Bioprocess Research Initiative
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Motivation
The development of an alternative fuels and chemicals industry in the U.S. will benefit the economy by reducing the deficit in the balance of trade and reliance on foreign sources of petroleum, by stimulating development in rural regions, and will help diminish the climate change problem. But to bring about a transformation of the energy infrastructure in the U.S., more research at universities (in partnership with business interests) is needed in order to improve bioconversion technologies. These improvements will help to make fuels and chemicals from renewable biomass resources economically competitive, environmentally beneficial, and acceptable to society.

Objective
The bioconversion research projects listed below will be structured to yield improvements in the overall conversion of woody biomass to energy products at minimum cost and with the least impact to the environment compared to conventional fossil based products. The studies will employ molecular biology approaches to improve the activity and specificity of key enzymes for converting woody biomass to fermentable sugars. Improvements to microbial strains that convert mixtures of sugars to ethanol or other products (chemicals, solvents, or bio-plastics) will also be a focus of the research. Research using integrated bioconversion processes will investigate engineering solutions that improve process energy efficiency and control of key process variables. Research issues to be addressed in this thrust area include:

- **Engineering of Cellulase Enzymes**: Cellulase enzymes break down cellulose into the sugar glucose. This research will improve these enzymes through random and site-directed mutagenesis techniques coupled with enzyme characterization studies.
- **Peptidomimetic Modification of Cellulase Activity**: Cellulase activity is affected by enzyme binding to the cellulose substrate, which can be modified and hopefully improved by a peptidomimetic approach, where small protein molecules interact with the cellulose binding domain.
- **Microbial Strain Improvement**: Using genetic engineering techniques, novel metabolic capability will be introduced into fermentive organisms in order to improve uptake of sugars and enhance yields of ethanol.
- **Integrated Bioprocess Engineering**: Studies will be conducted at the laboratory bench scale on linked equipment that mimics commercial scale processes to study engineering approaches to improve energy efficiency and recovery of valuable products.

Expected Outcomes
- Improved cellulose enzymes that could be patented and marketed for commercialization.
- Novel peptidomimetic molecules that improve cellulase activity and reduce enzyme costs.
- New strains of fermentative microorganisms that have unique and desirable metabolic capabilities for converting woody biomass into ethanol or other chemical products.
- New process engineering approaches for improving energy efficiency and profitability of biochemical processes for ethanol production from woody biomass.
- Highly skilled Ph.D., M.S., and undergraduate students to take positions in the emerging bio-based fuels industry.

Ongoing Research and Education Activities
Michigan Technological University has unique capabilities to perform the research in this area as a result of on-going research:
- Dr. Shonnard is working under the NSF MUSES and IGERT programs.
- Dr. Youngs is conducting peptidomimetic research under the MTU Research Excellence program.
- Drs. Shonnard and Bagley have created a new multidisciplinary minor in Bioprocess Engineering.