INTERNATIONAL NANOCELLULOSE STANDARDS

THE NEED AND PURPOSE OF STANDARDS FOR NANOCELLULOSIC MATERIALS

2011 TAPPI Nano Conference Workshop
June 9, 2011
INNOVATION

According to the recent National Academies Report

*Rising Above the Gathering storm, Revisited – Rapidly Approaching Category 5,*

“Innovation commonly consists of being the **first to acquire** new knowledge through leading edge research, being **first to apply** that knowledge to create sought-after products and services, often **through world-class engineering**; and being **first to introduce** those products and services into the marketplace through extraordinary entrepreneurship.”
INNOVATION OPPORTUNITY

- Use Nanotechnology to produce renewable materials made from Nanocellulose for a broad range of products

Commercialization will:
- **Preserve Existing Jobs** by allowing mature industries to remain competitive
- **Create New Jobs** through the launch of new products and markets in multiple industrial markets
- **Re-purpose** the Forest Products Industry
- Position the U.S. as the **Global Leader** in the manufacture of nanocellulose materials
BUT HOW?

Maybe we can use:
- CNC’s
- XNL’s
- NFC’s
- NCC’s
- MFC’s
- Cellulose Whiskers
- Crystalline Cellulose
- Micro Crystalline Cellulose
- Bacterial Cellulose Crystals
- NanoLignoCellulosic Fibrils

But Which One or Are they the Same?
STATE OF DEVELOPMENT IN THE U.S.

Italics = R&D Started

Applications
- Composites
- Bio Fuels
- Super Capacitors
- Clean Water
- Manufacturing Equipment
- Sensors

Basic Research
- Characterization
- Metrology
- EHS
- Modeling
- Dispersion
- Theory
- Medical Tissues
- Cell Adhesives
- Molecular Devices
- Bio Composites
- Membranes

Raw Materials
- Government Support
- CNC Production
- NFC Production

2011

Jobs
Tax Base
Growth
STATE OF DEVELOPMENT IN THE U.S.

- **Science Base (2010)**
  - Characterization of cellulose nanocrystals (Moon-Purdue)
  - Multiscale measurement of wood properties in situ – nano to macroscale (Jakes FPL/U of Wisconsin)

- **Generic Platforms (2009-2010)**
  - FPL Lab bench scale production of cellulose nanocrystals and nanofibrillar cellulose (20g batches)
  - NC State and University of Maine Lab Scale NFC.
  - NFCs and CNCs use in films and clear ballistic glass replacement (DOD-ARL)

- **Cellulose Nanomaterials Standards (2009-2010)**
  - Membership on ANSI and ISO technical working parties
STATE OF DEVELOPMENT IN THE U.S.

- **Generic Platforms**
  - Provide Nanomaterials to support R&D (nation-wide) activities (2011)
    - Produce 35 - 50KG/day batches of CNCs at USFS/FPL
    - Produce up to 500KG/day of NFCs at U of Maine-Orono
  - Develop economically-viable process technologies for CNCs, NFCs and TEMPO-NFCs (2012)
- Global Cellulose Nanomaterials Standards (2012)
STATE OF DEVELOPMENT IN THE U.S.

- **Science Base (2011-2015)**
  - Accelerate Research of cellulose nanocrystals and nanofibrillar cellulose
  - Accelerate Research in Advanced Manufacturing Techniques for American Industry

- **Joint Strategic Planning (2011-2013)**
  - Establish Industry/Government coordination
  - Establish Science Nodes with industry, government & university representation

- **Infratechnologies (2011-2013)**
  - Place additional USDA FS scientists at established University Cellulose Nanotechnology Centers (i.e. Georgia Tech, Penn State, U of Tennessee/Oakridge NL, NCSU; Oregon State; U of Maine, Purdue)
COMMERCIALIZATION FOCUS

Opportunity to replace fossil based materials with renewable resources

- Paper and Coatings
- Packaging
- Batteries
- Super-Capacitors
- Bio Plastics
- Nano Coatings
- Reinforced Polymers
- Smart Sensors
- High Efficiency Filters
- Light Weight Nano Composites
- Nano Membranes
- Photonic Devices
Wood-based cellulose nanomaterials have the potential to add **800,000 direct jobs** and **$200 billion to GDP** in the United States by 2020 with funding.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>DIRECT JOBS</th>
<th>GROWTH IN GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>United States</td>
<td>World</td>
</tr>
<tr>
<td>+2</td>
<td>1000</td>
<td>5,000</td>
</tr>
<tr>
<td>+5</td>
<td>24,000</td>
<td>60,000</td>
</tr>
<tr>
<td>+7</td>
<td>80,000</td>
<td>200,000</td>
</tr>
<tr>
<td>+10</td>
<td>800,000</td>
<td>2,400,000</td>
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*This projection is based on a recent analysis of nanomaterials growth projections by Mihail Roco of the U.S. National Nanotechnology Initiative and National Science Foundation, and assumes that cellulose-based nanomaterials achieve 20% penetration of the market projections for nanomaterials by the year 2020.*
### PUBLIC-PRIVATE PARTNERSHIP APPROACH

<table>
<thead>
<tr>
<th>Fundamental</th>
<th>Translation/Commercialization</th>
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<tbody>
<tr>
<td>• Develop Materials</td>
<td>• Pilot Plant (80/20)</td>
</tr>
<tr>
<td>• Characterization</td>
<td>• Demonstration Plant (50/50)</td>
</tr>
<tr>
<td>• EHS, LCA</td>
<td>• 1st Kind Plant (20/80)</td>
</tr>
<tr>
<td>• Standards</td>
<td>• Application Research</td>
</tr>
<tr>
<td>• Publications</td>
<td>• Product Prototypes</td>
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<tr>
<td>• Processing</td>
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All Fundamentals require Standards to be Commercially Effective.

- Process Definition
  - Produce Pilot Scale/Full Scale Quantities
  - Capital Project Development

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<tr>
<th>Participants Share Knowledge</th>
<th>Competitive Environment</th>
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</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Proprietary Knowledge</td>
</tr>
</tbody>
</table>

Ramp up over 4 yrs To $95M for 10 yrs

Partnership established On risk/reward

Business Model will dictate Collaborations between companies
WHY STANDARDS

- Nomenclature
  - Facilitate common understanding
- Metrology and Characterization
  - Grade Development
  - Quality Control and Validation
- EHS
  - Life Cycle Approach
  - Have appropriate protection as early as possible
  - Legal Risk Mitigation (liability avoidance)
- Material Specifications
  - Makes Commercialization Possible

Standardize the RAW MATERIAL not the FUNCTIONALIZED Material
WHY STANDARDS

- One standard
- Multiple grades

Ensure Existing Methods Ensure standardization (ISO 14000, etc..)
  Will ISO Re-Evaluate to ensure they are appropriate for NANO?
Are existing tests for toxicity, etc... valid for nano materials?
Is ISO talking to others?
  FDA, TSCA, EPA, NIOSH, OSHA, NIH, etc...
THANK YOU FOR YOUR CONTRIBUTIONS

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