Commercialization of Bio-Based Resins and Green Composites

Platts Renewable Chemicals Conference
Houston, Texas
October 18, 2012

Joe Fox
Director, Emerging & External Technologies
Ashland Performance Materials
An Overview of Ashland Inc.

• A global, diversified specialty chemical company with $8B in sales
  - *No longer Ashland Oil!*

• Strengthened by the acquisition of Hercules in 2008 and International Specialty Products (ISP) in 2011

![Product Images]

- Consumer Markets
- Water Technologies
- Specialty Ingredients
- Performance Materials

**Formulated Motor Oils**  **Water Treatment Chemicals**  **Functional Additives**  **Adhesives & Resins for Composites**

I am here representing Performance Materials
HQ = Dublin, OH
How Each Division of Ashland Touches a Biorefinery

• **Chemicals for a biorefinery**
  - Water Technologies (AWT)
    • Pulping aids
    • Corrosion, scale inhibitors
    • Extraction aid for corn oil

• **Chemicals from a biorefinery**
  - Performance Materials (APM)
    • Bio-based building blocks for resins
  - Specialty Ingredients (ASI)
    • High purity cellulose
    • Nano-cellulose
  - Consumer Markets (ACM)
    • Biolubricants
Ashland’s Interest in Biorenewable Raw Materials

• Ashland is interested in using bio-based raw materials to make our products.
  - For composite resins, adhesives, functional additives, lubricants, water treatment chemicals

• Motivation:
  - Lower cost, greater price stability, greater accessibility relative to petroleum-based raw materials
  - Pull from our customers for green, sustainable products

Drop-In Strategy:
• In some instances, we are using (or hope to use) bio-derived versions of building blocks that we already use. Examples:
  - Bio-derived propylene glycol
  - Bio-derived fumaric acid
  - Bio-derived butyl acrylate

  Driver = Green + Lower cost

Exploratory Research:
• In other instances, we are trying to incorporate bio-based building blocks that aren’t currently used. Examples:
  - Modified oils
  - Reactive intermediates

  Driver = Green + Higher Performance
Ashland Products That Use Biorenewable Raw Materials

- **Envirez™**: A family of bio-based resins. Used in a variety of interior & exterior building products.

- **Soyad™**: A formaldehyde-free, soy-based adhesive for plywood and particle board.

- **Natrosol™**: A thickener for water-based paints based on Hydroxyethyl Cellulose (HEC)
Envirez Resins

- Ashland has developed a family of unsaturated polyester (UPR) composite resins that are formulated using renewably-sourced and/or recycled raw materials.
Definition of Terms for this Presentation

• “Rapidly-renewable” or “Bio-based” = A raw material that is derived from natural sources within a 10 year cycle

• “Resin” = A thermosetting Unsaturated Polyester Resin (UPR) that contains either rapidly-renewable and/or recycled starting materials

• “Composite” = A polymer matrix composite made with a thermosetting UPR and....
  - A reinforcement material
    • Fiberglass
    • Natural fibers
  - Particulate material
    • Aluminum trihydrate (ATH)
    • Calcium carbonate
    • Color chips, pigments
    • Recycled glass
    • Other bio-based fillers

• “Green Composite” = A polymer matrix composite whose resin is made with either rapidly-renewable and/or recycled raw materials
First Generation Envirez

• The first Envirez resin was developed for agricultural equipment in the late 1990s.

• Motivation:
  - United Soybean Board wanted to find new applications for soybeans.
  - John Deere wanted to create products for farmers using the crops grown by farmers.

• Ashland’s response: Envirez 1807 was the first commercial bio-based UPR (2001).
Ashland’s Response: Envirez Resins

*ENVIREZ® 1807 was the first renewable resource-based UPR.*

- **maleic anhydride**
- **ethanol**
- **soybean oil**
- **ethylene glycol**
- **propylene glycol**

• ENVIREZ 1807 contained about 18% rapidly renewable content.
Products that Use Envirez - based SMC

Combine Styling Panels, 2001-02

Tractor Hood & Side Panels, 2004

Backhoe Hood Components, 2003

photos courtesy of John Deere
"From Corn & Beans to Machines"

- **FARMER Customers**
- **John Deere**
- **HarvestForm** - molded panels
- **MOLDER**
- **COMPOUNDER**
- **ENVIREZ®-based SMC raw material**
- **ASHLAND**
- **ethanol**
- **liquid resin**
- **refined soybean oil**
Evolution of Envirez

- Ashland has continued to invest in the research and development of green resins and the Envirez family has grown in several important ways.
  - Products with higher rapidly renewable content
    - Renewably-sourced diols
  - Products that use recycled raw materials
  - Products for other composite fabrication methods

- This evolution has enabled Envirez to penetrate other applications.
  - Marine
  - Infrastructure
  - Building & Construction
Evolution of Envirez: Increasing Biorenewable & Recycled Content

Soybean oil, Ethanol

Renewable Diols

Renewable + Recycled

Reactive Intermediates

2000

2012
Expanding the Use of Envirez Resins

- Ashland has developed a family of unsaturated polyester (UPR) composite resins that are formulated using renewably-sourced and/or recycled raw materials.
The Opportunity for Green Building Materials

• Explosive growth in LEED-certified buildings is beginning to occur.

LEED Floorspace

- The surge in demand for LEED-certified buildings should significantly increase the demand for building products made with rapidly renewable and/or recycled materials.


Chart from: GreenerBuildings.com webinar moderated by Joel Makower
Achieving LEED Certification

Buildings can be LEED certified, but not products. Products or materials can contribute toward points needed for LEED building certification.

- Points may be earned in the following categories:
  
<table>
<thead>
<tr>
<th>Category</th>
<th># Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable Sites</td>
<td>26</td>
</tr>
<tr>
<td>Water Efficiency</td>
<td>10</td>
</tr>
<tr>
<td>Energy &amp; Atmosphere</td>
<td>35</td>
</tr>
<tr>
<td>Material &amp; Resources</td>
<td>14</td>
</tr>
<tr>
<td>Indoor Environmental Quality</td>
<td>15</td>
</tr>
<tr>
<td>Innovation in Design</td>
<td>6</td>
</tr>
<tr>
<td>Regional</td>
<td>4</td>
</tr>
</tbody>
</table>

- LEED certification for new construction requires > 50 points.
  - Silver > 50, Gold > 60, Platinum > 80
The Value Chain for Green Buildings

Petroleum-based

Raw Material

Resin Intermediate

Fully-Formulated Resin

Fabricated Composite Building Product

Building Contractor

Ashland plays here.

Ashland’s customers play here.

The remainder of today’s presentation will focus here.

Bio-based

Recycled

Architects, building designers & interior designers influence the choice of building materials.
Sinks and Surfaces

- Uses Envirez Casting Resin
- Won the first Green ACE award at the 2009 American Composite Manufacturers (ACMA) show
Monroe Industries

Surfaces, Vanity Tops

- Uses Envirez Casting Resin & Recycled Glass

- Won the “Best of Show” Pinnacle award at the 2010 ACMA show
  - Product contains both rapidly renewable and recycled content

[Image of a bathroom vanity and a round table]
Biocomposites

- Use Envirez Infusion Resin and natural fibers
- Rapidly-renewable content comes from both the resin and the fibers.
Increasing the Awareness of Bio-Based Building Products

• The architects’ survey conducted by OBIC also indicated that there is an awareness gap regarding building products made with rapidly-renewable raw materials.

• Envirez is LEED-enabling technology.

• Mechanisms for increasing awareness:
  - GreenBuild
  - www.CompositeBuild.com
Greenbuild

- North America’s premier green building show
- Hosted by the U.S. Green Building Council
  - USGBC created the LEED program
- Attended by 20,000 - 30,000 people who specify, purchase and install building products
Increasing the Awareness of Bio-Based Building Products

• At Greenbuild 2010 and 2011, Envirez-enabled composite building products were showcased in a booth called CompositeBuild.com

Message to architects & contractors:

Composites made with bio-based resins are being used to make a portfolio of interior and exterior building products that can qualify for LEED credits.
CompositeBuild.com

- www.CompositeBuild.com was launched at Greenbuild 2010.
- It links architects, building designers & contractors to suppliers of Envirez-containing products.
Explore the CompositeBuild.com Residential House

Take a tour of the CompositeBuild.com residential home and see how engineered composite materials are used to meet your everyday needs.

Throughout the tour we will spotlight products that have attributes of interest to those involved in "green" building and living.
Select a Product Group

Solid Surface Counters
Engineered Stone Counters

Kitchens
Interested in a great looking countertop?
Need new cabinets in your kitchen?
Replacing a worn flooring system?
In addition to design options and durable, high quality performance, you will find that many engineered composite products are fabricated with low emission adhesives, and/or contain rapidly renewable and recycled raw materials.
Solid Surface Counters

Solid surface counters provide limitless design styles with a wide color and patterns. These surfaces are non-porous and can be renewed.

Vendura
Vendura Industries is a manufacturer and fabricator of its Vendura Solid Surface material. We offer 70 standard colors through an unlimited selection of pigments and granules available. Vendura Solid Surfaces is listed as a BioPreferred product by the USDA.

Bradley
Bradley Corporation is a leading manufacturer of commercial hand washing fixtures made of durable Terreon® and Terreon®RE solid surface materials and Evero™ natural quartz material. Architects and designers rely on Bradley for innovative, vandal resistant fixtures that are virtually maintenance-free and easy to install.

Swanstone
Swanstone® is a compression molded compound that blends polymer resins, fillers and reinforcement additives. Swanstone transforms these components into a finished surface material that has extreme resistance to heat, impact, expansion, and chemicals. Learn about Swanstone’s Our Planet Collection. These products meet the design and performance needs of eco-focused designers and owners. The Our Planet Collection contributes toward LEED credits for recycled and renewable content.

Many solid surface manufacturers have incorporated bio-based resin binders and/or recycled granule materials into their product lines.

Some products have been GreenGuard™ certified or listed on the USDA BioPreferred™ database.

Find a regional manufacturer of solid surface products for your local supply needs.
Looking to the Future

- We want to make it easier for architects & building designers to obtain LEED credits and for customers to qualify for BioPreferred database listing.
  - R&D efforts
    • Envirez resins with higher biorenewable and/or recycled content
    • Biocomposites made with Envirez and natural fibers
  - More products
    • Partnerships with composite fabricators
Ashland’s Partnering Strategy

- Performance Materials looks for both upstream and downstream partners in the value chain.

- Upstream partners
  - Biorenewable raw materials

- Downstream partners
  - Fabricators
  - Channel-to-market
Modification of an existing biorefinery to enable chemical production would be less capital-intensive than a greenfield site and could lead to faster job creation.
Vision for Chemical Production at a Pulp & Paper Mill

- Ashland does not intend to build or operate a biorefinery, but we represent a strong downstream channel-to-market partner for bio-based chemicals.
- We look for partners that have the necessary “hardware” and/or “software”.

Ashland uses these monomeric building blocks to make its Envirez resins.
Ashland’s Interest in Biorenewable Materials

<table>
<thead>
<tr>
<th>Performance relative to petroleum-based products</th>
<th>Higher</th>
<th>Comparable</th>
<th>Lower</th>
<th>Cost relative to petroleum-based products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher</td>
<td>New biorenewable building blocks “EXPLORATORY”</td>
<td>Biorenewable versions of existing raw materials “DROP IN”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significantly Lower</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

New biorenewable building blocks “EXPLORATORY”

Biorenewable versions of existing raw materials “DROP IN”
Chemical Production from a Biorefinery

• Specific chemicals Performance Materials is interested in:
  - Glycols:
    • Ethylene glycol (EG), Propylene glycol (PG)
  - Unsaturated di-acids
    • Fumaric acid, Itaconic acid
  - Acrylates
    • Butyl acrylate, 2-Ethylhexylacrylate
  - Aromatics
    • Isophthalic acid, Terephthalic acid
    • Replacements for Bis Phenol A

• Economics:
  - Bio-based chemicals must be cost competitive with their petroleum-based equivalents

• Technology gap:
  - Enzymes /organisms for selective conversion of biomass to these chemicals
    • Ashland does not have expertise in this area
Summary of Our Message

• Ashland is interested in using existing and new bio-based building blocks across its product lines.

• We are interested in working with organizations that have technology for the selective conversion of biomass to chemicals
  - Chemical conversion
  - Biological conversion

• We are interested in partnering to secure funding for the production of chemicals from a biorefinery
  - “Hardware” partners
    • Bioethanol refinery
    • Pulp and paper mill
  - “Software” partners
    • Enzyme / microorganisms
    • Catalysts
Thank You !!

Joe Fox
614-790-3686
jfox@ashland.com
*Trademark owned by a third party.

All statements, information and data presented herein are believed to be accurate and reliable, but are not to be taken as a guarantee, an express warranty, or an implied warranty of merchantability or fitness for a particular purpose, or representation, express or implied, for which Ashland Inc. and its subsidiaries assume legal responsibility.