**An integrated biorefinery**

Existing, and in some cases idle, pulp and paper mill infrastructure provides an opportunity to build a biorefinery industry. In addition to pulp, the industry produces an estimated two million tons of fiber sludge annually. This material is either discarded in a landfill or burned, adding millions of dollars to the cost of paper production. The composition of this sludge is about 50 percent cellulose and hemicelluloses, which could be converted into their constituent five- and six-carbon sugars. The sugar streams could then be fermented into bio-based chemicals and fuels as value-added co-products, thus earning pulp and paper companies increased sales and profits and, at the same time, reducing the environmental and fiscal burden of waste disposal.

Key technologies we have developed include a modified organosolv pulping process to separate biomass into lignin, cellulose, and hemicellulose fractions, and engineered microbes that convert sugars from biomass into energy-dense chemicals such as isoprene, β-pinene, prenol, and butanol. This yields sulfur-free lignin as a co-product, which is being studied for its utility as a feedstock for adhesives, fuel additives, carbon fiber and as a feedstock for fast pyrolysis oil.

Pulp and paper mill residuals are an ideal feedstock for a biorefinery since they are a waste stream that currently has little value and actually are a disposal expense to the mill.

**Five reasons to contact WIST:**

- Process improvement
- Minimize waste
- Reduce your environmental impact
- Use of renewable raw materials
- Sustainability advice

**Success together:**

Collaborative efforts that tap a range of expertise, experience and skills have the best chance of success in creating and promoting sustainable solutions.

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Isoprene for industry

Renewably-sourced isoprene may be a boon to industry, environment.

We aim to develop a fermentative unit to produce isoprene, an energy-dense hydrocarbon fuel precursor that can be used to manufacture numerous grades of fuel and serve as a platform chemical for production of polymers and other materials. Isoprene is a valuable feedstock used in the production of latex, rubber, plastics and pharmaceuticals, and it can also be used to produce liquid aviation fuels using inorganic catalyst technologies that currently exist in the petroleum industry. Our goal is to develop an isoprene production unit that will integrate with a lignocellulosic biorefinery we are developing (see back panel for more on the biorefinery). This unit will use engineered microbes to ferment wood sugars to isoprene and capture the isoprene from the vapor phase above the fermentation vessel. We have demonstrated these processes at the laboratory scale and are now deploying at the pilot scale.

The research team at WIST has already demonstrated that the sugars present in sludge can be liberated using commercially available cellulase enzymes and converted into isoprene using existing bacterial strains.

We propose to produce isoprene from pulp and paper mill waste streams commonly referred to as residuals. Cellulosic solids comprise the major component of these residuals. In the mill, residuals are either isolated and concentrated in solid form or biologically treated in a waste treatment facility. Residuals concentrated in solid form are commonly referred to as sludge and typically landfilled at the mill’s expense. Using this sludge to produce isoprene provides pulp and paper producers an opportunity to diversify their product stream and create new jobs while reducing waste.

WIST researchers have demonstrated a proof-of-concept isoprene fermentation system by transforming E. coli with multiple genes from the 2-C-methyl-D-erythritol 4-phosphate (MEP) pathway residing on multiple plasmids. These cell lines have produced isoprene from glucose, hydrolyzed cellulose, and hydrolyzed pulp mill sludge.

Isoprene is already traded globally, although currently it is derived from a petrochemical and not a bio-based source. Annual global consumption of isoprene is 1.7 billion pounds, of which more than 95 percent is used in the production of isoprene rubber, styrene-isoprene-styrene block copolymer (SIS) and butyl rubber.

The existing global isoprene market is approximately $2 billion. However, with an increase in supply and displacement of rubber sources the market will likely expand to over $30 billion.

WIST has published with the US Patent Office a method to produce isoprene with the use of a transgenic micro-organism.

Anaerobic Digestion

WIST researchers are working with students and with the UWSP campus community to build an anaerobic digestion demonstration system on campus.

Anaerobic digestion is a biological process in which food waste, grass clippings, animal manure, and other biodegradable waste is broken down by bacteria to make biogas. Biogas can be compressed and used to power vehicles or operate electrical generators. Anaerobic digestion can be deployed today throughout the rural Midwest, providing more than 15 percent of the region’s energy while simultaneously eliminating solid waste. Biogas from the UWSP demonstration project will power a campus vehicle and the remaining solids will be used to fertilize a campus garden. This system will be used for teaching, research and demonstration to help farms and businesses learn how to deploy this energy technology in their own situation.

American hazelnut: A better oilseed crop?

A merican hazelnut, a hardy shrub native to Wisconsin, could prove to be a valuable oilseed crop. Plant oils have many uses from food to fuel and perennial plants such as hazelnut are particularly attractive because they require lower annual inputs, and may provide environmental benefits such as wildlife habitat while yielding an economically valuable crop. Researchers are gaining a better understanding of the population genetic structure of American hazelnut, which will allow for improved selection of high-productivity genotypes.