2014-2015 ANNUAL REPORT

S-1041 Multistate Regional Project
The Science and Engineering for a Biobased Industry and Economy 2013 – 2018

Participating States and Agricultural Experiment Stations

- **Included in the Report:** Alabama, Arkansas, California, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Montana, Nebraska, New Jersey, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Washington, West Virginia and Wisconsin.
- **Not Included in the Report:** Arizona, Georgia, New York and Virginia

Organizing Committee: The organizing committee for the 2015 Annual meeting and symposium consisted of five members of S-1041:

1. Ganti S. Murthy, Associate Professor, Biological and Ecological Engineering, Oregon State University. (Chair of the S-1041 Multistate Committee for 2014-2015)
2. Chandra Theegala, Professor, Louisiana State University. (Vice Chair of the S-1041 Multistate Committee for 2014-2015)
3. Yebo Li, Professor, Ohio State University. (Secretary of the S-1041 Multistate Committee for 2014-2015)
4. Kent Rausch, Associate Professor, Agricultural and Biological Engineering, Univ. of Illinois at Urbana-Champaign. (Member of the S-1041 Multistate Committee)
5. M.E. Tumbleson, Emeritus Professor, Agricultural and Biological Engineering, Univ. of Illinois at Urbana-Champaign. (Member of the S-1041 Multistate Committee)

Organization of the report: This report was compiled based on the annual station reports submitted by individual station representatives by Ganti S. Murthy (Chair of the S-1041 Multistate Committee for 2014-2015). The report is divided into major sections focusing on the impacts, outcomes (accomplishments), outputs, target audience, participants and synergistic activities. The report sections were extracted from the individual station reports and are searchable by the "[STATE]". The report sections are arranged in the alphabetical order of the state names.

S-1041 2015 Annual Meeting and Symposium Attendees

Executive Summary

The S-1041 multistate committee consists of researchers from 33 land grant universities working on various facets of bioenergy and bioproducts such as feedstocks, biochemical and thermochemical conversion, techno-economic and life cycle assessment.

This report details the annual activities reported by university researchers in associated with various experimental stations in 29 states. The report is divided into sections focusing on impacts, outcomes (accomplishments), outputs, target audience and participants. ***More than 185 researchers of this committee including faculty members, postdoctoral scholars, graduate students, undergraduate students, high school students and their collaborators reported active and impactful research to achieve the objectives of this multistate Committee. Members have published 210 peer reviewed papers, 13 book chapters, presented 292 presentations, filed two patents, and advised 57 PhD/MS/BS dissertations/theses in the last year***.

Annual meetings of the S-1041 multistate committee are held to coordinate and share research from land grant universities across the nation. In the last few years, symposia were organized with leading researchers and speakers from funding agencies to share the latest research knowledge and coordinate future research. The 2015 S-1041 multistate committee meeting was held in OARDC (Ohio agricultural Research and Development Center), Ohio State University, Wooster, Ohio on 10-11 Aug, 2015. The two day meeting included field trips to various bioenergy and bioproduct related pilot scale testing facilities on the first day. On the second day, a symposium "Stakeholders Perspectives on the Bioeconomy" was held with a goal to develop an understanding of challenges in the evolution of the bioeconomy from a stakeholder perspective. Energy for Sustainability Program (CBET Division, National Science Foundation) supported this symposium through a $15,000 conference/symposium grant. The funds were used to provide travel support to 23 graduate students, awards for the poster competition and costs for the printed proceedings. A project website was created and the presentation from symposium speakers and the proceedings have been made available to general public at http://oardc.osu.edu/s1041/pageview.asp?id=3853.

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1. S-1041 Brief Description

The Science and Engineering for a Biobased Industry and Economy (S-1041) multistate committee consists of researchers from more than thirty land grant universities working on various facets of bioenergy and bioproducts such as feedstocks, logistics, biochemical and thermochemical conversion, techno-economic and life cycle assessment. The multistate committees are part of USDA efforts to coordinate research at land grant universities in nationally critical research areas. The S-1041 Committee is considered to be one of the expert committees in the area of bioenergy and bioproducts. The members are routinely consulted by the USDA to aid in peer review and conduct site visits of various USDA funded projects.

Annual meetings of the S-1041 multistate committee are held to coordinate and share research from land grant universities across the nation. The USDA supports these meetings through funding support for Agricultural Experiment Stations to send one representative from each state while many land grant universities provide support to additional faculty members to attend this meeting.

In the last few years, symposiums were organized with leading researchers and speakers from federal agencies to share the latest research knowledge and coordinate future research. A list of past S1041 annual meeting is provided in table 1. The average attendance at these meetings based on last three meetings is between 40-50 attendees representing several universities, USDA, DOE and other federal agencies.

S1041 has four major objectives focusing on feedstock development, processing, systems analysis and education and training themes. Each of these objectives is associated with specific tasks. The objectives and various tasks associated with these objectives for S1041 are detailed below:

1. OBJECTIVE A: Develop deployable biomass feedstock supply knowledge, processes and logistics systems that economically deliver timely and sufficient quantities of biomass with predictable specifications to meet conversion process-dictated feedstock tolerances.
    a. Task 1: Identify biomass feedstock type and availability for selected geographic regions based on agronomic and climate conditions.
    b. Task 2: Characterize physical and chemical properties of feedstock along the logistics supply for different geographic regions.
    c. Task 3: Develop and evaluate harvest, pre-process, handling, densification, storage, and transport methods for specific biomass feedstock end-users.
2. OBJECTIVE B: Investigate and develop sustainable technologies to convert biomass resources into chemicals, energy, materials and other value added products.
    a. B.1. Biological conversion technologies
        i. Task 1: Develop pretreatment methods for biological conversion processes.
        ii. Task 2: Develop conversion processes.
        iii. Task 3: Develop value-added, bio-based products from fractionated biomass.
    b. B.2. Value added products and markets based on thermochemical conversion technologies.

        i. Task 1: Develop pretreatment methods.
        ii. Task 2: Develop conversion processes.
        iii. Task 3: Develop and improve catalytic upgrading processes to convert intermediates to high quality and stable liquid fuels and products.
        iv. Task 4: Integrate thermochemical and biological conversion processes to produce biofuels and bioproducts.
        v. Task 5: Improve methods for characterization of intermediate products and process control.
    c. B.3. Biodiesel production processes
        i. Task 1: Characterize new feedstocks.
        ii. Task 2: Develop an understanding of fuel quality and performance issues from emerging crops.
        iii. Task 3: Develop and characterize innovative processes for biodiesel production.
        iv. Task 4: Develop and utilize co-products.

3. OBJECTIVE C: Utilize system analysis to support development of economically, socially and environmentally sustainable solutions for a bio-based economy.
    a. Task 1: Develop system models and data to represent integrated feedstock supply systems, including discrete processes and entire supply logistics.
    b. Task 2. Develop system models and data to assess sustainability of integrated conversion platforms.
    c. Task 3. Develop integrated system models to configure, analyze and optimize bioenergy and biofuel production systems.

4. OBJECTIVE D: Identify and develop needed educational, extension and outreach resources to promote the transition to a bio-based economy.
    a. Task 1: Serve as a knowledge resource base for bio-based economy.
    b. Task 2: Develop and market programs.
    c. Task 3: Develop and disseminate educational materials in high-priority topic areas.

2. IMPACTS

[ALABAMA]

1. Update database (as part of the NIFA-CAP project) that contains physical and chemical characteristics of over 400 samples of southern pine, Eucalyptus and hybrid poplar including the impact of harvesting and storage methods on these properties.
2. Secured grants to further biomass and bioenergy research, education and outreach activities.
3. Trained workforce for the future bioeconomy at the BS, MS and PhD levels.
4. Exposed K-12 students to bioenergy research.

[CALIFORNIA]

- Rice straw is a very promising feedstock for bioethanol production because it is an agricultural residue that complements food production and is produced in very large quantities on a worldwide basis. It has not been used extensively for biofuel production due to its recalcitrance to bioconversion. The novelty of our research is that pretreated rice straw without liquid-solid separation, washing or detoxification had the highest 7-day ethanol yield of all treatments examined. This is in contrast to prior research suggesting that processing of cereal straws after dilute acid hydrolysis is imperative for removing compounds inhibitory to microorganisms. This finding is significant as it has implications on the economics of rice straw conversion to bioethanol (VanderGheynst).
- Microalgae have potential to produce products that will reduce society's reliance on fossil fuels and address challenges related to food and feed production. Research by others has shown that nitrogen limitation reduces protein synthesis and channels carbon metabolism toward storage molecules including TAG. One of the drawbacks of using nitrogen limitation to induce TAG accumulation is the concomitant decline in algae growth. As a result, some researchers have proposed using two-stage cultivation systems in which algae are first cultivated with sufficient nitrogen to achieve rapid growth and then transferred to a nitrogen-limited medium. Such an approach would likely increase capital and operating costs compared to a single-stage culture. Our results are particularly significant because our co-culture system achieved a nitrogen-limited condition and lipid accumulation with no apparent tradeoff in algae growth rate. This is the first demonstration of the use of co-culture systems to improve lipid productivity and quality by microalgae (VanderGheynst).

- An equally important challenge associated with fuel production from microalgae is that cell disruption is usually required for collection and utilization of algal cytoplasmic starch for fermentation and efficient extraction of lipids. Since *Chlorella* viruses encode several enzymes that can degrade host cell walls during virus infection or progeny release, virus infection might be one approach to degrade the cell wall allowing cell wall and cytoplasmic polysaccharides to be used for biofuel and bio-product production. We found that after virus infection, cells with a low C:N ratio produced a 7.6 times higher burst size than cells with a high C:N ratio, suggesting that the nitrogen content in *C. variabilis* has a large influence on viral production and cell lysis. The results have implications on management of nitrogen for both the synthesis of products from algae and product recovery via viral lysis (VanderGheynst).

- The spatial modeling and optimization work has resulted in the development of user decision support tools and broader insight into sustainability implications for poplar and other biomass feedstock production. Detailed modeling of direct and indirect effects define resource, economic, and environmental constraints for biofuel and other bioenergy applications. Costs of aviation grade fuel from poplar, for example, are estimated to remain above current market prices for fossil-based liquids and demonstrate the level of needed capital and operating cost reductions or carbon-based and other incentives even with substantial economic multipliers that are required to compete in the absence of more specific policy regarding continued fossil fuel use (Jenkins)
- New enzymes and microbes that are capable to efficient convert the lignocellulosic biomass into biofuels and biochemical are important. A new-engineered fungus strain is available for high yield cellobionate production from cellulose without catalytic amount of laccase addition. This is the first example of cellobionate production from cellulose using a microbial fermentation system. The ethanol and isobutanol tolerance study provides useful information in guiding using *N. crassa* as host for biofuels production (Fan).
- Innovative pretreatment methods for improving the biodegradability of wheat straw and other lignocellulosic biomass will increase the rate of bioconversion processes and reduce the cost of overall bioconversion systems. Integrated bioethanol and biogas energy systems with sugar beet to ethanol as an example will serve as a energy efficient model for biorefinery. Co-digestion of different biomass feedstock improves the conversion efficiencies, process stability and overall economics of biogas energy production systems. Development and commercialization of high rate and high solids digestion technology allow the rapid deployment of anaerobic digestion technologies in both rural and urban communities as well as agricultural and food industry sites. The UC Davis Renewable Energy Anaerobic Digestion (READ) project serves as a good model for sustainable development (Zhang).

[HAWAII] The University of Hawaii has also received $200,000 research fund on "Anaerobic Biorefinery" from Western Regional Sun Grant in partnership with other S-1041 participant (Oregon State). The bioenergy textbook has been developed in partnership with S-1041 participant (Ohio State) and several contributors and reviewers are members of S-1041 group. Two high school students conducted science project on value-added product generation from invasive macro-algae. The students were selected to represent HI in the Intel International Science Competition in Pittsburg, PA. The students' project received 3rd place in the Science Competition. Two female biological engineering students who worked in Dr. Khanal's Lab on various aspects of bioenergy and biobased products continued their graduate research at Purdue University and Oak Ridge National Laboratory.

[IOWA]

Hydrolysis of low value/ high-fiber agricultural coproducts to produce biosurfactants:

Five liter fermentation of Bacillus subtilis strains of fibrous biomasses: This study could lead to development of efficient utilization of renewable fibrous biomass sugars for producing high value bio-surfactants which could be lower in toxicity and overall environmental impact.

Fractionation of surfactin isoforms: This study could lead to better understanding of the mechanism of various functional properties of individual fixed chain length surfactin and FA-Glu molecules, leading to development of efficient formulations and surfactant mixtures.

Fish feed extrusion projects: This study could lead to lowering the cost of fish feed as utilization of soy protein and oil is comparatively cheaper than fish oil and fish meal.

Ammonia pretreatment: This study could help develop a low inhibitor producing pretreatment method for increasing yield of bio-ethanol generation from corn stover.

Use technoeconomic evaluation to evaluate the economic feasibility of bio-conversion processes: process cost-effectiveness and product scenarios could be evaluated (modeled) for best decision making in biorefineries.

[INDIANA]

Potential for novel use of biomaterials for replacing petrochemical-based products and development of novel materials with unusual properties. Concrete sealant is being tested by several state DOTs on highway and bridge concrete surfaces. A commercial startup business has been created to produce this product.

Purdue Soybean Center

Accomplishments: A new center focused on addressing emerging global challenges throughout the soybean value chain has been established at Purdue. Using innovative multidisciplinary approaches with collaboration between industry, government, non-profits, and academic institutions, this new center will conduct research in such areas as animal and human nutrition sciences; food science; aquaculture; plant pathology; economics; engineering; genetics and breeding; agronomic production practices; and entomology to help tackle some of the complex challenges affecting the efficiency and profitability of the soybean industry as well as the food nutrition needs of the public.

[ILLINOIS]

1. Xylooligosaccharides (XOS) derived from a bioenergy crop, *Miscanthus x giganteus*, resulted in bacterial communities that would be beneficial in the human digestive tract. Production of high valued XOS as probiotics will be a high valued coproduct that could support fuel ethanol production from cellulosic biomass (Chen 2015, Chen et al 2014, 2015).
2. Investigation of heat transfer fouling behavior under controlled conditions provided experimental parameters that are sensitive to changes in process stream compositions and parameters. This will assist in determining which compounds and operating parameters cause accelerated fouling during bioprocessing of grains and biomass, a chronic issue that reduces efficiency and increases environmental footprint of biofuels (Challa 2015, Challa et al 2015, Tian et al 2015, Zhang et al 2015).
3. Coproduction of natural pigments with fuel ethanol from corn may improve economic sustainability of renewable fuels. Coproduction of pigments did not reduce ethanol production (Wang et al 2015).
4. In simulation models, biodiesel production from lipid producing sugarcane (lipid cane) appears to be more economical than soybean biodiesel in climates suited to production of lipid cane and in areas not well suited to row crop production (Huang et al 2015).

5. Production of ethanol from soluble sugars extracted from temperate × tropical maize was found to be a competitive alternative for biofuel production during simulation modeling (Huang et al 2015).

[KENTUCKY] Kentucky is providing training for 10 undergraduate research assistants, fourteen Masters of Science students, three PhD students and two postoctoral scholars in Biological and Agricultural Engineering related to this project.

[LOUISIANA] Use of RAS in asphalt compositions will impact economically paving industry by replacing of neat asphalts with up to 15% RAS.

[MINNESOTA] Production of current major biofuels, i.e., biodiesel and ethanol, is competing with food and feed demands, prompting the need to use non-food biomass feedstock for biofuel production. Thermochemical conversion of lignocellulosic biomass feedstock is a platform which can provide short and mid-term solutions. The major challenges for thermochemical conversion are the poor quality and stability of the products, and costs associated with feedstock collection, handling, transportation and storage. In our project, we developed innovative microwave assisted pyrolysis and hydrothermal liquefaction processes, and designed systems suitable for distributed conversion of biomass. We also studied and developed technologies for mass cultivation and conversion of algae to biofuels and bioproducts. Furthermore, we are developing a comprehensive approach to the utilization of three major waste streams, namely wastewater, scum, and sludge, in any municipal wastewater treatment plants, which can significantly reduce environmental impacts and boost the economic viability. Our work improved the lignocellulosic feedstock conversion efficiency, product quality and stability, and facilitated distributed conversion of biomass and hence reduced feedstock delivery costs. These outcomes have positive impacts on the overall technical and economic performance of thermochemical conversion technologies. Our wastewater based algae technology also provides significant environmental benefits in addition to biofuels and bioproducts.

[MISSISSIPPI] In collaboration with Ohio State University, University of Georgia, and Industrial partners, we won a grant award from the USDA-BRDI program in 2012 to optimize biogas to liquid hydrocarbon production system, and develop a continuous process to enhance the economic profitability of bioenergy system.

[MISSOURI] Undergraduate students involved with construction, startup and operations of marine shrimp production in aquaculture facility. Stakeholder tours and demonstrations.

[MONTANA]

Since wheat is the major cash and food crop in the Northern Great Plains, it is not feasible to replace wheat acres with camelina for biodiesel or aviation fuel feedstock production. We use camelina as a rotational crop for wheat. A rotation study was established in 2008 to study the effect of camelina on wheat yield and the economic return by using camelina as a rotational crop in wheat-based cropping systems. Results showed that average winter wheat yields reduced

13.2% relative to the fallow-winter wheat rotation. Winter wheat production decrease was offset in the cropping systems by 907 kg/ha camelina.

In collaboration with Kansas State University, University of Wyoming, and Industrial partners, we continue to work on the USDA-BRDI program funded projects to optimize camelina production system and develop byproducts from camelina meal to enhance the economic profitability of camelina biofuel/product system.

[NEBRASKA] A novel approach based on epidemiology was used to model enzymatic hydrolysis of lignocellulosic biomass in a fed-batch system and combined with optimal control theory to develop a new control strategy for fed-batch enzymatic hydrolysis of lignocellulosic biomass. The impact of solid loading and enzyme loading on enzymatic hydrolysis of alkali pretreated corn stover was investigated.

[NEW JERSEY] The insight developed was disseminated to the community via conferences, publications in peer-reviewed journals, and conference proceedings. An outreach component was also developed to educate local administration in NJ of the benefits of using waste to energy (e.g., local waste management facilities).

[OREGON] Several advances in development of model predictive controllers for algal production systems, impact of lignin properties on the droplet size during pretreatment, optimal enzyme ratios for cellulases were achieved.

[OKLAHOMA] Mobile power generation unit will soon be demonstrated to public and investors interested in using the system at off-grid location and to use waste biomass. Through syngas cleaning project, new knowledge is obtained on properties of biochar and environmental benefits of using biochar-based catalysts to clean syngas. Syngas cleanup is considered one of the most cost prohibitive operations in using gasification based fuels and chemicals. Results show that the novel biochar-derived catalysts have potential to reduce environmental impacts and provide economic benefits to biorefinery. Five refereed journal articles, one provisional patent application and several conference presentations were direct outputs of this project.

[PENNSYLVANIA]

Productions of biobased products by bioprocessing are getting more and more attention as we deplete petroleum resources. Many industrial feedstocks such as alcohols and organic acids come from petroleum. Also, production of renewable energy sources such as ethanol, methane (biogas), and hydrogen are getting high attention. Finally, production of food and feed supplements need to be more economical to improve the welfare of human and animals. Therefore, there is a need to produce these food/feed additives, feedstock and energy sources from non-petroleum resources. This is possible by bioprocessing both raw and by-products of agricultural materials via microbial fermentation. Fermentation processes need to be optimized at microbial, fermentation and downstream processing levels. At microbial level, the best strain for fermentation needs to be selected or developed by strain development. Economical media formulation and appropriate bioreactor design are needed for higher production rate during fermentation. Therefore, any improvement in these areas will enhance the production of value-added products via fermentation to enhance bioeconomy.

Lignocellulosic biomass provide an abundant and sustainable alternative to petroleum for the production of fuels, heat and electricity, chemicals and materials. This feedstock can produce low carbon fuels and and greatly reduce nutrient and sediment pollution if planted in the correct locations and times of year. Challenges include crop production and logistics, it remains difficult to transform into sugars, and the cost and scale required for large scale conversion to biofuels. Our group is addressing this challenge with a multi-faceted research program that includes storage, conversion, and separation of higher value chemicals from raw biomass. We are also engaged in system level analysis on a variety of economic, environmental, social and sustainability domains. This research holds the potential to enable a rural renaissance that would create markets for include biomass producers, provide opportunities for start-up companies and employees, and encourage manufacturing and further processing for rural economic development.

The Salis Lab maintains a website that enables biotech researchers to rationally design DNA sequences using biophysical model predictions (https://salislab.net/software). In the past year alone, over 10000 DNA sequences were designed by researchers from around the world for a wide variety of biotech applications.

[SOUTH CAROLINA]

Biomass research and training conducted at Clemson University includes:

1. Biodiesel pilot plant - conversion of waste cooking oils generated on campus to biodiesel to displace diesel fuel in campus vehicles - about 30% has been displaced over the past 3 years.

2. Biomass plant design - 10 MW biomass facility has been proposed for the Clemson campus - research on biomass feedstock was conducted.

3. Student Organic Farm - collaboration between Biosystems Engineering and the Student Organic Farm include introduction of Black Soldier Fly (BSF) digester now in operation and used for research of food waste and organic farm waste management.

4. Aviation biofuels and biomass feedstock research - use of algal and fungal oils for conversion to aviation biofuels using enzymatic catalysis and use of residues as adhesive additives to biomass pellets for gasification research.

5. Pretreatment technology - a patent has been filed for to a novel Triplex pretreatment process developed at Clemson in the Walker lab with Arpan Jain leading the project.

[SOUTH DAKOTA]

Fossil fuel reserves are not infinite therefore a secure and affordable energy which does not disrupting food supplies or deteriorate the environmental is a necessity. Currently first generation biofuels including bioethanol and biodiesel are mainly made from sugar, starch, vegetable oils, or animal fats. The use of these feedstocks are impacting human and animal food supplies and thus contributing to food shortage problems. As a result, the second and third generation biofuels are being developed from non-food lignocellulosic biomass such as woody and straw residues from agriculture and forestry, fast-rotation plants, non-food crops (possibly grown on marginal or non-arable land), organic fraction of urban waste, and algae-based feedstock. These technologies and feedstocks promise to be more sustainable, offering significant reductions of greenhouse gas (GHG) emissions and less sensitivity to fluctuations in feedstock costs.

The successful development of these thermochemical conversion technologies is likely to have important positive impacts and long-term benefits on the rural economy and job opportunities as regional biomass pyrolysis plants are constructed and become operational locally. Locating these pyrolysis plants in the proximity of feedstock supply solves the logistic problem of transporting low density biomass long distances. By densifying the output products with high energy content using the SDSU processes to locally produce a stable drop-in advanced biofuel, logistics issues can be addressed. Thus, the outcomes are not only expected to fundamentally advance the field of bio-refinery, but also to have simultaneous broad and highly positive societal impact. In addition, information on biofuel co-product utilization, economic potential, possible environmental impact, and other biomass feedstocks' suitability are likely provided for renewable biofuel industry and public awareness regarding to sustainable agriculture and advanced biofuels production.

[TEXAS]

The impact of the gasification research is the licensing of the TAMU technology from a couple of new private companies who have entered into licensing agreement with Texas A&M University. The list of companies are as follows:

1. Arriba Energy, Houston, Texas (c/o CEO, Renato Nuguid)
2. Lummus, Inc, Savannah, Georgia (c/o CEO, Steve Marbut)

It is expected that with the implementation of the USDA-NRCS-CIG Grant demonstration project, some private groups may also be interested in licensing this TAMU technology using dairy manure and other animal facilities in Texas and nearby states.

The preliminary impact of the biodiesel research was the development of a solid catalyst that would convert refined oil into biodiesel. A novel catalysts was identified for this purpose and research is now focused on utilizing biochar from spent meal as material for this purpose. An intellectual property disclosure (IP) is being prepared and submitted to the Office of Technology and Commercialization at Texas A&M University.

[WASHINGTON] Our research activities fit within the USDA's current efforts to convert wood and agricultural materials into valuable products that enhance rural income and avoid disposal issues. Development of technology for converting such materials would also support use of the roughly 368 million dry tons of forest resources that a DOE/USDA report projects to be available annually for sustainable production of fuels with lower emissions and reduced environmental hazards from spills than existing options. However, the current technologies used for biofuels production undervalues lignin's potential to address the nation's high quality liquid fuel requirements by burning it. The utilization of waste lignin as a feedstock for conversion to hydrocarbons offers a significant opportunity for enhancing the overall operational efficiency, carbon conversion rate, economic viability, and sustainability of biofuels production. The development of selective and robust catalytic processes specifically designed for lignin conversion must be a core effort for biorefineries to develop. The challenge, however, is the propensity of the aromatic lignin macromolecular assembly to condense and degrade, thereby generating high amounts of relatively intractable solid residues in some biorefinery processes. Therefore, depolymerization of lignin and its subsequent conversion into valued products is vital to enhance the profitability of biorefineries. Valorizing lignin remains a major goal in the realm of bioprocessing, and this can be accomplished through continued implementation of creative, catalytic tactics for favorably altering the reactivity and chemistry of lignin to yield transportation fuels and bioproducts.

[WEST VIRGINIA] During past year, two research articles are published and three research articles are under review. In addition, one graduate thesis and one conference proceeding are published. Additionally, 11 technical presentations were made to technical and non-technical audience.

[WISCONSIN] Projects assisted the training for 3 undergraduate students, 3 graduate students, and 3 post-doctoral scientists. Seven publications and 5 presentations were made in the last year.

3. OUTCOMES (ACCOMPLISHMENTS)

OBJECTIVE A: Reduce costs of harvesting, handling, and transporting biomass to increase competitiveness of biomass as a feedstock for biofuels, biomaterials and biochemicals.

- Task 1: Identify biomass feedstock type and availability for selected geographic regions based on agronomic and climate conditions.
- Task 2: Characterize physical and chemical properties of feedstock along the logistics supply for different geographic regions.
- Task 3: Develop and evaluate harvest, pre-process, handling, densification, storage, and transport methods for specific biomass feedstock end-users.

[ALABAMA] We continue to work on quantifying the properties of softwood and hardwood biomass that are important to the storage, preprocessing and transportation of these biomass feedstocks. For example, we have conducted comparative studies on grinding and drying sequence for loblolly pine chips, and physical treatments to reduce ash in chips of woody biomass. We also conducted studies on fluidization properties of woody biomass feedstocks.

[ARKANSAS]

Task 1: Quantify and characterize biological feedstocks

An algal production system was constructed at the University of Arkansas Swine Research Center near Savoy, Arkansas, located approximately 20 miles from University of Arkansas campus; the system uses swine wastewater as input to four parallel flow ways that are each 5 ft wide X 200 ft long on a 2% slope. Research has shown that water flow rates through the system can be reduced from 100 gpm to 7.5 gpm for each lane. These results have the potential to greatly reduce the input energy requirements required to run the algae production system.

The algae biomass is being evaluated as a feedstock to anaerobic digestion, pyrolysis and other bio-energy conversion platforms. With anaerobic digestion, different combinations of algae, swine manure and other agricultural residues are currently being evaluated.

Based upon test results and preliminary life cycle analysis, incorporation of co-digestion of swine waste and algae may have some promise. In such a system, the addition of algae to manure (including pretreatment of wastewater in the algae flow way) may encourage higher specific growth rates and higher biogas production. These systems may provide a strategy for swine farmers to reduce costs (of fossil fuel energy consumed) and to also reduce the overall system carbon footprint.

[HAWAII]

Task 1: Quantify and characterize biological feedstocks

As part of BRDI project, field trials for biomass yield and composition analysis at different irrigation regimes and elevation for energycane and banagrass hybrid have been conducted in Maui, HI. In the irrigation experiment, annual dry biomass yield of the banagrass hybrid was 30 and 19 Mg/ha at full plantation irrigation and 50%, respectively. Energycane annual dry biomass yield was 21 and 15 Mg/ha for the same irrigation levels, respectively. In the multi-elevation experiment, banagrass hybrid annual dry biomass yield was 40, 36, and 52 Mg/ha at the 30-, 300-, and 1000-m elevation sites, respectively. Energycane yield was 47, 25, and 65 Mg/ha at the same elevation sites.

Chemical composition of energy crops is a key factor affecting efficiency of biofuel and high value co-product generation in biorefineries, and ultimately the economic feasibility of biofuel industries. Additionally, the structural and chemical composition of the lignocellulosic energy crops varies between species (i.e., genotype), environmental conditions, and their interactions (i.e., genotype by environment interactions). This natural variation in composition of energy crops significantly affects both digestibility and overall methane yield during anaerobic digestion. Thus, we are examining the effects of locations and harvest years on the composition of selected energy crops and its subsequent effects on anaerobic digestibility for CH_4 production.

Task 2: Develop and evaluate harvesting, processing, and handling

As part of BRDI project, the field test results showed that both the biomass recovery rate and field efficiency are much higher in harvesting energycanes and banagrass compared to that in harvesting sugarcane. The tests were conducted with the harvesting rate ranged from 7 to 23 Mg/ha (dry mass). The average biomass recovery rate and field efficiency were 87% and 86%, respectively when harvesting energycane; and 83% and 81% for harvesting banagrass in comparing to 52% and 44% in sugarcane harvesting using the same harvester. Further analyses found that cane stubble leaning angles and machine off-track error could be two of the major attributors causing more biomass loss and machine down time: more upright growth of energycane and banagrass provided a more favorable situation for the harvester to track the crop rows more accurately, which in turn resulted in higher biomass recovery and field efficiency. The lab-based simulation study on base cutting has generated preliminary data suggesting that there is a linear relationship (R^2 = 0.97) between cutting disc torque requirements and the number of canes present in a cluster.

[OHIO]

Task 3: Develop and evaluate harvest, pre-process, handling, densification, storage, and transport methods for specific biomass feedstock end-users.

Experiments were conducted to evaluate the effect of harvesting date of miscanthus and giant reed (Arundo donax) on feedstock composition, enzymatic hydrolysis sugar yields and biogas production of anaerobic digestion. Two harvesting dates (fall and spring) for miscanthus and four harvesting dates (September, October, November, and December) for Gant reed were evaluated. Ensilage of giant reed only and with food waste or urea addition was also studied to evaluate the performance of giant reed ensilage. Results shown that miscanthus harvested in fall generated a 6% higher methane yield in average than miscanthus harvested in spring. Giant reed harvested later is beneficial for the ensilage with less dry matter loss during storage. Ensilage with or without urea addition had no significant effects on the enzymatic digestibility of giant reed, but ensilage with urea addition achieved a cumulative methane yield of 173 L/kg VS, which was 18% higher than that of fresh giant reed.

[KENTUCKY] Transportation efficiencies of traditional centralized biomass processing facilities were compared to a proposed distributed preprocessing network with centralized refining facilities. Centralized processing was defined as transport of baled corn stover directly from the field to the refinery. Distributed preprocessing with centralized refining was specified as transport of baled corn stover from the field to a biobutanol preprocessing depot and transport of a completely dewatered crude biobutanol solution from the depot to the centralized refinery. For both transportation systems, the location of the corn fields and refinery were fixed. With the distributed system, the biobutanol depot locations were variable and dependent upon differing maximum transportation (8 - 80 km) cutoffs for biomass transport from the field to biobutanol depots. The distributed designs produced a 38 - 59% reduction in total transportation cost with decreased (50 - 90%) fuel use when compared to the centralized system.

[MONTANA]
Montana State Univ. continues to evaluate camelina and other oilseed crops as potential feedstock for biodiesel and aviation fuels. The major work includes: 1) camelina cultivar evaluation for higher yield and better oil content/profile; 2) fertility study to determine optimal nutrient inputs; and 3) development of cropping system for camelina feedstock production. MT S U are testing camelina varieties and breeding lines at multiple locations across Montana for adaptation and yield potential. Cropping systems studies are carrying out at three locations in Montana to develop optimal production systems that generate good returns and do not compete for the land use with food crop. Fertility study is conducted at two locations at Moccasin and Pendroy, MT to determine the optimal input of fertilizer for high yield.

[MINNESOTA] Reduce costs of harvesting, handling and transporting biomass to increase the competitiveness of biomass as a feedstock for biofuels, biomaterials and biochemicals

Producing and processing biomass feedstock locally is an alternative approach to centralized production and processing. One of our focuses is mass cultivation of microalgae on locally available wastewaters, be it municipal wastewater or animal wastewater or food processing wastewater. The work on cultivating algae on municipal wastewater included testing of using glycerol, a byproduct from our scum-to-biodiesel process (See next section). In optimal condition, glycerol was found to significantly improve algal biomass yield and nutrient removal. It was also found the initial pH of the culture media is critical. Cultivating algae on food processing wastewater is a cheap and efficient way to both produce biomass and prevent environmental pollution. However, due to the imbalanced nutrient profile in wastewater, biomass yields of algae grown on dairy wastewater and meat processing wastewater were low. Although previously developed methods, such as aeration and acid digestion, could improve biomass yield, they also made the wastewater treatment process complex and improved the cost. This study successfully improved the biomass yield of algae grown on dairy wastewater and meat processing wastewater by mixing different wastewaters. Based on nutrient profile analysis, this work hypothesized that the lack of certain nutrients in some meat processing wastewater was the bottleneck for algae growth. The result showed that biomass yield (0.675-1.538 g/L) of algae grown on mixed wastewater was much higher than that on individual wastewater and artificial medium. Wastewater mixing removed the bottleneck for algae growth and contributed to the improvement of biomass. Furthermore, in mixed wastewater with enough nitrogen, ammonia nitrogen removal efficiencies (68.75-90.38%) and total nitrogen removal efficiencies (30.06-50.94%) were improved. Wastewater mixing also promoted the synthesis of protein in algal cells. Protein content of algae growing on mixed wastewater was improved to 60.87-68.65%, which is much higher than protein content of traditional protein source. Algae cultivation model based on wastewater mixing is an efficient and cheap way to balance nutrients profile and improve biomass yield. The strategy based on mixing wastewaters developed in this work is a simple way to balance nutrient profile of wastewater and improve biomass yield of algae and nutrient removal. In the past year, our work has resulted in high performance algae strains suitable for wastewaters, and novel photobioreactors (PBR), new cultivation techniques that utilize broader range of waste streams as carbon and nutrient sources, and novel harvest techniques. Mass cultivation of algae on wastewaters also effectively removes nutrients, and thus cleans the wastewaters. All these contribute to a low cost biomass feedstock production system.

[NORTH DAKOTA]

Task 1: Quantify and characterize biological feedstocks.

Corn gluten meal, distillers dried grains with solubles, and post-fermentation corn oil are being tested for extraction for carotenoids and other antioxidants. Solid phase extraction is being used for concentration from oil samples, and supercritical carbon dioxide and accelerated solvent extraction are being used for solid samples.

Integral reaction heat for pyrolysis and combustion for switchgrass, big bluestem and corn stalks were determined using TGA/DSC in the temperature range of 30 to 700°C. A concept of iso-conversion differential reaction heats was used to determine the differential reaction heats of each thermal characteristics segment of these materials. Results showed that the integral reaction heats were endothermic from 30 to 700°C for pyrolysis of switchgrass and big bluestem, but they were exothermic for corn stalks prior to 587°C. However, the integral reaction heats for combustion of the materials followed an endothermic to exothermic transition.

A draft of the ASABE standard on "Machine Vision Method of Forage or Biomass Particle Size and Size Distribution" was developed and will be processed for review and approval. The method uses an image of the particulate material, processes through an image processing system (ImageJ) and analyses the results a statistical computing programming language (R). Various particle size distribution parameters were obtained using this standard.

A machine vision plugin program for fitting particle size distribution models such as Rosin-Rammler, Gaudin-Shumann, exponential, and linear models applicable to particulate material was developed. Particulate coal and biomass are tested in an ongoing study.

Task 2: Develop and evaluate harvest, process and handling methods.

Process interactions between biomass densification and pretreatment and hydrolysis continue to be tested using corn stover. Evaluation of pelleting impacts is being planned using life cycle assessment.

Industrial-beet tissue was ensiled for 8 wk at 23 °C and various combinations of pH, moisture content (MC), and sugar:solids (SSR). MC and pH had statistically significant effects on sugar retention in beet tissue silage, whereas SSR had no significant effect. Some combinations of pH≤4.0 and MC≤67.5 % enabled high (≥90 %) sugar retentions in ensiled tissue; in one instance, retention was significantly >100% indicating some hydrolysis of polysaccharide. Sulfuric acid costs (on dry-basis sugar) to achieve effective 2.0≤pH≤4.0 for sugar retentions ≥90 % range from 3.7 $ Mg^{-1} to 13.9 $ Mg^{-1}.

The effect of water temperature and application of thin juice, in place of ambient tap water, in front-end processing (FEP) of extracting the raw juice from frozen and fresh industrial beets were determined. Form the study it is recommended that frozen beets are more suitable for extraction and 60°C hot water for fresh beets and 50°C for frozen beets for efficient juice extraction. Thin juice of <5°Brix instead of water was found efficient, considering the dilution effect and evaporation loads. On average, application of hot water (savings of $6.5/t of beets) and thin juice (savings of \$1.8/t of beets) produced good cost saving in FEP of beets with ambient water.

A novel theoretical size reduction specific energy consumption model that used physical parameters, such as mechanical shear stress, particle size distribution, and screen size was developed and tested for size reduction of corn stalks in knife mill at three moisture contents. The model fitted the experimental observation well ($R^2 \geq 0.95$), and the ANOVA indicated that the moisture content followed by screen size significantly influenced the energy consumption, but not the shear stress.

Using categorical regression grinder specific (knife mill and hammer mill) and generalized regression specific size reduction energy consumption models were developed after selecting the most influential variables (moisture content, screen size, shear stress, and geometric mean length) while testing three biomass species (big bluestem, corn stalks, and switchgrass). The single generalized model developed is capable of predicting the size reduction energy consumption for the three biomass species and two grinders ($R^2 \geq 0.83$) tested. This technique can be extended to other biomass and grinder types to obtain unified models.

Task 3: Model and analyze integrated feedstock supply and process systems.

Break even distance (BED), the distance a solid biofuel can be moved utilizing its energy content, was evaluated for several solid fuels in comparison with fossil fuel energy used in three modes of transport (truck, rail, and ship). Results indicated that the moisture content affected the BED negatively and ship transport is more efficient followed by rail and truck. It was found that a standard truck of wood chips has 2.6 times the energy required to travel along US perimeter, and interstate transport (<2680 miles) of biomass is possible while utilizing only a fraction of energy.

Logistics work on biomass bales aggregation and field stacks location and distribution is in progress. Preliminary results indicate that the total aggregation distance for making field stacks reduced substantially (50% to 96%) and the total additional transportation distance reduced (42% to 3.6%) as the number of field stacks increased (1 to 196; 1 quarter section field) when compared to aggregating all the bales to the corner outlet point.

Logistics simulation research on anticipatory grain cart movement in coordination with combine harvester is also in progress. Practical scenarios of grain cart movement and the savings in terms of driving distances and fuel consumed will be studied and compared as affected by various field variables.

[TENNESSEE] A multi-faceted bulk-format harvest logistics project monitored a demonstration-scale bulk-format system to harvest, collect, and deliver milled, low-moisture bulk-format switchgrass (SG) from fields to a depot to provide baseline data for analysis of commercial-scale systems. A bulk-format logistics system harvested 100 ha of SG, yielding 690 DMg of chopped SG delivered to a storage depot within a mean haul distance of 9.1 km. The harvest campaign was active 14 days during the winter, averaging 7.15 ha day^{-1} and SG moisture content of 13.45% (w.b.). Simultaneous monitoring of equipment operations with global positioning system (GPS) units provided automated tracking of operations and calculated interactions among seven pieces of equipment without researcher distractions in operator cabs. Researchers took non-intrusive field notes, such as tip-wagon unload points, to facilitate geographic information systems (GIS) analysis with custom, logical expressions to categorize each equipment track log data entry (1-Hz frequency) by operation. Categorization enabled the computation of field efficiency, utilization, equipment capacity, and system capacity, and ultimately system limiting factor apportioned to each piece of equipment. Since various farmer-owned fields of varying geometries were harvested, mower-conditioner turn times ranged from 1.83 to 7.97 min ha^{-1} and forage harvester turn times ranged from 2.47 to 12.10 min ha^{-1} - with lowest turn times exhibited in fields with long straight rows. Results reinforced that efficient biomass harvest logistics need improved field geometry that reduces turn times due to point rows or scattered production areas that reduce or inhibit continuous processing at full rated equipment width, and reduced haul distances. In-field preprocessing with a forage harvester decreased unload times with a bulk flow product. Diesel fuel use of 6.2% equivalency of harvested SG was reasonable, economical energy investment.

[WEST VIRGINIA]
Activity 1: Drying Characteristics of Woody Biomass (Singh)
Moisture desorption of green wood not only changes mechanical properties of wood but it also permanently alters its ultrastructural and pore characteristics, which, in turn, affects adsorption capacity. Therefore, the objective of this ongoing study is to evaluate drying characteristics of components of a ring porous and a diffuse porous. Rectangular blocks were cut from sapwood and heartwood of freshly cut green samples of red oak and yellow-poplar. The bocks were measured for weight, dimensions, and true volume using nitrogen adsorption before and after oven drying. The drying characteristics were measure by heating the samples at 105 °C under isothermal conditions. Results show that green specific gravity of red oak sapwood and heartwood were 0.53 and 0.55, respectively. Upon losing 71.26% water, sapwood shrunk 17.10% in volume. Additionally, sapwood was more porous (59.87%) than heartwood (44.83%). Sapwood also had more specific pore volume (1.14 cm^3/g) than heartwood (0.82 cm^3/g). Bark dries faster than sapwood or heartwood.

Activity 2: Loss of Porosity of Green Wood as Result of Drying (Singh)
Green wood once dried, never regains same amount of moisture even after soaking in water for days. Typical moisture contents of freshly cut red oak and yellow-poplar are 80% and 106%, respectively. In our typical "WDSC 340/540- Physical Properties of Wood" class, students oven-dry red oak and yellow-poplar at 105 °C to bone-dry conditions and then submerge the bone-dry wood in water for a week for moisture adsorption and swelling studies. After a weeklong soaking, the red oak moisture content increased to 28.3% while yellow-poplar moisture content became 53.1%. This essentially means that wood permanently loses more than 50% of its adsorption sites during the first drying, which is also true for other biomass species. Therefore, because of the first drying, a significant number of water adsorption sites are permanently lost. This critical information is not relevant if wood is to be used for traditional applications, like furniture, building construction materials, and for making wood-composites. However, loss of adsorption sites adversely affects products and process efficiencies if wood is to be used for making activated porous materials or it is be treated for extraction of sugars for ethanol making or pulp extraction.

Activity 3: Drying Characteristics of Wood Components and Wood Polymers (Singh)
Thin layer drying of red oak wood components (bark, sapwood and heartwood of red oak) and wood polymers (cellulose and lignin) were carried out using the thermo-gravimetric analyzer

(TGA) under isothermal condition at 105 °C in nitrogen atmosphere. The weight-time-temperature data from TGA was processed to plot drying characteristics curves. The drying characteristics curves were used to explain differences in drying behavior of samples tested. Results shows that the overall liquid diffusion coefficient of changes as sample becomes moisture deficient and lignin shows the lowest drying rate and time.

OBJECTIVE B: Investigate and develop sustainable technologies to convert biomass resources into chemicals, energy, materials and other value added products.

B.1. Biological conversion technologies

i. Task 1: Develop pretreatment methods for biological conversion processes.
ii. Task 2: Develop conversion processes.
iii. Task 3: Develop value-added, bio-based products from fractionated biomass.

B.2. Value added products and markets based on thermochemical conversion technologies.

iv. Task 1: Develop pretreatment methods.
v. Task 2: Develop conversion processes.
vi. Task 3: Develop and improve catalytic upgrading processes to convert intermediates to high quality and stable liquid fuels and products.
vii. Task 4: Integrate thermochemical and biological conversion processes to produce biofuels and bioproducts.
viii. Task 5: Improve methods for characterization of intermediate products and process control.

B.3. Biodiesel production processes

ix. Task 1: Characterize new feedstocks.
x. Task 2: Develop an understanding of fuel quality and performance issues from emerging crops.
xi. Task 3: Develop and characterize innovative processes for biodiesel production.
xii. Task 4: Develop and utilize co-products.

[ALABAMA]

Most of the studies we have conducted have focused on developing and validating models for biomass gasification, tar formation and syngas composition using experimental data from bubbling-bed fluidized-bed reactor. We continue to perform gasification studies on different biomass species (e.g. pine, eucalyptus, poplar, and switchgrass) with the goal of understanding the effect of biomass species/properties on syngas quality and contaminants (e.g. tar, and hydrogen sulfide), and with fate of these contaminants when gasification is conducted with different oxidizing media. Other projects being conducted that are related to this objective include biomass fast pyrolysis and hydrogen production from biobased materials. The impact from these projects is that we have developed information and models that will accurately predict syngas composition from biomass characteristics and gasifier operating parameters.

[ARKANSAS]

Objective B. Improve biofuel production processes.

Task 1: Develop pretreatment methods for biological conversion processes.

Inhibition of cellulase with rice straw hydrolyzates:

Pretreatment is an essential process to break down recalcitrant biomass. Dilute acid pretreatment is a pretreatment that is, among others, efficient and cost effective. However there are potential disadvantages in using dilute acid as a pretreatment, such as the production of degradation products. It is important to note that pretreatment and enzymatic saccharification are the two major upstream processes that affect the economic feasibility and sustainability of lignocellulosic biofuel production. Cellulase inhibiting degradation products that are generated during dilute acid pretreatment, increase enzyme usage, and therefore it is essential to mitigate their production. In an attempt to elucidate which degradation product was most deleterious to enzymatic hydrolysis, hydrolyzates were generated from rice straw and their effect on enzyme activity was determined. Ground rice straw was subjected to the following pretreatments, having a combined severity factor of 1.75: T1– 160°C, pH 1.7; T2– 180°C, pH 2.25; and T3– 220°C, pH 7.0. The liquid prehydrolyzates were freeze-dried and their inhibitory effects on the activity of a commercial cellulase cocktail, *endo*-cellulase and β-glucosidase, were determined using filter paper, carboxymethyl cellulose and cellobiose, respectively. Addition of 15 g L^{-1} of T1, T2, or T3 freeze-dried prehydrolyzates resulted in decreases of 67%, 57%, and 77% of CMC-ase activity of *endo*-cellulase, respectively. In the presence of 35 g L^{-1} of T1, T2, or T3 prehydrolyzates, the filter paper activity of cellulase cocktail was reduced by 64%, 68%, and 82%, respectively. Characterization of the freeze-dried prehydrolyzates showed that T3 had significantly higher xylo-oligosaccharides and total phenolic content than T2 and T1.

Water minimization in bioprocessing of poplar:

Populus deltoides L. biomass was pretreated in 0.98% (v/v) sulfuric acid at 140 °C for 40 min. Prior to enzymatic hydrolysis, pretreated biomass was either not washed, or washed with 1 ½, or 3 volumes of water, as compared to biomass. Rinsing the pretreated biomass with 1 ½ or 3 volumes of water resulted in glucose yields that were seven times greater than the non-wash treatment. Pretreatment hydrolyzates, wash waters and enzymatic hydrolysis hydrolyzates were analyzed for carbohydrate, aliphatic acid, aldehyde and phenolic content. An analysis of the wash waters showed the presence of gallic, vanillic, syringic, *p*-coumaric, ferrulic, *trans*-cinnamic and salicylic acids at concentrations below 0.07 mg mL^{-1}. Washed and non-washed enzymatic hydrolyzates showed significant differences in gallic, vanillic, ferrulic, and salicylic acid concentrations, indicating that these compounds could be in part responsible for inhibiting enzymatic hydrolysis. Non-washed and washed enzymatic hydrolysates were fermented to ethanol with self-flocculating SPSC01 and non-flocculating ATCC 4126 yeasts. While the biomass washed with 3 volumes of water produced the highest ethanol yields (up to 0.43 g g^{-1} glucose) and were significantly higher than those from the non-washed sample (≤ 0.28 g g^{-1} glucose), the ensuing differences between the 3 and 1 ½ wash samples were not significant. The SPSC01 strain generally outperformed the ATCC 4126 strain in ethanol fermentation efficiency, in particular when the non-washed hydrolysates were used as feedstock.

Task 3: Develop value-added, bio-based products from fractionated biomass

Value added in pine residue

Due to their heterogeneous nature, forest residues may not be used to their full potential as biorefinery or forestry feedstocks. Essential oils from forestry by-products, such as pine needles, have antimicrobial effects against pathogenic bacteria. Pine needle essential oils inhibit growth of *Staphylococcus aureus*, which is the causative agent for numerous human infections, ranging from superficial skin infections, deep abscesses and infections that are more serious. Crude essential oils from pine needles were proposed as a topical antimicrobial agent against both susceptible and methicillin resistant strains of *S. aureus* (MRSA). A Clevenger apparatus was used to extract essential oil from needles from a single clone of young loblolly pine (*Pinus taeda* L.). By GC/MS analysis, it was determined that the major components of the oil were α-pinene (0.52-1.02 mg g^{-1}), β-pinene (0.04-0.67 mg g^{-1}), limonene (0.00-0.06 mg g^{-1}), terpineol (0.01-0.18 mg g^{-1}), and (-) caryophyllene (0.02-0.52 mg g^{-1}), with quantities depending on sampling dates. Using the disk diffusion assay, results demonstrated that the EO had antimicrobial activity against four *S. aureus* strains.

[CALIFORNIA]

Task 1: Quantify and characterize biological feedstocks

- Lipid productivity and fatty acid composition are important metrics for the production of high quality biodiesel from algae. Our previous results showed that co-culturing the green alga *Chlorella minutissima* with *E. coli* under high-substrate mixotrophic conditions enhanced both culture growth and crude lipid content. To investigate further, we analyzed neutral lipid content and fatty acid content and composition of axenic cultures and co-cultures produced under autotrophic and mixotrophic conditions. We found that co-culturing *C. minutissima* with *E. coli* under high substrate conditions (10 g/L) increased neutral lipid content 1.9-3.1 fold and fatty acid content 1.5-2.6 fold compared to equivalent axenic *C. minutissima* cultures. These same co-cultures also exhibited a significant fatty acid shift away from trienoic and toward monoenoic fatty acids thereby improving the quality of the synthesized fatty acids for biodiesel production. Further investigation suggested that *E. coli* facilitates substrate uptake by the algae and that the resulting growth enhancement induces a nitrogen-limited condition. Enhanced carbon uptake coupled with nitrogen limitation is the likely cause of the observed neutral lipid accumulation and fatty acid profile changes. (VanderGheynst).

- Work continued on the development of an integrated geospatial optimization model to evaluate hybrid poplar feedstock production across the Pacific Northwest. The model is used to assess sustainability metrics on both a site-specific and system-wide basis and is spatially explicit and flexible to the desired resolution. The integration framework includes poplar growth models (3PG-Coppice, EPIC), bioenergy crop adoption (BCAM) and statewide agricultural production (SWAP) models to examine crop substitution effects, and a geospatial bioenergy systems model (GBSM) to determine optimal siting for biorefineries based on the desired regional outcomes. Environmental lifecycle assessment and socioeconomic impacts are also modeled, the latter via IMPLAN. A major objective is the development of interactive quantitative tools to support decision processes by landowners and others involved in the development of new biomass resources for biofuels and bioenergy. Crop budgets were developed from cost and return studies and enterprise budgets for a wide array of incumbent agricultural crops in addition to poplar for use in SWAP modeling to determine potential poplar production across the region on both irrigated and non-irrigated lands. A preliminary farm budget tool was developed as a decision support application for both regional and site specific analysis. IMPLAN modeling focused on direct and indirect employment associated with new biorefinery development capacity including feedstock supply and product delivery into final demand, and yields high indirect effects with overall economic multipliers ranging between 1.7 to 1.9 depending on state, and value added multipliers of up to 3.6. Modifications to the EPIC model to accommodate coppicing have been added in order to further assess environmental outcomes associated with poplar as a bioenergy feedstock (Jenkins)

B.1. Biological conversion processes

Task 1: Develop pretreatment methods for biological conversion processes

- Rice straw pretreatment was examined in a full factorial study at temperatures of 120°C and 160°C and 0% and 1% H_2SO_4. Pretreatment efficacy was assessed by measuring hydrolyzate composition and reducing sugar yield after enzymatic hydrolysis. Pretreatment with 1% H_2SO_4 and 160°C yielded the highest amount of reducing sugar, 259 mg/g dry matter, during enzymatic hydrolysis corresponding to 57% glucose conversion based on cellulose content of the pretreated solid. Under this pretreatment condition hydroxymethyl furfural and furfural were 0.19 and 0.68 g/L, respectively. Rice straw pretreated with 1% H_2SO_4 at 160°C was subjected to simultaneous saccharification and fermentation (SSF) using either *Saccharomyces cerevisiae* D_5A or recombinant *Escherichia coli* KO11. Solid and hydrolyzate separation and washing techniques were evaluated for their effect on ethanol production during SSF. Pretreated rice straw without liquid-solid separation or washing had the highest 7-day ethanol yield of 0.2 g ethanol/g dry substrate for *E. coli* KO11. This finding has economical implications on the processing of rice straw to bioethanol. (VanderGheynst).

- A pretreatment process for wheat straw using potassium hydroxide (KOH) and recycled black liquor as treatment reagent was developed and the minimum fresh chemical and water requirement were determined. Black liquor recycling in pretreatment process resulted in 75% reduction in fresh water use and 25% in KOH use, as compared to no recycling. It was found that after five batches of treatment, the concentrations of reducing sugar, chemical oxygen demand (COD), and K^+ in black liquor, reached stable levels. During the KOH pretreatment with black liquor recycling, 32-35% lignin was reduced in wheat straw. The pretreated straw showed reducing sugar yield of 336-366 mg/g total solid (TS) and methane yield of 290-303 mL/g volatile solid (VS) when it was subjected to enzymatic hydrolysis and anaerobic digestion, respectively (Zhang).

- Enzyme hydrolysis of sugar beet to achieve liquefaction was researched with focus on the enzyme separation and recycling. Novozymes cellulase (*Cellic CTec2`*) and pectinases (*NS22119*) were used for sugar beet. Centrifugation and ultrafiltration was used to separate enzymes. Different ultrafiltration membranes were tested. It was found that 10kDa and 50kDa membranes performed well for the enzyme separation wit 50kDa membrane being more efficient based on the flux. Loss of enzyme activities were noticed in the recycled enzymes. Our laboratory test results showed that enzyme recycling could save 50% of the fresh enzyme (Zhang).

Task 2: Develop conversion processes

- Microalgae have been proposed as a potential feedstock for biofuel production, however, cell disruption is usually required for collection and utilization of cytoplasmic polysaccharides and lipids. Virus infection might be one approach to degrade the cell wall. The concentration of yeast extract and presence of KNO_3 in algae cultivation media were investigated to observe their effects on *Chlorella variabilis* NC64A physiology and composition and the subsequent effect on production of *Chlorella* virus in infected cells. Cytoplasmic starch accumulation increased from 5% to approximately 35% of the total dry weight when yeast extract decreased from 1 g/L to 0.25 g/L. When cells were cultured with the lowest nitrogen levels the total polysaccharide accounted for more than 50% of the cell wall, which was 1.7 times higher than the content in cells cultured with the highest nitrogen levels. The C:N ratio of the algal biomass decreased by a factor of approximately 2 when yeast extract increased from 0.25 g/L to 1 g/L (VanderGheynst).

- *Neurospora crassa* has been engineered for direct cellobionate production from cellulose. In our previous effort, *N. crassa* was deleted six out of seven beta-glucosidase genes (*bgl*), the resulting strain F5 was bale to produce cellobiose as the major product and produce cellobionate as a minor product. We found that the regeneration of cellobiose dehydrogenase (CDH) by oxygen is the rate-limiting step in converting cellobiose to cellobionate. The rate and yield of cellobionate from cellulose can be improved by adding low concentrations of laccase and a redox mediator to the fermentation system to speed up cellobiose conversion to cellobionate. The cellobionate yield was optimized by varying fermentation conditions such as pH, buffer strength, and laccase and redox mediator addition time. Mass and material balances were performed. It was found that cellobionate yield from consumed Avicel was improved to 91% with the laccase and redox mediator addition (Fan).

- The alcohol consumption and tolerance of *N. crassa* were also investigated. *N. crassa* was found to be able to consume both a native alcohol-ethanol and a non-native alcohol isobutanol as the carbon source. The rate of ethanol consumption is faster than that of isobutanol. The deletion of the one of two major alcohol dehydrogenase gene (*adh1*) from the genome can efficiently prohibit both ethanol and isobutanol consumption by this strain, confirming this gene encodes an ADH responsible for alcohol consumption. The deletion of the *adh3* does not have any obvious effect on preventing alcohol consumption. *N. crassa* Δ*adh1* can tolerate up to 50 g/L ethanol and 8.8 g/L isobutanol when grown on glucose or Avicel as the carbon source. Such information are very useful for the biofuels community especially for those who are interested in using N. crassa as consolidating bioprocessing microorganism for alcohol production (Fan).
- Sugar beets were investigated as an extremely efficient, high-yielding industrial crop for renewable biofuel production. A non-traditional approach employing enzymatic liquefaction and fermentation of whole sugar beets for bioethanol combined with anaerobic digestion of stillage was developed and tested in the lab. A pilot demonstration of this process was conducted at the UC Davis Biogas Energy Project facility using approximately 40 tons of beets. To achieve rapid scale-up objectives, low severity pretreatment, readily available process equipment, commercial enzymes, industrial unmodified *S. cerevisiea* and minimal fermentation controls were employed. Triplicate 5-ton batch SSF fermentations averaged 0.36 gram-ethanol per gram-initial total solids, which was approximately 90% of that achieved in the lab under similar conditions. Biogas production from stillage at both lab and pilot operations indicate specific biogas production rates over 350ml CH_4/gVS are achievable and could be sufficient to offset a

majority of facility fuel requirements at industrial scale optimum conditions for beet liquefaction and fermentation were determined. A commercial demonstration beet. The ethanol plant has been designed and is currently under construction (Zhang)

- The UC Davis Renewable Energy Anaerobic Digestion (READ) facility jointly developed by CleanWorld and University of California, Davis (UC Davis) has been successfully operated since January, 2014. The READ facility was designed to treat 50 tons per day organic waste with electrical generation capacity of 690 kW from biogas. Additional 235 kW electrical generation capacity is provided from landfill gas.. A three stage thermophilic anaerobic digestion system is used with a total working volume of 450,000 gallons. The facility has four Capstone C200 Microturbines (CARB approved 31% +/- 2% efficiency, each rated @ 200 kW) for co-generation of electricity and heat and an organic Rankine-cycle (ORC) engine-generator (rated @ 125 kW) for converting waste heat from the microturbines into additional electricity. The feedstock characteristics for anaerobic digesters and assess the performance of processes and equipment used in the READ facility with respect to feedstock conversion, biogas and energy generation were determined. Feedstock included a variety of food waste and food processing waste with 30% total solids content on average. Approximately 95% of the wastes processed at the facility were loaded into the digesters. Digester effluent was mostly transported to the nearby farms for land application. The digester effluent has total solids content of 3-4% and pH close to 8.0. The ammonia concentration was 3000-4000 mg/L at the high feedstock loading (Zhang).

[HAWAII]

B.1. Biological conversion processes

Task 1: Develop pretreatment methods for biological conversion processes

For the dilute acid pretreatment of Napier grass (*Pennisetum purpureum*), the factors of Acid Concentration, Time, Temperature and Solid-to-Liquid Ratio were examined to see what effect and interactive effects these variables had on sugar release. A split plot experimental design was used to look at 2 levels of Time and Temperature (main plot) and 3 levels of Acid Concentration and Solid to Liquid Ratio (split plot), each combination was run in duplicate. A predicting model was generated using stepwise regression. Pretreatment factors of: Time, Temperature, Time X Temperature interaction, Solid to Liquid Ratio, Temperature X Acid Concentration interaction and Temperature X Solid to Liquid Ratio interaction were the most significant on predicting sugar release. Therefore all factors are important, however due to the interactive effects the value of one factor dictates the value of the other factor it interacts with.

Investigation of the data generated showed how the sugars glucose, xylose and arabinose react differently to pretreatment conditions. Glucose sugar release was enhanced by “harsher” pretreatment conditions, while xylose and arabinose release peaked at the milder conditions tested. Pretreatment conditions may need to be optimized for xylose removal and then followed by an adequate enzyme hydrolysis to maximize total sugar recovery rather than using harsher pretreatment conditions to try to remove glucose earlier but at the cost of turning other sugars into degradation compounds, which hurts the economics of the pretreatment process.

Task 2: Develop conversion processes

A series of batch experiments were conducted to investigate the effect of micro-oxygenation on VFAs production from lignocellulosic biomass under mesophilic conditions. Napier grass was used as the substrate and oxygen was injected into the mixture of biomass and inoculum at dosages (mlO_2/gVS_{added}) of 0 (control), 15, and 30 just before the start of the experiment. The results showed enhanced VFAs production of micro-oxygenated group compared with control. This could be associated with an increase in the population of facultative microorganisms and the enhanced hydrolytic extracellular enzymes production during micro-oxygenation. Moreover, the VFAs production had a strong quadratic correlation with O_2 dosage with R^2 of 0.80. With regards to the regression equation, it is predicted that the optimal O_2 dosage to produce the highest amount of VFA is 21 ml O_2/gVS_{added}. Methane production of oxygenated group was significantly lower than control. However, carbon dioxide production was not significantly different. This phenomenon could be from the increase of VFAs concentration in the liquid phase, which would have inhibited methanogens. Therefore, micro-oxygenation is an alternative method that can be applied to increase VFAs production from AD of lignocellulosic biomass.

As part of AD project, microbial community analysis was conducted. Three semi-continuous anaerobic bioreactors (R1, R2, and R3 inoculated with rumen content, mixture of both inocula and conventional AD inoculum, respectively) were operated for the co-digestion of Napier grass and cow manure. R2 exhibited the highest archaea/bacteria diversity including hydrolytic rumen bacteria, syntrophic bacteria, as well as methanogens. The mixed inocula could enhance the biodegradation of Napier grass due to the synergetic action of mixed microbial population. However, the start-up period should be closely monitored and the use of a co-substrate with high buffering capacity is recommended for the efficient digestion biomass using rumen contents.

B.3. Biodiesel production processes

Task 1: Characterize new feedstocks

The University of Hawaii group is working in partnership with Protaculture on using food wastes and other agri-residues for growing black soldier flies (BSF) for biodiesel production. The team has been conducting several field trials in Hawaii to optimize BSF yield under various environmental conditions.

Task 4: Utilize co-products

The BSF meal is rich in protein and different nutrients with good balance of amino acids suggesting the potential to replace fish meal protein (at least 60%) in aquatic feed formulations.

[ILLINOIS]

Objective B. Improve biofuel production processes

B.1. Biological conversion processes

Task 2: Develop conversion processes (Rausch, Singh)

Miscanthus x giganteus (MxG) is a warm season perennial grass that has gained attention as a bioenergy crop; it is a leading candidate because it produces high biomass yields and has low input requirements. Previously, we demonstrated xylooligosaccharides (XOS) can be produced through autohydrolysis and recovered by carbon adsorption followed by ethanol elution. There is a lack of information on the functionality of XOS from MxG and as a value added product for cellulosic ethanol. Our objective was to perform in vitro fermentation of MxG XOS with Bifidobacterium spp. and human fecal culture, to compare with commercial XOS products. Highly purified MxG XOS were cultured with beneficial bacteria, *Bifidobacterium adolescentis* and *Bifidobacterium catenulatum*. Both Bifidobacteria were able to utilize MxG XOS as a carbon source for proliferation while B. *adolescentis* grew faster than B. *catenulatum* with specific growth rates of 0.69 to 0.33/h-1. The substrate utilization was 84.1% by B. *adolescentis* and 76.9% by B. *catenulatum*. MxG XOS was cultured further with human fecal microbiota. Commercial XOS from Wako and pectin were used as comparisons. A pH decrease, from 7.1 to 5.0, was observed during 12 h of fermentation. Change in pH was similar for the MxG and Wako XOS cultures. MxG XOS produced 466.2 mg/g acetic acid, 74.6 mg/g propionic acid and 84.2 mg/g butyric acid; total short chain fatty acids were highest among the substrates. The beneficial bacteria Bifidobacterium spp. and Lactobacillus spp. population increased during the fermentation of MxG XOS. Compared with Wako XOS, MxG XOS had similar Bifidobacterium spp., Lactobacillus spp., *Escherichia coli* and *Clostridium perfringens* cell titers. We substantiated MxG XOS as a prebiotic candidate could be utilized by Bifidobacterium spp. and fecal microbiota, be converted into beneficial metabolites and stimulate probiotics growth.

In the US, more than 90% of fuel ethanol production is from the dry grind process. More than 200 maize processing plants use multiple effect evaporators to remove water from thin stillage during dry grind. Evaporator fouling occurs during thin stillage concentration and may be from deposition of proteins, fat, fiber and/or carbohydrates on evaporator surfaces. The consequences of fouling include increased capital costs, operating costs and environmental footprint of cleaning chemical disposal. Despite chronic problems of evaporator fouling in the corn process industry, there have been relatively few studies to understand thin stillage fouling.

Heat transfer fouling is the formation and accumulation of unwanted materials on heat transfer surfaces, which leads to a decrease in the overall heat transfer coefficient. Fouling of heat transfer equipment increases energy consumption and maintenance costs and thus decreases processing efficiency. In the fuel ethanol industry, evaporator fouling occurs when thin stillage is concentrated. Fouling affects the efficiency and environmental footprint of more than 200 biorefineries in the US. In the corn wet milling industry, evaporator fouling takes place as steepwater is concentrated. Steepwater results from the corn steeping process and is composed of solubilized kernel compounds, microbes and solids from recycled process streams. In the dry grind ethanol industry, thin stillage is the liquid fraction of unfermented materials from fermentation and is composed of carbohydrate, protein, fat and ash.

The objective was to investigate effects of total solids and compositional variation on evaporator fouling during thin stillage concentration. Many ethanol plants recover post fermentation corn oil; therefore, the effects of oil recovery on evaporator fouling also were studied. In earlier literature, glycerol accumulation in processing streams from thin stillage recycling was observed; therefore, experiments were conducted to compare the fouling rates when glycerol was added to thin stillage. Thin stillage (7% solids) had lower fouling rates compared to evaporator concentrates (8 to 11% solids). Addition of post fermentation corn oil (0.5 to 1.0%) increased thin stillage fouling rates but at higher oil concentration (1.5% added), rates decreased. At 10% solids content in evaporator concentrates, oil recovery had no influence on fouling rates. Glycerol addition (1%) to thin stillage increased fouling rates.

Research on corn processing fouling has investigated the effects of steepwater solids, corn oil, pH, Reynolds number, solids concentration and carbohydrates. However, effects of phytic acid concentration or phytase addition on fouling characteristics is not known. There are reports from industry suggesting phytic acid content is correlated positively with fouling rate and adding phytase to the process stream may reduce fouling. Researchers also have shown the solubility of certain phytic acid metal complexes, the product of chelation reaction between metal ions available in corn process streams (Mg, Ca, K) and phytic acid, can be influenced by adding phytase. Investigators studying one of these phytic acid metal complexes (Ca) concluded concentration was correlated positively with fouling in the dairy industry at high temperatures. Our purpose was to evaluate effects of phytic acid concentration and phytase addition on steepwater fouling behavior. Experiments were conducted using commercial steepwater with different phytic acid concentrations. Phytic acid concentrations of the samples were adjusted to vary from 25 to 75 mg/g sample. Fouling resistances were measured using an annular probe with a 7 L batch system. Mean fouling rate, maximum fouling resistance and induction period characterized fouling behavior.

Research on thin stillage fouling has been focused on effects of corn oil, pH, Reynolds number, solids concentration and carbohydrates. However, temperature effects on fouling rates have not been studied. Our objectives were to investigate the influence of bulk fluid temperature, initial probe temperature and their temperature difference on thin stillage fouling characteristics. Experiments were conducted using model thin stillage (1% starch solution) and commercial thin stillage with varying temperature conditions. Bulk temperatures were varied from 60 to 80°C and initial probe temperatures were varied from 100 to 120°C; thus, temperature differences varied from 20 to 60°C. Fouling resistances were measured using an annular probe with a 7 L batch system. Mean fouling rate, maximum fouling resistance and induction period were used to characterize fouling behavior. For commercial thin stillage, fouling rate and maximum fouling resistance increased as the initial probe temperature increased from 100 to 120°C. At 120°C initial probe temperature, fouling rate increased with bulk temperature. Using model thin stillage, similar results were observed. An induction period of 5 hr was observed for model thin stillage at initial probe temperature of 100°C. Induction period of model thin stillage increased and maximum fouling resistance decreased with decrease of bulk temperature. Using higher initial probe temperature, such as 120°C, and fluid bulk temperature of 80°C would provide repeatable and more rapid (within 5 hr) characterization of fouling behavior.

In a dry grind ethanol plant, distillers dried grains with solubles (DDGS) is the main coproduct which is used mainly in ruminant animal diets. Increasing the value of DDGS will improve the profitability of the dry grind ethanol process. Pigmented corn, which is rich in anthocyanin content, is an alternative feedstock for dry grind process but the effects of anthocyanin on fermentation characteristics in dry grind process are not known. The effect of anthocyanin in conventional (conventional starch hydrolyzing enzymes) and modified (granular starch hydrolyzing enzymes, GSHE) dry grind processes was evaluated. Ethanol conversion efficiencies of pigmented corns (78.4±0.5% for blue corn, 74.3±0.4% for red corn and 81.2±1.0% for purple corn) were comparable to that of yellow dent corn (75.1±0.2%) in both the conventional dry grind process and the modified dry grind process, using granular starch hydrolyzing enzyme (GSHE) (83.8±0.8% for blue corn, 81.1±0.3% for red corn, 93.5±0.8% for purple corn and 85.6±0.1% for yellow dent corn). The modified process uses GSHE to replace the high temperature liquefaction, which improves the anthocyanin stability in the process (Patras et al., 2011). Pigmented corn with rich anthocyanin content did not have a negative effect the fermentation characteristics for dry grind process; therefore, there is a potential to use pigmented corn in dry grind process, especially using GSHE.

[IOWA]

Research at this station falls under Objective B and C and the outcomes of these tasks are described below**.**

Objective B: Task 2

1. Hydrolysis of low value/ high-fiber agricultural coproducts to produce biosurfactants: Scale up study in 5-L bioreactor on fibrous biomass based hydrolysates has been completed and techno-economic evaluation is being conducted. Isoform fractionation of three surfactin isoforms has also been completed at a purity of 72%

Objective B: Task3

1. Fish feed extrusion projects: These are mainly focused on using soy protein and soy oil to replace fish meal and fish oil. Feed for rainbow trout, Nile tilapia, and cobia were made from these replacements.
2. Ammonia pretreatment: Ammonia pretreatment of corn stover for fermenting into ethanol.

[KANSAS] *Task 1: Task 1: Develop pretreatment methods for biological conversion processes*

KSU continues to conduct research on development of pretreatment methods for biological conversion processes with focus on 1) Ultrasonic Vibration-assisted Pelleting of biomass to increase biomass conversion efficiency; 2) synthesization of silica-coated magnetic acid-functionalized nanoparticles for biomass pretreatment; 3) Value-added utilization of biomass thermochemical conversion chars in syngas cleanup and conditioning. In addition, KSU is working on pretreatment methods using organic green solvents and milder alkali concentration to ensure better quality sugars. The sugars will be converted to fatty acids, butanediol and lactic acid via engineered microbial fermentation.

[KENTUCKY]

Task 1: Develop pretreatment methods.

We are conducting an ongoing study to evaluate the effect of chemical pretreatment on switchgrass, wheat straw, corn stover, and miscanthus using calcium hydroxide, potassium hydroxide, and sodium hydroxide at the same hydroxyl concentration. Our motivation is to determine if there is an alternative to sodium hydroxide that would be more compatible with general farm management. The results of this experiment will allow for the evaluation of the optimal alkaline chemical for pretreatment after laboratory experiments are conducted of the enzymatic hydrolysis of the pretreated biomass.

Task 2: Develop conversion processes

Typically enzymatic hydrolysis of lignocellulose involves a cocktail of enzymes, specifically cellulases and β-glucosidases. Enzymatic saccharification of pretreated corn stover was accomplished using only cellulase and the acetone-butanol-ethanol (ABE) fermentation products were equivalent to the treatment using both enzymes. *C. beijerinckii* was shown to be capable of metabolizing both cellobiose and glucose in the hydrolyzate, thereby saving the cost of β-glucosidases. Pretreated corn stover (PCS) was successfully converted to ABE products using *C. beijerinckii* without additional nutrients. Pretreated corn stover loadings a 60 g/L (six % (w/v) solids loading of PCS) corresponded to the highest butanol yield of 11.04 g/L with the butanol/ABE yields of 0.18 g/g/0.24 g/g. The maximum overall butanol/ABE yield (i.e., 0.22 g/g corn stover obtained in this work was about twice as high as the overall yield that previously obtained using corn stover (i.e.,0.13 g/g corn stover) or any other agricultural lignocellulose of which we are aware.

Task 3: Development of large scale algae production for biofuels and co-products

This project seeks to investigate and demonstrate the potential of using waste CO_2 and heat from a coal-fired power plant to cultivate algae, which could then be processed into value added products. Recent work has focused on the evaluation of recycling spent media and utilization of anaerobic digestion to produce biogas and allow for the recycling of the nutrients to the algae cultivation system. We are also working on development of harvesting and dewatering systems to facilitate the use of the resulting algae into value-added products, such as bioplastics.

[LOUISIANA]

The objective of this study was to conduct a comprehensive laboratory evaluation of the composition of asphalt mixtures containing recycled asphalt shingle (RAS) including stone-mastic asphalt. Laboratory testing evaluated molecular composition using gel permeation chromatography and the extent of aging from Fourier Transform Infrared spectroscopy data. High concentrations of high molecular weight RAS asphaltenes decreased the fracture resistance of the asphalt mixtures. The use of Hydrogreen, a biobased rejuvenating agent did not reduce the concentration of the highly associated asphaltenes and thus they failed to improve the cracking resistance of the modified mixes.

[MICHIGAN]

Objective B.1 Biological conversion technologies

Task 1: Develop pretreatment methods for biological conversion processes.

The David Hodge lab has fractionated lignins derived from biorefining processes to yield lignins enriched in targeted properties that were subjected to catalytic oxidation. It was demonstrated the aromatic monomer yields could be correlated to lignin properties. Ongoing work is focused on understanding cell wall properties that impact alkaline and oxidative pretreatment outcomes. We recently identified that that cell wall-associated transition metals provide a significant positive contribution to delignification efficacy during oxidative pretreatments and that these are strongly correlated to improvements in enzymatic hydrolysis yields.

Objective B.1

Task 2. Conversion Processes

The Mark Worden lab is developing technology for fermentations of gas feedstocks such as methane and hydrogen. These fermentations present a new set of engineering challenges: (1) low aqueous solubility of gases (2) high molar gas requirement (3) possible formation of explosive gas mixtures. Microbubbles are proposed as a part of the solution to these challenges. Microbubbles have an extremely large surface area per unit gas volume and a mass-transfer driving force that increases as the bubble shrinks. They offer the potential for extremely high volumetric mass-transfer coefficients (k_La) and gas-conversion efficiencies without forming incompatible gas mixtures. Experimental and modeling work is ongoing to measure and model the mass transfer coefficients. The model simulates the lower, highly turbulent region of the column as one large CSTR and the upper, less turbulent region as a series of smaller CSTRs. The Dennis Miller group focuses on biofuel components and commodity chemicals. The formation of propylene oxide (PO), a valuable intermediate for plastics production, from propylene glycol was achieved with over 85% selectivity in a continuous flow reactor. In a second project, details of the chemistry of ethanol condensation to butanol and higher alcohols, useful as biofuel constituents, have been recently examined. Adding or removing molecular hydrogen (H2) from the reaction mixture changes the direction of reactions substantially and gives insights into the key reactions. A detailed thermodynamic model of the phase equilibrium in the ethanol condensation reaction system that allows more accurate determination of the products formed in reaction has also been developed. Finally, the mechanism of catalyst deactivation in methyl furfural hydrogenation to dimethyl furan has been investigated; this reaction is representative of several furan-based reaction systems, all of which have exhibited loss of catalyst activity with time on stream.

The Carl Lira group focuses on property modeling of a biorenewable chemicals and fuels. Surrogate models of biorenewable-sourced jet fuel have been improved to match the cloud points within 6% and the distillation curves within an average of 5K. Bulk moduli of six alternative fuels and their blends with JP-8 have been measured up to 16,000 psi at 35C and 65C. The SAFT-BACK equation was found to be incapable or representing bulk modulus of aviation fuels. The GC-PC-SAFT equation is systematically low by about 15%. Property modeling is also important for process design of conversion processes. Industry is finding many challenges in modeling conversion of polar feedstocks to hydrocarbons. Models of hydrogen-bonding fluids are under development. We have demonstrated that the chemical theory and Wertheim's theory are exactly equivalent numerically, though the equations and theoretical development are quite different. Spectroscopic measurements and molecular simulations will be used to further characterize the hydrogen bonding parameters that are currently fitted macroscopically.

Objective B.2 Thermochemical Conversion

Task 2. Conversion

The Chris Saffron group envisions that use of torrefied biomass can prevent the unnecessary decommissioning of solid fuel furnaces that is occurring in response to recent EPA regulations. MSU's T.B. Simon Power Plant has performed a test burn of approximately 300 tons of torrefied wood pellets to determine the efficacy of this technology. Though largely successful, pellets are costly and certain fuel properties, e.g. grindability and hydrophobicity, could be improved. To examine different feedstocks and processing conditions, briquettes of torrefied biomass have been exposed outdoors to several freeze-thaw cycles to examine integrity. Water immersion, contact angle and droplet penetration methods are being developed to assess hydrophobicity. The different bonding configurations amongst the monolignols of lignin are believed to be especially important for making stable pellets or briquettes.

Task 3. Catalytic upgrading of thermochemical products

The Saffron and Jackson labs performs pyrolysis to create liquid bio-oil and electrocatalysis to reductively stabilize the bio-oil. Pyrolysis and electrocatalysis are envisioned at decentralized depots that are located near the areas of biomass harvest, with the goal of creating an energy dense fuel intermediate. Stable bio-oil is then hydroprocessed in a large central facility to create hydrocarbon fuels. As part of a related project, the lignin-derived fraction of bio-oil, comprised of molecules like guaiacol and syringol are demethoxylated and saturated to form cyclohexanol, a valuable Nylon 6,6 precursor. A system-wide energy audit reveals substantial energy upgrading of biomass when bio-oil is stabilized electrocatalytically. Such an approach is especially "green" when wind turbines and solar photovoltaics provide the electrical power.

[MINNESOTA]

Improve biofuel production processes.

While we continue to improve our microwave assisted pyrolysis (MAP) and gasification (MAG) processes, especially develop fast heating technique using microwave absorbents, we also began a new project which is focused on converting municipal scum to biodiesel. Scum is an oily waste stream collected from wastewater treatment process through skimming off the surface of the primary and secondary settling tanks. Currently scum is treated through (1) anaerobic digestion for biogas production or (2) landfill disposal. Biogas (methane, etc.) produced from anaerobic digestion has low energy density, low energy conversion rate and low economic value; while landfilling is costly, unsustainable and can cause many environmental problems. The Saint Paul Waste Water Treatment Plant (WWTP) spends $100,000 per year for just landfilling its produced scum. Scum contains about 60% useful oil which can be converted to biodiesel. If we convert the scum to biodiesel, it could not only produce two higher value products, biodiesel and glycerin, but also at the same time reduce environmental pollution and economic burden.

The conventional biodiesel conversion process includes acid catalyzed esterification and base catalyzed trans-esterification which is suitable for high quality oil. However due to poor feedstock quality of the scum, such as high solid and water content, high soap and fatty acid content, and high sulfur content, no effective process has been developed for converting such a material to biodiesel. Therefore the goal of our work was to develop a novel process and a system to convert scum to biodiesel that meets ASTM standard. In this project, many innovative and integrated process, such as, microwave assisted oil recovery, filtration, acid washing, and solvent extraction have being investigated to optimize rate and yield limiting factors like converting soap to free fatty acid (FFA), removing polar organic impurities, and reducing sulfur content in the recovered raw oil. Catalytic glycerolysis was developed and used to convert FFAs to glycerides using free recycled glycerin and to further reduce the sulfur content.
Identify, develop and evaluate sustainable processes to convert biomass resources into biochemicals, biocatalysts and biomaterials.

Our research also looks into biochar produced from microwave assisted pyrolysis of various biomass feedstocks. The physical and chemical properties of the biochar was investigated in connection with their potential use as fertilizer and soil amendment agent. In addition, production of EPA and DHA lipids from microalgae was investigated. Factors such as type of wastewater and nutrients, stress, temperature, and light on the synthesis of EPA and DHA were studied.

[MISSISSIPPI] Dr. Fei Yu's Bioenergy Research Group have investigated the real biogas purification process and figured out both hydrogen sulfide and oxygen were impurities for the next step methane reforming for liquid fuels production. We designed both nickel based and tungsten carbide based catalysts for methane dry reforming with addition of carbon dioxide for syngas production. We also continued to screen multi-functional catalysts for aromatic-rich gasoline range liquid hydrocarbon production during catalytic conversion of syngas. The syngas conversion to oxygenated compounds such as higher alcohols was also addressed for the integrated biomass to biofuel conversion process.

[MISSOURI] This project targets development and demonstration of open-air algal culture providing algal biomass for biofuels and bioenergy production utilizing CO2 and growth nutrients supplied from simultaneous maintenance of water quality supporting intensive aquaculture and animal feed co-production.

[NEBRASKA] Using the optimal control feeding strategy, glucose concentration and accumulated cellulose conversion reached up to 77.31 g/L and 72.08% in 100 h, which are 108.76% and 37.50% higher than in batch hydrolysis with same amount of enzyme consumption. Both enzyme and substrate loadings significantly effected conversion of glucan and xylan. Enzyme loading appears to impact conversion more than substrate loading.

[NORTH DAKOTA]
Task 1: Develop pretreatment methods for biological conversion processes
Preliminary work has shown that pelleting improves the effectiveness of using ultrasound as a biomass pretreatment. Ultrasound had had little to know impact on loose biomass slurries but increased subsequent hydrolysis yields from pelleted biomass by 20-30%.

Task 2: Develop conversion processes
A study was completed showing that β-glucosidase supplementation during biomass hydrolysis can be reduced by 80-90% from what is typically reported in the literature with no significant effect on hydrolysis rate or yield.

B.3. Biodiesel production processes
Task 3: Develop and characterize innovative processes for biodiesel production
The production of biodiesel from spent coffee grounds (SCG) is being investigated in collaboration with Chulalongkorn University in Thailand. SCG is a byproduct of the instant coffee industry, and contains up to 20% oil (db). A major challenge is the high moisture content of SCG, which leads to high levels of free fatty acids, depending upon the length of storage before drying and the drying method. In situ methods for simultaneous extraction plus transesterification achieved biodiesel yields >90%, and the biodiesel passed several common tests for quality, including OSI.

Task 4: Develop enabling technologies for biochemical production.
The epoxidation of sucrose soyate (ESS) was optimized for five parameters using mini-plants (30-g product per batch) and a Box-Behnken experimental design. Samples epoxidized at 60 – 65 ^{o}C for 4.5-5 h had conversion >98% even when reagent amounts were reduced 18-20%. Similar resin quality was observed when one of the optimal conditions was scaled-up to a 3 kg batch.

[OHIO]
B.1. Biological conversion technologies
Task 1: Develop pretreatment methods for biological conversion processes.
Fungal pretreatment of miscanthus and albizia was conducted for biogas production via anaerobic digestion. Fungal pretreatment with *Ceriporiopsis subvermispora* decreased the lignin content of miscanthus harvested in spring by 25.7%, but there was no significant delignification observed for miscanthus harvested in fall. Fungal pretreatment of miscanthus harvested in spring increased the specific methane yield by 25%, but fungal pretreatment caused a slight methane yield reduction for miscanthus harvested in fall. After 48 days of fungal pretreatment, degradation of lignin in albizia chips was found to be around 24%, which was about 2 times that of cellulose and hemicellulose. Fungal pretreatment of albizia chips resulted in more than 4-fold

increases in glucose and xylose yields during 72 h of enzymatic hydrolysis and a 3.7-fold increase in the cumulative methane yield during 58 days of SS-AD.

Task 2: Develop conversion processes.

We are continue develop and optimize the solid state anaerobic digestion process for biogas production from lignocellulose sic biomass. The effect of premixing methods on the performance of SS-AD was evaluated. Results showed that at feedstock to inoculum (F/I) ratios of 4 and 6, the two-layer partial premixing method obtained the highest methane yield, followed by one-layer partial premixing and complete premixing methods. SS-AD digesters failed at an F/I ratio of 8, regardless of the premixing method. Adding extra inoculum to the top of failed digesters resulted in recovery of methane production.

The microbiomes involved in liquid anaerobic digestionprocess have been investigated extensively, but the microbiomes underpinning solid-state anaerobic digestion (SS-AD) are poorly understood. Microbiome composition and temporal succession in batch SS-AD reactors, operated at mesophilic or thermophilic temperatures, were investigated using Illumina sequencing of 16S rRNA gene amplicons. A greater microbial richness and evenness were found in the mesophilic than in the thermophilic SS-AD reactors. Firmicutes accounted for 60 and 82 % of the total Bacteria in the mesophilic and in the thermophilic SS-AD reactors, respectively. The genus Methanothermobacter dominated the Archaea in the thermophilic SS-AD reactors, while Methanoculleus predominated in the mesophilic SS-AD reactors.

Interestingly, the data suggest syntrophic acetate oxidation coupled with hydrogenotrophic methanogenesis as an important pathway for biogas production during the thermophilic SS-AD. Canonical correspondence analysis (CCA) showed that temperature was the most influential factor in shaping the microbiomes in the SS-AD reactors. Thermotogae showed strong positive correlation with operation temperature, while Fibrobacteres, Lentisphaerae, Spirochaetes, and Tenericutes were positively correlated with daily biogas yield. This study provided new insight into the microbiome that drives SS-AD process, and the findings may help advance understanding of the microbiome in SS-AD reactors and the design and operation of SS-AD systems.

Solid-state anaerobic digestion of yard trimmings, composed of wood chips, lawn grass, and maple leaves, was conducted at 22% total solids at 55 °C for 45 days. Results showed digestion of mixed feedstocks generated earlier peaks and more methane than digestion of single components. The favorable peaking time (14 days) and methane yield (143 L/kg of VS) were achieved with equal fractions of the three components, increasing the methane yield by 80-200% compared to digestion of single components.

Multiple linear regression (MLR) and artificial neural network (ANN) models were explored and validated to predict the methane yield of lignocellulosic biomass in mesophilic solid-state anaerobic digestion (SS-AD) based on the feedstock characteristics and process parameters. Out of the eleven factors analyzed in this study, the inoculation size (F/E ratio), and the contents of lignin, cellulose, and extractives in the feedstock were found to be essential in accurately determining the 30-day cumulative methane yield. The interaction between F/E ratio and lignin content was also found to be significant. MLR and ANN models were calibrated and validated with different sets of data from literature, and both methods were able to satisfactorily predict methane yields of SS-AD, with the lowest standard error for prediction obtained by an ANN model. The models developed in this study can provide guidance for future feedstock evaluation and process optimization in SS-AD.

In solid-state anaerobic digestion (SS-AD) of cellulosic biomass, the volumetric methane production rate has often been found to increase with the increase in total solids (TS) content until a threshold is reached, and then to decrease. This phenomenon cannot be explained by conventional understanding derived from liquid anaerobic digestion. This study proposed that the high TS content-caused mass diffusion limitation may be responsible for the observed methane production deterioration. Based on this hypothesis, a new SS-AD model was developed by taking into account the mass diffusion limitation and hydrolysis inhibition. The good agreement between model simulation and the experimental as well as literature data verified that the observed reduction in volumetric methane production rate could be ascribed to hydrolysis inhibition as a result of the mass diffusion limitation in SS-AD.

Task 3: Develop value-added, bio-based products from fractionated biomass.

An integrated process was proposed and conducted by pretreating woodchips via Shiitake cultivation for improved methane yield during solid-state anaerobic digestion (SS-AD), and simultaneously producing mushrooms as a high-value co-product. Shiitake cultivation using woodchips as the main substrate ingredient obtained mushroom yields comparable to those using a commercial substrate. Enzymatic digestibility and cumulative methane yields (133–160 L kg————————————1 VS during 62 days of SS-AD) of pretreated substrates (spent mushroom substrate) were at least 1.5 times as high as those of untreated woodchips. Compared to a sole SS-AD process, the integrated Shiitake cultivation/SS-AD process increased methane production and solid waste reduction per kilogram of woodchips by about 1.5 and 8 times, respectively.

Polyols and waterborne polyurethane dispersions (CG-WPUDs) were produced from biodiesel derived crude glycerol. The polyols were produced from biodiesel-derived crude glycerol via a thermochemical conversion process, which converted crude glycerol components such as glycerol, free fatty acids, and methyl esters of fatty acids (FAMEs) into polyols under optimized reaction conditions. CG-WPUDs with different hard segments (41.0% to 63.2 wt %) were prepared from the crude glycerol-based polyols produced. PU coating films cast from CG-WPUDs showed increasing glass transition temperatures (Tg) from 63°C to 81°C when hard segment content increased from 41.0% to 63.2% and had good thermal stability up to 240°C. CG-WPUD based coatings showed excellent adhesion to steel panel surfaces, pencil hardness as high as F, but relatively low flexibility. This study demonstrated the potential of biodiesel-derived crude glycerol for the production of bio-based polyols and WPUDs

Crude glycerol-based waterborne polyurethane (CGWPU) was also used to modify soymeal-derived protein (SMP) with improved tensile strength and water resistance. SMP–CGWPU blend films were successfully prepared by casting the aqueous dispersions of SMP and CGWPU. The effects of CGWPU content on the structure and properties of the resulting films were investigated by Fourier transform infrared (FTIR) spectroscopy, scanning electron microscopy (SEM), differential scanning calorimetry (DSC), thermos gravimetric analysis (TGA), tensile tests, and water uptake measurements. Good compatibility was observed in the blend films, which resulted from strong intermolecular interactions, such as hydrogen bonding, that existed between SMP and CGWPU. With increasing CGWPU content, SMP–CGWPU blend films had improved water resistance, thermal stability, and tensile strength, but had decreased elongation at break. The performance of SMP–CGWPU blend films was comparable to the SMP films blended with commercial oil-based Minwax urethane (MU).

[OKLAHOMA]

Low-cost, mobile power generation unit capable of converting a broad range of carbonaceous feedstocks (Huhnke and Kumar)

Oklahoma State University (OSU) is currently working with a newly-formed company, RE:PODS (Renewable Energy: Power On Demand System, http://repods.com/), in scaling up OSU's patented downdraft gasifier to develop a mobile unit having a 50-100 kWe nameplate output. The patent is based on a laboratory-scale reactor which has a unique biomass pyrolysis and tar cracking conversion zone. The reactor design consists of an internal, separate combustion section where turbulent, swirling high-temperature combustion flows are generated resulting in low producer gas tar content. The gasifier operates under near atmospheric conditions and has few moving parts. In addition to the unique reactor design, the gasifier is capable of utilizing low bulk density carbonaceous materials which can be problematic to any gasification system. OSU is currently in the final stages of design, fabrication, and testing of a 60 kWe scale-up of the gasifier. Support for this scale-up has come from two OSU sources, i.e., OSU Research Foundation and Technology Development Center.

Development of biochar-based catalysts from syngas cleaning (Dr. Kumar)

The overall goal of the proposed research was to develop novel methods to use char derived from gasification for high-value applications in syngas conditioning. The first objective was to investigate effects of gasification condition and feedstock on properties of char derived from fluidized bed gasification. Results show that the surface areas of most of the char were 1–10 m2/g and increased as the equivalence ratio increased. Char moisture and fixed carbon contents decreased while ash content increased as equivalence ratio increased. The next objective was to study the properties of sorghum and red cedar char derived from downdraft gasifier. Red cedar char contained more aliphatic carbon and o-alkyl carbon than sorghum char. Char derived from downdraft gasification had higher heating values and lower ash contents than char derived from fluidized bed gasification. The gasification reactivity of red cedar char was higher than that of sorghum char. Then, red cedar char based catalysts were developed with different preparation method to reform toluene and naphthalene as model tars. The catalyst prepared with nickel nitrate was found to be better than that with nickel acetate. The nickel particle size of catalyst impregnated with nickel nitrate was smaller than that of catalyst impregnated with nickel acetate. The particle size of catalyst impregnated with nickel acetate decreased by hydrazine reduction. The catalyst impregnated with nickel nitrate had the highest toluene removal efficiency, which was 70%-100% at 600-800 °C. The presence of naphthalene in tar reduced the catalyst efficiency. The toluene conversion was 36-99% and the naphthalene conversion was 37%-93% at 700-900 °C. Finally, effects of atmosphere and pressure on catalytic reforming of lignin-derived tars over the developed catalyst were investigated. An increase in reaction temperature led to an increase in removal of most tar components except naphthalene. High pressure promoted the catalytic conditioning of lignin tar. Hydrogen promoted the conversion of lignin into non-condensable gas.

Syngas fermentation for butanol and hexanol production (Atiyeh)

Dr. Atiyeh's team has performed many projects on syngas fermentations including the production of higher alcohols such as butanol and hexanol from syngas. Butanol and hexanol have higher energy density than ethanol and are more compatible with fuel infrastructure. The production of higher alcohols (butanol and hexanol) from syngas by *Clostridium carboxidivorans* P7 was performed in collaboration with Drs. R. Huhnke & M. Wilkins (OSU) and Dr. R. Tanner's team (University of Oklahoma, OU). The objecticve was to develop a minimal synthetic medium and culture technique for production of higher alcohols from syngas. The results showed that butanol (over 1.0 g/L), hexanol (up to 1.0 g/L) and ethanol (over 3.0 g/L) were produced in bottle fermentations by strain P7. In addition, minimal medium and controlled supply of CO and H_2 should be used in characterizing candidate butanol and hexanol producing strains to select for commercial potential.

ABE (acetone-butanol-ethanol) fermentation using redcedar and switchgrass (Atiyeh)

Dr. Atiyeh's team has performed two projects on ABE fermentations using redcedar and switchgrass. This work was performed in collaboration with Dr. R. Tanner (OU), Dr. R. Wilkins (OSU) and Dr. T. Ezeji (The Ohio State University). Redcedar is an invasive softwood species causing problems in the Central Plains of the United States. Butanol production from eastern redcedar is more difficult than ethanol production due to more sensitivity of bacteria to the content of redcedar hydrolyzate. The goal of the study was to develop a conversion process for redcedar to butanol. The results showed that the type of buffer used is critical for efficient ABE fermentation. Acetate buffer was selected for enzymatic hydrolysis and ABE fermentation because citrate buffer inhibited ABE fermentation. Hydroxymethylfurfural, furfural, cinnamaldehyde, vanillic acid and syringaldehyde were among the inhibitors detected in the redcedar prehydrolyzate and hydrolyzate. Detoxification of redcedar hydrolyzate was required to remove inhibitors and enhance growth and butanol production. Butanol (13 g/L) and total ABE (19 g/L) were produced from detoxified redcedar hydrolyzate, which were comparable to glucose medium.

The second project was focused on process development of butanol from switchgrass and quantification of inhibitors and detoxification of hydrolyzate. Hydrothermolysis-pretreated switchgrass at solid loading of 14% was hydrolyzed using Accellerase 1500. *Clostridium acetobutylicum* ATCC 824 fermented the hydrolyzate to ABE. Fermentations of non-detoxified and detoxified switchgrass hydrolyzates were compared. The results showed that pH adjustment and CaCO3 addition to switchgrass hydrolyzate improved ABE production without detoxification. However, butanol production (6 g/L) was still very low due to presence of furanic and phenolic inhibitors in the hydrolyzate. Activated carbon detoxification removed detected inhibitors except cinnamaldehyde. In addition, detoxification of switchgrass hydrolyzate increased butanol titer from 1 to 11 g/L with a total of 17 g/L total ABE concentration. These results show the potential of butanol production from biomass feedstocks such as red cedar and switchgrass.

[PENNSYLVANIA]

Following projects have been studied: i) Strain selection and medium optimization for glucoamylase production from industrial potato waste by Aspergillus niger have been studied; ii) Enhanced bio-ethanol production from industrial potato waste by statistical medium optimization were performed; iii) Medium optimization for simultaneous saccharification and fermentation of ethanol from industrial potato waste by A. niger and S. cerevisiae was studied. iv) The project for production of human lysozyme by Kluyveromyces lactis K7 in biofilm reactors including fed-batch and continuous fermentations have been completed as well as online recovery of lysozyme; v) The project for production of alpha-keto acids by using microbial cell cultures have been completed including fed-batch and continuous fermentations; vi) The project for the production of lactic acid by Rhizopus oryzae microparticles additions has been completed which aimed to enhance lactic acid fermentation; vii) The cultivation conditions and medium composition a novel probiotic strain Bacillus pumilus STF26 have been studied.

This effort this year included progress on seven major areas of research. 1) We completed multiple experiments on aerobic and anaerobic storage of willow, switchgrass and miscanthus. 2) We investigated microbial conversion of biomass into carboxylic acids, publishing a paper on the use of nanofiltration for integrated acid separation. 3) We initiated a new project to understand the factors that contribute to greenhouse gas emissions during high solids manure storage. 4) We are working on a paper with the Idaho National Laboratory to quantify and simulate wet storage impacts on biomass supply chain logistics. 5) We initiated a new collaboration with Cornell University and the Oak Ridge National Laboratory on the ecosystem service valuation of perennial energy grasses and energy winter crops for water quality in the Chesapeake Bay. 6) We worked to quantify carbon offset benefits in forest and cropland bioenergy systems. 7) And finally, we completed a suite of experiments to develop and test synthetic monolignols as tracers in plant cell walls to determine cell structure and function. A range of papers were published on these topics as indicated below.

Following projects have been studied: i) A predictive biophysical model of translational coupling has been developed that enables the rational engineering of bacterial operons for metabolic engineering and synthetic biology applications; ii) A genetic circuit was engineered that uses mixed feedback loops to express similar amounts of T7 RNA polymerase in diverse host organisms, enabling the rational engineering of metabolic pathways without relying on host-specific promoters; iii) A 5-enzyme Entner-Doudoroff metabolic pathway was engineered that rapidly regenerates the cofactor NADPH in E. coli, and demonstrated that this modular pathway could be used to double the production titer of a terpenoid product; iv) A predictive biophysical model of translation-regulating riboswitches has been developed that was used to rationally engineer 62 RNA-based sensors that detect six different chemicals, including the environmental pollutant dinitrotoluene to engineer RNA-based sensors that can detect and respond to many types of environmental pollutants; v) A quantitative model of the CRISPR/Cas9 system was developed that explains how several factors collectively control Cas9’s ability to precisely cut genomic DNA sites and regulate transcriptional activity; vi) A non-equilibrium biophysical model of translation initiation was developed that accounts for differences in a mRNA’s folding kinetics. This model can be used to more accurately predict translation initiation rates of mRNA with several applications in Synthetic Biology and Metabolic Engineering.

[SOUTH CAROLINA]

Accomplishments

(1) Investigate and develop sustainable technologies to convert biomass resources into chemicals, energy, materials and other value added products.

(2) Develop modeling and systems approaches to support development of sustainable biomass production and conversion to bioenergy and bioproducts.

(3) Identify and develop needed educational resources, expand distance-based delivery methods, and grow a trained work force for the biobased economy

Algae-based technologies are fast growing and the growing demand for sustainable technologies is evident from the growing energy demand and global warming. Microalgae culturing for higher lipid contents have been a hot topic of intense discussion in the past years. Crude glycerol, a byproduct from biodiesel production seems to be an attractive feedstock for microbial cultivation and crude glycerol has been proven as a good alternative feedstock for cultivation of Chlorella protothecoides. The effect of impurities present in the crude glycerol is important to develop a method for high-density cultivation of microalgae to increase the commercialization potential of algae systems.

Through this study, a method to partially refine crude glycerol was developed to increase the suitability of biodiesel-derived glycerol for high-density cultivations. C. protothecoides grew best at an initial glycerol concentration of 90 g/L and a maximum biomass and lipid productivity of 4.45 and 2.28 g/L-day was achieved at an initial glycerol concentration of 120 g/L. Fed-batch studies increased the biomass and lipid concentrations and productivities. A maximum biomass and lipid concentration of 95.3 and 49.5 g/L-day was achieved while using PRG as a carbon source with a maximum productivity of 10.6 g/L-day. Yield biomass per substrate in the fed batch mode was observed to be 0.53. Comparing the data to published literature, these are the best results. Fatty acid profiles were observed to be very comparable to data published by other researches on C. protothecoides.

Further studies on the effect of salinity on the growth of C.protothecoides, yielded no statistical significance in the biomass concentration and lipid content at a KCl concentration of 10 and 20 g/L, and a NaCl concentration of 10 g/L. Further increase in NaCl concentration to 20 g/L decreased the maximum biomass concentration. No growth was observed at salt concentrations of 40 g/L. Increasing salt concentrations had no impact on the relative fatty acid percentage of oleic acid (most abundant fatty acid produced by Chlorella protothecoides). Biomass productivities were significantly lower in the presence of salts, indicating that the present of salts decreases the biomass productivity.

Increasing methanol concentrations were evaluated, and the results proved that methanol was not significantly consumed but evaporated by this species of algae. A methanol concentration 1 % (v/v) yielded similar biomass and lipid concentrations, Yx/s and Yp/s . The biomass productivity, however, was significantly lower with increase in methanol concentrations.

Xylose proved to be detrimental to the growth of C. protothecoides as increasing xylose concentrations decreased biomass concentration. No growth was observed at a xylose concentration of 30 g/L.

In summary, the effect of some impurities present in crude glycerol was evaluated and a method to refine crude glycerol proved successful. A method for high-density cultivation of C. protothecoides for increased productivities while using a waste stream is presented.

[SOUTH DAKOTA]

B.1. Biological conversion technologies

Task 1: Develop pretreatment methods for biological conversion processes.

SDSU continually works on integrating pretreatment and densification processes to reduce the logistical hurdles facing lignocellulosic feedstocks (corn stover, switchgrass, prairie cord grass, and big blue stem). A strategy of decentralized Regional Biomass Pre-processing Depots (RBPDs) was proposed and implemented. This RBPDs would use densified feedstocks coming from the two different processes: a) AFEX-pretreated and densified feedstocks; b) feedstocks from one-step extrusion and densification process. Both of these processes will produce dense, solid biomass pellets that retain their original composition and can use existing transportation/handling infrastructure. The RBPDs model will minimize transportation of low density feedstock bales and feed larger centralized bio-refineries. Densified biomass will be more efficiently transported to centralized processing facilities. The pelleted biomass will be converted via fast pyrolysis into bio-oil, bio-char, and syngas. The bio-oil will be further upgraded into the advanced fuels via a catalytic process, while the bio-char can serve as a solid fuel source or a soil amendment. Syngas can be used as power supply for operating the facility. It is estimated that about 20-25% of power supply can be achieved from the syngas depending on the composition of the gas.

B.2. Value added products and markets based on thermochemical conversion technologies.

Task 2: Develop conversion processes

The major works of SDSU on thermochemical conversion of biomass into advanced fuels include:

1) Integrated catalytic fast pyrolysis technologies with multifunctional catalyst technologies to improve biomass conversion efficiency and economic feasibility. Over 5 catalysts were prepared, tested, and characterization.

2) SDSU has developed the second generation catalytic fast pyrolysis system that can convert various lignocellulosic biomass (such as sawdust, corn stover, switchgrass, etc.) to hydrocarbon based advanced biofuels that are compatible with petroleum hydrocarbons and can be directly dropped into existing petroleum refineries for the production of "green" gasoline, diesel, and jet fuels. This research also make logistic advances by increasing the bulk density of raw biomass feedstock over 500% and almost 3 times the energy density. Regionally locating these pyrolysis bio-oil plants in the proximity of feedstock supply solves the logistic problem of transporting low density biomass long distances while providing job opportunities and expanding the rural economy. By densifying the output products with high energy content to locally produce a stable advanced biofuel, logistics issues are addressed.

3) Develop multifunctional catalyst systems for advanced fuel production. Different multifunctional catalysts have been synthesized and tested in the SDSU bio-oil upgrading process for the conversion of crude bio-oil to advanced fuels. Integration of these effective catalysts coupled with accurately controlling reaction conditions (heating rate, temperature, pressure, and residence time) in the SDSU process has effectively improved carbon conversion efficiency and quality of advanced fuels. Economical production of advanced biofuels with an over 60% GHG emission reduction is expected.

B.3. Biodiesel and Bio jet fuel production processes

SDSU has investigated oil extraction from sunflower, camelina, canola, flax, safflower, and carinata using two different approaches, cold press and solvent extraction. The oils produced were characterized for heating value, density, viscosity, pH valve, chemical composition (fatty acid profile), elemental composition, etc. The goal is to evaluate and compare the technical and economic feasibility of solvent extraction and cold press for efficiently extracting oils from various oilseeds for further conversion into bio jet fuels. A novel catalytic cracking process for converting these inedible oils (non-food oilseeds, animal fats, waste oils, etc.) to hydrocarbon based advanced biofuels is carried out. Sunflower, camelina, and canola oils have been successfully upgraded to hydrocarbon fuels.

[TEXAS]

Texas A&M University (TAMU) AgriLife Research (AgriLife), through the research effort of Dr. Capareda is continually developing thermal gasification technologies for various biomass resources. The emphasis for this year is the implementation of the USDA-NRCS-CIG grant entitled “Demonstration of water purification/treatment/recycling and power generation with net metering in a commercial-sized university dairy operated by the dairy industry”.

The mobile gasification unit developed at TAMU AgriLife Research (Figure 1 below) will be demonstrated at the Southwest Regional Dairy Center (SWRDC) in Tarleton State University, Stephenville, Texas in the Fall of 2016. The concept of net-metering will be demonstrated at this facility during the weeklong Farmer’s Week Event that will be organized.

Texas A&M AgriLife Research is also developing technologies for new oil seed crops. A Visiting Scientist from Central Queensland University (Dr. Nanjappa Ashwath) has extracted and characterize various new oil feedstock. One of these is the oil from Beauty Leaf Tree, quite abundant in Australia. This research evaluated fatty acid profile of this new seed crop and is developing new innovative processed for biodiesel production, specifically, the one-step biodiesel production using novel solid catalyst. The group is currently developing bio-char-based catalysts for the same purpose. Aside from biodiesel, the group has also identified novel catalysts for the conversion of refined oil into hydrocarbons. Inadvertently, the group has also found a sold catalysts that can convert refined oil into esters.

Another research that is being pursued is the conversion of the spent meal during mechanical oil extraction and converting this wastes into biofuels via fast pyrolysis studies. The results of this study will be presented in the 2015 Annual National Convention of the American Society of Agricultural and Biological Engineers (ASABE). It was found out that the spent meal after mechanical oil extraction has more oil and energy than the extracted oil itself. Hence, attention was focused on generating more biofuel product from this resource via fast pyrolysis. The amounts of solid biochar, liquid biooil and synthesis gas was quantified for each of the oil seed crop studied.

[WASHINGTON]

The current vision of biorefineries undervalues lignin’s potential to address the world’s high quality liquid fuel requirements. Despite the potential, selective conversion of lignin has proven to be challenging, mainly due to the heterogeneous and non-hydrolyzable cross-linked structure. Several catalytic upgrading routes, especially hydrodeoxygenation (HDO), have been extensively studied with the aim of producing fuel range hydrocarbons. Most HDO processes are accompanied by cleavages of both C-O-C and C-C bonds in lignin, which result in depolymerizing lignin to monomers that generally contain 6-9 carbon atoms, which have a moderate value in fuel usage. Although long chain hydrocarbons could be generated via coupling reactions of lignin-degraded monomers, it requires additional specific catalysts and processes that increase costs. Less effort has been focused on direct transformation of lignin-degraded dimers to long chain hydrocarbons, although these components represent a large portion of lignin-derived intermediates. Leveraging funded projects from DARPA, NSF, DOE-NREL, and Sun grant-DOT, we have successfully demonstrated novel principles of catalytic upgrading of biomass-derived lignin to biofuels and chemicals. Combinations of noble metal catalysts (e.g. Ru/Al_2O_3, Ru/C, Ru/graphene) in the presence of various acids (e.g. $ZnCl_2$, $AlCl_3$ and zeolites, including H^+-ZSM-5, H^+-Mordenite, H^+-Y and Beta- ZSM-5) were tested for hydrodeoxygenation (HDO) activity of technical lignins from different sources (e.g. corn stover, poplar wood, and lodgepole pine). Our results showed the generation of hydrocarbon (C_7-C_{18}) derivatives from biomass-derived lignin with high selectivity of C_{12}-C_{18} cyclic structure hydrocarbons via the cleavage of C–O–C bonds without disrupting the C–C linkages (8–8', 8–5' and 5'–5") in the lignin structure. Our results lead us to believe that the reactivity and structural features of technical lignins are key factors of catalyst selection in presence of hydrogen for producing a wide variety of hydrocarbon species (aliphatic and aromatic) that are commonly found in jet fuel blend stocks. In addition, the reactivity of lignin and its interactions with the chemical catalysis systems were studied to reveal the principles of the reaction mechanism, its control, and applications.

We are also being funded through the DOE to better understand the biological processing of biomass-derived lignin to lipids for biofuel production. This project is in collaboration with Texas A&M, Georgia Tech, and UBC on a joint research effort to engineer multiple microbial species (e.g. Rhodococcus opacus and Pseudomonas putida) and investigate the biological pathways for converting lignin to fuels and other valuable products. Results indicated that wild type and genetically engineered strains were able to convert lignin and accumulate lipids for fuel production.

Another research effort focuses on synthesis of biopolymers from lignin (e.g. supercapacitors). We seek to define avenues to convert lignin into lower cost biopolymers through applications of our learning. This is a joint effort with PNNL, NREL, and Texas A&M. 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. These carbonized lignins exhibited relatively high electrochemical performance in terms of specific capacitance, energy density and power with good capacity retention.

[WEST VIRGINIA]

Objective B2. Value added products and markets based on thermochemical conversion technologies

Activity 1: Develop Conversion Processes- Hydrothermal Carbonization of Blueberry Spent Osmotic Solution (Singh and Sivanandan)

Osmotic solution (OS) and spent osmotic solution (SOS) generated from the osmotic dehydration of blueberries were compared for their thermo-chemical decomposition behavior and hydrothermal carbonization. OS and SOS samples were characterized for total solids, elemental composition, and thermo-gravimetric analysis (TGA). In addition, hydrothermal carbonization was performed at 250 °C and for 30 min to produce hydrochars. Both samples produced, approximately, 40%–42% (wet-feed basis) hydrochar during hydrothermal carbonization but with different properties. The OS sample produced hydrochar, which had spherical particles of 1.79 ± 1.30 μm diameter with a very smooth surface. In contrast, the SOS sample produced hydrochar with no definite particle shape but with a raspberry-like surface. (Singh and Sivanandan, 2014)

Activity 2: Co-Processing of Pyrolysis Vapors with Bio-Chars for Ex-Situ Upgrading (Singh)

Co-processing of woody biomass with two bio-chars (bio-chars made from switchgrass and red oak bark) was studied as a way of upgrading the pyrolysis vapors. The clean woodchips were pyrolyzed with and without bio-chars under atmospheric pressure at the target temperature of 500 °C. The co-processing with both bio-chars showed a significant influence on the bio-oil yields, moisture content and pH value of bio-oils. However, the vapor-upgrading process significantly decreased the carbon yield of the bio-oil when using switchgrass bio-char for co-processing. The bio-oil yield decreased from 49.31% (non-bio-char) to 44.81% with the switchgrass bio-char and to 48.68% with the bio-char from the red oak bark. The lost mass of bio-oil ended-up in the gaseous phase as reflected in an increased content of carbon dioxide and carbon monoxide. (Jin et al., 2015)

Activity 3: Pyrolysis of Herbaceous Biomass Crops (Singh)

Pyrolysis and characterization of pyrolysis products of two biomass crops (Miscanthus and Switchgrass) grown on reclaimed coal-mining land in Appalachian region were carried out. The oven-dried samples were pyrolyzed in a fixed-bed batch reactor under an inert condition and at a temperature of 500 ^{0}C. Physio-chemical properties, ultimate and proximate analyses of the parent samples and pyrolysis products were carried out. About 30% yield were obtained for biochar while bio-oil production was in the range of 45 to 51% and the gas given off was between 19 and 25%. The carbon content of the biomass, bio-char and bio-oil were found to be 46.8 – 48.02%, 77.72 – 80.23% and 54.68 – 59.68%, respectively. Heating values were found to be between 19-20 MJ/kg, 28-29 MJ/kg and 23 – 26 MJ/kg for the biomass, bio-char and bio-oil, respectively.

Activity 4: Activated Carbons from Herbaceous Biomass Crops of West Virginia (Singh)

Activated carbon production from herbaceous biomass crops harvested from a reclaimed mining land in West Virginia was carried out in this study. Impregnation of biomass and biochar samples of switchgrass and miscanthus with phosphoric acid was performed and the impregnated samples were heat-treated at 900 ^{0}C using a thermogravimetric analyzer. The resulting carbonized samples are being characterized for their surface morphology, textural properties, adsorption capacity, and pore size distribution. In addition, the properties of the produced activated carbon will be compared to commercially available activated.

[WISCONSIN]

1. Dried Distillers Grains Based Polymer Dispersions for Paper Coatings.

Funding: USDA NIFA Critical Ag

Objectives: Develop a process to extract hemicelluloses as a gum material from DDG residual at a corn ethanol plant.

Industrial collaboration: Didion Inc. (Cambria, WI) and Appvion (Appleton, WI)

Furfural was produced from dried distillers grains (DDG) by a two-stage process including a dilute acid extraction of pentose followed by a reactive distillation dehydration (BRD) process. The maximum furfural conversion rate reached 68% (theoretical). In parallel, analyses of composition and in vitro true dry matter digestibility (IVTDMD) of DDG-residue after dilute acid extraction suggested potential animal feed values. An economic analysis estimated that making furfural from DDG and selling the DDG-residue as animal feed would make an extra 0.2 million US$/year revenue for a corn ethanol plant with capacity of 50000 kg DDG per day showing limited potential profitability improvement.

A process for extraction natural gum materials was developed by alkaline solution under different temperature, time and alkaline concentration. The highest yield were at approximately 30% (% of DDG) which was at approximately 70% of the theoretical yields possible based on the initial composition of the DDG. Models predicting the gum and alkali residue yields and compositions were generated and included into the economic analysis. The results showed that in order to make the DG gum process profitable to corn ethanol industry, DG gum price has to be at least$2.5/kg.

A process model for the entire system starting from dry grind milling corn-ethanol plant to processing of animal feed and hemicellulose paper coatings was built in ASPEN Plus for simulating the energy and mass balances across the system. The data obtained from the model will provide inputs for performing Life Cycle Assessment of products generated.

2. Accelerated Renewable Energy

Funding: USDA BRDI

Objectives: Assess a process to separate digested manure into value added components and investigate the potential to produce cellulosic ethanol.

Industrial collaboration: Soilnet (Oregon, WI), Braun Electric St. Nanzianz, WI), FEECO (Green Bay, WI), and Mapleleaf Dairy (Cleveland, WI).

Technical accomplishments are described in discrete categories including manure separation, energy production from manure fiber, biodiesel production, and life cycle assessment.

Manure Separation

The effect of cationic polymer flocculent in dairy manure liquid/solid separation operation was investigated through a fundamental study looking at both liquid/solid separation and reduction in pathogen via measurement of a pathogen indicator organism. This study was able to reveal that low charge density polyacrylamide (PAM) is effective for manure coagulation and flocculation but has a negligible effect on pathogen reduction in both nutrient rich and deficient conditions. This study also demonstrated that high charge density polydicyandiamide (PDCD) was not effective at coagulating dairy manure at its typical solids content, but had a positive impact on pathogen reduction. Moreover, it could further reduce the manure solids content in the low solids portion of manure after PAM separation. PDCD has potential as a new additive to a subsequent separation step of manure treatment, depending on the requirement and needs of the farm.

Energy production from manure fiber

Post-biogas digestion manure fibers are known to be highly recalcitrant to enzymatic digestion. Therefore we have looked at two different avenues to improve conversion of the remaining carbohydrates to ethanol. The completed studies did show improved digestion of fibers with this treatment; however the cost was too high for economic production of ethanol. Recycling of the pretreatment chemicals was considered and would reduce the manufacturing cost of finished product in the large scale production of biofuels but is economical infeasible at the smaller farm scale.

Biodiesel production

We have initiated an investigation into use of clarification polymers to improve biodiesel clarity and quality. Several cold press oils were obtained (Canola, Soy, Camelina) and crude corn oil. Preliminary experiments have been conducted to identify dosage and polymer type that are able to most effectively separate fatty acids and glycerol from the biodiesel.

Lifecycle analysis

Numerous samples were taken and analyzed to provide separation of solids and nutrients through Maple Leaf Dairy system. This information has been put into a mass/component balance and will be used as the lifecycle inventory for analyses. The data taken suggest large nutrient losses suggesting significant N losses to the system are occurring through volatization, which are opportunities to improve economic and environmental performance of the system.

OBJECTIVE C: Utilize system analysis to support development of economically, socially and environmentally sustainable solutions for a bio-based economy.

Task 1: Develop system models and data to represent integrated feedstock supply systems, including discrete processes and entire supply logistics.
Task 2. Develop system models and data to assess sustainability of integrated conversion platforms.
Task 3. Develop integrated system models to configure, analyze and optimize bioenergy and biofuel production systems.

[ILLINOIS]

Objective C. Build modeling and systems approaches to support development of sustainable biomass production and conversion to bioenergy and bioproducts (Rausch, Singh)

Biodiesel production from vegetable oils has increased progressively over the past two decades. However, due to the low amounts of oil produced per hectare from temperate oilseed crops (eg, soybean and canola), the opportunities for further increasing biodiesel production are limited. Genetically modified lipid producing sugarcane (lipid cane) possesses potential for producing biodiesel as an alternative feedstock because of sugarcane's higher productivity compared with soybean. Technoeconomic models were developed for biodiesel and ethanol coproduction from lipid cane, assuming 2, 5, 10 and 20% lipid concentrations in the harvested stem (dry mass basis). The models were compared with a conventional soybean biodiesel process model to assess lipid cane's competiveness. In the lipid cane process model, the extracted lipids were used to produce biodiesel by transesterification and the remaining sugar was used to produce ethanol by fermentation. The biodiesel production cost from lipid cane decreased from $0.86 to 0.59/L as the lipid content increased from 2 to 20%; this cost was lower than obtained for soybeans ($1.08/L). The ethanol production costs from lipid cane were between $0.39 and 0.45/L. The internal rate of return (IRR) for the soybean biodiesel process was 15.0% and the IRR for the lipid cane process went from 14.6 to 24.0% as the lipid content increased from 2 to 20%. Because of its high productivity, lipid cane with 20% lipid content can produce 6,700 L of biodiesel from each hectare of land; whereas, soybean can produce approximately 500 L of biodiesel from each hectare of land.

Temperate × tropical maize (TTM) is a maize hybrid (Zea mays L.) which was bred by crossing temperate and tropical parents for sugar and biofuel production. TTM has a prolonged vegetative growth and accumulates soluble sugar in the stalk which provides an opportunity to emulate the sugarcane ethanol industry in Brazil. Soluble sugars (sucrose, glucose and fructose) accumulate in the TTM stalk during maize development and the concentration could increase up to 30% (w/w) of dry material (Chen et al., 2014). Biomass yield of TTM can reach 8.0 tons per acre (dry basis). Technoeconomic models were developed to evaluate the economic feasibility of TTM for ethanol production. In the TTM process models, soluble sugars were extracted and fermented to produce ethanol. Bagasse, a byproduct in the TTM process, was burned to produce steam to generate electricity for the TTM processing plants, with the excess sold to the grid. Process model was built using SuperPro Designer software, which quantifies the processing characteristics, energy requirements, material flows and conversion efficiencies at each step. Ethanol production costs from TTM were between $1.70 and 2.09/gal, depending on the composition of TTM. Ethanol yield from TTM was 345 gallons per acre of land area, when TTM was harvested at R5 growth stage. Sensitivity analyses will be conducted to determine variations of the ethanol production cost with the variables used in the economic analysis.

[INDIANA]
Development of a bio-based concrete sealant (collaborators: Dr. Jason Weiss, Purdue Civil Eng.)

Accomplishments:

Technology for a methyl ester-based sealant for concrete that prevents water/salt ingress has been patented and is in the process of commercialization

Funding: Indiana Soybean Alliance and U.S. Federal Highway Administration

Impacts: Concrete is used extensively for construction, including highways, buildings, and consumer applications (driveways, sidewalks, home foundations, etc.). While concrete is very strong and durable, moisture/salt penetration combined with winter freeze/thaw conditions can dramatically shorten concrete lifetime. Our work has demonstrated a bio-based concrete sealant that has been shown to significantly reduce water and salt ingress into highway concrete surface (roadways, dividers, bridges, etc.), which results in a dramatic decrease in freeze/thaw damage. We have demonstrated that this sealant has significantly improved performance vs. current polymeric sealants at potentially much lower economic expense (as well as being bio-based vs. petro-based). Increased concrete life has been estimated to be between 5 and 30 years (note that this is economically significant as 1 mile of highway costs several million dollars to replace). This technology has been tested on local highways/streets and is currently in the process of being tested at industrial scale.

Publications/Patents:

U.S. Patent 8,962,729 (2015) Soy methyl ester polystyrene blends for use in concrete

Development of Technology to Predict the Cloud Point for Complex mixtures of Fatty Acid Methyl Esters

Our prior work with accurate prediction of the cloud point of long chain fatty acid methyl esters has been patented. A computational program is available for accurate calculation of the cloud point of complex mixtures of C12-C18 fatty acid methyl esters.

Accomplishments:

Developed accurate method to predict the cloud point of fatty acid methyl ester mixtures (biodiesel) using fundamental principles of molecular structure and interactions.

[IOWA]

Objective C: Task 3

Use technoeconomic evaluation to evaluate the economic feasibility of bio- conversion processes: By using a spread-sheet based model with multiple scenarios, the relationship between number of unit operations and total overall product cost was discerned under various assumptions.

[KANSAS]

C. Identify, develop, and evaluate sustainable processes to convert biomass resources into biochemicals, biocatalysts, and biomaterials (non-fuel uses)

KSU continue developing biochemicals for resin applications, particularly for adhesives and coatings. During the past year, KSU (PI) conducted research on making oilseed camelina a cost-effective bioenergy and biobased product feedstock in collaborated with Montana State University, University of Wyoming, and industries. The major accomplishments include: 1) continued crop rotation studies, camelina variety and fertility trails evaluation, and on-farm demonstration; 2) developed procedures for isolation of camelina protein and protein fractions, isolation and characterization of gums from camelina; camelina protein based adhesives, optimized camelina oil epoxidation, synthesized acrylic polyols from camelina oils, and developed novel bio-based coating materials; 3) defining cost effective pilot-scale bioprocessing capability for isolation of protein and protein fractions; and 4) conducted life cycle and economic analysis of camelina feedstock from agronomic production through to bioenergy and processed bioproducts.

[MICHIGAN]

Task 1. Supply systems
Bruce Dale group has studied the impact of farmgate pricing on biofuel feedstocks. Most economic models consider low farmgate prices, which will have a negative impact on farmer participation. The revised premise is that the final ethanol market price will dictate market penetration. At $40/dry ton 4.5 billion gallons of ethanol are projected from 43 biorefineries, and impacting constituencies for approximately 20% of the US senators and representatives. Doubling the farmgate price to $80/dry ton is projected to increase ethanol production by almost a factor of 10 to 42.1 billion gallons of ethanol from 207 biorefineries, impacting constituencies for approximately 75% of the US senators and representatives. The weighted selling price at $40/dry ton is $2.18/gal, and when double to $80/dry ton the selling price is $2.46/gal. For feedstock prices below $60/ton, each $1/dry ton increase in feedstock prices will generate 5700 FTEs. Above $65/ton, each $1/dry ton increase will generate about 1400 FTEs. Jobs are considered in all aspects of production from growing, plant construction and operations, and fuel marketing and distribution.

OBJECTIVE D: Identify and develop needed educational, extension and outreach resources to promote the transition to a bio-based economy.

Task 1: Serve as a knowledge resource base for bio-based economy.
Task 2: Develop and market programs.
Task 3: Develop and disseminate educational materials in high-priority topic areas.

[ALABAMA] The Alabama station is currently participating in three federally funded projects that involves training of undergraduate and graduate students for the biobased economy as follows: (a) NSF/IGERT ; (b) NSF/REU – Biofuels and bioproducts from lignocellulosic biomass, and (c) SEED fellow program for undergraduate students – a part of the USDA-NIFA IBSS (Southeastern Partnership for Integrated Biomass Supply System). Twelve Ph.D. and 55 undergraduate students are currently or have participated in these programs. Several undergraduate and graduate (M.S. and Ph.D. students) are also involved in the biomass and bioenergy programs at Auburn University. Other trained workforce activities include development and delivery of undergraduate and graduate courses, the development of procurement specialist course through the extension system, and hosting K-12 summer camp (for females, and for minority students).

[HAWAII] Dr. Khanal has been teaching bioenergy course to upper level undergraduate students. We have also contributed course materials for the BEEMS project led by Dr. Yebo Li of Ohio State University. Dr. Khanal and Dr. Yebo Li recently completed Bioenergy Textbook entitled "Bioenergy: Principles and Applications for release in fall 2015.

[ILLINOIS]

In February 2015, two short courses were taught: one on corn wet milling and one on fuel ethanol production technology. In addition, the 9th International Starch Technology Conference was held. Each short course was taught by eight experts: four faculty, two USDA-ARS scientists and two speakers from industry. Thirty participants from wet milling, dry grind ethanol and allied industries participated in the course. By offering the courses and conference together in a single week, participation by the industry was increased. These were designed as an outreach activity to members of the starch and biofuels industries.

[INDIANA]
Task 2 Distribute new knowledge to train workforce and general public
Student Product Development Contest

Accomplishments: Administered student entrepreneurship contest based on using soy and corn based materials to create novel products and applications
Publications: various news media articles
Funding: Indiana Soybean Alliance and Indiana Corn Marketing Committee
Impacts: Teaching students from multiple disciplines about entrepreneurship and product development using bio-based materials. Creation of potential commercial products/applications in a variety of industries/markets.

[OHIO]

Task 3: Develop and disseminate educational materials in high-priority topic areas.

Collaborating with peers from other states, we have developed a bioenergy textbook containing 28 chapters which will be published by Wiley in the fall of 2015.

[MINNESOTA]
Biobased economy is a relatively new field, and therefore has high demand for human resources. Our project has trained many students and junior researchers who either took on industry or academic jobs that require knowledge of renewable energy technology. Many of our findings have found their way in classroom teaching. Our thermochemical conversion and algae research activities have resulted in pilot scale facilities for demonstration to stakeholders.

[NEW JERSEY]
Qing Li: Post doc working on biomass to chemicals. Analysis resulted in a working paper we plan on submitting to a journal.
Shishi Wang: Completed a thesis on the economics of four waste-to-energy technologies. Her work was presented at the Cornell Dairy Environmental Systems and Climate Adaptations Conference, will be published in the conference proceedings, and was submitted to a journal

Mook Bangalore: His work led to a paper submitted to a journal.

Work on the political economy of biofuel policy was presented at the 8th Berkeley Bio-Economy Conference and led to a working paper (jointly with Dr. David Zilberman) and should be submitted to a journal in the fall.

[NORTH DAKOTA]
Task 2: Distribute new knowledge to train the work force and general public in biobased products and processing.
A series of five educational videos were written and filmed to answer basic questions and technoeconomic goals and challenges for biomass resources and biobased fuels. Videos are aimed at undergraduate students and for use as outreach in secondary schools or with Extension agents.

A technical workshop and demonstration on “Flood Affected Woody Biomass Utilization” was conducted (May 18, 2015) at NGPRL, USDA-ARS, Mandan, ND arranged by Agricultural and Biosystems Engineering, NDSU. The educational material developed addressed woody biomass status in ND, characteristics of feedstocks, high value (e.g., lumber, pellet) and low value (e.g., firewood, mulch, chips, shaving, sawdust, etc.) products production, and economic analysis of high and low value products. Presentations were made in the workshop and a local wood processor gave demonstration on lumber and wood chips production to the participants.

[OREGON]
Task 3.
Dr. Ganti Murthy presented a short course on Biofuels technologies in Addis Ababa University, Addis Ababa, Ethiopia in July, 2014. Two students in Bioenergy minor program were mentored for conducting their honors thesis research.

[SOUTH CAROLINA]
Training opportunities include use of pilot biodiesel, gasification and compost for training students and personnel to an experiment directly with university waste streams for bioenergy use.

[WEST VIRGINIA]

Activity 1: Graduate and Undergraduate Education (Singh)

The course WDSC 444: Biobased Energy Systems is being offered since Fall 2014 semester. In addition, a graduate level course WDSC-644 on Advanced Bio-based Energy Systems and an online web-based WDSC-104 Bioenergy has been proposed. In addition, Dr. Singh also teaches WDSC 100: Forest Resources in U.S. History (in class as well as web-based), which is a freshmen course.

Activity 2: Extension of Technology to Small Businesses (Singh and Sivanandan)

Drs. Singh and Sivanandan are engaging small food business owners to motivate them for transforming their waste for value added products through extension presentations and workshops.

[WISCONSIN]

Development of an Affordable Bioenergy and Bioproducts Laboratory-based Education
Funding: USDA / Higher Education
Collaborators: UW Platteville, UW Stevens Point
Objectives: Development and on-line distribution of bioenergy laboratory curricular material

Our project funded by a USDA Higher Educational Challenge grant increased the amount of educational material by developing twelve bioenergy lab activities and providing the resources on-line. The materials were designed to be either used to augment existing classes or as a stand-alone bioenergy lab class. All of the labs were designed to be low cost experimental investigation to maximize the number of students that can participate and their involvement in the activity. Educational material was developed including handouts and a video overview at https://energy.wisc.edu/education/classroom-materials

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Thesis and Dissertation (2014-2015):

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2. Lu, Yongwu. 2014. Catalytic conversion of syngas to higher alcohols over Cu-Fe based catalysts. Ph.D. Dissertation submitted to Mississippi State University.
3. Waste to energy: The case study of New Jersey
4. Deepak Kumar. 2014. Biochemical conversion of lignocellulosic biomass to ethanol: Experimental, enzymatic hydrolysis modeling, techno-economic and life cycle assessment studies. PhD Dissertation. Biological and Ecological Engineering. Oregon State University.
5. Abraham Mebrat. 2014. Investigation the potential of the microalgae consortium for algal biomass productivity, carbon sequestration and nutrient recovery from dairy manure. Addis Ababa University, Addis Ababa, Ethiopia.
6. Ankita Juneja. 2015. Model predictive control for optimum algal growth. PhD Dissertation. Biological and Ecological Engineering. Oregon State University.
7. Crystal Oldfield. 2015. Impact of lignin composition on enzymatic hydrolysis of cellulosic biomass. BS Honors Thesis. Bioresource Research. Oregon State University.
8. Shu Jiang 2014 Selective oxidation of biological matrixes for subsequent peroxidase and peroxidase-based quantitative analyses MS Dissertation. Food Science and Technology. Oregon State University
9. Tai, C. Towards Fed-batch Enzymatic Hydrolysis of Lignocellulosic Biomass for Bioethanol Production (2015) University of Nebraska-Lincoln.
10. Jacob Collins, Thesis Title: Thermal decomposition and gasification of carbohydrates, lipids, proteins and food wastes, Degree: MS, Graduation: May, 2015 from Oklahoma State University
11. Kezhen Qian, Thesis Title: Properties of gasification-derived char and its utilization for catalytic tar reforming, Degree: PhD, Graduation: May, 2015 from Oklahoma State University
12. Ram Isakki, Thesis Title: Reinforcement of polylactic acid using pyrene functionalized multi-walled carbon nanotubes. Degree: MS, Graduation: Aug, 2015 from Oklahoma State University
13. Sibo Cheng M.S. Bioproducts and Biosystems Engineering. June, 2015 Thesis: Techno-economic analysis of algae cultivation in wastewater.
14. Nonso A. Onuma M.S. Food Science and Nutrition. May, 2015 Thesis: Investigation of treatment effects on biodiesel production from sludge from municipal wastewater treatment plants
15. Monono, E., Pilot Scale Production, Characterization, and Optimization of Epoxidized Vegetable Oil-Based Resins, North Dakota State University, Fargo, 2015.
16. Vargas-Ramirez, J., Technical and Economic Assessments of Storage Techniques for Long-Term Retention of Industrial-Beet Sugar for Non-Food Industrial Fermentations, North Dakota State University, Fargo, 2015.

17. Zhouyang Xiang (PhD in BSE, May 2015) Thesis title: Valorizing Distiller's Grains to Improve Corn Ethanol Profitability and Sustainability.
18. Shengfei Zhou (PhD in BSE, May 2015) Thesis area: Ethanol Production Using Ambient-temperature Acid Pretreatment.
19. Zong Liu (PhD in BSE, February 2015) Thesis title: Dairy Manure Treatment and Analysis with Focuses on Pathogen Reduction and Protein Analysis.
20. PhD thesis: Kala Rajan Characterization of Cellulase Enzyme Inhibitors Formed During the Chemical Pretreatments of Rice Straw, April 2015, University of Arkansas
21. Jackson, Joshua. 2015. Optimal uses of biomass resources in distributed applications. Doctoral Dissertation. University of Kentucky.
22. Koeninger, Nicole. 2015. Determination of Soil Erosion with Varying Corn Stover Cover Factors. Master of Science thesis. University of Kentucky. 1/28/15
23. Hagan, Michael. 2015. Life Cycle Assessment of Biomass Harvesting for On-Farm Biofuel Production. Master of Science thesis. University of Kenucky. 5/1/15
24. Rodrigues, Carla Ines Soares. 2015. Evaluation of Different Sources of Hydroxyl on Biomass Pretreatment and Hydrolysis. Master of Science thesis. University of Kentucky. 2/19/15
25. Carey, Bobby D. 2014. Field Implementation of *Phanerochaete chrysosporium* Biomass Pretreatment: Fungal Identification and Inoculation Techniques. Master of Science thesis. University of Kentucy. 12/4/14
26. Hickman, Amanda. 2015. Effects of Inoculum Size, Airflow Rate, Bulk Density, and Particle size on the Scale-up of *Phanerochaete chrysosporium* pretreatment. Master of Science Thesis. University of Kentucky. 2/19/15.
27. Elia, Noelia M. 2014. Sequential co-culture of anaerobic bacteria on switchgrass in a continuous flow-through reactor for biofuel production. University of Kentucky.
28. Avanti Kukarni: Ph.D. Biosystems Engineering 2014. Biomass Gasification for Fuel and Power Application Using a Bench-Scale Bubbling Fluidized Bed Gasifier.
29. Ravishankar Mahadevan: M.S. Biosystems Engineering 2014. Experimental Study of Biomass Pyrolysis in a Fluidized Bed Reactor: Effect of Biomass Blending and In-situ Catalysis.
30. Sneha Nuepane: M.S. Biosystems Engineering 2014. Effect of Torrefaction on Biomass Structure and Product Distribution from Fast Pyrolysis.
31. Rajdeep Shakya: M.S. Biosystems Engineering 2014. Hydrothermal Liquefaction of Algae for Bio-oil Production.
32. Gbenga Olatunde: Ph.D. Biosystems Engineering (Major Professor) 2015. Fundamental Studies of Biomass Fluidization.
33. Ujjain Pradhan: M.S. Biosystems Engineering (Co-Major Professor) 2015. Physical treatments for reducing biomass ash and effect of ash content on pyrolysis products.
34. Oluwafemi Oyedeji: M.S. Biosystems Engineering (Major Professor) 2015. Moisture and Storage Time Effects on Grinding Characteristics of Loblolly Pine Woodchips.
35. Sergio Baravalle. 2015. "Rethinking Equality: A new concept for the redistribution of natural resources and sustainable development based on renewable energies," MS Thesis, Washington State University, Richland, Washington, April.
36. Aaron King, "Oleaginous fungi as a source of triacylglycerides for biodiesel production." M.S. Thesis, Department of Molecular Biosciences and Bioengineering, University of Hawaii at Manoa (Spring 2014).

37. Whitney Ray, “Greenhouse gas emission balance of biofuel feedstock for potential carbon trading.” M.S. Thesis, Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, (Fall 2014).
38. Sumil Thapa, “Anaerobic digestion of food waste.” M.S. Thesis, Department of Molecular Biosciences and Bioengineering, University of Hawaii at Manoa (Fall 2013).
39. Luigi Antonio Poggi. 2014. Ex-Situ upgrading of biomass pyrolysis vapors: Catalytic activity of switchgrass bio-char derived catalysts. M. S. Thesis, Laurea Magistrale in Ingegneria Energetica, Università degli Studi di Roma Tor Vergata
40. Challa, Ravi K., Ph.D., 2015. Characteristics of heat transfer fouling of thin stillage using model thin stillage and evaporator concentrates. PhD thesis. University of Illinois at Urbana-Champaign.
41. Chen, M.-H. 2015. Autohydrolysis of Miscanthus X giganteus for the production of xylooligosaccharides. PhD thesis. University of Illinois at Urbana-Champaign.
42. Amanda Hildebrand, A biochemicxal route for fuels and chemicals production from cellulosic biomass, Ph.D. thesis University of California , Davis. Advisor: Zhiliang Fan
43. Higgins, B. 2014. Co-culturing green algae with bacteria for enhanced growth and production of biofuel precursors. University of California, Davis. Advisor: J. VanderGheynst.
44. Natthiporn Aramrueang, 2014. Development of Optimal Enzymatic and Microbial Conversion Systems for Biofuel Production. PhD Dissertation. Univerisity of California, Davis. Advisor: Ruihong Zhang
45. Liston, Leah C. M.S., Purdue University, May 2015. Using Mixtures of Fatty Acid Methyl Esters as Phase Change Materials for Concrete.
46. Yixing Zhang. 2015. Optically pure D (-) lactic acid biosynthesis from diverse renewable biomass: microbial strain development and bioprocess analysis. PhD Dissertation. Kansas State University
47. Jonathan Wilson. 2015. Fermentation of dried distillers grains with solubles: scalability and physical properties analysis. PhD Dissertation. Kansas State University
48. Yanguang Liu. 2015. Extraction of value-added chemicals from biorefinery residues. MS Thesis. Kansas State University
49. Yadhu Guragain. 2015. Sustainable bioprocessing of various biomass feedstocks: 2,3 butanediol production using novel pretreatment and fermentation. PhD Dissertation. Kansas State University
50. Min Jung Kim. 2015. Physicochemal and adhesion properties of soy protein based adhesives. PhD Dissertation. Kansas State University
51. Coban, H.B. 2014. Conversion of amino Acids to their specific alpha-keto acids by microbial fermentation. Ph.D. Dissertation, Agricultural and Biological Engineering, Pennsylvania State University, Univeristy Park, PA.
52. Camargo, G. 2015. Water and Light Competition in Mixed Plant Communities. Ph.D. Dissertation, Agricultural and Biological Engineering, Pennsylvania State University, University Park, PA.
53. Pandey, J. 2015. Investigation of Lignin Interactions and Deposition in Plant Cell Walls. Ph.D. Dissertation, Agricultural and Biological Engineering, Pennsylvania State University, University Park, PA.

54. Kapp, N. 2014. Investigating Spatio-temporal Patterns of Lignification in Flowering-time Variants of the Model Grass Brachypodium distachyon. M.S. Thesis. Plant Biology, Pennsylvania State University, University Park, PA.
55. Xiong, B. 2014. The Development of Carboxylic Acid Separation by Nanofiltration Membrane for Carboxylate Platform Using Lignocellulosic Biomass. M.S. Thesis. Agricultural and Biological Engineering, Pennsylvania State University, University Park, PA.
56. Lewis, R. 2014. Effect of Storage Conditions on the Dry Matter, Composition, and Respiration Concentrations of Willow Chips. M.S. Thesis. Agricultural and Biological Engineering, Pennsylvania State University, University Park, PA.
57. Iman Farasat. 2015. Ph.D. Chemical Engineering. "Systematic optimization of metabolic pathways and genetic circuits using next-generation biophysical models and design algorithms", Pennsylvania State University, Univeristy Park, PA.

Patents and Invention Disclosures (2014-2015):

1. Provisional Patent: A multi-scale control framework for sustainable management of engineered algae production systems. Office for Commercialization and Corporate Development, Oregon State University. US Provisional Patent No: 62/190642. Filed 9th July, 2015. Inventors: Ganti S. Murthy and Ankita Juneja.

2. U. S. Patent 9,026,421 (2015) Method of Modeling Cloud Point of a mixture of Fatty Acid Methyl Esters using a Modified UNIFAC Model and a System Therefore.

Book Chapters (2014-2015):

1. Bioenergy Textbook. Springer. Eds. Y. Li and S. Khanal. (Expected in Fall 2015)
2. Murthy, G.S. 2015. Techno-economic assessment. In book: Bioenergy: Principles and Applications. Eds. Li, Y. and Khanal, S.K. (Invited and peer reviewed book chapter).
3. Murthy, G.S. 2015. Life cycle assessment. In book: Bioenergy: Principles and Applications. Eds. Li, Y. and Khanal, S.K.
4. Kumar, D. and Murthy, G.S. 2015. Enzymatic hydrolysis of cellulose for ethanol production: fundamentals, optimal enzyme ratio, and hydrolysis modeling in book: Microbial Cellulase Systems. Ed. Gupta, V.
5. Challa, R., Johnston, D.B., Singh, V., Tumbleson, M.E. and Rausch, K.D. 2014. Fouling rates of model carbohydrate mixtures and their interaction effects. In: Proc. Fouling and Cleaning in Food Processing: Green Cleaning (Wilson, D.I. and Chew, Y.M.J., eds.) pp. 12-19. Univ. Cambridge, UK.
6. Chen, C., and M. Berti. Oilseed-based Feedstock. 2015. In Li and Khanal (ed.) Bioenergy Textbook. Springer (in press).
7. Ercan, D., Demirci, A., and A. L. Pometto III. 2015. Applications of biofilm reactors for production of value-added products by microbial fermentation. In Biofilms in the Food Environment. 2nd edition. Pometto III. A. L. and Demirci, A., Eds. Wiley-Blackwell Publishing, Chichester, West Sussex, UK.

8. Richard, T.L. and H. El-Lakany. 2015. Bioenergy and Food Security. Pages. 462-483 in: Bioenergy and Sustainability: Bridging the Gaps. G.M. Souza, R.L. Victoria, C.A Joly, and L.M. Verdade (eds.). Scientific Committee on Problems in the Environment (SCOPE) – FAPESP – BIOEN – BIOTA+10 – FAPESP Climate Change, Sao Paulo, Brazil.
9. Diaz-Chavez, R., F.X. Johnson, T.L. Richard and H. Chanakya. 2015. Biomass Resources, Energy Access and Poverty Reduction. Pages 704-725 in: Bioenergy and Sustainability: Bridging the Gaps. G.M. Souza, R.L. Victoria, C.A Joly, and L.M. Verdade (eds.). Scientific Committee on Problems in the Environment (SCOPE) – FAPESP – BIOEN – BIOTA+10 – FAPESP Climate Change, Sao Paulo, Brazil.
10. Foust, T.D., D. Arent, I. de Carvelho Macedo, J. Goldemberg, C. Hoysala, R.M. Filho, F.E.B. Nigro, T.L. Richard, J.N. Saddler, J. Samseth, and C.R. Somerville. 2015. Energy Security. Pages 58-87 in: Bioenergy and Sustainability: Bridging the Gaps. G.M. Souza, R.L. Victoria, C.A Joly, and L.M. Verdade (eds.). Scientific Committee on Problems in the Environment (SCOPE) – FAPESP – BIOEN – BIOTA+10 – FAPESP Climate Change, Sao Paulo, Brazil.
11. Souza, G.M., R.L. Victoria, L.M. Verdade, C.A. Joly, P.E.A. Netto, C.H. de Brito Cruz, H. Cantarella, H.L. Chum, L.A.B. Cortez, R. Diaz-Chavez, E. Fernandes, G.B. Fincher, J. Goldemberg, L.A.H. Nogueira, B.J. Huntley, F.X. Johnson, S. Kaffka, A. Karp, M.R.L.V. Leal, S. P. Long, L.R. Lynd, I. de Carvelho Macedo, R.M. Filho, A.M. Nassar, F.E.B. Nigro, P. Osseweijer, T.L. Richard, J.N. Saddler, J. Samseth, V. Seebaluck, C.R. Somerville, L. van der Wielen, M.-A. Van Sluys, J. Woods, and H. Youngs. 2015. SCOPE Bioenergy and Sustainability. Pages 5-24 in: Bioenergy and Sustainability: Bridging the Gaps. G.M. Souza, R.L. Victoria, C.A Joly, and L.M. Verdade (eds.). Scientific Committee on Problems in the Environment (SCOPE) – FAPESP – BIOEN – BIOTA+10 – FAPESP Climate Change, Sao Paulo, Brazil.
12. Souza, G.M., R.L. Victoria, L.M. Verdade, C.A. Joly, P.E.A. Netto, H. Cantarella, H.L. Chum, L.A.B. Cortez, R. Diaz-Chavez, E. Fernandes, G.B. Fincher, J. Goldemberg, L.A.H. Nogueira, B.J. Huntley, F.X. Johnson, A. Karp, M.R.L.V. Leal, L.R. Lynd, I. de Carvelho Macedo, R.M. Filho, M.P. Massafera, A.M. Nassar, F.E.B. Nigro, P. Osseweijer, T.L. Richard, J.N. Saddler, J. Samseth, V. Seebaluck, C.R. Somerville, L. van der Wielen, M.-A. Van Sluys, J. Woods, and H. Youngs. 2015. Bioenergy Numbers. Pages 26-54 in: Bioenergy and Sustainability: Bridging the Gaps. G.M. Souza, R.L. Victoria, C.A Joly, and L.M. Verdade (eds.). Scientific Committee on Problems in the Environment (SCOPE) – FAPESP – BIOEN – BIOTA+10 – FAPESP Climate Change, Sao Paulo, Brazil.
13. Tanjore, D. and T.L. Richard. 2015. A Systems View of Lignocellulose Hydrolysis. In: Advances in Bioprocess Technology. R. Pogaku (ed.). Springer International Publishing, Zug, Switzerland.

Presentations (2014-2015):

1. Title of Presentation: Fermentation Basics for Biofuel Production

Title of Training/Workshop: 1st Annual Practical Short Course on "Fermentation and Separation for the Food and Drug Industries", A Practical, "Hands-On" Fermentation and Separation Workshop.

Sponsor/Organizer: Food Protein Research and Development Center, TEES Date: February 2-4, 2014 Venue: Texas A&M Institute for Preclinical Studies

2. Title: Post Harvest Loss Management Training for the Third World

Title of Training: Norman Borlaug Fellowship Funding: USDA through Borlaug Institute for International Agriculture Duration: 12 weeks Date: August 15-November 15, 2014 Venue: BAEN Research Labs Fellow Trained: Augustus Ninfaa (Ghana)

3. Mariano Marcos State University (MMSU), Philippines. July 3 and 4, 2014. "Output-Based Educational Techniques" and "Development of Comprehensive Biomass Thermal Conversion Research"
4. The University of the Philippines at Los Baños (UPLB), Philippines. June 18, 2014. Lecture on "Design of Thermal Conversion Systems".
5. Brune, D. E., Bioprocessing of Microbial Biomass Enabling Sustainable Marine Shrimp Production, Aquaculture America, 2014, Seattle WA, Feb 2014.
6. Brune, D. E., Sustainable Marine Shrimp Production in the United States, Aquaculture America 2014, Seattle WA, Feb 2014.
7. Brune, D. E., Environmentally friendly, zero-discharge seafood production in the Midwestern United States: Cost and energy analysis, 2014 National Extension Energy and Environment conference, Ames Iowa, Sept 2014.
8. Brune, D. E, Zero Discharge Aquaculture, Mizzou Advantage & the Chancellor's Distinguished Speakers Program Water Challenges and Opportunities; A symposium in celebration of 50th Anniversary of Missouri Water Resources Research Center, October 7-8, 2014.
9. Brune, D.E., Lincoln University-Cooperative Research/Extension Seminar Series, Sustainable Salt Water Shrimp Culture, System, Jan 2014
10. Bao, Z., Lu, Y., Yan, Q., Street, J., Li, Y., and Yu. F. 2015. Methane dry reforming with carbon dioxide via Ni-based bimodal catalyst. 2015 American Society of Agricultural and Biological Engineers Annual Meeting. New Orleans, LA. July 26-29, 2015. Oral Presentation.
11. Yan, Q., Street, J., To, F., Li, Y., and Yu. F. 2015. Liquid hydrocarbons from biogas via reforming, syngas cleaning and catalytic conversion. 2015 American Society of Agricultural and Biological Engineers Annual Meeting. New Orleans, LA. July 26-29, 2015. Oral Presentation.
12. Yu, F. and Lu. Y. 2015. Higher alcohol synthesis over Three-dimensionally ordered macroporous Cu-Fe catalysts. 15th National Youth Conference on Catalysis of China (15thNYCC). Hefei, China. July 19-23. Oral Presentation.
13. Yu, F. and Bao. Z. 20.15. The development of Ni-based bimodal catalyst for methane reforming with carbon dioxide. 15th National Youth Conference on Catalysis of China (15thNYCC). Hefei, China. July 19-23. Poster Presentation.
14. Bao, Z., Lu, Y., Yan, Q., Li, Y., and Yu. F. 2015. The development of Ni-based bimodal catalyst for methane reforming with carbon dioxide. 24th North American Catalysis Society Meeting. Pittsburgh, PA. June 14-19, 2015. Poster Presentation.

15. Lu, Y., Yu. F., Bao, Z., Tao, F., Shan, J., Wu, T., and Halder. G. 2015. In situ AP-XPS, EXAFS/XANES, synchrotron powder diffraction studies of three-dimensionally ordered macroporous Cu-Fe catalyst for higher alcohols synthesis from syngas. 24th North American Catalysis Society Meeting. Pittsburgh, PA. June 14-19, 2015. Poster Presentation.
16. Yu, F. 2015. Integrated gasification syngas conditioning and catalytic conversion process for biomass to wide-cut diesel production. 2015 International Conference on Energy and Environmental Systems Engineering (EESE2015) Beijing, China. May 17-18, 2015. Poster Presentation.
17. Yu, F. 2014. Syngas to Alcohols and Hydrocarbons. 2014 ATLAS seminar to ExxonMobil Chemical Co. Baytown, TX. November 3, 2014. Oral Presentation.
18. Bao, Z., Lu, Y., and Yu, F. 2014. The activity and stability of dry reforming of methane over Ni-based Catalysts. 2014 AIChE Annual Meeting. Atlanta, GA. November 16-21, 2014. Poster Presentation.
19. Lu, Y., Yu, F., Shan, J., and Tao, F. 2014. In situ Surface Chemistries and Catalytic Performances of Three-dimensionally Ordered Macroporous Cu-Fe Catalysts for Higher Alcohols Synthesis from Syngas. 2014 AIChE Annual Meeting. Atlanta, GA. November 16-21, 2014. Oral Presentation.
20. Cornell Dairy Environmental Systems and Climate Adaptations Conference The 8th Berkeley Bio-Economy Conference
21. Murthy, G.S. and Tabatabaie, S.M.H. 2015. Effect of climate on environmental impacts of camelina biofuel production. Proceedings of 49th Annual Convention of Indian Society of Agricultural Engineers (ISAE). Ludhiana, India.
22. Murthy, G.S. and Kumar, D. 2015. Optimization of enzyme mixture and dosage profile during cellulose degradation for bioethanol production. Proceedings of 49th Annual Convention of Indian Society of Agricultural Engineers (ISAE). Ludhiana, India.
23. Arbuckle, P., Kahn, E., Loneman,A., McCarthy, S., Tabatabaie, S.M.H. and Murthy, G.S. 2014. Unit process data collection for specialty crop production. Proceedings of 9th international conference on life cycle assessment in the Agri-Food sector (LCA Food 2014). San Francisco, CA.
24. McDanial, A. and Murthy, G.S. 2014. Development of an life cycle impact assessment method based on GBEP indicators. S1041-The science and engineering for a biobased industry. New Orleans, LA.
25. Tabatabaie, S.M.H. and Murthy, G.S. 2014. Life cycle assessment of biodiesel production from canola and camelina in the Pacific Northwest. S1041-The science and engineering for a biobased industry. New Orleans, LA.
26. Tabatabaie, S.M.H. and Murthy, G.S. 2015. Effect of weather and geographical location on the environmental impacts of camelina. ASABE Abstract No.152188884. ASABE, St. MI.
27. Tabatabaie, S.M.H. and Murthy, G.S. 2015. Developing life cycle inventory data for science-based strawberry production sustainability metrics. ASABE Abstract No. 152188895. ASABE, St. MI.
28. Kumar, D. and Murthy, G.S. 2015. Hydrolysis of microcrystalline cellulose by cellobiohydrolase I and cellobiohydrolase II from Trichoderma reesei. ASABE Abstract No. 152190084. ASABE, St. MI.
29. Kumar, D. and Murthy, G.S. 2015. Development and validation of a kinetic model for enzymatic hydrolysis of cellulose. ASABE Abstract No. 152190067. ASABE, St. MI.

30. McDaniel, A. and Murthy, G.S. 2015. Evaluation of environmental impacts of biofuels from sugarcane and napier grass produced in Hawaii. ASABE Abstract No. 152188615. ASABE, St. MI.
31. McDaniel, A. and Murthy, G.S. 2015. A consequential life cycle assessment of advanced biofuel production in Hawaii. ASABE Abstract No. 152188621. ASABE, St. MI.
32. Oldfield, C. and Murthy, G.S. 2015. The effect of lignin S/G ratios on enzymatic hydrolysis and surface area of lignin droplets formed during dilute acid pretreatment. ASABE Abstract No. 152188796. ASABE, St. MI.
33. Xu, L., White, S. and Murthy, G.S. 2015. Nitrogen and phosphorus uptake kinetics by
34. Chlorella vulgaris grown in treated land fill leachate. ASABE Abstract No. 152189558.ASABE, St. MI.
35. Jiang, S. and Penner, M.H. 2014 Peroxidase-based hydrogen peroxide assays in biological systems. Am. Chem. Soc. Annual Meeting, Fall 2014, San Francisco
36. Tai, C. and Keshwani D.R. 2015. Epidemic model based optimal control strategy for fed-batch enzymatic hydrolysis of lignocellulosic biomass. 2015 ASABE Annual International Meeting. July 2015, New Orleans, LA.
37. Emanuel, E., Keshwani, D.R., and Tai, C. 2015. Enzyme adsorption and cellulose conversion during hydrolysis of alkali-pretreated corn stover. 2015 ASABE Annual International Meeting. July 2015, New Orleans, LA.
38. Liu, K., H. K. Atiyeh, O. P. Planas, T. Ezeji, V. Ujor, J. Overton, K. Berning, M. Wilkins and R. S. Tanner, “Production of Butanol from Switchgrass with and without Detoxification”, 2015 ASABE Annual International Meeting, New Orleans, LA, Jul 26-29, 2015. Oral.
39. Phillips, J.R., H. K. Atiyeh and R. L. Huhnke, “Enhanced Mass Transfer in Gas Fermentation Reactors”, 2015 ASABE Annual International Meeting, New Orleans, LA, Jul 26-29, 2015. Oral.
40. Overton, J. and H. K. Atiyeh, “Production of Butanol from Switchgrass using a Novel Detoxification Process”, 2015 ASABE Annual International Meeting- KK Barnes Student Paper Competition, New Orleans, LA, Jul 26-29, 2015. Oral.
41. Atiyeh, H. K., J. R. Phillips and R. L. Huhnke, “Process Control for Enhanced Ethanol Production Using Syngas Fermentation”, Bioenergy 2015: Opportunities in a Changing Energy Landscape, Walter E. Washington Convention Center, Washington, D.C., USA, June 23-24, 2015. Poster.
42. Devarapalli, M., H. K. Atiyeh, J. R. Phillips, R. S. Lewis and R. L. Huhnke, “Continuous Production of Ethanol from Syngas in a Trickle Bed Reactor by Clostridium ragsdalei”, AIChE’s 2014 Annual Meeting, Atlanta, GA, November 16-21, 2014, Oral.
43. Phillips, J. R., H. K. Atiyeh and R. L. Huhnke, “Enhanced Mass Transfer in Syngas Fermentation”, AIChE’s 2014 Annual Meeting, Atlanta, GA, November 16-21, 2014, Oral.
44. Liu, K., H. K. Atiyeh, O. P. Planas, K. D. Ramachandriya, M. R. Wilkins, T. C. Ezeji, V. Ujor and R. S. Tanner, “Butanol Production from Eastern Redcedar”, AIChE’s 2014 Annual Meeting, Atlanta, GA, November 16-21, 2014, Poster.
45. Lewis, R. S., J. J. Orgill, H. K. Atiyeh and M. Devarapalli, “Syngas Fermentation of Clostridium ragsdalei P11 in a Hollow Fiber Reactor”, AIChE’s 2014 Annual Meeting, Atlanta, GA, November 16-21, 2014, Oral.
46. Isakki, R., A. Kumar, S. Krishnan; S. Harimkar. Reinforcement of Polylactic Acid (PLA) using Multi – Walled Carbon Nanotubes (MWNT). ASABE International Meeting, July 26 – 29, 2015, New Orleans, Louisiana. Poster presentation.

47. Bhoi, P., A. Kumar, R. Huhnke. Comparative performance of internal combustion engine using biomass producer gas and natural gas as fuels. ASABE International Meeting, July 26 – 29, 2015, New Orleans, Louisiana. Oral presentation.
48. Yang, Z., A. Kumar, R. L. Huhnke, M. Buser, S. Capareda. Fast Pyrolysis of Eastern Red Cedar Sapwood and Heartwood in Various Reactors. ASABE International Meeting, July 26 – 29, 2015, New Orleans, Louisiana. Oral presentation.
49. Reforming of lignin-derived tars over char supported catalysts. ASABE International Meeting, July 26 – 29, 2015, New Orleans, Louisiana. Oral presentation.
50. Modeling and Gasification of Food Waste and its Major Components. ASABE International Meeting, July 26 – 29, 2015, New Orleans, Louisiana. Poster presentation.
51. Frazier, A. Kumar, E. Jin. Life cycle assessment of biochar verses metal catalysts used in syngas cleaning. ASABE International Meeting, July 26 – 29, 2015, New Orleans, Louisiana. Poster presentation.
52. Ruan, R. 2015. Innovative microwave-assisted fast gasification of biomass and solid wastes for biofuels and biochemicals production. *2015 International Conference for Bioeconomy - Green Biological Manufacturing*. Tianjin, China.
53. Ruan, R. 2015. Innovative rural eco-township-a turly sustainable developmet model. *TIB Distinguished Lecture Series.* Chinese Academy of Sciences. Tianjin, China.
54. R. Ruan, Q. Xie, Y. Cheng, S. Liu, P. Peng, B. Zhang, P. Chen, L. Baker, P. Urriola, G. Shurson. 2015. Energy and chemical extraction from waste organics. *The Future of Organic Wastes in Minnesota Conference*. Continuing Education and Conference Center, Saint Paul, Minnesota.
55. Ruan, R., E. Anderson, M. Addy, Y. Nie, C. Bi, N. Onuma, X. Ma, H. Zheng, P. Chen, D. Li. 2015. Conversion of scum to biodiesel. LCCMR and MCES Demonstration and Site Visit. St. Paul, MN.
56. Ruan, R. 2015. Innovative Thermochemical Conversion Technologies for Waste Utilization and Renewable Energy and Chemicals Production. Track 4. Advanced Biofuels and Biochemicals. *International Biomass Conference & Expo.* Minnespolis Convention Center, Minneapolis, MN.
57. Ruan, R. 2015. Shelf life study of raw and roasted almonds for Chinese market - A report to the Almond Board of California, ABC *Almond Quality & Food Safety Committee Meeting*. Modesto, CA.
58. Ruan, R., P. Chen, Q. Xie, P. Peng, S. Liu, B. Zhang, E. Anderson, Y. Cheng, Y. Liu, K. Muthukumarappan. 2015. Distributed production of DME based fuels using microwave technology and direct catalytic synthesis. *2015 North Central Regional Sun Grant Center Annual Meeting*, Bloomington, MN.
59. Ruan, R., P. Chen, Q. Xie, S. Liu, B. Zhang, P. Peng, E. Anderson, Y. Cheng, Y. Liu, Min Min, Nonso Onuma. 2015. Development of Novel Fast Pyrolysis and Gasification Processes. *2015 North Central Regional Sun Grant Center Annual Meeting*, Bloomington, MN.
60. Ruan, R., M. Min, E. Anderson, P. Chen. 2015. Biorefining scum for energy, metals and nonmetals reduction, and algae growth. Metro Council Environmental Service St. Paul Wastewater Treatment Plant, St. Paul, MN.
61. Ruan, R. 2015. Innovative thermochemical and biological technologies for waste utilization and renewable energy and chemicals production. Taiyuan University of Technology, Shangxi, China.

62. Ruan, R. 2015. Development and application of concentrated electric field technology for non-thermal pasteurization of liquid foods. Emerging Food Technology Workshop, Seoul, South Korea.
63. Ruan, R. 2015. Innovative dynamic high pressure nonthermal extraction and pasteurization technology for bioavailability improvement and safety assurance. Emerging Food Technology Workshop, Seoul, South Korea.
64. Ruan, R. 2015. Development and application of fast microwave assisted gasification technology for biomass utilization. Sinopec Star Petroleum Co., Ltd. Beijing, China
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70. Ruan, R. 2014. Innovative Technologies for Waste Utilization and Renewable Energy and Chemicals Production. College of Environmental Science and Engineering and Tianjin Municipal Solid Waste Resources Technology and Engineering Center, NanKai University. Tianjin, China.
71. Ruan, R. and P. Chen. 2014. Innovative Waste Utilization Technologies. LCCMR Site Visit. St. Paul and Rosemount, MN.
72. Ruan, R. 2014. Innovative Bio-renewable Energy and Chemicals Production Research. MOST International Cooperation Program Planning and Discussion Meeting. Tianjin, China.
73. Ruan, R. 2014. Innovative Technologies for Waste Utilization and Renewable Energy and Chemicals Production. Tianjin Bohai PetroChem Company. Tianjin, China.
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75. Ruan, R. 2014. Improving and Maintaining Bioavailability of Phytochemicals and Solublized Fibers in Plant Materials. 16th Annual Meeting of China Association for Science and Technology. Kunming, China.
76. Ruan, R. 2014. Renewable energy an d biobased economy research and development. Minnesota Bipartisan Issues Group, Minneapolis, MN.
77. Ruan, R. 2014. fMAP and fMAG for brewery byproducts utilization. Luzhou Laojiao Liquor Company, Sichuan, China.
78. Ruan, R. 2014. Fast microwave pyrolysis and gasification technology for solid waste utilization. Fujian Institute of Research on the Structure of Matter, CAS, Fuzhou, China

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85. Cobb, B., and S. W. Pryor, Antioxidant Concentration of Post-fermentation Corn Oil from Dry Grind Ethanol Production, RRV15-042 ASABE North Central Intersectional Meeting. Fargo, ND. Apr 10-11, 2015.
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90. Momin, M. A., C. Igathinathane, and J. Shen. 2015. Economic analysis of flood affected woody biomass utilization. 2015 ASABE North Central Intersectional Conference, North Dakota State University, April 10 – 11, 2015, Fargo, ND. Paper number: RRV15-022.
91. Momin, M.A., R.M. Towfiqur, S.M. Sabrina, and C. Igathinathane. 2015. Computer vision system for grading mangos in Bangladesh. Paper number: 152189402. 2015 ASABE Annual International Meeting, New Orleans, Louisiana, July 26 – 29, 2015.
92. Monono, E.M., D.P. Wiesenborn. Heat transfer analysis of a 38 L reactor for the production of epoxidized sucrose soyate, Paper No. 152190724. ASABE Annual International Meeting, New Orleans, LA Jul 26-29, 2015.
93. Nahar, N. Higher Pretreatment Solid Loading and Lower Enzyme Loading Using Corn Stover Pellets. NDSU, RRV15-037 ASABE North Central Intersectional Meeting. Fargo, ND. Apr 10-11, 2015.

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98. Tumuluru, J.S., C. Igathinathane, and D. Archer. 2015. Energy analysis and break-even distance for transportation for biofuels in comparison to fossil fuels. Paper number: 152188618. 2015 ASABE Annual International Meeting, New Orleans, Louisiana, July 26 – 29, 2015.
99. Tuntiwiwattanapun, N., C. Tongcumpou, D. Wiesenborn. Determining crucial parameters to maximize biodiesel yield of in-situ transesterification process with acetone co-solvent, Paper No. 152178906. ASABE Annual International Meeting, New Orleans, LA Jul 26-29, 2015.
100. Vargas-Ramirez, J., A. Pothula, I. Cannayen, S. W. Pryor, D. Haagenson, D. Wiesenborn, Sugar retention in ensiled industrial-beet tissue Paper No. 152190193. ASABE International Meeting. New Orleans, LA Jul 26-29, 2015.
101. Yu, M., and C. Igathinathane. 2015. Biomass size reduction energy generalized regression model. 2015 Bio-Industry Summit, NDSU Fargo, ND, May 28, 2015.
102. Yu, M., and C. Igathinathane. 2015. Biomass size reduction model based on particle size distribution, mechanical shearing stress, and biomass species. Paper number: 152190065. 2015 ASABE Annual International Meeting, New Orleans, Louisiana, July 26 – 29, 2015.
103. Liu, Zong and Troy Runge. Dairy Manure Protein Analysis Using UV-Vis Based on the Bradford Method. 2015 ASABE Annual International Meeting, New Orleans, LA (July 28, 2015).
104. Liu, Zong, Zach Carroll, Sharon Long, and Troy Runge. Cationic Polymer and High-speed Centrifugation Effects on Pathogen Reduction during Manure Solid / Liquid Separation. 2015. Waste to Worth Conference, Seattle, WA (April 1, 2015).
105. Zhou, Shengfei, Troy Runge, Paul Weimer, and Ronald Hatfield. Producing ethanol from alfalfa stems with an acid ensilage pretreatment. 248th ACS National Meeting and Exposition. San Francisco, California (August 10, 2014).

106. Xiang, Zhouyang and Troy Runge. Film and coating with enhanced properties by cross-linking oxidized xylan with soy protein. 248th ACS National Meeting and Exposition. San Francisco, California (August 10, 2014).
107. Liu, Zong and Troy Runge. Effects of polymer and centrifugation speed on pathogen indicators reduction in dairy manure. Paper No. 141905438, 2014 ASABE Annual International Meeting, Montreal QB (July 15, 2014).

108. Negulescu I., et al. **"**Binder Composition and Intermediate Temperature Cracking Performance of Asphalt Mixtures Containing Recycled Asphalt Shingles," 2015 Association of Asphalt Paving Technologist Annual Meeting, March 8-11, 2015 Portland Marriott Downtown Waterfront, Portland, OR

109. Negulescu et al., "Design Consideration of Asphalt Mixtures Containing RAP and/or RAS: Asphalt Rejuvena tion", USDOT Federal Highway Administration, Binder Expert Technical Group Meeting, University of Massachusetts Dartmouth - Fall River, MA, April 9-10, 2015.

110. Sharma, R., Lamsal B. Production of Biosurfactants Using Bacillus subtilis on Pretreated Biomass Hydrolysates in 5-L Bioreactor. Oral presentation at AOCS 2015 annual meeting. May 3-6, Orlando, FL.

111. Sharma R, Lamsal B. Use of Bioenhancers to Improve Growth and Product Quality of Biosurfactants. Oral presentation at AOCS 2015 annual meeting. May 3-6, Orlando

112. Angele Djioleu and Danielle Julie Carrier. Antimicrobial and antioxidant activity of centrifugal partition chromatography fractions of sweetgum bark water extracts. New Orleans, July 2014. Oral

113. Kala Rajan and Danielle Julie Carrier. Enzymatic hydrolysis inhibitors in rice straw hydrolyzates. New Orleans, July 2014. Oral

114. Joe Barrett Carter and Jun Zhu. 2015. The effects of algae pre-treatment on the biomethane potential of swine wastewater. Poster presentation

115. Angele Djioleu and Danielle Julie Carrier. Sweetgum bark: Good and bad news as a biorefinery feedstock. Ohio State University, Wooster, OH August 2015.

116. Kala Rajan and Danielle Julie Carrier. Insights into cellulase enzyme inhibition by the hot water hydrolyzates of rice straw. Ohio State University, Wooster, OH August 2015.

117. W. Yao , Sue E. Nokes, Michael D. Flythe, Barbara L. Knutson, Bert C. Lynn, Stephen E. Rankin, Mike Montross. 2014. Improvement of biomass conversion by periodic flushing system. Institute of Biological Engineering 2014 Annual Conference, Lexington, KY, March 6-8, 2014.

118. Modenbach, A., Nokes, S. Effects of solids loadings in sodium hydroxide pretreatment and enzymatic hydrolysis of corn stover. Presented at the IBE Annual Meeting, Lexington, KY. March 2014.

119. Carey, Bobby, Sue E. Nokes. 2014. Field Implementation of *Phanerochaete chrysosporium* Biomass Pretreatment: Fungal Identification. Presented at the IBE Annual Meeting, Lexington, KY. March 2014

120. C. Crofcheck, C., A. Shea, M. Crocker, M. Wilson, J. Groppo, M. Montross. Life cycle assessment on a large scale algae CO_2 mitigation system for a coal-fired power plant. Poster presentation at the ASABE Annual International Meeting, New Orleans, LA, July 2015.

121. Crofcheck, C., X. E, S. Nokes, M. Montross. 2015. Modeling Mass and Heat Transfer in Baled Lignocellulosic Feedstock During Solid-state Aerobic Fungi Pretreatment and Anaerobic Bacteria Fermentation. Podium presentation at the Annual Institute of Biological Engineering Meeting, Clayton, MO, March 2015.

122. Crofcheck, C. 2014. Utilization of Microalgae for CO_2 Mitigation and the Production of Value-Added Products. Invited podium presentation at the ASABE Annual International Meeting, Montreal, Canada, July 2014.

123. Rhea, N., C. Crofcheck, and J. Groppo. 2014. Evaluation of sedimentation and vacuum assisted filtration on microalgae with polymeric flocculant addition. Podium presentation at the Annual Institute of Biological Engineering Meeting, Lexington, KY, March 2014.
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125. Fasina, O., Oyedeji, O.A., Adhikari, S. and McDonald, T. 2015. Effects of moisture content and storage time on specific grinding energy and physical properties of loblolly pine. ASABE Annual Meeting Presentation, New Orleans, July 26-29.
126. Pradhan, U., Fasina, O., Adhikari, S. and McDonald, T. 2015. Physical treatments for reducing biomass ash and effects on bio oil yield and quality. ASABE Annual Meeting Presentation, New Orleans, July 26-29.
127. Fasina, O., Till, D., Goncalves, B. and Gallagher, T. 2015. Physical characteristics of short rotation woody biomass. Sungrant Regional Conference, Auburn, AL. February 2-4. ASABE Annual Meeting Presentation, New Orleans, July 26-29.
128. Wang, Z., Adhikari, S. Shakya, R. and Valdez, P. 2015. Upgrading biocrude from hydrothermal liquefaction of algae using activated carbon supported metal catalysis. ASABE Annual Meeting Presentation, New Orleans, July 26-29.
129. Kulkani, A., Abdoulmoumine, N., Baker, R., Adhikari, S. and Bhavani, S. 2015. Air gasification of switchgrass with olivine as bed material in a bench-scale fluidized bed gasifier. ASABE Annual Meeting Presentation, New Orleans, July 26-29.
130. Cross, P., Adhikari, S. and Baker. R. 2015.Eucalyptus gasification and optimization of reactor conditions. ASABE Annual Meeting Presentation, New Orleans, July 26-29.
131. McDonald, M. and Adhikari, S. 2015. Optimization study of Novolac resins utilizing fast pyrolysis bio-oil characteristics. ASABE Annual Meeting Presentation, New Orleans, July 26-29.
132. Bin Yang "Aqueous Phase Hydrodeoxygenation of Biomass-Derived Lignin to Its Substructure Based Hydrocarbons and Chemicals", 37th Symposium on Biotechnology for Fuels and Chemicals, San Diego, CA, April 27th, 2015.
133. Hasan Coben, Xiaoyun Xue, Francisco J. Soto, Daochen Zhu, and Bin Yang "Pathways for Biological Conversion of Lignin to Lipids", 37th Symposium on Biotechnology for Fuels and Chemicals, San Diego, CA, April 27th, 2015.
134. Libing Zhang, Hongliang Wang, Marie Swita, John Cort, and Bin Yang "Kinetic Characterization of Softwood Aqueous Flowthrough Pretreatment under Neutral and Alkaline Conditions", 37th Symposium on Biotechnology for Fuels and Chemicals, San Diego, CA, April 28th, 2015.
135. Hongliang Wang, Hao Ruan, Haisheng Pei, Libing Zhang, Melvin Tucker, and Bin Yang, "Catalytic Production of Aviation Fuel Hydrocarbons from Softwood Derived Lignin", AIChE annual meeting, Atlanta, GA, November 20th, 2014.
136. Lishi Yan, Ava A Greenwood, Akram Hossain, and Bin Yang, "A Comprehensive Mechanistic Kinetic Model for Dilute Acid Hydrolysis of Switchgrass Cellulose to Glucose, 5-HMF and Levulinic Acid", AIChE annual meeting, Atlanta, GA, November 20th, 2014.
137. Libing Zhang, Lishi Yan, Dhrubo Laskar, John Cort, Zheming Wang, and Bin Yang, "Characterization of Flowthrough Pretreated Solid Residual and Removed Lignins", AIChE annual meeting, Atlanta, GA, November 20th, 2014.

138. Ju-Won Jeon, Libing Zhang, Jodie L. Lutkenhaus, Dhrubojyoti D. Laskar, John P. Lemmon, Daiwon Choi, Manjula I. Nandasiri, Ali Hashmi, Jie Xu, Radha K. Motkuri, Carlos A. Fernandez, Jian Liu, Melvin P. Tucker, Peter B. McGrail, Bin Yang, and Satish K. Nune, "Controlling Porosity in Lignin-Derived Nanoporous Carbonfor Supercapacitor Applications", AIChE annual meeting, Atlanta, GA, November 19th, 2014.
139. McDaniel, A., A. Hashimoto, and G.S. Murthy. 2015. Evaluation of environmental impacts of biofuels from sugarcane and Napier grass produced in Hawaii. ASABE Abstract No. 152188615.
140. McDaniel, A., A. Hashimoto, and G.S. Murthy. 2015. A consequential life cycle assessment of advanced biofuel production in Hawaii. ASABE Abstract No. 152188621. ASABE, St. Joseph MI.
141. Hashimoto, Andrew, Richard Ogoshi, Devin Takara, Samir Khanal, Susan Crow. High-Yield Tropical Feedstocks for Bioenergy Production. European Biomass Energy Conference, Hamburg, Germany, June 23-26, 2014.
142. Kablan, R.A., R.M. Ogoshi, A. Youkhana, and M. Nakahata. 2014. Spatial and temporal distribution of soil moisture In drip irrigated tropical grasses grown in Hawaii. ASA, CSSA, SSSA International Annual Meeting, November 2-5, 2014, Long Beach, California.
143. Ogoshi, R., R. Kablan, A. Youkhana, and M. Nakahata. 2014. Biomass yield response to temperature for three tropical grass species. ASA, CSSA, SSSA International Annual Meeting, November 2-5, 2014, Long Beach, California.
144. K.C., Surendra*, and Khanal, S. K. Effect of crop maturity stage and size reduction on digestibility of energy crop for biomethane production by anaerobic digestion. American Society of Agricultural and Biological Engineers (ASABE) 2014 Annual International Meeting, Jul 13-16, 2014, Montreal, QC, Canada.
145. Drielak, E*., and Khanal, S.K. Investigation of acid concentration, retention time and temperature on dilute acid pretreatment of banagrass. American Society of Agricultural and Biological Engineers (ASABE) 2014 Annual International Meeting, Jul 13-16, 2014, Montreal, QC, Canada.
146. Takara, D*., and Khanal, S.K. Biorefining potential of a high-yielding tropical feedstock for biofuel and biobased products. American Society of Agricultural and Biological Engineers (ASABE) 2014 Annual International Meeting, Jul 13-16, 2014, Montreal, QC, Canada.
147. Nitayavardhana, S*., and Khanal, S.K. Bioconversion of sugarcane-to-ethanol wastewater into fungal protein for animal feed applications. American Society of Agricultural and Biological Engineers (ASABE) 2014 Annual International Meeting, Jul 13-16, 2014, Montreal, QC, Canada.
148. Khanal, S.K.* and Nitayavardhana, S. Sugarcane-to ethanol biorefinery: Protein-rich fungal biomass production on vinasse for animal feed and organic food production. 10th International Conference on Renewable Resources and Biorefineries**,** Valladolid, Spain, Jun 4-6, 2014.
149. Chayanon Sawatdeenarunat, and Samir K. Khanal. "Enhanced volatile fatty acids production with micro-oxygenation during anaerobic digestion of lignocellulosic biomass", 27th Annual CTAHR and COE Student Research Symposium, University of Hawai'i at Mānoa, April 10, 2015.
150. K.C. Surendra, Robert Olivier, Jeffery K. Tomberlin, and Samir K. Khanal. "Bioconversion of food wastes to biodiesel and animal feed through insect farming", Poster

presentation, 27th Annual CTAHR and COE Student Research Symposium, University of Hawaii at Mānoa, April 10, 2015.

151. Duc Nguyen and Samir K. Khanal. "Oxidation reduction potential (ORP)-based microaeration system for anaerobic digestion", Poster presentation, 27th Annual CTAHR and COE Student Research Symposium, University of Hawaii at Manoa, April 10, 2015.

152. Shilva Shrestha[a]*, Xavier Fonoll[b], Joan Mata-Alvarez[b], Lutgarde Raskin[c] and Samir K. Khanal[a]. "Anaerobic digestion of lignocellulosic biomass using rumen content as inoculum for enhanced biogas production", Oral presentation, 27th Annual CTAHR and COE Student Research Symposium, [a]University of Hawaii at Manoa, [b]University of Barcelona, [c]University of Michigan, April 11, 2015.

153. Jarupat Kanjanarong, Piyarat Boonsawang, Samir Kumar Khanal. "Hydrogen sulfide (H2S) Removal by Using Bichar", Poster presentation, 27th Annual CTAHR and COE Student Research Symposium, University of Hawaii at Manoa, April 9, 2015.

154. Meulemans, Jabez, Susan E. Crow, John Yanagida, and Jonathan Deenik. "Linking global warming potential and economics to the sustainability of biochar use in Hawaii agriculture", Poster presentation, CTAHR Student Research Symposium, University of Hawaii at Manoa, April 9, 2015.

155. Khanal, S.K., The Sixteenth Royal Golden Jubilee - Ph. D. Congress (RGJ-Ph.D. Congress XVI), Pattaya, Thailand (Jun 11-13, 2015). "*My 12 years of research journey with Thai students and visiting scholars on energy and environment.*"

156. Khanal, S.K., Leading Edge Technology 2015 (LET-2015), International Water Association, Food Waste Workshop, Hong Kong (May 31st, 2015). "*Co-treatment of organic solid wastes in the sewage treatment facilities for waste reduction and energy recovery*."

157. Khanal, S. K., Local Feed Workshop, Aquatic Feeds and Nutrition Department Oceanic Institute of Hawaii Pacific University, Waimanalo, HI (Nov 21, 2014). "*Utilization of local agri-processing by-products to produce fungal protein for aquatic feed production*."

158. Khanal, S.K., International Conference on Emerging Trends in Biotechnology (ICETB-2014), New Delhi, India (Nov 6-9, 2014). "*Fractionation of tropical feedstocks for bioenergy and biobased products*."

159. Khanal, S.K., Department of Biotechnology, BOKU University of Natural Resources and Life Sciences, Vienna, Austria (Aug 29, 2014)."*Resource recovery from wastes/residues*."

160. Khanal, S.K., Dept. of Civil and Environmental Engineering, Technion University – Israel Institute of Technology, Haifa, Israel (Jul 17, 2014). "*Bioconversion of water (water) into resources*."

161. Khanal, S.K., School of Biochemical Engineering, Addis Ababa Institute of Technology, Addis Ababa, Ethiopia (Jun 27, 2014). "*Biotechnology for resource recovery from waste (water)*."

162. Khanal, S.K., Dept. of Civil and Environmental Engineering, Hong Kong University of Science and Technology, Hong Kong (May 16, 2014). "*Converting waste (water) into value-added products*."

163. Khanal, S.K., Dept. of Civil and Environmental Engineering, Hong Kong University of Science and Technology, Hong Kong (May 15, 2014)." *Emerging trends in environmental biotechnology for waste valorization*."

164. Khanal, S.K., Dept. of Environmental Engineering, Fudan University, Shanghai, China (May 13, 2014). "*Resource recovery from waste (water)*."

165. Khanal, S.K., College of Environmental Science and Engineering, Tongji University, Shanghai, China (May 12, 2014). "*Resource recovery from waste (water)*."
166. Khanal, S.K., International Conference on Progress on Biogas III (Sep 10-11, 2014), Stuttgart, Germany. "*Examine the effects of crop maturity and size reduction on digestibility of energy crop for biomethane production*."
167. Khanal, S.K., 10th European Symposium on Biochemical Engineering Sciences, Lille, France (Sep 8 to 10, 2014). "*Green processing of tropical feedstocks for biofuels and high value co-products*."
168. Khanal, S.K., State Institute of Agricultural Engineering and Bioenergy, Hohenheim University, Stuttgart, Germany (Jul 10, 2014). *"Biogas production from tropical crops."*
169. Khanal, S.K., Universidad de Santander, Cucuta, Colombia (Apr 4, 2014). "Sustainable bioenergy production: Opportunities and challenges."
170. Khanal, S.K., Chonnam National University, Gwanju, South Korea (Feb 27, 2014). "*Fractionation of tropical feedstocks for bioenergy and biobased products."*
171. Oluwatosin Jerry Oginni and Kaushlendra Singh. Pyrolysis of Bioenergy Crops (Switchgrass and Miscanthus) Grown on Reclaimed Mining Land in West Virginia. 2015 ASABE Annual International Meeting, Paper no: 152164303.
172. Oginni, O., and K. Singh. 2015. Pyrolysis of Lignocellulosic Biomass from Appalachian Region. 69th Forest Products Society International Convention, Atlanta, Georgia. June 10-12, 2015.
173. Oginni, O., and K. Singh. 2015. Biomass Pyrolysis for Bio-oil and Activated Carbon Production. Poster Presentation at 69th FPS International Convention, Atlanta, Georgia. June 10-12, 2015.
174. Oginni, O. and K. Singh. 2015. Pyrolysis of Bioenergy Crops (Switchgrass and Miscanthus) Grown on Reclaimed Mining Land in West Virginia, Presentation number 152164303, ASABE Annual International Meeting, New Orleans, LA July 25-29, 2015.
175. Rahimi, S. and K. Singh. 2015. Drying Characteristics of Wood and Herbaceous biomass. Presentation number 152189544, ASABE Annual International Meeting, New Orleans, LA July 25-29, 2015.
176. Singh, K. and L. Sivanandan. 2015. Making Food Business Green- Transforming Waste into Biofuels Bioenergy. Food Drying Workshop at Marshall County Activities Authority Service Barn, Moundsville, WV May 27, 2015.
177. Akharume, F., K. Singh, L. Sivanandan. 2015. Drying Characteristics of Wood and Wood Polymers using TGA 701 (Proximate Analyzer). S-1041 Multistate Project Meeting, Wooster, OH August 10, 2015.
178. Oginni, O. and K. Singh. 2015. Activated Carbons from Herbaceous Bioenergy Crops. S-1041 Multistate Project Meeting, Wooster, OH August 10, 2015.
179. Singh, K. and L. A. Poggi. 2015. Comparing Fluid Cracking Catalyst and Switchgrass Biochar derived Catalysts for Thermal Decomposition of Acetic Acid. S-1041 Multistate Project Meeting, Wooster, OH August 10, 2015.
180. Singh, K. and L. Sivanandan. 2015. Hydrothermal carbonization of Spent Osmotic Solution (SOS) generated from osmotic dehydration of blueberries. S-1041 Multistate Project Meeting, Wooster, OH August 10, 2015.
181. Jin, W., K. Singh, and J. Zondlo. 2015. Co-processing of Pyrolysis Vapors with Biochars for exsitu Upgrading. S-1041 Multistate Project Meeting, Wooster, OH August 10, 2015.

182. Challa, R.K., Johnston, D.B., Singh, V., Tumbleson, M.E., Engeseth, N.J. and Rausch, K.D. 2015. Thin stillage fouling multiple effect evaporators. In: Intl. Starch Technol. Conf. (Rausch, K.D., Singh, V. and Tumbleson, M.E., eds.) p. 2 (Abstr. No. 1). Urbana, IL.

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185. Chen, M.-H., Bowman, M.J., Dien, B.S., Cotta, M.A., Iten, L.B., Rausch, K.D., Tumbleson, M.E., Whitehead, T.R. and Singh, V. 2015. Hydrothermolytic production of xylooligosaccharides form Miscanthus x giganteus: characteristics, purification and functional tests. In: Intl. Starch Technol. Conf. (Rausch, K.D., Singh, V. and Tumbleson, M.E., eds.) p. 4 (Abstr. No.4). Urbana, IL.

186. Chen, M.-H., Bowman, M.J., Dien, B.S., Cotta, M.A., Iten, L.B., Rausch, K.D., Tumbleson, M.E., Whitehead, T.R. and Singh, V. 2014. Production, separation and functional tests of xylooligosaccharides from Miscanthus x giganteus in the cellulosic ethanol process. In: Proc. AACC Int. Conf. Abstr. No. P-37. Providence, RI.

187. Chen, M.-H., Bowman, M.J., Dien, B.S., Cotta, M.A., Swanson, K.S, Whitehead, T.R., Fahey, Jr., G.C., Beloshapka, A.N., Iten, L.B., Bauer, L.L., Rausch, K.D., Tumbleson, M.E. and Singh, V. 2015. *In vitro* fermentation of xylooligosaccharides from *Miscanthus* × *giganteus*. In: Proc.: Sci. Engr. Biobased Industry. (Rausch, K.D. and Tumbleson, M.E., eds.). p. 16. Abstr. No. 7. Wooster, OH.

188. Chen, M.-H., Bowman, M.J., Dien, B.S., Rausch, K.D., Tumbleson, M.E. and Singh. V. 2014. Xylooligosaccharides (XOS) production from Miscanthus x giganteus in cellulosic ethanol process. In: Proc. Corn Util. Technol. Conf. Abstr. No. S-10. NCGA, St. Louis, MO.

189. Chen, M.-H., Dien, B.S., Vincent, M.L., Below, F.E., Rausch, K.D., Tumbleson, M.E. and Singh. V. 2014. Effect of harvest maturity on carbohydrates for ethanol production from sugar enhanced temperate x tropical maize hybrids. In: Proc. Sci. Engr. Biobased Industry. (Murthy, G.S., Wilkins, M.R. and Tumbleson, M.E., eds.) p. 07 (Abstr. No. 04). New Orleans, LA.

190. Chen, M.-H., Liu, W., Moose, S.P., Rausch, K.D., Tumbleson, M.E. and Singh, V. 2014. Wet milling and starch properties of glossy 15 gene overexpressed maize kernels. In: Proc. Corn Util. Technol. Conf. Abstr. No. S-09. NCGA, St. Louis, MO.

191. Huang, H., Chen, M.-H., Below, F.E., Gentry, L.F. and Singh, V. 2015. Technoeconomic analysis of ethanol production from temperate × tropical maize. In: Proc.: Sci. Engr. Biobased Industry. (Rausch, K.D. and Tumbleson, M.E., eds.). p. 32. Abstr. No. 15. Wooster, OH.

192. Huang, H., Danao, M.-G.C., Rausch K.D. and Singh, V. 2015. Diffusion and production of carbon dioxide in bulk corn at various temperatures and moisture contents. In: Intl. Starch Technol. Conf. (Rausch, K.D., Singh, V. and Tumbleson, M.E., eds.) p. 10 (Abstr. No. 5). Urbana, IL.

193. Huang, H., Long, S.P. and Singh, V. 2015. Technoeconomic analysis of biodiesel and ethanol coproduction from lipid producing sugarcane. In: Proc.: Sci. Engr. Biobased Industry. (Rausch, K.D. and Tumbleson, M.E., eds.). p. 30. Abstr. No. 14. Wooster, OH.

194. Mumm, R.H., Goldsmith, P.D., Rausch, K.D. and Stein, H.H. 2015. Corn ethanol production in the US: land use, corn grain yield, ethanol processes and coproduct utilization. In: Intl. Starch Technol. Conf. (Rausch, K.D., Singh, V. and Tumbleson, M.E., eds.) p. 25 (Abstr. No. 8). Urbana, IL.

195. Ramchandran, D., Johnston, D.B., Rausch, K.D., Tumbleson, M.E. and Singh, V. 2015. Seasonal variation in dry grind ethanol production associated with incoming corn variability. In: Intl. Starch Technol. Conf. (Rausch, K.D., Singh, V. and Tumbleson, M.E., eds.) p. 18 (Abstr. No. 9). Urbana, IL.

196. Ramchandran, D., Johnston, D.B., Rausch, K.D., Tumbleson, M.E. and Singh, V. 2015. Seasonal variation in dry grind ethanol production associated with incoming corn variability. Poster No. 13. NC-213. Kansas City, MO.

197. Ramchandran, D., Rausch, K.D., Tumbleson, M.E. and Singh, V. 2014. Physiologic changes in cereal grains during storage. In: Proc. Corn Util. Technol. Conf. Abstr. No. S-03. NCGA, St. Louis, MO.

198. Rausch, K.D., Belyea, R.L., Singh, V., Clevenger, T.E., Tumbleson, M.E. and Raskin, L.M. 2015. Nutrient flows in maize wet milling streams. In: Intl. Starch Technol. Conf. (Rausch, K.D., Singh, V. and Tumbleson, M.E., eds.) p. 22 (Abstr. No. 11). Urbana, IL.

199. Rausch, K.D., Pruiett, L.E., Wang, P., Xu, L., Belyea, R.L. and Tumbleson, M.E. 2015. Laboratory measurement of yields and composition of dry milled corn fractions using a shortened, single stage tempering procedure. In: Intl. Starch Technol. Conf. (Rausch, K.D., Singh, V. and Tumbleson, M.E., eds.) p. 20(Abstr. No. 10). Urbana, IL.

200. Tian, J., Johnston, D.B., Engeseth, N.J., Singh, V., Tumbleson, M.E. and Rausch, K.D. 2015. Phytic acid concentration and phytase addition effects on fouling characteristics of steepwater. In: Proc.: Sci. Engr. Biobased Industry. (Rausch, K.D. and Tumbleson, M.E., eds.). p. 88. Abstr. No. 41. Wooster, OH.

201. Wang, Z., Huang, H., de Mejia, E., Li, Q. and Singh, V. 2015. Comparison of fermentation characteristics between pigmented corn and yellow dent corn in two dry grind process methods. In: Proc.: Sci. Engr. Biobased Industry. (Rausch, K.D. and Tumbleson, M.E., eds.). p. 96. Abstr. No. 45. Wooster, OH.

202. Zhang, Y.B., Johnston, D.B., Engeseth, N.J., Singh, V., Tumbleson, M.E. and Rausch, K.D. 2015. Temperature effects on heat transfer fouling of thin stillage from ethanol production. In: Proc.: Sci. Engr. Biobased Industry. (Rausch, K.D. and Tumbleson, M.E., eds.). p. 104. Abstr. No. 49. Wooster, OH.

203. Jenkins B, V. Bandaru, N. Parker, Q. Hart, Q. Hart, B-N. Yeo, J.Medellin-Azuara, Y. Pei, Y. Li, J. Crawford, E. Budsberg, P. Tittmann, J. Mertz, J. Hanna, and S. Kaffka. 2015. Comprehensive assessment of the sustainability of biofuel production in the U.S. Pacific Northwest region from hybrid poplar. 23rd European Biomass Conference and Exhibition, Vienna, Austria: June1-June 4, 2015.

204. Higgins B, Gennity I, Samra S, Fiehn O, VanderGheynst J. The role of cofactors in algal-bacterial symbiosis for enhanced biofuel production. Presented at the 2015 Symposium on Biotechnology for Fuels and Chemicals, La Jolla, CA.

205. Jabusch, L. Higgins B, Labavitch J, Fiehn O, VanderGheynst JS. Characterization of Chlorella cell walls under nitrogen replete-deplete growth conditions. Presented at the 2015 Symposium on Biotechnology for Fuels and Chemicals, La Jolla, CA.
206. Harrold D, VanderGheynst JS. Nitrogen Dependence of Cellulase and Hemicellulase Activities Secreted by Lignocellulose Degrading Microbial Communities. Presented at the 2015 Symposium on Biotechnology for Fuels & Chemicals. SanDiego, CA.
207. Ceballos SJ, Pace S, Singer S, Simmons B, Thelen M, VanderGheynst JS. Isolating individual organisms and microbial communities that thrive in a lignin rich environment. Presented at the 2015 Symposium on Biotechnology for Fuels & Chemicals. SanDiego, CA.
208. Pace S, Ceballos S, Harrold D, Trower W, Simmons B, Singer S, Thelen M, VanderGheynst JS. Thermophilic enrichment of microbial communities in the presence of Tetrabutyl phosphonium chloride and Tributylethylphosphonium diethylphosphate ionic liquids. Presented at the 2015 Symposium on Biotechnology for Fuels & Chemicals. SanDiego, CA.
209. Hildebrand, A, Szewczyk, E., Kasuga, T., Fan, Z. Engineering Neurospora crassa for improved cellobionate production from cellulose, accepted for oral presentation, at the 36th Symposium on Biotechnology for Fuels and Chemicals, at the Hilton Clearwater Beach, Clearwater Beach, FL USA.
210. Hildebrand, A, Szewczyk, E., Kasuga, T., Fan, Z. Engineering Neurospora crassa for improved cellobionate production from cellulose, presented at the 2015 AICHE annual meeting, Atlanta, GA
211. Fan, Z., Sun, Y., Han, S., Ma, D., Conversion of glucose and gluconate mixture to ethanol by E coli. AH003, presented at the 2015 AICHE annual meeting, Atlanta, GA.
212. Tyler Barzee, Ruihong Zhang, Abdolhossein Edalati, Hamed El-Mashad, 2015. Sustainable bio-fertilizer production from anaerobically digested organic wastes. Presentation at 2015 Annual International Meeting, July 26-29, 2015, New Orleans, LA.
213. Zhang, R.H. 2014. Green energy from food waste, Invited Presentation at Clean Tech Conference and Expo. Santa Barbara, CA. May 10, 2014.
214. Zhang, R.H. 2014. CleanWorld: Transforming organic waste into green energy, invited presentation at energy vision workshop, Springfield, VA. June 16, 2014
215. Zhang, R.H. 2014. UC Davis renewable energy anaerobic digestion project, invited presentation at california bioresource alliance symposium, UC Davis. September 16, 2014.
216. Ge, X., Xu, F., Li, Y. 2015. Comparison of giant reed and miscanthus as feedstocks for bioenergy and bioproducts. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.
217. Xu, F., Li, Y., Wang, Z. 2015. Use of respirometer in the evaluation of the fractal kinetics of the solid-state anaerobic digestion of corn stover. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.
218. Zhang W., Ge, X., Li, Y., Yu, Z., Li, Y. 2015. A methanotrophic bacterium isolated from solid state anaerobic digestion system. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.
219. Liu, S., Ge, X., Dong, R., Pang, C., Li. Y. 2015. Effect of urea addition on giant reed ensilage and subsequent methane production by anaerobic digestion. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015. ASABE Paper No. 152190221.
220. Wang, F., Xu F., Li, Y. 2015. Comparison of digestate from solid anaerobic digesters and effluent from liquid anaerobic digesters as inocula for solid state anaerobic digestion of yard

trimmings. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015. ASABE Paper No. 152190124.

221. Vasco Correa, J., Ge, X., Li, Y. 2015. Fungal pretreatment of non-sterile *Miscanthus x giganteus* for enhanced sugar yield in enzymatic hydrolysis. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.

222. Liu, S., Xu, F., Liew, L. N., Li, Y. 2015. Food waste addition for enhanced giant reed ensiling and methane production. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015. ASABE Paper No. 152219857.

223. Jiang Y., Xu, F., Liew, L. N., Li. Y. 2015. Solid-state anaerobic co-digestion of kitchen food waste and food packages. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.

224. Sheets, J., Ge, X., Li. Y. 2015. Effect of limited air exposure and comparative performance between thermophilic and mesophilic solid-state anaerobic digestion of switchgrass. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.

225. Xu, F., Li. Y. 2015. Emergy analysis of solid-state anaerobic digestion and liquid anaerobic digestion systems for bioenergy production and waste management. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.

226. Yang, L., Ge, X., Wan, C., Yu, F., Li, Y. 2015. Pathways for converting biogas to transportation fuels. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.

227. Zhang W., Ge, X., Li, Y. 2015. A new strategy for removal of hydrogen sulfide from biogas during solid-state anaerobic digestion. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.

228. Sheets, J., Ge, X., Zhang W., Li, Y. 2015. Conversion of biogas to methanol using novel methanotrophs isolated from solid-state anaerobic digestate. ASABE Annual International Meeting, New Orleans, LA, July 26-29, 2015.

229. Dang, Y., Wang, F., Luo, X., Li, Y. 2015. Value-added Conversion of Waste Cooking Oil and Used PET Bottles from Campus Waste into Biodiesel and Polyurethane Foams. 2015 Polymer Initiative of Northeast Ohio (PiNO) Conference. Cleveland, OH. June 12, 2015.

230. Vasco Correa J., Ge, X., Li, Y. 2015. Enhanced Enzymatic Digestibility of *Miscanthus×giganteus* by solid-state fungal pretreatment without sterilization. 2015 OARDC Annual Conference. Columbus, OH. April 16, 2015.

231. Sheets J. P., Li, Y. 2015. Effect of limited air exposure and comparative performance between thermophilic and mesophilic solid-state anaerobic digestion of switchgrass. 2015 OARDC Annual Conference. Columbus, OH. April 16, 2015. *(Second place award in Ph.D. category)*

232. Lin Wei, James Julson, Shouyun Cheng, Xianhui Zhao, Yong Yu, 2015. Accurately Controlled Catalytic Fast Pyrolysis of Biomass for Drop-in Fuels. The ASABE Annual International Meeting, July 26 – 29th, 2015, New Orleans, LA.

233. Xianhui Zhao, Lin Wei*, Shouyun Cheng, Yong Yu, James Julson, 2015. Catalytic cracking of carinata oil for hydrocarbon biofuel over Zn/Na-ZSM-5. The ASABE Annual International Meeting, July 26 – 29th, 2015, New Orleans, LA.

234. Shouyun Cheng, Lin Wei*, Yu Shen, Xianhui Zhao, Yong Yu, Linhong Jing, 2015. Isolate protein peptides from defatted Camelina and Canola meals. The ASABE Annual International Meeting, July 26 – 29th, 2015, New Orleans, LA.

235. Xianhui Zhao, Lin Wei. 2015. Catalytic cracking of inedible camelina oil over nickel modified ZSM-5 catalyst, April 11, 2015. The ASABE/CSAE intersectional meeting, Fargo, North Dakota.
236. Shouyun Cheng, Lin Wei, Yu Shen, Linhong Jin. 2015. Isolate protein peptides from defatted Camelina and Canola meals. The ASABE/CSAE intersectional meeting, Fargo, North Dakota.
237. Yinbin Huang, Lin Wei, 2015. Hydrodeoxygenation for upgrading raw bio-oil using Pd/C. The ASABE/CSAE intersectional meeting, Fargo, North Dakota.
238. Xianhui Zhao, Lin Wei, James Julson, 2015. Comparison of biodiesel and green diesel produced from inedible vegetable oils. National Biodiesel Conference & Expo Jan. 19-22. Fort Worth, Texas.
239. Lin Wei, K. Muthukumarappan, James Julson, Jimmy Gu, 2015. Oil Extraction from non-food Oilseeds for Renewable Aviation Fuel Production. North Central Regional Sun Grant Center Annual Meeting, March 18 - 19th, 2015 Minneapolis, MN.
240. Lin Wei, Doughlas Raynie, James Julson. 2015. Torrefaction and Pyrolysis of Lignocellulosic Biomass to Fungible Fuels. North Central Regional Sun Grant Center Annual Meeting, March 18 - 19th, 2015 Minneapolis, MN.
241. Lin Wei, James Julson, 2015. Catalytic Fast Pyrolysis of Ag & Forest Residues for Aromatic Fuel Additives. North Central Regional Sun Grant Center Annual Meeting, March 18 - 19th, 2015 Minneapolis, MN.
242. Yong Yu, Lin Wei. 2015. Kinetic models of biomass pyrolysis**.** April 11, 2015. The ASABE/CSAE intersectional meeting, Fargo, North Dakota.
243. Muthukumarappan, K. 2014. Advanced Biofuels: Challenges and Opportunities. Invited Plenary Presentation at the BIT's 4th Annual World Congress of Bioenergy-2014, Sep 21-23, Qingdao, China. Conference Proceedings: 037.
244. Muthukumarappan, K. 2014. Characterization of Cyanobacteria Growth Rate in a Bubble-Column Photo-bioreactor. Invited Plenary Presentation at the BIT's 3rd Annual International Congress of Algae-2014, Oct 16-18, Dalian, China. Conference Proceedings: 235.
245. Muthukumarappan, K. 2014.Novel Pretreatment and Compaction Methods for Bioethanol Production. Invited plenary session speaker at the BIT's 5th World Gene Convention-2014, November 13-16, Haikou, China, Conference Proceedings: 183.
246. Muthukumarappan, K. and Wei, L. 2014. A Novel Continuous Oilseed Extraction Method for Jet Fuel Production. Invited presentation at the Bio Pacific Rim Summit on Industrial Biotechnology and Bioenergy, December 7-9, San Diego, CA.
247. Croat, J.R., M. Berhow, B. Karki, K. Muthukumarappan, and W.R. Gibbons. 2015. Conversion of Canola Meal into a High Protein Feed Additive by Submerged and Solid-state Fungal Incubation Processes. Presented at the 2015 AOCS Annual Meeting, May 3-6, Orlando, FL.
248. Kaur, J. and Muthukumarappan, K. 2015. Effect of extrusion processing parameters on physical properties and sugar recovery of canola meal for aqua feed production. Presented at the2015 *IFT Annual Meeting & Food Expo*, July 11-14, Chicago, IL.
249. Kaur, J. Karki, B. and Muthukumarappan, K. 2015. Extrusion pre-treatment of solvent extracted camelina and carinata meal for maximum sugar recovery. Presented at the *ASABE Annual International Meeting*, July 26-29, New Orleans, LA.
250. Karki, B., Muthukumarappan, K. and Gibbons, W.R. 2015. Production of High-Protein Carinata and Soybean Meal with Reduced Level of Anti-Nutritional Factors by Using

Ultrasonication Pretreatment and Microbial Fermentation Process. Presented at the *ASABE Annual International Meeting*, July 26-29, New Orleans, LA.

251. Karki, B., Muthukumarappan, K., Gibbons, W.R. 2015. Terpenes as Green Solvents for the Development Oil Extraction Method for Jet Fuel Production from Carinata and Camelina Meal. Presented at the *ASABE Annual International Meeting*, July 26-29, New Orleans, LA
252. Karki, B., Muthukumarappan, K., Gibbons, W.R. 2015. Liquid CO2-Assisted Extrusion Processing: A Novel Approach of Developing High Protein Feed Replacers from Carinata and Camelina Meal. Presented at the *ASABE Annual International Meeting*, July 26-29, New Orleans, LA.
253. Kamireddy, S., Karki, B., Muthukumarappan, K. 2015. Improving the Saccharification Yield of Soybean Meal by Using Liquid-CO2 Assisted Extrusion in a Single Screw Extruder. Presented at the *ASABE Annual International Meeting*, July 26-29, New Orleans, LA.
254. Kamireddy, S., Karki, B., Muthukumarappan, K. 2015. Evaluation of Sugar Yields of Apple Pomace by Using Extrusion in a Single-Screw Extruder. Presented at the *ASABE Annual International Meeting*, July 26-29, New Orleans, LA.
255. Lee J, Guragain YN, Bastola KP, Vadlani PV. Lipid Production from Lignocellulosic Biomass: Efficient strategies for pretreatment induced inhibitors. Alternative Fuels and Enabling Technologies II, AIChE Annual Meeting, Salt Lake City, Utah, November 8-13, 2015
256. Guragain YN, Bastola KP, Borrios R, Kingsly ARP, Vadlani PV. Innovative pretreatment strategies to generate high-quality sugars from a broad spectrum of biomass resources. American Chemical Society National Meeting, Denver, Colorado, March 22-26, 2015
257. Bastola KP, Bhadriraju V, Guragain YN, Vadlani PV A modified Folin-Ciocalteu colorimetry method for the determination of total phenolics in biomass samples. American Chemical Society National Meeting, Denver, Colorado, March 22-26, 2015
258. Demel E, Zhang Y, Vadlani PV, D-lactic acid biosynthesis from corn stover using engineered lactobacillus plantarum. 249th ACS National Meeting & Exposition. Denver, CO. March 22-26, 2015.
259. N. Appiah-Nkansah, K. Zhang, B. Rooney, and D. Wang. 2015. Model Study on Extraction of both Fermentable Sugars and Starch using Artificial Mixture of Sweet Sorghum Biomass and Sorghum Flour. The 23rd European Biomass Conference and Exhibition, 6/1-4, 2015, Vienna, Austria.
260. N. Appiah-Nkansah, K. Saul, B. Rooney, and D. Wang. 2015. Incorporation of sweet sorghum juice into current dry-grind ethanol process for improved ethanol yields, energy savings and water efficiency. The 23rd European Biomass Conference and Exhibition, 6/1-4, 2015, Vienna, Austria.
261. N. Appiah-Nkansah, K. Zhang, B. Rooney, and D. Wang. 2015. Incorporation of sweet sorghum juice into current dry-grind ethanol process for improved ethanol yields, energy savings and water efficiency. The IBE 2015 Annual Conference will be held at: March 5-7, 2015, St. Louis, Missouri.
262. D. Wang. Advanced bioconversion of energy crops into biofuels. 2015. 8th Annual world congress of Industrial Biotechnology. 4/25 to 4/28, 2015. Nanjing, China (Invited).
263. D. Wang and F. Xu. 2015. Photoperiod-sensitive sorghum as a viable energy crop for biofuel production. The Energy & Materials Research Conference. 2/25 to 2/27, 2015. Madrid, Spain.

264. N. Appiah-Nkansah, B. Rooney, and D. Wang. 2014. Incorporation of sweet sorghum juice into current dry-grind ethanol process for improved ethanol yields and energy efficiency. Biomass 2014: Growing the Future Bioeconomy. July 29 –30, Washington, D.C.
265. K. Saul, N. Appiah-Nkansah, and D. Wang. 2014. Incorporation of sweet sorghum juice into the current dry-grind ethanol process for improved ethanol yields, energy savings, and water efficiency. RCN Conference on Pan American Biofuels and Bioenergy Sustainability. 7/23-25, 2014. Recife, Brazil (poster first place).
266. N.B. Appiah-Nkansak, K. Kaelin, W. Rooney, and D. Wang. Incorporation of sweet sorghum juice into current dry-grind ethanol process for improved ethanol yields, energy savings and water efficiency. 2014. ASABE Annual Meeting, 7/13 to 7/17, 2014, Montreal, Quebec Canada. Paper No. 141896129.
267. X.S. Sun. 2015. Oilseeds as a Platform Feedstock for Biobased Polymers and Applications, Keynote speaker, In Honor Richard Wool Symposium, 19th Green Chemistry and Engineering, July 14-16, 2015 MD.
268. Y. Li, X.S. Sun. 2015. Pressure-sensitive adhesives and coatings from camelina oils. 19th Green Chemistry & Engineering Conference, July 14-16, 2015, oral presentation, N. Bethesda, MD.
269. C. Li, J. Sung, X.S. Sun. 2015. Substantial improvement of epoxidized plant oil materials via double networks. 19th Green Chemistry & Engineering Conference, July 14-16, 2015, poster presentation, N. Bethesda, MD.
270. H. Liu, X.S. Sun. 2015. Soy Oil Derived Waterborne Polyurethane Improve Wet Adhesion Strength of Soy Protein Wood Adhesives. K-State Research Forum, poster presentation, March, 31, 2015, Manhattan, KS.
271. Y. Li, D. Wang, X.S. Sun. 2015. Epoxidized and acrylated camelina oils for UV curable wood coatings. 3rd USDA NIFA BRDI Camelina Project Meeting, August 19-20, 2015, poster presentation, Manhattan, KS.
272. J. Sung, Y. Li, X.S. Sun. 2015. Thermal properties of dihydroxyl fatty acid derivatives for bio-based wax applications. 3rd USDA NIFA BRDI Camelina Project Meeting, August 19-20, 2015, poster presentation, Manhattan, KS.
273. X. Zhu, D. Wang, X.S. Sun. 2015. Physicochemical and structural properties of crosslinked camelina protein. 3rd USDA NIFA BRDI Camelina Project Meeting, August 19-20, 2015, poster presentation, Manhattan, KS.
274. Izmirlioglu, G. and A. Demirci. 2014. Optimization of fermentation parameters for production of ethanol from industrial potato waste by simultaneous saccharification and co-fermentation in biofilm reactors. Conference of Society for Industrial Microbiology and Biotechnology. St. Louis, MO. Abstract # 30524.
275. Ercan, D., A. Demirci, and V. M. Puri. 2015. Modeling of human lysozyme production by Kluyveromyces lactis K7 in biofilm reactor. Institute of Food Technologists Annual Meeting. New Orleans, LA. Abstract # 026.
276. Izmirlioglu, G. and A. Demirci. 2015. Ethanol fermentation from industrial potato waste in biofilm reactors. 37th Symposium on Biotechnology for Fuels and Chemicals. St. San Diego, CA. Abstract # 29592.
277. Izmirlioglu, G. and A. Demirci. 2015. Medium optimization of simultaneous starch saccharification and ethanol fermentation in biofilm reactors. 37th Symposium on Biotechnology for Fuels and Chemicals. St. San Diego, CA. Abstract # 29611.

278. Richard, T.L. Making the Numbers Count: Toward a general framework for bioeconomy carbon accounting. University of Freiburg. June 8, 2015. Freiburg, Germany.
279. Zhu, Y., Bukowski, N., Doyle, L., Vergari, A., Pandey, J., Anderson, C., & T. L. Richard. 2014. Development of a lignin toolbox on one" negligible" auxiliary. Presented at the 248 National Meeting, American Chemical Society, August 10-14, 2014. San Francisco, CA. In: Abstracts of papers of the American Chemical Society (Vol. 248). American Chemical Soc., Washington, DC.
280. Cangiano, M.L., A.R. Kemanian, F. Montes and T.L. Richard. 2014. Net ecosystem carbon exchange of maize and shrub willow for bioenergy. Presented at 138th ASA/CSSA/SSSA International Annual Meetings, Nov. 2-5, 2014. Long Beach, CA.
281. Ramcharan, A., A. Kemanian and T.L. Richard. 2014. Can winter rye be a carbon sink energy source? A biophysically-modeled case study Presented at 138th ASA/CSSA/SSSA International Annual Meetings, Nov. 2-5, 2014. Long Beach, CA.
282. Salis H.M. 2014. Predictive Biophysical Models for Engineering Synthetic Genetic Systems. Indo-US Program on Systems and Synthetic Biology. New Delhi, India. November 9-12. (invited)
283. Salis H.M. 2015. The Pathway Map Calculator: an Automated Learning Algorithm to Determine a Pathway's Optimal Expression Levels. The Society for Industrial Microbiology and Biotechnology (SIMB) Annual Meeting. Philadelphia, PA. July 3-7. (invited)
284. Farasat I. and H.M. Salis. 2015. Scalable System-wide Design of TF- and dCas9-Based Genetic Circuits. Synthetic Biology: Engineering, Evolution, and Design. Boston, MA. June 11-13.
285. Espah Borujeni A., D.M. Mishler, J. Wang, W. Huso, and H.M. Salis. 2015. Automated Design of Synthetic Riboswitches from Diverse RNA Aptamers. Bi-Annual Meeting of the Synthetic Biology Engineering Research Center (SynBERC). Berkeley, CA. April 2.
286. Espah Borujeni A., D.M. Mishler, J. Wang, W. Huso, and H.M. Salis. 2015. Automated Design of Synthetic Riboswitches from Diverse RNA Aptamers. International Conference on Biomolecular Engineering. Austin, TX. January 11.
287. Ng C.Y., C. Maranas, and H.M. Salis. 2014. Design and Optimization of a Synthetic Pathway for Improved NADPH Regeneration. American Institute of Chemical Engineering (AIChE) Annual Meeting. Atlanta, GA. November 14-17.
288. Tian T., I. Farasat, and H.M. Salis. 2014. Autonomous control of metabolism with synthetic sensor-circuits. American Institute of Chemical Engineering (AIChE) Annual Meeting. Atlanta, GA. November 14-17.
289. Ng C.Y., C. Maranas, and H.M. Salis. 2014. Design and Optimization of a Synthetic Pathway for Improved NADPH Regeneration. Bi-Annual Meeting of the Synthetic Biology Engineering Research Center (SynBERC). Cambridge, MA. September 14.
290. Chen, C. 2014. Alternative cropping systems for central Montana shallow soils. Abstract. ASA, CSSA, &SSSA International Annual Meeting, Nov. 2-5, 2014. Long Beach, CA.
291. Chen, C., R. Keshavarz-Afshar, and A. Bekkerman. 2015. Intensified dryland cropping systems for food and fuel production. Western Society of Crop Science Annual Meeting, June 16-17, Logan , UT.

5. TARGET AUDIENCE

[ALABAMA] Engineers, Scientist, Policymakers, K-12 and college students.

[ARKANSAS] Target audience includes scientific peers, undergraduate and graduate students, grass root groups interested in renewable energy, and elected officials. Project results will be disseminated through formal peer-reviewed publications, classroom teaching, on-line teaching, internships with undergraduate students, and extension to state officials and interested participants.

[CALIFORNIA] The target audience includes community, policy makers, industry and other stakeholders involved in the deployment of biofuel systems and researchers participating in biofuel and bioenergy investigations. The research findings and decision support tools resulting from sustainability research can be used by extension and other academic investigators and private developers to disseminate knowledge about possible environmental impacts and economic implications for biofuel systems and to assist in specific 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] Interactions with target audience included: poster presentations to fellow bioenergy researchers (Multi-state Project S-1041 "The Science and Engineering for a Biobased Industry and Economy," Sun Grant Association, USDOE Bioenergy Technologies Office, Office of Naval Research), presentations at national and international meetings (Crop Sciences Society of America, Agronomy Society of America, Soil Science Society of America, American Society of Agricultural and Biological Engineering), student symposia (College of Tropical Agriculture and Human Resources Student Research Symposium), community and elementary students (experiment station field days and elementary school outreach), and collaborators (HC&S supervisors and field crews, and NRCS-Plant Material Center manager, supervisor and field crews).

[ILLINOIS] Our target audience covers the spectrum from crop production to end use. On a regular basis, we meet with and disseminate information to crop producers, crop genetics industry, agricultural chemical companies, commodity production groups (e.g., Illinois Corn Marketing Board, National Corn Growers Association), grain industry groups (e.g., North American Millers Association, Corn Refiners Association), corn processor representatives, and government regulatory agencies.

[IOWA] Biorefinery companies, feed companies, scientific community and general public

[KANSAS] All crop producers in the world, especially camelina producers in Montana, Wyoming, Kansas, and middle west great plains in the USA; Agricultural professionals; Biobased products/biofuel industries; Scientists in the field of plant science, biofuels, biomaterials, bioeconomy, etc.

[KENTUCKY] Biofuel scientific community, graduate students, post-doctoral students, faculty.

[LOUISIANA] Asphalt paving industry

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

[MISSISSIPPI] Our target audience for this work includes commercial growers and manufacturers of biofuels and other scientists in the field of biomass or biogas conversion into liquid fuels.

[MISSOURI] Professional researchers and bioenergy, bioprocess and aquaculture stakeholders, investors and operators

[NEW JERSEY] Professional (scientists and business) personal, decision makers, farmers and utility companies

[NORTH DAKOTA] Agricultural producers, biofuel and biomass processors, biofuel investors, other researchers, university students.

[OHIO] Farmers, agricultural and bio-based industry.

[OKLAHOMA] Scientists, engineer, policymakers, entrepreneurs and Investor in bioenergy and biobased products.

[OREGON] Researchers at peer institutions and federal laboratories. Graduate, Undergraduate and high school students.

[PENNSYLVANIA] The target audience for Dr. Ali Demirci's research includes science discovery and biomass processing companies ranging from small start-ups. Agricultural stakeholders include state and national organizations, state and federal agencies. Communities are interested in these technologies from economic and community development perspectives. 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), scientific journal articles and extension publications. The project results will be benefit bioprocessing/fermentation industry in general as a result of production of value-added products and bioenergy from raw agricultural products or by-products.
The target audiences for Dr. Tom Richard's 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.
The target audience for Dr. Howard Sellis's research includes science discovery and biomass processing companies ranging from small start-ups. Agricultural stakeholders include academic and industrial members of the Synthetic Biology and Metabolic Engineering fields, state and national organizations, state and federal agencies. Communities are interested in these technologies from economic and community development perspectives. 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), scientific journal articles and extension publications. The project results will be benefit bioprocessing/fermentation industry in general as a result of production of value-added products and bioenergy from raw agricultural products or by-products.

[SOUTH CAROLINA] The results have been disseminated to students, peers through journal articles and book chapters, and to the National Biodiesel Board meetings.

[TENNESSEE] Original Equipment Manufacturers (OEM) are targeted for the design, manufacture, and market equipment systems related to the harvest, handling, storage, transport, densification, pre-processing, and conversion of biomass to fuel and co-products. In other words, the target considers the potential new cellulosic biofuels industry for farm-to-biorefinery.

Farm producers, biomass supply logistics firms, truckers, and biorefineries are targeted for the impact of supply logistics on conversion processes. Farmers are an important target for creating economically-viable biomass feedstock supplies since they make important decisions regarding the production and harvest of biomass crops to meet specifications acceptable to downstream conversion processes. Supply logistics firms can affect the quality of biomass since exposure to climatic elements affects biomass degradation and introduction of inhibitors. Truckers move biomass from farms to depots and/or biorefineries and possibly other points along the supply chain. Their understanding of moving biomass with seasonal harvest constraints and specification quality are paramount in the successful deployment of a supply chain. Biorefineries need of understand the importance of defining target biomass specifications that affect their processes, and the acceptable range of tolerances as it affects the cost of supply and conversion.

[WISCONSIN] Technical audience through papers and presentations.

6. PARTICIPANTS:

1. ARKANSAS
    a. Danielle Julie Carrier, Biological and Agricultural Engineering
    b. Thomas A. Costello, Biological and Agricultural Engineering
2. ALABAMA
    a. Sushil Adhikari
    b. Oldiran Fasina
3. CALIFORNIA
    a. Bryan M. Jenkins, University of California, Davis
    b. Stephen R. Kaffka, University of California, Davis
    c. Yueyue Fan, University of California, Davis
    d. Quinn Hart, University of California, Davis
    e. Varaprasad Bandaru, University of Maryland
    f. Nathan Parker, Arizona State University
    g. Rick Gustafson, University of Washington
    h. Amanda Hildebrand, University of California, Davis
    i. Takao Kasuga, University of California, Davis
    j. Hui Lin, University of California, Davis
    k. Zhiliang Fan, University of California, Davis
    l. Jean VanderGheynst (UC Davis)
    m. Brendan Higgins (UC Davis)
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    r. John Labavitch (UC Davis)
    s. Oliver Fiehn (UC Davis)
    t. Yi Zheng (Clemson)
    u. Yu-Shen Cheng (National Yunlin University of Science and Technology)
    v. Steve Singer (LBNL)
    w. Blake Simmons (Sandia)
    x. Michael Thelen (LLNL)
    y. Ruihong Zhang (UC Davis)
    z. Tyler Barzee (UC Davis)
    aa. Abdolhossein Edalati (UC Davis)
    bb. Hamed El-Masha(UC Davis)
    cc. Natthiporn Aramrueang (UC Davis)
    dd. Steve Zicari (UC Davis)
4. HAWAII
    a. Samir Khanal
    b. Andrew Hashimoto
    c. Richard Ogoshi
    d. John Yanagida
5. ILLINOIS
    a. Principal Investigators:

        i. Kent Rausch, ABE
        ii. Vijay Singh ABE
        iii. Mike Tumbleson ABE
    b. Co-Investigators*
        i. Julie Carrier University of Arkansas
        ii. Grace Danao ABE
        iii. Bruce Dien NCAUR, ARS
        iv. Nicki Engeseth FSHN
        v. Jia Guo Crop Sciences
        vi. David Johnston ERRC, ARS
        vii. Yong-Su Jin FSHN, Institute for Genomic Biology
        viii. Suryang Kwak FSHN
        ix. D. K. Lee Crop Sciences
        x. Nasib Qureshi NCAUR, ARS
    c. Graduate Students
        i. Ravi Challa
        ii. Sun Min Kim
        iii. Ben Plumier
        iv. Divya Ramachandran
        v. Ju Tian
        vi. Zhaoqin Wang
        vii. Yizhe Bruce Zhang
    d. Post Docs
        i. Haibo Huang
        ii. Ming-Hsu Chen
6. IOWA
    a. Dr. Buddhi Lamsal, Department of Food Science and Human Nutrition.
    b. Dr. Kurt Rosentrater, Agricultural and Biosystems Engineering Department
    c. Dr. Rajraman D.; Agricultural and Biosystems Engineering Department
    d. Rajat Sharma
    e. Bill Colonna
7. KANSAS
    a. Susan X. Sun
    a. Donghai Wang
    b. Praveen Vadlani
8. KENTUCKY
    a. Sue Nokes
    b. Czarena Crofcheck
    c. Michael Montross
9. LOUISIANA
    a. Ioan I Negulescu
10. MICHIGAN
    a. Carl Lira
    b. Dennis Miller
    c. Chris Saffron

d. Mark Worden
e. David Hodge
f. Bruce Dale
g. Jackson

11. MINNESOTA
   a. Roger Ruan
   b. Paul Chen
12. MISSISSIPPI:
   a. Fei Yu, Ph.D., Associate professor, Department of Agricultural and Biological Engineering, Mississippi State University, Box 9632 Mississippi State, MS, 39762
13. MISSOURI:
   a. David E Brune, Professor Bioprocess and Bioenergy Engineering, University of Missouri, Columbia MO. 65211
14. MONTANA
   a. Chengci Chen
   b. Peggy Lamb
   c. Kent McVay
15. NEBRASKA
   a. Deepak Keshwani, Associate Professor, Biological Systems Engineering, Univ. of Nebraska, Lincoln.
16. NEW JERSEY
   a. Gal Hochman (Rutgers University)
   b. Qing Li (Rutgers University)
   c. Shishi Wang (Rutgers University)
   d. Mook Bangalore (Rutgers University)
   e. Scholastica Okoye (Rutgers University)
17. NORTH DAKOTA
   a. Cannayen Igathinathane
   b. Scott Pryor
   c. Dennis Wiesenborn
18. OHIO
   a. Yebo Li (PI)
   b. Vasco Correa Juliana
   c. Xumeng Ge
   d. Liangcheng Yang
   e. Fuqing Xu
   f. John Sheets
   g. Xinjie Tong
   h. Xiaolan Luo
   i. Ratanachat Racharaks
   j. Stephen Y. Park
   k. Mary Wick
   l. Zhe Liu
   m. Jiying Zhu
19. OKLAHOMA

a. Mark Wilkins
b. Ajay Kumar
c. Hasan Atiyeh
d. Raymond Huhnke
e. Michael Buser

20. OREGON
   a. Principal Investigators: Ganti S. Murthy, Michael H. Penner
   b. Graduate Students: William Hohenschuh, Allexander McDaniel, S.M.H. Tabatabaie Haider Khadhum, Shu Jiang, and Tuba Karraarslan
   c. Undergraduate students: Lily Xu, Crystal Oldfield, William Wallach, Jared Johnson, and Lettie Morse
   d. High School students: Nicole Niskansen and Jacob Thor.
21. PENNSYLVANIA
   a. Ali Demirci
   b. Tom Richard
   c. Howard M. Salis
   d. R.J. Elias (Penn State)
   e. P.H. Patterson (Penn State)
   f. A. L. Pometto III (Clemson University)
   g. I. Turhan (Akdeniz University, Turkey)
   h. T. Tekinay (Gazi University, Turkey)
   i. Charlie Anderson (Penn State University)
   j. Jay Regan (Penn State University)
   k. Manish Kumar (Penn State University)
   l. Gong Chen (Penn State University)
   m. Bruce Dale (Michigan State University)
   n. Lee Lynd (Dartmouth College)
   o. Justin Gallivan (Emory University)
   p. Costas Maranas (Penn State University)
   q. Thomas Wood (Penn State University)
   r. Hal Alper (University of Texas at Austin)
   s. Andrew Ellington (University of Texas at Austin)
   t. Christopher Voigt (MIT)
   u. Richard Murray (CalTech)
   v. Jingxin Wang (West Virginia University)
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22. SOUTH CAROLINA
   a. Terry Walker
23. SOUTH DAKOTA
   a. Lin Wei
   b. Kasi Muthukumarappan
24. WASHINGTON
   a. Bin Yang

25. WEST VIRGINIA
    a. Kaushledra Singh
    b. Litha Sivanandan
26. WISCONSIN
    a. Troy Runge
    b. Sundaram Gunasekaran
27. TENNESSEE
    a. Prof. Alvin Womac, Biosystems Engineering, The University of Tennessee.
28. TEXAS
    a. Sergio Capareda, PhD, PE
    b. Nanjappa Ashwath, PhD
    c. Amado Maglinao, PhD
    d. Nam Hyungseok, Graduate Student
    e. Jinjuta Kongkasawan, Graduate Student
    f. Alexander Ido, Graduate Student

7. SYNERGISTIC ACTIVITIES:

1. ALABAMA
    a. The investigators are involved in NIFA CAP project with investigators from North Carolina, Tennessee and Georgia.
    b. Investigators serve on panel review teams of several grant agencies in United States.
2. ARKANSAS
    a. Danielle Julie Carrier working with Mark Wilkins, Oklahoma State University Investigating fungal degradation of switchgrass in a controlled storage environment. Sun Grant South Central / Oklahoma State University/USDA. Total Award Amount: $110,000. Total Award Period Covered: 10/01/14 – 08/31/16
    b. Danielle Julie Carrier working with Vijay Singh, University of Illinois. This unfunded collaboration resulted in: Chen H-H**, Rajan K,** Carrier DJ and Singh V. (2015). "Separation of xylose oligomers from autohydrolyzed *Miscanthus x giganteus* using centrifugal partition chromatography." *Food and Bioproducts Processing* 95: 125-132. (and will be counted in 2016 report).
3. CALIFORNIA
    a. More general knowledge of algal systems has been disseminated by means of curriculum development and teaching at the K-8 and undergraduate levels. Participant Brendan Higgins taught a series of lessons on algal bioreactors and photosynthesis to three 6th grade classes at Leonardo Da Vinci K-8 School in Sacramento during the 2014-2015 school year. Students constructed bioreactors and measured algal growth in the presence and absence of light. Participant Lauren Jabusch was an NSF GK-12 RESOURCE fellow during the 2014-2015 academic year and taught lessons related to algal cell walls. Students constructed algenate capsules to simulate algal polysaccharide cell walls and learned about polysaccharide hydrolysis.
    b. Brendan Higgins also developed a laboratory exercise that was integrated into the freshman engineering design course "Foundations in Biological Systems Engineering" at the UC Davis. As part of this course, student groups constructed algal photobioreactors and cultivated algae over several weeks. This laboratory exercise taught the students how to measure nitrogen in the medium before and after algae growth. This activity demonstrated to students that algae have the ability to remove nutrients from wastewater.
    c. The geo-spatial model can be applied to multiple states including California, Washington, Oregon, Idaho, and Montana.
4. IOWA
    a. There is ongoing collaboration with Louisiana State University and Columbia University on testing marine toxicity and surface properties of biosurfactants/ isoforms produced at ISU.
5. KANSAS
    a. KSU is a lead PI of the BRDI project entitled "Enhancing economic viability of camelina as biofeedstock: optimization and demonstration of the production system and bioproduct development" collaborated with Montana State University, University of Wyoming, and industries. KSU also continues to lead and participate in the Sun Grant Regional bioenergy projects with Oklahoma State

University, Texas A&M University and North Carolina State University. KSU is also part of another USDA-BRDI project lead by Ceramatec Inc.

6. KENTUCKY
    a. University of Wisconsin ABE department – worked with an MS student on an LCA for our on-farm bioprocessing system.
7. MINNESOTA
    a. We collaborated with investigators at South Dakota State University, Washington State University, and Mississippi State University in research and grant writing activities. We established external partnerships with agencies and companies including Minnesota Metropolitan Council Environment Services, Minesga.
8. MISSISSIPPI
    a. We are continuing to participate in the USDA Biomass Research and Development Initiative (BRDI) project collaborating with Ohio State University, University of Georgia and industry collaborators such as quasar energy group (quasar), American Electric Power (AEP), Aloterra Energy, Marathon, and Case IH. Our semi-continuous process for biogas conversion into liquid hydrocarbon contains biogas purification, methane dry reforming, and catalytic conversion steps. The real biogas to biofuel process will be tested in the following year.
9. NEBRASKA
    a. Loren Isom, University of Nebraska – Industrial Agricultural Products Center
    b. <u>South Dakota State University</u>: coordinated with Dr. K. Muthukumarappan and his graduate students on extrusion research efforts utilizing University of Nebraska – Industrial Agricultural Products Center equipment and laboratory facilities.
    c. <u>USDA/DOE BRDI program</u>: coordinated with Daniel Cassidy, BRDI program leader to follow-up on coordination of project reviews for BRDI projects nearing completion. All of the projects considered for review in the spring of 2015 received project extensions, so site-visit reviews will not be scheduled until spring 2016.
10. NEW JERSEY
    a. Work with Shishi Wang led to cooperation between the New Jersey station and the Ohio station (Dr. Yebo Li)
    b. Work with Qing Li led to cooperation with the University of Missouri (Dr. Caixia Wan).
11. PENNSYLVANIA
    a. Most of our research is coordinated with larger research and extension teams. Of particular note are the NorthEast Woody/Warmseason Biomass (NEWBio) Consortium, which includes a dozen universities and national labs and includes regions and stakeholders in Ohio, West Virginia, Maryland, Pennsylvania, New York, Delaware, Maryland New Jersey, Vermont, New Hampshire, Connecticut and Maine. The Richard Lab is also participating in multi-state supply chain research project as part of the FAA ASCENT Center of Excellence for alternative aviation fuels, and in that project are collaborating with Washington State University, Purdue, the University of Illinois, the University of Tennessee and MIT.
    b. Salis served on an NSF review panel in the BBBE program (Engineering).

c. Salis co-chaired sessions at the American Institute of Chemical Engineer's annual meeting and at the Society for Industrial Microbiology and Biotechnology's annual meeting.
d. Salis co-advised the 2014 iGEM undergraduate team with Tom Richard.

12. OHIO
    a. We have collaborated with Mississippi State University (Dr. Fei Yu) and University of Georgia (Dr. Sudagar Mani) working on the BRDI project for the production of liquid hydrocarbon fuels from lignocellulosic biomass via anaerobic digestion.
13. OREGON
    a. University of Hawaii.
    b. Washington State University.
    c. Northern Regional Research Center, ARS, USDA, Peoria, Illinois.
    d. Addis Ababa University, Addis Ababa, Ethiopia.
14. OKLAHOMA
    a. University of Oklahoma
    b. Ohio State University
    c. Kansas State University
    d. North Carolina State University
15. TEXAS
    a. Development of collaborative research and commercialization proposal with Texas Tech University (c/o Dr. Michael farmer)
    b. Writing of collaborative papers for oublication with Oklahoma State University (c/o Dr. Ajay Kumar)
    c. Host to faculty visits (OSU, Dr. Ajay Kumar and Auburn University, Dr. Sushil Adhikari)
16. WEST VIRGINIA
    a. Organizing committee member for hosting the Bioenergy Day on July 28, 2015, New Orleans, LA during the American Society of Agricultural and Biological Engineers' Annual International Meeting
    b. Proposals reviewed for USDA Higher Education Challenge Grant
    c. Lead the preparation and publication of a standard: ANSI/ASABE S516 - Terminology for Forest Operations and Equipment
    d. Hosted Boyd-Scott Graduate Student Research Award Competition for M.S. and Ph.D categories