



**The National Ag-Based Lubricants Center
& Transportation Sustainability**

Wes James
March 31, 2006

**University of Northern Iowa's
National Ag-Based Lubricants (NABL) Center**



National Ag-Based Lubricants Center

www.uni-nabl.org





What is NABL?



What is NABL?

- NABL is a non-profit outreach program of the University of Northern Iowa's Business and Community Services (BCS) department
- NABL specializes in research, development, and facilitating the growth of viable markets for vegetable oil-based industrial lubricants



What is NABL?

History of NABL

- 1991: Started as a Research Project
- 1995: Ag-Based Industrial Lubricants Research Program (ABIL) was established
- 2006: Expanded into *National Ag-Based Lubricants Center* (NABL)



What is NABL?

- A natural outgrowth of UNI's Ag-Based Industrial Lubricants Research Program (ABIL)
- NABL will leverage 15 years of ABIL research expertise and product development to support growth of the U.S. biobased lubricants industry
- National focus for research and technology transfer activities



What is NABL?

NABL's Mission Statement:

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



What is NABL?

Objectives

- Research, develop, and test viable biolubricant discoveries
- Examine the environmental impact of emerging technologies
- Demonstrate the performance of biobased lubricants

Goals

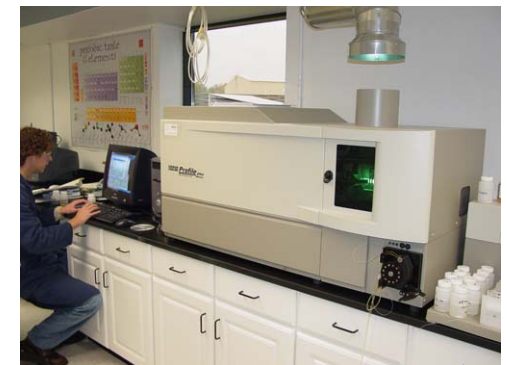
- Alleviate questions about the performance of biobased products
- Establish testing protocols and standards appropriate to biobased lubricants
- Promote market acceptance of biobased products – leading to the growth of a national biolubricants industry



NABL Program Objective

NABL will facilitate commercialization of biobased lubricants by:

- Providing comprehensive analytical and performance testing services to the growing biolubricant industry
- Fostering development of industry infrastructure, including accepted performance standards appropriate to biolubricant formulations





NABL Program Objective

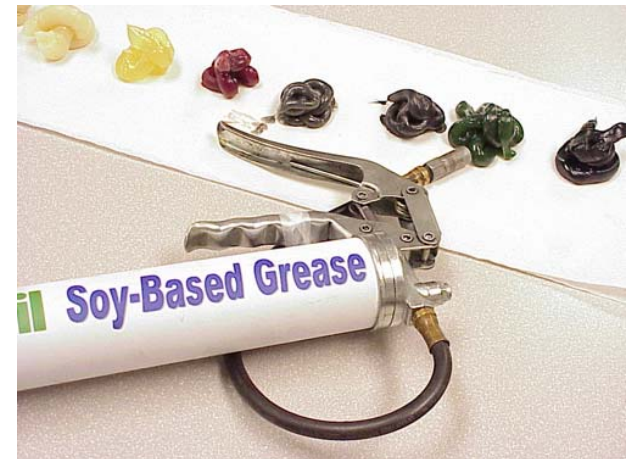
- Advocating for market and industry acceptance of biobased lubricants as viable replacements for traditional non-renewable petroleum lubricants



Rail Curve Grease



Metalworking Fluids



Other Greases



Who Benefits from NABL's Work?

- US Biobased Manufacturers
- US Railroads
- US Trucking Companies
- US Metalworking/Machining Industry
- US Agricultural Producers
- US Environment





Who Works with NABL?

- Portec Rail Products
- John Deere
- Crete Carrier Corporation
- Weyerhaeuser
- Goodrich Corporation – Turbine Fuel Technologies
- Hornady Manufacturing Company
- Northeast Iowa metalworking industries
- Iowa Soybean Association

(and many others)



What Has NABL Accomplished?

- Since 1991, over 30 new soybean oil-based lubricant formulations
- Over 3 million pounds/year of soy-based grease is used by US railroads
- Soy-based grease creates new demand for over 5 million pounds/year of soybean oil projected to 25 million pounds in 2 years.





What Has NABL Accomplished?

- NABL is nationally known as a leading technical service organization with a reputation for unique expertise toward crop-based industrial lubricants
- NABL is one of the best-equipped vegetable oil-based lubricants and grease testing facilities in the country
- NABL has built a lubricants testing program including
 - *Performance* testing
 - *Analytical* testing
 - *Tribology* testing
 - *Biodegradability* studies

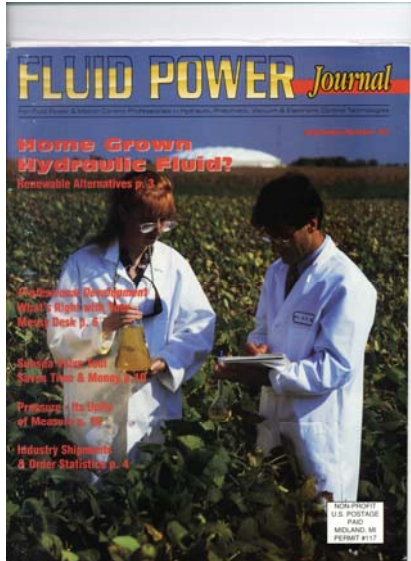


NABL R&D Results

- 9 patents or joint patents
- Over 40 proprietary formulations
- Numerous publications including a book chapter
- First multi-season grease
- First biobased stick lubricant
- First soybean oil based transformer fluid
(currently marketed by Cargill)
- Patented soy based wood preservative



Soy Lube Recognition



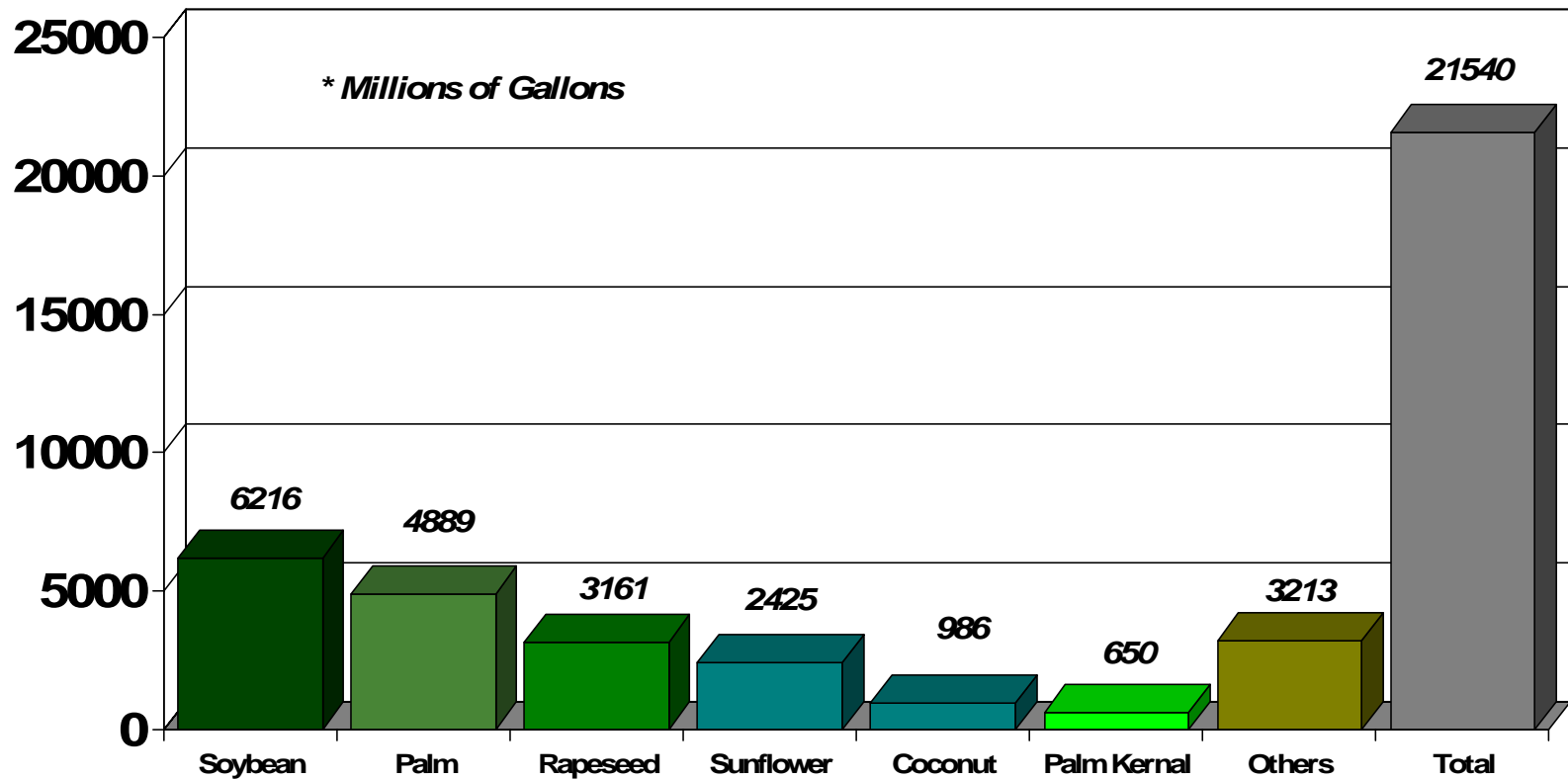
Why Vegetable Oils?



Why Vegetable Oils?

- Original idea came from a student's paper
- First funding was provided in 1991 by the Iowa Soybean Promotion Board to study soy based hydraulic oil
- Soybean oil was found to be unstable in its natural form
- Phase 1: Five years spent solving shortcomings of soybean oil

Worldwide Vegetable Oil Production





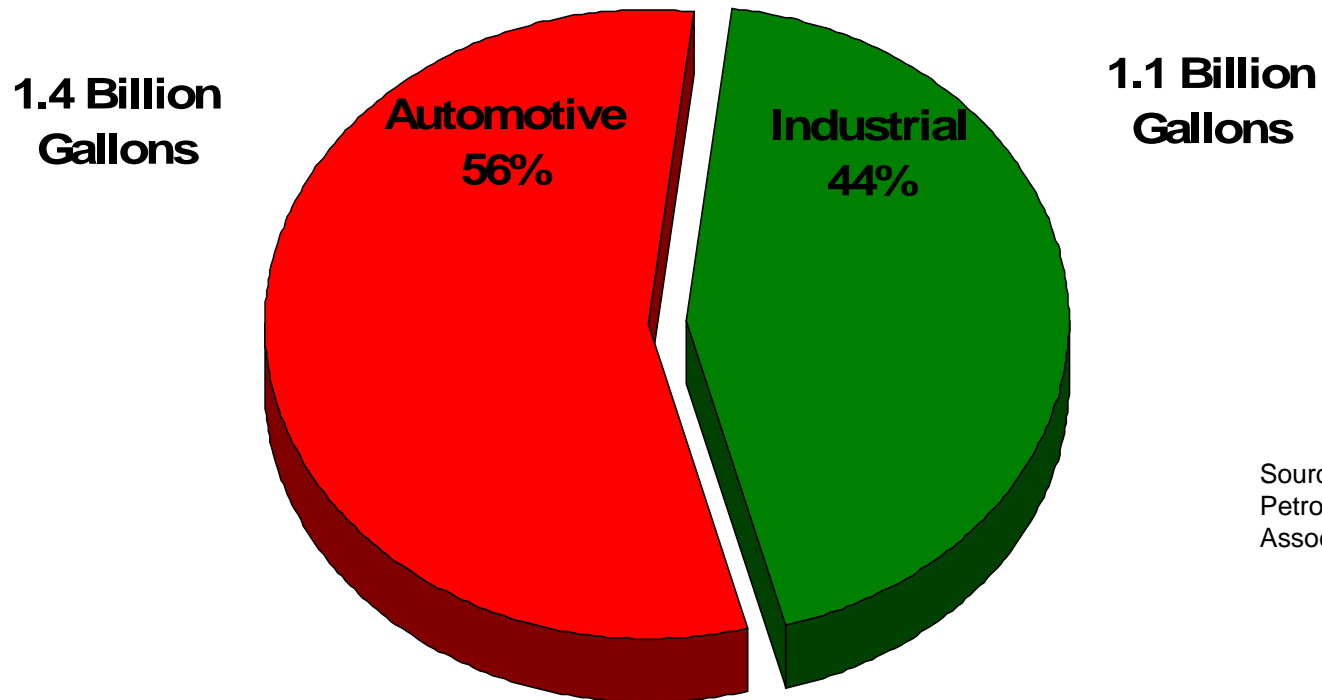
Why Vegetable Oils?

- Meet and Exceed Performance:
 - Naturally better lubricants, better viscosity/pressure performance, superior thin film strength, excellent Viscosity Index, better adherence to metals.

- Environmental, Health and Safety:
 - Features include low toxicity and higher flash/fire points,
 - Readily biodegradable, having a reduced impact on our environment.

- USA Grown:
 - Soy products are renewable, domestic alternatives offering opportunities for rural development, while reducing our dependence on foreign oil

Domestic Lubricant Market



Source: National
Petrochemical Refiners'
Association

2.5 Billion Gallons Total

Advantages of Soybean Oil

- Naturally a Better Lubricant
- Better Viscosity/Pres. Performance
- Superior Thin Film Strength
- Excellent Viscosity Index
- High Flash/Fire Points

Advantages of Soybean Oil

- USA Grown and Abundant
- Offers the Best Price/Performance
- Established Infrastructure
- Can Meet Quantity Demands of the Industry

Disadvantages of Soybean Oil

- If Untreated, Lacks Oxidative Stability
- If Untreated, has High Pour Point
- Generally More Expensive than Petroleum

Soybean Oil – Oxidized/Polymerized

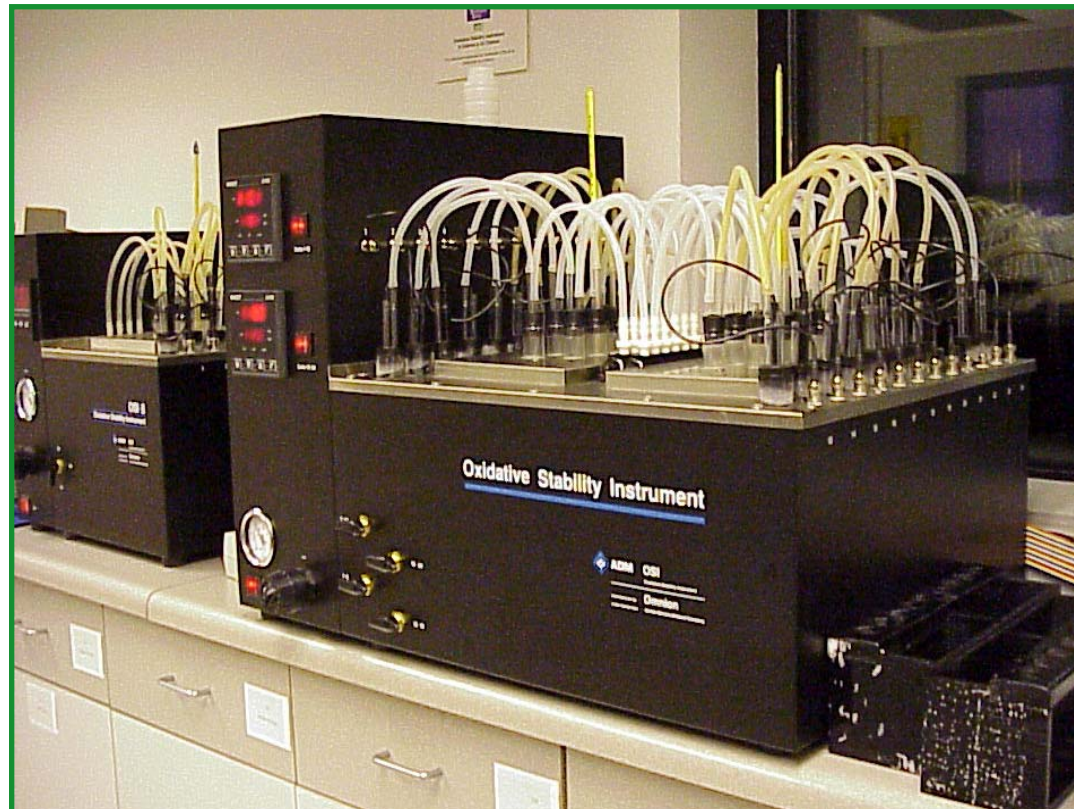


Why Vegetable Oils?



- This bucket of vegetable oil-based lubricant was sold by a business
- The customer called ABIL with questions
- This is what happens when lubricants oxidize

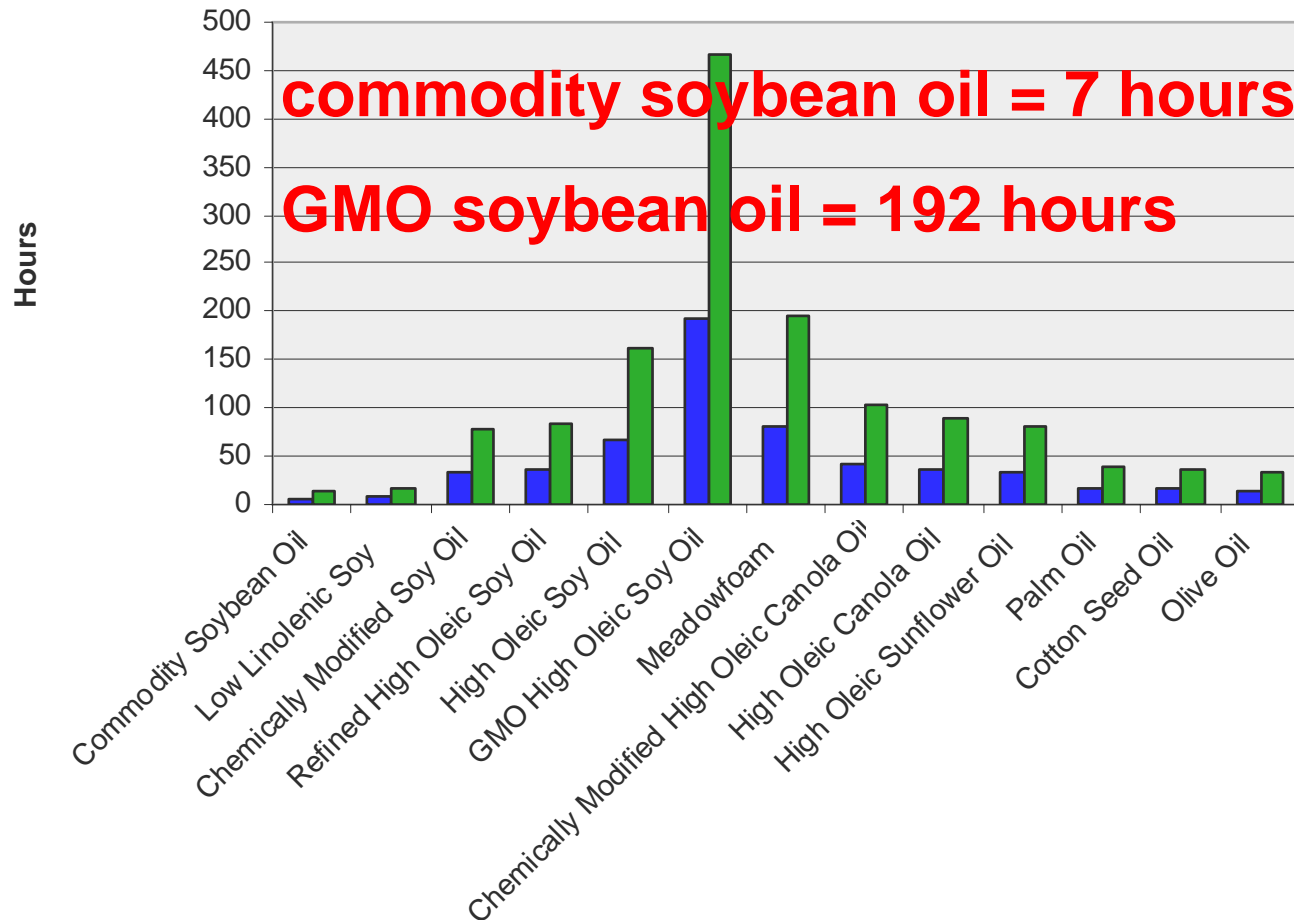
Oxidative Stability Instrument



Why Vegetable Oils?

Oxidative Stability Index and Active Oxygen Method

■ OSI Values (hours @ 110 C)
■ AOM Values (hours @ 97.8 C)





Why Vegetable Oils?

Current Status in the U.S.:

Breakthroughs in the genetic enhancement of soybeans, and advances in formulations technology allows us to produce products that meet and exceed performance standards, yet they are economical.



Phase 2:

Five Years of Product Development

Over 40 industrial lubricants were developed from soybean oils.

- Tractor Hydraulic Fluids
- Industrial Hydraulic Fluids
- Truck Greases
- Rail Curve Greases
- Cotton-Picker Spindle Grease
- Bar & Chain Lubricants
- Food Grade Fluids / Greases
- Multi-purpose Gear Lubes
- Metalworking Fluids
- Dust Control / Suppressants
- Concrete Form Release
- Transformer Fluid



Tractor Hydraulic Fluids



Chain Saw Bar Lubricants



Soy and cotton oil based cotton picker spindle greases



Gear Lubes



Two Cycle Engine Oil



Meet and exceed industry standards, yet cost the same as petroleum products

Soy based metalworking fluids have:

- **better lubricity**
- **higher flash and fire point**
- **better thin film strength**
- **lower volatility**
- **higher viscosity index**



Benefits Observed

- *Performance matching that of synthetic products at costs approaching petroleum-based metalworking fluids*
- *Evidence of health benefits from reduction in dermatitis to respiratory impacts*
- *Safety benefits due to higher flash/fire points and lower volatility*

Soy Based Metalworking Fluids:

- Straight Oil Cutting Fluids
- Water Emulsifiable Cooling Fluids
- Way Oil
- Hydraulic Oil
- Gear Oil



- Metal Removing
- Metal Forming
- Metal Treating
- Metal Protecting
- Emulsified Cooling





Product Development

Case Study:

“Snow Grade” Hydraulic Oil



“Snow Grade” Hydraulic

➤ Issue: Pour Points

➤ Solutions:

- *Winterization*
- *Addition of Pour Point Depressants*
- *Blending with low pour point products*

➤ Field Tests with DOT



“Snow Grade” Hydraulic

Snow-Grade Hydraulic Fluid in Field





Product Development

Case Study: Semi-Truck Grease

*High oleic soybean oil-based grease
made with Li, Al complex and Clay*



Soy-based Fifth Wheel Grease





- **JULY 2002** – Crete Carriers, an Acklie Transportation affiliate (one of the six largest trucking firms in the U.S.), approves soy-based truck grease and converts two terminals and 200 semi-trucks (full conversion began in 2003).
- **Crete Carriers Corp.** – In 2003, after a year long field demonstration involving 1 terminal and 200 semi's, Crete approved an ABIL-developed “Heavy Duty” truck grease company-wide. The Acklie group has begun conversion to soy-based grease nationwide.

Crete Carrier Corporation



From left:

Pat Donohue, Director of Maintenance,

Karel Znamenacek Jr., VP of Operations for Crete Carrier Corp.,

Lou Honary, UNI-ABIL Director

Truck Grease Field Test:

Operator surveys

Visual inspection

Long term use and comparisons

Grease National Test Sites



1. Cool/Wet
2. Enviro/Political
3. Low Humidity/Snow
4. Dry/Hot
5. Cold/Snow
6. Moderate/Diverse
7. Moderate/Warm/Moist
8. Hot/Moist

Iowa's Governor Vilsack Introduces SoyTruk -1999



Decals on Semi's Using Soy Products





Product Development

Case Study: Rail Curve Grease

Purpose:
Reduce friction, wear, and
noise



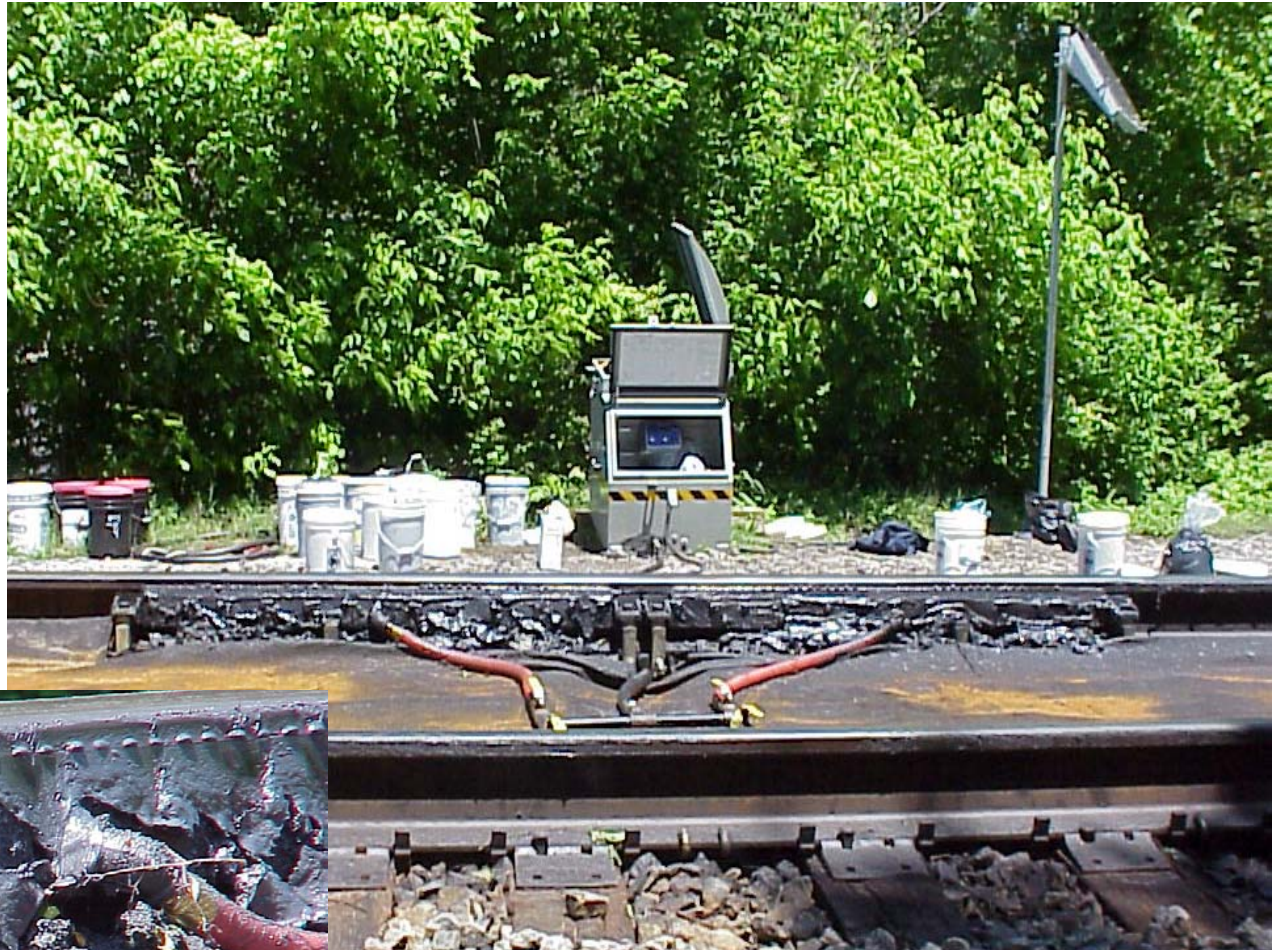


Test of Applicability

High Rail



Portec Protector IV Wayside Applicator



NS Field Test: Equipment



NS Field Test: Grease



NS Field Test: Performance Observation



NS Field Test: Performance Observation

- Carry showed to be approximately 5.5 miles outside from the applicator
- Consumption was estimated to be about 20% less than the conventional grease used

NS Field Test: Follow Up

- Perform energy saving studies of friction reduction by greasing tangent tracks
- A study sponsored by the Iowa Energy Center will be showing the benefits of lubricating the straightaway tracks on locomotive fuel saving.

Biodegradable or Biobased?



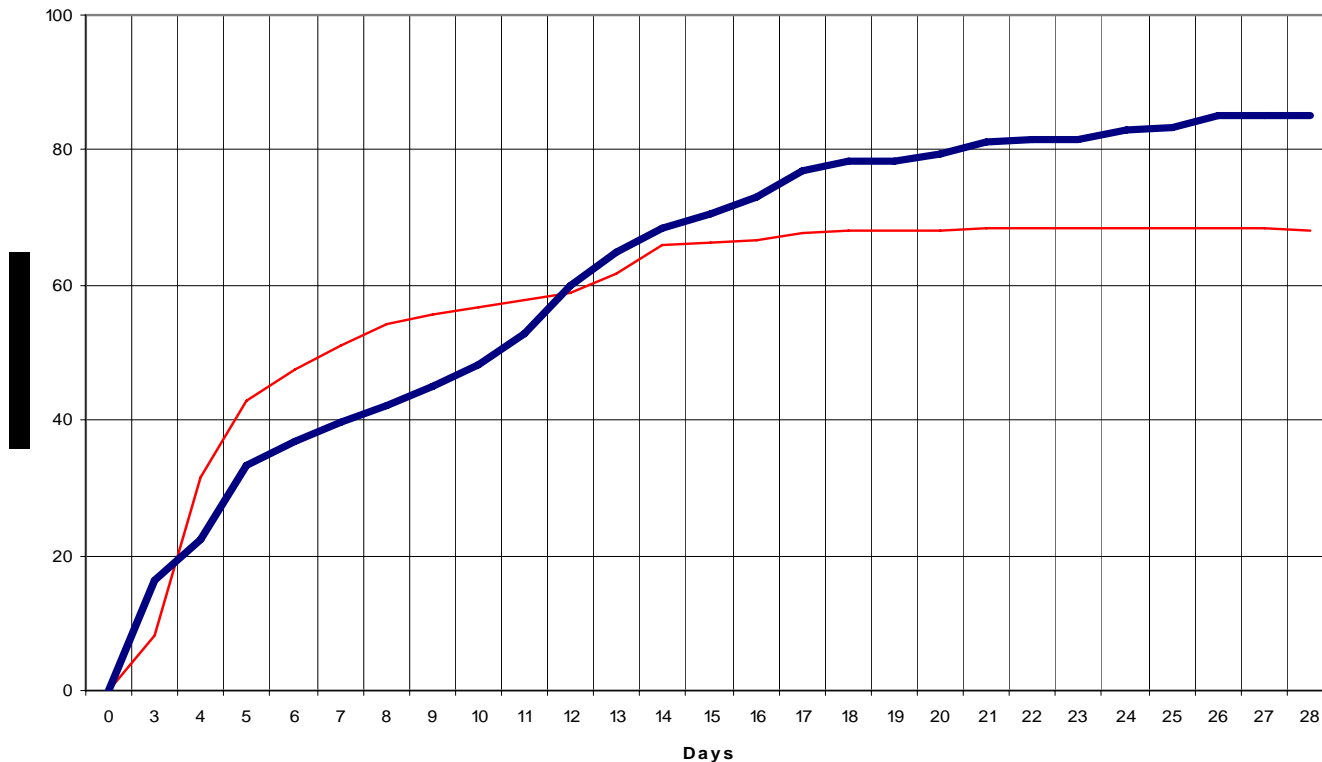
Biodegradable or Biobased?

- **No single definition of biodegradability exists –**
- **Two widely used designations are “readily” and “inherently” biodegradable:**
 - Readily biodegradable is defined as degrading 80% in 21 days (often an OECD referenced method).
 - Inherently biodegradable defines no timing or degree of biodegradability.
- **USDA’s term “biobased”** – to avoid controversies of the term biodegradable, the USDA introduced the term “biobased” for products comprised of 51% or more “bio” materials.

- When microorganisms mineralize the test substance they consume O_2 and produce CO_2
- CO_2 produced is measured and recorded by Electrolytic Respirometer (ER)
- Oxygen production is calculated and stored on a computer database
- This data is used to compute the % biodegradation having occurred



Biodegradable or Biobased?



 Aniline

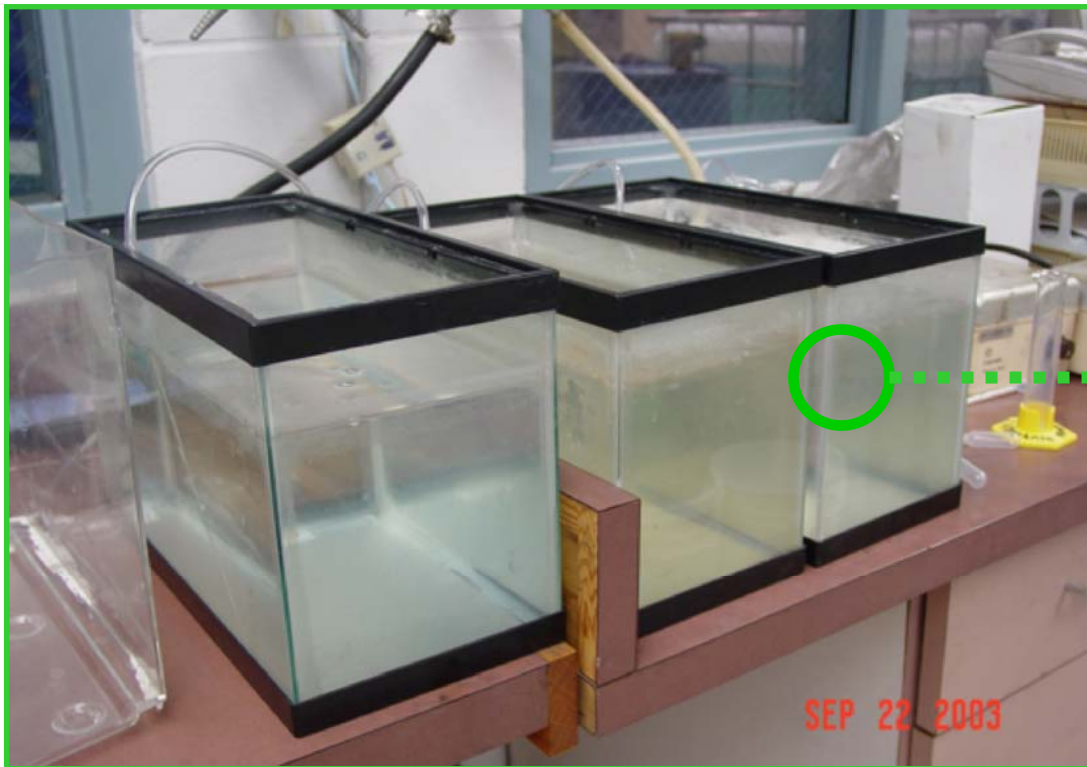
 Soy-Based Rail Curve Grease (50mg/L)



Biodegradable or Biobased?

- Soy-based rail grease showed an 85.1% biodegradability rate
- Soy-based rail grease is considered *“readily biodegradable”*

Acute Toxicity Study



Daphnia Magna



Daphnia Magna

- Daphnia are *small crustaceans* that live in fresh water such as ponds, lakes and streams
- Daphnia are excellent organisms to use in toxicity tests because they are *sensitive to changes* in water chemistry and are *simple and inexpensive* to raise

Test Parameters

- Daphnids used are less than 24 hours old
- Water accommodated fraction (WAF) performed to determine the loading rate which caused 50% mortality after stated time (EL₅₀)
- Test material is added directly to the dilution water and individual WAF's are developed for each test exposure loading

■ *Biodegradability Study*

- The *grease at 50 mg/L showed an 85.1% biodegradability rate* in the 28 day test period
- The grease is considered “*readily biodegradable*”

■ *Toxicity Study*

- Determined that soy-based rail curve grease had *insignificant toxicity for an EL_{50} greater than 100 - 1000 mg/L*



Phase 3:

Five years commercialization



Commercialization

- First approach: license to farmer co-ops
- Second approach: seek out petroleum and agricultural companies
- Final approach: Form a for-profit company



Developing Resources for Soy-Based Fluids

2000 - 2006 - Licensed over 40 products to market





Storage and Dedicated Transportation



The Need for Identity Preservation



Grease Blending From Pilot Plant to Production

1998



2002



2000



2004

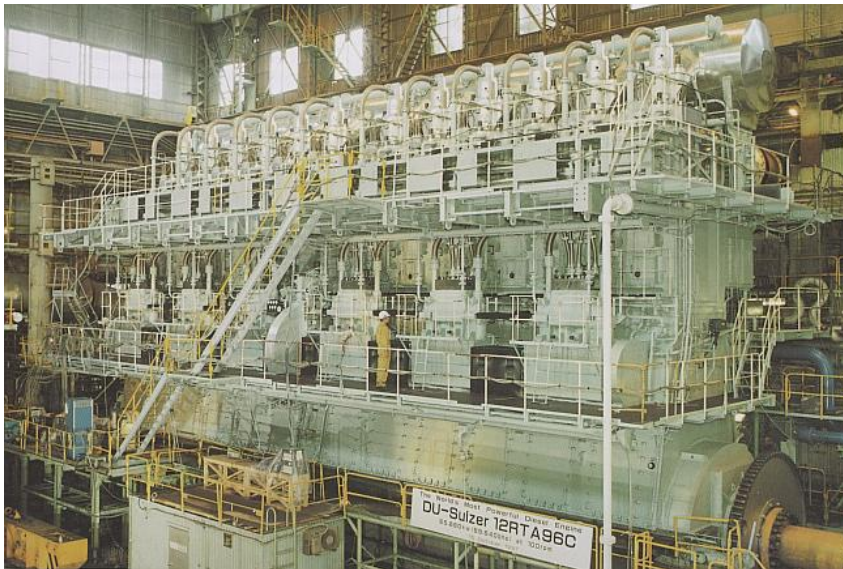
Retail Products





What's Next?

- **1st - Expand scope to include Automotive Lubricants and Fuels & to reduce dependence on petroleum**
- **2nd - Expand service area to help the entire nation and put Iowa on the map**
- **3rd - Balance service-to-the-public with fee-based-services to provide financial self-sustenance**



Diesel Engine Oils



Two Stroke Cycle Engine Oils

SoyDiesel

Ethanol



Bosch DRI



GM Multec

Fuel and Injector Research



Analytical lubricants testing

Chemistry Laboratory Capabilities

- Lovibond Tintometer Color Measurement System IP17
- 798 MPT Titrino, and 832 Karl Fisher
- Demulsibility Apparatus - ASTM D2711
- Foaming Apparatus - ASTM D892
- Liquid Particle Counter
- Oxidative Stability Instrument - AOCS Cd 12b
- Low Temperature Viscosity Bath ASTM D445
- Cloud & Pour Point apparatus D6479, D2500
- Scanning Brookfield Viscosity ASTM D5133
- Brookfield Viscosity ASTM 2983
- Automatic Viscosity Bath ASTM D445
- Quenchalyzer ASTM D6200
- Dielectric instrument ASTM D877
- Foam Test Rig

Laboratory Capabilities

Analytical Laboratory

- CHNS/O Analyzer Fourier Transform Infrared (FTIR) and Near IR Spectrophotometer
- Gas Chromatograph Mass Spectrophotometer (GC-MS)
- Inductively Coupled Plasma (ICP) Emission Spectrometer
- Liquid Chromatograph Mass Spectrometer (LC-MS)
- Ultraviolet and Visible Absorption Spectrophotometer (UV-Vis)
- X-Ray Fluorescent Spectrometer
- Microscope

Performance Laboratory

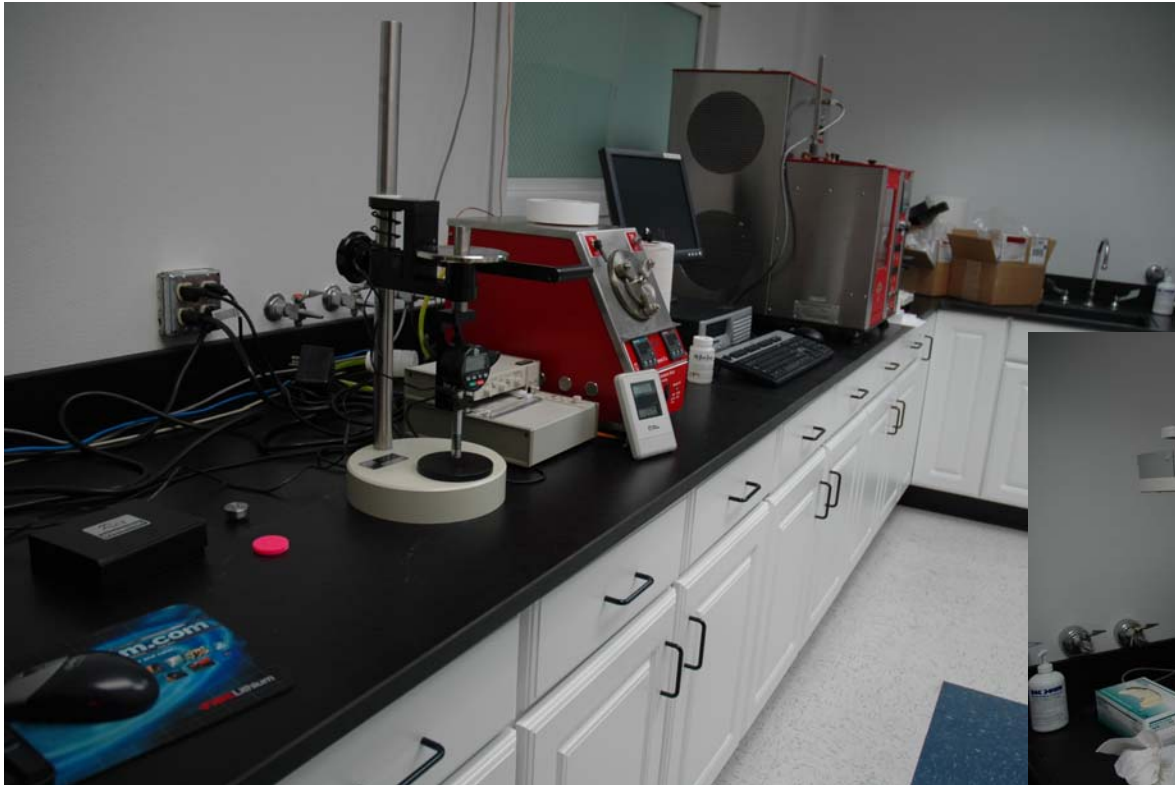
- (2) Vickers 20V Hydraulic Test Stands - (ASTM D2271 & ASTM D2882)
- (1) Vickers 20VQ Hydraulic Test Stand
- (1) Vickers 35VQ Hydraulic Test Stand
- (1) Two-Cycle Engine Oil Test Stand
- (1) Oilgear Piston Pump Test Stand
- Centrifuge & Pasteurization
- Matsuura Machining Center
- Wood Preservation System

Chemistry Laboratory

- Lovibond Tintometer Color Measurement System IP17
- 798 MPT Titrino, and 832 Karl Fisher
- Demulsibility Apparatus - ASTM D2711
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- Automatic Viscosity Bath ASTM D445
- Quenchalyzer ASTM D6200
- Dielectric instrument ASTM D877
- Foam Test Rig
- Centrifuge

Biodegradability and Toxicity Laboratory

- Electrolytic Respirometer – OECD / 301F
- Aquatic Toxicity Test / Daphnia



Analytical lubricants testing

Laboratory Capabilities

- **Specialized research knowledge specific to biobased industrial lubricants**
- **Scientists and technicians maintain proficiency on an array of sophisticated tools used in biobased development**
- **Precisely evaluate the unique performance characteristics of renewable fluids: hydraulic fluids, rail lubricants, semi-truck greases, metalworking fluids, and specialty items**

Tribology Laboratory

- Cleveland Humidity Cabinet - ASTM D1748
- Pour Point - ASTM D97
- Dropping Point Apparatus ASTM D2265
- 4 Ball Wear - ASTM D4172, D2266
- 4 Ball EP - ASTM D2596/D2783
- Multi-Specimen (20 different tests)
- Pin & Vee Block - ASTM D3233
- Grease Apparatus - ASTM D1743
- Grease Penetrometer - ASTM D217
- Ball on Three Disk
- Tapping Torque ASTM D5619
- Hydrolytic Stability ASTM D2619
- Koehler Grease Mobility US Steel Method
- Koehler Water Washout ASTM D1264
- Scar Measurement system
- Thermotron Temperature chamber
- TFOUT & RBOT ASTM D2272, D4742
- Timken OK Load ASTM D2509, D2782
- Evaporation Loss tester ASTM D2595
- Pensky-Martens Flash tester ASTM D93
- Wheel Bearing Grease tester ASTM D 4290, D3527
- Oil Separation test apparatus ASTM D 1742
- Copper Corrosion ASTM D4048
- Environmental Chamber
- Cleveland Open Cup Flash & Fire point ASTM D92



What's Next?



Analytical materials testing

Analytical Laboratory Capabilities

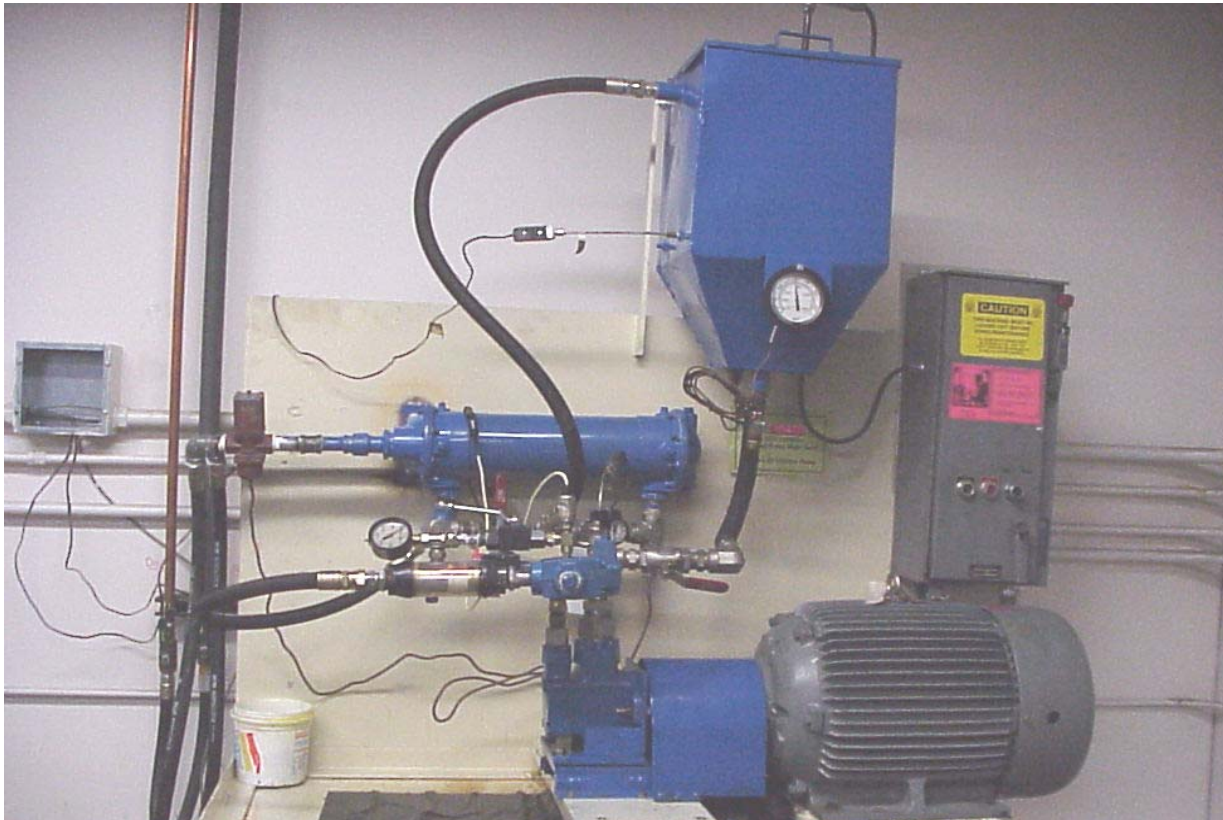
- CHNS/O Analyzer Fourier Transform Infrared (FTIR) and Near IR Spectrophotometer
- Gas Chromatograph Mass Spectrophotometer (GC-MS)
- Inductively Coupled Plasma (ICP) Emission Spectrometer
- Liquid Chromatograph Mass Spectrometer (LC-MS)
- Ultraviolet and Visible Absorption Spectrophotometer (UV-Vis)
- X-Ray Fluorescent Spectrometer
- Scanning-Brookfield Viscometer



Friction and Wear Testing

Tribology Laboratory Capabilities

- Cleveland Humidity Cabinet - ASTM D1748
- Pour Point - ASTM D97
- Dropping Point Apparatus ASTM D2265
- 4 Ball Wear - ASTM D4172, D2266
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**Performance Testing – According to
ASTM standards**

Biodegradability Testing



Biodegradability and Toxicity Laboratory Capabilities

- Electrolytic Respirometer – OECD/ 301F
- Aquatic Toxicity Test / Daphnia

What's Next?



SoyTimber™



SoyLumber™



SoyTimber and SoyLumber





Research the use of specialty beans for industrial lubricants

- **More than 40 states have targeted biosciences:**
 - **Florida -- \$500 million commitment**
 - **Michigan - \$40 million annually for 20 years**
 - **California – 3 new \$100 million bio institutes**
 - **Wisconsin - \$317 million, 10 year program**
 - **Ohio: \$11 million**
 - **Iowa - \$16.4 million over 5 years**

- **Cooperation between programs like UNI's NABL Center, ISU's CIRAS and CCUR, and others create the best opportunity for midwestern states to compete successfully for biobased economic development**

Conclusions:



Conclusions

Vegetable oils present superior lubricity and performance when oxidation and pour point issues are addressed.

Even ignoring environmental issues, vegetable oil-based lubricants and greases have the potential to compete w/o the need for legislative mandates.



Conclusions

In the United States, the government’s “leadership by example” philosophy is paving the way for Biobased products to reach federal purchasers.



Conclusions

In the State of Iowa, the government’s “salesmanship by example” philosophy is getting Biobased products into State-owned equipment.

In the United States, advances in genetics of seed oils have created opportunities for farmers to engage in value-added biobased lubricants markets.

In the United States, the concern for environment, now augmented by national security concerns, have created new impetus for promoting biobased products.



Conclusions

Biobased products have barely 20 years of history vs. their petroleum counterparts. Field test data and use by the leaders of targeted industries can build consumer confidence and market acceptance.

**Equal and better performance
+ price parity
+ government initiatives =**

Market Success

Questions?





Interesting Trivia

1. 1/3 of US railroads are using soy based rail curve grease
2. Soy based metalworking fluids are being used in:
 1. Aircraft manufacturing companies: Goodrich and General Electric
 2. Tractor manufacturers: John Deere
 3. Munitions manufacturers – Hornady bullets
3. Over the last two years, over 40,000 acres of specialty IP GMO soybeans were grown in Iowa specifically for use in industrial lubricants
4. Lubricants are sold \$8.00 - \$20.00/gallon, adding considerable value to farm products