Bio-Based Polymers from Soy Chemistry

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United Soybean Board
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Presentation Outline

- Production and Uses of Soybeans in the US
- Funding by Farmers for New Uses of Soybeans
- Examples of New Uses in Thermoset Plastics
- Drivers for Change to Renewable Feedstocks
Soybeans 2008
Harvested Acres by County

Acreage Planted
2009  77.5 million
2008  75.7 million
2007  64.7 million
2006  75.5 million
US Soybean Producers
Basic Soybean Composition

- 36% Protein
- 15% Soluble Carbohydrates (Sucrose, stachyose, raffinose, others)
- 15% Insoluble Carbohydrates (Dietary fiber)
- 18% Oil (0.3% Lecithin)
- 16% Other
US Uses of Soybeans
2008

- Salad/Cooking Oil
- Baking/Frying Oils
- Industrial Products
- Biodiesel
- Margarine
- Other Edible Products
- Poultry Feed
- Swine Feed
- Beef Feed
- Dairy Feed
- Pet Feed
- Other Feed
- Exported Meal
- Exported Beans
- Exported Oil

Pounds Produced: 177.5 Billion
Pounds Used: 174.7 Billion

Source: www.soystats.com
Farmers direct all USB activities
68 Farmers - appointed by the Sec. of Agriculture make up the USB Board of Directors
They represent 600,813 US soybean producers

Mission
- Increase domestic utilization and exports of U.S. soybeans.
- Increase the production of a better U.S. soybean to meet the needs of the end user.
United Soybean Board Programs

- International Market Development
- Production
- Domestic Market Development
- Producer Communications
- New Industrial Uses
One of the Major Goals of the United Soybean Board is to utilize Checkoff $ to increase industrial demand for soybeans and their derivatives (oil and meal).

Soy oil and Soy meal have been found to be excellent chemical precursors.
How Is This Done?

- The Soybean Check-off Program provides funds for the development of new industrial products and applications.

- USB seed money provides a growing number of portfolios of new industrial products through key technical and trade shows, and technical advisory panel (TAP) meetings.

- To assist in implementing a program for developing new uses for soybeans, the USB contracted with Omni Tech International, LTD (OTI).
New Uses Target Areas

Currently OTI is monitoring progress in the following project areas:

- Plastics (28)
- Adhesives (11)
- Fibers (6)
- Coatings/Inks/Solvents (10)
- Emerging Industrial Opportunities (15)
Current Active Projects in Plastics

- 8415 Lear Corporation: Increasing soy levels in polyurethane foams for auto.
- 8454 John Cerny: Industry exposure to soy pultrusion composite
- 8470 Iowa State University: Formulation development to reduce water solubility
- 8471 University of Missouri: High soy content and performance thermoset polymers
- 8485 Johnson Controls: Soy polyols for auto seating – vibration technology
- 8486 Johnson Controls: Increasing soy content in polyols for auto seating
- 8492 Ashland Chemical: Soy oil for industrial use in unsaturated polyester resins
- 8496 University of Michigan: Soy foam for automotive applications
- 9410 Kansas Polymer Res. Ctr.: Development of glycerin for polymeric products
- 9412 Troy Polymers: Recycling of polyurethanes based on soy polyols
- 9413* Missouri Univ. of S& T: Soy-based UV resistant polyurethane pultruded composites
- 9414* BioPlastic Polymers: Development of soy-based isocyanates from soy meal
- 9415 Biobased Technologies: Soy-based water-blown pour-in-place insulation foam
- 9416 Biobased Technologies: High soy content half-pound polyurethane spray foam
- 9417 Polyworks LLC: Utilizing soy polyol in polyurethane gel products
- 9418 Biobased Technologies: Soy-based polyol with flame retardant function
- 9419* National Composite Center: Soy meal/flour as filler for thermosetting polymer products
- 9425 Ford Motor Company: Soy flakes/soyoil in automotive thermoplastic applications
- 9429 Hot Buttered Elves: Manufacturing Wallabes with soy made in the USA
- 9417* University of Minnesota: Soy-based replacement for phthalate plasticizers
- 9425 Battelle: Soy oil/glycerin modification for high polyl reactivity
- 9426* Washington State University: Development of soy protein-based thermoplastics
- 9486* Sealed Air Corporation: Development of an isocyanate-free packaging foam
- 9487* Pittsburg State University: Hyperbranched polyols for flexible foams
- 9491 Biobased Technologies: Water blown polyurethane spray roofing foams
- 9492 Biobased Technologies: Soy polyols for the flexible foam market
- 9495* Battelle: Glycerol adducts as biobased crosslinkers and waxes
Examples of Funding in Fibers and Chemicals That Make-up Plastics

FIBERS

- 9428  Marvin Technology Associates
- 9457*  New Jersey Institute of Technology
- 9459*  Washington State University
- 9480  Clemson University
- 9482*  Tens Tech, Inc.

  Development of cost effective soy flake-based fiber
  Cost-effective soy protein fiber
  A benign technique for soy protein fiber spinning
  Soy protein processing routes for fibers and films
  Processing finishes and surface modifiers for soy fiber

EMERGING INDUSTRIAL OPPORTUNITIES

- 9456*  Ohio State University
- 9493*  University of Tennessee
- 9494*  Rice University

  Fermentation of soy meal for fumaric acid and ethanol
  Acrolein from crude glycerol by supercritical water tech.
  Soy meal fermentation for succinates and high protein feed
New Uses
Research & Development

Anything you can make out of petroleum, you can make out of soybean oil. The question is, can you make money doing it?

Source: Henry Ford Museum
The USB Model for Development and Commercialization of Biobased Products

- Call for proposals from academic and industrial communities
- Review pre-proposals
- Solicit final proposals
- Brief technical and commercial evaluations by three reviewers
- Evaluations and recommendation to the NUC
- Projects funded and research initiated
- Technical Advisor Panels (TAPs) link innovators to market access
- New products developed and commercialized
MARKET SEGMENT

Thermoset Plastics:

* Polyurethanes

* Unsaturated Polyester Resins
A Demonstration Funded by the United Soybean Board

Source: John Deere
Ashland Inc. Envirez® UPE Resin

Source: John Deere
Funding in Polyurethanes

- Many Projects in the $80,000-120,000 range instead of large projects. Could be smaller or higher.

- Funding of Universities, Individuals, Small and Large Companies.

- Specifically, polyurethanes
  - 1996 Petrovic, Kansas State University, “Plastic Materials from Soy Oil by Use of Urethane Chemistry.”
Polyurethane Applications for Soy Polyols

- Flexible Foam
- Spray Insulation Foams
- Elastomeric Protective Coatings
- Structural Composites
- Adhesive/Coatings
- RIM Structural Foams
Flexible Foam Cushioning

Source: Ford
SoyOyl® Urethane Truck Bed Liner

(20 trucks = An Acre of Soybean Oil)

Source: Urethane Soy Systems Company
DRIVERS FOR CHANGE

- Renewable/Sustainable/Home Grown Raw Material
- Favorable Environmental Life Cycle/Energy Efficiency
- Cost Effective versus Petro-chemical
- Globally Available
- Government Purchasing Support for Biobased Products
- Corporate Environmental Response
Original BEES Analysis in 2003

Environmental Performance

Note: Lower values are better
Study was Updated in 2009

- Databases for both soy and petro polyol changed due to many factors
  - Changes in supporting LCIs
  - Higher soy ag yields (13%)
  - Increased water use (more irrigated acres)
  - Much less energy to crush beans (50%)
  - Different soy polyol process technology
  - Less energy use for petro polyol
Soy polyol still has a more favorable life cycle profile than petro polyol such as:

- Global warming potential
- Fossil fuel depletion
- Criteria air pollutants
- Smog formation potential
- Fuel energy
- Human health exposure
Some Comparisons of Soy vs. Petro Polyols

- **Global Warming**
- **Smog Formation Potential**
- **Fossil Fuel Depletion**
In Summary

- Funding of New Uses of Soybeans by the United Soybean Board has resulted in New Uses of Soybeans
- Appreciative of Continued Use and Investigation of these Materials in Industrial Applications
- Funding in New Areas of Fibers & Plastics and Fermentation Technologies to Produce Chemicals and a Higher Value Protein for Food
Soy.
A natural renewable feedstock for industry.