Alabama Research and Development Enhancement Fund
Quarterly Report
December 2021

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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 treating PFAS from the field water using optimized Ga/TNTs@AC. We have acquired important experimental data on the adsorption kinetics, isotherms, and photodegradation of PFOS (as a model PFAS). The adsorption kinetic data showed that 2%Ga/TNTs@AC (3 g/L) was able to rapidly and nearly completely remove PFOS (100.06 μg/L) within 10 min under the field water matrix conditions, namely, the field water matrix showed negligible effect on the adsorption rate and extent of PFOS by Ga/TNTs@AC.

While Ga/TNTs@AC was still able to photodegrade the pre-sorbed PFOS (35.5% after 4 hours of UV irradiation), the water matrix showed some notable inhibition on the photodegradation. This inhibitive effect was expected, and we will mitigate the effect through various engineered means as stated in the proposal. Moreover, we are developing even more powerful materials to achieve more effective photocatalytic destruction of PFAS.

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 this research project is to install a knitting research lab at Auburn University that is capable of prototyping and producing novel mosquito bite blocking knits that are comfortable in hot weather. During this quarter we discovered 3 new novel knitted structures that block mosquito bites raising the total of bite blocking structures to 5 unique knits. We also developed scientific methodologies to measure heat retention and thus the comfort of these garments. We are writing up these results and anticipate filing a second provisional patent and two publications in the next quarter to report these great results. We are succeeding and are negotiating production of the textiles with local Auburn knitting companies.

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.

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 sixth quarter of funding by continuing to expand pharmacogenetic testing at existing partner sites (Auburn University, Miles College, Drake State, Oakwood University), and pursuing new ADECA/ARDEF-funded programs and partners. We are also in the final stages of testing 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.

Research and development of the Roadmap and Index for Sustainability and Resiliency (RISR) model has been completed and the engagement process finalized. The model is constructed around the business systems of an organization and its functions. Each of the categories of effects is mapped to the disruptive event types and also to the business systems and functions they impact. The model will evaluate the capabilities a business has in place for both sustainability and resiliency. Sustainability is the ability a business has to prepare for, respond to, and recover from a disruptive event. Resiliency is the ability a business has to adapt to a changing environment. An assessment will be conducted to evaluate the capabilities of the practices in place in each of these areas, and generate a score. The model is constructed to allow a drill-down investigation into the score to identify opportunities for improvement and allow for cross-cutting the results by business component and disruptive event impact categories. Beta testing is underway with an Alabama manufacturer to prove out the assessment process and solicit feedback from the business to improve the engagement process. The service to support Alabama businesses has been branded Future Ready. A logo has been designed and a website is being stood up. Outreach material is being developed to engage business and industry, as well as leverage economic development organizations. White papers are drafted to serve as both educational and marketing of the RISR purpose and availability.

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 the third quarter, the team finished finalizing the 2017 pivot count and has completed a preliminary estimation of irrigated areas for 2019. The machine learning product produced by the UAH team was used in the 2019 analysis. It was found the accuracy was greatly increased over the national level products, however, it did overestimate compared to the manually-mapped pivots. Despite this, the ML-based map did prove useful in guiding the manually mapping progress. Initial datasets are being compiled with the TerrSet land use change model. TerrSet

will be used to project the 2006 -2019 irrigated areas to 2040. This information will be verified through consultations with extension agents in the most irrigated areas around the state.

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 October to December 2021, the team designed and executed a survey of Uber drivers in the Birmingham region to collect detailed Uber trip data. The Uber trip data collection started on 12/15/2021 and ended on 01/06/2022. It involved 8 Uber drivers from the Birmingham region that provided a total of 4,229 trip records. In order to accomplish this task, a preliminary questionnaire was created and used to verify eligibility of the Uber drivers interested in the study based on their historical Uber records; and, we registered the eligible study participants. Drivers could join the study if they drove Uber in Jefferson and Shelby counties during 2019 and/or 2021. After signing up, drivers were contacted, and arrangements were made to meet with our research team members in person. During the meeting, our trained personnel extracted their data history from their Uber profile web. The trip details were captured by taking a screenshot for each trip from their weekly statement. The image captured provided exact information about the trip date, start and end time of the trip, trip duration and approximate locations of the trip's origin and destination. The data captured requires postprocessing in order to determine the GPS coordinates of the origin and destination of each trip based on the trip details and map provided in the image, since the detailed location of a street/avenue is not provided other than the street/avenue name. This postprocessing will be conducted in the next reporting period.

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. The 6th version of the mask has been produced, which allows for printing the nose piece in flat form first and then heating it below the plastic transition temperature to conform to the user's face; this should provide better sealing. Leakage studies have been conducted using lasers to examine the leakage of air during inhaling and exhaling. These studies will improve the effectiveness of the masks. An antibacterial coating material has been received which will be applied to the masks using an atomizer machine in the lab. The masks will be tested during physical activities by measuring heart rate and blood oxygen content.

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 last quarter of 2021 focused on the characterization of the two polymers referred to as P1 and P2, which were selected as fiber-modifying agents for the functionalization of the fibers utilized for the fabrication of the formaldehyde paper-based device (PAD).

Analytical techniques including Fourier Transform Infrared (FTIR) spectroscopy, elemental analysis, acid orange 7 method, and acid-base titration were useful to study the chemical composition of P1 and P2.

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.

A second successful non-survival study was performed with the latest version of the small-diameter artificial vascular grafts. A reinforced layer of 3D printed material has been added to the exterior of the graft to aid in the suturing process, and some antiplatelets agents were added. The grafts have withstood blood pressure with no major leaks. One last non-survival study will be performed in February and then the first survival study is planned for March-April. The survival study will require sterilization of the grafts prior to implantation.

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. During the fourth quarter we assessed the success on bacterial colonization of the fibers, as well as the viability of the bacteria after being immobilized and freeze-dried.

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.

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.

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.

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.

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 students for entering the industrial and government workforces and contributing to the implementation and advancement of the emerging manufacturing technology through Additive Manufacturing. Resources from this grant will expand our Additive Manufacturing Laboratories thereby enhancing and expanding our education and research capabilities. This collaborative environment will provide our students with the skills necessary to support research and development activities within industry and government.

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.

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.

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.

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.

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.