S-1075 Multistate Regional Project

The Science and Engineering for a Biobased Industry and Economy

2019 – 2020 Annual Report

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S1075 Chair for 2019-2020

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

Individual Stations Submitting Reports:

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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]

Kentucky

1) Comparative evaluation of industrial hemp cultivars Industrial hemp has gained resurgent interest recently for applications in various sectors. We evaluated 11 different industrial hemp [6 fiber-only and 5 dual-purpose (fiber and grain)] cultivars and compared their potential as a commodity crop for biofuel and bioproducts via combined agronomical, experimental, and economic analysis approaches. Composition analyses suggest large variations on the glucan, xylan and lignin contents among the tested hemp cultivars while the theoretical ethanol yields ranged from 91 to 101 gallons/dry ton hemp stems predicted based on the glucan and xylan contents. Results from dilute acid pretreatment and enzymatic hydrolysis suggest practical ethanol yields of 70-91 gallons /dry ton hemp stems, with the highest ethanol yield of 91.1 gallons /dry ton hemp stems from the Futura 75 cultivar and the lowest of 70.6 gallons /dry ton hemp stems from the Codimone cultivar. Based on the agronomic data, the per hectare hemp stem biomass yield ranged 2933 kg to 8340 kg for fiber-only cultivars, while 3582 kg to 7665 kg for the dual-purpose cultivars. In addition to the stems, field trial for the dual-purpose cultivars showed grain yields ranges from 555 to 1083 kg/ha. Preliminary cost analysis indicates that overall dual-purpose cultivars have advantages over fiber-only cultivars in terms of potential per hectare gross profit, with Bialobrzeskie and NWG 331 being the highest among all tested cultivars. These combined evaluations illustrate that industrial hemp has a significant potential becoming a promising regional commodity crop for producing both biofuels and value-added products. (this work has been published recently in ACS Sustainable Chemistry and Engineering)

Minnesota

We conducted research on utilizing animal wastewater to produce biomass that can be used as biofuel feedstock and food products. We are taking a closed loop system approach consisting of animal manure pretreatment (modified AD), biochar production and filtration, hydroponic, and algae cultivation. A major improvement in AD is the development of vacuum assisted thermophilic AD process that can effectively remove ammonia nitrogen and hydrogen sulfide, effectively reducing the inhibition of AD by ammonia and sulfur compounds and hence improving the methane yields and fast nutrient removal, resulting in effluent more suitable for biomass production. We studied the relationship between AD treatment and algae and vegetable growth. We also investigated the effect of an algae stage on hydroponic vegetable cultivation. The effluent was used to grow microalgae and hydroponic vegetables. In addition, we conducted a preliminary study on the effect of photocatalysts and intense pulsed light on the conversion of organics into carbon sources usable for microalgae.

Missouri

The primary requirement to increase carrying capacity of aquaculture production systems is to maintain water oxygen, carbon dioxide and ammonia concentrations within acceptable levels. Natural or enhanced aeration is used to maintain oxygen and carbon dioxide levels, while photoautotrophic (algae), chemoautotrophic (nitrification) or heterotrophic microbial growth may be used to maintain control of ammonia nitrogen levels. In the 1960’s un-aerated aquaculture ponds, referred to as extensive systems, was observed to yield 1,000-2,000 lb/ac of fish or shrimp in freshwater or marine systems. To further increase production to “super-intensive” levels, farmers turned to alternative biological treatments techniques, fixed-film nitrifying reactor (trickling filters), or suspended-culture (biofloc) microbial reactors. Heterotrophic systems require external organic supplementation in addition to feed application. Optimal microbial levels in the range of 200-400 mg/l keep pace with needed ammonia removal while not

imposing excessive oxygen demand. Shrimp production in excess of 40,000 lb/ac-cycle is achievable. Nitrifying systems require aeration power of 50-60 hp/ac, whereas heterotrophic system aeration requirement can exceed 60-80 hp/ac. An added advantage of super-intensive aquaculture is the potential to provide zero-discharge operation, eliminating water and sludge discharge by converting microbial biomass production to useful byproducts.

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 yield and higher nitrogen use efficiency; 2) genetic modification to improve camelina nitrogen use efficiency. Camelina is a promising oilseed crop that is under intensive development mainly for bioenergy production. However nitrogen is the biggest energy input and production costs, and therefore, nitrogen use efficiency needs to be improved. Dr. Chen's research group at MT S U is testing camelina varieties and breeding lines for adaptation, yield potential and nitrogen use efficiency. Dr. Lu's lab at MT S U is conducting genetic engineering to improve camelina yield and nitrogen use efficiency. Chen's group are currently also working on sugar beet and industrial hemp.

New Jersey

1) Stable and consistent growing of duckweed using vertical structures: Develop a 6-tier duckweed production module (DPM), with a 1 m2 footprint, outfitted with LED augmentation. Standardize duckweed strain for DPM by comparative selection on commercial fertilizer and wastewater media to select fast growth and high protein strains. Couple the duckweed production module with aquaculture installations (still work in progress).

New York

This project takes advantage of our large bioenergy experimental site on wetness-prone marginal soils, representing a primary land resource for production of bioenergy and bioproduct feedstocks in NY. To improve sustainability of feedstock production, we are testing improved management to reduce fertilizer nitrogen and soil carbon losses, and to increase yields with improved switchgrass variety and establishment practices. Outcomes include successful full establishment of the new Liberty switchgrass (a hybrid upland/lowland variety with increased yields) switchgrass on four 1-acre test strips. It had been planted via no-till conservation drill in summer 2017 after a similar seeding in 2016 failed due to severe drought. Primary treatments at the wetness-prone marginal land site (with quadruplicate RCB ~1 acre plots) include Shawnee, Shawnee +67 lbN/ac, Liberty +67 lbN/ac, and fallow grassland control. A very wet fall 2018 and spring 2019 had prevented full-scale harvest of all switchgrass stands for that growing season. As a result, emergence in 2019 was somewhat delayed by the mulching effect of the prior stands. Yields within these primary treatments are also determined at subplots representing the range of soil drainage classes (somewhat-poorly to somewhat well-drained). Hand-harvest yield measurements in fall 2019 thus required laborious hand sorting of current and prior biomass. Full-scale harvests were carried out in early November. Spring 2020 emergence was delayed several weeks by abnormally cool weather but the season has proceeded normally. Pre-emergence glyphosate treatments (typically used for weed control during establishment) were again made as part of a continuing herbicide mobilization study. Growth in 2020 has been robust and we look forward to fall 2020 yield comparisons of the fully mature Liberty vs. Shawnee stands uncomplicated by prior season biomass carryover. A soil organic matter manuscript arising from an earlier dissertation was published, and a manuscript describing switchgrass establishment and yields since 2013 is in preparation.

North Dakota

The biomass logistics operation infield is a significant activity involving time and energy. Two of the infield biomass logistics research efforts performed are (1) tracks impacted field area simulation using kinematics and geometry for different equipment, and operation scenarios – work completed and

published; (2) simulation of biomass bales infield aggregation logistics energy for tractors and automatic – submitted to the Biomass & Bioenergy journal; and (3) forage economics calculator – web application developed using html+javascript – work in progress. Detail of item (1) is presented below and for items (2) and (3) will be reported later. The traffic caused by the farm equipment in mechanized agriculture generates track impacted areas that aggravate the soil compaction in the fields. A developed R simulation program evaluated the track impacted area and operational time of the equipment during bale aggregation along with harvesting and baling using kinematics and geometrical principles. Distance traveled by equipment and their respective track widths (footprint) determined the track impacted areas under different scenarios. Tracks impacted areas simulated for automatic bale picker (ABP) with several bales/trip (8 – 23 bales/trip) and areas (1 – 259 ha) were compared with a control method using a tractor that can handle 1 and 2 bales/trip. The logistics simulation used the developed more realistic curvilinear method (circular turning paths developed for the harvester, baler, tractor, and ABP) and compared with simpler Euclidean paths. Overall, the impacted areas by the curvilinear method were 1.06 – 1.29 times the Euclidean for bale aggregation but were not statistically different ($p \geq 0.49$). Results indicated that the baler followed by harvester produced the least impacted area and ABP the most. Developed prediction models determined the curvilinear track path from Euclidean distances, impacted area from the field area, bales/trip, and biomass yield for different operations, as well as overall operational time fitted well to the results ($0.95 \leq R^2 \leq 0.99$). A small ABP of 8 bales/trip (which is also capable of 11 bales/trip) was recommended based on efficient bale aggregation and least impacted area.

Pennsylvania

Co-PI: Tom Richard Outcomes: In support of Objective A, we are modeling feedstock production and harvesting strategies that spatially identify and efficiently manage economically marginal subfield areas. This year we improved and validated a high resolution biophysical and economic model to identify unprofitable areas and identified market pathways to profitably convert this land to perennial biomass production. We are also characterizing risks associated with feedstock and supply chain uncertainties along the value chain. Co-PI: Jude Liu Outcomes: A project on testing of dynamic cutting strength of miscanthus stalk using a high-speed test device. The laboratory tests were conducted in the machinery lab located in the agricultural engineering building at Penn State. Maximum cutting force and specific cutting energy were measured. Experimental variables included positions (at the bottom of the plant and in the mid-height), node and internode at these positions. A master's thesis is being written based on these studies. Another project just started to evaluate industrial hemp decorticating systems. No outcomes available, yet.

South Dakota

Two PIs Dr. Kasiviswanathan Muthukumarappan and Dr. Lin Wei participated in the Objective A. A new research of control release nitrogen fertilizer (CRNF) was carried out to improve nitrogen used efficiency and minimize environmental impacts in productions of biomass feedstocks and other crop products. Two innovative processes of CRNF fabrication were developed. A new research funding ($25,000) from the Governor's Office of Economic Development was received to support the research. Two processes of biomass pretreatment for nanocellulose extraction and nanocomposite production were also developed in this year. By integrating the advantages of these two processes, the logistical problems of transporting raw, low bulk density biomass long distances were addressed to enable efficient and economical production of biopolymer-based nanocomposites, biofuels, and other bioenergy products. Four graduate students (1PhD and 3M.S.) were recruited to participate in the projects. The research results were published in 2 peer-reviewed journal papers and 3 conference papers.

Tennessee

An alternate biomass logistics supply was evaluated for cotton module technology to be applied to chopped switchgrass. Results indicated susceptibility of module stability due to various load and tamp formations of module. 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 -as an effective barrier to weeds and is biodegradable. A database of the natural variability of properties of 45 hardwood residue samples collected across the southeast was generated to evaluate the impact on thermochemical conversion.

Washington

Selection of the best wheat variety for cellulosic ethanol production is very important. With dozens of varieties available, information on the sugar yield of different straws is needed to help farmers choose the most profitable wheat variety, for both grain yield and straw yield. Thirty winter wheat lines from the Pacific Northwest of the US were chosen for analysis based on historical and current production. Two pretreatment methods, dilute acid and hot water, were compared to determine the optimum pretreatment condition for wheat straw. Using the optimum dilute acid pretreatment condition, sugar yields from the straw of the 30 wheat varieties were compared. The differences in variety performance were then evaluated based on relationships among several measured parameters, including straw yield, grain yield, and chemical composition of biomass. The ranges of chemical composition for the 30 wheat straw varieties were 33.7-36.3% glucan (proxy for cellulose), 16.8-19.5% xylan (proxy for hemicellulose), and 18.4-20.6% lignin. Results also showed significant differences in sugar yield, which varied between 0.239-0.401 g g-1 dry matter of raw biomass across wheat straw varieties. Among the 30 tested varieties, Weatherford was selected as the best for dual-purpose wheat because it ranked highest in straw yield and potential sugar production per ha and 6th-highest in grain yield. The biomass research work also included development of algae biotechnology. WSU algae research has focused on the mixotrophic culture as a strategy to increase biomass productivity and production of the high-value products. During the reporting period, we evaluated the impact of different organic carbon sources and different lighting regime on biomass productivity and accumulation of astaxanthin as high-value products.

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, we are 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. 2) In another project, we have 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.

California

Work continued on developing a new route for biofuels and chemicals production from cellulosic biomass. Namely, utilizing an engineered fungus strain to convert the cellulose contained in cellulose to cellobionic acid without any enzyme addition, in a subsequent step, converting cellobionic acid to fuels and chemical. We studied the conversion of cellobionate to ethanol and co-fermenting cellobionate and glycerol for homoethanol production. Our study found that both the engineered strains of Klebsiella oxytoca BW21 and WT26 can effectively use cellobionate for ethanol production. When cellobionate was used as the sole carbon source by K. oxytoca BW 21, the ethanol yield was only about 67%. Co-fermenting cellobionate and glycerol using an engineered K. oxytoca strain led to the ethanol yield

improvement to 95%. Research was conducted to produce polyhydroxyalkanoates (PHA) from food waste by using Haloferax mediterranei. Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) is co-polymer in PHA family with outstanding plastic properties among various types of biodegradable polymers. Food waste pretreated with enzymatic hydrolysis or anaerobic fermentation were tested as the substrates. The feedstocks were subjected to membrane filtration to obtain particle-free nutrient solutions, which were used to culture the microbes. Batch reactors with controlled temperature, aeration, salinity and pH were used for PHBV production experiments. Cell growth and PHBV yields were investigated with different substrate loadings. The results suggested that both feedstocks resulted in an effective production of PHBV. Anaerobically fermented food waste achieved PHBV yields of 0.08-0.15 g/g sCOD from initial substrate loadings of 15.0-46.4 g sCOD/L. For food waste hydrolysate, the PHBV yields were higher, 0.13 and 0.19 g/g sCOD, from initial loadings of 22.6 and 43.8 g sCOD/L, respectively. The average content of PHBV was 35-68% of cell dry mass, with HV portion averaging 12-22 wt% of PHBV content. Further experiments are ongoing to investigate reaction kinetics in fed-batch reactors and to test the PHBV produced from food waste for its thermoplastic properties and biodegradability. Research was also conducted to develop and optimize the extraction methods for sugars and antioxidants from almond hulls. A 2-step extraction method was developed by using hot water followed by 50% ethanol aqueous solution to extract both water and ethanol soluble antioxidants and sugar from almond hulls. From 1 lb dry almond hulls, 0.461 lb of sugars and 0.034 lb of antioxidants were extracted. The extracts were used to produce edible fungi A. awamori under different conditions were determined. The produced fungal pellets contained 19 % protein, 14.9% crude fat and 18.7% fiber on a dry basis. More research is underway to increase the yield of fungal biomass by utilizing fibers as well as sugars in the hulls and evaluate the nutritional value and health benefits of antioxidant and fungal biomass products.

Hawaii

Khanal's Lab has been working on the use of black soldier flies (BSF) 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. 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. Su Lab investigated alternative feedstocks, especially lipid-based feedstocks. The investigation resulted in developing plant-based oils as an effective carbon source, as well as a biocompatible solvent for efficient extraction of oleochemicals such as astaxanthin secreted by the yeast Yarrowia lipolytica. Genetic and modeling tools have been developed to further the strain engineering and metabolic engineering analysis. These efforts will greatly advance our ability to use yeast biorefinery to produce high-value oleochemicals from

abundant and underutilized lipid feedstocks.

Illinois

Li et al (2019) found that steeping pericarp from purple corn using sulfur dioxide could be used to recover high levels of anthocyanins, a potential replacement for FD&C Red 40 dye. Juneja et al (2019a) conducted techno-economic analysis on recovery of phosphorus from DDGS. Potential phosphorus recovered from a would reduce phosphorus in the DDGS coproduct as well as create a new phosphorus coproduct to be marketed separately. Juneja et al (2019b) determined the feasibility of producing D-psicose and ethanol at a modified dry grind ethanol facility. Using a new yeast strain, KAM-2GD, simulations found the modified facility could have an internal rate of return of 15% and produce D-psicose at a cost of $0.43/kg. Kumar et al (2019) found that germ soakwater increased free amino nitrogen and zinc levels, resulting in 28% higher fermentation rates and shortened fermentation times during beverage brewing. The germ was more valuable due to higher concentrations of oil following the soaking process. Kurambhatti et al (2019) analyzed the used of several fractionation processes to make the corn dry grind process more profitable by increasing the number of coproducts made during ethanol production. Simulations found that a wet fractionation process that recovered germ and pericarp fiber was the most profitable of the processes analyzed. Wang et al (2019) combined three technologies to improve a more efficient process for converting corn stover and sugarcane bagasse into ethanol. Dilute alkaline deacetylation, combined thermochemical and mechanical shear pretreatment and fermentation using two commercial Saccharomyces yeast strains were used. The optimized yeast blend lowered the amount of yeast required by 80%. You et al (2020) developed model fluids to simulate fouling properties of thin stillage. Due to complex composition, perishable nature and biological variability, commercial thin stillage gives variable fouling characteristics. A model fluid containing glucose and yeast protein gave reasonably similar fouling characteristics to commercial samples.

Iowa

Extrusion processing was conducted on treated soy-based ingredients to produce diets for yellow perch feeding trials. Results demonstrated that yellow perch can respond well to soy-based ingredients vs. traditional fish meal protein, with equivalent growth performance and mortalities. These results will be useful to aquatic feed manufacturers as well as fish producers as they consider fish meal alternatives in perch feeds. Corn Steep Liquor is shown to support growth of Lactococcus lactis: A recent project supported by ISU' Biobased Products seed grant and industry, Corn Steep Liquor is being studied for microbial production of Recombinant Antifreeze Proteins for Food Applications. Corn Steep Liquor is a coproduct of corn wet-milling process and contains soluble sugars and protein; it needs to be dried for low-value animal feed applications. The overall goal of this project is to design and optimize the production of recombinant anti-freeze proteins (AFPs) using Lactococcus lactis for potential food and industrial applications. A plasmid construct that has the Ocean Pout AFP III sequence has been created and expressed in Lactococcus lactis. This plasmid construct has the Ocean Pout AFP III sequence codon-optimized for expression in Lactococcus lactis. The vector contains a backbone that is functional in E. coli as well as L. lactis, which makes it convenient for cloning applications. Modified bacteria was grown on M17 media, and supernatant were frozen at -20°C for 30 min. Supernatant with induced AFPIII production and secretion (Afp+) did not freeze compared to control. These modified strains will next be grown on media supplemented with Corn Steep Liquor from 10-100% levels. Corn Steep Liquor was also evaluated for fermentation grown of wild type Lactococcus lactis and comparable growth was seen with M17 media. Further outcome will include production of Antifreeze Proteins using 100% Corn Steep Liquor based fermentation medium and recovery and applications in food products

Kentucky

1) The Impact of Red Clover Drying Rate and Storage Conditions on Isoflavone Bioavailability
Isoflavones are biologically active plant secondary metabolites that have various benefits in humans and animals. Benefits of isoflavones derived from forage plants fall into the categories of natural products,

nutraceuticals, natural feed additives and functional feeds. Isoflavones have been seen to serve as anticarcinogens due to their antioxidant properties. They have also been seen to reduce cardiovascular diseases and reduce hot flashes in menopausal women. In ruminants, biomass isoflavones derived from forage plants, like red clover, have been seen to improve meat quality, reduce acidosis, improve fiber digestion, increase muscle mass ratio, and promote weight gain. The aim of this project is to add value to red clover, by studying how different drying and storage conditions sustain red clover isoflavones before it is fed to ruminants. This study is important because red clover grows only in the summer and it is necessary to feed it to ruminants, as stored hay, during the Fall and winter seasons. An ex-vivo study is also going to be done to further understand how the ruminant's digestive system responds to the various drying conditions used to dry the red clover before its stored. 2) Application of bio-based super absorbent polymers (hydrogels) for efficient soil water management and improved soil health The productivity of crops depends to a large extent on the ability of soil to provide the right amount of water to the growing plants while supporting beneficial soil microorganisms. Hydrogels have emerged as a viable option to use in retaining rain and irrigation water which is made available to the crop as soil dries. This project seeks to utilize lignin-based hydrogels as a means of efficiently managing soil water availability while acting as carriers of beneficial soil microorganisms. Lignin is a by-product of the bio-refinery industries, so lignin is relatively inexpensive to obtain and use for the synthesis of hydrogels. Many studies have used hydrogels for soil water management, however synthetic hydrogels are expensive and have slow biodegradation rates. There is a dearth in knowledge about how lignin hydrogels will affect soil moisture retention and beneficial microbes like Rhizobia. Further research is thus needed to quantify the performance of lignin-based hydrogels as soil amendments for increasing soil water retention and acting as beneficial microbial carriers. The use of lignin as a source of hydrogel production will eventually lead to the reduction of waste streams of lignin from biorefineries and potentially be a means of carbon sequestration by returning carbon to the soil. 3) Natural deep eutectic solvent mediated extrusion for continuous high-solid biomass pretreatment Recent advances in deep eutectic solvents (DESs) provided a relatively low-cost choice with comparable performance to ionic liquids for biomass fractionation and lignin extraction application. Despite the recent studies on DES pretreatment, most of the reported DES pretreatment processes employ batch processes at low biomass loadings ranging from 5% to 10%. Low biomass loading reported in literature hinders its practical use. In this study, for the first time, a twin-screw extruder was used for pretreating biomass sorghum bagasse at solid loadings up to 50%, mediated by a neutral pH DES, choline chloride: glycerol (ChCl:Gly). This continuous extrusion process led to high glucose and xylose yields of >85% from enzymatic saccharification of the pretreated sorghum. A combination of microscopic, spectroscopic, and X-ray diffraction analyses demonstrate a high degree of defibration and disruption of the biomass structures; however, little or no change in chemical compositions. Further evidence from gel permeation chromatographic and NMR spectroscopic analyses indicate that ChCl:Gly-mediated extrusion preserved the basic lignin structure characteristics and showed insignificant differences between extruded biomass at a solid loading of 30% and 50%. This study demonstrates the potential of DES-mediated extrusion as a highly effective continuous high-solid biomass pretreatment technology for industrial-relevant applications. The DES-mediated high-solid extrusion at a short time without compromising the benefits of high sugar yields obtained at high DES loading could improve the overall economics of DES-based pretreatment processes. (this work has been accepted as a journal article in Green Chemistry)

Louisiana

Pyrolysis of hydrolytic lignin in gas phase using laser heating Pyrolysis of hydrolytic lignin (HL) in the newly designed, gas phase continuous droplet evaporation (CDE) and continuous atomization (CA) reactors, was studied. The products distribution was strongly dependent on the heterogeneous character of either delivery of lignin solution into CDE reactor (in-situ formation of solid phase) or sampling conditions using quartz wool in both CDE and CA reactors. The effect of residence time, initial concentration of HL solution and injection temperature on products distribution in CDE reactor was investigated and discussed in terms of mass and heat transfer limitation. The experimental data confirm

that at low initial mass delivery rates of lignin (micrograms per second) and by increasing initial lignin concentration (up to 40 times), the formation of phenolics is slightly intensified (6 times). However, the solid surface or any condense phase that forms in-situ during reaction in the gas phase may largely govern the pyrolysis processes. The detailed experimental examination of homogeneous pyrolysis of lignin in both gas-phase reactors by implication of diverse analytical techniques (GC, GPC, LDI, FTIR, EPR, NMR) revealed break down of HL macromolecules into oligomer-fragments after pyrolysis at negligible amounts of phenolics detected. A mechanistic interpretation of primary steps for formation of dominant intermediate products – oligomers and oligomer stable radicals, is represented.

Michigan

Engineering Tools for Modeling of Polar Fluids (Lira). Improved spectroscopic methods for study of alcohols in hydrocarbons (e.g. alcohols in petroleum) provides association constant values for alcohols. Presented work on ethanol-gasoline fuel evaporation. Traditional models incorrectly predict liquid-liquid phase splitting for blends greater than about E13. Our model does not have this issue. Ethanol blends show an increased incremental heat of vaporization as the last ethanol evaporates and our model captures this behavior. Electrocatalytic upgrading (Saffron). Electrocatalytic upgrading (Saffron). Expanded the number of bio-oil monomers that were subjected to electrocatalysis; e.g., 4-propylguaiacol is converted to propylcyclohexane by electrocatalytic upgrading. Lignin dimers were cleaved using electrocatalytic hydrogenation to form cyclohexanol. Examined simple mixtures of bio-oil model compounds to observe their behavior during electrocatalysis over skeletal nickel; evidence of one organic molecule facilitating another's hydrogenation.

Minnesota

We continue to improve microwave-assisted gasification and pyrolysis. A new lab-scale system was fabricated. The latest design of the microwave-assisted pyrolysis system features continuous downdraft operation and a mixing silicon carbide ball bed reactor. Results showed that the system was able to operate stably for hours and produce high-quality gas products with improved efficiency compared to literature. Substantial work has been conducted to develop and evaluate of catalysts and catalytic cracking and reforming of volatiles. Both in situ and ex situ sequential two-step fast catalytic microwave-assisted pyrolysis and gasification were investigated. Catalytic reactor design and catalyst regeneration are being investigated.

Mississippi

We continue to investigate the biogas (including methane and carbon dioxide) dry reforming to syngas. And we also screened carbon supported nano catalysts for liquid hydrocarbon production from catalytic conversion of biogas derived syngas.

Missouri

Over as the last 50 years aquaculture productivity has increased from 1,000- 2,000 lb/ac to over 45,000 lb/ac, by adding increasing levels of aeration from 1-2 hp/ac to as much as 90 hp/ac. Natural levels of algal productivity can control ammonia levels in extensive or conventional fish culture ponds, but as feed loading surpasses 100 lb/ac-d, pond algal productivity cannot keep pace with ammonia removal and carbon fixation requirements. Enhanced photosynthetic techniques such as, partitioned aquaculture and split-ponds allows feed loading in excess of 200 lb/ac-d supporting fish production in excess of 10,000-14,000 lb/ac at algal fixation rates of 6-12 gm-C/m2-d. Productivity exceeding sustainable algal growth capacity requires culture systems utilizing nitrifying and/or heterotrophic microbial growth to keep pace with nitrogen loading at feeding rates exceeding 600-800 lb/ac-d. In spite of intense energy usage, and elevated feed rates, super-intensive aquaculture offer potential to provide sustainable seafood production in terms of energy and water requirements per unit of aquatic biomass produced. Integrated super-intensive systems, harvesting and converting microbial biomass production needed to maintain water quality, can provide valuable co-products while simultaneously reducing or eliminating water or waste

discharge to the environment.

Nebraska

Research on production of polyhydroxybutyrate (PHB) using *Paraburkholderia sacchari* was continued using a 3L bioreactor. This research scaled up results of a previous PHB production study in shake flasks. Fed-batch techniques were compared to standard batch fermentation. Two feeding strategies were tested in fed-batch mode. One was a “low” strategy that fed in pulses medium containing 40 g/L sugars and the other was a “high” strategy containing 80 g/L sugars. A maximum PHB concentration of 67 g/L with a yield of 0.33 g PHB/g sugar was produced using fed-batch high feeding strategy from a sugar mixture mimicking hydrolyzed corn kernel fiber (CKF) after alkaline pretreatment. The high strategy resulted in greater PHB yields and concentrations than the low and batch fermentation strategies. Additionally, work continued on developing systems to non-destructively measure PHB concentration in intact cells. A technique to measure PHB concentration and cell concentration with flow cytometry and fluorescent spectrophotometry was tested with different dyes and permeabilizers. A previous study which used Nile Red to dye cells resulted in good linear fitness between PHB concentration and fluorescence intensity, but poor fitness between cell concentration and fluorescence intensity. Nile Red and BODIPY dyes were compared in terms of linear fitness between fluorescence intensity, PHB concentration and cell concentration. Also, the effect of adding ethanol as a permeabilizer to increase dye uptake on linear fitness was measured. Use of BODIPY and ethanol increased linear fitness between fluorescence intensity and PHB concentration and cell concentration as opposed to Nile Red and no ethanol permeabilizer. Also, even with Nile Red, and increase in linear fitness between cell concentration and fluorescence intensity was observed compared to our previous study. This was due to the ethanol permeabilizer reducing cell aggregation (observed by fluorescent microscopy), which allowed for a better cell count during flow cytometry.

North Dakota

Biorefinery profitability depends on the revenues generated from co-products. Dry milling operations main co-product is dried distillers grains with solubles (DDGS). The amount of DDGS produced is steadily increasing since 1990, with 44.5 million tons of DDGS generated in the USA in 2016, selling for $0.06-0.07/lb. The prices of DDGS fluctuate based on the price of corn. The majority of DDGS is utilized as animal feed, though high fiber content of DDGS limits its uses mainly for ruminants. Finding new value-added products to utilize DDGS, which are not dependent on corn prices would benefit the biorefinery. There are ongoing research to develop a method for fractionating DDGS into high protein and high fiber, which could contribute additional economic benefit. A high protein and low fiber fraction will have a greater value as animal feed for non-ruminants, such as swine, poultry, and fishes. On the other side, a high fiber fraction will have more potential of using in building composite materials. However, minimal research has been conducted regarding DDGS use in composite materials. The inclusion of DDGS fiber for composites materials significantly benefits the industry that relies on petroleum-based products. The main goal of this project was to promote the use of DDGS for commercial low-density particleboards. Different amounts of DDGS can be used for making particleboards depending on the physical and mechanical properties' desire for a specific application. Oil recovered from DDGS can be a high-value product over animal feed to provide an additional profit to ethanol plants. The heavy fraction of DDGS condenses the oil from whole DDGS by eliminating fibers and specific sized particles. The objective of this study was to determine the effect of particle size of DDGS on oil recovery using enzymes. Enzymatic hydrolysis considered a promising approach for oil recovery without any changes in current ethanol plant design. Different commercial enzymes protease, cellulase, and hemicellulase were tested separately and in combinations to determine their effect on oil recovery from fractionated part of DDGS. The use of each enzyme individually resulted in a considerable amount of oil recovery except hemicellulase. Following enzymatic hydrolysis of the sieved-aspirated heavy fraction DDGS, oil recovery was significantly improved than whole DDGS. Overall, fractionation and enzyme hydrolysis showed promise in increasing oil recovery from DDGS. Bale net wraps are made of non-biodegradable plastics

and reported to accumulate and form stomach blockage when consumed by animals. Stomach blockage is not only painful and often leads to death but also result in great loss to farmers. Therefore, the production of edible bale net wrap, with similar properties to conventional bale net wrap, is an enviable solution to farmers. Interestingly, corn components (starch, oil, zein, and fiber) are suitable for making edible biomaterials, but, with poor mechanical properties. We hope to overcome these challenges by using biochemical processes to linearize and then crosslink corn-biopolymers to form composite suitable for making edible bale net wrap. The main goal of this research is to produce edible bale net wrap from corn. Recently, the soybeans economy has been greatly affected due to overreliance on exportation. A long term and permanent solution to sustain the soybean market is achievable through multidisciplinary innovative technology that will lead to alternative uses of soybeans. Since product quality is dependent on the type and condition of processing, it is time to rethink how soybeans are being processed. Due to reaction specificity and low operating temperature, enzyme aided processing (EAP) could overcome the challenges with conventional processing. Enzyme aided processing allows aqueous extraction feasible that is environmentally friendly and operates at a low temperature that will not denature proteins. One strategy to reduce EAP costs is to recycle enzymes by attaching them on nanoscaled supports for easy recovery and reuse. The objectives of this research include 1) To produce magnetic nanobiocatalysts for soybeans liquefaction, and 2) To synthesis soybeans biomolecules with improved functionalities Blessed thistle (Cnicus benedictus L.) has recently been identified as a multipurpose crop with optimal biomass and seed yield when grown on poor soils. The plant can be used in the restoration of lands not suitable for crop production, while its biomass, seeds, and oils are used for different applications in medicine and biofuel production. In collaboration with researchers in the plant sciences, we looked at the potential of blessed thistle species being planted on marginal lands and the conversion of its oil to biodiesel.

Oklahoma

(1) Syngas fermentation for production of alcohols and fatty acids (Atiyeh and Huhnke): Dr. Atiyeh's team continued the development of gas fermentation using biochar in bottle assays and continuous stirred tank reactor (CSTR). Biochar contains minerals and metals that can serve as nutrients for bacteria. Results showed enhancement in ethanol and butanol production in the media with biochar compared to expensive standard medium. In another project, continuous fermentations in two-stage reactors with and without cell separation system were performed. A third project was related to examining the ability of four new syngas fermentation strains (*Clostridium carboxidivorans* P7A, Strain A, Strain B and Strain C) for production of ethanol from syngas. All strains produced ethanol, butanol and hexanol and respected fatty acids from syngas. Preliminary results showed that P7A is the best butanol and hexanol producer, while Strain B is the best acid producer. However, additional improvement is required to enhanced growth and productivity of the four strains. This research will open opportunities to continue characterization of the physiological, enzymatic and genetic responses of the new strains for potential development as robust industrial strains for higher alcohols production. Three papers were published in peer-reviewed journals.

(2) Development of a control algorithm to maximize the conversion of syngas to ethanol (Atiyeh and Huhnke): Dr. Atiyeh's team have been developing various tools to facilitate design and control of large-scale bioreactors with increased alcohol productivity and selectivity and gas utilization to make the hybrid conversion process to produce biofuels economically viable. This was disclosed in three US Patents. One of the methods was focused on the development of a control algorithm to maximize the conversion of syngas to ethanol and increase productivity based on mass transfer, kinetics, and thermodynamic parameters of the fermentation process. The algorithm provides an effective new tool for process design and control of fermentation, described in 2020 US Patent No. 10,640,792.

(3) Novel biocatalytic conversion of biomass to butanol (Atiyeh): Dr. Atiyeh's team with researchers from Ohio state University has been developing butanol production process with high yield and carbon conversion using novel biocatalysts. In one project, the team has developed a process for co-fermentation of sugars, CO2 and H2 into butanol using strains tolerant to lignocellulose derived microbial inhibitory compounds (LDMIC). LDMICs such hydroxymethylfurfural, furfural and phenolic compounds are

generated during pretreatment of lignocellulosic biomass. We also performed a comparison of the life cycle environmental impacts of petroleum and corn-based butanol and jet fuel production pathways to those from switchgrass using traditional ABE fermentation and novel co-fermentation of sugars, CO2 and H2 into butanol with new LDMIC-tolerant biocatalysts. One paper was published in peer-reviewed journal. One paper is in review and one US Patent Application Publication appeared in 2020.

(4) Syngas Generated from Co-gasification (Kumar & Huhnke) Municipal solid waste (MSW) was mixed with switchgrass and co-gasified using Oklahoma State University's patented 60-kW downdraft gasifier. The general composition of the MSW was: food (14.6%), paper (27%), yard trimmings (13.5%), plastics (12.8%), metals (9.1%), rubber, leather and textiles (9%), wood (6.2%), and other (7.8%). Proximate analysis (weight %, dry basis) showed that MSW consisted of 77.5% volatile matter, 8.7% fixed carbon and 13.7% ash, and had 4% moisture content (wet basis). Switchgrass consisted of 78.6% volatile matter, 17.5% fixed carbon and 3.9% ash, and had 8% moisture content. Ultimate analysis (weight %, dry basis) showed carbon, hydrogen, oxygen, and nitrogen to be 50.7%, 6.1%, 29.1%, and 0.14%, respectively, for MSW, while switchgrass was 49.6%, 5.7%, 40.4% and 0.30%, respectively. Feedstock was gasified at 0, 20 and 40% co-gasification ratios (CGRs), which is the ratio of MSW content in the feedstock mixture. Maximum temperatures in the reactor's combustion zone ranged from 700-900°C with an average temperature of 800°C. Syngas was cleaned using a cyclone separator and wet-scrubbed using an acetone-water mixture. The maximum heating value of syngas were 6.91, 7.74, and 6.78 MJ/Nm3 for CGRs of 0, 20, and 40%, respectively.

Pennsylvania

Co-PI: Tom Richard Outcomes: In support of Objective B we are investigating microbial conversion of biomass into methane and carboxylic acids through various modes of anaerobic mixed culture fermentation, with a strong emphasis on mechanical cotreatment (milling during fermentation, mimicking the rumination and cud-chewing of a cow). This year we characterized the microbiomes and identified several organisms that appear to tolerate the stress of milling and can functionally replace those that do not. Co-PI: Ali Demirci Outcomes: 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 continued. In this study, it was proposed that DDGS can replace the high-cost feed-stocks to produce these enzymes. To achieve this goal, this phase of the study evaluated the effect of salts (KH_2PO_4, $CaCl_2 \cdot 2H_2O$, $MgSO_4 \cdot 7H_2O$, $FeSO_4 \cdot 7H_2O$, $CoCl_2 \cdot 6H_2O$, and $MnSO_4 \cdot H_2O$), peptone, and yeast extract on enzyme secretion and to optimize the nitrogen source for maximum enzyme productions by using various Aspergillus niger and Trichoderma reesei strains . In another project, Bacterial Cellulose (BC) has been studied with co-culturing. BC due to its high porosity, high tensile strength, biocompatibility, and crystal structure, is a value-added product that can be used in many different applications including biomedical, pharmaceutical, cosmetic, fiber composite, and filtration. Agitated fermentation, compared to conventional static cultivation method, is also reported to improve the BC production, but there is a lack of research regarding combining agitated fermentation and polysaccharide additive. Moreover, it might not be practical to use pure polysaccharides directly in industrial scales due to high cost. Therefore, this research is undertaken to study the effect of adding pullulan, an α (1-6) linked maltotriose polymer produced by the fungus Aureobasidium pullulans on enhancing the production and mechanical behaviors of BC cultivated by agitated fermentation. In a different study, various models were evaluated and utilized to observed values and kinetic parameters of the batch ethanol fabrication from carob extract in the suspended-cell stirred tank reactor (SCSTR). The best model was detected with the model comparison parameters. The results indicated that the model Stannard (ST) successfully predicted biomass production data, ethanol production, and sugar consumption. Consequently, the model ST can work as a universal function in predicting observed values and kinetics of batch ethanol generation from carob extract in an SCSTR. Co-PI: Howard Salis Outcomes: In a collaboration with LanzaTech Inc., the Salis Lab developed new technologies for engineering Clostridium autoethanogenum, which is a bacterial strain capable of catabolizing CO, CO_2, and H_2 gas feedstock and converting it into valuable chemicals.

These technologies accelerate the design-build-test-learn cycle for metabolic engineering and broaden the types of products that can be synthesized using this special organism. For example, using our newly developed Non-Repetitive Parts Calculator, we designed, constructed, and characterized 1200 non-repetitive promoters for controlling enzyme expression levels across a 10,000-fold range in Clostridium autoethanogenum. This toolbox of promoters enables metabolic engineers to introduce the expression of several heterologous (non-native) enzymes and rationally control their reaction rates. Co-PI: Stephen Chmely Outcomes: We have begun investigating 3D printing of advanced composite materials that contain cellulose nanocrystals (CNCs). These materials are printed on a small scale using a commercial DLP 3D printer, and we monitor improvements in modulus using tensile testing. We have shown modest increases in performance of commercial prototyping resins by including 0.1 wt% CNCs that have been suitably modified to enhance their dispersion in the hydrophobic resin materials.

South Carolina

Cottonseed oil, a relatively minor vegetable oil, is of great interest due to its natural antioxidant composition, mainly from endogenous gossypol observed to enhance the life of biodiesel from which it was derived (Moser, 2012). A major concern of producers is enhancing the life of biodiesel to increase its selling capacity. Many researchers add antioxidants in the post production phase, but with gossypol being naturally present it may become a strong contender in the market. Since the crop cannot be used for food because gossypol is toxic, cottonseed oil containing gossypol does not directly compete with food crops (De Sousa, De Moura, De Oliveira, & De Moura, 2014; Dunn, 2005; Wang, Howell, Chen, Yin, & Jiang, 2009). Glandless cottonseed oil not containing gossypol has a visual appearance like that of other vegetable oils and may be used in food. This oil was compared to measure the effect of gossypol for conversion in terms of possible inhibition. Novozymes Inc. recently released Eversa Transform® as a liquid lipase. Several optimal parameters were recommended in the user handbook. The purpose of this investigation was to determine how influential methanol:oil molar ratio, water content and lipase content are to the conversion of biodiesel from cottonseed oil. This examination will also provide data that determines how effective Eversa Transform® is at converting fringe feedstocks as opposed to the recommended waste cooking and refined soybean oils. Eversa Transform was used as an enzymatic catalyst to transform glandless and crude (heavy pigment) cottonseed oils into biodiesel. The oils were reacted with methanol at a 6:1 molar ratio with modified amounts of water, lipase, and temperature. Reactions were conducted in the presence of lipase and water at doses of 2, 5, and 8 wt% and 1, 3, and 6 wt%, respectively. Product composition and conversion were determined using the gas chromatography method of ASTM D6584. Oxidative stability was determined following EN 15751.

South Dakota

The research of biopolymer-based nanocomposites and their new applications in smart food packaging were performed in this period. A new process of combining hydrolysis and homogenization (2H) process for cellulose and nanocellulose extraction was designed and tested. This 2H process was able to extract cellulose nanofiber (CNF) and cellulose nanocrystals (CNC) from corn stover and prairie cordgrass. The produced CNF and CNC were combined with activated carbon, biochar, and polylactic acid (PLA) to fabricate nanocomposite films for uses in CRNF fabrications and biosensor development. A functional nanocellulose and activated carbon (NAC) film indicator was successfully developed to monitor freshness of foods (beef and turkey) in real time. An effective prototype of CRNF was produced. Depending on the operating conditions, the nutrient release patterns of this CRNF products are controllable and predictable to synchronize with the demand of corn growth. The releasing time of 80% N from the CRNF sample was more than 20 days, which was better than that of existing similar products of control release fertilizers. The results showed significant commercial potential in precision agriculture application.

Tennessee

In collaboration with colleagues at the Malaysian Palm Oil Board, we have formed biobased surfactants from sugars and fatty acids using immobilized lipases as biocatalysts, and glycolipid biosurfactants from

fermentation using bacteria. The modification of lignin with poly(□-caprolactone) appears promising to valorize industrial low-value lignins. We have synthesized lignin grafted poly(□-caprolactone) (lignin-g-PCL) copolymers via ring-opening polymerization of □-caprolactone with different types of lignins varying on botanical sources (i.e., G-type pine lignin, S/G-type poplar lignin, and C-type Vanilla seeds lignin) and lignin extraction methods (Kraft and ethanol organosolv pulping). The lignin-g-PCL showed remarkably improved compatibility and dispersion in acetone, chloroform, and toluene in comparison to non-modified lignins. Hemicellulose is an often-overlooked component of lignocellulosic biomass during pulp milling and usually is lost as a by-product in the black liquor. Therefore, we designed a method to fractionate low and high molecular weight hemicellulose polysaccharides from crude plant liquor and are developing an application to promote human gut health.

Virginia

Outcome 1. A wet fractionation process to produce protein concentrates and dietary fiber from brewer's spent grain, a waste biomass from brewing industry.

Outcome 2. A thermophilic and alkaliphilic fermentation process to efficiently convert food wastes to value-added 2,3-butanediol.

Outcome 3. A chemically modified nanocellulose material.

Washington

Leveraging research grants funded by the National Renewable Energy Laboratory, and the Seattle-based Joint Center for Aerospace Technology Innovation, our team developed a patented catalytic technology that converted biomass-derived lignin into jet fuel range hydrocarbons. Results showed that the complete suite of molecules that are required for jet fuel could potentially be obtained from biomass feedstocks. The fact that these molecules show sealant volume swell comparable to aromatics opens the door to the development of jet fuels with no aromatics, very low emissions, and very high-performance characteristics. Currently, we are in progress of collaborating with Boeing and other companies to test the fuel quality of lignin-derived hydrocarbons and/or chemicals as well as evaluate the techno-economic feasibility of the proposed integrated co-production of cellulosic ethanol and lignin biofuel at a large commercial scale, resulting in promising data and valuable insights for future research. Furthermore, several grants were recently funded by the Department of Energy-EERE to better understand the biological processing of biomass-derived lignin to produce lipids, bioplastics, and carbon fiber. With such funding support, our applied biological research focuses on building fundamental knowledge of the bacterial conversion of aromatic lignin in order to inform the design of resilient, industrially relevant synthetic microorganisms for biofuels and bioproducts via key metabolic nodes. In addition, in collaborating with PNNL, we demonstrated a simple and efficient one-step method to obtain high-surface-area porous carbons from renewable and low-cost lignin precursors for the first time. The carbonized lignin exhibited a relatively high electrochemical performance in terms of specific capacitance, energy density, and power, with good capacity retention. Besides national labs, some industrial professionals have also contacted me for potential collaboration in developing other value-added products from lignin, which will extend my research capacity in the future. In the biomass conversion area, we also continued research in anaerobic digestion, sequential hydrothermal liquefaction (SeqHTL) and cell factory development. We developed hyperthermal anaerobic digestion platform for high rate production of volatile fatty acids, we further integrated the platform with a Yarrowia lipolytica based cell factory for producing biochemical such as glycolic acid. We also applied the SeqHTL technology developed at WSU for recovering bioactive compounds from potato processing wastes and for processing lignocellulose.

Wisconsin

(1) Fabrication of aerogel from biomass for water and air purification and energy harvest. (2) Lignin valorization to chemicals, fuels and materials. (3) Synthesis of oligosaccharides from biomass sugars as

potential probiotics. (4) Identification of biomass constituents as adsorbent for iron and arsenic.

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

Higgins is engaged in process model development (mass balance and nutrient transformation) and life cycle assessment of the aquaponics facility at Auburn University. 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. Our efforts have also identified unit operations that contribute most to losses of nutrients and water.

California

Work continued on integrated systems modeling and spatial analysis as part of the development of a decision support application to determine optimized supply chains for electricity and fuels from biomass. The modeling approach includes spatial mapping of forest resources in California, including dead and dying stock that represent significant fire hazard, coupled with GIS estimations of transport distances and costs, technoeconomic modeling of feedstock processing and conversion, lifecycle environmental assessment, and distribution costs for product delivery into final demand. A web-compatible version of the FRCS model was developed for forest biomass harvesting cost analysis. Lifecycle data were translated to web-compatible files and an LCA model written for direct integration into the web application. Geospatial resource data were assembled for the Sierra Nevada region of California with a transportation model overlay. A substation data layer was added to estimate costs of electricity delivery into the grid infrastructure for overall product lifecycle cost estimation.

Michigan

Oil-enhanced sorghum (Saffron). Additional capital cost for transesterification is justified for converting modified sorghum when both ethanol and biodiesel are cogenerated as fuel products. Biomass co-firing decision support tool (Saffron). Multiple pretreatment options and process configurations are modeled. Model calibrated and verified using case study data. A 5% substitution of biomass was found to be economical and reduce emissions.

Missouri

Solids production from pond culture typically settles to the bottom of the pond and degrades anaerobically releasing ammonia and organic back into the water column, adding to treatment and aeration needs. However, VSS production from super-intensive systems can be diverted to filter-feeding cultures, such as tilapia or brine shrimp, eliminating need for water or sludge discharge and disposal, and can provide additional income as fish-meal replacement, or additional human seafood products. In spite of the high energy requirement for mixing and aeration in super-intensive systems, because of high productivity per unit area, the energy requirement per kg of product in these systems is below the 8 kw-hr/lb required for chicken production.

Nebraska

On-going work on integrating models for the Corn-Water-Ethanol Beef System for sustainability analysis and educational games. Specific work this past year includes: development of a theoretical framework for using research-based models in serious educational games and integrating region-specific information on farming inputs into LCAs using extension resources

New Jersey

Couple the duckweed production module with aquaculture installations. Quantify the projected costs and benefits of the optimized duckweed system by integrating the primary data obtained into an economics analysis to evaluate its market potential.

North Dakota

Enzymatic hydrolysis of biomass releases fermentable sugar for ethanol production. The high price of enzymes still contributes significantly to bioprocessing costs. Enzyme immobilization and recycling via membrane separation are promising technologies to recover enzymes and bioprocessing costs. However, most immobilization techniques reduce enzyme activities and membrane technology is susceptible to fouling. Cellulase enzyme were immobilized on polymer strands to make polymer-enzyme conjugate (PEC). This immobilization technique allows quick membrane recovery of enzymes and did not reduce enzyme activity. PEC performance was higher than that of free enzymes at high biomass loading. PECs were recovered using a high molecular weight cut-off (50 kDa) membrane. Extending exposure to hydrolytic conditions reduces recovered PEC performance. Recovery and reuse of PECs safe 60% makeup enzyme needed during subsequent biomass hydrolysis. The combination of PEC and membrane technologies has the potential to reduce hydrolysis cost during cellulosic bioprocessing.

Oklahoma

(1) An economic feasibility study for ethanol production from various feedstocks in a co-op and regional scale biorefineries (Atiyeh): Dr. Atiyeh's team with other researchers have estimated the economic feasibility of ethanol production via the hybrid gasification-syngas fermentation technology from selected livestock, agricultural and forest residues such as wheat straw, wheat straws blended with dewatered swine manure, and corn stover. Ethanol production potential was estimated based on syngas produced from various feedstocks. Feedstock, pretreatment, capital and operating costs for a co-op scale 1-2 million gallon per year (MGY) and a regional scale 50 MGY facilities were estimated. Results showed ethanol production cost heavily depends on the facility size and feedstock costs as recently reported in a peer-reviewed journal.

(2) Economics of Distributed Power Generation via Gasification of Biomass and Municipal Solid Waste (Kumar & Huhnke): More than one billion people worldwide still lack access to electricity. Rural electrification via gasification has the potential to satisfy electricity access and demand. This study conducts an economic evaluation of rural electrification through gasification of biomass and municipal solid waste (MSW) using a 60 kW downdraft gasifier, developed at Oklahoma State University. The effects of feedstock cost, electricity selling price, feed-in-tariff, tipping fee, tax rate, and the output power are evaluated using major financial parameters: the net present value, internal rate of return, modified internal rate of return, simple payback period, and discounted payback period, and sensitivity analysis. Results show that the downdraft gasification power system offers a payback period of 7.7 years, while generating an internal rate of return, modified internal rate of return, and net present value of 10.9%, 7.7%, and $84,550, respectively. Results from a sensitivity analysis indicate that the feed-in-tariff has the greatest positive contribution to the project's net present value. Using MSW, the gasification power system potentially reduces carbon dioxide, nitrogen oxides, and sulfur dioxide emissions as compared to direct combustion and landfill. The technology provides a promising future for rural electrification utilizing biomass and MSW whilst offering economic and environmental benefits for local communities.

Pennsylvania

Co-PI: Tom Richard Outcomes: In support of Objective C, we also continued experimental and modeling efforts to understand and enhance system-level opportunities to find synergies between profitable on-farm biomass production, advanced conversion technologies, and innovative market

products. We have intensified academic and private sector collaborations on the ecosystem service valuation 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. We continue our work to quantify carbon offset benefits in forest and cropland bioenergy systems, including opportunities for Biomass Energy Carbon Capture and Storage (BECCS)

South Dakota

Another PI, Dr. Zhengrong Gu, studied on developing biosensors for applications in food safety and environmental monitoring. The research will be helping information collecting and data mining for big data applications. This will provide useful information for decision making and system analysis in food and agricultural production.

Tennessee

We developed multiphase gasification and fast pyrolysis modeling tools to investigate the chemistry of biomass thermal deconstruction and their governing physics of the conveyance and conversion systems. The models will help tune the selectivity of gasification and fast pyrolysis processes to generate valuable product streams.

Virginia

Outcome 1. System-level techno-economic analysis (TEA) to evaluate the economic feasibility of converting corn stover to butyl acetate using genetically modified bacteria.

Washington

In fact, biological processing of lignin to bioproducts (e.g. lipids, PHA, and carbon fiber) has not been carried out at pilot, demonstration, or commercial scale. Thus, techno-economic analysis currently serves to not only identify primary cost drivers of lignin bioprocessing, prioritize research directions, but also project the economic impacts of lignin coproduction integration through development of process designs in order to mitigate technical risk for scale-up and improve the cost competitiveness in the next generation biorefinery as a whole. When the coproduction plant is envisioned as a bolt-on process into a cellulosic ethanol plant, additional operation units and processing steps in the integrated new biorefinery design result in higher overall capital and operating costs. Techno-economic analysis (TEA) results showed that high lignin conversion to value-added products and low cost product separation with high yields were essential to economic success. The reduction of minimum ethanol selling price (MESP) was found directly affected by the coproduct selling price, which was a direct function of plant productivity (i.e. lignin utilization and conversion). The projected minimum coproduct selling price will decrease as the technologies developed in this study mature over time. Thus, the advent of biorefineries that convert cellulosic biomass into fuel ethanol will generate substantially more lignin, and efforts are needed to transform it into higher value products. Our analysis work also included evaluation of the feasibility of the SeqHTL process, especially in comparison with the traditional one stage and direct hydrothermal liquefaction (DHTL) process. We conducted a TEA on using SeqHTL for processing algal biomass and found it being advantages over the DHTL process in terms of production cost of biofuels.

Impacts

Alabama

1) Developed new bioprocess for biofuel and biochemical production; 2) Secured federal grants for further biomass and biochemical research, education and outreach; 3) Develop connections and collaborations with colleagues from other institutes and stations

California

Conversion of cellobionate and cellobionate and glycerol to ethanol via microbial engineering and

microbial fermentation demonstrated that Klebsiella oxytoca strains could effectively use cellobionate for ethanol production for the first time. The co-fermentation strategy can drastically improve the ethanol yield from cellobionate and glycerol. Conversion of food and other organic waste into Polyhydroxyalkanoates (PHA) will lower the cost of PHA production, making the PHA more affordable as biodegradable plastics. Production of edible fungal biomass from almond and walnut hulls will create high value food and health products from agricultural byproducts. The development of the forestry biomass decision support application informs the development of sustainable product streams and to help guide research and policy decisions. The availability and development of bioenergy and bioproduct industries and improved decision tools to support feasible project development are very important.

Hawaii

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 involved collaboration with several colleagues within the S1075. Several of the funded projects were through close collaboration with members of S1075 and with active networking during several S1075 onsite meetings. Current work from the Su lab at the University of Hawaii helped to advance our 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.

Illinois

A model fluid that simulates thin stillage will help evaluate causes of fouling and cleaning strategies for fuel ethanol production. Fouling of heat transfer surfaces increases the environmental footprint and decreases the sustainability of evaporation and biofuel processes. Ethanol producers and biorefineries have a clearer picture of how multiple products (D-psicose and ethanol) can be made during fermentation that potentially improve long term profitability of facilities. Phosphorus from DDGS can be recovered separately, creating a DDGS coproduct with lower environmental impact and also creating a separate phosphorus coproduct for higher valued uses. Anthocyanins from corn can provide a natural food dye that does not have the health implications that FD&C Red dye has. New methods to produce fermented beverages can improve efficiency and profitability of beverage facilities. Wet fractionation improves profitability of ethanol production facilities.

Iowa

Techno-economic analyses were conducted on three commercial soybean processing systems: expelling, solvent extraction, and enzyme-assisted aqueous extraction. Our studies found that although hexane extraction was most efficient and least cost, aqueous extraction actually had lower environmental impacts. This research will be useful to soybean processing companies as they consider how to expand current operations or construct new facilities

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.

Kentucky

Through the support of S-1075, four graduate students (including two minority and one female students) were trained. The research outcomes were presented at international conferences and published as journal articles. The results of hemp related study were presented at the annual meeting of S-1084 (a sister multi-state project focusing on hemp cultivation) and the hemp filed day cosponsored by S-1084. The hemp field day attracted hundreds of farmers and hemp processors from Kentucky and other states.

Louisiana

The proposed project was significantly impacted by S1075, as the reported work is a collaborative effort between the Louisiana and Kentucky respective Experiments Stations. The main grant was submitted as an interstate collaboration, whose seeds were planted at the annual S0175 meetings (and its preceding incorporations).

Michigan

In collaboration with Dr. Scott Pryor at North Dakota State University and Dr. Mark Wilkins at the University of Nebraska, Dr. Chris Saffron was awarded travel funds from the NSF to support graduate student attendance at the 2019 S1075 Meeting and Symposium. In total, 18 graduate students were provided travel support to attend this meeting and present a poster at the Symposium. As the 2019 meeting was in Golden, Colorado, these students were provided a guided tour of the National Renewable Energy Laboratory (NREL). At the symposium that was part of the S1075 meeting, students interacted with several NREL scientists and engineers during and after their poster session. These interactions are invaluable for building future collaborations between the S1075 Land Grant Institutions and NREL. New collaborations are developing with NREL on fuels.

Minnesota

Our work on pretreating animal manures to produce effluent suitable for microalgae and vegetables to grow would have a significant impact on alternative biomass production. The thermochemical conversion of lignocellulosic biomass feedstock is a platform that can provide short and mid-term solutions. 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 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 and in commercialization. Our related facilities were also used for demonstration to stakeholders.

Missouri

Publication of invited book chapter providing knowledge to fish and shrimp farmers enabling co-products and biofuels from intensive and super-intensive aquaculture production

Montana

We found that nitrogen is the largest energy input and production cost, which affect the energy balance and profitability of feedstock production system. We are currently focused on genetic modification to improve camelina nitrogen use efficiency. For sugar beet research, Chen’s group continues to study no-till practice for sugar beet feedstock production, because tillage is a high energy cost and high environment impact practice, which will affect the sustainability of biomass feedstock production. We have developed a no-till production system that has been adopted by some sugar beet growers in Montana. For industrial hemp research, Chen’s group is currently evaluating industrial hemp varieties for their adaptation to Montana’s environment for seed, fiber, and CBD production. We are also studying the optimal planting date for high yield and quality hemp.

Nebraska

Models for predicting production of PHB by *P. sacchari* from different combinations of xylose, arabinose and glucose were determined. These models can be used by biorefineries to estimate yield of PHB by *P. sacchari* when using various biomass sources. Game simulations integrating cattle and ethanol production and surrounding water supplies are educating children about the food-energy-water nexus in a fun way.

New Jersey

This project increased awareness among farmers to the economic viability of the growing of duckweed. The project trained several Rutgers students in aquaponics assembly and mechanics, gain insight into biotic interactions, develop skills to become a field-advancing consultant, and translate their knowledge by mentoring other students.

Oklahoma

Global generation of municipal solid waste (MSW) is predicted to reach over 2.2 billion tons/year in 2025. Landfilling and incineration, the two most common conventional techniques for MSW processing, negatively impact public health. One of the studies developed and demonstrated electricity generation by co-gasification of two underutilized resources: MSW and agricultural biomass. Biochars from various sources were used in medium formulation that enhanced ethanol and butanol production from syngas, which was reported in four journal papers. Results are part of three patents on the syngas fermentation technology developed.

Pennsylvania

Increased use of economically-viable and sustainable processes will require deliberate development and refinement of novel technologies. 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. The breadth of these intersecting problems is so vast that constructive solutions can only be developed and implemented through collaborations that cross traditional disciplinary boundaries. 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 have a two-fold benefit: first, these materials are generally less expensive than those derived from petroleum, so there would be an immediate cost benefit.

South Carolina

The conversion to fatty acid methyl esters averaged 98.5% across all samples. Temperature had the most significant effect on conversion ($p < 0.0035$). Lipase and water dosages did not affect conversion, while each had an effect with temperature that was significant across the difference between 3 and 1 wt% water content and between 8 and 5 wt% enzyme content between the two temperatures ($p = 0.0018$ and 0.0153), respectively. Induction periods (oxidative stability) of the glandless and crude cottonseed oils were significantly different, but there was no difference between the two oil conversions based on oil type.

South Dakota

1. Provided innovative technologies to improve fertilizer use efficiency in production of biomass feedstocks and food supplies. 2. Reduced environmental impacts by utilizing agricultural resides and minimizing GHG emission and NPK fertilizers runoff or leaching into water system during biomass and food production. 3. Provided education and training opportunities for diverse students and workforces. 4. Delivered new knowledge and technologies to public and producers through publications and workshops.

Tennessee

The activities in objectives A through C will be impactful by reducing the risks associated with the deployment of biomass conversion technologies.

Virginia

The developed processing technologies coupled with techno-economic analysis have a great impact on developing technically feasible and economically viable routes to convert low-value waste biomass to value-added chemicals, which supports the objectives of the S1075 multistate project. The investigated chemical modification/functionalization of nanocellulose could pave the way for the use of nanocellulose

in wound healing.

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/Bioenergy industry, farmers, co-operatives, agri-processors, scientists, policy makers general public, and researchers/graduate and undergraduate students.

Illinois

Ethanol producers, Biorefineries, Enzyme and yeast producers, Producer and commodity organizations

Iowa

Processing companies that manufacture bio-based products, food, and feed ingredients Aquaculture producers Animal feed manufacturers Corn wet-milling industry Companies developing novel biobased chemicals (early stage TEA)

Kansas

1. Crop growers and farmers: by using biomass and oil seeds.

2. Biofuel industry: by development of biofuels

3. Adhesive and resin industry: by development of biobased adhesive and resins

Kentucky

Target audiences include the biofuel and bioproduct research community, the farmers and processors, biotechnology industry.

Louisiana

Other researchers in plant sciences, chemistry, and engineering; R & D personnel in all agricultural field (production, harvesting, logistics, processing) and food and biological engineering, microwave equipment manufacturers, other related industries are also included in the target audience for this project. Audience also includes the stakeholders in the Louisiana agriculture via popular magazine articles, and various state and federal governmental agencies and other policy makers, which can make scientific-based policy decisions using the outputs from this project.

Michigan

Academic and Industrial Professionals

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 audiences 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.

Missouri

Farmers, investors, researchers and other stakeholders interested in installation, operation and implementation of intensive, and super-intensive, zero-discharge aquaculture production.

Montana

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

Nebraska

Grain and oilseed producers, policy makers, ethanol companies, plastics and packaging companies, bioproduct entrepreneurs

New Jersey

Policy makers, Industry, Academia

New York

The target audiences for this work are 1) academic researchers and regulatory/policy conducting sustainability assessments, but even more importantly 2) growers (and their advisors) who will be better able to site, plan and manage feedstock crops, and will benefit from greater confidence in the yields and sustainability of a bioenergy/bioproduct cropping system that is compatible with current farming practices.

North Dakota

Agricultural producers, biofuel and biomass processors, biofuel investors, other researchers, university students

Oklahoma

Scientists, engineers, graduate students, postdoctoral fellows, product developers, and the public.

Pennsylvania

The target audiences for this research include a) the science and engineering research community, b) biomass processing companies ranging from small start-ups to large multi-national companies, c) policy analysts and decision makers, and d) potential biomass producers and the general public. Stakeholders include state and national organizations, state and federal agencies, companies and industry consultants. There is also strong public interest in understanding the environmental impacts of the biomass production and processing technologies as well as comparisons to conventional petroleum-derived products. These various stakeholders are being engaged through ongoing extension education programming that includes public presentations, short courses, websites (www.bioenergy.psu.edu, eXtension, and NEWBio.psu.edu), scientific journal articles and extension publications. The project results will be benefit biomass producers, the bioprocessing/fermentation industry and the rural public in general as a result of production of value-added products and bioenergy from raw agricultural products or by-products.

South Carolina

Biosystems Engineering researchers and students from multiple disciplines interested in biofuels. Biofuel producers including farmers of feedstock materials and biofuel production facilities.

South Dakota

1. 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 programs 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 ready them for their careers in 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. 4. Public and customers: This audience is targeted because the biomass-derived materials and products developed from the research will ultimately be used by customers. The customer's needs, likes, and acceptances should be considered in the research. This audience is targeted through publications of research results, conferences or workshops, website, and extension/outreach activities.

Tennessee

Vegetable and specialty crop growers, agricultural plastic manufacturers, and the scientific community

Virginia

Food processors, brewery industries, farmers, manufacturers of medical supplies

Washington

This research-based experiential learning and teaching can help our society to foster future leaders in industry, academia and government in developing sustainable clean technology to produce bioenergy and bioproducts for demands vital to our future. The problems associated with the bioprocessing of biomass to fuels and chemicals are among the most interdisciplinary areas and are true blend of science, technology, engineering and mathematics (STEM).The proposed education program will provide a rich environment to teach K-12, undergraduate and graduate students a general strategy to define and solve open-ended problems that should be valuable to them in dealing with complex real problems as well as develop students' multidisciplinary team working skills. Throughout the project, data relevant to the above hypothesis will be collected through student surveys, science project products, and interviews in order to establish the progress of teaching modules' success at improving the engagement of student participants in STEM learning and their attitudes towards science and STEM careers as well as their working skills. In addition, our studies will be guided by our industrial partners and government agencies to provide valuable data and facilitate near term commercial use. The postdoctoral and graduate student researchers supported by the project were involved in all aspects of the proposed studies, and had cross-training opportunities in multi-disciplinary research area as different subfields, including lignin chemistry, catalytic chemistry, biomass pretreatment, synthetic chemistry and biology, and chemical process design. They took the lead on experimental design, setup, and data analysis.

Wisconsin

Researchers (industrial and academic) and policy-makers.

Related Publications

Alabama

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Related Presentations

Alabama

Peng, H., L. Bashan, B. Higgins. 2020. Comparison of algae growth in the presence of PGPB and non-PGPB bacteria (poster). Auburn University Research Symposium, April, 2020 (online).

Box, J., B. Higgins. 2020. Development of algal-bacterial wastewater treatment systems that are effective in the presence of antimicrobial processing aids used in the poultry processing industry (poster). Auburn University Research Symposium, April, 2020 (online).

Dey, P., D. Chakraborty, R. Prasad, A. Gamble, Y. Feng and B. Higgins. 2019. Characterization of Phosphorus (P) in Poultry Litter and Determination of P Extraction Efficiency of Extractants. ASA, CSSA and SSSA Annual Meetings. San Antonio, Texas, November 10-13, 2019.

Dey, P., R. Prasad, D. Chakraborty, B. Higgins, A. Gamble, and Y. Feng. 2019. Phosphorus (P) Characterization in Poultry Litter of Various Ages and Composition. ASA, CSSA and SSSA Annual Meetings. San Antonio, Texas, November 10-13, 2019.

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H. Peng, L. de-Bashan, B.T. Higgins. 2019. Effects of Azospirillum brasilense on Microalgae UTEX2714 and UTEX 2341 Bioproduct Application. October 23, Auburn University College of Agriculture Poster Showcase

P. Goodling, H. Peng2, B.T. Higgins. 2019. Fecal coliforms die out in Spirulina algae cultures grown on aquaponics wastewater. October 23, Auburn University College of Agriculture Poster Showcase

Higgins, B.T., Q. Wang, M. Hyman, A. Wilson. Upgrading high-strength wastewaters into zooplankton fish feed. Auburn University Faculty Research Symposium. Auburn, AL. October 4th, 2019

P. Jiménez-Bonilla, David Blersch, Yifen Wang, Luz-Estela Gonzalez-de-Bashan, Y. Wang. Autolysin gene deletion in Clostridium saccharoperbutylacetonicum N1-4 increased strain stability and production for biobutanol fermentation. 2019 Bioenergy Sustainability Conference. Nashville, TN, October 21-22, 2019.

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California

Wang, K., S. Cai, C. Chen, J. Fan and R. Zhang. 2019. Production of Biodegradable Plastics from Food Waste. Presentation at ASABE Annual International Meeting. Boston, July 8.

Jenkins, B.M. 2020. An online application for decision support in siting woody biomass-to-electricity facilities in California, Rural Economic Development/Forest Management Wood Utilization Workgroup Meeting, Governor's Office of Planning and Research, Virtual Online Webinar, 13 July 2020.

Wang, K., Y. Chen, S. Zicari, R. Zhang. 2020. Production of Polyhydroxyalkanoates from Food Waste by Haloferax mediterranei. ASABE 2020 Annual International Meeting. July 13-15. Cao, L., T. Barzee, H.

El Mashad, Y. Chen, Z. Pan and R. Zhang. 2020. Production of Antioxidants and Fungal Biomass from

Almond Hulls for Food Applications. ASABE 2020 Annual International Meeting. July 13-15

Hawaii

Wongkiew, S., Park, M.R., Chandran, K., and Khanal, S.K*. Innovative aquaponic system for resource recovery. 2019 Innovation Conference on Sustainable Wastewater Treatment and Resource Recovery, November 24-28, 2019, Shanghai, China (Oral).

Khanal, S.K., Invited speaker, International Conference on New Horizons in Biotechnology, Trivendrum, India (Nov 20-23, 2019). "Nanobubble Technology Applications in Environment and Agriculture."

Khanal, S.K., Invited speaker, Sun Grant Center Western Regional Center, Oregon State University, Corvallis, OR (Aug 21, 2019). "Bioenergy and biobased products from biowastes/agri-residues."

Khanal, S.K., Invited speaker, Special seminar at Shandong University, Qingdao (July 9, 2019). "Recovery of resources from wastes (water)."

Kansas

1. Y. Yang, M. Zhang, J. Li, D. Wang. 2019. Effects of particle size on biomass pretreatment for biofuel production. Proceeding of the ASME 2019 14th International Manufacturing Science and Engineering Conference, 6/10-14, 2019, Erie, PA.

D. Wang. 2019. D. Biofuels and Biomaterials from grains and Oil Seeds. 2nd International Forum on the Science and Technology Development of Grains, Oils and Foodstuffs Zhengzhou, China, Nov. 15-17, 2019.

Vin-Nnajiofor, M., Zheng, Y., Shi, J., 2020. Flexible Bio-Based Plastics Derived from CO2 and Organic Waste. 2020 ASABE International Meeting, Omaha, NE, USA.

Xiao, R., Zheng, Y., 2020. Investigation of composition, structure and bioactivity of extracellular polymeric substances from original and stress-induced strains of Thraustochytrium striatum. Institute of Biological Engineering, 2020 Annual Conference, Athens, GA, USA.

J. Li, M. Zhang, D. Wang. 2019. Biomass pretreatment by magnesium oxide for reducing sugar degradation and water consumption in biofuel production. ASABE Annual Meeting, 7/7 to 7/10, 2019, Boston MI, US. Paper No. 1900157.

Youjie Xu, Jun Li, Zhanguo Xin, Scott Bean, Mike Tilley, and Donghai Wang. Water-soluble sugars of pedigreed sorghum mutant stalks and their recovery after pretreatment. American Society of Agricultural and Biological Engineers Annual International Meeting, July 14th, 2020, poster, virtual, United States.

Youjie Xu, Jikai Zhao, Jason Griffin, Weiqun Wang, and Donghai Wang. Hemp: A New Crop for Nutritious Food in Kansas. American Society of Agricultural and Biological Engineers Annual International Meeting, July 14th, 2020, oral, virtual, United State.

Kentucky

Oyetunji R, Nokes S., Flythe M. The effect of drying rate and storage conditions on the persistence of isoflavones in red clover hay. S-1075 Multistate Committee Annual Meeting and the Symposium on Science and Technology Driving the Bioeconomy (International) July 2019, Poster Presentation. July 2019

Kalinoski R.M., Shi J. 2019. Antimicrobial properties of lignin bio-oil derived from catalytic transfer hydrogenolysis of alkali treated corn stover lignin in supercritical ethanol with a Ru/C catalyst. S-1075 Multistate Committee Annual Meeting and the Symposium on Science and Technology Driving the Bioeconomy. Golden, CO. July.

Kalinoski R.M., Shi J. 2019. Antimicrobial Properties of Lignin Derivatives from Thermochemical Depolymerization. ASABE Annual International Meeting. Boston, MA. July.

Kalinoski R.M., Shi J. et al., 2019. Comparative Evaluation of 11 Industrial Hemp Varieties as Potential Energy Crops, the Hemp Field Day, Lexington, KY. Aug 23.

Michigan

Killian, W.G.; Bala, A.M.; Peereboom, L.; Storer, J.A.; Norfleet, A.T.; Jackson, J.E.; Lira, C.T. "Spectroscopic characterization of hydrogen bonding of ethanol in hydrocarbons for applied evaporative modeling" Presented at the American Chemical Society Spring 2020 Virtual Meeting, 2020. https://doi.org/10.1021/scimeetings.0c06040.

Killian, W.G.; Bala, A.M; Peereboom, L.; Storer, J.A.; Norfleet, A.T; Jackson, J.E.; Lira, C.T. "An Improved Spectroscopic Method for Determination of Association/Solvation Parameters Used in Process Models" paper 664c, Presented at the Annual Meeting of the AIChE, Orlando, FL, November 10-15, 2019.

Fasahati, P.; Liu, J.J.; Saffron, C.M. "Process Design and Economic Analysis of Ethanol and Diesel Production from Genetically Modified Lipid-Accumulating Sorghum" Presentation given at the American Institute for Chemical Engineering Annual Meeting. November 2019. Orlando, FL.

Zhang, Z.; Saffron, C.M. "Mapping Reaction Pathways of Biomass Fast Pyrolysis Using Isotopically Labeled Plant Cell Culture" Presentation given at the American Institute for Chemical Engineering Annual Meeting. November 2019. Orlando, FL.

Khin Zaw, K.S.; Kasad, M.; Saffron, C.M. "Electrocatalytic Hydrogenation of 4-Propylguaiacol, a Bio-Oil Model Compound" Poster given at the American Institute for Chemical Engineering Annual Meeting. November 2019. Orlando, FL.

Das, S.; Saffron, C.M. "Electrocatalytic Hydrogenation of Lignocellulosic Biomass to Hydrocarbon Fuels: Life Cycle Assessment and Technoeconomic Analysis" Presentation given at 236 Meeting of The Electrochemical Society. October 2019. Atlanta, GA.

Jackson, J.E.; Hao, P.; Zhou, Y.; Saffron, C.M. "Building paths to fuels and chemicals: Mild aqueous electrocatalytic energy upgrading of lignin and related model compounds" Presentation given at ACS. 2019. Orlando, FL.

Minnesota

Roger Ruan. 2020. Non-thermal plasma-induced nitrogen fixation. Kennedy Research LLC and Lorentzen Investments virtual meeting organized by UMN OTC.

Roger Ruan, Nan Zhou, Renchuan Zhang, Peng Peng, Yunpu Wang, Feiqiang Guo, Lingqin Liu, Leilei Dai, Shiyu Liu, Yiqin Wan, Erik Anderson, Xiaodan Wu, Dengle Duan, Shuhao Huo, Kun Li, Pengfei Cheng, Junzhi Liu, Xiye Chen, Yanling Cheng, Yuhuan Liu, Min Addy, Wenguang Zhou, Kirk Cobb, and Paul Chen. 2019. Sustainable circular economy technologies development and applications. NHBT-2019, Trivandrum, India.

Roger Ruan, Nan Zhou, Shiyu Liu, Paul Chen, Min Addy, Yunpu Wang, Feiqiang Guo, Yanling Cheng, Yuhuan Liu, Yingdan Zhu, Xiye Chen, Kirk Cobb. 2019. Microwave-assisted catalytic fast pyrolysis process and system for renewable energy production from solid wastes. Biofuels & Bioenergy and Green Energy & Expo 2019. Rome, Italy

Roger Ruan, Renchuan Zhang, Nan Zhou, Peng Peng, Yunpu Wang, Feiqiang Guo, Lingqin Liu, Leilei Dai, Shiyu Liu, Liangliang Fan, Erik Anderson, Yiqin Wan, Hongli Zheng, Xiaodan Wu, Dengle Duan, Shuhao Huo, Kun Li, Pengfei Cheng, Junzhi Liu, Qian Lu, Xiye Chen, Yanling Cheng, Hui Liu, Qing Wang, Yuhuan Liu, Min Addy, Wenguang Zhou, Kirk Cobb, and Paul Chen. 2019. Development of sustainable circular economy technologies. The 10th Asian-Pacific Conference on Algal Biotechnology (10th APCAB). Nanchang, Jiangxi.

Roger Ruan, Renchuan Zhang, Nan Zhou, Peng Peng, Yunpu Wang, Feiqiang Guo, Lingqin Liu, Leilei Dai, Shiyu Liu, Kuan Ding, Bo Zhang, Liangliang Fan, Erik Anderson, Yiqin Wan, Hongli Zheng, Xiaodan Wu, Dengle Duan, Shuhao Huo, Kun Li, Pengfei Cheng, Junzhi Liu, Qian Lu, Xiye Chen, Yanling Cheng, Yuhuan Liu, Min Addy, Wenguang Zhou, Kirk Cobb, and Paul Chen. 2019. Sustainable Technologies Development and Applications in Complete Solid and Liquid Waste Utilization and Treatment. 2019. Southeast University, Nanjing, Jiangsu

Roger Ruan. 2019. Biorefining Technologies Development and Applications in Complete Solid and Liquid Waste Utilization and Treatment. 2019. Nanjing Forestry University, Nanjing, Jiangsu

Roger Ruan, Nan Zhou, Yunpu Wang, Feiqiang Guo, Kuan Ding, Yaning Zhang, Bo Zhang, Shiyu Liu, Junwen Zhou, Yanling Cheng, Peng Peng, Min Addy, Paul Chen, Yuhuan Liu, and Kirk Cobb. 2019. Catalytic fast microwave-assisted thermochemical conversion of solid wastes for energy and fuel production. The 1st International Conference on Energy and Environment (1st ICEE), Nanjing, Jiangsu

Roger Ruan. 2019. Innovative Technologies Development and Applications in Complete Solid and Liquid Waste Utilization and Treatment. Nanjing Research Institute for Agricultural Mechanization, Ministry of Agriculture and Rural Affairs. Nanjing, Jiangsu

Roger Ruan. 2019. Innovative Biorefining Technologies for Complete Solid and Liquid Waste Utilization and Treatment. In Symposium on Biofuels and Sustainable Development, International conference on Biofuels and Bioenergy, Theme: Water, Food, and Energy, April 29 - May 01, 2019, San Francisco, California.

Roger Ruan, Peng Peng, Paul Chen, Charles Schiappacasse, Nan Zhou, and Yanling Cheng. 2019. Development of non-thermal plasma (NTP) for sustainable agricultural applications. Mechanical Engineering Department Seminar, University of Minnesota. Minneapolis, MN.

Roger Ruan. 2019. Sustainable Food Production/Processing and Circular Economy Technologies. Agricultural Research Organization – Volcani Center, Institute of Soil, Water and Environmental Science, Newe Ya'ar Research Center, Israel.

Roger Ruan, Peng Peng, Paul Chen, Charles Schiappacasse, Nan Zhou, Yanling Cheng, and Min Addy. 2019. Non-Thermal Plasma (NTP) Ammonia Synthesis and Nitrogen Fixation. Lorentzen Investments – U of MN Ammonia Research Meeting, Minneapolis Campus.

Roger Ruan and Brian Bauer. 2019. Biomass to Energy Conversion Technologies. Forest Stewardship Campaign Initial Summit, Santa Rosa, CA.

Missouri

Brune, D. E., Zero-Discharge Marine Shrimp Production, North Central Regional Aquaculture Meeting, Feb 2020, Columbus Ohio. Brune, D.E., Autotrophic and Heterotrophic Microbial Water Treatment in Extensive to Super-Intensive Fish and Shrimp Culture, Invited Presentation at Aquaculture America International Meeting, Honolulu HI. Feb 2020.

Montana

Sutradhar, A., C. Chen., and R. Garza. Evaluation of industrial hemp seeding date and variety for eastern Montana. MonDak Ag Research Summit. December 12, 2019, Sidney, MT.

Sutradhar, A., and C. Chen. 2019. Sugar beet yield and sugar content response to micronutrients in tilled and no-till sugar beet. MonDak Ag Research Summit, December 12, 2019. Sidney, MT.

Chen, C., A. Sutradhar, and W. Franck. 2019. Tillage and nitrogen management for sugar beet production. ASA-CSSA International Meeting, Nov. 10-13, San Antonio, TX.

Chen, C., B. Stevens, W. Iversen, A. Sutradhar, W. Franck., and S. Franck. 2019. Agronomic and economic benefits of irrigated peas. MonDak Ag Research Summit. December 12, 2019. Sidney, MT

Nebraska

Brown, B., C. Immethun, M. Wilkins, R. Saha. 2020. Rhodopseudomonas palustris bioplastic production from lignin. University of Nebraska-Lincoln Graduate Student Symposium, Feb 21, 2020

Brown, B., C. Immethun, M. Wilkins, R. Saha. 2020. Conversion of Lignin into biodegradable plastic by Rhodopseudomonas palustris. ASABE Annual Meeting, 14 Jul, 2020.

Long, D., Immethun, C. M., Wilkins, M. & Saha, R. 2019. Development of a non-leaky inducible system for tunable gene expression in Actinobacillus succinogenes 130 Z and application for increased succinic acid production. AIChE annual meeting. Orlando, FL, USA

Monhollon, L., Keshwani, D.R. 2020. Leveraging Crop Budgets to Assess Environmental Impact of Agricultural Operations. Presented at 2020 ASABE Virtual Annual Conference.

Continuous Succinic Acid Production by Actinobacillus Succinogenes in a Hollow Fiber

Vallecilla-Yepez, L., M.R. Wilkins. 2020. Membrane packed-bed biofilm reactor. ASABE Annual Meeting, 14 Jul, 2020.

New Jersey

"Integrating the aquatic macrophyte Lemnaceae for sustainable aquaculture" Rutgers University "Aquaculture and Photosynthesis Based Filtration Systems" Rutgers University.

New York

Richards, Brian K., Ryan V. Crawford, Srabani Das, Cedric Mason, Cathelijne R. Stoof, Steven Pacenka, Julie Hansen, Jamie L. Crawford, Tammo S, Steenhuis, Donald R. Viands. Invited presentation: Perennial Grass Feedstock Production on Wetness-Prone Marginal Soils in New York. Switchgrass V Conference. Urbana. IL. July 2019. doi: 10.13140/RG.2.2.21798.27208

North Dakota

Huda, S., and Nahar N. 2020. Increased Oil Recovery from Distillers Dried Grains with Solubles (DDGS). ASABE Annual International Meeting, July 13 – 15, 2020 Virtual Conference (Oral Presentation).

Regmi, S, Bajwa, D, and Nahar N. 2020. Value Addition of Corn Distillers Dried Grains with Solubles (DDGS) by Fiber Separation and Application of DDGS Fiber to manufacture Low-Density Particleboards. ASABE Annual International Meeting, July 13 – 15, 2020 Virtual Conference (Oral Presentation).

Pennsylvania

Richard, T.L., A. Bharadwaj and I. Amador-Diaz. Biomimetic Rumination: Cotreatment's Energy Return on Energy Investment. AIChE annual meeting. Nov. 11, 2019. Orlando, FL.

Lynd, L., E. Holwerda, D. Olson, X. Liang, M. Laser, C. Wyman, J. Hannon, L. Wang, C. Maranas, T.L. Richard, G.A. Tuskan, and B. Davison. Reinventing Biorefining. Sustainable Bioenergy Plenary Session, AIChE annual meeting. Nov. 11, 2019. Orlando, FL.

Vazhnik, V., M. Roni, J. Hansen, S. Bansal and T.L. Richard. 2019. Crop allocation spatial decision-making using stakeholder engagement, sustainability indicators and multi-attribute optimization. Presented at INFORMS Annual Meeting, October 20-23, Seattle, Washington

Veronika V., S. Herbstritt, M. Griffel, T.L. Richard and J. Hansen. 2019. Perennial grasses in integrated landscape designs: carbon drawdown, profit potential, and ecosystem service opportunities. Research to Action: The Science of Drawdown: Research to Action, Sep 16-18, 2019, University Park. PA

Bharadwaj, A., J.A. May, E. Holwerda, L.R. Lynd, and T.L. Richard. 2019. Cotreatment enhanced

anaerobic digestion of lignocellulosic biomass. The Science of Drawdown: Research to Action, Sep 16-18, 2019, University Park. PA.

Demirci, A. 2019. Biofilm reactors for biofuel production and fermentation facilities at Penn State. School of Agricultural, Forest and Food Sciences. Bern University of Applied Sciences Bern, Switzerland.

Iram, A., A. Demirci, and D. Cekmecelioglu. 2019. Screening of bacterial and fungal strains for cellulase and xylanase production using distillers' dried grains with solubles as the feedstock. The Science and Engineering for a Bio-based Industry and Economy (S-1075) Multi-State Project Annual Conference. Golden, CO.

Iram, A., A. Demirci, and D. Cekmecelioglu. 2019. Screening of bacterial and fungal strains for cellulase and xylanase production using distillers' dried grains with solubles as the feedstock. Graduate Student Poster Session. Dept. of Agricultural and Biological Engineering Penn State University, University Park, PA.

Hu, H, J.M. Catchmark, and A. Demirci. 2019. Study of a novel co-culturing fermentation for bacterial cellulose nanocomposite production. Graduate Student Poster Session. Dept. of Agricultural and Biological Engineering Penn State University, University Park, PA.

Hu, H., Catchmark, J.M., and Demirci, A. 2020. Study of a novel co-culturing fermentation for bacterial cellulose nanocomposite production. ASABE Paper No. 2000031. American Society of Agricultural Engineers. St. Joseph, MI. 12 pp.

Iram, A., A. Demirci, and D. Cekmecelioglu. 2020. Bacterial and fungal strain selections for cellulase and xylanase production using distillers' dried grains with solubles (DDGS). ASABE Paper No. 2000032. American Society of Agricultural Engineers. St. Joseph, MI. 9 pp.

Liu, J. 2019. Field Performance Analysis of a Tractor and a Large Square Baler, Northeast Agricultural and Biological Engineering Conference, June 16 – June 19, Lac Beauport, QC, Canada.

Liu, J., Collins, A., Graybill, J., Roth, G. 2019. Industrial Hemp Planting, Harvesting and Decorticating. ASABE Annual International Meeting, July 7 – July 10, 2019. Boston Marriott Copley Place, Boston, MA.

Salis, H.M. 2019. Automated Design of Large Genetic Systems for Engineering Organisms. Invent Penn State. State College, PA. Salis, H.M. 2019. Automated Design of Large Genetic Systems for Engineering Organisms. NSF Square Table Workshop on Programmable Interfaces. Arlington, VA.

Salis, H.M. 2019. Toolboxes of Non-Repetitive Genetic Parts. DARPA SD2 Workshop. Boston, MA.

Salis, H.M. 2019. Automated Design of Large Genetic Systems for Engineering Organisms. Workshop on a Synthetic Biology Manufacturing Innovation Institute. Boston, MA.

Salis, H.M. 2019. New Technologies in Synthetic Biology. SBME Roadmapping Workshop. Arlington, VA.

Salis, H.M. 2020. Toolboxes of Non-Repetitive Genetic Parts for Engineering Clostridia. DOE Genomic Sciences Meeting. Washington D.C. Chmely, S.C. 3D Printing with Lignin by Stereolithography. Presented at the Millennium Café weekly seminar series. October 15, 2019. University Park, PA.

Chmely, S.C. Frontiers in Biorefining: Chemicals and Products from Renewable Carbon. Presented at the Penn State Catalysis Seminar Series. February 26, 2020. University Park, PA.

Chmely, S.C. 3D Printing with Biomass-derived Polymers. Presented at the Convergence Center on Living Multifunctional Materials Systems (LiMC2) Joint Webinar series Penn State/Albert-Ludwigs-Universität Freiburg. May 28, 2020. Webinar: University Park, PA/Freiburg im Breisgau, Germany. Chmely, S.C. Agriculture and the Promise of Advanced Manufacturing: 3D Printing with Lignin.

Presented at the Annual International Meeting of the American Society of Agricultural and Biological Engineers (Virtual and On Demand). July 13-July 15, 2020. Online virtual webinar.

South Carolina

Zanin E, S Anderson, CD Thornton, TH Walker, 2017, Optimization of FAME Production using Eversa® Transform and Methyl Acetate, National Biodiesel Board Annual Meeting, San Diego, CA, Jan, Poster Presentation.

South Dakota

Zhisheng Cen, Lin Wei*, Cheng Zhang. 2020. Developing a control-release nitrogenous fertilizer by combination of biochar and sodium alginate, Paper #: 2000573. ASABE Annual International Meeting, July 13-15, 2020, Virtual & On Demand.

Abdus Sobhan, Kasiviswanathan Muthukumarappan, Lin Wei*, 2020. Development of bio-nanocomposite films by combination of PLA and biochar for smart food packaging. Paper #: 2000566. ASABE Annual International Meeting, July 13-15, 2020, Virtual & On Demand.

Abdus Sobhan, Kasiviswanathan Muthukumarappan, Lin Wei*, 2020. Development of a novel PLA coated bio-nanocomposite film indicator for monitoring meat freshness. Paper #: 2000568. ASABE Annual International Meeting, July 13-15, 2020, Virtual & On Demand.

Nadee Kaluwahandi, Lin Wei, Kasiviswanathan Muthukumarappan*, 2020. Opportunities and Challenges of Cold Plasma in Food Processing. Paper #: 2000969. ASABE Annual International Meeting, July 13-15, 2020, Virtual & On Demand.

Tennessee

D.G. Hayes [invited presenter], Biobased Surfactants: An Overview, American Oil Chemists' Society Annual Meeting, St. Louis, 5-8 May 2019.

DG. Hayes [invited presenter], M.B. Anunciado, A.F. Astner, H.M. O'Neill, B.R. Evans, S.V. Pingali, V.S. Urban, M. Flury, H. Sintim, J.M. DeBruyn, S.M. Schaeffer, S. Bandopadhyay, M. English, C. Miles, S. Ghimire, A.L. Wszelaki, and J. Moore, When Worlds Collide: Relationships Between the Life Cycle of Biodegradable Plastic Mulches and Ecosystems, BioEnvironmental Polymer Society (BEPS) Annual Meeting, Greenville, SC, 5-7 June 2019.

M.B. Anunciado (oral presenter), C.D. Cowan-Banker, A.F. Astner, L.C. Wadsworth, and D.G. Hayes, Effect of environmental weathering on microbial assimilation of biodegradable plastic mulches under ambient soil and composting conditions, BioEnvironmental Polymer Society (BEPS) Annual Meeting, Greenville, SC, 5-7 June 2019.

D.G. Hayes [invited presenter], Biobased Surfactants: Overview and Recent Trends, AOCS China Section Conference, Guangzhou, China, 9-10 November 2019

D.G. Hayes [invited presenter], Enzymatic Synthesis of Sugar and Sugar Alcohol Esters, AOCS China Section Conference, Guangzhou, China, 9-10 November 2019

D.G. Hayes [invited presenter; keynote], Biobased Surfactants: Overview and Recent Trends, 2nd International Forum on the Science and Technology Development of Grains, Oils and Foodstuffs, Zhengzhou, China 16 November 2019.

D.G. Hayes [invited presenter; keynote], Biobased Surfactants: An Expanding Product Sector Ripe for Opportunities for Oil Palm, PIPOC, Kuala Lumpur, Malaysia, 19-21 November 2019.

D.G. Hayes [invited presenter], Dissolution in Ionic Liquids (and Deep Eutectic Solvents?): an Environmentally Sustainable Approach for the for the Pretreatment of Lignocellulosic Biomass, PIPOC, Kuala Lumpur, Malaysia, 19-21 November 2019.

D.G. Hayes [invited presenter], Biobased Surfactants: Overview and Recent Trends, Future of Surfactants Conference, Boston, 23-24 September 2020

Rajan, K., D'Souza, D., Carrier, D. J., Labbe, N. A sustainable pathway for bio-product development from switchgrass", Switchgrass V conference, Champaign, IL, July 24, 2019.

Virginia

J. O'Hair, D. Yu., Q., Jin, N. Poe, S. Zhou, H. Huang*. Thermophilic Alkaliphile Bacillus licheniformis YNP5-TSU for production of 2, 3-butanediol. Society for Industrial Microbiology and Biotechnology Annual Meeting, Ft. Myers, Florida, October, 2019.

Q. Jin, Z. Wang, Y. Feng, A. P. Neilson, A. C. Stewart, S. F. O'Keefe, Y.T. Kim, M. McGuire, G. Wilder, Z. He, H. Huang*. Red grape pomace biorefinery for the production of oil, polyphenols, lignin, biofuels and biochars. 2019 S1075 Multistate Meeting. Golden, Colorado. July, 2019.

Y. He, D. D. Kuhn, Ó. A. Galagarza, Z. W. Taylor, B. D. Wiersema, H. Wang and H. Huang*. Wet fractionation process to recover protein-rich product from brewer's spent grain as a replacement feed ingredient for fishmeal in shrimp diet. 2019 S1075 Multistate Meeting. Golden, Colorado. July, 2019.

Q. Jin, A. Damle, N. Poe, H. Wang, J. Wu, H. Huang*. Butanol Production from Food Waste by Immobilized Cell Fermentation and Advanced Membrane Separation System. 2019 IFT Annual Meeting, New Orleans, LA, June 2019.

Y. He, D. D. Kuhn, J. A. Ogejo, S. F. O'Keefe, C. Fernández Fraguas, H. Wang, B. D. Wiersema, H. Huang*. Optimizing enzymatic separation of protein-rich product from brewer's spent grain. New Orleans, LA, June 2019.

D. Yu, N. Poe, J. O'Hair, S. Pinton, S. Zhou, H. Huang*. Production of 2,3-Butanediol using Bacillus licheniformis YNP5-TSU from Yellowstone National Park. 2019 ASABE Meeting, Boston, MA, July, 2019.

Washington

"Sustainable Energy Future", Rantasalmi high school, Rantasalmi, Finland, Dec. 13th, 2019

"Low Cost Biofuels and Bioproducts from Plant Biomass", Aalto University, Espoo, Finland, November 29th, 2019. https://www.aalto.fi/en/events/low-cost-biofuels-and-bioproducts-from-plant-biomass.

"Advanced Technologies for Low Cost Sugar and Lignin", Toulouse Biotechnology Institute, Toulouse, France, November 21, 2019.

"The Sustainable Biofuels and Bioproducts from Plant Biomass", Toulouse Biotechnology Institute, Toulouse, France, November 19, 2019

"The Outlook on U.S. Biorefinery", Abo Akademi University John Gadolin Process Chemistry Centre, Turku, Finland, 28th of October, 2019.

"Current challenges and opportunities in biorefinery for production of low cost biofuels and bioproducts", Towards Sustainable Bioeconomy, SmartBio Annual Meeting, University of Turku, Turku, Finland, 9th of October, 2019 in Auriga Business Center. http://www.smartbio.fi/save-date-smartbio-annual-meeting-29102019

"The Outlook on U.S. Biorefinery", Abo Akademi University John Gadolin Process Chemistry Centre, Turku, Finland, 28th of October, 2019.

"Sustainable Biofuels and the American Dream", American Voices XXVII, University of Turku, Turku, Finland, October 11, 2019 https://www.fulbright.fi/about-us/events/american-voices-seminar

"Understanding of Cellulose Structure by The Nonlinear Vibrational Spectroscopy", Material Platform,

Aalto University, Espoo, Finland, September 7th, 2019 https://www.aalto.fi/en/events/understanding-cellulose-structure-by-nonlinear-vibrational-spectroscopy

“Low Cost Biofuels and Bioproducts from Plant Biomass”, Faculty of Biology, University of Latvia, Riga, Latvia, October 3rd, 2019

“Future Biomass Processing Node, Low-Cost Biofuels and Bioproducts from Plant Biomass”, VTT, Espoo, Finland, September 19th, 2019

“Lignin to Drop-in Jet Fuel Hydrocarbons”, ST1 Company, Finland, September 5th, 2019

“Catalytic Upgrading Lignin to Drop-in Jet Fuel Hydrocarbons”, Chemical Engineering Department Seminar, Aalto University, Espoo, Finland, August 17th, 2019

“Lignin-Based Jet Fuel Production”, 2019 JCATI Symposium, Seattle, WA, April 11, 2019. “Outlook: Fuels and Chemicals in Plant Biomass”, Workshop on Catalytic Reactions with Ion Transfer through Interfaces, Espoo, Finland, August 16, 2019.

Zhangyang Xu, Chunmei Pan, Xiaolu Li, Naijia Hao, Arthur J. Ragauskas, Yuanqiao Pu, Bin Yang* “Enhancement of Polyhydroxyalkanoate Production by Co-feeding Lignin Derivatives with Glycerol in Pseudomonas Putida KT2440”, AIChE annual meeting, Orlando, FL, Nov. 11th, 2019.

“Catalytic Design Platform for Lignin Upgrading to Chemicals and Fuels”, Workshop on Catalytic Reactions with Ion Transfer through Interfaces, Espoo, Finland, August 15, 2019.

Xiaolu Li, Yucai He, Libing Zhang, Haoxi Ben, Zhangyang Xu, Matthew J. Gaffrey, Yongfu Yang, Wei-jun Qian, Shihui Yang, Joshua Yuan, Scott E. Baker, Bin Yang, “Discovery of potential pathways for biological conversion of poplar wood into lipids by co-fermentation of Rhodococci strains” 2019 S-1075 Multistate Committee Annual Meeting and the Symposium on Science and Technology Driving the Bioeconomy, Denver, CO, July 30, 2019.

Bin Yang, “Lignin Jet Fuel Production” 2019 S-1075 Multistate Committee Annual Meeting and the Symposium on Science and Technology Driving the Bioeconomy, Denver, CO, July 30, 2019.

Zhangyang Xu, Libing Zhang, , Zheming Wang, Hongfei Wang, and Bin Yang, “Understandings of Thermal Transformation of Cellulose Surface and Crystalline Core by in-situ Nonlinear Vibrational Spectroscopy”, 41st Symposium on Biotechnology for Fuels and Chemicals, Seattle, WA. May 1st, 2019.

Xiaoyu Wu, Bin Yang, Songmei Li, Chongmin Wang. “Rational-designed graphene-like 2D carbonaceous materials from chitin and lignin for energy-related applications”. 41st Symposium on Biotechnology for Fuels and Chemicals, Seattle, WA. April 28th, 2019

Wisconsin

Ning Li, Zheng Li, and Xuejun Pan. Quantitation, depolymerization, and demethylation of lignin in inorganic ionic liquid. 2019 AIChE Annual Meeting, November 10-15, 2019, Orlando, FL.

Ning Li, Jee-Hwan Oh, Jan Peter van Pijkeren, George Huber, and Xuejun Pan. Synthesis of oligosaccharides directly from mono- and di-saccharides as potential prebiotics in inorganic ionic liquid. 2019 AIChE Annual Meeting, November 10-15, 2019, Orlando, FL.

Ning Li, Zheng Li, Tianjiao Qu, and Xuejun Pan. Lignin isolation, depolymerization, demethylation, and quantitation with inorganic ionic liquid. The 1st International Lignin Symposium, September 13-15, 2019, Sapporo, Japan.

Xuejun Pan. Insights into the isolation and structural changes of lignin in inorganic ionic liquid. ACS Fall 2019 National Meeting, August 25-29, 2019, San Diego, CA.

Theses and Dissertations

Alabama

Pablo Jimenez, PhD Dissertation, 12/2019. “Enhancing the robustness of Clostridium saccharoperbutylacetonicum N1-4 for butanol production through metabolic engineering and cell immobilization strategies.”

Haixin Peng, PhD Dissertation, 7/2020. “Effects of growth-promoting bacteria in suspended green algae cultures for bioenergy and bioproduct development.”

California

Barzee, T. 2020. Processing and Utilization of Anaerobic Digestate as Biofertilizer for Production of Crops and Microalgae. PhD Dissertation. University of California, Davis.

Hawaii

Fernanda R. Oliveira (Ph.D.) “High rate anaerobic digestion process for treatment of sulfate-laden industrial wastewater with simultaneous removal of hydrogen sulfide using biochar.”

Kansas

Jun Li. 2020. Biomass pretreatment by metal oxides for reducing sugar degradation and water consumption in biofuel production, PhD dissertation, Kansas State University

Sang Li, 2020. Bioconversion of Meat and Bone Meal (MBM) and Starch into Astaxanthin, MS theses, Kansas State University

Minnesota

Shiyu Liu Ph.D. Bioproducts and Biosystems Engineering October, 2019 Thesis: Microwave-assisted catalytic thermochemical conversion of organic solid wastes for biofuels production

Renchuan Zhang Ph.D. Bioproducts and Biosystems Engineering April, 2020 Thesis: An innovative thermal-vacuum stripping assisted thermophilic anaerobic digestion process and system for complete utilization of liquid swine manure.

Nebraska

Li, M. 2019. Adding value to lignocellulosic biorefinery: Efficient process development of lignocellulosic biomass conversion into polyhydroxybutyrate. Ph.D. Dissertation. Lincoln, NE: University of Nebraska. 168 p.

Pennsylvania

Halper, S. 2019. Design Optimization Algorithms for Synthetic Biology Applications. Ph.D. Dissertation. Pennsylvania State University, University Park, PA.

Bharadwaj, A. 2020. Microbial Adaptation and Cotreatment-Enhanced Biomass Solubilization in Lignocellulosic Anaerobic Digestion. Ph.D. Dissertation. Pennsylvania State University, University Park, PA.

Vazhnik, V. 2020. Farm Landscape Design Decision Support to Increase Economic, Environmental and Social Benefits Using Stakeholder Engagement, Sustainability Assessment and Spatial Analysis. Ph.D. Dissertation. Pennsylvania State University, University Park, PA.

Hu, H. Production of Bacterial Cellulose with Enhanced Mechanical Properties Using Pullulan Additive and Co-Culturing Methods. M.S. Thesis. Pennsylvania State University, University Park, PA.

South Carolina

Stanley Anderson, 2018, Evaluation of Parameters Affecting the Performance of Lipase Transesterification Using Cottonseed Oil, M.S. Thesis, Clemson University.

Tennessee

Marife B. Anunciado, 2020, Changes in physicochemical properties of biodegradable mulch due to weathering and ageing and their influence on biodegradation. PhD dissertation, Environmental and Soil Science, University of Tennessee

Washington

Ayca Seker, 2019. Extraction of polyphenols from fruit processing wastes, Washington State University, Pullman, WA 99164 Na Pang, 2019. Synergistic effect of photosynthesis and carbon metabolism on microalgal growth and biosynthesis under mixotrophic conditions, Washington State University, Pullman, WA 99164

Xiao, Fu., 2019. Manganese assisted fungal treatment of lignocellulosic biomass for biofuels production, Washington State University, Pullman, WA 99164 Maryam Dacaritouchaee, 2019. Comprehensive study on lignocellulosic biomass degradation with radical systems. Washington State University, Pullman, WA 99164

Synergistic activities

Alabama

1) Dr. Yi Wang collaborates with the Virginia station, and obtained a DOE grant. Wang also provided the engineered strains for their project for the PI at the Virginia station. 2) Investigators serve on panel review of several grant agencies in United States.

California

Collaboration was carried out with the researchers from University of Minnesota and Kansas State University. USDA NIFA proposals were jointly developed and submitted.

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. Ganti S. Murthy, Oregon State University: Techno-economic Analysis of Bioenergy System; Dr. Kaushlendra Singh, West Virginia University: Biochar Applications for Sustainable Agriculture; 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.

Kansas

Kansas researchers worked with researchers from Kentucky and Nebraska on joint proposals and publications.

Kentucky

UK researchers have worked with researchers at Kansas, Louisiana, Montana and Mississippi on joint proposals and publications.

Louisiana

One project with S1075 committee members Dr. Jian Shi, Dr. Sue Nokes at the University of Kentucky.

Minnesota

We collaborated with investigators at South Dakota State University, Washington State University, Mississippi State University, Stanford University, Berkeley Lab — Lawrence Berkeley National Laboratory, and Resynergi Inc. in research and grant writing activities. We established external partnerships with agencies and companies including Minnesota Metropolitan Council Environment Services, Minesga.

Missouri

Cooperative Research with Mississippi State University and National Warm-water Aquaculture Center at Stoneville Mississippi to develop water quality sensing systems to improve zero discharge aquaculture production

Montana

Collaborating with Dr. Jian Shi at University of Kentucky, and Dr. Haibo Huang at Virginia Polytech.

Nebraska

A large joint proposal was written with S1075 members from the Kansas and Kentucky experiment stations as well as the USDA-ARS office in Lincoln.

New Jersey

This work led to synergistic activities with Indiana State University, Rhode Island University, as well as with local aquaculture associations.

New York

Field site operation has been supported by synergistic research projects including Northeast Sun Grant (Smart, Richards, Kemanian; Optimizing Nutrient Uptake in Shrub Willow & Switchgrass to Provide Multiple Ecosystem Services) and USDA-NIFA Project 2018-67019-27802 (Richards, Aristilde, Steenhuis; Characterizing and mitigating glyphosate herbicide mobilization in agroecosystems).

Oklahoma

We worked on publications and projects with North Carolina State University, Kansas State University, and Ohio State University.

Pennsylvania

Co-PI 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.

South Carolina

Working with Bryan Moser for biofuel anaylsis, USDA Peoria lab.

South Dakota

Research collaborations in proposal submissions, experiments, technology and equipment/tools' support, and information exchange with other states (MN, MS, ND, NE, MI, GA, etc.).

Tennessee

Collaborations with Oak Ridge National Laboratory and University of North Texas.

Virginia

Collaborating with researchers at Auburn University to conduct system-level techno-economic analysis for the conversion of corn stover to butyl acetate. Collaborating with researchers at Kansas State University to conduct system-level techno-economic analysis for the production of antioxidant peptides from corn distiller's grain.