Biobased Greases and Lubricants: From Research to Commercialization

Biomass R&D Technical Advisory Committee

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Outline

• **UNI-NABL:**
  – Background and History
  – Recent Activities and Future Endeavors

• **Market Opportunities**
  – Lubricant Sales and Usage
  – The Effect of Biofuels

• **Government Influence on the Biobased Products Industry**
  – State Initiatives (Iowa)

• **Commercialization of Biobased Lubricants**
  – UNI-NABL Experience
  – Price Comparison with Petroleum Products

• Conclusions
Problem: Excess Capacity

*Millions of Gallons*

- Soybean: 6216
- Palm: 4889
- Rapeseed: 3161
- Sunflower: 2425
- Coconut: 986
- Palm Kernal: 650
- Others: 3213
- Total: 21540
Opportunity: $20 Billion

Automotive 56%

Industrial 44%

1.4 Billion Gallons

1.1 Billion Gallons

2.5 Billion Gallons Total
UNI-NABL History

• 1991: Formed as a Research Project

  ![Abil Logo]

• 1995: Expanded into the Ag-Based Industrial Lubricants (ABIL) Research Program

  ![NABL Logo]

• 2000: Commercial Spin off to market products
Research and Development Work

• 7 patents or joint patents
• Proprietary formulations
• First multi-season grease
• First biobased stick lubricant
• Patented soybean oil based transformer fluid
• Patented soy based wood preservative
UNI-NABL History

UNI-NABL

SoyLube

Growers et al.

(SoyLube is a sister product to Soy diesel)
UNI-NABL History: 2006 - 2011
4th Five years: Transition to a National Center and Continuation of Market Advocacy

- Expanded scope to include all lubricants
- *Applied* biolubricants research and field testing
- Testing and technical support resource for the biobased and biofuels industry
- Participation in standard-setting committees
- Continued publications and presentations
UNI-NABL Today: 2006-Present

Provide Overall Support for the Growing U.S. Biobased Industry

**Mission:**

To provide a national focus for research and technology transfer activities that creates and nurtures the commercialization of biobased *lubricants* which will expand market opportunities for the agricultural community, minimize environmental impact, and help the United States become more energy independent.
Advocacy and Promotion
Advocacy and Promotion
Analytical Lubricants Testing

($5M equipment acquisition for biolubes and biofuels)
Analytical materials testing

($5M equipment acquisition for biolubes and biofuels)
Analytical lubricants testing
($5M equipment acquisition for biolubes and biofuels)
Friction and Wear Testing
($5M equipment acquisition for biolubes and biofuels)
Performance Testing
($5M equipment acquisition for biolubes and biofuels)
UNI-NABL Future

Diesel Engine Oils
UNI-NABBL Future

SoyDiesel

Ethanol

Fuel and Injector Research
UNI-NABL Future

Research the Use of Specialty Crops for Industrial Lubricants
Market Statistics
Petroleum Demand: Gasoline Prices

Average Annual U.S. Gasoline Price to End-Users 1984-2006
(Source: DOE, EIA)
Governmental Focus on Biobased Products in the U.S.
Factors Affecting the Success of Biobased Products

◊ Demand for petroleum
◊ Farmers Investments
◊ Federal Initiatives
◊ State Initiatives
◊ Technology Advancement
### USDA Recently Designated Biobased Products – BioPreferred


<table>
<thead>
<tr>
<th>No.</th>
<th>Product Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hydraulic Fluids for Mobile Equipment</td>
</tr>
<tr>
<td>2.</td>
<td>Urethane Roof Coatings</td>
</tr>
<tr>
<td>3.</td>
<td>Water Tank Coatings</td>
</tr>
<tr>
<td>4.</td>
<td>Diesel Fuel Additives</td>
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<tr>
<td>5.</td>
<td>Penetrating Lubricants</td>
</tr>
<tr>
<td>6.</td>
<td>Bedding, Bed Linens &amp; Towels</td>
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<tr>
<td>7.</td>
<td>Adhesive &amp; Mastic Removers</td>
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<tr>
<td>8.</td>
<td>Insulating Foam for Wall Construction</td>
</tr>
<tr>
<td>9.</td>
<td>Hand Cleaners &amp; Sanitizers</td>
</tr>
<tr>
<td>10.</td>
<td>Composite Panels</td>
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<tr>
<td>11.</td>
<td>Fluid-Filled Transformers</td>
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<tr>
<td>12.</td>
<td>Biodegradable Containers</td>
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<tr>
<td>13.</td>
<td>Fertilizers</td>
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<tr>
<td>14.</td>
<td>Metalworking Fluids</td>
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<tr>
<td>15.</td>
<td>Sorbents</td>
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<tr>
<td>16.</td>
<td>Graffiti &amp; Grease Removers</td>
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<tr>
<td>17.</td>
<td>Two-Cycle Engine Oils</td>
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<tr>
<td>18.</td>
<td>Lip Care Products</td>
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<tr>
<td>20.</td>
<td>Hydraulic Fluids for Stationary</td>
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<tr>
<td>21.</td>
<td>Equipment</td>
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<tr>
<td>22.</td>
<td>Biodegradable Cutlery</td>
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<tr>
<td>23.</td>
<td>Glass Cleaners</td>
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<td>24.</td>
<td>Greases</td>
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<tr>
<td>25.</td>
<td>Dust Suppressants</td>
</tr>
<tr>
<td>26.</td>
<td>Carpets</td>
</tr>
<tr>
<td>27.</td>
<td>Carpet &amp; Upholstery Cleaners</td>
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## Vision Goals:

<table>
<thead>
<tr>
<th></th>
<th>Units</th>
<th>2000</th>
<th>2004</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
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<tbody>
<tr>
<td><strong>Biofuels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market share (%)</td>
<td></td>
<td>0.7</td>
<td>1.2</td>
<td>4.0</td>
<td>6.0</td>
<td>10.0</td>
<td>20.0</td>
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<tr>
<td>Consumption (billion gasoline-equivalent gallons)</td>
<td></td>
<td>1.1</td>
<td>2.1</td>
<td>8.0</td>
<td>12.9</td>
<td>22.7</td>
<td>51.0</td>
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<tr>
<td><strong>Biopower</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market share (%)</td>
<td></td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
<td>5.5</td>
<td>7.0</td>
<td>7.0</td>
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<tr>
<td>Consumption (Quadrillion Btu)</td>
<td></td>
<td>2.0</td>
<td>2.1</td>
<td>3.1</td>
<td>3.2</td>
<td>3.4</td>
<td>3.8</td>
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<tr>
<td><strong>Bioproducts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Production (billion lbs)</td>
<td></td>
<td>12.8</td>
<td>17.6</td>
<td>23.7</td>
<td>26.4</td>
<td>35.6</td>
<td>55.3</td>
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State Initiatives

Iowa Efforts

✦ Senate File 2185 (1998)
  Purchasing preference for soy hydraulic oils.

✦ Senate File 2249 (2000)
  Amended SF 2185 to include soy lubricants and greases.

  Provides a sales / use tax exemption for purchasers of soy rail lubricants.
State Initiatives

Iowa Efforts

◊ Senate File (2005)
State Corporate Income Tax Credit $2.00/gallon up to 2000 gallon per company for switching to soy based METALWORKING FLUIDS.

◊ Senate File (2006)
State Corporate Income Tax Credit of $2.00/gallon up to 20,000 gallons per company for switching to soy based TRANSFORMER Oil.
Advantages of Vegetable Oils

• Naturally Better Lubricant
• Better Viscosity / Pressure Performance
• Superior Thin Film Strength
• Excellent Viscosity Index
• Lower Volatility
• High Flash / Fire Points
Disadvantages of Vegetable Oils

- If Untreated, Lack Oxidative Stability
- If Untreated, Have High Pour Points
- Generally More Expensive than Petroleum
Commercialization Pitfalls

- Oxidation breakdown
- Polymerization of the oil
- Long term performance issues
Oxidation of Vegetable Oils
(Naturally)
Oxidation of Vegetable Oils
(Naturally)
Oxidation of Vegetable Oils
(in machinery)

ASTM D2271 Pump Test
Oxidation of Vegetable Oils
(in machinery)

Viscosity chart in 1000 hour pump test
Oxidation of Vegetable Oils
(by mistake!?!)

[Image of a bucket and a microscope]
Controlled Oxidation
Solution Approaches

- Genetic enhancement of seed oils
- Breeding techniques to find new more stable varieties
- Advances in chemical modification techniques
- Better or improved additive technologies
Oxidative Stability Instrument
OSI Comparisons

Oxidative Stability Index and Active Oxygen Method

GM Soy OSI = 192
Conventional Soy OSI = 7
## Continued Comparisons

<table>
<thead>
<tr>
<th>Test</th>
<th>Mid-Oleic/1% Linolenic Results</th>
<th>Ultra Low Linolenic Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pour Point (°C)</td>
<td>-7.0</td>
<td>-7.0</td>
</tr>
<tr>
<td>Cloud Point of Transparent Fluids (°C)</td>
<td>-5.0</td>
<td>-5.0</td>
</tr>
<tr>
<td>Pensky Marten Closed Cup Flash Point (°C)</td>
<td>282</td>
<td>273</td>
</tr>
<tr>
<td>Viscosity Index Calculation</td>
<td>211</td>
<td>223</td>
</tr>
<tr>
<td>Oxidative Stability Index (hours)</td>
<td>14.91</td>
<td>9.51</td>
</tr>
<tr>
<td>Four Ball Wear Test @ 40 kgf</td>
<td>0.66</td>
<td>0.67</td>
</tr>
<tr>
<td>Four Ball Weld (kg)</td>
<td>126</td>
<td>126</td>
</tr>
<tr>
<td>Acid Number</td>
<td>0.09</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Commercialization Efforts

- Licensing
- Sale of Technology
- Formation of a Commercial Entity
www.elmusa.com
Challenge: Segregation

Storage and Dedicated Transportation
The Leading Manufacturer of Biobased & Biodegradable Lubricants & Greases
Commercialization Efforts
Commercialization Efforts
Commercialization Efforts
Commercialization Efforts
Commercialization Efforts
Political Recognition
Other Products

• Metalworking Fluids
  – Straight Oils
  – Water Emulsified

Coolants
SoyStik™ Stick Lube
ELM Truck Grease
Crete Carrier Corp. and affiliated companies use soy grease
**Price Comparison:**

**Commercialized Biobased Products vs. Conventional**

- Hydraulic Tractor Fluid: 1.5 – 2x
- Food Grade Hydraulic Fluid: 1-1.5x
- Industrial Hydraulic Fluid: 1-2x
- Chain Saw Bar Lubricants: 1-1.5x
- Multi-Purpose Truck Grease: SAME
- Soy & Cotton Oil-Based Greases: 1-1.5x
- Rail Curve Grease: (0.9) - 1.2x
- SoyStik™ Stick Lube: SAME
- Metalworking Fluids: 1-1.5x
- Gear Lube: 1.5-2x
- SoyLubes in Retail: 1-1.2x
Researchers at the University of Northern Iowa created this industrial lubricant from local soybeans. Soybean oil oxidizes in machines, so the professors had to stabilize it through genetic and chemical modification. Amtrak and the Beijing subway grease their rails with the product. And it's an ecofriendly lubricant: When it drips into the earth, bacteria consume it, which rejuvenates petroleumsoaked soil.

Pounds sold in 2006: three million. Price: A 14-ounce tube wholesales for $1.80; a 2,100-pound container, $4,100.
Soy-canola- bio- Lubes

Technology is Transferable
Problem to Opportunity

1st Five years: Addressing Shortcomings of Soybean Oil for Industrial Use
Concept Started from Experiments with Wood Bearings
Lab Inspection
Field Test of Bio Oil Impregnated Boards
Field Test of Bio Oil Impregnated Boards
Impregnation Process
Sign Posts – Field Test
Railroad Ties Field Test
Wood Preservatives

Soy based creosote substitute for posts, ties, and poles
Summary:

• Biobased products are being recognized as critical to the U.S. economy, national security, and environment.

• Biobased products are being promoted at state and federal levels, and by U.S. growers, the industry and the government.

• Biobased products offer the greatest potential for revitalizing U.S. rural communities; adding-value to commodities.

• Biobased products are building a strong performance history: meeting and exceeding performance specifications and becoming cost competitive.
Summary:

- Biofuels have created awareness and momentum for biobased products.

- Increase in the price of petroleum due to increased worldwide demand offers opportunity for investment in biobased products.

- In the U.S. the products are being marketed on the basis of economy and performance.

- Federal Government uses leadership by example to promote the products.

- Demand for bio-products increases economic incentive and advances in seed oil technology.
Conclusions

- NABL Technology is transferable to other crop oils such as rapeseed oil (and canola oil), sunflower oil, palm oil, and many other vegetable oils.

- To increase global use of biobased lubricants, the goal of NABL is to ensure Indigenous crop oils could be used for industrial lubes and grease.

- Future research will identify crop oil properties that would be suitable for biobased lubricants and native to given geographic locations.
Thank You!

www.uni-nabl.org