Utilization of Digested Bovine Biomass for Value-Added Biocomposites

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& Adj. Prof. of BioProducts at
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FPL: Dr. Henry Spelter
UW-P: Prof. Tim Zauche

Housing Market in the U.S.

- 10-year average was 1.63 mil / year
- 215 m² (2500 ft²) average home size, about doubled in last 25-years
- +90% of those homes employ wood-framing & sheathing in construction

US Census website Jan09 & Smith & Bailey 2002

Challenges in EWC processing

- Raw material availability
- Processing complexities
- Energy Issues
- Enhancing WPC properties
- Economics
- Durability
- Sustainability

Shortages of Wood Materials

“Fiber shortages now plague particleboard markets. Only a handful of industrial particleboard and medium density fiberboard producers in North America are running at full capacity. Most are constrained to five days or less due to lack of furnish. Further, many mills have curtailed operations temporarily after running out of fiber. Despite lackluster demand, reported prices of 3/4-inch industrial particleboard ... have risen +16% since mid-2007 in part due to increasing fiber and resin costs.”

(Random Lengths 4 April 2008)
Section 1.3.1.3 Biofuels versus food

"In 2008 there has been an ongoing global debate about rising food prices and causes. ... Food shortages have been blamed on production of liquid biofuels from crops such as corn and sugarcane. ... "... woody biomass is favorable ... it does not compete with food when it comes from forests, or residues and recycling of wood and paper products.”

History: FPL-UWP-UM work with ADBF

- In 2006, FPL networked with UW-P & UMinn to get a $30K grant from Ag.Development & Diversification of Wis. DATCP to study potential for using ADBF with wood for EWC
- FPL shows potential of ADBF as hybrid EWC
- Eng. MDF from ADBF (Winandy & Cai 2008)
- Wet-form Hardboard (Hunt & Dvorak, In-progress)
- Economic potential for 1:1 substitution for wood (Spelter et al 2008)
Why use fibers & not particles?
High aspect ratio & more surface area

Commercial Western pine flour (left) vs. refined fiber (right) [both at 40-mesh]
**Modulus of Elasticity: Dry-form Particleboard**

![Graph showing Modulus of Elasticity for Dry-form Particleboard](image1)

- Note: 2.4 GPa ≈ 350,000 psi

(Winandy & Cai, BioResources 2008)

**Modulus of Elasticity: Dry-form Fiberboard**

![Graph showing Modulus of Elasticity for Dry-form Fiberboard](image2)

- ANSI 208.1 = 2.46 GPa
- 2.58 GPa
- 2.59 GPa

(Winandy & Cai 2008)

**Flexural Strength of Dry-form Particleboard**

![Graph showing Flexural Strength for Dry-form Particleboard](image3)

- ANSI 208.1 = 16.5 MPa
- 21.1 MPa
- 20.7 MPa
- 24.8 MPa

Note: 16.5 MPa ≈ 2,400 psi & 20 MPa ≈ 2,900 psi

(Winandy & Cai, BioResources 2008)

**Modulus of Rupture: Dry-form Fiberboard**

![Graph showing Modulus of Rupture for Dry-form Fiberboard](image4)

- 2,000 psi
- 3,000 psi
- 4,000 psi
- 5,000 psi

(Winandy & Cai 2008)

**Internal Bond: Dry-form Fiberboard**

![Graph showing Internal Bond for Dry-form Fiberboard](image5)

- UF - SG 0.670
- UF - SG 0.800

(Winandy & Cai 2008)

**Thickness Swell: Dry-form Fiberboard**

![Graph showing Thickness Swell for Dry-form Fiberboard](image6)

- UF - SG 0.670
- UF - SG 0.800

(Winandy & Cai 2008)

<table>
<thead>
<tr>
<th>Production item</th>
<th>Prices</th>
<th>Unit</th>
<th>Costs</th>
<th>Revenue</th>
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<tbody>
<tr>
<td>Particleboard</td>
<td>$300</td>
<td>$/10^3 ft²</td>
<td>$24,000,000</td>
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<td>Wood chips</td>
<td>$65</td>
<td>$/o.d.t.</td>
<td>$1,118,537</td>
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<td>Shavings/sawdust</td>
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<td>ADBF</td>
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<td>Fiber waste (trim, etc.)</td>
<td>$12</td>
<td>$/%</td>
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<td>Urea formaldehyde</td>
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<td>Wax</td>
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<td>Labor, production⁴</td>
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<td>Labor, technical⁵</td>
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<td>Electricity</td>
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<td>Propane</td>
<td>2.5</td>
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<td>Administration and overhead</td>
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<td>$3,272,795</td>
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<td><strong>Total</strong></td>
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<td><strong>$23,074,786</strong></td>
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<td><strong>Profit (loss)</strong></td>
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<td><strong>$925,214</strong></td>
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</table>

**Research Needs: Composites**
- Define Fundamental Relationships of Wood & ADBF morphology and surface chemistry
- Impact of fiber type & quality on composite processing conditions
- Compatibility of Wood & ADBF for various EWC product types (MDF, OSB, SCL, etc.)
- Define optimal engineering and utilitarian value-added among EWC product types

**Research Needs: Economics**
- More rigorous assessment of optimal economic value of ADBF
- Identify problematic dairy processes and how they affect EWC performance
- Cost of production for ADBF once processes are optimized for various EWC product types
- Optimization of economic value-added among various EWC product types

**Research Needs: Chemistry**
- Define ADBF morphology
- Define bulk and surface chemistry of ADBF
- Effect of AD process control on above two
- Effects of Dairy Operations on ADBF
  - Influence cow type, feed, season of year, location, AD equipment, AD process control
  - Ammonia: control & abatement
  - Define levels, why occurring, & how to mitigate

**Conclusions**
- Use of ADBF in EWC and WPC presents potential for high-performance products
- EWC using ADBF has potential for enhanced value added as wood resources experience increased demand and price as bio-fuels
- Working cooperatively with FPL leverages research value
- Significant research is needed to understand, optimize, and then commercialize use of ADBF in EWC and WPC

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Thank you & Questions