Developing a Biomaterials Industry in North Dakota

F. Larry Leistritz
Nancy M. Hodur
Donald M. Senechal

Department of Agribusiness and Applied Economics
North Dakota State University

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The Concept:

- Cellulose nanowhiskers (very small fibers) would be processed from wheat straw and mixed with a biobased polymer to produce a low cost, biodegradable replacement for glass fibers in polymer composites.
Today

Glass Fibers

Petrochemical Based Polymers

Glass-Filled Resin

Molded Components

Tomorrow

Cellulose Nanofibers

Cellulose-Filled Resin

Bio-based Polymers

Molded Components
The Advantages

- Lightweight – *one half the bulk density of glass*
- Biodegradable
- Safe to handle
- Less energy intensive
- Less destruction of process equipment
- High sound absorption
- No conversion costs for composite production
- Lower cost
Aim
Commercialize the first generation nano-sized, biodegradable fiber reinforcements

Vision
Nano-based biomaterials industry in North Dakota

Goal
Develop and produce cellulose nanofibers at a cost and performance level to compete with glass fibers

Applications
Reinforced composites for automotive, aerospace, consumer products, electronic and military applications
Current Project: Technology and Commercial Development

- Development and scale up of cellulose nanofiber production
- Economic assessment of business opportunity in North Dakota
- Development and scale up of applications of cellulose nanofibers in polymer composites
- Create an investment prospectus
An integrated biorefinery could use the by-products of nanofiber production to produce ethanol and other high value chemicals.

The concept is *economically attractive* as it *captures greater value* from biomass feedstock and reduces environmental impact.
Cellulose Nanofibers Biorefinery Process Flow Diagram

- Wheat Straw
- Milling
- AFEX
- Enzyme Treatment
- Chemical Treatment(s)
- Sizing
- Cellulose Nanofibers
- Hemicellulose, Lignin By-Products
- Fermentation
  - Ethanol
  - Succinic Acid
  - Butanetriol
  - Xylitol

Free-Standing Cellulose Nanofibers Production Process
Integrated Cellulose Nanofibers Production Plant with an Ethanol Biorefinery Plant
AFEX Process Technology

An ammonia based treatment process that breaks down the structure of cellulose and hemicellulose so that the polymeric five and six carbon sugars can be hydrolyzed to fermentable sugars.
Advantages of using wheat straw with the AFEX process technology

- Higher percentage of cellulose and lignin than major alternatives
- Lower cost than competing feedstock such as corn stover and switchgrass
Benefits of a Biomaterial Industry in North Dakota

- Initial processing must occur near the source of the feedstock.

- Early estimates suggest a commercial biorefinery would require 900,000 tons of wheat straw annually.

- More than 1.5 million big bales
Nanocomposite Production Process Flow

First Stage Processing
Cutting & Sizing (North Dakota)

Second Stage Processing
Produce Cellulose Fibers (North Dakota)

Compounding Produce Nanocomposite Pellets (North Dakota)

MBI Polymers

Wheat Straw

Auto Parts

Molding

Figure 1
Benefits of a Biomaterial Industry in North Dakota (cont.)

- Well placed to capture the economic impacts of an emerging industry (bio-technology, silicone valley)

- Additional income for wheat producers

- Employment opportunities, especially in rural areas

- Profits
Economic Impacts

- Biorefinery producing 50 million gallons per year (MGY) of ethanol would require 900,000 tons of straw annually.

- Biorefinery would employ 77 workers and result in more than $50 million in annual payments to ND entities.
Economic Impacts (cont.)

- At an ethanol price of $1.80/gallon (2005 average), the biorefinery would earn a positive net return

- Adding CNW production to the biorefinery would add several jobs and enhance the profitability of the venture
Demonstration of CNF from recycled paper
Demonstration of CNF from corn stover & wheat straw
Definition of product specifications
Established preliminary process economics
Evaluate integration with ethanol plant

Pre-Pilot process design and engineering
Preparation and evaluation of CNF samples
Preparation and evaluation of composite materials
Refine process definition, design, engineering and capital and operating costs
Pilot plant design and engineering

Pilot plant construction
Preparation and evaluation of large scale CNF samples
Preparation and evaluation of large scale composite materials
Refine process definition, design, engineering and capital and operating costs
Validation of feedstock assumptions and integration feasibility with an ethanol plant

Business Partner: TBD

Ideas

1. Preliminary Investigation
   - Michigan State University
   - MBI International

2. Detailed Investigation
   - Pre-Pilot process design and engineering
   - Preparation and evaluation of CNF samples
   - Preparation and evaluation of composite materials
   - Refine process definition, design, engineering and capital and operating costs
   - Pilot plant design and engineering

3. Development
   - Pilot plant construction
   - Preparation and evaluation of large scale CNF samples
   - Preparation and evaluation of large scale composite materials
   - Refine process definition, design, engineering and capital and operating costs
   - Validation of feedstock assumptions and integration feasibility with an ethanol plant

4. Validation

5. Commercial Launch

Tech/Com. Feasibility?
Product Concept
Value Proposition
Business Plan
Marketing Plan

1. Preliminary Investigation
2. Detailed Investigation
3. Development
4. Validation
5. Commercial Launch

Ideas

Business Plan
Marketing Plan

Cellulose Nanofiber Project

Cellulose Nanofiber Project
The pilot plant is an important milestone.

– Allow North Dakota to establish a leading position in research and commercialization of an important emerging industry.

– Provide the basis and foundation for the development of a bioproducts cluster in ND
Generalized Commercial Model

MBI Technology

Other Technologies

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NewCo, LLC
Equity: MBI, Private Investors, North Dakota

Pilot Plant

Production Facility
North Dakota State University
Department of Agribusiness and Applied Economics

Dr. Larry Leistritz, Principal Investigator, Distinguished Professor of Agricultural Economics

Nancy M. Hodur, Research Scientist
MBI International
Mark Stowers, CEO

- A private, nonprofit technology research and business-development corporation

- Develop and commercialize bio-based products and processes through new business start-ups, strategic alliances, and partnerships across the country.

- Commercialized technologies and **created 10 new companies**. Examples of products include:
  - Lactic Acid/Polylactic Acid--Joint venture with Cargill (88-98)
  - Thermoplastic Starch Resins--Joint venture with Japan Corn Starch (93-03)
  - 3-hydroxybuyrolactone, a key building block for statins (Crestar)--Synthon Chiragenics (96-04) (sold to Avecia)
Natureworks, LLC (1997)
Incorporating work done by MBI

A substitute for fibers in clothing, carpeting, and packaging (containers and bottles)

Cumulative investment of over $850 million
- Former joint venture between Cargill and Dow located in Blair, Nebraska
- Now wholly owned by Cargill
- Employs more than 100 people
- Annual revenues of $150 million annually with projections of at least $300 million
- First new polymer developed in over 20 years
The Windmill Group, LLC

- Donald M. Senechal, Founding Principal
- Thirty years as leading management consultant for Food and Agribusiness
- Established North Dakota headquarters in 2004
Questions?

Larry Leistritz can be reached at: 701-231-7441
Email: lleistri@ndsuext.nodak.edu

Don Senechal can be reached at: 701/465-3200
Email: donald.senechal@verizon.net

Mark Stowers can be reached at: 517/336-4612
Email: stowers@mbi.org