ACS Summer Program
July 25, 2013

Pine Chemicals:
*Sustainability and Innovation*
What is **Sustainability**?

Among the many ways that sustainability has been defined, the simplest and most fundamental is: “to endure.”

- “Sustainability performance is critical to the forest products industry. In this industry, sustainability means preserving and growing the economic contributions of the industry, fostering the well-being of the communities in which we live and work, and ensuring our resources and raw materials will be as plentiful to future generations as they are today.” *(AF&PA)*

- Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations. *(EPA)*

- The goal of sustainability is to increase long-term shareholder and social value, while decreasing industry’s use of materials and reducing negative impacts on the environment. *(Int’l Trade Admin.)*

**Sustainability**: Management of economic, social & environmental performance to add value

**Environmental**:  
- Energy – fuel, oil, alternative  
- Water  
- Greenhouse gas emissions  
- Sustainable supply chain  
- Waste reduction – medical, hazardous, non-hazardous, construction  
- Recycling/reprocessing/re-use  
- Agriculture/organic foods  
- Packaging  
- Life Cycle product content

**Economic**:  
- Accountability/transparency  
- Corporate governance  
- Stakeholder value  
- Economic performance/Intensity  
- Financial objectives

**Social**:  
- Community investments  
- Working conditions  
- Health/nutrition  
- Diversity  
- Human rights  
- Anticorruption and bribery  
- Safety  
- Public policy and advocacy  
- Socially responsible investing

“Triple bottom line”

- Sustainable
World Focus on *Sustainability*

- Recent McKinsey Survey: Increasing Interest in Sustainability
  - More than 50% of executives surveyed consider Sustainability “very” or “extremely” important in a wide range of areas including overall corporate strategy.

- Recent KPMG report:
  - Climate change and resource scarcity will be serious issues in the medium and long term for companies world wide.

- KPMG Sustainability Mega Forces:
  - Population Growth, *Climate Change*, *Energy & Fuel*
  - Food Security, Ecosystem Decline, *Deforestation*

- United Nations Conferences: June 2012 RIO+20; 7 Areas of Focus:
  - Water, Oceans, *Disaster Readiness*. 
What is the Pine Chemical Industry?
What is the Pine Chemical Industry?

Pine Chemistry refers to the recovery and distillation of bio renewable co-products from a Pine Tree, via the Kraft Pulping Process or Tree Tapping, that are then typically upgraded into ingredients used in a variety of materials we all see in our everyday lives. Some of these applications include: adhesives, paints and coatings, inks, soaps and detergents, lubricants, fuel additives, tires, roads, fragrances, and chewing gum.
According to the UN FAO, “When sustainable forest management is practiced, the values of the natural forest can largely be maintained.” This means that managed forests can continuously provide habitat, protect biodiversity and maintain clean water and economic and social benefits in a never-ending cycle.

According to International Paper, “From a commercial perspective, growing forests is a long-term effort; the cycle is as short as four to seven years for eucalyptus plantations in tropical climates, about 35 years in temperate zones such as loblolly pine in the southeastern United States, and more than 100 years in colder zones such as spruce and fir species in Russia. As long as growing, harvesting and using wood fiber is economically viable, the cycle – no matter how long – can be infinitely repeated.”

Courtesy of International Paper
Pulp and Paper Industry: AF&PA Sustainability

- Increase Paper Recovery for Recycling
  - **Goal:** Increase our fiber recovery rate to exceed 70% by 2020.

- Improve Energy Efficiency
  - **Goal:** Improve our industry’s energy efficiency in purchased energy use by at least 10% from 2005 to 2020.

- Reduce Greenhouse Gas Emissions
  - **Goal:** Reduce emissions by at least 15% from 2005 to 2020.

- Sustainable Forest Practices
  - **Goal:** Increase the amount of fiber procured from certified forestlands or through certified fiber sourcing programs in the U.S. from 2005 to 2020; and work with governments, industry and other stakeholders to promote policies around the world to decrease illegal logging.

- Strive for the Safest Possible Workplace
  - **Goal:** Establish a vision for zero injuries and measure progress toward that vision by improving our safety incidence rate by 25% from 2006 to 2020.
Sustainability: Stakeholders

Regulatory & Government

Employees

What is Most Material to the Business?
CST & BLS $\rightarrow$ CTO are bio-renewable co-products from the Kraft pulping process which serve as raw materials for pine chemical bio-refineries.

Source: STFI Peter Axegard July 2005
Kraft Pulp and Paper process drives by product supply of Turpentine (CST) & Crude Tall Oil (CTO)

Factors Affecting Recovery

- Wood Storage Practices
- Wood Species: Softwood
- Seasonal Affect
- Pulping Rates
- Pulping Process
  - Batch vs. Continuous
  - Decanting & Storage

CTO & CST By Product Recovery Helps Paper Mills

- Safety Programs
- Environmental Costs
- Improves Operating Performance
Composition of Crude Tall Oil

<table>
<thead>
<tr>
<th></th>
<th>Southern USA</th>
<th>Northern USA &amp; Canada</th>
<th>Scandinavia</th>
<th>New Zealand &amp; Chile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Number</td>
<td>165</td>
<td>135</td>
<td>132</td>
<td>158</td>
</tr>
<tr>
<td>Resin Acids %</td>
<td>41</td>
<td>30</td>
<td>23</td>
<td>43</td>
</tr>
<tr>
<td>Fatty Acids %</td>
<td>51</td>
<td>55</td>
<td>57</td>
<td>40</td>
</tr>
<tr>
<td>Neutrals %</td>
<td>8</td>
<td>15</td>
<td>20</td>
<td>14</td>
</tr>
</tbody>
</table>

Like any natural product some variability is expected
Bio-refining and Upgrading: Green Chemicals: CTO

CTO

DISTILLATION/REFINING

Components
- Fatty acids (tall oil)
- Rosin acids
- Sterols
- Pitch

Applications
- Paints & Coatings
- Biolubricants
- Fuel additives
- Performance polymers
- Inks
- Adhesives
- Paper-making
- Roadmarking
- Tyres
- Health-enhancing Food Additives
- Pharmaceuticals
- Bioliquids for Renewable Energy

Enabling substitution of
- Edible vegetable oils
- Fossil feedstocks
- Fossil feedstocks
- Gum rosins from China
- GM soy oil deodistillates
- Fossil feedstocks

TOFA
Rosin
Sterols
Pitch

Oleic & Linoleic Carboxylic Fatty Acids
Abietic, Palustric, Neoabietic
Phytosterols (i.e. β-Sitosterol)
Polymeric
Bio-refining and Upgrading: Green Chemicals: CST

Applications:

- Flavors: Beverages, Sweets, Food
- Fragrances: Beauty Care, Home Care, Fine Fragrances
- Adhesive Resins: Packaging, Non-Wovens, Pressure Sensitive, Tires
Video Discussion:

What did you learn from the ACC Pine Panel Video?
**Video Discussion:**

1. Pine Chemical Industry has evolved over the last 80 years
2. Meaningful economic impact to the US Economy
4. Mature and Well established Industry
5. CTO supply is Inelastic and depends on the Pulp and Paper Industry
6. Pine Chemicals Carbon Footprint is favorable to Petroleum Alternatives
7. NA supplies more than 50% of the CTO used around the world
8. Green Innovation plus Functionality creates value
9. Bio Energy is generally good
10. An even playing field is needed without Subsidies
11. Global Industry

Pine Chemical Bio Refineries are a great example of a **Sustainable** Bio Renewable Industry
What is the Pine Chemical Industry?

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Total: 1,019,500 MT per Year

- **CHINA** 中国
  - 754,000 MT/YEAR (74 %)

- **BRAZIL** 巴西
  - 94,000 MT/YEAR (9 %)

- **INDONESIA** 印度尼西亚
  - 74,000 MT/YEAR (7 %)

- **INDIA** 印度
  - 40,000 MT/YEAR (4 %)

- **MEXICO** 墨西哥
  - 20,000 MT/YEAR (2 %)

- **ARGENTINA** 阿根廷
  - 12,000 MT/YEAR (1 %)

- **NEPAL** 尼泊尔
  - 10,000 MT/YEAR (~1 %)

- **OTHER COUNTRIES** 其他国家
  - 7,000 MT/YEAR (>1 %)

- **PORTUGAL** 葡萄牙
  - 3,000 MT/YEAR (>1 %)

- **RUSSIA** 俄罗斯
  - 5,500 MT/YEAR (>1 %)
An example of a modern and well developed technique!

- A cut is done every 15 to 21 days to expose new wood.
- One worker manages about 7,000 pine trees per season.
- Yield of about 6 kg per tree per season (10 months).
- The Pine Tapping Company employs the worker.
- Chemical stimulants are used to enhance crude gum yield.
- A tree can be tapped for crude gum for about 12 years.
- New pine trees are planted yearly to sustain the forest.
Bio Renewable Raw Materials

Pine Tree
Pine chips (1) ODTPC

Fiber
Black Liquor
BLS (75 lb)
CST (0.5 gal)

Pulp (0.5 ton)
Chemical / Energy
CTO (40 lb)

Alpha 60-70%
Beta 20-25%

Pine Tree
Tapping

Crude Gum

Turpentine

Rosin

Citrus Oils

Oranges Processed
For Juice Concentrate

d’Limonene
What is *Innovation*?

- "An innovation is something original, new, and important - in whatever field - that breaks in to (or obtains a foothold in) a market or society" (*Wikipedia*)

- Innovation is needed to secure a sustainable future. Member companies support research and development with academic institutions, at the plant level, and through independent research councils. (*AF&PA*)

- Green Innovation combined with Functionality creates value and a sustainable future for the Pine Chemical Industry. (*Pine Chemistry Panel*)

- The process of translating an idea or invention into a good or service that creates value or for which customers will pay. (*Business Dictionary*)

- ‘..when we talk about innovation, we talk about working from the customer back, not from the lab out. Start by putting yourself in the shoes of the end-user of the product or service, spend time with them, figure out what's unsatisfactory or unattractive about the current experience, and then design backward from there to create new innovations.’ (*Geoffrey Moore, IBM*)
Arizona Chemical’s Vision

The World’s Leading Innovator in **Sustainable** Chemical Solutions
Pine Chemical Principles

Sustainability & Innovation

- Life cycle and GHG impact
- Green innovation and maximizing value creation
- Cascading use of bio-renewable materials
- Level playing field for bio-products based on performance metrics
- Market based economics **without** subsidies
Climate Change (GHG)
Pine Chemicals vs. Alternatives

Pine Chemicals Carbon Footprint is 55% lower

Emissions associated with Arizona Chemical production

Emissions associated with substitutes of Arizona Chemical products

Data: Arizona Chemical vs. Alternatives:
Pine Chemical Principles

Innovation and Value Creation

Green Innovation + Functionality = Value Creation

Sustainable Success
Arizona Chemical Green Innovation

1970 DECADES OF GREEN INNOVATION

- **HOT MELT POLYAMIDE ADHESIVES**
  - Solvent free

- **FLOATATION CHEMICALS**
  - Replaces diesel

- **TERPENE RESINS FOR POLYMER ADDITIVES**
  - Replaces hydrocarbon polymers

- **HIGH SOLID POLYAMIDE**
  - Low VOC flexo inks and coatings

- **BIODEGRADABLE CHAINSAW LUBRICANTS**
  - Less hydrocarbon based waste in environment

- **FATTY ACID ESTER SOLVENTS FOR INKS**
  - Replacement of hydrocarbon solvents

- **SYLVAPRINT HSR LITHO INK RESINS**
  - Less use of metallic based gelling agents

- **TACKIFIERS FOR HOT MELT ADHESIVES**
  - Reduces solvent usage

- **TOFA AS A LUBRICITY ADDITIVE FOR LOW SULFUR DIESEL**
  - Lower SO\textsubscript{x} emissions

- **BIODEGRADABLE HYDRAULIC FLUIDS**
  - Less hydrocarbon based waste in environment

- **LOW SULFUR TOFA AS A LUBRICITY ADDITIVE**
  - Lower SO\textsubscript{x} emissions
Green Innovation and value creation

World Class Tackifiers

- Our technology innovations create value for adhesive manufacturers by helping to improve products while achieving their sustainability goals.
- Sylvapack™ RE100RC enables significantly improved char performance in EVA hot melts compared to conventional tackifiers.

Tire Safety and High Performance

- Tread enhancement additives work with the tire to improve traction and breaking distance.
- The same additives improve the polymer-filler interaction helping to lower the rolling resistance of the tire and saving fuel.

Visible Road Markings for Driver Safety

- Our innovations allow higher use of recycled materials in new pavements, rather than being thrown into landfills as in the past.
- Our products increase the durability and luminosity of road markings on pavements.
# Bio Renewable Content: Adhesives

<table>
<thead>
<tr>
<th>ARIZONA CHEMICAL</th>
<th>ALTERNATIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BRC %</strong></td>
<td><strong>BRC %</strong></td>
</tr>
<tr>
<td>Rosin Ester</td>
<td>C5 Hydrocarbon Resins</td>
</tr>
<tr>
<td>85</td>
<td>0</td>
</tr>
<tr>
<td>Terpene Phenols</td>
<td>HC Resins</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Styrene Terpene Resins</td>
<td>Hydrocarbon Resins</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Hot Melt Polyamides</td>
<td>EVA’s, Polyurethanes, polypropylenes</td>
</tr>
<tr>
<td>70</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Hot Melt Polyamides</td>
<td>EVA’s, Polyurethanes, polypropylenes</td>
</tr>
<tr>
<td>70</td>
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<tr>
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</tr>
<tr>
<td>70</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Aqueous Dispersions</td>
<td>Hydrocarbon Resins</td>
</tr>
<tr>
<td>50 (in water)</td>
<td>0</td>
</tr>
<tr>
<td>Modified Rosin</td>
<td>Hydrocarbon Resins</td>
</tr>
<tr>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>Terpene Resins</td>
<td>Hydrocarbon Resins</td>
</tr>
<tr>
<td>99</td>
<td>0</td>
</tr>
</tbody>
</table>

**Notes:**
- **BRC %** stands for Bio Renewable Content Percentage.
-**ALTERNATIVE** indicates the type of alternative material used.
Pine Chemical Principles

Sustainability & Innovation

- Life cycle and GHG impact
- Green innovation and maximizing value creation
- Cascading use of bio-renewable materials
- Level playing field for bio-products based on performance metrics
- Market based economics without subsidies
Creating Value with Cascading Use of Bio Mass

BIO MASS → PRODUCT A

Co-product

PRODUCT A → PRODUCT B

Co-product

PRODUCT B → PRODUCT C

Co-product

PRODUCT C → PRODUCT D

Residue suitable for Energy purposes

Biomass co-product value is maximized before final residue is disposed.
Pine Chemical Principles

- Sustainability & Innovation
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Bio-refining and Upgrading: Green Chemicals: CTO

- Focus on value creation
- Cascading usefully applied
- Business based on true market needs
Pine Chemicals and Arizona Chemical

- Well Positioned in the Bio Renewable Chemical space
- Profitable and Mature Industry
- Investing for the Future
  - New Bio Renewable Product Capacity in 2012
  - Hiring: Scientists; Engineers; and Commercial Professionals
- Ripe for Innovation and Growth
Arizona Chemical R&D

Completion Scheduled for Mid Year 2014
Pine Chemicals: Summary

• Forerunner in Bio Refining
  • Pine Trees to Kraft Pulp Mill to CTO & CST
  • Pine Trees to Crude Gum to Rosin and Turpentine

• Creating Value through Innovation
  • Sustainable Future Balancing Green and Functional Properties
    • World Class Tackifiers
    • Tire Safety and Performance
    • Road Markings for Driver Safety

• Efficient Use of Raw materials
  • Carbon Footprint
  • Cascading Use of Materials
  • Sustainable Leadership in Bio Renewable Chemicals
New More Intelligent Business Model

Classic Business Model: Value Creation
• Supplier – Customer
• Measure and manage performance
• Continuous improvement

Intelligent Business Model – Classic Model with Sustainable Solutions
• Life cycle with GHG impact
• Green innovation and maximizing value creation
• Cascading use of raw materials, products, services
• Equal treatment of businesses
• More efficient use of resources

Sustainable solutions are more complex and challenging, requiring Innovation and Collaboration with Key Stakeholders to be Successful