Transforming Agriculture into Renewable Materials

Ohio BioProducts Innovation Center
Integrated Biorefinery

**Feedstocks**
- agriculture/forestry
- crops/residue
- wood residue
- livestock manure
- industrial/municipal
- municipal solid waste
- co2 emissions
- food/industrial byproducts

**Processes**
- extraction/separation
  - mechanical, chemical
- bioconversion
  - microbes, algae
- hydrolysis
  - acids, enzymes
- gasification
  - high heat, low oxygen
- pyrolysis
  - catalysis, heat, pressure

**Uses**
- food
  - oil
  - proteins
  - carbohydrates
  - additives
- fuels/energy
  - ethanol/butanol
  - biodiesel
  - heat
  - electricity
- materials
  - plastics
  - fibers
  - adhesives
  - rubber
  - paints/coatings
  - dyes/pigments/ink
  - detergents/solvents
Importance of Polymers to Ohio

US Market Position

#1 Polymers
Importance of Polymers to Ohio

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#1 Polymers

paints & coatings

adhesives

OBIC Ohio BioProducts Innovation Center
Importance of Polymers to Ohio

US Market Position

#1 Polymers

paints & coatings
rubber
adhesives
Importance of Polymers to Ohio

US Market Position

#1 Polymers

- paints & coatings
- rubber
- adhesives
- soaps
Importance of Polymers to Ohio

Plastic is Ohio’s #4 export
Current Source of Polymers

Oil
### U.S. Petroleum Market

<table>
<thead>
<tr>
<th>Use</th>
<th>Value</th>
<th>Value/Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>≈ 67% transportation fuel (auto, air, truck, rail, etc)</td>
<td>$350 billion</td>
<td>$5.2 billion</td>
</tr>
<tr>
<td>≈ 7% materials (chemicals, polymers, etc)</td>
<td>$255 billion</td>
<td>$36.4 billion</td>
</tr>
</tbody>
</table>

Why BioProducts

Future of Oil

• Increasing Global Demand
• Uncertain Supply
• Volatile Price
Why BioProducts

Future of Oil

• Increasing Global Demand
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Worldwide Material Demand
Projected by Dept. of Energy

- renewables
- oil

Today  | 2020  | 2050
Why BioProducts

Impact of BioTech

• Utilize natural diversity of plant kingdom
• Design plant traits
• Target specific chemical functionality
Why BioProducts

Renewable biopolymers are important sources of innovation.

NE Ohio Polymer Strategic Roadmap
*Battelle, 2004*
Industry & Technology

ECONOMIC SECTORS
- Polymers
- Energy
- Ag

NEW TECHNOLOGY
- Nanotechnology
- Biotechnology
- Polymer Photonics
- Agbiosciences
- Sensors
- Biochemistry

OUTCOMES

Growing Existing Companies
- Polymer & Ag
- Wind turbines
- Solar Energy
- Flexible Electronic Displays
- Energy Storage
- Medical devices

Building New Industries
- Biorefinery
- Smart materials
- Fuel Cells
- Hi-perf structures
- Drug delivery devices
- Nanofoams
- Biomass to Energy

OBIC Ohio BioProducts Innovation Center
Rate of Innovation

Original Pathway
OBIC Overview

Established June 2005 by $11.5 million grant from Ohio’s Third Frontier Program

Key Strategies:

• Targeting investments to enhance research capabilities

• Fostering innovation through academic/industry networks

• Linking research to address industry needs
Networks are Key to Innovation
Bridging Ohio’s Top Industries

agriculture
$93 billion

OBIC

polymers
$49 billion
Industry Leaders
Research Collaborators

- The Ohio State University
- Battelle
- The University of Akron
- Applied Polymer Research Center
- U.S. Department of Energy
- National Labs
- USDA
- United States Dept of Agriculture
- Agriculture Research Service
- Ohio Plant Biotechnology Consortium
- OBIC Ohio BioProducts Innovation Center
Technical Capabilities

- Material Engineering
- Agriculture Bioscience
- Chemistry
- Genetics
- Nanotechnology
- Bioprocessing
- Biotechnology

OBIC Ohio BioProducts Innovation Center
Project Validation & Selection

- Business Ideas
- Technology Ideas
- Concepts

Management Team Selection Criteria
- Strategic Fit
- Probability of Success
- Economic Driver

Project Portfolio Risk
- Valuation
- Technology
- Markets/ Applications

Business Idea Genesis
- Opportunity Identification And Screening
- Conceptual Business Case Development
- Business Plan Development
Project Examples

- Soybeans
- Natural Rubber
- Natural Fiber Reinforced Plastic
Soybeans

A biological factory of...

• oil
• protein
• carbohydrates
Biotechnology to Chemistry

- Programs target desired plant traits for specific industrial applications
- Advanced equipment investment allows for $15,000x$ faster DNA analysis
Soybeans

Chemistry to Application

• Optimizing soy chemicals for industrial use

• Collaboration with Battelle’s internationally recognized program in bioproduct development
Soybean Application

Plastic Additives
$5.8 billion market

Printer Toner
$9 billion market

R&D 100
Ohio Soybean Council
Battelle
The Business of Innovation

OBIC Ohio BioProducts Innovation Center
Natural Rubber

Required for high performance applications

• aviation
• commercial trucks
• agriculture equipment
• automotive
Currently the US must import 100% of its natural rubber. Domestic alternative is needed!
Natural Rubber

Programs target domestication & application of alternative source:

Russian Dandelion

*Taraxacum kok-saghz*
Fiber-Reinforced Plastic

Plastic is commonly reinforced to enhance performance ($25 billion market)

Wide range of applications:

• automotive
• furniture
• industrial
Fiberglass is predominant plastic reinforcement

Breakthrough plant fiber provides alternative

NFCC Natural Fiber Composite Corp.

P&G

ASHLAND

OBIC Ohio BioProducts Innovation Center
Program to develop plant-based fiber as alternative

- lighter, lower cost, increased performance
- renewable, environmentally-friendly

College of Engineering &
Ohio Agricultural Research & Development Center (OARDC)
Strategic Position

Ohio & Great Lakes Region

- Strong Polymer & Agriculture Sectors
- Supply Chain/Logistics in Place
- Strong Research Capabilities
- Natural Resources & Location

Ohio's Comprehensive Supply Chain

Agriculture
Processors
Chemical/Polymer Manufacturers
Compounders/Formulators
Product Manufacturers
Consumers
Post-Consumers

OBIC Ohio BioProducts Innovation Center
Economic Sustainability Requires

- Integrated Biorefineries
- Portfolio of Products
- Flexibility
Integrated Biorefinery

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Uses
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  - ethanol/butanol
  - biodiesel
  - heat
  - electricity
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  - plastics
  - fibers
  - adhesives
  - rubber
  - paints/coatings
  - dyes/pigments/ink
detergents/solvents
Lead the Way!

• “Race to the Moon” commitment
• Public/private networks essential for innovation
• Advocacy & leadership for common good
• Enhance economy, environment & quality of life
For more information...

bioproducts.osu.edu
Advocacy & Leadership

BioPolymer Advocacy

Wayne Earley
PolymerOhio

Sharell Mikesell
Ohio Polymer Strategy Council
Rural Jobs Initiative

• Making Ohio a world leader in renewable energy & bioproducts

Jack Fisher
Ohio Farm Bureau Federation

Advocacy & Leadership
Advocacy & Leadership

Turn Around Ohio Plan

• Establish Ohio as a leader
• Enhance bioeconomy
• Challenge industry to innovate

Ted Strickland
Governor

Robert Boggs
Ohio Dept. of Agriculture

Lee Fisher
Lt. Governor & Director of Ohio Dept. of Development
Industry & Technology

ECONOMIC SECTORS
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- Biomass to Energy

OBIC Ohio BioProducts Innovation Center
House Bill 233

- Ohio Agriculture to Chemicals, Polymers & Advanced Materials Task Force
- Passed Unanimously & signed by Gov. Strickland

Honorable Steve Reinhard
State Representative
Intersections of Technologies

- Energy & Conservation
- Electronics
- Information Technology
- Transportation
- Building & Construction
- Biomedical
<table>
<thead>
<tr>
<th>Innovation Type</th>
<th>&lt;2 yrs (1)</th>
<th>3-5 yrs (2)</th>
<th>&gt; 5 yrs (3)</th>
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</thead>
<tbody>
<tr>
<td>Revolutionary (3)</td>
<td>0</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>New Product/Process (2)</td>
<td>30</td>
<td>38</td>
<td>8</td>
</tr>
<tr>
<td>Modification (1)</td>
<td>28</td>
<td>5</td>
<td>2</td>
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</tbody>
</table>

OBIC Concept Portfolio
n=118
Strategy

• Create Networks
• Enhance Capabilities
• Empower Leadership
Process of Commercialization

Translational

Funding

Grants & Contracts
Private industry
Academia

Pre-prototype (Pre-Seed)
Prototype (Seed)

“Valley of Death”

Product Age (Years) 0 1 4 7

Private industry
SBIR/STTR
Third Frontier

Private industry
Venture Capital

Early VC

Later VC

Concept
Discovery

Pre-prototype
Prototype

0 25 50 75 100 125

Product Market Entry

Funding

Grants & Contracts
Private industry
Academia

Pre-prototype (Pre-Seed)
Prototype (Seed)

“Valley of Death”

Product Age (Years) 0 1 4 7

Private industry
SBIR/STTR
Third Frontier

Private industry
Venture Capital

Early VC

Later VC

Concept
Discovery

Pre-prototype
Prototype

0 25 50 75 100 125
Innovation: Technology Commercialization

PHASES OF DEVELOPMENT

IMAGINING
INCUBATING
DEMONSTRATING
MARKET ENTRY
GROWTH

ODOD, adapted from Jolly, V.K. (1997)
Third Frontier Initiative catalyzes broader connections & stronger networks with proven commercialization processes and leadership.

**Ohio Polymer Strategy Council**
- IMAGINING the Commercial Opportunity
  - Mobilizing Resources for Incubating

**Ohio Farm Bureau**
- INCUBATING to Define Commercializability
  - Mobilizing Resources for Demonstrating

**Third Frontier**
- DEMONSTRATING Products & Processes in Commercial Context
  - Mobilizing Resources for Market Entry
- MARKET ENTRY to Prove Commercial Viability
  - Mobilizing Resources for Growth & Sustainability
- GROWTH & SUSTAINABILITY to Generate Financial Returns

**PHASES OF DEVELOPMENT TO CREATE PROOF**

- Strategy & Policy
- Research & Applications Development
- Commercialization & Company Attraction
Integrated Bioeconomy

Economic Sustainability Requires

- Integrated Biorefineries
- Portfolio of Products
- Flexibility
Technical Capabilities

Gaps:

• Materials-Flow Study
• Techno-Economic Analysis
• Proof-of-Concept
• Pilot-Scale Biorefinery
• Applications Development
Technical Capabilities

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