of food production with low GHG emissions can be achieved through renewable fuels (e.g, renewable diesel, cellulosic ethanol). This study also focuses on synthesizing the information, data collection, elaborating the boundaries of operations, detailing the roadmap, and designing suitable models that lead to the development of a web-based demonstration tool to calculate CO_2 emission levels during various operations on croplands.

Transition to net-zero agriculture: Circular bioeconomy and renewable energy applications – In the quest for sustainable development and climate change mitigation, the idea of a "Net-zero" scenario was proposed and received a lot of traction lately, in which the balance between greenhouse gas (GHG) emissions and GHG removal is maintained. Agriculture is a significant contributor to carbon footprints, accounting for a substantial portion of global greenhouse gas emissions, including the use of fossil fuels in farming operations, deforestation for agricultural expansion, and the release of methane and nitrous oxide gases from livestock and agricultural practices. Furthermore, the resulting climate change from "business-as-usual" approaches poses a substantial threat to the agricultural sector, impacting food production, water resources, and rural livelihoods. The circular bioeconomy approach emphasizes reducing carbon footprints in agriculture from various sources, by adopting sustainable farming practices, promoting organic waste recycling, and implementing nutrient cycling systems. The research objectives are to identify the challenges and barriers faced by the agriculture sector in transitioning to a net-zero emissions framework, propose a conceptual solution framework, and evaluate the benefits and trade-offs, applied to a unit of agricultural land as a system boundary. Mass and energy flow analysis (input, output, and feedback) around the selected boundary of agricultural operations and evaluating different scenarios will be the methodology followed, while the major outputs will be the benefits (yield, net energy, and economics) with trade-offs at different scenarios. The studied initial framework can be expanded to represent and evaluate an increasingly comprehensive set of field operations to represent activities in agriculture and ranching, as well as develop user-friendly tools (webtool using HTML, CSS, and JavaScript) in future research studies.

Grain mass estimation is critical in many precision agriculture applications, especially in yield monitoring

during harvest procedures. A new clean grain mass estimation method using Radio Frequency (RF) sensing technology is discussed. RF sensing technology is sensitive to moisture content and grain properties. In this study, a vector network analyzer (VNA) and a pair of horn antennas were used to collect phase shift and attenuation data from 1 to 18 GHz of grain samples (soybean, canola, and corn) on a static testbed in an anechoic chamber. Using multiple variable linear regression analysis, a comprehensive clean grain mass estimation model was developed based on the dielectric properties of the grain samples derived from the S-Parameters at 13 GHz. Dielectric (e') constant/properties and phase shift were introduced into the regression models and generated a grain mass estimation result with R2 values of 0.976, 0.977, and 0.989 for soybean, canola, and corn samples, respectively. The results indicate that RF sensing technology can reveal how grain attributes interact with electromagnetic fields at a certain frequency and has the potential to provide more accurate sensing methods for estimating grain mass in multiple precision agricultural applications.

Ohio

We are currently analyzing methods for improving the logistics of feedstock (lignocellulosic and oilseeds) for biobased industries. In addition, we are also exploring different approaches and tools to estimate the availability of different feedstocks and potential for their utilization in biorefineries and power plants.

Pennsylvania

Following outcomes have been obtained by the various co-PIs for Objective A:

Co-PI: Tom Richard - In support of Objective A, Agricultural maps illustrating feedstock production and harvesting strategies that spatially identify and efficiently manage economically marginal subfield areas are now available for the Commonwealth of Pennsylvania and are being shared with agricultural producers.

Co-PI: Jude Liu - Continued working on the Mid-Atlantic Sustainable Biomass Consortium for Value-Added Products (MASbio, USDA-NIFA) project during this reporting period. Worked on biomass harvesting technology. A master thesis on "Modeling baling systems to optimize switchgrass harvesting" was completed in May 2023.

Co-PI: Hojae Yi - Developed a biomass scale cubical triaxial tester that can quantify bulk mechanical properties of milled biomass. Using this data, a Finite Element model has been developed to predict the incipient hopper flow patterns, which will aid identify and minimize handling issues. An inter-particle mechanics tester was also developed to quantify the friction and adhesion between biomass particles. Corn stover and southern pine residue particles of different tissue types are being characterized. These values is being used in Discrete Element model to predict and identify the root cause of biomass handling issues.

Tennessee

Terminal velocity is a fundamental aerodynamic property often used to separate plant anatomical components. Professor Womac developed a vertical wind tunnel was fabricated to investigate whether terminal velocities of switchgrass stem internodes and nodes were distinctly different. Wind tunnel features included a clear observation section for suspended particles and fine adjustment of airflow. Each sample terminal velocity was measured with 45 anemometer readings from nine locations and five repeated measures. The experiment evaluated two sample moisture contents [52% and 15% wet basis, (w.b.)], three particle lengths (0.64, 1.27, and 2.54 cm), node versus internode, and 12 replications. The 6,480 anemometer readings provided significant differences between factors and interactions. The greatest magnitude in mean terminal velocity difference was 4.55 m s^{-1} (i.e. 9.62 to 5.07) that resulted in a velocity ratio of 190% [(9.62/5.07) x 100]. The least magnitude of mean terminal velocity difference, while significant, was 0.36 m s^{-1} (i.e. 6.59 to 6.23). This offered a limited difference and may indicate that separations may need to be confined within groups of moisture category and/or particle length. Terminal velocity measurements were most similar to those calculated using the Mohsenin (1970) spherical particle equation.

Dr. Womac developed custom-built research-scale module builder and loader to evaluate logistics alternatives based on dry bulk density and module integrity failures [2]. Factors tested included different SG grinders/ particle spectra, moisture content, and numbers of module fill layers and tamps versus seed cotton. The research-scale module builder and loader were engineered to operate using similar principles as commercial units, except using only 0.7% of the biomass to fill the unit. It was discovered that the research-scale model resulted in reduced bulk density for cotton and SG potentially due to less over-burden. It was also discovered that dry bulk density of SG increased due to improved packing of SG particles from a forage harvester. The majority of SG modules failed due to reduced particle interlocking of short particles.

Dr. Abdoulmoumine developed a rapid imaging technique that could measure the morphological features of biomass particle assemblies and generate size and shape distribution information for input into discrete element models (DEM). These DEM can then be sued for evaluating the flow behavior of biomass particles greater geometric fidelity between the model particles and the actual biomass particles. We have developed correlations between the structural constituent (cellulose, hemicellulose, and lignin) contents of switchgrass, loblolly pine, and hybrid poplar and their shear strengths. We have established cellulose and hemicellulose have a strong correlation (R2 > 0.80) with shear strength while lignin does not have a statistically significant correlation with shear strength.

Dr. Hayes showed that the performance of a plastic mulch film prepared from a blend of the biopolymers polylactic acid and polyhydroxyalkanoate is equally as effective as commercially available biodegradable mulch films for the production of vegetables and specialty crops. The mulch film serves as an effective barrier to weeds and is biodegradable when tested according to standardized testing methods, even when existing as micro- and nanoplastics.

Texas

The TAMU Group embarked on a new project funded by Shell International Exploration Group entitled: Development of In-Motion Pyrolysis Systems for Biochar Incorporation. This project will design a mobile pyrolyzer attachment to a combine for immediate conversion of wastes into biochar, biooil and syngas.

TAMU Group continues to implement conversion of MSW wastes including plastics and rubber tires for biochar and biofuel production. Scaling up studies are underway in preparation for the design of a system to generate 170 MW power (Dominican Republic) and 150 MW power (Puerto Rico)

A new Circular Bioeconomy Systems Project funded by Frontier Bioenergy Systems (Austin, TX) was also implemented to convert dairy and feedlot manure into biochar for carbon capture and sequestration (CCS) project and electrical power.

Outcomes related to Objective B. [Research and develop technically feasible, economically viable and environmentally sustainable technologies to convert biomass resources into chemicals, energy, materials in a biorefinery methodology including developing co-products to enable greater commercialization potential.]

Alabama

We have several projects for the investigation and development of sustainable technologies for the conversion of biomass to bioenergy and biochemicals.

1) In one project supported by DOE, Dr. Yi Wang's lab is engineering Clostridium strains for fatty acid ester production. Then the fatty acid esters produced using the engineered strain from corn stover hydrolysates will be evaluated as a bioblendstock for diesel fuel. In the past year, Dr. Wang's lab engineered a train that could produce butyl acetate up to 35 g/L, which is highest that has ever been report for microbial production fatty acid ester. Dr. Wang's lab is seeking further funding support for scaling up the process.

2) Brendan Higgins has developed an algal-bacterial process for the treatment of anaerobic digestate and conversion of the nutrients into algae. These algae are then fed to zooplankton to create a natural, protein-rich fish feed. This system directly recycles nutrients from agricultural wastes back into the food

production system. This project was funded in May of 2020 by NIFA. In the past year, we have started constructing a pilot scale system, and discovered at least one organic molecule in anaerobic digestate that inhibits algal growth. We have submitted two papers based on the work in this project, both of which are under review.

3) B. Higgins is developing (in collaboration with others) an algal-bacterial process to treat poultry processing wastewater so that it is safe to use in hydroponic irrigation. Nutrients in this wastewater are partially sequestered by algae, generated a small biomass stream for potential valorization. However, most nutrients are used by plant crops. This project was funded in January of 2021 by NIFA. We have run 3 lettuce production trials in the pilot scale system and found that with nutrient supplementation, poultry processing wastewater can produce lettuce yields rivaling traditional hydroponic production. Moreover, all Salmonella and E. coli in the water die out in the treatment train and no pathogens have been detected on harvested lettuce. We published an article in ACS ES&T Engineering based on work on this project.

4) B. Higgins is the PI (with Sushil Adhikari as the Co-PI) of a recently-funded NSF REU site focused on converting biological waste materials into products of value. We successfully recruited our second cohort of students and all 9 of them are nearing completion of their summer program.

5) B. Higgins is the PI on an NSF project (Environmental Sustainability Program) to study algal integration into coupled and decoupled aquaponics systems. This project also involves operation of research aquaponics in regional high schools as well as systems operated at Auburn University. We will study the impacts of algae on nitrification, pathogen levels, and product quantity and quality. We have constructed and are currently operating 12 aquaponics systems at Auburn University and have constructed and delivered another 12 systems to regional high schools.

6) B. Higgins is the PI on a recently-funded NIFA SAS grant, "Re-imagining Controlled Environment Agriculture in Low-carbon World." This project involves 18 investigators across 5 institutions. Research areas include (among others): 1) Use of bioenergy for heating and cooling of greenhouses, 2) Use of wastewaters as fertilizer and water displacement, 3) Development of new plant and cultivation practices that reduce energy demand. Dr. Sushil Adhikari is a co-PI on this project.

7) Dr. Sushil Adhikari (in collaboration with RTI International) is working on producing hydrogen from municipal waste, coal and biomass using gasification technology. This project is funded by the US Department of Energy-NETL. The goal of this project is to produce 99.99% pure hydrogen and evaluate several syngas contamination technologies.

8) Dr. Sushil Adhikari (in collaboration with University of Delaware, New Mexico State University, Trinity College Dublin, Ireland and Department of Agriculture, Northern Ireland) is working on engineering biochar for phosphorus absorption and desorption. Dr. Hossein Jahromi is the Co-PI of this project. This project is funded by the USDA-NIFA (A1414).

9) Dr. Hossein Jahromi (Co-PIs: Drs. Sushil Adhikari, Brendan Higgins and Robert Jackson) is working on biolubricants production from waste cooking oil. This technology has been filed for patent and is funded by the USDA-NIFA (A1531).

10) Dr. Sushil Adhikari (Co-PIs Drs. Hossein Jahromi, Soledad Peresin and Paul Bartley) is working on using biochar for producing plant containers from downed timbers. This project will evaluate various biobased plastics and biochar for producing horticulture plant containers. This project is in collaboration with Tuskegee University. This project is funded by the US Forestry and Endowment Fund.

California

Research was conducted to produce polyhydroxyalkanoates (PHA) from cheese processing byproducts by using *Haloferax mediterranei*. Whey permeate and delactosed whey permeate (DLP) were studied as a substrate for growing *Haloferax mediterranei*. About 30% lactose consumed was converted into PHA, which was determined to be PHBV. *H. mediterranei* was acclimated to consume galactose and glucose in the hydrolyzed whey permeate and DLP. The bioreactors for cultivating *Haloferax mediterranei* were scaled up to 20 L. The PHA produced will be used to manufacture the food packaging materials.

Gluconic acid was evaluated as a novel pretreatment agent on wheat straw. Pretreatment was carried out over a range of gluconic acid concentrations (0.125M-1M) and a range of pretreatment temperatures (160-190□C) and durations (30-90 minutes), followed by enzymatic digestion of the pretreated solids. The sugar yields in stage 1 (pretreatment) and stage 2 (enzymatic digestion) were investigated. The overall xylose yield was highest at the condition of 0.125M gluconic acid, 170 ^{o}C, and 30 minutes. The overall glucose yield was highest at 190 ^{o}C and 0.5M gluconic acid. The overall glucose and xylose yield was highest at 170 ^{o}C, 0.5M gluconic acid. Hemicellulose hydrolysate, which was generated at the pretreatment using 0.125M gluconate at 170 ^{o}C for 60 minutes, was evaluated for ethanol production. The gluconate contained in the de-toxified hemicellulose hydrolysate can be fermented to ethanol along with other hemicellulose sugars present in the detoxicated hydrolysate. The pretreated solids can be effectively converted to ethanol using *Escherichia coli* AH003 via simultaneous saccharification and fermentation with the cellulase loading of 20 FPU/g cellulose.

We also investigated the production of cellobionate from the lignocellulosic substrate by the strain *Neurospora crassa* HL10. When Avicel was used as the substrate, the system was redox mediator limited. The addition of an artificial redox mediator led to higher cellobionate production. When NaOH-pretreated wheat straw was used as the substrate, adding an exogenous redox mediator was unnecessary because the lignin in the pretreated wheat straw could serve as the redox mediator. However, the amount of laccase produced by strain HL10 on pretreated wheat straw was relatively low, which led to slow cellobionate production. Cycloheximide successfully induced high-level laccase production in *N. crassa* HL 10. With the addition of 3 µM of cycloheximide, the strain *N. crassa* HL10 produced about 57 mM cellobionate from pretreated wheat straw containing the equivalent of 20g/L cellulose without the addition of any enzyme or redox mediator, and the conversion time was shortened from 8 days to 6 days. About 92% of the cellulose contained in the pretreated wheat straw is converted to cellobionate.

Hawaii

Khanal's Lab has been working on the use of the black soldier flies (BSF) (*Hermetia illucens*) to convert organic wastes including food wastes and agri-residues into BSF larvae for both animal feed and biodiesel production. We have been successful in maintaining native colony of BSF, developing effective mating chamber and producing larvae on diverse organic wastes/residues. We are currently working on process automation and scale-up, with a goal of developing zero waste insect-based biorefinery for valorization of waste and biofuel production.

Khanal's Lab has also been working on innovative anaerobic digestion (AD) biorefinery for highly complex feedstocks. The AD biorefinery concept have been developed using lignocellulosic feedstock to convert hemicellulose into biogas and cellulose and lignin into multiple products via thermochemical conversion. In another AD research, Khanal's Lab has employed ORP-based microaeration for anaerobic digestion/co-digestion of agri-residues, sewage sludge and food wastes. By combining reactor performance results, mass balance analyses, microbial community characterization data, and bioenergetics evaluation, an alternative pathway of volatile fatty acids conversion through synergistic association of anaerobic and facultative microorganisms, bypassing syntrophic reactions typically found in anaerobic digestion processes, has been demonstrated. This novel operational strategy can be applied as an effective process control approach for full-scale AD system at high organic loading rates, and offers significant economic and logistical merits.

Khanal's Lab continues to work on nitrogen transformations in aquaponics with nanobubble technology. Our study examines nitrogen utilization efficiency (NUE) under different hydraulic loading conditions, and pathways of nitrogen transformations via nitrogen-stable isotope and microbial community analyses. This study also looks at nitrous oxide (N2O), a highly potent greenhouse gas emission, and its subsequent contribution to global climate change. We have further expanded this research to incorporate nanobubbles technology to improve the productivity of fish and organic produce, and bioponics to include organic wastes as a nutrient source for food production.

Khanal's Lab has also been exploring production, characterization, and conversion of micro- and macroalgae for feed, fuel, and high value bioproducts applications. Our lab is exploring innovative technologies, including nanobubble technology and phase change materials for enhancing the performance of algal biomass productions. Additionally, we are exploring potential of algal biomass for various biomaterials production in collaboration with different research groups.

Su lab has made important advances in three research areas: (1) engineering a yeast-based microbial cell factory for producing high-value terpene products from sugar and lipid feedstocks; (2) development of a microbial fermentation process to defat and add proteins to insect (Black Soldier Fly larvae, BSFL) meals as unique aquatic feeds; and (3) value-added technology development of ground papaya seeds as a natural biofumigant for sustainable management of soil-borne plant pathogens. Under this broad umbrella of research undertaking, research in Su lab explored new opportunities in utilizing abundant but largely overlooked lipid wastes, as well as massive food wastes and niche ag byproducts as feedstocks for manufacturing of valuable products, and to use state-of-the-art techniques in systems and synthetic biology, metabolic engineering, protein engineering, microfluidics, and bioprocess engineering to fill the scientific knowledge gaps necessary for developing advanced microbial factories and bioprocesses that produce useful products from waste, and for establishing innovative/nonconventional applications of value-added products derived from renewable waste feedstock. This research will advance public welfare by developing innovative technologies to grow the economy in Hawaii while keeping our environment clean.

Du lab works on the lipid metabolism in photosynthetic organisms including plants and microalgae, as well as lipid biosynthesis and turnover in soil fungi and bacteria. A particular interest of the Du lab is to under the dynamic of the membrane and storage lipids and the role of lipid metabolism in development and stress response. Du lab is also interested in using engineering and synthetic approaches to produce valuable bio-products in microalgae and establish co-production systems with synthetic consortia of algae, bacteria, and fungi. Another project in Du lab is to develop research instruments such as environmental photobioreactors for algae incubation.

Illinois

Oilcane was developed as a feedstock for drop in fuel production. The lipid yield of of 0.20 tons/ha or 55% of total lipid was obtained from conditions in Florida. The vegetative tissues of the oilcane were processed to prevent lipid degeneration. This enables the oilcane to become a feedstock for biodiesel production using regular sugarcane production methodologies.

Purple stemmed Miscanthus x giganteus was evaluated as a source of anthocyanins. A green, chemical free pretreatment process was used to recover the anthocyanins. The pretreatment process improved enzymatic digestibility of the biomass and increased recovery of glucose by 2.1 fold. The anthocyanin stream could serve as an additional coproduct when converting miscanthus biomass.

Continuing educational efforts include a corn wet milling workshop offered to the grain processing industry and marketing and commodity groups. This workshop remains in high demand and fills to capacity during each offering. The workshop is now being offered twice yearly and has reached more than

500 industry representatives.

Kansas

We improved wet adhesion of plant protein-based adhesives through protein modification using depolymerized lignin and polyamide-epichlorohydrin (PAE). We conducted research on development of affordable, biodegradable, durable, disposable containers for food service utilizing biomass and biorefinery by-products. We evaluated the potential of hempseeds protein for plant protein-based adhesives. We also developed the technologies to convert cellulosic biomass and waste materials into biofuels and chemicals with improved yield and efficiency, technologies to treat and valorize the black liquor and hydrothermal liquefaction wastewater (HTLWW) for value-added products, and technology for lignin-based 3D printed wearable triboelectric nanogenerators for personal health.

14 peer-reviewed journal articles were published. 5 meeting presentation and invited presentation were delivered. 1 patent issued.

Kentucky

A lignin-based hydrogel was synthesized, and its impact on soil water retention was determined in silt loam and loamy fine sand soils. Hydrogel treatment significantly increased water retention at saturation/near saturation by 0.12 $cm^3\ cm^{-3}$ and at field capacity by 0.08 $cm^3\ cm^{-3}$ for silt loam soil compared to a control treatment with no added lignin hydrogel. Hydrogel application significantly increased water retention at -3 cm to -15,000 cm soil water pressure head by 0.01 - 0.03 $cm^3\ cm^{-3}$ for the loamy fine sand soil. Calculations demonstrated that at a 1% (w/w) concentration or lower, lignin-based hydrogels in silt loam and loamy fine sand soils would not increase plant available soil water storage. The incorporation of lignin-hydrogels significantly decreased saturated hydraulic conductivity. In unsaturated conditions, application of the lignin-based hydrogel at 0.1 and 0.3% (w/w) increased hydraulic conductivity. New pedotransfer functions (PTFs) for predicting saturated hydraulic conductivity were developed using machine learning (ML) and a large public database. Random forest regression and gradient boosted regression both gave the best performances with R2 =0.71 and RMSE = 0.47 cm h^{-1} on the validation data set. The concentration of lignin-alginate hydrogel added to *Rhizobial* cell culture did not affect cell survival. All treatments of wet bioencapsulated beads achieved a similar yield of 97%, however, the presence of starch in the lignin-alginate beads increased the survival of *Rhizobium* cells.

We developed and implemented a process-intensified approach for fermentative volatile fatty acids (VFAs) production from Brewer's spent grain (BSG), along with methods to enhance VFA yield and recovery through novel VFA extraction and esterification techniques enabled by green solvents and enzyme immobilization. These findings provide a potential solution to the sustainable utilization of BSG waste from the brewing industry.

Microalgae cells of *Haematococcus pluvialis* were immobilized using the edible fungal strain *Aspergillus awamori* for potential food applications. The study investigated the impact of fungal loading, pellet geometry, and initial microalgae cell concentration on the immobilization performance and product characteristics. It was found that higher fungal loading and larger fungal pellets contributed to increased immobilization performance while increased initial microalgae concentration inhibited the process. Larger fungal pellets had decreased biomass density, which led to decreased surface concentration of immobilized microalgae but deeper penetration within the pellets. Kinetic and equilibrium models were applied to allow for process prediction and manipulation of key operational parameters allowed the product composition to be tuned to desired criteria. This study provides new insights to the fungal-assisted microalgae immobilization process and demonstrates a novel application in bioproduct customization.

Bourbon, or whiskey, production in Kentucky has been estimated to double within the next five years and an increase in the main by-product from bourbon distillation, stillage. Stillage is composed mostly of water along with the fermented grains after distillation. Stillage is expensive to dispose of and difficult to store due to the high biodegradability, posing a risk to the environment given the low pH and high chemical oxygen demand (COD). Anaerobic digestion has been identified as a potential solution for stillage valorization, but little research has been performed. Stillage from different mash bills has varying physicochemical properties, total solids (TS), volatile solids (VS), pH, and minerals and macronutrients. Distilleries employ varying distillation parameters and coupled with the heterogeneous makeup of the stillage from mash bills, is thought to have an impact on the biomethane potential of stillage. With a minimum methane production of 291.17±3.45 NmL/g VS and a maximum methane production of 419.19 ± 2.61 NmL/g VS out of 10 stillage samples from four distilleries with a food to microbe ratio of 1 g VS/ g VS and an organic loading rate (OLR) of 10 g VS/L, mash bill and distillation parameters were determined to impact stillage biomethane potential.

Michigan

Dr. Carl Lira continued his work on improving spectroscopic methods for the study of alcohols in hydrocarbons (e.g. alcohols in petroleum) to provide association constant values for alcohols. Traditional models incorrectly predict liquid-liquid phase splitting for blends greater than about E13, which is more correctly modeled by our improved approach. Of note, ethanol blends show an increased incremental heat of vaporization as the last ethanol evaporates and our model captures this behavior. Four articles were published regarding this work in 2022 and 2023.

Minnesota

In attempt to produce clean syngas for liquid fuel production, we teamed up with other stations to integrate unique lignocellulosic feedstock preprocessing, gasification, and syngas cleanup steps. Biomass preprocessing involves dehydration and cleaning for a feedstock with low moisture, minimal impurities, high carbon efficiency, and high energy density. Microwave-assisted gasification (MAG) is employed, utilizing an effective microwave absorbent for improved heating rate, uniformity, and residence time. MAG eliminates the need for a gas carrier, resulting in syngas with higher energy density and at least 40% less nitrogen. The syngas is then cleaned using a catalytic reactor and cleanup units to remove tar, sulfur, and contaminants. Residual solids are converted to carbon monoxide (CO). Our technology will be verified using a proven liquid fuel production process compatible with biomass-derived syngas. We continue to develop a series of ZSM-5 zeolites with varying surface acid density and pore structure to understand the relationship between catalyst structure and catalytic performance for plastic cracking. We discovered a non-linear correlation between Brønsted acid site density and catalyst lifetime. Initially, the lifetime declines with increased acid site density but then rises, indicating an intriguing pattern. Introducing mesoporosity extends the catalyst lifetime, and we designed a hierarchically structured ZSM-5 zeolite with improved performance due to more open channels and increased Brønsted acid sites.

Mississippi

Woody wastes, forestry residues and municipal solid waste are abundant in the southeastern United States. The conversion of these kind feedstocks to liquid biofuels could be benefit to the carbon capture, and also make biofuel competitive as an inexpensive biofuel additive if new or more efficient technology can be identified. If the proper integrated process can be developed, one dry ton of biomass feedstocks could produce around ten gallons of renewable aviation fuels.

North Dakota

Concrete is used globally due to its useful mechanical and durability properties. However, concrete requires a massive amount of cement, which is the second-largest source of carbon emission (5-7% of global CO_2 emissions) due to its high energy consumption. The gelatinization effect of corn starch as a binder has been explored in the place of cement in concrete. However, there is a need to optimize the various processing conditions to enhance the material strength of the corn starch-based material known as CoRncrete. Two experiments were conducted to optimize the ratio of sand, starch, water, curing temperatures, and time. The compressive and tensile strength of the CoRncrete samples were analyzed. The results showed that the optimum processing conditions having a sand grain size of 0.250-0.425 mm, a mixture ratio of starch, water, and sand 1:1:5, and curing temperature and time of 110 °C and 24 h can yield a maximum compressive strength up to 18.9 MPa. Statistical analysis revealed that the size of sand grains and curing temperatures had the most significant impact on the material's strength. Microstructural analysis, employing scanning electron microscopy (SEM) and micro-computed tomography (microCT), unveiled numerous internal pores and cracks within the hardened cubic blocks, which significantly decreased the strength. Consequently, future investigations should concentrate on reducing internal pore spaces and cracks to enhance the durability of CoRncrete.

Plastics are synthesized from petroleum products that are nonrenewable and not biodegradable, leading to environmental and public health challenges. Although polylactic (PLA) based biomaterials have been identified as alternatives, they are expensive. One way to reduce PLA cost is to blend with starch. However, PLA is not readily mixed with starch due to their contrasting water behavior. We evaluated the impact of lecithin as a compatibilizer in polylactic acid and starch film at different component ratios aside the lecithin that remains constant. A solvent casting method was used to produce the films. The properties of the films were analyzed using mechanical performance test, thermal test (Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis), scanning electron microscope (SEM) analysis, Fourier Transform Infrared Spectroscopy as well as water related analysis (water absorption, contact angle and solubility). The Results show that inclusion of lecithin in PLA/starch composite leads to enhanced mechanical properties compared to the composite without lecithin. The DSC analysis such as the Tg, Tc, Tcc and Tm was relatively stable among the films but the thermograph of PLA/starch display two peaks whose distance is impacted by lecithin. In addition, SEM and FTIR revealed that the addition of lecithin improved the interfacial adhesion between the two polymers. This was observed through the influence of lecithin on the positioning and dispersion pattern of starch granules and distinct transmittance characteristics of the FTIR. The improved compatibility of PLA/starch makes the resulting films less susceptible to water penetration and dissolution. In summary, this work demonstrated the possibility of using lecithin as emulsifier between PLA and starch which could expand the application of PLA/starch film especially in packaging industries and bale net wrapping.

Ohio

Our focus was on waste valorization, primarily through hydrothermal carbonization of the high moisture waste to produce hydrochar for different applications.

Oklahoma

Development of Biological Gas Conversion Processes for Fuels and Chemicals (Atiyeh): Dr. Atiyeh's team has made progress in advancing gas fermentation for converting syngas and CO2 into biofuels and biobased products. The growing interest in reducing greenhouse gas (GHG) emissions and carbon capture has renewed attention on technologies like biological CO2 conversion. The team has developed a method to convert CO_2 into various products, including alcohols, contributing to GHG reduction and waste stream utilization. The team evaluated five gas fermentation strains, including *Clostridium Carboxidivorans* P7, *C. ragsdalei* P11, *C. muellerianum* P21, and strains A and B isolated in Oklahoma. These strains demonstrated the ability to convert syngas and CO_2 into alcohols and fatty acids. Strain P21 exhibited promising results, producing multiple alcohols and acids from CO_2 with varying inocula pre-grown on different substates. Further optimization is needed to enhance growth, productivity, and selectivity of these strains. The team is also working on refining tools for designing and controlling large-scale bioreactors to improve alcohol productivity, selectivity, and gas utilization. Several methods, detailed in recently awarded U.S. Patents (US 10,640,792; US 10,053,711; US 10,017,789), have been developed to support these efforts. Additionally, one paper has been published in a high-impact peer-reviewed journal, and the project has contributed to the training of one Post-Doc and one PhD student.

Production of Jet Fuel Intermediates from Biomass and Carbon Dioxide by a Novel Co-Fermentation Process (Atiyeh): Dr. Atiyeh's joint team from Oklahoma State University and Ohio State University has made significant progresses in the development of a high-yield butanol production process based on a unique co-fermentation approach. This method involves converting biomass-derived sugars and gas into butanol, showing an increase in product yield by over 15% and reduced CO_2 emissions compared to traditional methods. The team also utilized CRISPR-based gene editing to engineer Clostridium carboxidivorans for metabolic optimization. They successfully developed lignocellulose-derived microbial inhibitory compounds (LDMIC)-tolerant strains of *Clostridium beijerinckii* and *C. carboxidivorans*, which led to growth and ABE production even in the presence of inhibitory compounds. Furthermore, the team's co-fermentation approach is detailed in a recent U.S. Patent (US 11,180,779). We conducted a life cycle environmental impact comparison between petroleum and corn-based butanol/jet fuel production and the switchgrass-based traditional ABE fermentation, showcasing the eco-friendliness of their novel process. The project's achievements include the publication of four papers in high-impact peer-reviewed journals, the awarding of one patent, and the submission of another patent application. The project has also provided training opportunities for one Post-Doc, two PhD students, and one MS student.

Pennsylvania

Following outcomes have been obtained by the various co-PIs for Objective B:

Co-PI: Tom Richard - The patent pending process of thermophilic alkaline anaerobic digestion was tested with several new feedstocks including prairie grass mixtures, corn stover, and winter rye biomass. A new two-stage digester design was also tested and is patent pending. A research publications characterizing the microbiomes and their biochemical activity using under a wide range of conditions is in development, integrating results from proteomics, transcriptomics, and metagenomics.

Co-PI: Ali Demirci - The project to produce hydrolytic enzymes production from distillers dried grains with solubles (DDGS) for cellulosic biomass hydrolysis for biofuels and other uses have been completed. In this phase the study, the effect of dilution factor, agitation, and aeration in 2 L bench-top bioreactors was evaluated with A. niger and dilute acid-treated DDGS slurries and comparison of common carbon sources with unhydrolyzed, dilute acid and steam hydrolyzed DDGS for lignocellulolytic have been evaluated for the enzyme productions by fungal strains and also the fermentation parameters were optimized in 2 L benchtop bioreactors as well as effect of microparticles have been studied. In a different study, Interactions of torrefaction and alkaline pretreatment with respect to glucose yield of hydrolyzed wheat straw. With a collaboration with Akdeniz University in Turkey, kinetic modeling, sensitivity analysis, and techno-economic feasibility of ethanol fermentation from non-sterile carob extract-based media in Saccharomyces cerevisiae biofilm reactor under a repeated-batch fermentation process.

Co-PI: Howard Salis - Engineering organisms to convert biomass resources into bioproducts requires fine control over its gene expression levels, for example, to add new metabolic pathways and maximize carbon and energy flows through existing metabolic pathways. We've developed improved models for predicting and controlling gene expression levels utilizing biophysics and machine learning, including a "Multi-Sigma Promoter Calculator" and version 2.0 of a "mRNA Stability Calculator". We recently applied the models to express plastic-degrading enzymes in marine bacteria that grow in saltwater. We developed a web interface to the models, which have been used to design over 1,000,000 genetic systems.

Co-PI: Jeffrey Catchmark - Optimized a pure starch-based paperboard barrier coating that can replace low density polyethylene (LDPE) laminates and Per- and polyfluoroalkyl substance (PFAS) coatings on food packaging and other packaging products. This was done in conjunction with several companies who wish to commercialize the product. Optimized a manufacturing process for producing a starch foam based hemostatic wound care product. Worked on a new textile coating that imparts both water and oil resistance that could replace Per- and polyfluoroalkyl substance (PFAS) coatings on clothing, upholstery, carpeting and other such products. Began working on soilless systems for agriculture and plant production.

Co-PI: Stephen Chmely - We have continued our work on biomass fractionation and 3D printing with lignin. We developed a new catalytic system based on mixed-metal oxides that catalyze the transfer hydrogenation of lignin using biomass-derived ethanol. This has the potential to substantially enhance the carbon footprint of the fractionation process by using earth-abundant catalysts and biomass-derivable reagents. Our 3D printed objects containing lignin have varying degrees of mechanical performance compared to non-renewable controls, but we are working on modification reactions to enhance their performance properties.

Co-PI: Juliana Vasco-Correa - We have built a lab-scale solid-state bioreactor design to treat dilute methane emissions with mixed cultures, envisioning a biobased system that can be commercialized as a product and that benefits economically from carbon markets. We have experimentally assessed methods for enrichment of said culture. We have also developed a process model for the soli-state bioreactor based on first principles and are currently working on integrating microbial modeling into the process model. We have experimentally assessed the feasibility of small-scale on-farm pelleting.

Co-PI: Sibel Irmak - Our team continued on working on developing biodegradable polymers from biorenewable materials that can be used in agriculture for various purposes. We also continue to perform research on developing novel catalysts for hydrothermal conversion of woody biomass to hydrogen in higher yields with an economically feasible approach. The catalysts developed so far have been testing on utilization of dead trees in Pennsylvania forests for hydrogen gas production.

Co-PI: Hojae Yi - We continued to work on intensifying the lignin-first fractionation process using a continuous reductive catalytic reactor in which the solvent and milled biomass are fed continuously at the same time. We aim to develop an engineered biomass fractionation reactor design that can be scaled up with minimal issues.

South Dakota

SD station developed various effective technologies to utilize different biomass feedstocks for syntheiszing biomaterials, nanocomposites, and other bioproducts.

The PI Dr. Lin Wei focused on developing effective and affordable biochar-based control release fertilizers (BCRNFs) to improve the sustainability of agricultural production by utilizing agriculture and forest residues/wastes, energy crops, and other renewable resources. He has established a pilot sale BCRNF production line for commercialization the technologies to promote local economy and increase farmer incomes. The new technologies reduced environmental impacts while improving precision agriculture sustainability by applying BCRNFs in different crop productions (e.g., corn, wheat, etc.) The new technologies produced healthy and safe foods and functional bio-products by using co-products or wastes from bio-refinery industries.

The Co-PI, Dr. Kasiviswanathan Muthukumarappan worked on development of bioresins from soybean oil and renewable composites from thermoset resins, and feed pellet processing of Camelina and Carinata meal.

The Co-PI, Dr. Zhengrong Gu developed various biomass conversion technologies for applications in bioenergy, food safety, and agricultural productions. The project included: Activated carbon pad to deliver glucosinolates and myrosinase enzymes to extend the shelf-life of strawberries; Separate Glucosinolates from non-food oil-seeds as value added co-products and improve nutrition value of oil-seeds as animal feed; Biorenewable graphene from new thermochemical biorefinery process, etc.

Tennessee

Dr. Labbé has spear-headed the development of technologies for the conversion of whole lignocellulosic biomass into hydrophobic films, fractionation of hemicellulose for prebiotic ingredient formulation in chicken feed applications, and nanolignin production for omniphobic additives in thermoformed molded fiber containers. The overall goal of Dr. Labbé's research program is to achieve complete utilization of lignocellulosic biomass and develop biobased alternatives to petrochemical-derived chemicals, fuels, and polymeric materials.

During the previous project period, Dr. Labbé investigated the effect of hemicellulose pre-extraction at different hot water pretreatment severity in order to improve lignocellulosic biomass dissolution in ionic liquids and subsequently regenerate hydrophobic thin films. This research showed that hemicellulose pre-extraction at 160 °C for 90 min led to the enrichment of cellulose by 39% and lignin by 140% in hybrid poplar wood when compared to pretreatment durations of 0, 20 and 60 min. The resulting biomass dope with ionic liquid (1-ethyl-3-methylimidazolum acetate) was 50% more viscous and formed 26% denser films, upon anti-solvent regeneration, with slit shaped pores. These films exhibited a water contact angle exceeding 100° and less than 1% shrinkage when exposed to moisture; both properties make them ideal for biobased hydrophobic applications in sensors, multiphase composites, and smart devices.

Dr. Labbé's main focus is valorizing all components of lignocellulosic biomass. Hence, the hemicelluloses removed via hot water pre-extraction in the previous research were subsequently used for developing prebiotic ingredients. Prebiotics are indigestible dietary fibers that promote gut health. Hemicelluloses extracted via hot water at 160 °C for 60 min from hybrid poplar, pine wood, and switchgrass biomass were enriched in oligosaccharides (degree of polymerization, DP = 2 to 6) by 7 – 13% and polysaccharides by 70%. High throughput *in vitro* growth rate assays using probiotic bacteria and their sugar consumption kinetics showed that *Lactobacillus* spp. preferentially consumed xylooligosaccharides, whereas Bifidobacteria consumed galactose and *Bacteroides* spp. consumed mannooligosaccharides leading to a growth rate exceeding 8.6 $\log_{10}$ cells/mL. Thus, hot water extracted hemicelluloses have immense potential to function as prebiotic ingredients.

Finally, in the previous year, Dr. Labbé also investigated the potential for developing nanolignin based omniphobic coatings for thermoformed molded fiber products. Her team developed chemically modified lignin micro- and nano-particles that coated fiber products at 100 nm thickness, and imparted water contact angle exceeding 125° and oil contact angle of at least 40°. Such omniphobic biobased coatings have huge potential to replace the harmful "*forever chemicals*" (per- and polyfluoroalkyl substances or PFAS) routinely used in disposable dinnerware. Further research is undertow with Georgia Tech. to improve the technoeconomic feasibility of lignin isolation from black liquor, as well as downstream incorporation of functionalized nanolignin additives via partnership with regional molded fiber manufacturers (Genera Inc., Vonore, TN).

Dr. Li contributed to four peer-reviewed journal publications by collaborating with colleagues at Oak Ridge National Laboratory, Sha'anxi Normal University, and Nanjing Forestry University. His group primarily contributed the knowledge and characterization techniques in lignin structural elucidation, including ultraviolet spectrophotometry, Fourier transform infrared spectroscopy, and one- and two-dimensional NMR spectroscopies.

Dr. Li's group also have made progress in the lignin-derived biodegradable copolymers and nanocellulose-derived functional groups. Recent results showed that lignin with a higher molecular weight and aliphatic OH favors copolymerization, leading to lignin-*g*-PCLs with longer PCL arms. Moreover, lignin incorporation improves thermal stability, hydrophobicity, and UV-blocking ability but reduces the lipase hydrolyzability of the copolymers. We also demonstrated that lignin-*g*-PCL-coated filter paper could successfully separate chloroform–, petroleum ether–, and hexane–water mixtures with an efficiency up to 99.2%. The separation efficiency remains above 90% even after 15 cycles. The structural differences of copolymers derived from the fractionation showed minimal influence on the separation efficiency. This work provides new insights into lignin-based copolymerization and the versatility of lignin valorization.

The food-grade cationic surfactant, ethyl lauroyl arginate (LAE), was used to modify CNC for emulsion stability improvement. We contend that the LAE reduced the electrostatic repulsion by partially neutralizing the CNC surface charge and increased its packing density around the droplet interface. The CNC/LAE and cinnamaldehyde mixture formed an oil-in-water Pickering emulsion with an average droplet size of 5.54 µm. The emulsion-added films led to significant inhibition of microbial growth of *E. coli*, *S. aureus,* and *B. cinerea*. Moreover, there was no significant adverse effect on the films' mechanical properties, water vapor permeability, or solubility with 1% and 2% emulsions added. Lastly, the antimicrobial films with 2% emulsion inhibited the deterioration rate of strawberries by 52.2%. The CNC-LAE-cinnamaldehyde Pickering emulsions-added films demonstrate a promising application for antimicrobial food packaging.

Dr. Harper's global research objective is to reduce the impact that energy production has on the environment. We accomplish this by engineering lignin-based carbon fibers that selectively capture carbon dioxide from mixed gas streams. We address USDA's program priority by adding significant value to lignin, a nonfood coproduct of paper and biofuel production, while reducing carbon emissions. Lignin is primarily produced in rural areas, and the addition of a high value product adds to rural economies. Specifically, we have 1) synthesized non-woven carbon fiber fabrics and activated carbon with high surface areas (>3,200 m^2/g). The activated carbons have been modified to produce functional nano particles, Carbon Quantum Dots (CQDs). We have demonstrated that fibers (LACFs) decorated with carbon quantum dots (CQDs) 2) selectively capture carbon dioxide gas from combustion processes by tailoring adsorption sites of LACFs to exploit the much larger quadrupole moment of carbon dioxide relative to other flue gases, such as nitrogen and oxygen. 3) We employ a high-throughput modeling effort will identify optimal CQD architecture (size, functionality and extent of heteroatom doping) for target LACF/CQD membranes based on a binding strength indicator; 4) the top candidates will be synthesized and tested for adsorption selectivity. Future modeling work will be informed and refined iterative by analytical analysis. We will test the hypothesis that we can synthesize LACF/CQD membranes tailored to achieve carbon dioxide selectivity, performance, and cost-point for large-scale deployment. By testing this hypothesis, we gain a fundamental understanding into the processing-structure-property-performance relationship of LACF/CQD resulting in the development of a practical membrane.

We will leverage this research to train graduate and undergraduate students to use the methods described to rapidly develop biomaterials by combining modeling and experimental methods to determine processing-structure-property-performance relationships. In turn, we will strive to have stakeholder involvement to guide materials development and student training.

Dr Wang's group investigates approaches to utilize less energy and water in the manufacture of nano lignin. Conventional ultra-fine grinding, one the most popular methods to produce nanolignin, not only uses a lot of water but also consumes vast amount of energy to grind and separate lignin from the suspension. To decrease energy and water consumption, Dr. Wang proposed an ultrafine friction grinding method that works at a high concentration of lignin suspension, which could address the challenges of producing nanolignin at low solids content. In this research, we investigated the energy efficiency and particle size distribution of LNPs produced at four different solid concentrations (1, 20, 30 and 40 wt. %). Our results show that the 20% solid concentration had the best energy efficiency performance for the same particle size requirement (~150 nm), with 3.1 kWh per kg of nanolignin produced, which is much lower than the energy required for process at 1 wt. % (30 kWh). This means we can save up to 90% energy and use very little water (only 5%) if we adopt this technology. Morphology analysis shows that under ultrafine friction grinding process, the lignin particles undergo substantial changes in both their particle size and morphology, which could be used in much wider applications.

Dr. Hayes formed bicontinuous microemulsion-based delivery systems composed of biobased oils (e.g., isopropyl myristate and limonene) for delivery of antimicrobial peptides to chronic wounds that possess activity against several bacteria that are prominent in skin.

Texas

The TAMU Group is designing an in-motion pyrolyzer that is attached to a commercial corn, sorghum and silage combine for immediate conversion into biooil and biochar with the syngas to be used as fuel for the pyrolyzer. The TAMU group is also designing a unique pyrolyzer to convert MSW, plastics and rubber tires into fuels that will eb used to run a gas turbine and generate electrical power. The biochar will be used as carbon capture and sequestration (CCS) material. The TAMU groups is also designing a high-rate anaerobic digestion (AD) system with solids separation system that will convert dairy manure into biogas with the sludge being used as composted materials. Likewise, composted feedlot manure will be gasified to generate electrical power and biochar for CCS studies as well.

Virginia

1) Developed a thermochemical process to convert switchgrass into high-value sodium-ion battery anodes.
2) Designed a fermentation process to convert food waste into renewable 2,3-butanediol.
3) Completed preliminary experiments for the encapsulation of enzymes in alginate beads for the biocatalytic conversion of biomolecules in flow mode, as opposed to batch mode

Washington

We continued to develop industrially relevant processes and catalysts to convert lignin to sustainable aviation fuel (SAF) using fixed bed continuous hydrotreating reactors and colloidal catalysts via one-step catalytic depolymerization-hydrodeoxygenation. Our team has demonstrated the Ru-based catalyst synthesis at larger scale with industrial partner's support (Advanced Refining Technologies). We have demonstrated continuous HDO lignin to LJF for the first time, achieving high yields of LJF from alkali lignin. An estimated 65% of the mass ended up in the jet fraction after distillation, which removed molecules contributing to the predicted low flash point and high viscosity at -40 °C. Additional work is needed to provide more detailed predictions to corroborate the above distillation comment.

Outcomes related to Objective C. [Perform system analysis to support and inform development of sustainable multiple product streams (chemicals, energy, and materials) and use the insights from the systems analysis to guide research and policy decisions]

Alabama

B. Higgins is engaged in process model development (mass balance and nutrient transformation) and life cycle assessment of the the algal-bacterial-zooplankton process to upcycle anaerobic digestate nutrients into fish feed. The outcome of this effort is to identify "hot spots" within the system that could benefit from improvements that reduce the environmental footprint of the facility. The efforts have also identified unit operations that contribute most to losses of nutrients and water.

Yi Wang is working with collaborators to perform the Life Cycle Analysis (LCA; EcoEngineers in Des Moines, Iowa) and Techno-Economic Analysis (TEA; Dr. Haibo Huang from Virginia Tech) on the fatty acid ester production process. The results provide essential evidence that demonstrates the sustainability and economic viability for the bioprocess for ester production.

California

Decisions to build biopower facilities, like those for most other infrastructure developments, occur within a complex framework of technical, environmental, ecological, social, political, financial, and economic considerations. With data and prior experience often limited, modeling to explore sensitivities to solution alternatives can be employed to help support the decision processes. Biomass resources associated with the extreme tree mortality in California and elsewhere throughout the U.S. and the world currently constitute a primary ecological concern but also represent opportunities to increase renewable energy supplies as part of improved management approaches. A decision support system (DSS) model was developed for lifecycle techno-economic and environmental assessments quantifying the potential impacts of electricity generation.

The web-based Forest Resource and Renewable Energy Decision Support System (FRREDSS) provides site-specific project development guidance on potential feedstock availability as well as estimated economic and environmental performance. The model enables users to assess short- and longer-term feedstock availability and potential economic feasibility and environmental impacts for biopower facilities. The current resource database derives from the USFS national data collection for the Sierra Nevada region of California.

The spatial analysis integral to the model yields proximity to feedstock, landings, and road networks, along with estimated delivered costs of feedstock at the facility and overall levelized cost of energy (LCOE) as electricity transmitted to the nearest substation. The spatial analysis includes related attributes, including defined fire hazard zones where wildfire mitigation, particularly within wildland-urban interface areas, may have relevance to project siting. Details of the model are included in Li (2022), Li et al. (2023a), and Yeo et al. (2023). The model provides preliminary information to help inform more detailed engineering, environmental, and other studies critical to the final determination of overall project feasibility and decisions to proceed. The model is flexible toward future enhancements to expand the types of facilities considered, the available resource data and resource uncertainties, and many other factors influencing decision outcomes.

Case studies critically examine the ability of the model to predict costs and benefits for the use of forest resources (Li, et al., 2023b). For combinations of forest treatments and harvesting systems selected, LCOE ranges from $135 to $575/MWh of electricity generated when modeling a 25 MWe facility using a conventional boiler-steam cycle, and from $183 to $588/MWh for a 3 MWe gasification facility, the latter having access to feed-in tariffs in California ranging up to about $200/MWh. Optimization based on a minimum feedstock delivered cost objective function reduces the LCOE and can be effectively realized at lower computational intensity and time than needed for complete evaluation over the full resource dataset by using a partial geospatial search technique employing an expansion factor method developed for this purpose (Li, et al., 2023b). Due principally to the differences in harvest and transportation costs, the optimized solution may source feedstock from a substantially different distribution than for the proximity-defined solution. Substantial environmental benefits in the form of reduced or net negative greenhouse gas emissions are projected to be achieved from utilizing forest resources to generate electricity as compared to conventional open pile burning for disposal and from the displacement of grid electricity given the current mix of nonrenewable and renewable sources in the state, suggesting additional economic benefits from carbon credits. Other incentives may apply in recognition of the increasing need for more dispatchable renewable energy complementing the large and increasing generation from solar and wind resources.

The FRREDSS model is currently being imbedded as part of a larger integrated digital marketplace implementation to add additional and improved local resource quantification and spatial data. The marketplace tool will also extend the lifecycle environmental analysis. Other model enhancements are in development, including more detailed uncertainty and financial risk assessment estimates, supply competition analyses, other conversion systems and product types, user-contributed feedstock opportunities, automated (AI) interpreted image processing, and recognition for improved feedstock quantity and property estimation, among others.

Michigan

Dr. Chris Saffron's group investigated a decentralized biofuel system consisting of pyrolysis depots to make partially upgraded bio-oil for subsequent hydroprocessing in centralized refineries for hydrocarbon production. Fast pyrolysis bio-oils are partially upgraded in the depots using electrocatalytic hydrogenation and deoxygenation, which is powered by renewable electricity. Life cycle assessment reveals how this system can become "carbon negative" when using corn stover as a feedstock. Lower land use, i.e. smaller land areas, are needed when using the decentralized pyrolysis system when compared to centralized cellulosic ethanol. Water use and eutrophication are also lower when compared to cellulosic ethanol, owing to higher conversion yields. Finally, an economic analysis revealed a pathway of system improvements that lead to minimum hydrocarbon fuel selling prices below $2.60 per gallon of gasoline equivalent when collecting a 10% internal rate of return. Electricity cost was the most sensitive variable, as decreasing purchased electricity prices from 6.56 cents/kWh to 3 cents/kWh decreased the minimum fuel selling price by 65 cents/gallon of gasoline equivalent.

Missouri

Global seafood production is 392 billion lbs/yr, with 192 billion lbs/yr provided by aquaculture. U.S. seafood catch amounts to 9.3 billion lbs/yr, with an additional 6.8 billion lbs/yr of seafood product imported. U.S. aquaculture production is 658 million lb/yr, currently totaling 7.1% of seafood catch but of growing importance. U.S. per capital seafood consumption is 42 lbs/person-yr, compared to 83 lbs beef, 112 lbs chicken and 67 lbs of pork. Life-cycle analysis (LCA) or embodied resource use (ERU) is frequently used to assess the impact of agricultural practices on the environment. Aquaculture net energy requirements range between 2.9-13.7 kw-hr/kg live-wt for recirculating aquaculture systems to as little as 0.1 kw-hr/kg direct + 1.5 kw-hr/kg embodied energy for extensive Asian catfish/tilapia ponds. Water usage in enhanced catfish aquaculture is estimated at 3,628 liters/kg at a net energy usage of 4.5 kw-hr/kg. Life-cycle analysis of a zero-discharge prototype RAS targeting production of 42,000 lb-bass/yr, suggests a water usage of 504 liters/kg at an energy consumption totaling 13.7 kw-h/kg-live wt. In contrast, embodied beef, pork, and poultry water usage is estimated at 7,700, 2,994 and 2,160 liters/kg-live weight respectively, at a livestock net energy requirement at 34, 14 and 5.0 kw-h/kg-live weight product. Literature values of intensive RAS GHG potential suggest 1.2-1.4 kg-C/kg-live-weight (2.4-2.8 kg-C/kg final product) with extensive pond production estimated at 0.4-0.5 kg-C/kg-live. Life-cycle analysis of a mid-Missouri climate-controlled zero-discharge recirculating fish production system suggests a water usage/kg at 6.5%, and GHG emission rate at 14.4% per kg as compared to beef production.

Nebraska

Simulation modeling combined with applied statistics facilitates evidence-based decision-making to guide policy analysis. This ongoing project aims to develop an integrated modeling framework of the Corn-Water-Ethanol-Beef (CWEB) nexus as a tool for decision-making that can also be an educational resource to foster systems thinking. The CWEB also provides an interesting case to study circularity. This project centers on a specific case study around a corn-based ethanol biorefinery in Nebraska to analyze the transition to a more circular system. The simulation provides insights to discuss what happens if we move one step closer to or away from circularity.

North Dakota

The ruminant rumen houses hyper-ammonia-producing bacteria (HAB) that produce ammonia with minimal energy use. Here we developed a mimicry process to produce bio-ammonia, a solution of ammonia and ammonium. The rumen microbes were used to ferment soybean (SYB), soybean protein isolate (SPI), and pepsin-hydrolysate (HP) for bio-ammonia production. The maximum bio-ammonia produced from SYB, SPI, and HP were 0.65, 1.2, and 1.1 g/L, respectively. The presence of non-protein in SYB hindered bio-ammonia production and the processing of SYB to SPI and HP significantly ($p < 0.05$) increased bio-ammonia production. HP was converted to bio-ammonia quicker than SPI suggesting that enzymatic hydrolysis increases bioprocessing efficiency. Metagenomic analysis of a sample culture revealed that the HAB population is predominantly Klebsiella quasivariicola (73%), Escherichia coli (6%), and Enterobacter cloacae (6%). The bioprocessing steps developed would enable industrial ammonia production to achieve a low CO_2 footprint.

Ohio

We conducted TEA and LCA of different agricultural and biobased systems including lactic acid production from lignocellulosic feedstocks, integrated farming system for crop production, application of biomass mulches for grape vine protection during winter, crop monitoring using unmanned aerial systems, shallow geothermal heat exchanger system for greenhouses, feedstock logistics system for corn stover and pennycress, and production of different biofuels and bioproducts.

Pennsylvania

Following outcomes have been obtained by the various co-PIs for Objective C:

Co-PI: Tom Richard - Experimental and modeling efforts were completed that increase understanding and enhance synergies between profitable on-farm biomass production, advanced conversion technologies, and innovative market products. Academic and private sector collaborations provided important new results document the ecosystem service values of perennial energy grasses and energy winter crops for water quality in the Chesapeake Bay region as well as the Upper Mississippi Basin watersheds in Iowa.

Experimental and modeling research quantified carbon offset benefits in forest and cropland bioenergy systems.

Co-PI: Juliana Vasco-Correa - We have developed superstructure-based optimization deterministic and stochastic models for the assessment of the economic feasibility and uncertainty of emerging routes for lignin valorization with biological upgrading. We developed a techno-economic model of small-scale on-farm pelleting. We are currently working on techno-economic analyses and life cycle assessments of the methane biofiltration system and the anaerobic co-digestion of manure with lignocellulosic feedstocks.

Co-PI: Christine Costello - The Costello lab has developed a farm-scale life cycle assessment of a dairy farm to provide a platform to evaluate a variety of land cover changes, such as adding perennial grass species and/or winter cover, in relation to food-energy-water systems goals. Likewise, we have developed an LCA to evaluate duckweed cultivation and use on dairy farms. Finally, we have created a Materials Flow Analysis model for the Chesapeake Bay watershed to evaluate how nitrogen and phosphorous flows could be changed over the region given farm-level management choices.

South Dakota

SD station developed sensor/biosensors to improve food safety by utilizing biochar and nanocelloses and other biopolymer composites. SD station integrated AI, image processing, internet of thing (IoT) with bioprocessing technologies and food supply chains to improve decision making and production management practices."

Tennessee

Surface interactions with carbon materials can limit their utility. Dr. Harper's group is developing nano-particles from lignin to change the surface charge characteristics to allow for preferential binding of targeted molecules, such as CO_2, by combining computational models with analytical tools. Outcome: We have designed several nanoparticles, carbon quantum dots and magnetic nanoparticles, that allow for preferential binding of materials to carbon surfaces. Analytical and computational experiments confirm these new nanoparticles improve surface sorption of carbon dioxide, proteins, electrolytes, and pollutants for a host of new applications in medicine, energy, and environmental remediation.

Texas

The TAMU Group has incorporated life cycle analysis (LCA) and techno-economic analysis (TEA) in all of the projects implemented. Numerous circular economy concepts have been incorporated in all research and testing agreement projects such as: carbon footprint (CF), carbon capture and sequestration (CCS), and carbon intensity (CI). The group is following the ASABE Circular bioeconomy principles in all projects implemented.

Virginia

Conducted techno-economic analysis for evaluating the economic feasibility of converting to convert dried distiller's grain with soluble (DDGS) into antioxidant peptides.

Washington

The techno-economic analysis (TEA) of cellulosic ethanol biorefinery with coproduction of both PAN/lignin blend-based CFs and PHA using lignin from the cellulosic ethanol process is performed. The results show the effects of the price of PHA and Carbon Fiber on MESPs when all of the lignin produced by the ethanol plant is used to coproduce PHA and Carbon Fiber. When the selling price of Carbon Fiber is fixed, MESP changes little with the selling price of PHA, indicating that the selling price of PHA has little effects on MESP. When the price of PHA was fixed, MESP changed significantly with the change of the price of Carbon Fiber, indicating that Carbon Fiber had great effects on MESP. This is due to the high yield and price of Carbon Fiber, and its income has a greater impact on the income of the ethanol co-production PHA and Carbon Fiber plant. It is interesting to see that MESP becomes negative when Carbon Fiber is sold at more than $23 /kg, which means that the income generated by Carbon Fiber cannot even make the entire cogeneration plant lose money even when the ethanol has no market value.

Impacts

Alabama

AL station developed new bioprocess for biofuel and biochemical production; secured federal grants for further biomass and biochemical research, education and outreach; develop connections and collaborations with colleagues from other institutions and stations.

California

Conversion of cheese whey waste and wheat straw for lactobionic acid production can lower the cost of lactobionic acid production and reduce waste. Polyhydroxyalkanoates (PHA) is the fastest growing biodegradable bioplastic, with its production capacity expected to increase 9-fold by 2025 and its global bioplastic market share to expand to 11.5%. PHA has similar properties to thermoplastics and can be used in a wide range of applications, including packaging film and containers. Utilizing low-value lactose from large dairy manufacturing sites for PHA production is a scalable solution. The research can be used by others to develop alternative solutions for utilizing low-value co-product or waste dairy and other food byproduct streams. The development of the forestry biomass decision support application directly addresses Objective C/Task 2 to inform the development of sustainable product streams and to help guide research and policy decisions. California, in particular, but the western U.S. more generally, has experienced disastrous wildfires in the past several years that call for more extreme management strategies that benefit from the availability and development of bioenergy and bioproduct industries and improved decision tools to support feasible project development.

Hawaii

Khanal's Lab has been actively involved in renewable energy, environmental biotechnology, waste-to-resources research with focus on sustainability. Specifically, Khanal's research activities on bioconversion of organic wastes into bioenergy, high solids anaerobic digestion for waste remediation and bioenergy production, energy efficient anaerobic wastewater treatment process, micro-aeration-based AD process for enhanced bioenergy generation, high-value agriculture via aquaponics-bioponics, and algal biomass production for diverse applications, involved collaboration with several colleagues within the S1075. Several of the funded projects were through close collaboration with members of S1075.

Su lab's current work helped to advance the understanding of how underutilized renewable lipids can be utilized as an alternative carbon feedstock for producing useful biobased products. The study has an important positive impact on sustainable valorization of agricultural wastes/byproducts and development of bioeconomy.

Du lab has developed an efficient bio-flocculation method to harvest microalgae, using sustainable fungal mycelium that contains valuable biomass such as polyunsaturated fatty acids and essential amino acids. The method can significantly reduce the cost of harvesting microalgae and produce feedstocks for biodiesel and nutraceuticals. Du lab has contributed to the development of novel gene editing toolkits for microalgae such as marker-free CRISPR and overexpression systems, which are used for making high-value compounds such as terpenoids in microalgae. Du lab has developed a model of photobioreactors for algae cultivation and research.

Kansas

The enabling technologies of utilization of agriculture feedstocks and by-products developed for biobased materials and bioenergy are critical to our sustainable economic development. The new knowledge generated can be useful reference to both academia and industries in the field.

Michigan

Sustainable and carbon negative biofuels are needed to fuel the US light duty, heavy duty, airline, and marine fleets. Technoeconomic analysis and life cycle assessment reveal that decentralized pyrolysis-electrocatalytic hydrogenation depots, followed by centralized hydroprocessing, has significant potential for making such biofuels.

Minnesota

Production of current major biofuels, i.e., biodiesel and ethanol, is competing with food and feed demands, prompting the need to use non-food biomass feedstock for biofuel production. Our work on pretreating animal manures to produce effluent suitable for microalgae and vegetables to grow would have significant impact on alternative biomass production. Thermochemical conversion of lignocellulosic biomass feedstock is a platform which can provide short and mid-term solutions. The major challenges for thermochemical conversion are the poor quality and stability of the products. Our work on microwave assisted catalytic conversion of biomass and plastic wastes has improved the yield and quality of bio-oil and syngas. These outcomes have positive impacts on the overall technical and economic performance of thermochemical conversion technologies. Our research projects provided opportunities to undergraduate graduate students and junior researchers to participate in experimental work, data collection, processing and analysis, and scientific writing and presentation. Many of our findings have found their way in classroom teaching. Our mass cultivation and thermochemical conversion facilities were used for demonstration to stakeholders.

Mississippi

When fossil fuel (none renewable fuel) prices rise, the broader public will start to find clean energy alternatives (renewable fuel). It is not just for the environmental benefit, but also in hopes of eventually saving fuel expense. The broader public will get benefit in the reasonable fuel cost based on our biorefinery process.

Missouri

Development of life cycle analysis and resource effectiveness of aquaculture; Research activities related to production of biodegradable polyester polymers from dairy processing wastes and lignocellulosic biomass, solvent systems for improving digestibility of cellulose pulp and lignin valorization

Montana

Since wheat is the major cash and food crop in the Northern Great Plains, it is not feasible to replace wheat acres with camelina for sustainable aviation fuel feedstock production. We use camelina as a rotational crop for wheat. In order to make camelina a profitable crop, variety development and genetic improvement is needed, along with the cropping systems optimization.

We found that nitrogen is the largest energy input and production cost, which affects the energy balance and profitability of feedstock production system. We are currently focused on national selection and/or genetic modification of high NUE traits to improve camelina oil yield and NUE. Plant growth promotion soil micro-organisms are also studied to promote camelina growth.

For sugar beet research, Chen's group continues to study fertility and no-till practice for sugar beet feedstock production, because tillage and nitrogen are the high energy costs and high environment impact practices, which will affect the sustainability of biomass feedstock production.

Ohio

Through S-1075 project we provided opportunities to collaborate with researchers from different institutions and assembled expertise from wide range of researchers on solving problems of common interest.

Oklahoma

Oklahoma's research revolutionizes gas fermentation technology for efficient and eco-friendly biorefineries, driving economic growth through intellectual property. The tools developed streamline production mechanisms and operational costs, while also enabling applications in biopolymers and biobased chemicals, fostering economic and environmental benefits. Furthermore, our novel biocatalytic conversion process has far-reaching effects, transforming grasses like switchgrass into butanol, a jet fuel intermediate, with reduced CO2 emissions and higher yields than traditional methods. Additionally, its potential extends to the jet and fossil fuel sectors, as replacing 25% of U.S. jet fuel consumption with biobased butanol could yield over $800 million in local community benefits, a value poised to increase with rising global aviation fuel demand.

Pennsylvania

Having the ability to rapidly assess emerging conversion technologies toward developing systems that are economically and environmentally sustainable. Implementation of economically viable and sustainable processes is urgent due to three converging issues: decrease in productive agricultural land; using unsustainable methods to clear land for agricultural production and increasing world population. These intersecting problems is so vast that constructive solutions can only be developed and implemented through collaborations. Innovating engineering tool sets to design and operate reliable biomass handling equipment based on first-principle that can be applied at industrial scale and help minimizing down time due to handling issues. Replacing existing petroleum-based energy and products with those that are stemming from biomass and other agricultural products will require research and development. Incorporation of renewable polymers in materials used for additive manufacturing will provide the materials are generally less expensive than those derived from petroleum, so there would be an immediate cost benefit. Furthermore, creating analytical frameworks, guided by life cycle assessment, to identify best practices and support the agricultural sector in relation to policy-relevant assessment and metrics.

- Eight graduate students (5 PhD 3 MS) and 35 undergraduate students participated in the project.

- Published 12 conference papers/posters/presentations and 1 peer-reviewed journal paper.

- Updated our research website to reflect the research results and newest knowledge of biomass conversion and bioproduct development at: https://lw9898.wixsite.com/linweiwebsite .

Tennessee

Professor Womac continued to contribute significant research findings through refereed articles that dealt with fundamental issues of biomass logistics. The research utilized novel research devices for evaluating cotton module technology and terminal velocity of individual biomass particles suspended in fine-tune-adjusted vertical air streams. The target audience learns of the prescriptive details required to supply and convert biomass into useable products. The impact is to reduce the risks associated with the deployment of biomass supply/logistics and conversion technologies. Reducing this risks is based on creating biomass supply chains that yield predictable quality and quantity of raw ingredients for conversions that produce positive economic outcomes for the served sectors and industries. To do this, TENNESSEE tackles a wide range of problems involving improved field production, enhanced identification of biomass properties, alternative logistics supply systems, and improved conversion processes.

Dr. Labbé is working in conjunction with biorefineries namely Rayonier Advanced Materials (RYAM, Jesup, GA), and Genera Inc. (Vonore, TN), as well as the Georgia Institute of Technology to develop sustainable and scalable technologies for utilizing lignin and hemicellulosic co-products. Dr. Labbé's research program is also designed to reach a wider audience through extension and educational activities targeting the industry stakeholders and general public. A survey was conducted amongst 1034 US consumers in 2022, aged 18 to 55, to assess their knowledge about USDA approved biobased products and harmful chemicals commonly used in consumer products like PFAS. Based on the survey results, Dr. Labbé's team will launch widespread outreach activities in 2023-24 to disperse information about the harmful effects of PFAS, and to educate the general public about the ongoing research efforts in industry and academia to develop eco-friendly biobased alternatives. Dr. Labbé's team has also launched a summer mini course in Energy Science & Engineering, which taught 6 graduate students, in May-June 2023, to effectively communicate their research in biomass conversion and bioproduct development. The promotional videos produced by these students will be posted on YouTube and subsequently, efforts will be made to widen the reach of the students' work through social networking and mass media communications.

Dr. Li's group made significant impacts to the academia, industry, and the public in the past year. Dr. Li's group have contributed 4 publications in high-tier and peer-reviewed journals and 6 technical presentations at international conferences; Dr. Li has also mentored 3 graduate students and 2 undergraduate students. One undergraduate has been hired by Oak Ridge National Laboratory as Science Associate after spending about 3 years in Dr. Li's group in assisting in bio-derived products research. The other undergraduate student has been awarded the Advanced Undergraduate Research Activity Fellowship in the Summer 2023. PhD student Kailong Zhang has been recognized as the 2023–2024 Oscar Roy Ashley Graduate Fellowship of the University of Tennessee. One graduate student has received the University of Tennessee

Student/Faculty Research Award 2022-2023. Lastly, Dr. Li has obtained funding support from Tennessee Corn Promotion Board for his project of catalytic converting corn into value-added chemicals.

Mitigating climate change's most extreme potential effects from fossil fuel burning requires unprecedented global carbon sequestration. The materials used for carbon capture must be renewable, economically feasible, abundant, and recyclable, able to recover the adsorbed gas. Carbon quantum dots (CQD) are evaluated as materials to decorate the interior pore space of model carbon surfaces to achieve selective carbon dioxide adsorption from gas mixtures. Dr. Harper's group accomplished making lignin-based fibers. Electrospinning of fibers has been inconsistent because of environmental conditions in the lab. Carbon quantum dot production has increased. We can produce CQD's with and without nitrogen doping from a top-down approach. Preliminary results demonstrated that a chemically activated lignin surface has higher sorption capacity than commercial carbon materials. We have activated melt-blown hardwood lignin carbon fibers. We used an activation procedure that was optimized for softwood-based lignin. The result was only marginally successful. We used classical molecular dynamics (MD) simulation to evaluate the effect of CQD size and composition on the selectivity of CO_2 relative to N_2 and O_2. The CQDs are modified through nitrogen doping the interior aromatic structure or functionalization of the edges with amine groups. CQDs show selective adsorption for CO_2 relative to N_2 and O2 in all cases. The magnitude of the selectivity is a function of CQD size and the amount of doping and functionalization. In this exploratory study, a maximum CO_2:N_2 selectivity of 4.3 and CO2:O2 selectivity of 3.1 were obtained on isolated CQDs at 300 K without structural optimization. This preliminary computational study sets the framework for optimizing the CQD atomic architecture on a CQD/AC adsorbent.

Newly developed greener process makes it possible to prepare lignin nanoparticles inexpensively and use much less energy and water, which greatly facilitates the large-scale application of LNPs. Dr. Wang's work shows that various grades of LNPs can be produced by controlling the number of grinding cycles and lignin concentration. Lignin nanoparticles may be used in material industry, food packaging, agriculture, batteries and medical industry.

Texas

The following are the impacts of the TAMU developed thermal conversion technologies:

a. Reduction of wastes generation in food and animal industry

b. Cleaner environment coupled with the production of sustainable biofuels and biomaterials

c. Addresses global warming and circular economy

d. Mitigation of greenhouse gas emission

e. Addresses sustainable development goals that recognize ending poverty while improving health and education, reduce inequality and spur economic growth while tackling climate change and working to preserve our oceans and forests.

Virginia

The developed thermochemical and fermentation processes have the potential to advance the bioeconomy efforts of S1075. The developed flow biocatalysis processes have the potential to advance the bioeconomy efforts of S1075.

Target Audience

Alabama

1. Academic researchers and university/college students.
2. Engineers, Scientists, Industries, and Policymakers.
3. K12 students

California

The target audience includes stakeholders involved in the deployment of biofuel systems and researchers participating in biofuel and bioenergy investigations. The research findings and decision support tools can be used by extension and other academic investigators, government policy makers, and private developers to develop and disseminate knowledge about possible environmental impacts and economic implications for biofuel systems and to assist in specific policy and investment decisions. In addition, researchers in the field can use insights of the work to further advance the methods and approaches for enhanced decision support and sustainability assessment.

Hawaii

Biobased industry, farmers, processors, scientists, and policy makers, high school, undergraduate and graduate students

Illinoi

Scientists working in the area of energy crop production and conversion, industries developing and improving the sustainability of crop utilization for biofuels, biochemicals, biomaterials and food ingredients.

Kansas

Crop growers, farmers, companies will be the immediate beneficiaries of the investigation by finding new applications of soybean meals, oils and its derivatives for adhesives and coatings, agricultural feedstock processing industries, resin and biobased fuel related industries. Oilseeds and biomass related farmers and industris will also benefit from this study to find a way to utilize their products. The general public will benefit from the results, because biobased adhesives and fuels are environmentally friendly. In addition, the findings from this project will advance the bioadhesives and biofuel knowledge base and stimulate future developments within the biobased adhesive and biofuel industry. In addition, biomass and bioenergy industries will be the immediate beneficiaries of the advanced technologies for biofuel production.

Michigan

The target audience included academia, high school students, and local stakeholders with interests in biofuels, biochar, life cycle assessment and technoeconomic analysis.

Minnesota

Our research findings were publicized to the academic community through peer-reviewed publications and conference presentations. On-site demonstrations were conducted to showcase our results to a broad range of audience including academic researchers, government officials, funding agencies, students, entrepreneurs, and the general public. Some research findings were brought to classroom teaching. Graduate and undergraduate students were involved in the research projects.

Mississippi

Commercial biomass growers, waste management companies and fuel manufacturers will get benefit based on the research of waste gasification, gas reforming, and syngas conversion to liquid biofuels and /or value-added chemicals. If the integrated process is feasible and economical, they will get the technique in patents.

Montana

Oilseed producers, sugar beet producers, bioenergy and bioproduct processors, scientific communities.

Nebraska

Ag Policy makers and Ag Sustainability researchers.

Ohio

The target audiences for this reporting period were scientists, engineers, and representatives from academia, industries and agricultural commodity groups attending professional scientific conferences, meetings, and workshops.

Oklahoma

The target audiences include biofuel and biobased product producers, waste to energy producer, government officials involved in bioenergy policy, farmers interested in biomass production, researchers, and undergraduate and graduate students interested in bioenergy. Other target audiences include chemical, petrochemical, agricultural, biotechnology and environmental industries interested in the conversion of waste streams, coal or natural gas to carbon monoxide, carbon dioxide and hydrogen followed by biological conversion to useful products.

Pennsylvania

The target audiences for this proposed research include the science and engineering research community; biomass processing companies ranging from small start-ups to large multi-national companies; policy analysts and decision makers; potential biomass producers; bio-industry, environmental/water resources/ecosystems managers, waste managers, and the general public. Stakeholders include state and national organizations, state and federal agencies, companies and industry consultants.

South Dakota

The target audience includes research professionals, undergraduate and graduate students, farmers and biomass producers, government agencies, and industrial processors.

1. Professionals in the research community: We are targeting agricultural engineers and biomass processing scientists. An understanding of our research results will help them develop hypotheses and effective processes that will advance their own research programs. We will target these individuals through peer-reviewed publications and presentations at scientific and professional meetings.

2. Undergraduate and graduate students: Undergraduate students are targeted through lab classes and/or summer internship programs. The research program will help them prepare for graduate school or a career in biomass production or processing. Graduate students are targeted by directly participating in research activities for their thesis/dissertations. These students will get professional training to prepare them for their careers, in not only in academia, but also agriculture, food, energy, and biorefinery industries.

3. Farmers and biomass producers: This audience is targeted because biomass feedstocks will be supplied by farmers. They are targeted through formal and informal classroom instruction (many undergraduate students will choose agriculture, food, energy, and biomass production as an occupation) and extension/outreach activities.

Tennessee

Womac: Biomass producers, cooperatives, consultants, extension, and general biomass logistics industry

Li: Academia, universities, some related industries

Abdoulmoumine: Target audience includes the scientific community, technology developers, and industry stakeholders with biomass thermochemical conversion processes in their technology platform.

Hayes: Vegetable and specialty crop growers, agricultural plastic manufacturers, scientific community

The target audience also includes the readership of the journals listed below and the professional conferences and workshop attendees. The journals include Carbon, with a readership of scientists and engineers among many disciplines who use carbon-based materials, ACS Sustainable Chemistry and Engineering, with an audience interested in sustainable chemistry, ChemistryOpen, with a broad audience interested in chemistry; and ACS Omega, with a broad audience interested in chemistry. The conferences and workshops include the American Chemical Society (ACS) and the American Institute of Chemical Engineers, which include chemists, material scientists, and many other scientists from cross-disciplinary fields. Further, industrial producers of lignin and fractionation technology (Domtar, Valmet, Sweetwater, Genera Inc., Rayonier Inc.), producers of carbon materials (General Graphene), and industrial emitters of carbon dioxide (Eastman Chemical, Volkswagen, TVA), and other end users (Poultry and animal feed industry, Sustainable aviation fuel industry are the target audiences.

Texas

Target audience for this project include the following: a) Faculty, researchers, and extension specialists; b) farmers and ranchers; c) commodity teams (cotton, corn and soybean group); d)Students (graduates and undergraduate students)

Virgina

Waste management companies, biomass farmers and processors, battery companies, manufacturers of chemicals and pharmaceuticals.

Related Publications

Journal Articles

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2) Ma, Y., Liu, S., Wang, Y., Wang, Y., Processing wet microalgae for direct biodiesel production: optimization of the two-stage process assisted by radio frequency heating. International Journal of Green Energy 2023, 20, 477-485.

3) Xing, D., Li, X., Wang, Y., Deng, S., Jin, C., Zhao, Y., Guo, L., The comprehensive impact of phosphorus sources on microalgae biochemical metabolism and phosphorus transformation. Journal of Water Process Engineering 2023, 51, 103477.

4) Kalvakaalva, R., M. Smith, S.A. Prior, G.B. Runion, E. Ayipio, C. Blanchard, D. Wells, D. Blersch, S. Adhikari, R. Prasad, T. Hanson, N. Wall, B.T. Higgins. 2023. Mass-Balance Process Model of a Decoupled Aquaponic System. Journal of the ASABE (in press).

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10) Poulami Roy, Hossein Jahromi, Tawsif Rahman, Jonas Baltrusaitis, El B. Hassan, Allen Torbert, Sushil Adhikari. 2023. Hydrotreatment of pyrolysis bio-oil with non-edible carinata oil and poultry fat for producing transportation fuels. Energy Conversion and Management. Vol. 245, pg. 107753.

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12) Poulami Roy, Hossein Jahromi, Tawsif Rahman, Sushil Adhikari, Farshad Feyzbar-Khalkhali-

Nejad, Tae-Sik Oh. 2022. Understanding the effects of feedstock blending and catalyst support on hydrotreatment of algae HTL biocrude with non-edible vegetable oil. Energy Conversion and Management. Vol. 268, 115998

13) Hossein Jahromi, Tawsif Rahman, Poulami Roy, Sushil Adhikari. 2022. Hydrotreatment of solvent-extracted biocrude from hydrothermal liquefaction of municipal sewage sludge. Energy Conversion and Management. Vol. 263, pg. 115719.

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Thesis and Dissertations

1) Tawsif Rahman, Ph.D. Biosystems Engineering. Biocrude production from biomass and plastics via hydrothermal liquefaction for fuel and chemicals. December 2022.

2) Poulami Roy, Ph.D. Biosystems Engineering. Hydrotreatment of biomass and waste derived hydrothermal and pyrolysis liquid intermediates to produce fuels and lubricants. December 2022.

3) Bryan Holt, M.S. Biosystems Engineering. Developing and optimizing micro-resolution mosquito bite blocking textiles. Spring 2022.

4) Li, K. 2022. Integrated economic and environmental modeling of forest biomass-to-electricity in California. Unpublished M.S. thesis, University of California, Davis, California.

5) Kyle Rafael Marcelino (M.S.). "Application of nanobubble technology in floating raft aquaponics." (Summer 2022).

6) Renisha Karki (M.S.). "Anaerobic co-digestion with cow manure and coffee pulp: Evaluation of process instability." (Summer 2021).

7) Jikai Zhao. 2022. Minimizing water consumption for biofuel and bioproduct conversion from lignocellulosic biomass. PhD Dissertation, Kansas State University.

8) Dmitri Mataya. 2023. Development of an Integrated Biological Wastewater Treatment System for the Full Utilization of High. University of Minnesota

9) Leilei Dai. 2023. Catalytic microwave-assisted pyrolysis of waste plastics for fuels and chemicals. University of Minnesota

10) Ozlem Karakas. 2023. Thermochemical conversion of algal biomass and agricultural plastic waste to fuels and materials Nitrogen Livestock Waste. University of Minnesota

11) Gautam, S. 2022. Selection of camelina genotypes growing in different nitrogen regimes for nitrogen use efficiency. M.S. Thesis. Montana State University.

12) Tulip, Shibli. 2023. Optimizing the Comprehensive Strength of a Corn-based Construction Material. MS Thesis. Proquest.

13) Lumu, Stuart. 2023. Optimization of Drying and Storage Conditions of Floral Hemp for Cannabinoids Extraction. MS Thesis. Proquest.

14) Adeniyi, Adewale. 2023. Development of Bioprocessing for Biological Ammonia Production. MS Thesis. Proquest.

15) Rahul Thunuguntla, Ph.D. Biosystems Engineering, Oklahoma State University, 2018 - 2023. Dissertation: Enhancing C1 Gas Fermentation Efficiency for C2-C6 Product Formation Using Novel Acetogens: a Comparative Analysis of Medium Formulations, Biochar Application, Inoculum Preparation, and Bioreactor Strategies. July 2023

16) Battisto, E. 2022. Additive manufacturing of sustainable composite materials containing cellulose nanomaterials. (Ag and Bio Engineering). Pennsylvania State University.

17) Jefferson, T. 2023. Modeling the hop pelleting production process for small scale Pennsylvania growers. M.S Thesis. Pennsylvania State University. University Park, PA.

18) Li, Zhaoran. 2022. Optimization of Hot Water Pretreatment of Switchgrass for Acidogenic and Anaerobic Digestion. M.S. Thesis. Pennsylvania State University

19) Suresh, S. 2023. User-centered design and construction of a modular biofilter system for reduction of greenhouse gas emissions. M.S Thesis. Pennsylvania State University. University Park, PA.

20) Madison A. Oehler, Encapsulation of Antimicrobial Peptides in Bicontinuous Microemulsions for Topical Delivery to Surgical Site Infections and Chronic Wounds, MS, Biosystems Eng, Univ Tennessee, 2022

21) Ekramul Ehite, Ph.D., Major Advisor: Abdoulmoumine. Title: Examining the relationship between lignocellulosic biomass structural constituents and its flow behavior.

22) Ross Houston, Ph.D., Major Advisor: Abdoulmoumine. Title: Understanding lignin's fast pyrolysis through examination of the thermolysis mechanisms of model oligomers.

23) Anton F. Astner, Analysis of Physicochemical Properties and Terrestrial Dynamics of Mechanically Formed Micro- and Nanoscaled Particles from Agricultural Plastic Mulches, PhD, Biosystems Eng, 2022

24) Fritria. Ph.D. Thesis: "Understanding the Roles of Mineral Matter in Biomass Processing to Biofuels", Washington State University, Richland, Washington, April 2023.

25) Can Liu, Ph.D., Biosystems Engineering, University of Kentucky, 2023. Dissertation: A process intensification approach to improve volatile fatty acids production, extraction, and valorization, https://uknowledge.uky.edu/bae_etds/105/

26) Adjuik, T.A. Ph.D., Biosystems Engineering, University of Kentucky, 2022. Dissertation: Exploration of lignin-based superabsorbent polymers (hydrogels) for soil water management and

as a carrier for delivering Rhizobium spp.

27) Suvro Talukdar (M.S.), Biosystems Engineering, University of Kentucky, 2023. Microalgae Immobilization with Filamentous Fungi: Process Development for Sustainable Food Systems. August 2021 to May 2023.

28) Danielle Hockensmith (M.S.), Biosystems Engineering, University of Kentucky, 2023. Impact of Physicochemical Characteristics and Distillation Parameters on the Biomethane Potential of Bourbon Stillage. August 2021 to May 2023

29) Lopez, Gary, (M.S.), Biosystems Engineering, University of Kentucky, 2023. Densification of Hemp Floral Biomass Pre and Post-Extraction: Determination of Pellet Physical Characteristics. https://uknowledge.uky.edu/bae_etds/96

Presentations

1) K. Badr, L. Murphy, Y. Wang, J. Wang. Understanding the redox shift in a Clostridium tyrobutyricum mutant strain for butanol production through genome-scale metabolic modeling. 2022 AIChE Annual Meeting. Phoenix, AZ. November 13-18, 2022.
2) Y. Wang. Engineer Clostridium for renewable fatty acid ester production. Clostridium XVI-International Conference. Institut National des Sciences Appliquées, Toulouse, France, September 14-17, 2022 (Delivered virtually).
3) Higgins, B.T., A. Fallahi, Q. Wang. 2023. Identification and destruction of algal growth inhibitors in anaerobic digestate. International Conference on Bioprocess and Sustainability. Tsukuba, Japan. March 25-26.
4) Rezaei, S., D. Cline, B.T. Higgins. 2022. Investigation of Decoupled Algal-biofloc Aquaponics Technology for Deployment in Food Deserts. AU College of Agriculture Research Symposium. Auburn, AL. Oct 20.
5) Arthur, W., Z. Morgan, D.E. Wells, D.V. Bourassa, B.T. Higgins. 2022. Bioponic system for nutrient recovery from poultry processing wastewater. AU College of Engineering Research Symposium. Auburn, AL. Oct 20.
6) Arthur, W., Z. Morgan, D.E. Wells, D.V. Bourassa, B.T. Higgins. 2022. Bioponic system for nutrient recovery from poultry processing wastewater. AU College of Agriculture Research Symposium. Auburn, AL. Oct 20.
7) Higgins, B.T., S. Rezaei. 2022. Investigation of decoupled algal-biofloc aquaponics technology for deployment in food deserts. AU Aquaponics Symposium. Auburn, AL. Sep 29.
8) Higgins, B.T., S. Adhikari. 2022. Insights from year 1 of the REU Site: Research experience through collaborative teams in bioprocessing for conversion of waste into products of value. ASEE NSF EEC Grantees Conference. Arlington, VA. Sep 22-23.
9) Higgins, B.T., M. Thomas, S. Sprague. 2022. Using molecular tools to discover organisms responsible for taste and odor episodes in a drinking water reservoir. Alabama Water Resources Conference. Orange Beach, AL. Sep 7-9.
10) Arthur, W., M. Reina, L. Orellana, A. Urrutia, A.P. Jackson, S. Kitchens, K.S. Macklin, S.B. Price, B.T. Higgins, D.V. Bourassa. 2022. Microbiological survey of wastewater and solids from poultry processing plants after DAF treatment. Poultry Science Association Annual Meeting. San Antonio, TX. Jul 11-14.

11) Wang, Q., B.T. Higgins. 2022. A long-term outdoor algal culturing study using high-strength anaerobic digestate (oral). International Meeting of American Society of Agricultural and Biological Engineers. Houston, TX. Jul 17-20.
12) Wang, Q., Alireza Fallahi, Alan E. Wilson, B.T. Higgins. 2022. Engineered algal systems for the treatment of anaerobic digestate: a meta-analysis (poster). International Meeting of American Society of Agricultural and Biological Engineers. Houston, TX. Jul 17-20.
13) Manish Sakhakarmy and Sushil Adhikari. Depolymerization of lignocellulosic biomass via pyrolysis. College of Agriculture Graduate Poster Showcase, Auburn University. October 20th, 2022. Poster Presentation
14) Ashish Bhattarai, Ayden Kemp, Sushil Adhikari and Oladiran Fasina. Conversion of household plastics, biomass and coal into hydrogen using fluidized-bed gasification. 10th Annual Graduate Engineering Research Showcase, Auburn University, October 20th, 2022. Poster Presentation
15) Tawsif Rahman, Hossein Jahromi, Poulami Roy, Ashish Bhattarai, and Sushil Adhikari. Valorization of plastic waste by catalytic hydrothermal liquefaction. 10th Annual Graduate Engineering Research Showcase, Auburn University, October 20th, 2022. Poster Presentation
16) Poulami Roy, Tawsif Rahman, Robert Jackson, Hossein Jahromi and Sushil Adhikari. Biomass-based catalyst development for the conversion of non-edible vegetable oils to fuel-range hydrocarbons College of Agriculture Graduate Poster Showcase, Auburn University. October 20th, 2022. Poster Presentation
17) Hossein Jahromi and Sushil Adhikari. Ecofriendly biolubricant production from waste cooking oil and lignocellulosic biomass-derived oxygenates. American Society of Agriculture and Biological Engineers (ASABE) Annual Meeting. July 17-20, 2022.
18) Tawsif Rahman, Hossein Jahromi, Poulami Roy, Sushil Adhikari. Influence of red mud catalyst and reaction atmosphere on hydrothermal liquefaction of Algae. American Society of Agriculture and Biological Engineers (ASABE) Annual Meeting. July 17-20, 2022.
19) Poulami Roy, Hossein Jahromi, Sushil Adhikari and Tawsif Rahman. Understanding the synergistic effects of feedstock blending and catalyst support on hydrotreatment of algae HTL biocrude with non-edible vegetable oil. American Society of Agriculture and Biological Engineers (ASABE) Annual Meeting. July 17-20, 2022.
20) Ashish Bhattarai, Sushil Adhikari, Oladiran Fasina, Ayden Kemp, Haley Mason. Household plastics and coal feedstock into hydrogen using fluidized-bed gasification. American Society of Agriculture and Biological Engineers (ASABE) Annual Meeting. July 17-20, 2022.
21) Wang, J., Kasuga, T., Fan, Z.,. Cellobionate Production from Sodium Hydroxide Pretreated Wheat Straw by Engineered Neurospora crassa HL10. 45th Symposium on Biotechnology for Biomaterials, Fuels and Chemicals, Portland, OR, May 2023
22) Marcelino, K.R.,* Wongkiew, S., Surendra, K.C., and Khanal, S.K. Application of nanobubble technology in floating-raft aquaponics—updated findings. S-1075 Multistate Annual Meeting and the Symposium on Science and Technology Driving the Bioeconomy, July 13, 2023, Omaha, Nebraska, USA (2nd place, best poster).
23) Kwon, J.S.,* and Khanal, S.K. Optimization of cultivation parameters for R. oligosporus in local agro-industrial wastes for aquafeed applications. Multistate Annual Meeting and the Symposium on Science and Technology Driving the Bioeconomy, July 13, 2023, Omaha, Nebraska, USA (Poster presentation).
24) Lopchan Lama, S.,* Marcelino, K.R., Surendra, K.C., and Khanal, S.K. Application of biochar and nanobubble technology in aquaponic system. S-1075 Multistate Annual Meeting and the Symposium on Science and Technology Driving the Bioeconomy, July 13, 2023, Omaha, Nebraska, USA (Poster presentation).
25) Khan, M.,* Chuenchart, W., Surendra, K.C., and Khanal, S.K. Artificial intelligence-based modeling and optimization of anaerobic co-digestion with micro-aeration. S-1075 Multistate Annual Meeting and the Symposium on Science and Technology Driving the Bioeconomy, July 13, 2023, Omaha, Nebraska, USA (Poster presentation).

26) Chuenchart, W.,* Surendra, K.C., Khan, M., and Khanal, S.K. Time series machine learning application in anaerobic co-digestion of food waste and sewage sludge with microaeration. International Conference on Solid Waste 2023: Waste Management in Circular Economy and Climate Resilience (ICSWHK2023), May 31-June 03, 2023, Wan Chai, Hong Kong, China (Oral presentation).
27) Shitanaka T.,* Higa, L., Bryson, A., Bertucci, C., VandePol, N., Lucker B., Khanal, S.K., Bonito, G., Du, Z-Y. Flocculation of oleaginous green algae with Mortierella fungi. The International Conference on Algal Biomass, Biofuels, and Bioproducts. June 14, 2023. Waikoloa, Hawaii. (Oral presentation).
28) Shitanaka, T.,* Lowe, L., Marcelino, K.R., Kaur, M., Surendra, K.C., and Khanal, S.K. Harnessing nanobubble technology to alleviate oxygen deficiencies in Schizochytrium culture. College of Tropical Agriculture and Human Resources Showcase and Research Symposium (CTAHR SRS 2023), March 27, 2023, University of Hawaii at Manoa, Honolulu, Hawaii, USA (Oral presentation)
29) Chuenchart, W.,* Surendra, K.C., and Khanal, S.K. Application of Artificial Intelligence in Anaerobic Co-digestion with Microaeration. College of Tropical Agriculture and Human Resources Showcase and Research Symposium (CTAHR SRS 2023), March 27, 2023, University of Hawaii at Manoa, Honolulu, Hawaii, USA (Oral presentation).
30) Marcelino, K.R.,* Wongkiew, S., Surendra, K.C., and Khanal, S.K. Application of nanobubble aeration in floating-raft aquaponics. College of Tropical Agriculture and Human Resources Showcase and Research Symposium (CTAHR SRS 2023), March 27, 2023, University of Hawaii at Manoa, Honolulu, Hawaii, USA (Oral presentation).
31) Marcelino K.R., Shitanaka T., Surendra K.C., and Khanal S.K. * Application of nanobubble aeration in floating-raft aquaponics. 1st International Conference on Bioprocess and Sustainability (ICBS 2023), March 25-26, 2023, University of Tsukuba, Japan (Keynote speaker).
32) Hamada, S.,* Marcelino K.R., Surendra K.C., and Khanal S.K. Monitoring aquaponic systems remotely through a cloud network. Summer Undergraduate Research Experience Symposium (SURE 2022), July 29, 2023, University of Hawaii at Manoa, Honolulu, Hawaii, USA (Oral presentation).
33) Lopchan Lama, S.,* Marcelino, K.R., Surendra, K.C., and Khanal, S.K. Application of biochar and nanobubble technology in aquaponic system. College of Tropical Agriculture and Human Resources Showcase and Research Symposium (CTAHR SRS 2023), March 27, 2023, University of Hawaii at Manoa, Honolulu, Hawaii, USA (Oral presentation).
34) Khan, M.,* Chuenchart, W. Surendra, K.C., and Khanal, S.K. Artificial intelligence-based modeling and optimization of anaerobic co-digestion process. College of Tropical Agriculture and Human Resources Showcase and Research Symposium (CTAHR SRS 2023), March 27, 2023, University of Hawaii at Manoa, Honolulu, Hawaii, USA (Oral presentation).
35) Shitanaka, T.,* Lowe, L., Marcelino, K.R., Surendra, K.C., and Khanal, S.K. Ultrafine bubble aeration to improve biomass and lipid levels of Schizochytrium. 18th International Symposium of Fine Bubble Technology, December 21, 2022, Keio University, Japan (Oral presentation).
36) Lowe, L.,* Shitanaka, T., Surendra, K.C., Khanal, S.K. Physicochemical properties of air ultrafine bubbles generated using a ceramic membrane. 18th International Symposium of Fine Bubble Technology, December 21, 2022, Keio University, Japan (Oral presentation).
37) Du, Z. Co-production of high-value biomaterials using algae-fungi symbiotic system. Annual Meeting of the Phytochemical Society of North America, Jul 24-28, 2022, Blacksburg, Virginia, USA.
38) Shitanaka, T., Marcelino, K.R., Surendra, K.C., Du, Z.-Y., and Khanal, S.K. Carbon dioxide nanobubbles as a delivery system to enhance microalgal productivity. S-1075: Science and Engineering for a Biobased Industry and Economy, Research Meeting, July 15-16, 2022, Houston, Texas, USA (Poster presentation).
39) Chuenchart, W., Surendra K.C., and Khanal S.K. Application of machine learning on performance prediction of co-digestion with microaeration. S-1075: Science and Engineering for a Biobased

Industry and Economy, Research Meeting, July 15-16, 2022, Houston, Texas, USA (Poster presentation).

40) Marcelino K.R., Shitanaka T., Surendra K.C., and Khanal S.K. Application of air nanobubbles in floating-raft aquaponics. S-1075: Science and Engineering for a Biobased Industry and Economy, Research Meeting, July 15-16, 2022, Houston, Texas, USA (Poster presentation).

41) Khanal, S.K., Chuenchart, W., and Khan, M. Data-driven approaches for modeling anaerobic digestion. 17th World Congress on Anaerobic Digestion, June 17-22, 2022, Ann Arbor, Michigan, USA.

42) Khanal, S.K. Micro-aeration enhances methanogenesis and process stability. 17th World Congress on Anaerobic Digestion, June 17-22, 2022, Ann Arbor, Michigan, USA.

Chuenchart, W*., Surendra, K.C., and Khanal, S.K. Application of machine learning on performance prediction of co-digestion with microaeration. 17th World Congress on Anaerobic Digestion, June 17-22, 2022, Ann Arbor, Michigan, USA (Oral presentation).

43) Marcelino, K.R*., and Khanal, S.K. Nanobubble technology in aquaponics. 2021 International Conference on Sustainable Biowaste Management April 12-14, 2021, Hong Kong SAR, PR China (Oral presentation).

44) Chuenchart, W*., Karki, R., Surendra, K.C., and Khanal, S.K. Integration approach of anaerobic co-digestion and microaeration as an alternative solution for municipal organic waste management. 2021 International Conference on Sustainable Biowaste Management, April 12-14, 2021, Hong Kong SAR, PR China (Oral presentation).

45) Karki, R*., Chuenchart, W., Surendra, K.C., and Khanal, S.K. Anaerobic co-digestion of coffee pulp and cattle manure for enhanced biomethane production. 2021 International Conference on Sustainable Biowaste Management, April 12-14, 2021, Hong Kong SAR, PR China (Oral presentation).

46) Wang, X., Zheng, Y., 2023. Microalgal biomass enrichment induced by thermos-responsive polymers. ACS Spring 2023, Indianapolis, IN, USA.

47) Ding, L., Shi, J., Edmonson, A., Lin, Y., Zheng, Y., Wright, M.M., 2023. Understanding and mitigating sulfur variability in forest residues. 45th Symposium on Biomaterials, Fuels and Chemicals. Portland, OR, USA.

48) Liu, M., Shi, J., Zheng, Y., 2022. Bioleaching to produce clean loblolly pine for thermochemical conversion. 2022 ASABE International Meeting, Houston, TX, USA.

49) Wang, X., Zheng, Y., 2022. Unravel the nature behind the smart polymer-induced microalgal biomass enrichment. 2022 ASABE International Meeting, Houston, TX, USA.

50) Li, S., Liu, M., Zheng, Y., 2022. Amylolytic enzyme production of Thraustochytrium striatum from starchy substrates. 2022 ASABE International Meeting, Houston, TX, USA.

51) Saffron, C.M. "Biochar 101." Presentation given at the Biochar in Michigan Agriculture meeting hosted by the Great Lakes Biochar Network. July 17, 2023. Kalamazoo, MI.

52) Saffron, C.M.; Das, Sabyasachi; Sak, R.; Kasad, M. "Corn Stover to Electrobiofuels: Technoeconomics and Life Cycle Assessment." Presentation given at the ASABE Annual International Meeting. July 10, 2023. Omaha, NE.

53) Saffron, C.M.; Person, M. "Biochar." In the Weeds Podcasts. March 20, 2023. https://www.canr.msu.edu/field_crops/in-the-weeds

54) Saffron, C.M. "Technoeconomic and Life Cycle Assessment of Electrobiofuel Production." Webinar given at the Conference on Engineering Research Technology Innovation and Practice (CERTIP) conference. Nsukka, Nigeria. January 25, 2023.

55) Kasad, M.; Jackson, J.E.; Saffron, C.M.3 "Electrocatalytic upgrading of lignin derived oxygenated aromatic compounds to biobased cycloalkanes." Poster given at the USDA S1075 Multistate meeting and Symposium. Houston, TX. July, 2022.

56) Saffron, C.M. “Thermochemical Conversion Technologies for Biochar Production.” Webinar given for Forest Research and Development in collaboration with the U.S. Biochar Initiative and the Southern Regional Extension Forestry. May 19th, 2022.
57) Roger Ruan, Leilei Dai, Nan Zhou, Suman Lata, Yanling Cheng, Yunpu Wang, Yuhuan Liu, Kirk Cobb, Paul Chen, Hanwu Lei. 2023. Catalytic Microwave Assisted Pyrolysis of Organic Solid Waste for Energy, Fuels, Chemicals, and Materials Production. 2023 ASABE Annual International Meeting, Omaha, NE. 205 Recent Advancement in Renewable Energy Resources and Technologies, ES-Energy Systems Guest Speaker Session. July 11, 2023, Am.
58) Roger Ruan, Leilei Dai, Nan Zhou, Suman Lata, Yanling Cheng, Yunpu Wang, Yuhuan Liu, Kirk Cobb, Paul Chen, Hanwu Lei. 2023. Organic Solid Waste for Energy, Fuels, Chemicals, and Materials Production. 2023 Green Development International Symposium – Energy Transition and Innovation for Carbon Neutrality. Chongqing. June 10, 2023.
59) Roger Ruan, Leilei Dai, Dmitri Mataya, Junhui Chen, Suman Lata, Nan Zhou, Renchuan Zhang, Lu Wang, Yanling Cheng, Min Addy, Yunpu Wang, Yuhuan Liu, Ozlem Jarakas, Raissa Rossi, Kirk Cobb, Paul Chen, Hanwu Lei. 2023. Research Progress in Sustainable Solid and Liquid Waste Utilization for Circular Economy Development. Shihezhi University seminar. June 6, 2023.
60) Roger Ruan, Leilei Dai, Dmitri Mataya, Junhui Chen, Suman Lata, Nan Zhou, Renchuan Zhang, Lu Wang, Yanling Cheng, Min Addy, Yunpu Wang, Yuhuan Liu, Ozlem Jarakas, Raissa Rossi, Kirk Cobb, Paul Chen, Hanwu Lei. 2023. Sustainable Solid and Liquid Waste Utilization for Circular Economy Development. Huadong University of Technology seminar. June 5, 2023.
61) Roger Ruan. 2023. Research Progress in Solid and Liquid Waste Utilization and Food Engineering. Zhongkai Agricultural Engineering University seminar. June 4, 2023.
62) Roger Ruan, Leilei Dai, Nan Zhou, Suman Lata, Yanling Cheng, Yunpu Wang, Yuhuan Liu, Kirk Cobb, Paul Chen, Hanwu Lei. 2023. Catalytic microwave assisted pyrolysis of organic solid waste for fuels, chemicals, and materials production. International Conference on Solid Waste 2023: Waste Management in Circular Economy and Climate Resilience (ICSWHK2023), Plenary Speaker. Hong Kong, China. May 31, 2023.
63) Roger Ruan. 2023. Environmental Engineering and Biotechnology for a Sustainable Circular Economy Development. Opening speech at the 2023 International Joint Conference on Environmental Engineering and Biotechnology (CoEEB 2023). Malmo, Sweden. May 20, 2023.
64) Roger Ruan, Leilei Dai, Dmitri Mataya, Junhui Chen, Kirk Cobb, Nan Zhou, Renchuan Zhang, Lu Wang, Yanling Cheng, Min Addy, Paul Chen, Hanwu Lei. 2023. Innovative Solid and Liquid Waste Utilization for Sustainable and Circular Economy Development. Plenary Speaker at the 2023 International Joint Conference on Environmental Engineering and Biotechnology (CoEEB 2023). Malmo, Sweden. May 20, 2023.
65) Roger Ruan. 2023. Complete utilization of plastic waste for materials, chemicals, and hydrogen production for sustainable circular plastic economy development. Minneapolis South Rotary Club. Minneapolis, MN. May 9, 2023.
66) Junhui Chen, Leilei Dai, Dmitri Mataya, Kirk Cobb, Paul Chen, Roger Ruan (speaker). 2023. Enhanced treatment of anaerobic digestion effluent through efficient nutrient utilization using stepwise microalgal cultivation. The State of Water: 2023 Water Network Virtual Poster Symposium. University of Minnesota. April 19, 2023.
67) Roger Ruan, Leilei Dai, Dmitri Mataya, Junhui Chen, Kirk Cobb, Nan Zhou, Renchuan Zhang, Lu Wang, Yanling Cheng, Min Addy, Xiangyang Lin, Paul Chen, Hanwu Lei. 2023 Solid and Liquid Waste Treatment through Utilization for Circular and Sustainable Economy Development. Department of Agricultural Engineering Seminar, Northeast Agricultural University, Harbin, March 20, 2023.
68) Roger Ruan, Leilei Dai, Leilei Dai, Dmitri Mataya, Kirk Cobb, Paul Chen, Yanling Cheng, Xiangyang Lin. 2023. Novel Refining Systems and Processes for Biomass and Solid Waste to Energy Conversion. 2023 Biomass Refining Technology Forum, Zhenzhou, March 18, 2023.

69) Roger Ruan, Leilei Dai, Leilei Dai, Dmitri Mataya, Kirk Cobb, Paul Chen, Yanling Cheng, and Xiangyang Lin. 2023. Novel Systems and Processes for Waste to Energy Conversion. Global Energy Meet (GEM-2023) - Converting non-recyclable waste into Advanced Biofuels. Plenary Presentation, March 6, 2023.

70) Brune, D. E., Resource Utilization in Heterotrophic vs Autotrophic Marine Shrimp Production, Institute of Biological Engineers International Meeting, Athens GA, April 2022

71) Brune D. E., Resource Utilization in Heterotrophic vs Autotrophic Shrimp Production, ASABE Paper Number: 2200812, Annual International Meeting, July 2022

72) Brune, D. E., Resource Utilization in Heterotrophic vs Autotrophic Marine Shrimp Production, Presentation at North Central Regional Aquaculture Center Meeting, Eau Claire, Wisconsin, Feb 2023

73) Brune, D. E., Aquaculture Intensification and Embodied Resource Utilization, Institute of Biological Engineers International Meeting, Iowa State University, April 2023.

74) Brune, D. E., Aquaculture Intensification and Embodied Resource Utilization, American Society of Agricultural and Biological Engineers, Omaha NE. July 2023.

75) C Wan. Bioupcycling of Waste Streams into Polyhydroxyalkanoates: Opportunities and Challenges. 4th International Conference on Bioresource Technology for Bioenergy, Bioproducts & Environmental Sustainability, May 14-17, 2023, Lake Garda, Italy.

76) Hanwen Zhang, Nan Zhao, Shuhong Yang, Caixia Wan. Direct Induction of Porous Graphene from Lignocellulosic Biopaper for Multifunctional Electronics. Oral presentation, ASABE, July 9-12, Omaha, NE.

77) Hanwen Zhang, Shuhong Yang, Caixia Wan. Revealing Characteristics of Laser-induced Graphene in Relation to Lignin Structures. Poster, ASABE, July 9-12, Omaha, NE.

78) Qianwei Li, Caixia Wan. Simultaneous Biomass Fractionation and Xylan Conversion using Deep Eutectic Solvents. Poster, ASABE, July 9-12, Omaha, NE.

79) Qianwei Li, Yisheng Sun, Caixia Wan. Enzymatically Regulated Nanofibrillation of Lignocellulosic Biomass Pretreated by Deep Eutectic Solvents. Poster, ASABE, July 9-12, Omaha, NE.

80) Shuhong Yang, Hanwen Zhang, Caixia Wan. Low-defect laser-induced graphene derived from lignin. Poster, ASABE, July 9-12, Omaha, NE.

81) Krishanthi Mapa Mudiyanselage, Caixia Wan. Waste to Bioplastics: Medium-chain Polyhydroxyalkanoates from Waste-derived Organic Acids. Poster, ASABE, July 9-12, Omaha, NE.

82) Marcela Barbosa Meirelles Rezek, Dan Li, Caixia Wan. Development of Mixed-culture Fermentation of Soybean Meal for Improved Nutritional Values. Poster, ASABE, July 9-12, Omaha, NE.

83) Gautam, S., Chen, C. 2022. Selecting High Nitrogen Use Efficient Camelina Genotypes for Bioenergy Feedstock Production. Baltimore: 2022 ASA-CSSA-SSSA Annual Meeting.

84) Chen, C., Lim, C., Gautam, S., Franck, S., Etesami, M., Lu, C. 2022. Camelina Response to Nitrogen Fertilizer Input and Identification of High Nitrogen Use Efficiency Genotypes. Bozeman: 2022 AAIC Conference.

85) 2. A multimethod simulation to assess the value of circularity of a Corn-Water-Ethanol-Beef system. Corteva DELTA Symposium. Indianapolis, IN. August 07-09, 2023.

86) Galad, M., E. Monono, S. Sulaymon, N. Sarker. 2023. Modification of a 200-L Grain Conditioner to a Pilot Scale Vacuum Steam Pasteurizer. Paper No. 2300691 ASABE International Meeting Omaha July 09-12, 2023
87) Oyewole T., E. Monono, N. Sarker, 2023. Optimization of the refining process parameters of crude epoxidized soybean oil. Paper no: 2300526 ASABE International Meeting Omaha July 09-12, 2023.
88) Ajayi-Banji, I.O., Monono, E., Hellevang, K. (2023). Evaluating the Allowable Storage Time (AST) of Two Mature Soybean Varieties at Four Moisture Levels and Typical Storage Temperatures. Oral Presentation. ASABE International Meeting Nebraska July 9 -12, 2023.
89) Monono E. and N. Sarker. 2023. Silphium Seed: A Potential Bioenergy Crop. Paper No. 2300208. ASABE International Meeting Omaha July 09-12, 2023
90) Wilson, P., N. Sarker, E. Monono. 2023. Comparison of The Refining and Bleaching Conditions for Mechanical and Solvent Extracted Hemp Seed Oil. Paper No. 2300633 ASABE International Meeting Omaha July 9-12, 2023.
91) Huda, S., N. Sarker, E. Monono. 2023. Quality Assessment and Refining of Crude Distiller Corn Oil. Paper No. 2300535 ASABE International Meeting Omaha July 09-12, 2023.
92) Tazeen, H., Joice, A., Tufaique, T., Igathinathane, C. 2023. Net-Zero Agriculture: Challenges, Opportunities, and Tools Development. ASABE Paper No. 0806, Circular Bioeconomy Systems (CBS) Day Mini-Symposium Event, ASABE Annual International Meeting, July 9–12, 2023, Omaha, Nebraska.
93) Tazeen, H., Tufaique, T., Joice, A., Igathinathane, C. 2023. Transition to net-zero agriculture: Circular bioeconomy and renewable energy applications. Science and Engineering for a Biobased Industry and Economy. S-1075 Poster Abstracts and Presentation. July 13, 2023. "Travel award" awarded $570.
94) Hammed, A., Bello, I., & Adeniyi, A. (2023, April). Development of Bioprocessing for Biological Ammonia Production. In 45th Symposium on Biomaterials, Fuels and Chemicals. SIMB.
95) J. Tatum, A. Shah. 2023. Modeling to Minimize Energy Requirements for In-bin Drying of Different Grain Types in a Small-Scale Dryer for Developing Countries. ASABE AIM, July 9-12, Omaha, NE. [Poster]
96) J. Tatum, A. Shah. 2023. Design of Earth-to-Air Heat Exchange System for Season Extension in Commercial Greenhouse in Ohio. ASABE AIM, July 9-12, Omaha, NE. [Oral]
97) A. Khanal and A. Shah. 2023. Evaluating the life-cycle environmental impacts of whole-plant corn logistics for biobased industries. ASABE AIM, July 9-12, Omaha, NE. [Oral]
98) S. Dhakal, S. Khanal, A. Manandhar, A. Shah. 2023. Monitoring Surface Coal Mine Areas using Remote Sensing. 2023 CFAES Annual Research Forum. March 27-29, Columbus, OH. [Poster]
99) J. Tatum, A. Shah. 2023. Case study in applying techno-economic assessment methods for appropriate technologies for developing countries. ASABE AIM, July 9-12, Omaha, NE. [Oral]
100) A. Manandhar, I. Dami and A. Shah. 2023. Techno-economic analysis of using biomass mulches for winter protection of vineyards in Ohio. ASABE AIM, July 9-12, Omaha, NE. [Poster]
101) A. Manandhar, S. Khanal and A. Shah. 2023. Techno-economic analysis of implementing UAV technologies for crop health monitoring. ASABE AIM, July 9-12, Omaha, NE. [Poster]
102) A. Manandhar, I. Dami, A. Shah. 2023. Techno-economic analysis of using biomass mulches for winter protection of vineyards in Ohio. 2023 CFAES Annual Research Forum. March 27-29, Columbus, OH. [Poster] (Third place, Research staff category)
103) A. Timilsina, A. Shah. 2023. An introduction to Integrated Farm System Model (IFSM). IDEAS Wayne County Farmer Meeting, February 25, Wooster, OH. [Oral]

104) A. Timilsina, A. Shah. 2023. An introduction to Integrated Farm System Model (IFSM). IDEAS Western Ohio Farmer Meeting, February 11, New Bremen, OH. [Oral]

105) A. Manandhar, I. Dami, A. Shah. 2023. Techno-economic analysis of using biomass mulches for winter protection of vineyards in Ohio. Ohio State University Plant Sciences Symposium 2023, March 2-3, Columbus, OH. [Poster]

106) Thunuguntla, R., H.K. Atiyeh, R. L. Huhnke and R. S. Tanner, Unlocking the Potential of Clostridium Microorganisms: Investigating C2-C6 Alcohol Synthesis from Syngas, S-1075- Science and Engineering for a Biobased Industry and Economy, Omaha, Nebraska, July 13-14, 2023. Poster.

107) Thunuguntla, R., H.K. Atiyeh, R. L. Huhnke and R. S. Tanner, Effect of medium formulation on the ability of novel acetogens to convert CO2 into value added C2 to C6 products, ASABE 2023 Annual International Meeting; Omaha, Nebraska, July 9-12, 2023. Oral.

108) Thunuguntla, R., H.K. Atiyeh, R. L. Huhnke and R. S. Tanner, Production of alcohols and fatty acids from CO2 by Clostridium muellerianum sp. nov. strain P21, ASABE 2023 Annual International Meeting; Omaha, Nebraska, July 9-12, 2023. Oral.

109) Thunuguntla, R., H.K. Atiyeh, R. L. Huhnke and R. S. Tanner, Physiological characterization of novel acetogens to produce C2 to C6 products using C1 gases, Oklahoma Research Day, University of Central Oklahoma, Edmond, OK, March 3, 2023. Poster.

110) Thunuguntla, R., H.K. Atiyeh, R. L. Huhnke and R. S. Tanner, Conversion of CO2 into C2 -C6 products by Clostridium muellerianum sp. nov. strain P21, 2022 AIChE Annual Meeting, Phoenix, Az, November 13-18, 2022. Oral.

111) Thunuguntla, R, H.K. Atiyeh, R.L. Huhnke and R.S. Tanner Biochar Assisted Biological Conversion of Carbon Dioxide to Chemicals, 2022 envision The Future AEEOK/OREC Roger Farrer Annual Energy Conference; Stillwater, Oklahoma, September 28, 2022. Poster.

112) Iloba, I., C. Okonkwo, H.K. Atiyeh, V. Ujor and T. Ezeji "The effect of biochar on ethanol production by Saccharomyces cerevisiae using anaerobic digestion effluent as nutrient source", ASM Microbe 2022, Washington, D.C, June 9-13, 2022. Poster.

113) Thunuguntla, R, X. Sun, H. Zhang and H.K. Atiyeh Effects of biochar source and production parameters on microbial conversion of C1 gases to C2-C6 products, ASABE 2022 Annual International Meeting; Huston, Texas, July 17-20, 2022. Oral.

114) Thunuguntla, R, H.K. Atiyeh, R.L. Huhnke and R.S. Tanner Impact of novel acetogens inoculum techniques on production of C2 - C6 products from CO2, Food Science Research Symposium, Food and Agricultural Products Center, Oklahoma State University; Stillwater, Oklahoma, March 8, 2022. Oral.

115) Thunuguntla, R, H.K. Atiyeh, R.L. Huhnke and R.S. Tanner â€œBioethanol Production from CO2 in a Stirred Tank Rector (STR), 2022 Annual Meeting of the Oklahoma Section of ASABE, Stillwater, Oklahoma, February 25, 2022. Oral.

116) Catchmark, J. M. 2022. Challenges and opportunities for biorenewable materials. Biorenewables Symposium, Advanced Biomaterials Panel, Center for Biorenewables, Penn State University, University Park, PA. April 14.

117) Catchmark, J.M. 2022. Production of sustainable food packaging and handling product,"" USDA CARE project directors meeting, USDA, University Park, PA. August 4.

118) Chmely, S. 2022. Biorefining as America’s Newest Frontier. Regional Opportunities for Biomass and Bioproducts Graduate Seminar, The Mid Atlantic Biomass Consortium (MASBio), Live and

Online. April 4.

119) Chmely, S. 2022. Engineered Nanointerfaces to Enable Plant-Inspired 3D Printing Using Renewable Materials,"" Frontiers in Biorefining 2022, UT Center for Renewable Carbon, USDA NIFA SE SunGrant Center, St Simons Island, GA. October 24-27.

120) Chmely, S. 2022. Tuning the nanointerface in nanocellulose-containing multicomponent stereolithography resins using a biobased surfactant affords 3D printed objects with enhanced performance properties. Nanoscale Science and Engineering for Agriculture and Food Systems, Gordon Research Conferences, Manchester, NH. June 19-24.

121) Chmely, S., Battisto, E. W., and Catchmark, J.M. 2022. Engineered Nanointerfaces to Enable Plant-Inspired 3D Printing Using Renewable Materials. Nanoscale Science and Engineering for Agriculture and Food Systems, Gordon Research Conferences, Manchester, NH. June 19 – 24.

122) Chmely, S., Battisto, E. W., and Catchmark, J.M. 2022. Surfactant-coated cellulose nanofibers lend enhanced performance properties to 3D printed composite materials using stereolithography,"" ACS Fall 2022, American Chemical Society, Chicago, IL. August 21-25.

123) Chmely, S., Battisto, E., and Catchmark, J.M. 2022. Engineered Nanointerfaces to Enable Plant-Inspired 3D Printing Using Renewable Materials,"" ACS Fall 2022, ACS, Chicago, IL. August 21-25.

124) Faluyi, M. and Irmak, S. 2023. Are dead forest trees good feedstocks for production of gas biofuel, hydrogen? Climate Solutions Symposium, Penn State University, May 22-23.

125) Faluyi, M. and Irmak, S.. 2023. Evaluation various forest trees in Pennsylvania for hydrogen production by hydrothermal gasification. Biorenewables Symposium, Penn State University, April 20-21.

126) Ferguson, J., Gonzalez, C., and Vasco-Correa, J. 2022. Identification of common microbial communities of methanotrophs in methane biofilters. Annual Biomedical Research Conference for Minoritized Scientists (ABRCMS), Anaheim, CA. November 10

127) Godwin, J. A., Babusci, J.P., and Chmely, S. 2022. Catalytic depolymerization of lignin over metal oxide catalysts. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, MD.

128) Godwin, J.A., Babusci, J.P., and Chmely, S. 2022. Catalytic depolymerization of CELF Lignin using mixed-metal spinel-group catalysts. ACS Spring 2022, American Chemical Society, San Diego, CA.

129) Gonzalez Arango, C., and Vasco-Correa, J. 2023. Mechanistic modeling of methane biofiltration systems,"" Institute of Biological Engineers (IBE) Annual Conference, Ames, IA. April 14.

130) Gonzalez, C., and Vasco-Correa, J. 2022. Development of a mathematical model for methane biofiltration systems from a biofilm phenomena approach. ASABE Annual International Meeting, Houston, TX. July 18.

131) Gonzalez, C., and Vasco-Correa, J. 2022. Mathematical model of air biofiltration technology for the mitigation of methane emissions,"" Latin American Conference on Environmental and Chemical Process Systems Engineering, Online. July 21.

132) Gonzalez, C., and Vasco-Correa, J. 2022. Mathematical modeling of air biofiltration technology for the mitigation of methane emissions. S1075: The Science and Engineering for a Biobased Industry and Economy, Multistate project meeting, Houston, TX. July 15,

133) Gonzalez, C., and Vasco-Correa, J. 2022. Mechanistic model for methane-contaminated air

biofiltration systems. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, MD. August 1.

134) Gonzalez, C., and Vasco-Correa, J. 2023. Mathematical modeling of air biofiltration technology for the mitigation of methane emissions. Center for Biorenewables Symposium, University Park, PA. April 21.

135) Gonzalez, C., Peacock, V., Geiger, T., and Vasco-Correa, J. 2023. Air biofiltration technology for the mitigation of diluted methane emissions. Climate Solutions Symposium, Penn State Institutes of Energy and the Environment, University Park, PA. May 23.

136) Iram, A., A. Demirci, and D. Cekmecelioglu. 2022. The effect of dilution factor, agitation, and aeration on cellulase and hemicellulase production in the DDGS-based media by Aspergillus niger strains. ASABE Paper No. 2200147. the ASABE Annual International Meeting, Houston, Texas.

137) Iram, A., A. Demirci, and D. Cekmecelioglu. 2022. The optimization of inoculum, agitation, and aeration for production of hydrolytic enzymes in DDGS-based media by Aspergillus niger. ASABE Paper No. 2200146. the ASABE Annual International Meeting, Houston, Texas.

138) Jefferson, T., Rademacher, E., Ciolkosz, D. E., and Vasco-Correa, J. 2023. Analyzing the economic feasibility of establishing a hop enterprise in Pennsylvania. American Society of Brewing Chemists (ASBC) Meeting, Pittsburg, PA. June 4.

139) Jefferson, T., Rademacher, E., Ciolkosz, D. E., and Vasco-Correa, J. 2023. Technoeconomic analysis of establishing a hop enterprise in Pennsylvania. Gamma Sigma Delta Research Symposium, University Park, PA. March 30.

140) Jefferson, T., Rademacher, E., Ciolkosz, D. E., and Vasco-Correa, J. 2023. Technoeconomic analysis of establishing a hop enterprise in Pennsylvania. Graduate Exhibition, Graduate School, University Park, PA. March 24.

141) Jefferson, T., Rademacher, E., Ciolkosz, D. E., and Vasco-Correa, J. 2022. Techno economic analysis of hops to determine feasibility of local brewing industry demands. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, MD. August 1.

142) Kaur, J. and Irmak, S. 2023. Developing bio-based plastics with multiple benefits for agriculture. Biorenewables Symposium, Penn State University, April 20-21.

143) Kaur, J. and Irmak, S. 2023. Sustainable and climate-friendly bioplastics for agriculture. Climate Solutions Symposium, Penn State University, May 22-23.

144) Li, Y., Slosson, J. C., Yi, H. 2022. Microscale Mechanical Testing of Biomass Particles Using Image Analysis Method. Presented at the ASABE 2022 Annual International Meeting, Houston, Texas.

145) Lin, W.-S. and Catchmark, J.M., 2022. Cellulose-based polyelectrolyte complexes as sustainable package adhesive. ACS Spring Virtual Conference, ACS. March 20-24.

146) Lope, J., Yazdanpanah, N., Berenjian, A., and Demirci, A. 2022. Synchronized mixing, bubble size distribution, and kla high-fidelity simulation for optimization, and scale-up for benchtop. Pharmaceutical Discovery, Development and Manufacturing Forum. Biofilm Bioreactor. Abstract # 642189. AIChE Annual Meeting. Phoenix, AZ.

147) Nazemi, P. and Catchmark, J.M. 2022. Production of sustainable and biodegradable products,"" Global Sustainable Action: It Starts with Us Conference, Penn State University, University Park, PA. November 5.

148) Peacock, T., Lopez, R., Gonzalez, C., Greenlee, L., Bruns, M. V., and Vasco-Correa, J. 2022.

Activated hydrochar for CO_2 capture in methane biofilters. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, MD. August 1.

149) Peacock, V., Gonzalez, C., Bruns, M. V., and Vasco-Correa, J. 2023. Microbial efficiency in oxidizing low-concentration methane through biofiltration. Climate Solutions Symposium, Penn State Institutes of Energy and the Environment, University Park, PA. May 23.

150) Peacock, V., Gonzalez, C., Bruns, M. V., and Vasco-Correa, J. 2023. Analysis of microbial efficiency in oxidizing low-concentration methane through biofiltration. Undergraduate Exhibition, Undergraduate Research and Fellowships Mentoring Office, University Park, PA. April 12.

151) Peacock, V., Gonzalez, C., Bruns, M. V., and Vasco-Correa, J. 2023. Analysis of microbial efficiency in oxidizing low-concentration methane through biofiltration. Gamma Sigma Delta Research Symposium, University Park, PA. March 30.

152) Rademacher, E., Jefferson, T., Porcano, H., Ciolkosz, D. E., and Vasco-Correa, J. 2023. Experimental and techno-economic analysis of hops pelletization in Pennsylvania. American Society of Brewing Chemists (ASBC) Meeting, Pittsburg, PA. June 5.

153) Richard, T.L. Anaerobic Digestion and RNG: A new paradigm? Renewable Natural Gas Opportunities Short Course, Lancaster, PA. June 8, 2022.

154) Richard, T.L. Anaerobic Digestion Microbiology, and the Carbon Economy. Renewable Natural Gas Opportunities Short Course, Lancaster, PA. June 8, 2022.

155) Richard, T.L. Renewable Natural Gas: Powering Sustainable Energy with

156) Sustainable Food Systems. Penn State Ag. Council. University Park, PA. October 14, 2022.

157) Rohi, M., Arya, A. and Chmely, S. 2022). Introduction of Kraft Lignin as an Environmentally Friendly Component for Improving Mechanical Properties of 3D Printing Resins based on Soybean Oil. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, MD..

158) Rohi, M., Chmely, S., and Arya, A. 2022. Introduction of modified Kraft lignin to enhance mechanical performance of 3D printed resins based on soybean oil. ACS Fall 2022, American Chemical Society, Chicago, IL.

159) Rokita, J, Catchmark, J.M., Chen, C., Armen, S. B., and Linskey Dougherty, M. 2022. Hemostatic foams for wound treatment,"" TechConnect World 2022, TechConnect World, Washington, DC. June 13.

160) Shreve, M., K. Hirl, A. Bharadwaj, J. Regan and T.L. Richard. The effect of pH, temperature, and retention time on microbiome and product formation during anaerobic digestion of senescent switchgrass. Presented at the 17th World Congress on Anaerobic Digestion, June 21, 2022. Ann Arbor, MI.

161) Slosson, J. C., Li, Y., Yi, H. 2022. Determining Friction Coefficient and Traction Adhesion Force Between Corn Stover Particles of Anatomical Fractions. Presented at the ASABE 2022 Annual International Meeting, Houston, Texas.

162) Vasco-Correa, J. 2022. Materials and processes challenges and opportunities in the transformation of carbon and hydrogen economies,"" Materials Day, Materials Research Institute, University Park, PA, October 21, Invited.

163) Vasco-Correa, J. 2022. Materials and processes challenges and opportunities in the transformation of carbon and hydrogen economies. Millennium Cafe, Materials Research Institute, University Park, PA, October 11, Invited.

164) Vasco-Correa, J. 2022. Sustainable energy production panel. Sustainable Energy for a Sustainable Future, American Society of Agricultural and Biological Engineers (ASABE), San Juan, Costa Rica, October 24, Invited.

165) Vasco-Correa, J. 2023. Trends in bioprocessing and biorefining for a developing bioeconomy. Institute of Biological Engineers (IBE) Annual Conference, Ames, IA. April 15.

166) Vasco-Correa, J., and Peacock, V. 2022. Anaerobic digestion-based hybrid biorefinery for bioenergy and biomaterials. Sustainable Energy for a Sustainable Future, American Society of Agricultural and Biological Engineers (ASABE), San Juan, Costa Rica. October 24.

167) Wu, Y., and Vasco-Correa, J. 2022. Economic optimization of lignin valorization biorefinery system with biological upgrading,"" INFORMS Annual Meeting, Institute for Operations Research and the Management Sciences (INFORMS), Indianapolis, IN. October 19.

168) Wu, Y., and Vasco-Correa, J. 2022. Using superstructure optimization to design economically feasible biorefineries based on emerging lignin valorization technologies. Sustainable Energy for a Sustainable Future, American Society of Agricultural and Biological Engineers (ASABE), San Juan, Costa Rica. October 24.

169) Wu, Y., and Vasco-Correa, J. 2023. Economic optimization of lignin valorization biorefinery system with biological upgrading. College of Engineering Research Symposium, Engineering Graduate Student Council (EGSC), University Park, PA. April 12.

170) Wu, Y., and Vasco-Correa, J. 2023. Optimizing lignin valorization in biorefinery systems with biological upgrading for economic viability. Gamma Sigma Delta Research Symposium, University Park, PA. March 30.

171) Wu, Y., and Vasco-Correa, J. 2023. Optimizing lignin valorization in biorefinery systems with biological upgrading for economic viability. Graduate Exhibition, Graduate School, University Park, PA. March 24.

172) Wu, Y., Chmely, S., and Vasco-Correa, J. 2022. Optimization of lignin valorization with bio-upgrading. Northeast Agricultural and Biological Engineering Conference (NABEC), Edgewood, MD. August 1.

173) Yi, H., Lanning, C. J., Dooley, J. H., Puri, V. M. 2022. Finite element modeling of post-incipient biomass flow from a gravity hopper. Presented at the ASABE 2022 Annual International Meeting, Houston, Texas."

174) Abdulkarim Aldekhail, Lin Wei*, Kasiviswanathan Muthukumarappan, Robiul Islam Rubel, Salman Alanazi. Design Different Coating Materials for Biochar-Based Control Release Nitrogen Fertilizer to Improve Water Quality in Agricultural Production. Annual South Dakota Water Conference. October 11, 2022. Brookings, SD 57007.

175) Salman Alanazi, Lin Wei*, Kasiviswanathan Muthukumarappan, Robiul Islam Rubel, Abdulkarim Aldekhail. . Effect of water uniformity of precsion irrigation on crop growth Annual South Dakota Water Conference. October 11, 2022. Brookings, SD 57007.

176) Anne C. M. Cidreira, Lin Wei*, Challenges and opportunities of biopolymer-based coating control release nitrogen fertilizers for improving water quality in agriculture. Annual South Dakota Water Conference. October 11, 2022. Brookings, SD 57007.

177) Robiul Islam Rubel, Lin Wei*, Salman Alanazi, Abdulkarim Aldekhail, Anne C. M. Cidreira. Controlled release fertilizer: a way to improve water quality in agriculture. Annual South Dakota Water Conference. October 11, 2022. Brookings, SD 57007

178) Lin Wei*, K. Muthu, Abdus Sobhan, Steven Bowden. Develop an effective plasma coating technology to inhibit biofilm formation on stainless steel surfaces for dairy processing applications. July 26, 2022, Minneapolis, MN.

179) Lin Wei*, K. Muthu, Abdus Sobhan, Steven Bowden. Develop An Innovative Biochar-Based Biosensor for Rapid Detection of Food. July 26, 2022, Minneapolis, MN.

180) Robiul Islam Rubel, Salman Alanazi, Abdulkarim Aldekhail, Sikander Ameer, Lin Wei*. Smart Fertilizer: Smart Choice for Future. May 23, 2022, SD Eastern Water Conference, Brookins, SD 57007.

181) Lin Wei* Some basic concepts of mathematical modeling for agricultural digitalization. ASABE annual meeting, July 17 - 20, 2022. Houston, Texas.

182) Robiul Islam Rubel, Lin Wei*, Yajun Wu, Surbhi Gupta, Salman Alanazi. Biochar Based Controlled Release Nitrogen Fertilizer for Corn Yield Improvement. ASABE annual meeting, July 17 - 20, 2022. Houston, Texas.

183) Sikander Ameer and Lin Wei* Effects of control release nitrogen fertilizer on maize yield by using biosolid, compost and biochar in greenhouse. ASABE annual meeting, July 17 - 20, 2022. Houston, Texas.

184) Robiul Islam Rubel, Lin Wei*, Yajun Wu, Surbhi Gupta, Salman Alanazi. Biochar Based Controlled Release Nitrogen Fertilizer for Corn Yield Improvement. USDA NIFA S1075 multi-state research project annual meeting, July 15 - 16, 2022. Houston, Texas.

185) Robiul Islam Rubel, Lin Wei*. Challenges and Opportunities of Plasma Enhanced Chemical Vapor Deposition for Preventing Biofilm on Stainless Steel Surface. IFT Great Plain Subsection food sciences and technologies symposium, Brookings, SD 57007.

186) Kailong Zhang & M Li. Cellulose nanofibers templated metal-organic frameworks for fluorescent-visual detection and adsorption of pesticides. ACS Spring 2023 National Meeting & Exposition, Mar 2023, Indianapolis, MN. (Oral presentation)

187) K Zhang & M Li. Sulfonated cellulose nanofibers templated metal–organic frameworks for the rapid dye removal. Frontiers in Biorefining, October 2022, St. Simons Island, GA. (Poster)

188) Mi Li et al. Physicochemical characterization of lignins using inverse gas chromatography and dynamic vapor sorption. ASABE AIM 2022, July 2022, Houston, TX. (Oral presentation)

189) K Zhang, Antimicrobial food packaging with cinnamaldehyde stabilized by ethyl lauroyl arginate and cellulose nanocrystals. USDA S-1075 2022, July 2022, Houston, TX. (Poster)

190) Ross Houston and Nourredine Abdoulmoumine. Investigation of the thermal deconstructions of β-β' and 4-O-5 linkages in lignin model oligomers by density functional theory. ACS Fall 2022, August 21st - 25th, 2022 Chicago, IL

191) Nourredine Abdoulmoumine. Pushing the boundary of biomass fast pyrolysis' chemistry through combined computational and experimental approaches. 2022 Frontiers in Biorefining, October 24th - 27th, 2022. St. Simons Island, GA

192) Conner Pope, Nourredine Abdoulmoumine, and Nicole Labbé. Carbon capture with sustainable adsorbent materials. 2023 AIChE Spring Annual meeting, March 12th - March 16th, 2023, Houston, Texas.

193) Conner Pope, Tawsif Rahman, Gabriel Goenaga Jimenez, Sushil Adhikari, Thomas Zawodzinkski, Nicole Labbé, and Nourredine Abdoulmoumine. Improving Biochar Surface Area for CO2 Adsorption through Potassium Hydroxide Chemical Activation. 2023 AIChE Spring Annual meeting, March 12th - March 16th, 2023, Houston, Texas.

194) DG Hayes** (invited), Sustainability aspects of the production and life stages of surfactants. American Oil Chemists' Society Annual Meeting, Atlanta, May, 2022

195) MA Oehler* (poster presenter), DG Hayes**, DH D'Souza, M Senanayake, V Gurumoorthy, SV Pingali, HM O'Neill, Encapsulation of Melittin in Bicontinuous Microemulsions for Topical Delivery, ASABE Annual Meeting, Houston, July, 2022

196) DG Hayes** (invited), MA Oehler, DH D'Souza, M Senanayake, V Gurumoorthy, SV Pingali, HM O'Neill, Encapsulation of Antimicrobial Peptides in Bicontinuous Microemulsions for Topical Delivery to Surgical Site Infections and Chronic Wounds, Japan Oil Chemists' Society Annual Meeting, Sept, 2022, virtual

197) 1. Capareda, Sergio C. 2023. Biomass and Energy Development for the Food Manufacturing and Processing Industries. Plenary Speaker for the 2023 Annual Meeting of the Philippine Society of Agricultural and Biosystems Engineers, 34th Philippine Agricultural Engineering Week and 9th ASEAN Regional Convention held on April 24-28, 2023, at SMX Mall of Asia, Manila, Philippines.

198) Y. Li, D. Xia, Q. Jin, L. Tao, F. Lin, H. Huang, Hydrothermally Assisted Conversion of Switchgrass into Carbon Materials as High-Performance Anodes for Sodium-Ion Batteries. Oral Presentation, 2023 Annual ASABE Meeting, June, Omaha, Nebraska.

199) Y. Li, D. Xia, Q. Jin, L. Tao, F. Lin, H. Huang, Hydrothermal Conversion of Switchgrass into Hard Carbon for Sodium-Ion Battery. Poster Presentation, 2023 USDA S1041 Multi-State Meeting, June, Omaha, Nebraska.

200) G. Kukal, M. Roman, Continuous flow biocatalysis using glucose oxidase with in-line monitoring through Raman spectroscopy. Poster Presentation, ACS Spring 2023, Indiana Convention Center, 3/26/23, Indianapolis, IN

201) Xiaolu Li, and Bin Yang*, "A Redox Proteomics Approach to Understanding of Lignin Conversion in Rhodococci" 44th Symposium on Biomaterials, Fuels and Chemicals (SBFC), New Orleans, LA, May 3rd, 2022.

202) Doyle, L., Barzee, T. 2023. Production of Mycoprotein Hydrogels for 3D Bioprinting and Cellular Agriculture. Oral (Lightning Talk), American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting (AIM). Omaha, NE. 7/12/2023.

203) Talukdar, S., Barzee, T. 2023. Mathematical Modeling of the Fungal Assisted Immobilization of Microalgae Cells: Impact of Fungal Activity State and Bioreactor Operational Parameters. Oral, ASABE AIM. Omaha, NE. 7/10/2023.

204) Hockensmith, D., Barzee, T., Crofcheck, C. 2023. Anaerobic Digestion of Stillage: Comparison of the Biomethane Potential Based on Mash Bill and Distillation Parameters. Poster, ASABE AIM. Omaha, NE. 7/11/2023.

Synergistic activities with other stations and states

Alabama

1) Dr. Yi Wang collaborates with the Virginia station; we work together to obtain a DOE grant and submit several other grant applications. Wang also provided the engineered strains for their project for the PI at the Virginia station.

2) Investigators serve on the review panel for several grant agencies in United States.

California

Collaboration included researchers from the University of Maryland and the University of California, Berkeley. Collaboration on bioplastics production included researchers from Kansas State University and USDA ARS Western Regional Research Center.

Hawaii

Su lab is actively collaborating with Dr. Yinjie Tang of the Washington University in St. Louis in the State of Missouri.

Khanal's lab is actively collaborating with the following national and international collaborators:

Prof. Karthik Chandran, Columbia University: Nitrogen Transformations in Aquaponic

Prof. Lutgarde M. Raskin, University of Michigan: Microbial Community Analysis in AD System Digesting Cellulosic Biomass

Prof. Hong Liu, Oregon State University: Machine learning applications in anaerobic digestion.

Dr. Bongkeun (BK) Song Ph.D., College of William & Mary: Microbial communities in NB-aerated aquaponics

Dr. Deb Jaisi, Delaware University: Chemical Characterization of Biochars for Sulfide Removal from Biogas

Prof. Sushil Adhikari, Auburn University: Integrated Anaerobic Biorefinery and Thermochemical Conversion

Prof. Jeffrey Tomberlin, Texas A& M University: Black Soldier Flies (BSF) for Organic Waste Valorization.

Kentucky

UK researchers have worked with researchers at 14 states including Kansas, Louisiana, Ohio, Virginia, Vermont, Florida, Idaho, North Carolina, Nebraska, Michigan, Mississippi, Tennessee, California, and Iowa on joint proposals and publications

Massachusetts

Collaborative research and patent application: Univ. North Texas – formaldehyde emission from wood.

Minnesota

We collaborated with investigators at the University of Missouri, Washington State University, Mississippi State University, Stanford University, Berkeley Lab — Lawrence Berkeley National Laboratory, NREL, Resynergi, Quasar Energy Group, Maas Energy in research and grant writing activities. We continue to work with agencies and companies including Minnesota Metropolitan Council Environment Services, Holistic Health Farms, Forsman Farms, Resynergi and Minesga.

Missouri

Co-listings with North Central Regional Aquaculture Center; https://www.ncrac.org/

Montana

Chen's group at Montana State University has been working with University of Kentucky conducting multi-state hemp variety trials. Chen's group also worked with Virginia Tech to evaluate hemp protein characteristics. Chen's group is currently participating a DOE funded camelina project led by Dr. Chaofu Lu at Montana State University which involves many scientists from DOE lab at Berkley University, UC Davis, USDA-ARS Pullman etc.

Nebraska

Development of educational video games related to research models in partnership with IANR Science Literacy (visit growable.unl.edu)

Ohio

Collaboration with researchers from different institutions while gathering expertise to solve problems of common interest.

Oklahoma

Collaborated with Thaddeus Ezeji, Ohio State University, Ohio and Ajay Shah, Ohio State University, Ohio. Also collaborated with industry (Texoma Manufacturing, OK).

Pennsylvania

Co-PI (Dr. Richard) directs the Northeast Sun Grant Center of Excellence for USDA; serves as Deputy Technical Director of the DOE's National Risk Assessment Partnership for geologic carbon storage (consortium of five DOE National Labs (2011-present) as well as serves as co-chair of the National Council for Science and the Environment's Energy Education Community of Practice (2017-present). A major agricultural equipment company CNH provided field harvesting equipment and operator team for the field studies. In addition, Idaho National Lab provided field supplies and analyzed field crop samples. Co-PI (Dr. Costello) co-chaired three sessions of the International Symposium on Sustainable Technologies, June 2021. These sessions included curated presentations about methods and case studies of sustainability assessment of systems, e.g., life cycle assessment focused on waste management, bioprocesses, and nutrient cycling from leading research universities and federal research laboratories. Co-PI (Dr. Chemely) has been working with investigators at the University of Tennessee Institute of Agriculture (UTIA) and the University of Tennessee College of Veterinary Medicine (UTCVM). Co-PI (Dr. Catchmark) has been serving on the College of Agricultural Sciences Entrepreneurship and Innovation Board. Co-PI (Dr. Vasco-Correa) is part of the council for the Institute of Biological Engineering (IBE), the vice-chair of the Processing Technical Community of the American Society of Agricultural and Biological Engineers (ASABE), and the co-convener of the Bioeconomy Solutions Critical Issues Initiative of the Penn State Institute for Sustainable Agricultural, Food, and Environmental Science (SAFES). Co-PI (Dr. Chemly) has been working with investigators at the University of Tennessee Institute of Agriculture (UTIA) and the University of Tennessee College of Veterinary Medicine (UTCVM) and West Virginia University on the as part of a USDA-funded SAS project.

South Dakota

Collaborated with Mississippi State University and University of South Florida to submit proposal of clean hydrogen production from mixture of biomass and plastic wastes for DOE 2022 RFP

Tennessee

Collaboration with Oak Ridge National Laboratory, University of North Texas, TX Kansas State University, KS, Auburn University, AL, Nanjing Forestry University (China).

Co-chair, ES-220 Conversion of Biomass to Biofuels, ASABE AIM 2021

Organizer, ACS Annual Conference CELL Division, Fall 2021 and Spring 2022

Vice-president, ES-220 Bio-based Energy, Fuels and Products Committee, ASABE

Texas

TAMU Established collaboration with the following Research Institutions and Researchers: Pacific Northwest National Laboratory (PNNL) (Dr. Marifel Olarte), Penn State University (PSU) (Dr, Meng Wang), Montana State University Northern (MSUN) (Dr. Randy Maglinao)

Virginia

Collaborating with researchers at Kansas State University to conduct system-level techno-economic analysis for the conversion of DDGS to peptides

Washington

Collaboration with PNNL, NREL, ORNL Collaboration with Texas A&M Collaboration with University of Tennessee Collaboration with University of North Dakota.