Improving the Economics of Lignocellulose Conversion to Transportation Fuels

Patricia M. Irving

InnovaTek

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InnovaTek Vision

Convert unique ideas to workable chemistry and hardware to provide sustainable solutions for the world we live in.

Move the world away from wasteful fossil fuel combustion and toward efficient energy generation from renewable biofuels.

InnovaTek Company Information

- Incorporated in December 1997
- Richland WA Science & Engineering Park
- Reached profitability and positive net equity in 2002

- Assets are the knowledge base and IP developed with $22 million in private, government, and owner funding
- Technologies being sold under product evaluation agreements or jointly developed with systems integrators and other large partners
- ~15 employees, all with advanced degrees

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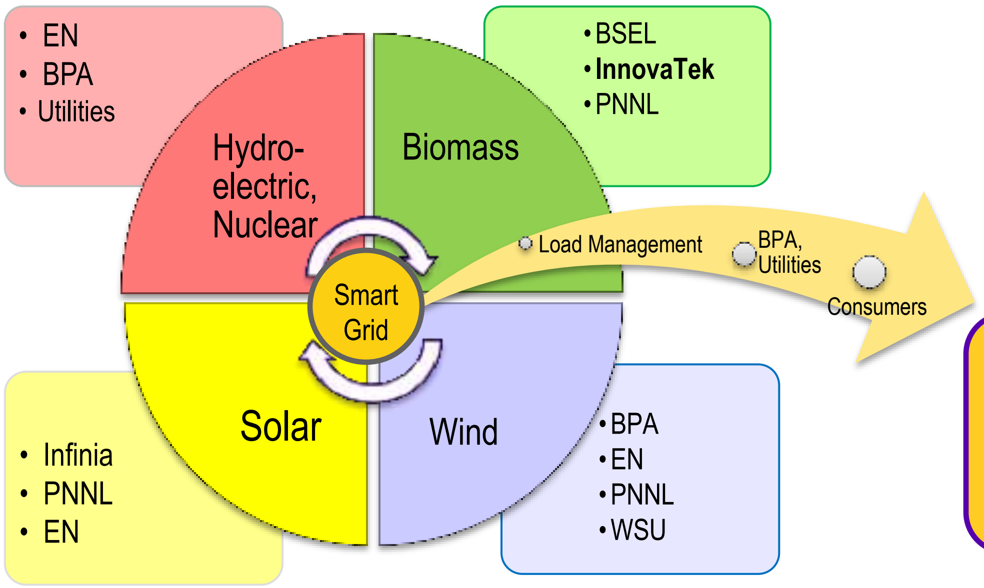
Mid-Columbia Energy Initiative

A private and public sector partnership that provides integrated energy solutions based on clean, carbon-neutral technologies.



Meets 2020 electrical load growth needs with renewables.

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InnovaTek's Sustainable Power Goal

Develop chemical processing technology and advanced catalysts to produce clean hydrogen and renewable fuels

- **Proprietary fuel processing technologies to create hydrogen for fuel cell power systems**
- **New product lines being developed for biomass refineries**

APU Produces 10 kW_e from BioJet Fuel

Integrated fuel cell and InnovaTek biofuel processing technology

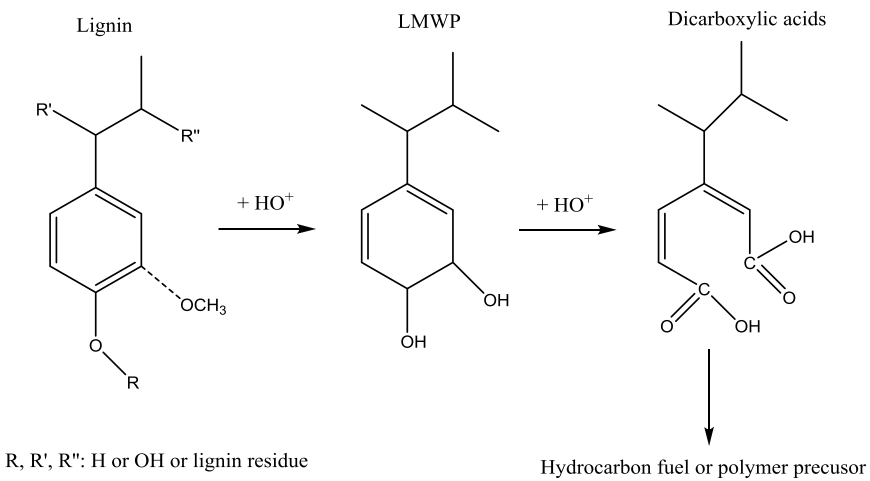
Some synergies

Solutions that may help improve biorefinery economics:

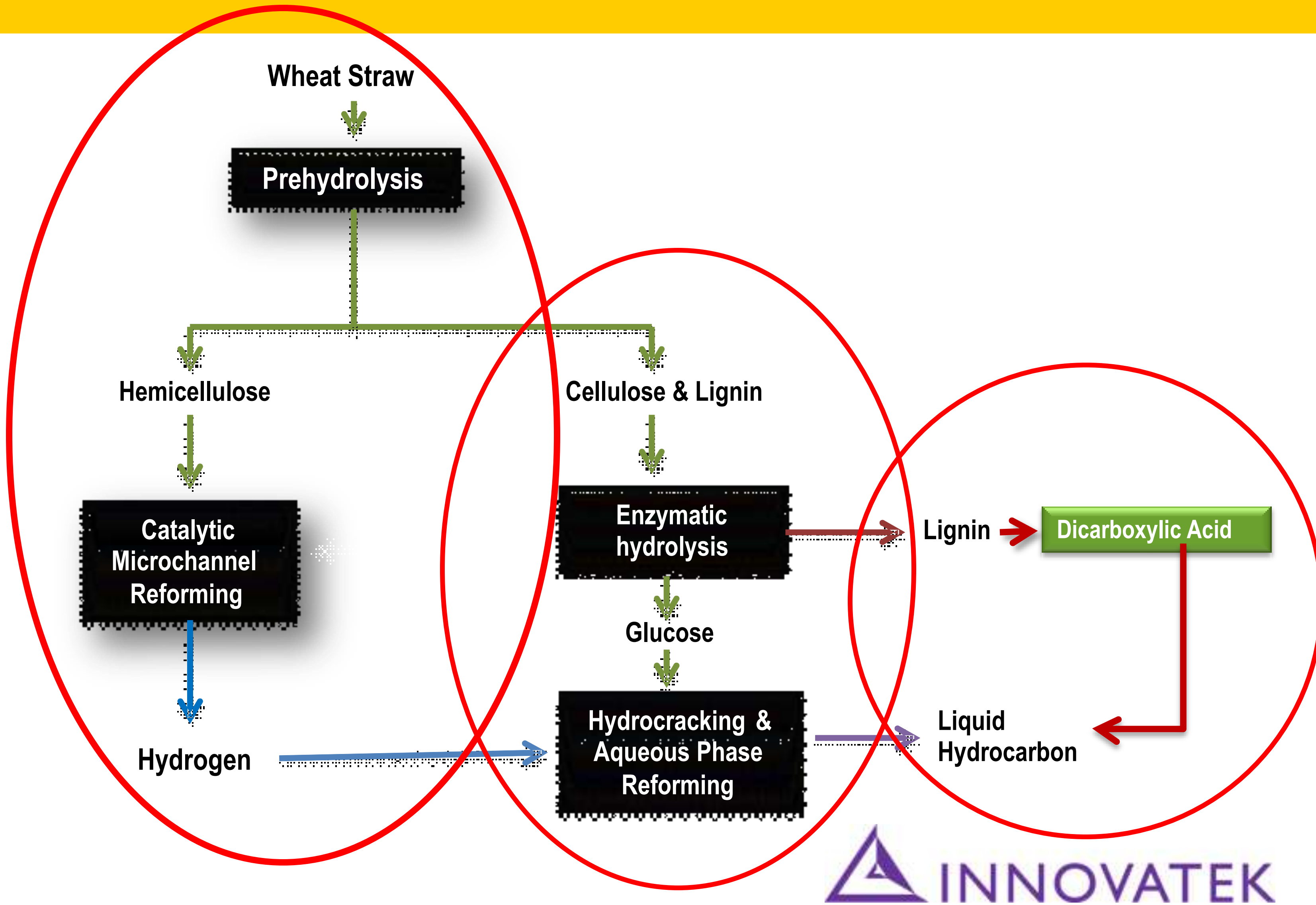
- Catalytic reforming to produce hydrogen
- Micro-channel reactors for efficient processing

BioProducts Program Goals

1. Maximize the value of each lignocellulosic biomass component to improve the economics of producing green liquid fuels
2. Replace fossil hydrocarbons with biomass as source for hydrogen supply for hydro-processing
3. Improve processing through “intensification” using advanced catalysts and microchannel reactors



Biomass to Biofuel Conversion Process



Phase I Approach

- Optimize the pre-hydrolysis process to recover xylose from hemicellulose fraction
- Develop reforming catalyst to convert xylose to hydrogen
- Design a micro-channel reforming reactor to increase catalytic activity and conversion for the reforming reaction

Prehydrolysis Optimization

Work performed in collaboration with Dr. Xiao Zhang, WA State University

Objective – achieve a high xylose recovery yield (>85%) and produce a concentrated sugar stream (>7% w/v) from wheat straw

Optimized conversion of biomass through selection of

- reaction thermal conditions
- reaction time,
- reactant concentrations,
- reactant chemistry

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Hydrogen Production from Xylose

Use hydrogen from hemicellulose for the conversion of glucose to liquid hydrocarbon

- Will reduce the capital and operational costs of the process; eliminating need for natural gas

	% of wheat straw	Recovered Monomeric sugars, g/1000 g wheat straw	H_2 Produced from xylose or required for glucose conversion, g /1000 g straw
Hemicellulose (Xylose)	29	280	15.13
Cellulose (Glucose)	38	401	13.38

Highly active proprietary catalyst optimized for micro-channel reactor

InnovaTek's Proprietary Catalysts

iTek® catalysts were developed for reforming multiple types of hydrocarbons

Nano-chemistry is used for micro-channel reactor catalysts

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Xylose Reforming Catalyst Development

Provides high activity and durability; resists carbon deposition

1. **Additives incorporated to modify structural and electronic properties of active sites**
2. **Homogeneous dispersion of active components to the catalyst matrix with very high surface area**
3. **Optimized metal crystallite size with high surface area as well as high stability**

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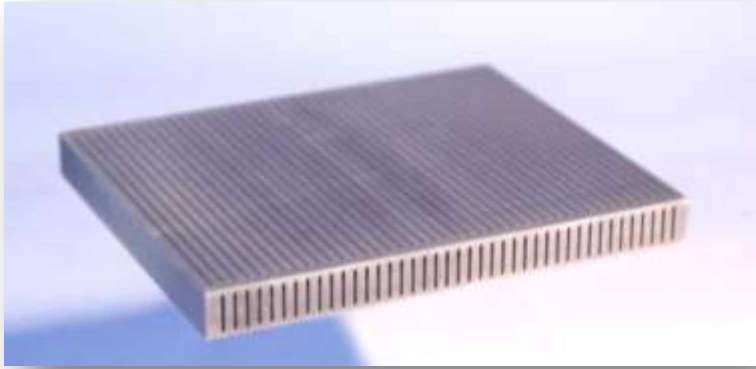
Microchannel Catalytic Processing

- Intensified chemical reaction rates that are 10-1000x faster and higher conversion efficiency than conventional systems
- Compact, efficient design is perfect for distributed production of fuels on a small decentralized basis
- Processing channels in the millimeter range
- Higher heat and mass transfer allows use of more active catalysts



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Microchannel Reactor Design

- Reduces limitations in the transport of heat or matter thereby allowing rapid reaction rates
- Creates strong concentration gradients in the direction of the reaction path

> - High processing rate with low dP
> - Minimizes reactor & catalyst volume to reduce size & cost

Close-up of reaction & HX channels

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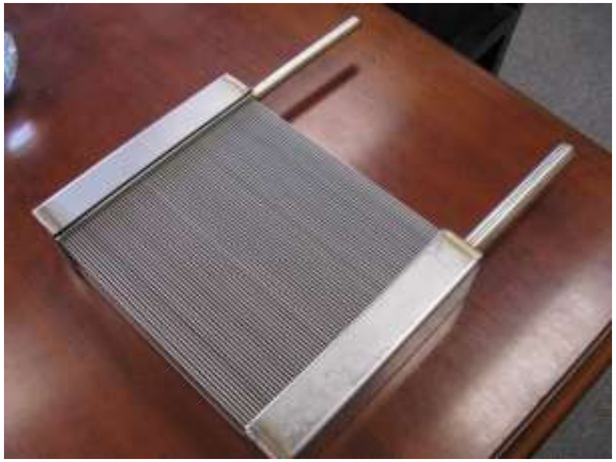
Process Intensification and Economics

- Hydroprocessing reactions need to create an effective triple-phase interface between the liquid hydrocarbons, gaseous hydrogen and solid catalyst
- Through improved mixing and mass transfer, microchannel technology improves this interface, thereby intensifying the reaction
- As a result of improved volumetric and catalytic productivity, microchannel systems can have lower capital and operating costs than conventional systems



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Distributed Scale Advantages

Modular

- Transportable to remote locations near source of feedstock
- Scale-up by “numbering up”

Lower Risk

- Smaller plants require smaller investments
- Inherently safer

Reduced Costs

- Lower capital costs
- Lower operating costs

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Products are original designs and chemistry that we create, fabricate, and test in our facility

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