Alabama Research and Development Enhancement Fund
Quarterly Report
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shonda.gray@adeca.alabama.gov

Street Address: 401 Adams Avenue, Suite 560
Montgomery, Alabama 36104-4325

Mailing Address: Post Office Box 5690
Montgomery, Alabama 36103-5690

Background

The Alabama Innovation Act (AIA) was established by Legislative Act #2019-404 and became effective June 6, 2019. The Act designated the Alabama Department of Economic and Community Affairs (ADECA) as the state agency to establish and administer the Alabama Research and Development Enhancement Fund (ARDEF) Program.

The purpose of the ARDEF Program is to encourage new and continuing efforts to conduct research and development activities within the state. The Fund is designated to receive appropriations from the legislature, or from the receipt of gifts, grants, or federal funds to be expended for the purpose of increasing employment opportunities and products and services available to the citizens of Alabama.

Overview of 2020 Program Year

Projects Funded Under 2020 Round One Grant Period

Applicant	Amount
Auburn University – Removal of Per- and Polyfluoroalkyl Substances (PFAS) in Water and Landfill Leachate in Alabama	$193,960.00
Auburn University – Knitting Micro-Resolution Mosquito Bite Blocking Textiles	$868,145.00
Auburn University – Advanced Biosensors from Forestry Products and Agricultural Resources	$245,864.77
HudsonAlpha Institute for Biotechnology – Advancing Genomic Health in Community Clinics and Employee Wellness Settings	$969,409.00

Auburn University – Removal of Per- and Polyfluoroalkyl Substances (PFAS) in Water and Landfill Leachate in Alabama

This project aimed to remove and destroy the so-called forever chemicals, per- and polyfluoroalkyl substances (PFAS), from Alabama water and landfill leachate. PFAS have been detected in chemical manufacturing wastes and landfill leachate in Alabama and have caused some serious cases of drinking water contamination in the state. Ongoing health concerns and regulatory development associated with PFAS are threatening the sustainable development of the Alabama economy and business. The goal of this research was to develop an innovative "Concentrate-&-Destroy" technology to cost-effectively remove and degrade PFAS in water and landfill leachate. The new remediation technology will provide the affected industries and water utilities with a powerful remediation means to mitigate the PFAS-related issues, thereby assuring sustainable development of the economy and the wellbeing of Alabama citizens.

Within this quarter, our research focused on evaluating the effects of pH and common cations in water on PFAS adsorption and enhancing PFAS photodegradation by Ga/TNTs@AC through addition of Fe3+. We acquired important experimental data on the adsorption and photodegradation of PFOS (as a model PFAS). The adsorption data showed that acidic condition is more favorable for PFOS (20 mg/L) removal. In addition, the presence of cations (10 mM Na+, K+, or Ca2+) could enhance the PFOS uptake on 2%Ga/TNTs@AC under the identical conditions.

While the water matrix in the field water showed some notable inhibition on the PFOS photodegradation, the introduction of Fe3+ in the reaction system during the photodegradation process could remarkably facilitate the PFOS degradation efficiency. We were able to achieve >70.0% of PFOS mineralization and 80.4% photodegradation when 60 µM Fe3+ was present, which are nearly three times higher than those without Fe3+.

Auburn University – Knitting Micro-Resolution Mosquito Bite Blocking Textiles

Insects transmit crippling diseases to humans. Nearly a half-million people die of malaria each year. In Alabama, citizens encounter Dengue and Zika virus invasions as well as a multitude of encephalitis variants. The worse vector-borne diseases are transmitted in the hottest climates like Alabama, and it is uncomfortable to wear the thickest clothing. This project will research different textile and weave patterns to create clothing that is cool in heat and capable of blocking mosquito bites and develop prototypes based on this research. Beyond the prototype phase, research will be done to measure the effectiveness this product will have on the Alabama economy.

The purpose of our project is to knit micro-resolution mosquito bite blocking textiles that are comfortable in hot weather. This is the seventh quarterly report for this project. During this quarter we developed a methodology to measure and assess air permeability of our textiles. We graduated our first master's student, and we are submitting their research in a publication this coming quarter. We also found one more new class of knitted textiles that are capable of blocking which will expand the project. At this point we have a total of 6 unique knitted structures that block. We worked with Auburn knitting company to develop a market plan for manufacture and sale of the textiles. To promote the project, we also began generating video reports and training videos to advance knitting technology in Alabama. We produced a total of 18 YouTube videos to share the message.

Our best video received 941 views:
https://www.youtube.com/watch?v=mCRoAxPuMBM&list=PLH9_064rL71AEfekFjqkFUeOeCETTXmcq&index=1

Auburn University – Advanced Biosensors from Forestry Products and Agricultural Resources

The main goal of this project is to utilize Alabama's forestry products and agricultural resources for extracting cellulosic nanomaterials (CNM) by using these nanomaterials in advanced biosensing. As timber production and other agricultural products are essential for the economy in Alabama, these materials are a great resource for obtaining cellulosic nanomaterials.

Outstanding laboratory facilities along with the support from ADECA are enabling scientific knowledge contributions and revalorization of agricultural and forestry waste products as biosensors. Trees and crops contain tiny materials known as cellulose nanomaterials (CNMs). Developing new applications for CNMs could enable forestry and crop waste to provide additional economic benefits for Alabama citizens. An Auburn University research team is exploring using CNMs from cotton, soybean hulls, and wood to produce sensors for the detection of allergens and water contaminants. Thus far, the team has shown that CNMs can be used to absorb carbofuran which is a common pesticide. They have also shown that CNMs can be used to absorb beta-

lactoglobulin, a milk allergen. In ongoing work, they are improving the chemistry to make sensors that cannot only absorb multiple species but also selectively detect the materials of interest (analytes). The long-term goal of this work is to have a family of portable CNM sensors that can be used by citizens to test for water contaminants and food allergens.

This project is focused on using Alabama's forestry and agricultural products such as wood, cotton, and soybean hulls as sources of an exciting nanomaterial called cellulose nanocrystals (CNC). Cellulose nanocrystals are found in all biomass. Their high strength, large specific surface area, and natural organic chemistry make them exciting for a range of applications. We are focused on developing sensors to improve water safety and the health of Alabama citizens. Specifically, we are working on modifying CNCs to enable them to be used to detect pesticide residues in water. We are also exploring their use in detecting food allergens such as milk allergen, β-lactoglobulin. We are using laboratory tools such as Quartz Crystal Microbalance with Dissipation (QCMD) and Surface Plasmon Resonance (SPR) to validate our approach. So far, we have increased the stability of the CNC when exposed to water and demonstrated analyte absorption. Our current focus is on increasing the selectivity of the detection and understanding differences between the agricultural and forestry derived CNC's. The outstanding lab facilities of Auburn University and the support from ADECA are helping the research team continue to gain insights on how an exciting material hiding in our abundant forestry and agricultural resources can be transformed to enable Alabama citizens to detect contaminants and allergens in their water and food.

HudsonAlpha Institute for Biotechnology – Advancing Genomic Health in Community Clinics and Employee Wellness Settings

Genomic medicine is a form of precision medicine that uses approaches customized to each patient to treat disease and optimize prescription medicine based on a genetic profile. This project will test and develop a genomic health complete delivery system for Alabama patients and physicians at healthcare systems and community hospitals with limited expertise in genomics. This system includes 1) Partnering with Auburn University to develop community-based models for health programs, 2) Refining and optimizing the process including insuring access by rural and underserved areas, and 3) Developing the health IT infrastructure needed to fully integrate genetic test reporting and education into an electronic health records system. The proposed development of new products and services will result in improved health outcomes for Alabamians, opportunities for employers to increase competitiveness and reduce costs, and modernization of health care in an equitable way for Alabama communities, large and small, regardless of socioeconomic status.

We have made progress in the seventh quarter of funding by continuing to expand pharmacogenetic testing at existing partner sites (Auburn University, Miles College, Drake State, and Oakwood University), and have recently added Alabama A&M to the project. We will soon begin testing and roll-out of a HIPAA-compliant portal that will enable delivery of genetic test results to clinicians and patients, coupled with just-in-time educational content.

Projects Funded Under 2020 Round Two Grant Period

Applicant	Amount
University of Alabama in Huntsville – Alabama Business Resiliency and Sustainability Index and Roadmap	$746,104.00
University of Alabama in Huntsville – Rural Employment and the Need for an Alabama Irrigated Acreage Survey, Demand Estimate and Forecast	$172,073.00
University of Alabama at Birmingham – A Comprehensive Data Science Software Toolkit to Improve Alabama's Mobility Planning for Serving Businesses and Vulnerable Populations	$394,926.00
Auburn University – Design, Fabrication and Testing of Novel Medical Facemasks to Prevent COVID-19	$75,374.00
Auburn University – Formaldehyde Paper-based Device (PAD) for a Cost-efficient Detection of Formaldehyde Emissions from Wood Panels	$247,142.00
University of Alabama at Birmingham – Commercialization of Small Diameter Artificial Vascular Graft for an Animal Trial	$906,458.00
Bashan Institute of Science – Exploring the Use of Cellulose Fibers as Microcapsules for Plant Growth-promoting Bacteria (PGPB) Inoculants	$7,500.00

University of Alabama in Huntsville – Alabama Business Resiliency and Sustainability Index and Roadmap

Recent events, such as the global COVID-19 pandemic, are having detrimental impacts on companies throughout Alabama, including the products and services they provide and the citizens they employ. Other impactful events that can occur may include the sudden loss of a major customer or supplier, a natural disaster, or even a diminishing source of skilled labor. The objective of this project is to research potential impacts on businesses and organizations across several business sectors to develop and deploy a comprehensive Resiliency and Sustainability Index and Roadmap (RSIR) model. The RSIR can be further tailored to fit each business sector and individual organization. Additionally, the UAH team will directly support businesses in the customization and implementation of their RSIR along with assistance in developing the ability to execute the roadmap and plan should the need arise.

The Roadmap and Index for Sustainability and Resiliency (RISR) assessment process has been improved to facilitate more meaningful discussion with the business and reduce their time commitment during an assessment. The detailed model remains the same to retain the comprehensiveness of the assessment and drill-down value of the results. The approach to conducting the assessment has been redesigned to shift from a question-by-question type interview to a more open discussion on each segment of the model. It is anticipated that the time commitment for the business being assessed will be reduced by approximately 50% while maintaining the quality of the results.

Outreach materials are being finalized under the Future Ready brand. The Future Ready website is up and running at futurebusinessready.org and currently being updated with additional content. The initial workshop to business and industry was hosted by The Catalyst Center for Business &

Entrepreneurship and successfully completed with over 70 attendees. Four additional workshops are being scheduled for the next quarter.

The beta test has been completed with an Alabama manufacturer to prove out the assessment process and solicit feedback from the business to improve the engagement process. Other businesses are being recruited as part of the full engagement schedule.

University of Alabama in Huntsville – Rural Employment and the Need for an Alabama Irrigated Acreage Survey, Demand Estimate and Forecast

As irrigated agriculture develops in our rural communities, it is imperative Alabama has the tools and data needed to ensure water resources are available for sustainable economic development. The goals of this project are to update the existing manual center pivot irrigation survey completed by UAH for the years to include 2017 and 2019 and develop a state-specific machine-learning framework from multiple sources of remote sensing products to efficiently and semi-autonomously identify the irrigated areas in Alabama to include all irrigated land such as golf courses and other irrigation system types beyond just center pivots. This information will be used to update the report "Estimates of Future Agricultural Water Withdrawal in Alabama", produced by the Water Resources Center, Auburn University for OWR in 2017. The result will include updated estimates as well as methodologies utilizing more recent urban growth and land use change data. The results and outcomes of this project will support the Alabama Department of Economic and Community Affairs (ADECA) Office of Water Resources (OWR) to accurately analyze and forecast water use across the State.

During Q1 22, the team finalized the estimation of irrigated areas for 2019 and now have a complete data of irrigation from 2006 – 2019 for the years that the NAIP imagery is available (2006, 2009, 2011, 2013, 2015, 2017, 2019).

Additionally, the UAH team has refined the satellite-based automatic irrigation detection scheme over the AL domain since the last report time. Leveraging the various signals from multiple satellite products as well as an improved machine-learning analytic framework, we can achieve a relatively high recall rate (> 80% - 95%) across different crop landscapes and regional climate features. In the next step, the team continues to improve the precision of modeling outputs while improving the code accessibility for a python-based tool that supports map generation for the future beyond the project timeline.

Lastly, the TerrSet Land Change Modeler was used to estimate irrigation acreages out to 2040 employing a variety of methods that are in the software including the Multi-Layer Perceptron and Decision Forest models. We run the model scenarios using LULC data for 2006 and 2016, soil groups, roads, and streams data.

University of Alabama at Birmingham – A Comprehensive Data Science Software Toolkit to Improve Alabama's Mobility Planning for Serving Businesses and Vulnerable Populations

This project focuses on the development of a comprehensive data science software toolkit to support transportation planning for Alabama's businesses and vulnerable populations. Research activities include: (i) use of transportation user surveys and open data source collection to build a

web-based data portal for mobility analysis in Alabama; (ii) development of agent-based urban transportation simulation models, and employment of machine learning techniques for transportation forecasts; and (iii) use of the developed tools to study scenarios that address pressing mobility needs in Alabama. Examples include (1) building a COVID-19 simulator to explore how various business reopening strategies affect the population's mobility and hence the virus spread; and (2) studying the impact of shared mobility services such as Uber/Lyft/Via, Zyp BikeShare stations and dockless electric scooters on local traffic congestion, transit use; and accessibility and mobility of vulnerable populations. The project will provide helpful recommendations to transportation policymakers about transportation initiatives that can help Alabamians, including economically and physically disadvantaged ones, to gain access to jobs and critical amenities in an equitable and efficient manner.

During the reporting period of January to March 2022, the team has been working on postprocessing and cleansing the Uber drivers' ride data collected from our Uber driver survey that is IRB approved. We surveyed 8 different drivers in Greater Birmingham, and we have collected 4,229 Uber ride screenshots with the identity information properly anonymized. Taking screenshots from smartphones is found to be the most efficient and least error-prone way compared with asking the drivers to extract their ride information for us by themselves, which would otherwise require a lot of training on the participants' side. A separate group of team members use the pool of anonymized screenshot images for postprocessing and future analysis. One challenge in the postprocessing is that a screenshot image only provides vague origin and destination street names at the top to protect passenger privacy, along with a small trajectory image overlayed on top of a map; in contrast, we would like to recover the location coordinates of the origin, destination, and critical points on the trajectory with reasonable accuracy. For this purpose, we designed a bonus project to distribute the screenshots to 155 students who are taking CS 685/785 Foundations of Data Science at UAB Department of Computer Science, guiding them to use Georeferencer (https://www.georeferencer.com) to first align each screenshot map to the actual map, and then find origin and destination locations as well as key locations on the trajectories. This data extraction process is now complete, and our team is still working on cleansing the student submissions but has cleansed most of the student annotations. Using the cleansed data, we have conducted analysis with trajectory heatmap plots and a D3.js visualization of ride interactions between different zip code areas. Our next step is to complete the cleansing of the extracted data and use spatiotemporal network kernel density estimation to fit the ride data distribution, which will then be used to generate realistic Uber ride day-plans to be integrated into our current MATSim simulation model to bring insight on the impact generated by TNC demand and traffic.

Auburn University – Design, Fabrication and Testing of Novel Medical Facemasks to Prevent COVID-19

This research will focus on design, fabrication, and testing of novel medical face masks to reduce and prevent spread of coronavirus COVID-19. Various woven, knitted and nonwoven fabrics and their combinations will be examined to be used in surgical face masks and N95 respirators. Computer aided design (CAD) of fabrics will be generated and virtually tested. After choosing the right fabrics based on these computer tests, prototypes of Surgical Face Mask Level 1 and N95 respirator will be produced. These masks will be tested against the ASTM (formerly known as American Society for Testing and Materials), Food and Drug Administration (FDA) and National Institute for Occupational Safety and Health (NIOSH) standards. Upon passing the tests, the technology and know-how that is developed will be used either in a start-up company or will be

licensed to an existing U.S. commercial textile company to mass produce masks and respirators for public use in the next phase.

During this reporting period, improvements of the facemask design continued. Prototype-7 of the mask series retains the shape and construction of the previous iteration but includes the addition of a silver nanoparticle coating provided by HeiQ Materials. The coating material was atomized using a broadband ultrasonic generator and applied using an ultrasonic nozzle. To evenly dispense the coating onto the substrate, a programmable coating system I&J4300-LF Benchtop Dispensing Robot was utilized to automate dispensing. To test the performance of the masks, and to evaluate the performance effects of the silver nanoparticle coating, a test was performed in which the mask was worn during light exercise. Blood-oxygen percentage was recorded before and after each walking session, and heartrate was recorded throughout each session.

The tests all had very similar heart rate performance, which indicates that wearing a mask with or without a coating does not significantly affect heart rate behavior during light prolonged exercise.

Auburn University – Formaldehyde Paper-Based Device (PAD) for a Cost-Efficient Detection of Formaldehyde Emissions from Wood Panels

Formaldehyde emission can be toxic to people depending on the time of exposure coupled with formaldehyde concentration. This level of exposure is generally not high in forest products because companies that make indoor products currently measure formaldehyde through quality control techniques. Companies also use safe adhesives (“glues”) by partnering with their suppliers. Nevertheless, these companies are regulated to federal standards such as the California Air Resources Board (CARB) to ensure this safety. To assist with the more expensive and laborious methods in CARB, this project endeavors to create a relatively cheap paper-based sensor that changes color based on formaldehyde exposure. Such a product can help to reinforce the safety of our forest products while maintaining the jobs of our many Alabamians.

The project entitled "Formaldehyde paper-based device (PAD) for a cost-efficient detection of formaldehyde emissions from wood panels" focuses on the development of a prototype of a paper-based device (PAD) for measuring formaldehyde concentration in air. The ultimate goal for the project is to develop an easy, rapid, accurate analytical tool for the determination of formaldehyde in air, at concentration levels below 1 ppm.

The research work conducted during the first quarter of 2022 focused on the fabrication of the formaldehyde sensor tool (FAST) for the detection of formaldehyde in air, and the validation of the colorimetric tool using ASTM D6007-14.

For this purpose, image analysis and statistical treatment have been conducted to determine the error of the method and to evaluate the performance of this tool for measuring the volatile compound. The activities have been performed according to the proposed timeline.

University of Alabama at Birmingham – Commercialization of Small Diameter Artificial Vascular Graft for an Animal Trial

The goal of the project is to finalize the development of an artificial vascular graft for surgical implantation. The graft has relevance to the current COVID-19 pandemic in that numerous patients

are reporting kidney infections and blood clots. UAB has been working on this project since 2007 and has reached a point where funds are needed for an animal trial. Once this graft has been validated through this process, we plan to market it to a biomedical implant company to set up a division in Alabama or to establish a spin off company for the production and distribution. This graft has the potential for an estimated $50 million in annual sales based on conservative estimates of the number of surgical interventions that could use the implant in an unmet market and lead to a number of jobs for highly skilled workers in the State of Alabama.

We have completed the final non-survival animal procedure and report that it also was successful. We are now preparing for the first survival study where we plan to have three groups of animals: a control group which will consist of the graft prepared with no modifications, a group with the graft prepared with a plasma treatment, and a group with grafts prepared with plasma treatment and a special peptide bonded to the surface of the graft. These animals will be observed for 21 days and then euthanized and the grafts extracted for analysis.

Bashan Institute of Science – Exploring the Use of Cellulose Fibers as Microcapsules for Plant Growth-Promoting Bacteria (PGPB) Inoculants

Inoculation of plants with plant growth-promoting bacteria (PGPB) that enhance the yield of crops and growth performance of environmental plants is an old practice. Two main factors control the success of inoculation—effectiveness of the bacteria and application technology. If the suspensions of bacteria are inoculated into the soil without a proper carrier, the bacteria population declines rapidly. These unprotected inoculated bacteria must compete with the often better-adapted native microflora and withstand predation by soil microfauna. Consequently, a major role of formulation of bioinoculants is to provide a more suitable microenvironment, combined with physical protection for a prolonged period to prevent a rapid decline of introduced bacteria. This project explores the feasibility of using cellulose fibers as carriers, to improve survival and enhance the PGPB viability. In the last quarter of the project, we assessed the effective colonization of the fibers by the bacteria, having a visual record of this association. The results evidenced the potential of cellulose fibers for carrying *Azospirilum brasiliense* and helped our team to complete the first phase in the search for a long-term cost-efficient inoculant system.

Overview of 2022 Program Year

Projects Funded Under 2022 Grant Period

Applicant	**Amount**
The University of Alabama – Innovative Wood-Concrete Composite Structural Elements for Resilient Modular Building and Transportation Structures	$341,679.00
Auburn University – Advanced Liquid Transportation Fuels from Co-Liquefaction of Forest Biomass and Waste Plastics	$727,677.00
Auburn University – Novel Biotechnology that Converts Agricultural and Municipal Waste into Bioplastics	$294,008.00
HudsonAlpha Institute for Biotechnology – Next Generation Crops for a Diverse Alabama Agricultural Economy	$968,365.00

The University of Alabama in Huntsville – Versatile Training to Provide an Agile, Advanced Manufacturing Workforce in Alabama	$603,206.00
Auburn University – Polymer Smart Machines	$268,353.00
University of North Alabama – Surface Plasmon Resonance-based Biosensors	$10,353.33
Auburn University – Novel and Sustainable Feed Binder from Soybean Hulls	$300,432.00
The University of Alabama at Birmingham– Amputation	$700,000.00
The University of Alabama at Birmingham – Pneumococcal Vaccine	$635,926.67

The University of Alabama – Innovative Wood-Concrete Composite Structural Elements for Resilient Modular Building and Transportation Structures

This research project focuses on the development of innovative materials and construction techniques that can help improve the sustainability and resilience of Alabama building and transportation infrastructure. The overall research goal of this project is to develop innovative hybrid structural building elements using fiber reinforced concrete and laminated wood materials (traditional lumber and/or bamboo); and characterize their performance under several loading conditions. As part of this research, we will develop two types of hybrid elements and perform large-scale testing of these elements whereby they will be subjected to mechanical and impact loading (representing expected debris impact during a tornado event). We will also investigate the acoustic and thermal performance of these elements to understand their energy efficiency for building applications. The novel and validated structural elements can provide opportunities to attract new industries and supply chains related to prefabricated building systems.

We hired a PhD student to start working on the research project; and we are currently in the process of recruiting another student to start in August (3rd quarter of this year). The PhD student started on January 15th. We have characterized the mechanical behavior of UHPC material for development of the hybrid panels. We have also done a literature review related to composite CLT-Concrete construction to identify potential gaps and to arrive at specifics of testing.

Auburn University – Advanced Liquid Transportation Fuels from Co-Liquefaction of Forest Biomass and Waste Plastics

The main goal of this project is to advance economic development in Alabama (and the nation) through reinvigoration of our natural resource-based industries and to establish new industries based on advanced liquid fuels from woody biomass grown in the state and the waste plastics collected from our local cities. Woody biomass prevalent in Alabama will be co-liquefied with waste plastics using a pyrolysis technology, which will then be subjected to hydrogen treatment to produce jet- and diesel- fuels. The funding from the Alabama Innovation Fund will be used to overcome technical barriers faced in converting woody biomass to biofuels and waste plastics recycling. The research will be focused on developing: (i) a process that would require lower capital and operating cost for biomass liquefaction; (ii) catalysts for the production of jet- and diesel-fuels; and (iii) a pathway for recycling waste plastics for the production of liquid fuels along with woody biomass. The team will leverage existing infrastructure and expertise at the Center for Bioenergy and Bioproducts at Auburn University.

The goal of the project is to produce transportation fuels using biomass and non-recyclable waste plastics. The Recipient has secured four different biomass samples (southern pine, hybrid poplar,

Eucalyptus, and Douglas fir), and the samples are being characterized for their physical and chemical properties. Initial hydrothermal liquefaction experiments were conducted at 300°C for 30 minutes. The biocrude yield varies from 12 to 22 wt.%, resulting in the highest yield from hybrid poplar. The produced biocrude is being characterized for its calorific content, carbon, hydrogen and sulfur. Almost 50% of the biomass was converted into biochar. These samples are also being analyzed for their properties.

In the next quarter, the Recipient will evaluate the effect of pine biomass liquefaction at three temperatures (250, 300 and 350°C) with water and ethanol as solvents. The mass and energy data will be collected along with the full characterization of the products obtained. Further, the Recipient will perform initial testing of biocrude samples for upgrading to a transportation fuel.

Auburn University – Novel Biotechnology that Converts Agricultural and Municipal Waste into Bioplastics

Alabama is one of the top agricultural producing states in the U.S., with annual agricultural exports exceeding $1 billion. As a result, there is a significant amount of organic wastes produced in the state, and Alabama ranks 14th among all states in terms of biogas generation potential from organic waste through anaerobic digestion (AD). These organic wastes represent an underutilized renewable feedstock for biofuel and biochemical production. This project aims at researching and assessing the economic feasibility of converting organic wastes into bioplastics. Specifically, the project will develop and optimize a prototype of a patent pending biotechnology that enables the conversion of organic wastes into bioplastics, and to assess its technical and economic feasibility at scale through techno-economic analysis (TEA). In the proposed technology, a microalgae-methanotroph coculture will be cultivated in a novel patent-pending circulation coculture biofilm photobioreactor (CCBP) to convert biogas (both methane and carbon dioxide) derived from organic wastes into microbial biomass while simultaneously recover chemicals from AD effluent to produce treated clean water. The produced mixed microbial biomass can be economically processed to produce high-value bioplastics that are in rising demand. The project will advance the progress of the patent pending biotechnology towards commercialization, which has potential to create many new jobs in the State of Alabama.

During Q1 2022, the project team identified two substratum materials to be used for the patent-pending circulation coculture biofilm photobioreactor. Extensive experiments were conducted to show that the two materials have resulted in M. buryatense 5GB1- A. Platensis cocultures grow much faster when they are on substratum than when they’re in liquid due to their direct exposure to biogas and light. They’re also tough, durable and cheap: suitable for commercialization. These results validated our hypothesis and paved the way for the next steps of the project.

HudsonAlpha Institute for Biotechnology – Next Generation Crops for a Diverse Alabama Agricultural Economy

The HudsonAlpha ADECA/ARDEF project, in collaboration with Auburn University Crop, Soil and Environmental Science and Pathology Departments, and Alabama A&M Winfred Thomas Agricultural Research Station will develop a pilot pipeline to import and test new crop varieties that could be deployed by Alabama farmers. We will connect the advanced agronomy crop research at Alabama Land Grant Institutions to the advanced plant genetic and genomic science expertise at HudsonAlpha. For two crops, barley and beans, the team will bring in diverse

germplasm, plant and evaluate cultivars to advance in additional trials. Barley will be tested as an overwinter crop for a spring harvest in Northern and Southern Alabama and dry beans will be tested as a summer crop in North Alabama. The team will evaluate disease, environmental, and weed pressure and other important agronomic traits for a crop to be successful in our challenging farming climate. As part of the goals, the partners will focus on increasing economic awareness of local barley and beans, connecting into existing educational and career development frameworks, and partnering with end users for brewing and food applications to increase the value of these Alabama crops. As this project develops, the teams will work with local farmers who are interested in planting alternative crops and engage stakeholders in workshops to discuss the science of next generation crop development to expand partnerships and apply this strategy to more crops useful for Alabama. With this newly developed research and collaborative infrastructure to bring in additional crop options, we can take control of the future of Alabama farming by optimizing the genetics and germplasm for Alabama, train new scientists in advanced plant science, open up new economic development in agriscience, and expand the current impact of local food and beverage industries.

In Q1, we completed planting out barley varieties at two Auburn Field stations (Tennessee Valley and EV Smith) and at Alabama A&M (Winfred Thomas) to over winter for a late spring harvest. The planted varieties were selected from previous pilots and contain material from North Dakota State, Virginia Tech, and some commercially available cultivars. After the winter which was severe in North Alabama we had significant cold damage to spring barley cultivars, but overall expect to have good yields in most of the selected cultivars. We also have begun to hire staff including a project manager to interface with the field work and outreach and added an economic modeler to do impact predictions. On the end use application of barley, Auburn Co-PIs have purchased a small-batch malter and are collaborating with the Auburn University Brewing Science program to potentially integrate barely malting into their teaching activities. We have also reached out to local businesses interested in developing malting capabilities in order to stimulate the use of barely from this trial program. Finally, we have begun doing test crosses with high yielding barley lines to develop populations on which we could select for Alabama growers to meet agronomic conditions here in Alabama. Up and coming activities include barley harvest in late Spring and planting of a diverse bean collection at Alabama A&M for the summer growing season.

The University of Alabama in Huntsville – Versatile Training to Provide an Agile, Advanced Manufacturing Workforce in Alabama

The overall goal of the proposed institutional collaboration is to assist in the transition of Alabama from a low-labor-cost manufacturing state to a leader in the research and development of next generation manufacturing sciences. To meet this goal, our primary objective is to expedite trans-disciplinarily, inter-disciplinarily, and multi-disciplinarily training of Alabama for entering the industrial and government workforces and contributing to the implementation and advancement of the emerging manufacturing technology through Additive Manufacturing.

Quotations have been obtained for equipment necessary to expand our Additive Manufacturing Laboratories thereby enhancing and expanding our education and research capabilities. Student teams from UAH and Calhoun Community College (CCC) have been formed to address projects that will assist companies in qualifying and certifying additive manufactured components.

Auburn University – Polymer Smart Machines

This project aims to research and develop the foundational building blocks of polymechatronics, which will enable the realization of 3D printable polymer smart machines. The research and development includes designing, fabricating, modeling, and characterizing piezopolymer versions of traditional mechanical and electrical building blocks such as actuators, sensors, energy harvesters, energy storers, and analog & digital circuit elements. Conventional 3D printed structures do not actuate or compute. However, if successful, the proposed project will lead to the first 3D printable smart machines that can actuate and compute without the need of externally-manufactured actuators and circuits. Compared to traditional devices, polymer smart machines are expected to be less expensive, easier to manufacture, biocompatible, recyclable, use less energy, operate over a larger range of temperatures, offer new functionalities, and be more environmentally friendly. Such attributes are expected to enable a wide spectrum of novel mechatronic components and products for consumers.

The start date of this project was moved to March 16, 2022 due to unforeseen delays in getting the research assistant through Auburn University security clearance, an expedited visa, and another security clearance by the Institute for Electronics and Nanotechnology (IEN), which is where the devices will be fabricated. All security clearances are expected to be completed within April. While waiting for clearance, we have been involved with the design, modeling, and simulation of devices that will be fabricated for this project. The results of our design and simulation work are being formalized into our first journal paper on this project. Regarding the status of the international patent, we have received our first response from the USPTO. Several of the claims have been allowed, and we are addressing the remaining issues posed by the patent examiner.

University of North Alabama – Surface Plasmon Resonance-based Biosensors

Biosensors are devices that convert a biological response into an electrical signal; and, they are increasingly prevalent across multiple industries including (i) food industry to check and verify the quality of the vegetables, fruits and meat, (ii) medicine and health industry to diagnose biological samples for diseases, ailments etc., and (iii) monitor safety industry to identify harmful chemicals. The current state of biosensors' sensitivity is often limited to minute concentrations of the molecules/agents under testing, usually in the range of 5 ng/mL. Due to this limitation, the biosensor output may lead to a failed detection and/or recognition that might cause harm to life.

A novel technique will be used to enhance the sensitivity of the biosensors based on the principle of surface plasmon resonance (SPR). Numerical investigations have suggested that this novel technique can improve the sensitivity by at least 5-fold, which facilitates easier detection of biomolecules in concentrations not possible using other biosensors. Upon building and successful testing of the SPR sensor system with regular glucose samples, the plan is to detect cow milk allergy agent and Staphylococcal enterotoxin B (SEB), which are important biomolecule agents in the food industry. The proposed biosensor setup can also be used for medical diagnostics.

A conventional SPR setup was built and tested to obtain the SPR curve of a 50 nm gold film layer structure. Graphene transfer sheets were used to deposit graphene layers on the gold film, and ohmic contacts forming a capacitive cell. Next, the capacitive cell will be biased and the effect of electric voltage on the SPR curve will be studied.

Auburn University – Novel and Sustainable Feed Binder from Soybean Hulls

The goal of this project is to establish a low cost, high value, and novel compound feed binder from soybean hulls (SBH), a co-product of soybean processing for oil and meal production. The specific objectives of this project are twofold: 1) to scale-up feed binder production to around 1.5 kg/hour and optimize process conditions for production; and 2) to scale-up shrimp feeding trials simulating shrimp farming operations at a commercial shrimp operation in West Alabama. Successful completion of this project will establish a high value and novel compound feed binder platform using 100% soy hulls that is ready for commercial scale productions and applications with significant economic and environmental benefits: it will significantly enhance competitive advantage of shrimp farmers in Alabama by reducing their feed costs. This will in turn improve employment opportunities in seafood farming and processing sector, making more local seafood and services available to the citizens of Alabama. In addition, it will also significantly improve water quality by reducing leached nutrients.

We have purchased and installed two pieces of new equipment that allow a production of our feed binders in a pilot scale (1.5 kg o.d. per hour) in our laboratories. One is a Universal Pulverizer (Model 30B) for grinding and crushing soybean hulls (SBH) feedstock to granules. The other equipment is a double planetary mixer (TDPM-10 model) which is equipped with an oil heater and coated to suit our purpose of producing our feed binders. We have also completed the testing and calibration of these two pieces of equipment.

University of Alabama at Birmingham – Amputation

Approximately 1.6 million people live with an amputation within the U.S., and amputation cases are expected to rise to approximately 3.6 million by 2050. 185,000 people have an amputation each year in the U.S., with a significant increase noted associated with COVID-19 infection. The conventional technology is unable to adapt to the dynamic residual limb as it atrophies over time and swells with heat or weight gain. Percutaneous osseointegrated prostheses (POP) are a promising development for the limb-prosthesis interface involving the direct skeletal attachment of the prosthetic device. Alongside the promising benefits of POP, significant risks are present at the bone-implant interface including superficial and deep infection, inflammation, insufficient osseointegration, lack of vascularization, and implant loosening. The main goal of this project is to develop the multifunctional nanomatrix coating on POP that can be clinically translated for improved osseointegration of prosthetics, and other types of orthopedic and dental implants in order to help promote healing and prevent infection. The project has successfully started, recruited research staffs, and made progress to synthesize the multifunctional nanomatrix coating.

University of Alabama at Birmingham – Pneumococcal Vaccine

Streptococcus pneumoniae is a leading cause of bacterial pneumonia and meningitis, resulting in more than 2 million pneumococcal infections and more than 6,000 deaths each year in the United States. Mortality rates are high especially in very young, elderly, and immunocompromised individuals. In Alabama, invasive *Streptococcus pneumoniae* represents a special concern to the State's aging population, as well as in the rural and economically deprived communities with limited access to routine health care. The currently available pneumococcal vaccines in clinic, *e.g.*, PPV23 and PCV13, have limitations. For example, PPV23 is not effective in children younger

than two years old, the elderly, and immunocompromised individuals; and while PCV13 is effective for children, it has limited serotype coverage (fewer than PPV23) and requires an inconvenient four-dose immunization schedule for infants and young children. Moreover, none of these clinical vaccines provide effective protection against *S. pneumoniae* serotype 3 (ST3), a significant cause of morbidity and mortality worldwide. In this project, we will develop enhanced PPV23 and PCV13 vaccines which can provide increased protection with reduced number of immunizations. The enhancement will be achieved by employing the potent new vaccine adjuvants recently discovered in the Principal Investigator's laboratory at UAB. Success of this project will benefit the citizens of Alabama and have broader positive impacts on global health as well.

For this project, we set the timeline and deliverables for each quarter. We have made steady progress in the first quarter, and reached the milestone set in the research proposal. All the instruments, supplies, chemicals, and biological and immunological reagents are in place. The mice for animal study will arrive on April 18th, and we will be ready to conduct the immunological study proposed for the 2nd quarter. The protocol for animal study was approved by the UAB Institutional Animal Care and Use Committee (IACUC) on 29-Mar-2022 (Animal Project Number (APN): IACUC-22509), and the project was also registered with the UAB Institutional Biosafety Committee (OH&S#: 22-042) on 23-Mar-2022. In the first quarter, we did not encounter any unexpected issues; the project proceeded smoothly as expected.