FPL Research Emphasis

Forest Biorefinery and Biomass Utilization

The Forest Products Laboratory (FPL) is well-placed to pursue research opportunities to improve the economics of producing transportation fuel and chemicals from biomass. Development of profitable biorefineries will help reduce the cost of forest management, dependence on fossil fuels, and production of greenhouse gases.

- Decades of fire suppression have disrupted the natural fire cycle of U.S. forests, and currently large areas of forest lands are littered with an unnatural accumulation of stunted trees and woody debris. Fires on these overstocked stands are more intense and harder to control and often result in catastrophic crown fires that kill older trees and fire-adapted tree species. An estimated 8.4 billion dry tons of material needs to be removed from the National Forests and is available for production of wood products, chemicals, and energy. Profitable uses are needed for the removed material to reduce the costs of forest management.
- Known fossil fuel reserves are declining, and supply projections indicate that the most easily recovered deposits of crude oil will be exhausted in the next decade. Business concepts that convert wood resources into liquid fuels and chemical feedstock are becoming cost competitive. Trees are one of the best potential sources of biological fuel and chemicals—they grow in soils that will not support other plants; do not require fertilizer, herbicides, or pesticides; and accumulate biomass density for several years before incurring harvest costs.
- Combustion of fossil energy resources is increasing the atmospheric concentration of carbon dioxide and other greenhouse gases. Computer models predict that changes in atmospheric composition will increase global temperatures and cause profound changes in weather patterns. Fuels derived from biomass are generally regarded as greenhouse gas neutral because the amount of CO2 released on combustion equals the amount adsorbed from the atmosphere and sequestered by the plant through photosynthesis. As international concerns over global warming and greenhouse gas generation rise, governmental support for biological fuels will increase and likely reduce investment risks.

Utilizing lignocellulose as a raw material for transportation fuel and chemicals will require further research in several areas:

- Improved methods that reduce collection and transportation costs
- Pretreatments that make more cellulose available for enzymatic saccharification or derive value from lignin
- Efficient ways to use the five-carbon sugars in hardwoods
- Value from resistant cellulose
- Co-production of specialty chemicals with greater value than ethanol and paper pulp
- Improved gasification with less char and a higher energy yield
- Transportation fuels and higher value chemicals from product gas

Building on a long history of handling and treating wood and our ability to develop strong multidisciplinary teams, FPL experts in wood structure, wood chemistry, microbiology, enzyme technology, chemical engineering, and economics will work together toward several research goals:

***Economic analysis*—**Perform strategic economic analyses to determine if forest biorefinery and related biomass utilization concepts are feasible and to direct R&D towards critical economic objectives; analyze the business case for each concept (production costs, profitability, competitiveness, and likely investment returns); develop production models (relating production and investment costs to physical process parameters), pricing models (relating price of products or raw materials to scale of production), and financial models (relating investment returns to production costs, revenues, and prices)

***Pentose fermentation*—**Increase fermentation rate and sugar/alcohol tolerance of the organisms; produce higher value products; study regulation, rate-limiting factors, and biochemistry involved in transformation of five-carbon sugars

***Cellulose pretreatments*—**Focus on cellulose solvents compatible with a saccharification process

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and recovering crystalline cellulose for conversion to valuable products

***Value prior to processing*—**Develop basic knowledge of separation and collection of wood components; investigate effects of pretreatment processes on primary product; focus on retaining primary product properties while maximizing pre-hydrolysis yield of sugars and hemicellulose oligomers

***Products from lignin*—**Develop pretreatments that extract valuable compounds from lignin (oxidation, biochemical approaches) in coordination with the saccharification research

***Refining pyrolysis oils*—**Reduce complexity of product mixtures; develop anaerobic fermentation system to produce methane from the low-molecular-weight compounds; develop use of pyrolysis oils as high-energy-density intermediate for more economical shipping

***Pyrolysis methods*—**Develop new methods of gasification (for example, innovative application of liquid metal flash pyrolysis to increase gas production and reduce char formation)

Technology transfer and partnership interests have already been identified with both industrial and academic partners.