Biobased Chemicals

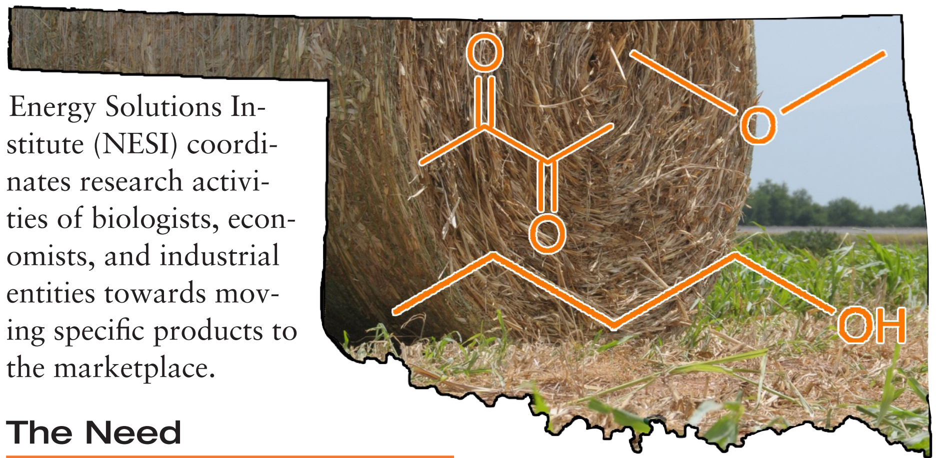
A multidisciplinary bioengineering platform for biochemical commodity discovery

The U.S. economy critically depends on a wide array of chemical products, ranging from plastics to jet fuel. These chemical products are at the core of essential activities such as transportation, electricity generation, and a wide range of products and materials produced by the chemical industry. Currently, the necessary compounds are almost exclusively derived from non-renewable fossil fuels. The development of effective methods for the renewable and biological generation of a range of chemical products will greatly increase agricultural productivity and profitability while at the same time reducing the negative environmental impacts of the use of fossil fuels.

For a limited number of cases, the conversion of specific biomass feedstocks to specific chemical end products has been achieved, ranging from functioning proofs-of-concept to industrial-scale production. These cases demonstrate the enormous potential of the biological generation of the chemical products needed to drive our current and future economies.

We propose to develop new, biobased approaches for the generation of a wide array of products and value-added chemicals from cheap and abundant biomass resources.

Our vision involves an integrated "pipeline" in which the National Energy Solutions Institute (NESI) coordinates research activities of biologists, economists, and industrial entities towards moving specific products to the marketplace.



The Need

The U.S. Department of Energy has identified 12 chemicals that can be converted into a large number of high-value chemicals and materials. The industrial-scale, cost-effective production of these chemicals using cheap and abundant nonfood biological resources is a crucial step with the potential for tremendous economic impact for a wide range of industrial fields.

In addition to bulk chemicals, there is a growing need for cost-effective production of boutique chemicals. These compounds are currently chemically synthesized at an extremely high cost. Examples include antibiotics, anti-cancer drugs, and anti-viral agents. Applications of the research pipeline at the core of this project will include the development of novel engineered pathways for the production of such chemicals.

This pipeline will start with biological diversity in microbial metabolic capabilities, biodiversity in relevant enzymes, and diversity in biomass feedstocks; will generate and identify improved enzymes and microorganisms; and will lead to improved bioconversion processes from biomass input to value-added chemical products.

Sustainable biological generation of chemical products at an industrial scale in an economically viable manner has proven to be challenging for many applications. Three recurring problems are often involved:

- Performance of enzymes needed for performing chemical processes is insufficient.
- Efficiency of the conversion of feedstock into final product is too low.
- Financial cost of the conversion process from biological feedstock to product is too high.

What is urgently needed is a generally applicable approach to address these challenges.

Goals

We will develop a new platform for making discoveries that enable the biological production of chemical compounds of economic importance. We will achieve this by integrating four interdependent and synergistic approaches:

- Quantitative modeling of the complex chemical processes needed for converting biomass feedstocks into chemical product to identify problematic steps in the chain.
- Use of biodiversity and accelerated evolution to identify enzymes and microorganisms capable of efficiently performing the needed bio-conversion processes.
- Establish powerful novel approaches for the rapid analysis of many different enzymes and biomaterials to identify those with a desired combination of properties. Unique technologies will include rapid analysis of a large number of enzymes and high-precision chemical imaging of biomaterials.
- Economic evaluation of the bioconversion process and devising approaches to achieve cost effectiveness. Through NESI, the scientific discoveries will be guided through contacts with industry partners to address market needs and desired outcomes. Successful integration of these approaches will allow development of substantially improved processes for the biological conversion of biological feedstocks into chemical products.

Wouter Hoff, Ph.D., Project Head

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The project will be performed by an interdisciplinary team of world-renowned experts in the following areas: microbial diversity; diversity and biotechnology of microbial enzymes; pathway engineering in microbes; molecular characterization of enzymes; high-throughput measurements on enzymes; and quantitative modeling of biomolecular processes.

Benefits

- Oklahoma farmers will be able to market the remaining cellulosic crop residues for the generation of chemical compounds in addition to selling their cash grain crop such as corn and wheat.
- Crop sources such as drought-tolerant switchgrass and sorghum will have value-added benefits to Oklahoma farmers and will stimulate rural economy.
- New feedstocks like red cedar will be identified that provide optimal pairing between biomass input and chemical product.
- This project will generate economic competitiveness in biology-based renewable technologies
- This project will provide students with advanced multidisciplinary training in biomaterials science and technology.
- The proposed research platform will place researchers in Oklahoma in a competitive position for federal, state and private funding, contributing to a range of biotechnological and economic processes.

For More Information

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