



Drive quality.



Drive one.



Drive green.

# Can you Be-leaf it?

## Ford Motor Company's Research in Bio-based Materials



Drive safe.

Debbie Mielewski, PhD  
Plastics Research Technical Leader  
Materials and Nanotechnology  
Ford Research and Advanced Engineering



Drive smart.

SPE ACCE  
September 15-16, 2009

## Novel Materials

Develop materials that are lighter in weight, cost effective, greater performance, and provide a competitive advantage

- Nanocomposites
- Shape Memory Polymer



Exfoliated PP/clay nanocomposite



Deformed Shape

Recovered Shape

## Biomaterials

Develop materials from renewable crops that can replace petroleum-based plastics and will also reduce weight and cost

- Soy Based Polyurethane Foams
- Natural Fiber Composites
- PLA



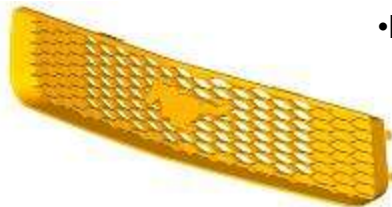
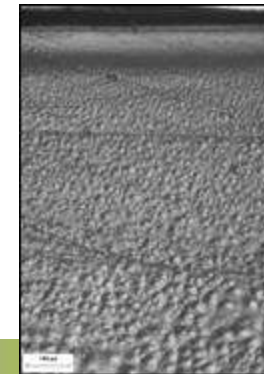
## Ford N.A. Plastics Research

Objective: Develop novel materials and processing techniques supporting lightweight, sustainable, high performance automotive plastics

## Polymer Processing Optimization

Optimize polymer processing through the use of effective models and novel processing methods. Understand the relationships between processing, microstructure, and performance.

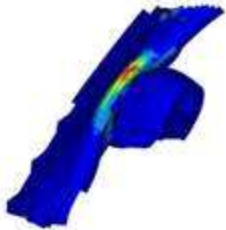
- Virtual Plastics Processing
- Aluminum Tooling for Injection Molding
- Super Critical Fluid Processing
- MuCell



## High Strain Rate Performance

Optimize materials selection and materials-based design for impact applications

- Flex
- Tensile
- Impact





# Why Biomaterials? Why Now?

- Increased use of renewable feed stocks and agricultural products
- Reduce dependence on foreign petroleum (\$150 barrel ?)
- Reduce the negative effects on human health and the environment
  - respiratory illnesses
  - carbon sequestration
- Improved performance in select functions
- Increased consumer awareness-marketing differentiation





# Ford Motor Company's Commitment

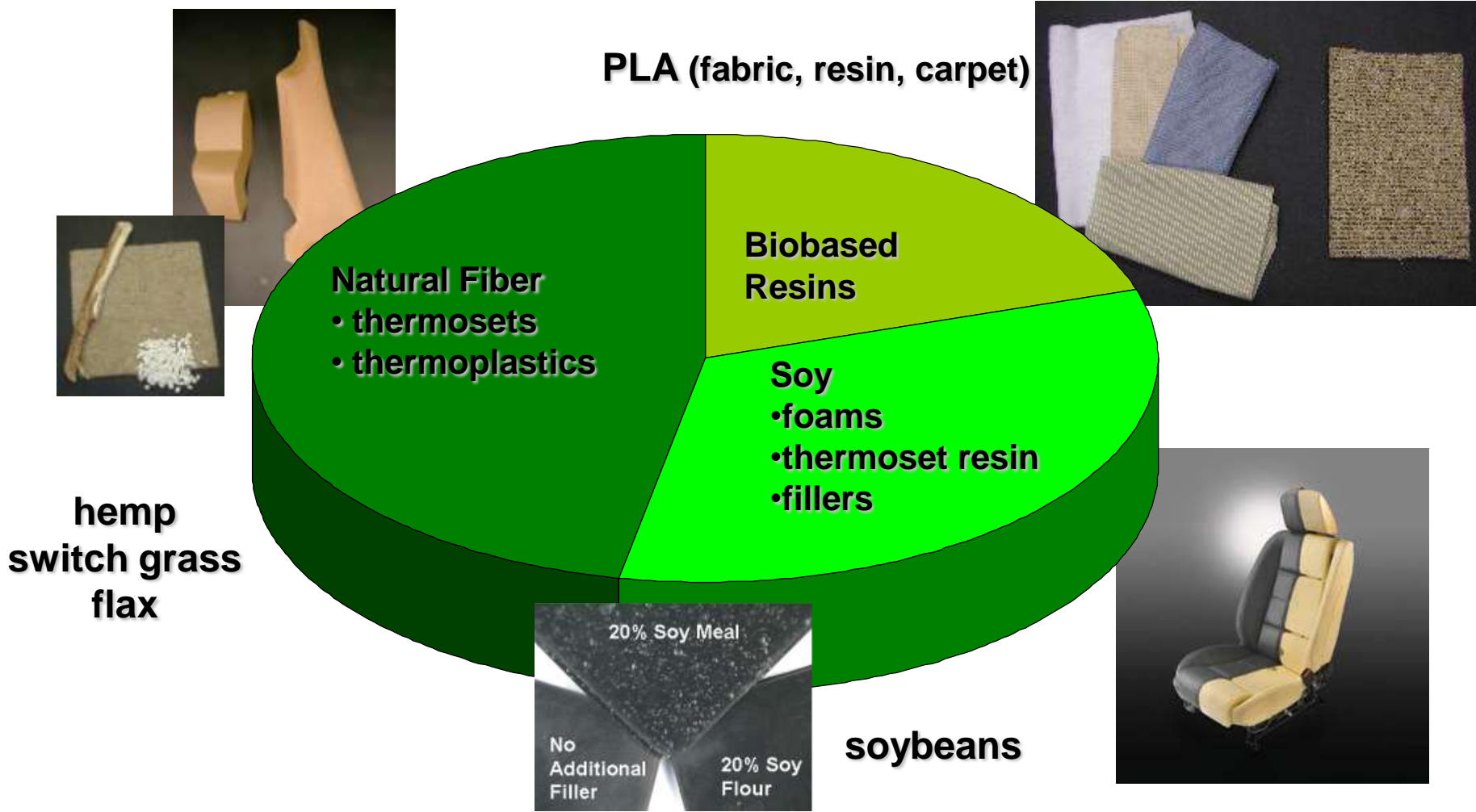


"Ford is committed to offering customers affordable, **environmentally friendly technologies** in vehicles they really want. We are focused on providing solutions that can be used not for hundreds or thousands of cars, but for millions of cars because that is how Ford can truly make a difference."

-Alan Mulally, President & CEO Ford Motor Company



# Ford Biomaterials Overview





# R&A Research Projects Using Soy in Plastics



## SOYBEANS

18%

82%

**Soy Oil**

**Soy Meal**

Sheet Molding Compound

Flexible Foam

Rubber

Rigid Foam





# Soy-Based Foam Technology

- Can we use oil from soybeans to make seats?
- Technology Overview: Use of soy polyol in formulating flexible polyurethane foam for seating applications.
- USB support on development from 2004-2007



Photo by Lynn Betts, USDA Natural Resources Conservation Service.



# Challenges of Developing and Implementing Industry First Soy Foam



## Technical Challenges

- Microstructural optimization
- Specific formulations for various interior applications
- Reduction of soy odor in foam (patent applications)
- Passing materials requirements including ILD, tear, staining, fogging
- Scale-up from laboratory to production formulation
  - Processing
  - Properties
  - Reactivity profile
  - Blend stability

## Implementing Challenges

- 1<sup>st</sup> implementer hurdles
  - Materials specifications
  - Program support
- Scale-up technology
- Plant complexity
  - Additional chemical line or tank
  - Multiple products
- Supply chain availability



# Overcoming Technical Challenges



**Developing new formulations through design of experiments**

## Prior to Optimization of Soy Foam Formulations



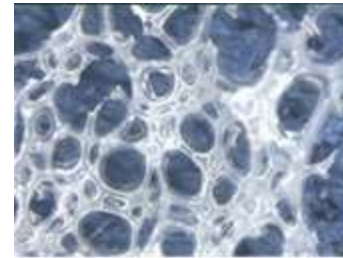
Petroleum Foam  
(0% Soy Polyol)



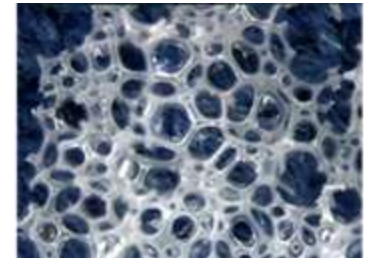
Soy Foam  
(25% Soy Polyol)



## After Extensive Chemical Developments of Soy Foam Formulations



0% Soy



25% Soy



**Petroleum Foam**

**Soy-Based Foam**



# Microstructure looks good ... now what?

- **Odor, fogging and staining are 3 key issues!**
- **Concern:** “rancid” odor detected in soy foam by foam odor panelists; cause for material rejection
- **Cause:** low molecular weight side products in polyol produce odor
- **Technical accomplishments:**
  - Masking of odor through addition of volatile fragrances and neutralizing agents
  - Encapsulation of foam with gas impermeable layers
  - Ultraviolet light synthesis method
  - Stripping of polyol with thin film evaporation method



# Implementation of Soy Foam on 2008 Mustang



- Applications: seat cushion, seat back
- Soy content: 12% polyol replacement
- Implemented: August, 2007
- Soy foam usage: 2.2 Million pounds per year
- Extensive media coverage and interest



# Technology Migration: Programs Using Soy Foam



- Ford Mustang
- Ford Expedition
- Lincoln Navigator
- Ford F-150
- Ford Escape
- Mercury Mariner



- Ford Focus
- Lincoln MKS

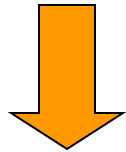




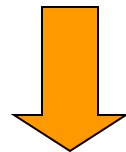
# Environmental Impact and New Directions



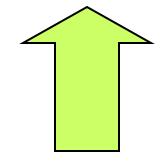
- Environmental impact of current Ford soy foam programs



**5.3 Million lbs. CO<sub>2</sub>/year**



**1 Million lbs. petroleum oil**



**1 Million lbs. soy oil**

- Next steps for soy foam progression:
  - Increase types of foam applications, such as headrests, instrument panel, headliner
  - Increase migration to other programs
  - Increase percentage of soy content in foam
  - Usage and development for other industries; furniture, agriculture



## Ford licensing its soy-foam seat technology

Posted Dec 17th 2007 1:57PM by [Sam Abuelsamid](#)  
Filed under: [Emerging Technologies, Etc.](#)

Last July, [Ford showed off their newly-developed soy-foam seats](#). The new seat material has since gone into production in several 2008 models including the Mustang, F-150 and others. Ford has now reached a licensing agreement with John Deere and Sears Manufacturing Company for the soy-foam. Deere will be using the plant-based foam for seats in their tractors. Ford will be offering a variety of their technologies for licensing through Ford Global Technologies, LLC.

[Source: Ford]



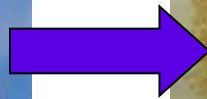
# Can we use the other part of the bean?



- Technology Overview: Use of soy meal in formulation and processing of automotive plastics.



Photo by Lynn Betts, USDA  
Natural Resources  
Conservation Services





# R&D Using Soy Fillers in Plastics

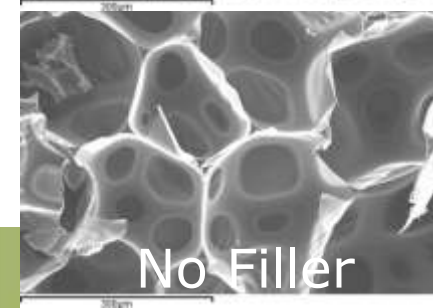
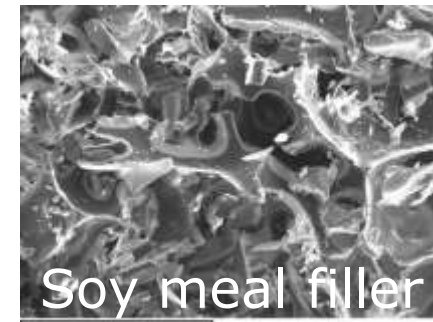
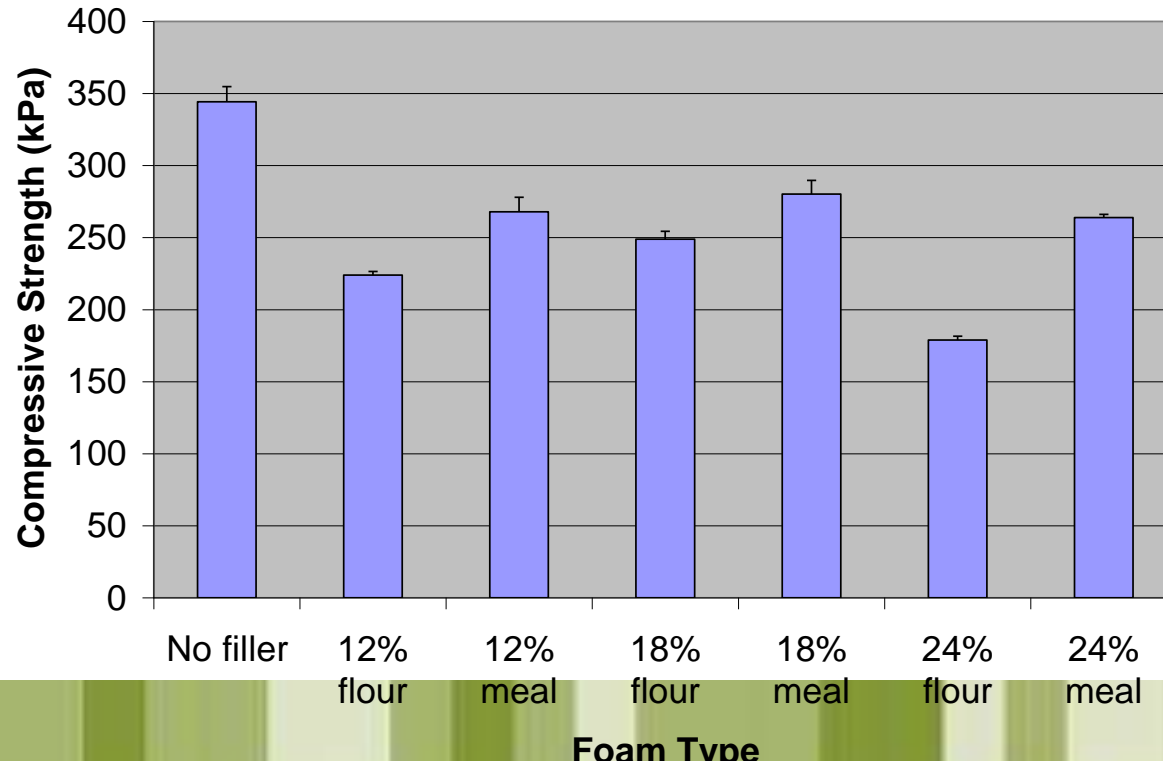
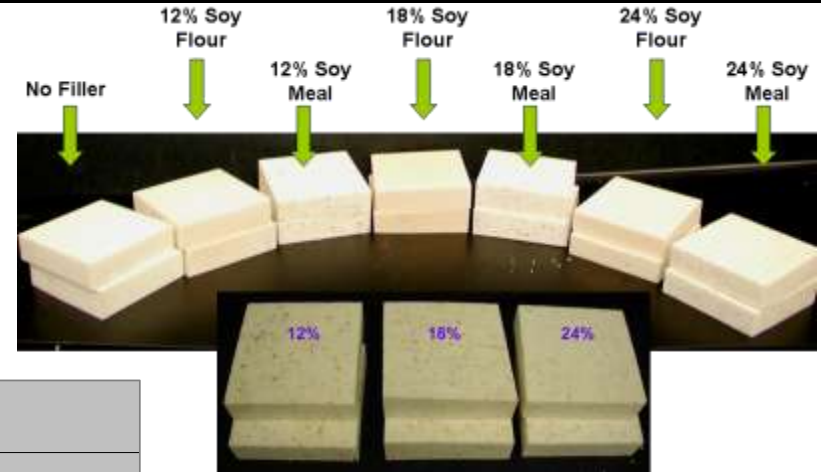
- Researching soy flour filler in a variety of plastic matrices:
  - Rigid polyurethane foam
  - Natural Rubber
  - EPDM (ethylene propylene diene monomer)
  - PP (polypropylene)
  - TPO (thermoplastic polyolefin)
- Collaborating with suppliers on soy filler in automotive parts:
  - Cowl plugs and fender stuffers (PVC)
  - Air deflectors and radiator deflector shields (TPE, EPDM)
  - Interior trim (TPO, TEO)



# Soy Fillers in Rigid PU Foams



- Potential Applications:
  - Package tray
  - NVH Foams
  - Energy Absorption Foams (pillars, bumper)



200x

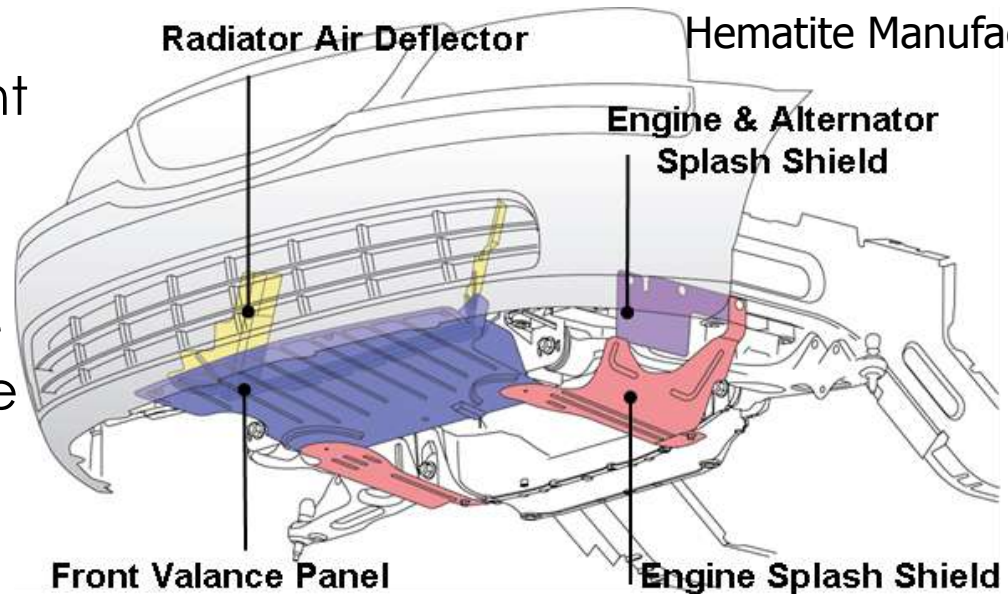


# Molding Trials- Soy fillers in EPDM

(Hematite Manufacturing)

Schematic courtesy of Hematite Manufacturing

- Part appearance: Excellent
- Texture: Good
- Overflow Tear: Excellent
- Lowering tool temperature improves part appearance and properties
- Odor: no concern





# Soy Fillers in Commercial EPDM-

Replacing 10% Carbon Black Filler with Soy Flour  
(Hematite Manufacturing)



Test	10% Soy Flour	No Soy Flour	Target
Tensile Strength (MPa)	6.28	9.62	
Elongation (%)	331	396	
Modulus (MPa)	5.97	8.25	
Tear (kN/m)	28.54	30.99	
Durometer	89	86	
Density (g/cm <sup>3</sup> )	1.26	1.25	
Low Temp. Brittleness (3 min. @ -40F)	Fail	Pass	

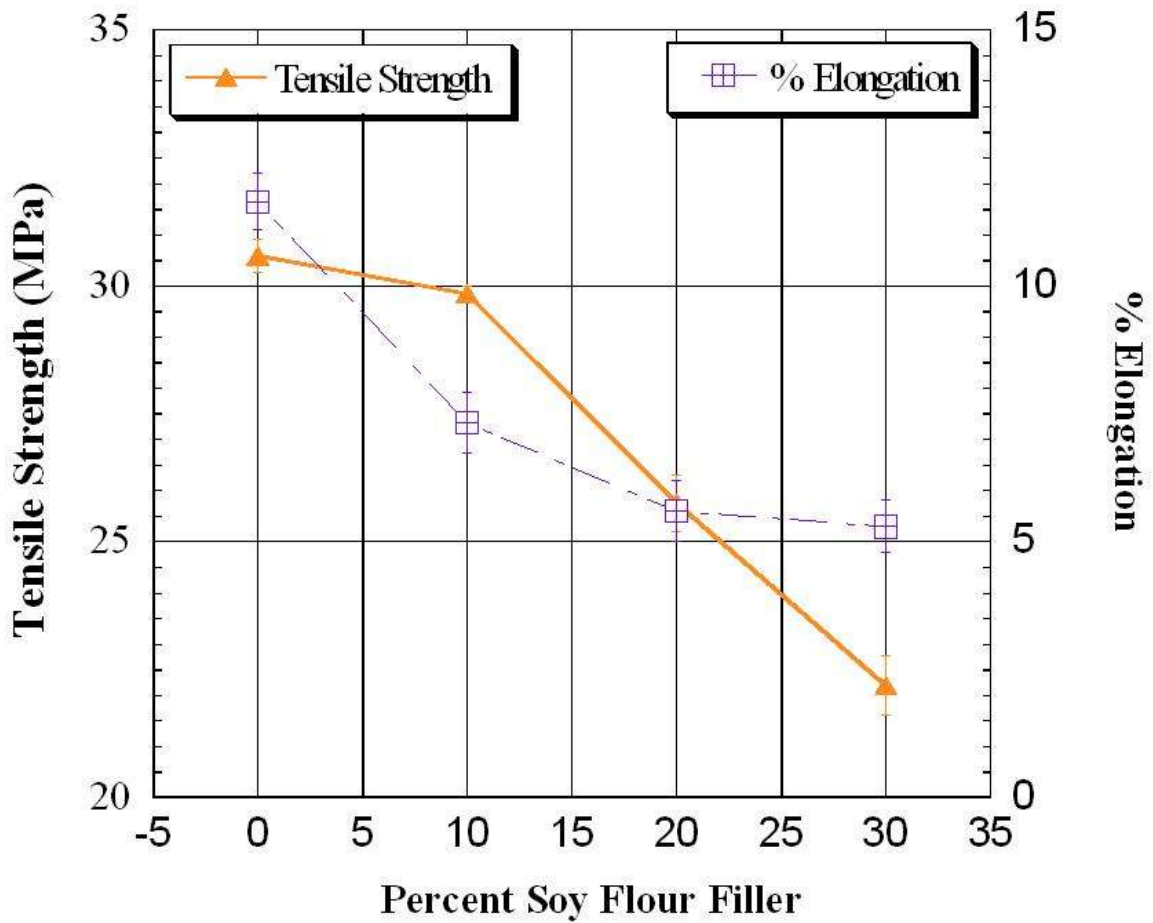


# Soy Fillers in Polyolefins:

## 10-30% Soy Flour in PP



Soy Flour in PP, Following ASTM D638, 50mm/min. rate





# Summary of R&D with Soy in Automotive Plastics



- **Soy Oil in Flexible PU Foam**
  - In production
- **Soy Fillers in Rigid PU Foam**
  - Able to incorporate up to 24% filler, but moisture absorption a concern
- **Soy Fillers in Natural Rubber**
  - Positive results using up to 30% soy flour
- **Soy Fillers in EPDM**
  - Obtained promising physical results; collaborating with supplier on parts
- **Soy Fillers in Polyolefins**
  - New project to use soy fillers in PP, TPO, TPE





# Natural Fiber Benefits

## Weight Reduction

- lower density:
- potential savings up to 30%

*natural fiber: 1.3 – 1.5 g/cm<sup>3</sup>*  
*glass fiber: 2.6 g/cm<sup>3</sup>*

## Cost Comparison

- glass fiber: \$0.50 – \$0.90/lb
- natural fiber: \$0.30 – \$0.80/lb
- potential cost savings up to 20%

## Renewable resource (“green”)



# Natural Fiber Reinforcements



sisal fiber



kenaf fiber



jute fiber



hemp fiber



coir fiber



flax fiber



wood



cellulose fiber



# NF SMC: Compression Molded Parts



Thunderbird back outer finish panel



F-150 fender reinforcement



Taurus engine valve cover



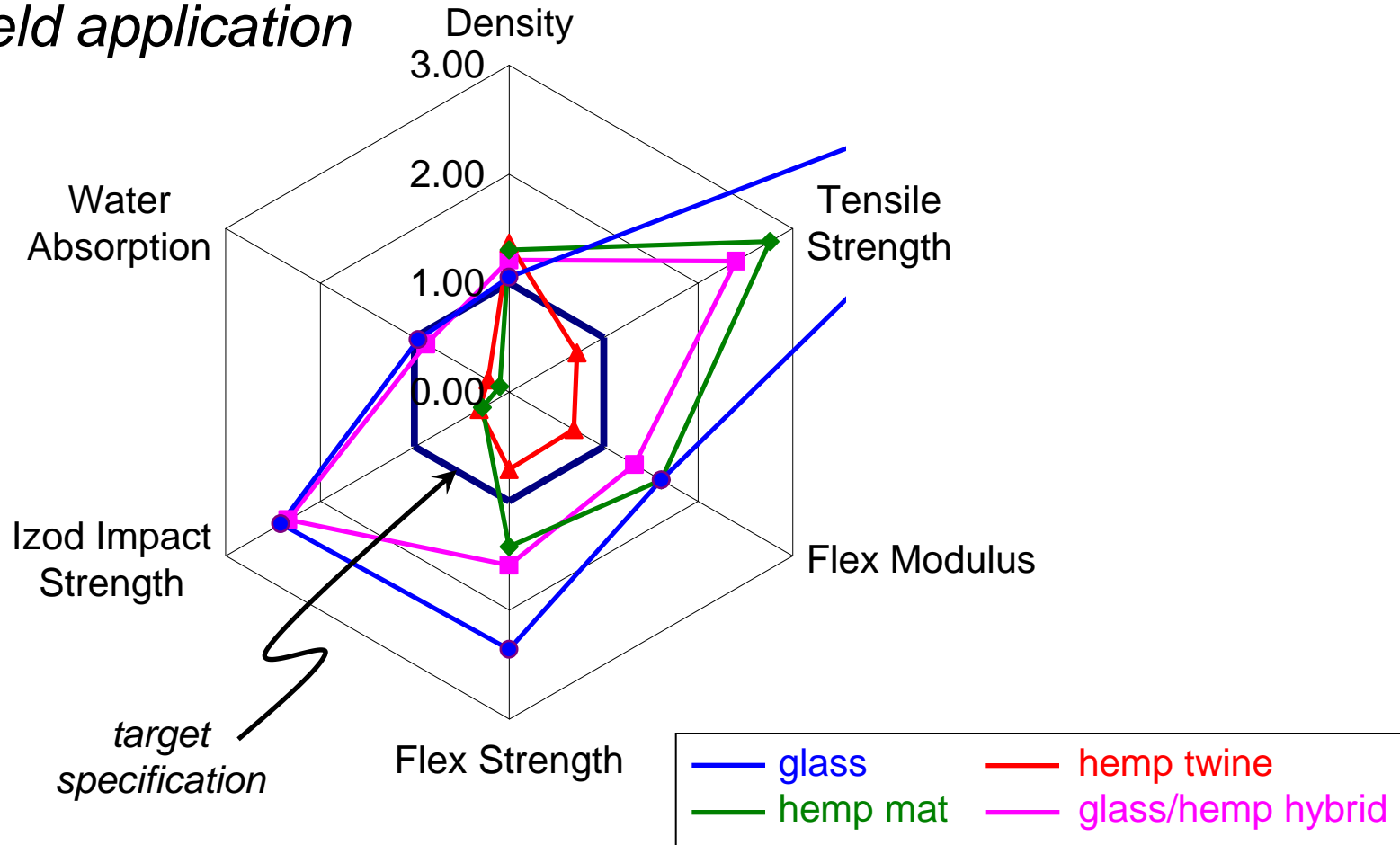
Fusion tow impact shield





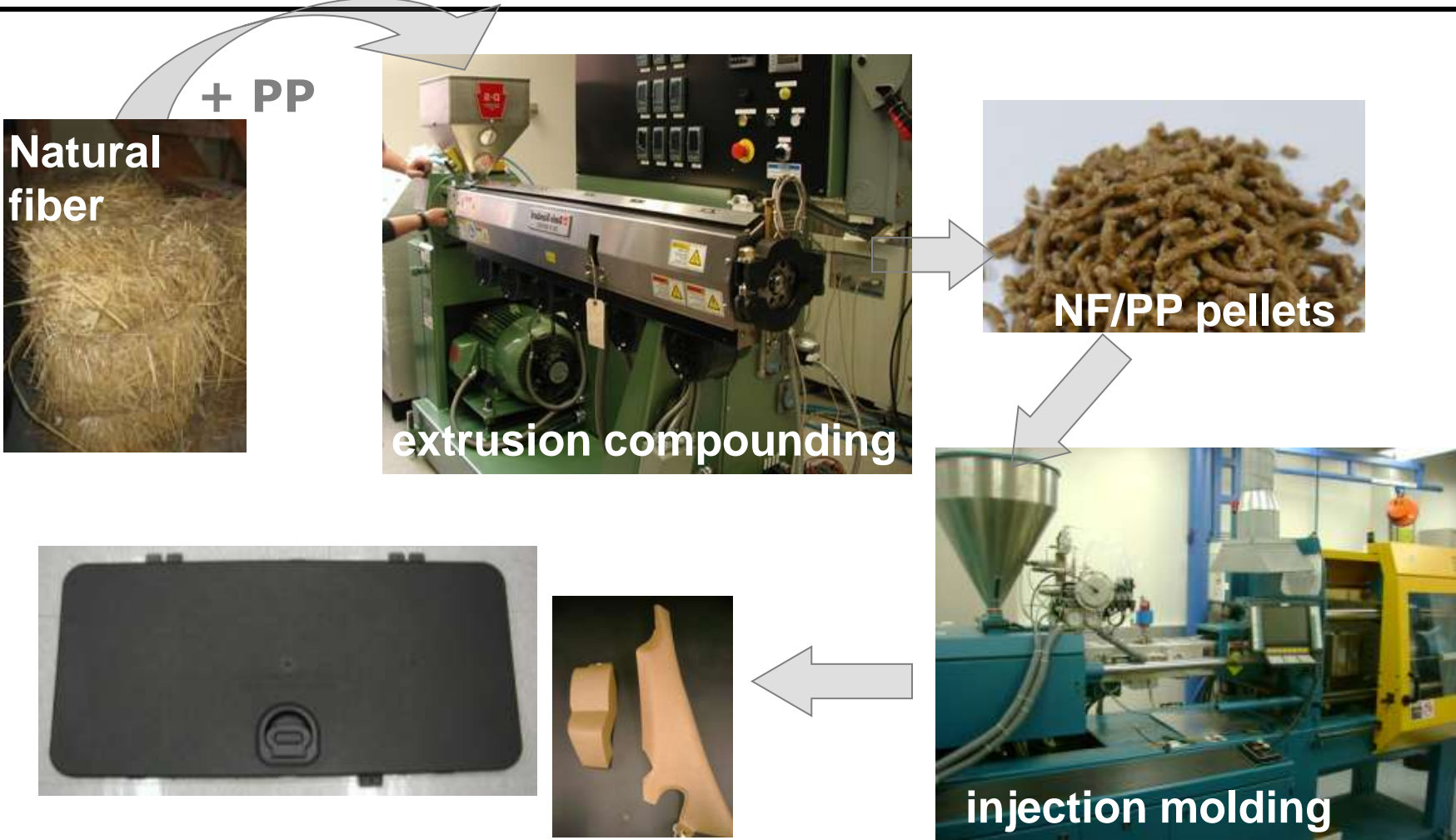
# NF SMC: Performance

*noise shield application*



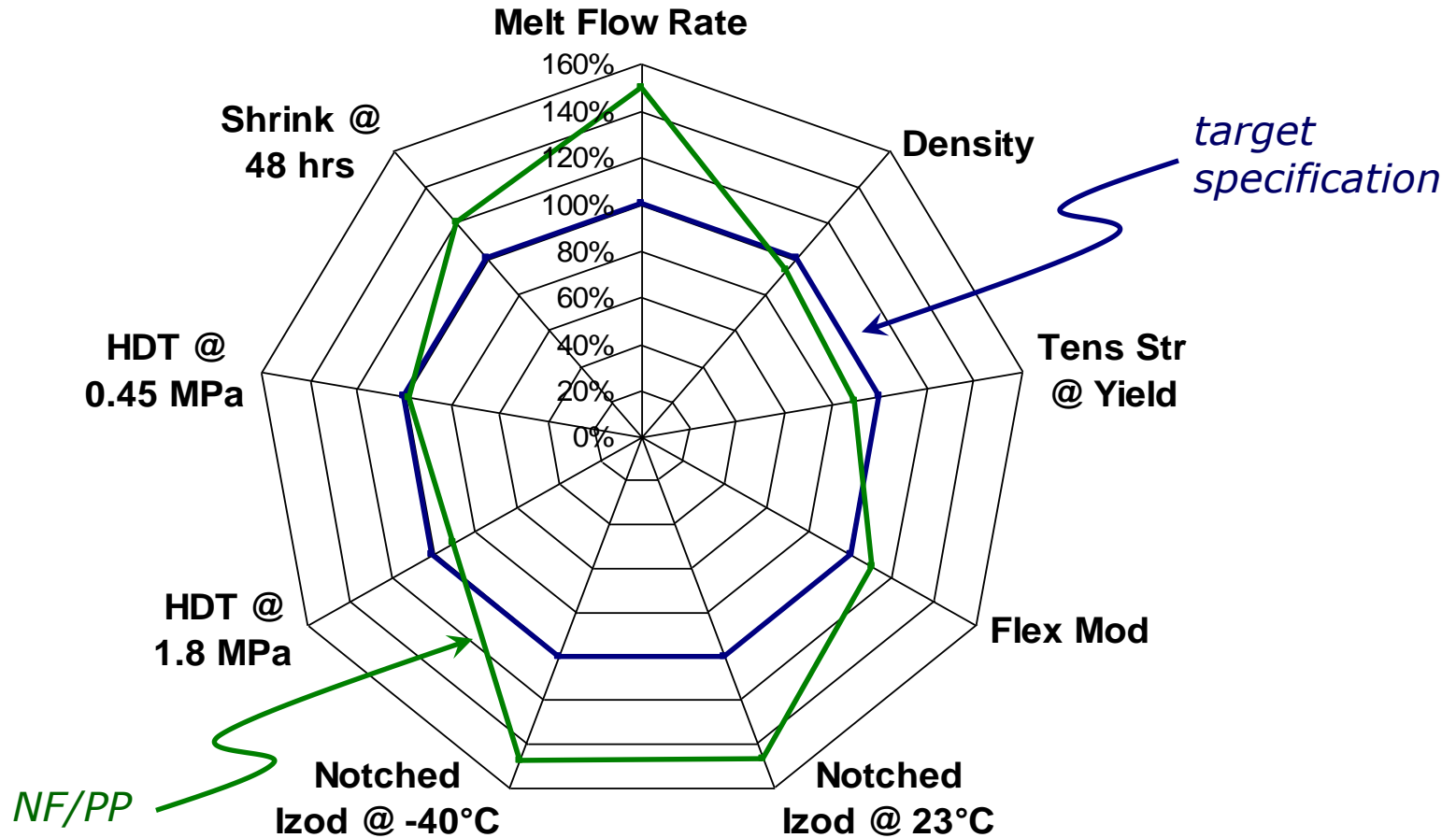


# Natural Fiber/PP for Injection Molding Applications





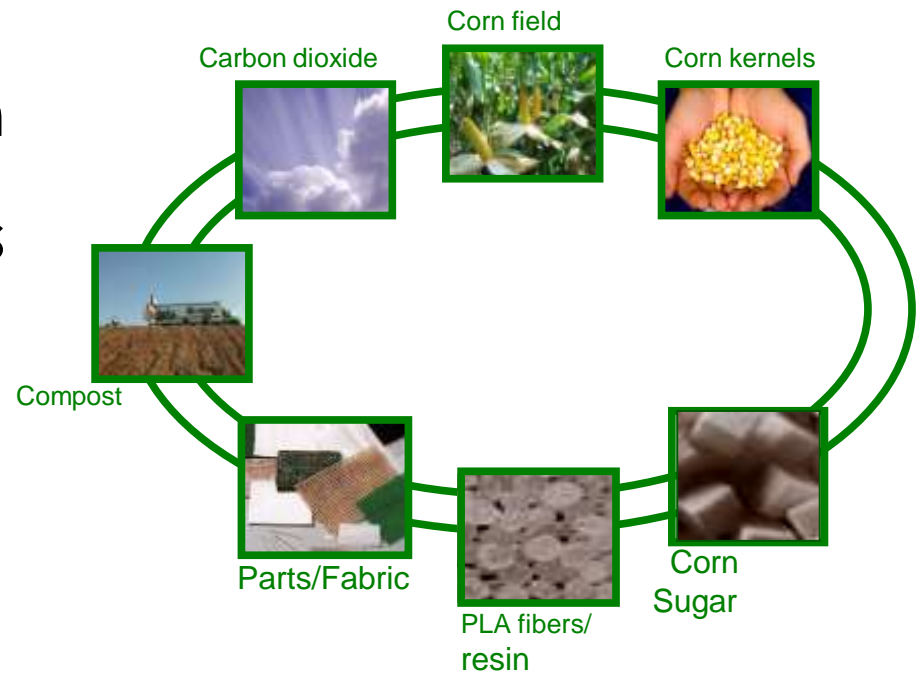
# NF/PP: Performance





# 100% Renewable Resin: PLA

- **Poly lactide (PLA)** -type of plastic derived from 100% renewable resources such as corn, sweet potatoes, sugar cane or sugar beets
- **Advantages:**
  - renewable resource
  - fossil fuel reduction
  - compostable
  - recyclable
  - reduced CO<sub>2</sub> emissions
  - processed into various end use products



*Life Cycle of PLA*

*Photos courtesy of NatureWorks*



# PLA In The Marketplace

- Disposables market
  - Packaging
  - Films
  - Water bottles
  - Food service ware
  - Nonwovens
- Apparel
- Home & Office
  - Upholstery
  - Bedding
- Durable Goods
  - Electronics casing
  - Automotive?



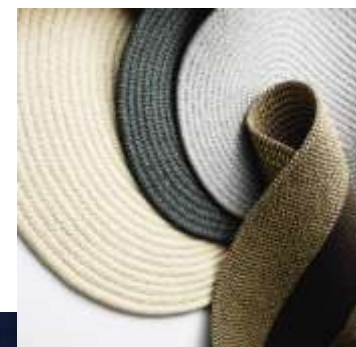
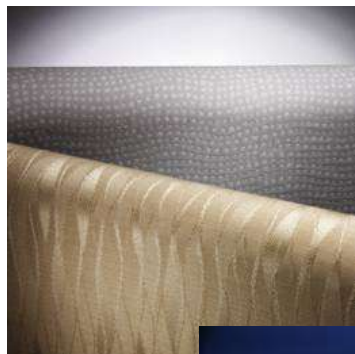
*Photos courtesy of NatureWorks*



# PLA Potential Automotive Applications



- Textiles
  - Carpet
  - Floor mats
  - Upholstery
- Manufacturing
  - Packaging
  - Protective wrap
- Interior – Injection molded applications
  - Trim
  - Non-appearance parts

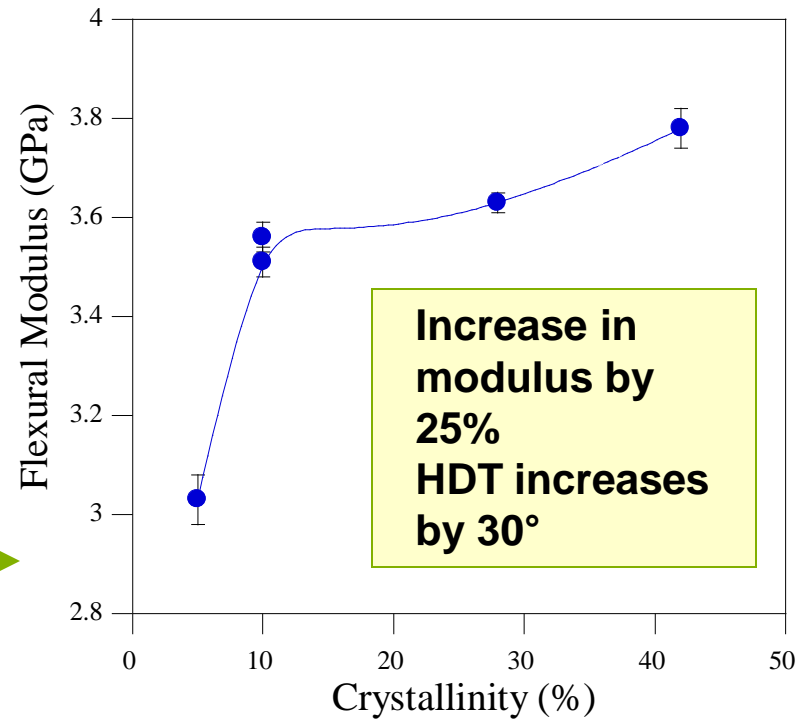




# Technical Challenges for Injection Molded PLA



- Mechanical property performance
  - Impact strength
  - HDT
- Injection molding processing issues
  - Longer cycle times due to the slow crystallization rate of PLA
  - Favors amorphous structure vs. the desired crystalline structure
    - Crystalline PLA improves mechanical properties and durability
- Long term durability
  - Achieve balance between durability and compostability (end-of-life)





# Improving Performance

- Through optimizing injection molding processing conditions
- Through the addition of natural fillers
  - Benefits of adding natural fillers
    - Act as a nucleating agent
      - Improve crystallization rate
      - Increase overall crystallinity
    - Act as a reinforcement
      - Improve overall mechanical performance
    - Create a truly “green” composite
      - Will not negatively affect the compostability of the composite
  - Fillers evaluated to date
    - Talc, nanoclays, EBS, cellulose, soy flour



# Next Steps For Biomaterials

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- Continued Research support for three main thrust areas in biomaterials projects (soy, nat fiber, PLA)
- Leverage biomaterial development with material suppliers and non-competing partners
- Work jointly with our Product Development partners to further develop the internal market at Ford for biomaterials
- Complete Ford material and component level testing to obtain material approvals
- Communicate our work and progress to our customers!



# Acknowledgements



Ford Biomaterials Research Group



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Questions?



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