

Developing Polymer Nanocomposites for Automotive Applications



Patricia Tibbenham
Ford Motor Company
Research & Advanced Engineering

What are Nanocomposites?

- A nanometer is just one billionth of a meter. The particles under evaluation are about the size of a virus.
- Aspect ratios of these particles offer huge surface areas.
- Nano-sized particles have potential in plastics because low loadings do more than heavier loadings of other fillers.

Different Types of Nanofillers

- Clay Nanofillers –lower cost
 - Modified Montmorillonite
- Carbon Nanofillers – higher cost
 - Nanofibers
 - Nanotubes

Unique Combinations

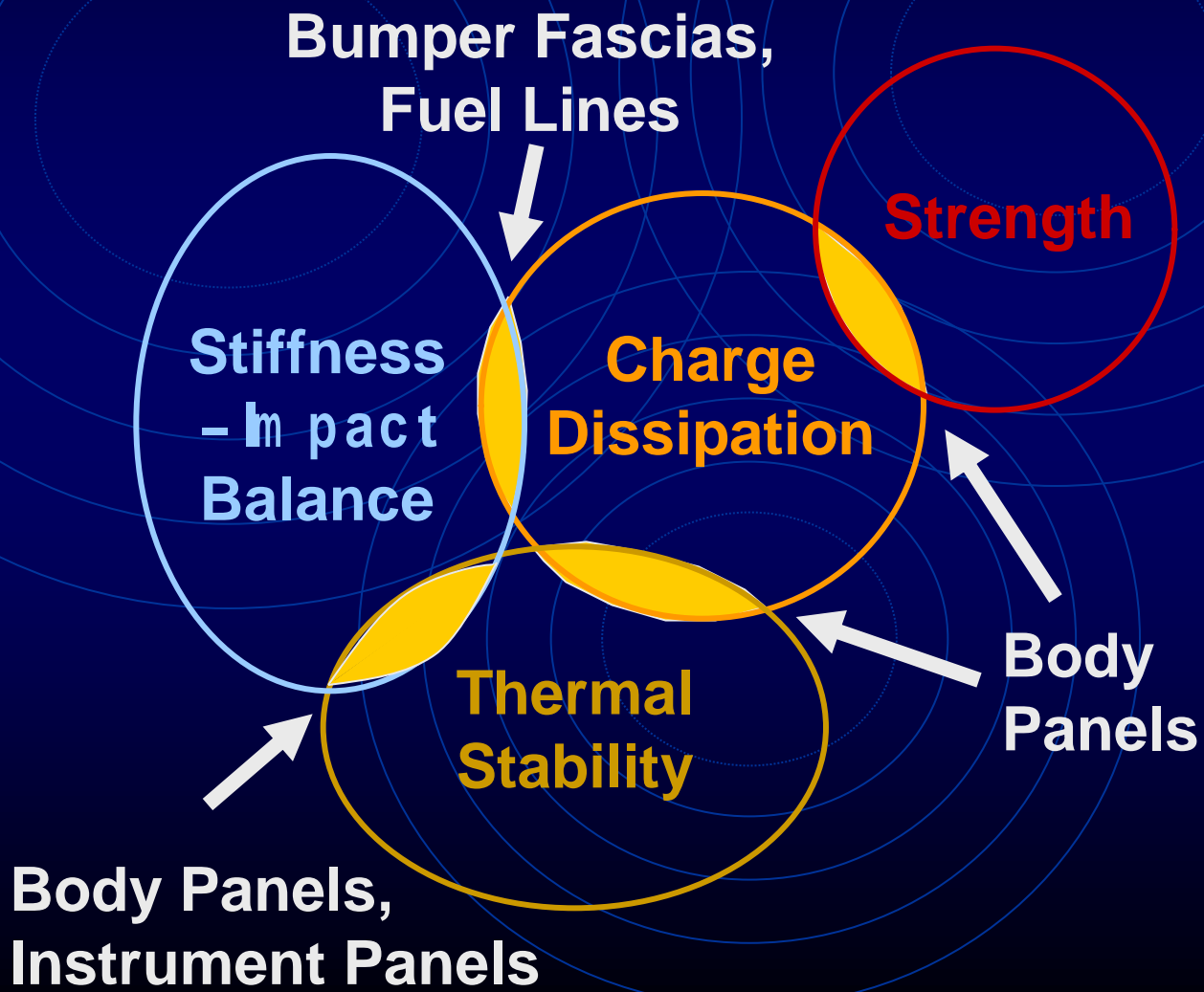
- Clay with thermoplastic materials
- Carbon with thermoplastic and thermoset materials

The compatibility of the matrix and the filler can provide dramatically different properties for unique applications.

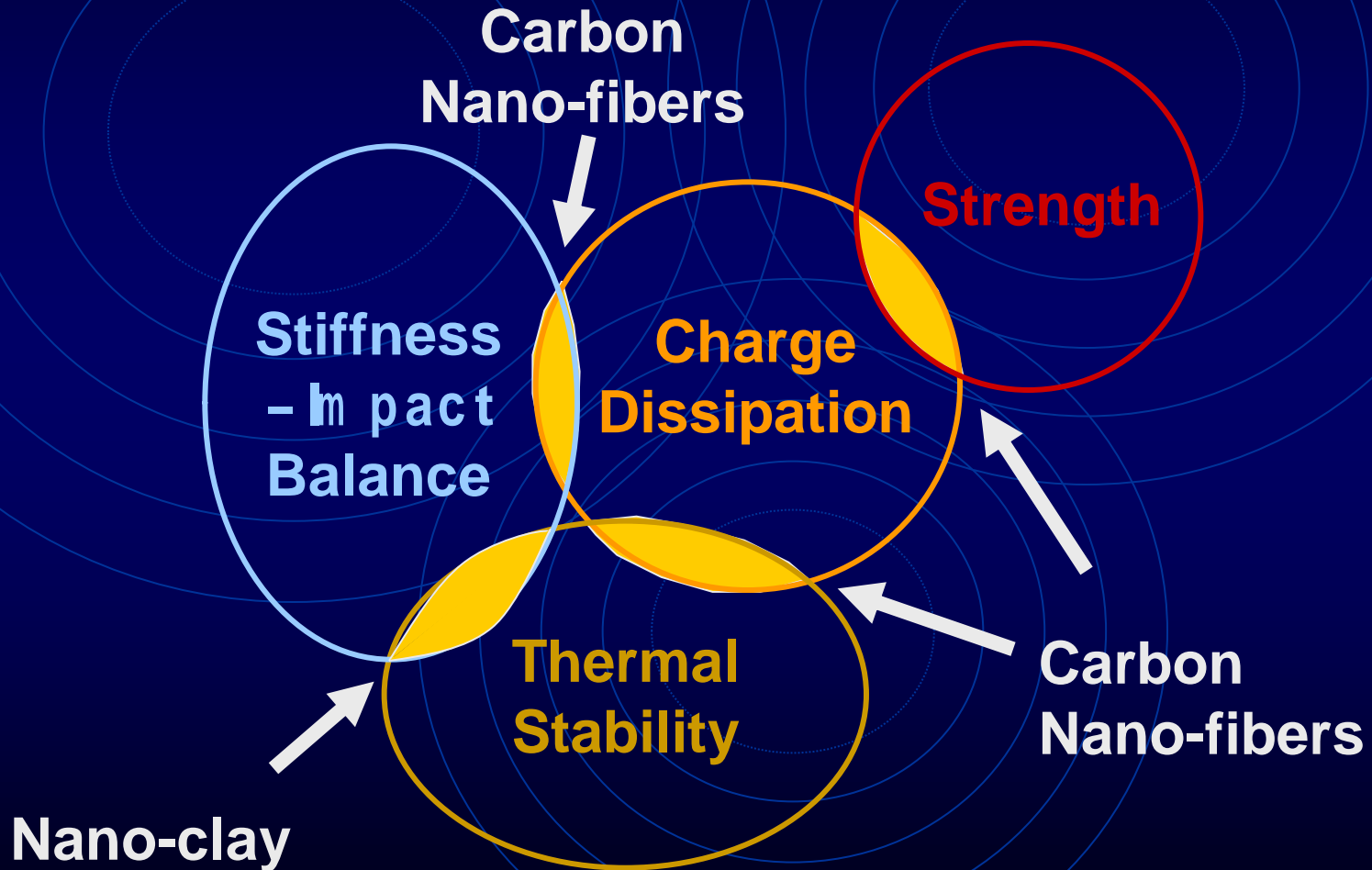
Why Nanocomposites?

- Improve charge dissipation
- Improve surface quality
- Improve stiffness-toughness balance
- Reduce permeability
- Improve thermal stability
- Reduce part weight

Potential Automotive Applications



Potential Nanofillers for Automotive Applications



Case Studies of Nanocomposites for Automotive

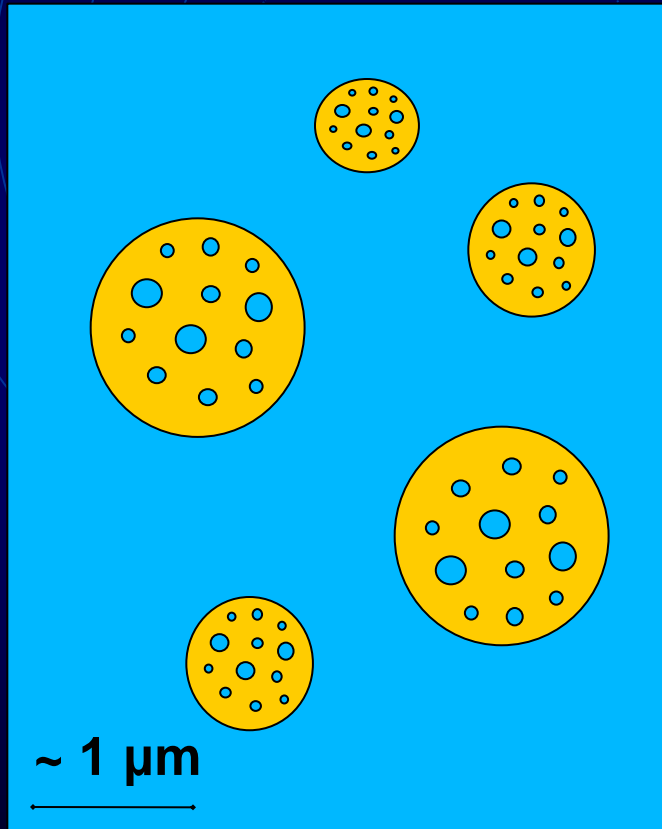
1. Clay nano-reinforced TPO for improved stiffness; **“reducing part thickness”**
2. Clay nano-reinforced TPO for improved stiffness-toughness balance; **“reducing talc & rubber”**
3. Carbon nano-fiber reinforced SMC for; **“improved charge dissipation”**

Business Case 1 and 2

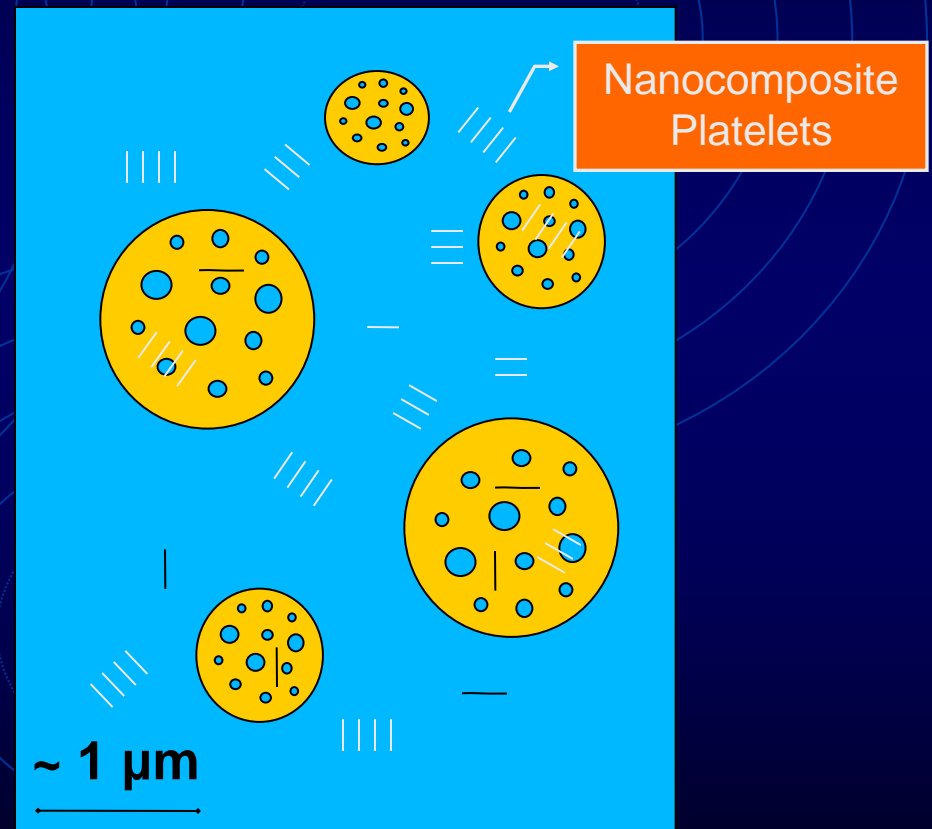
- TPO Clay-Nanocomposite opportunities:
 - Increased stiffness & reduced density
 - Thinner wall stock
 - Lower part weight
 - Improved scratch resistance
 - Reduced thermal sensitivity
- TPO Clay-Nanocomposite limitations:
 - Reduced impact properties at low temperatures
 - Cost, cost, cost

TPO Clay Nanocomposite Morphology

Generic TPO



Clay Nanocomposite Reinforced TPO



■ PP Matrix

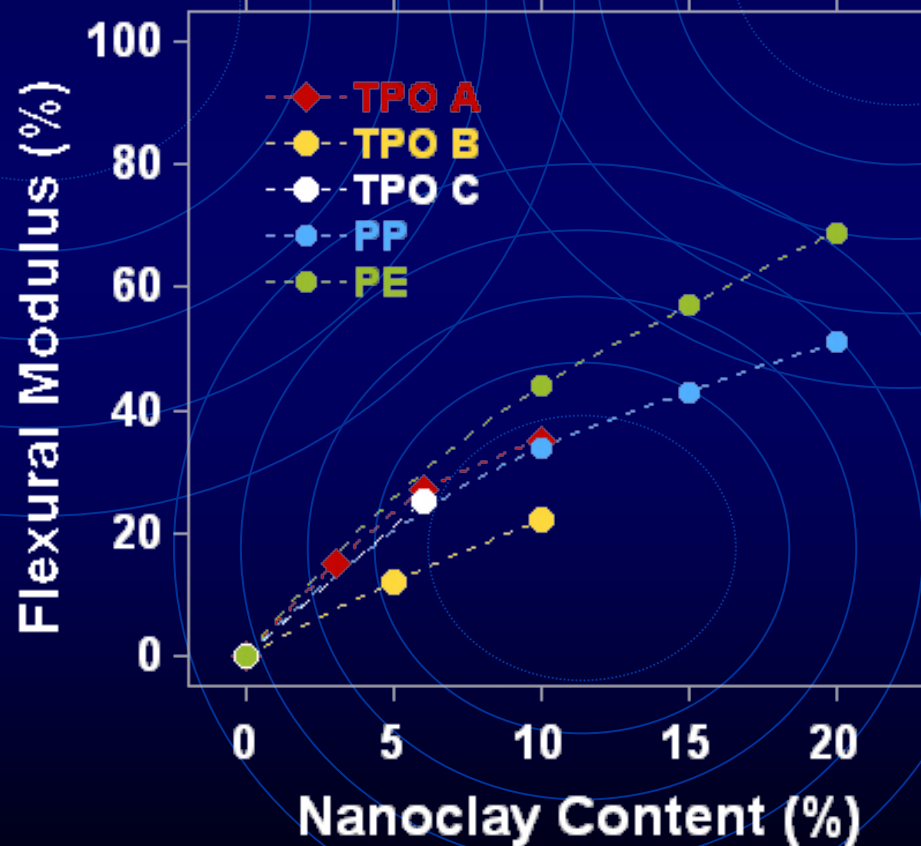
■ Elastomeric Phase

TPO Clay Nanocomposite Morphology

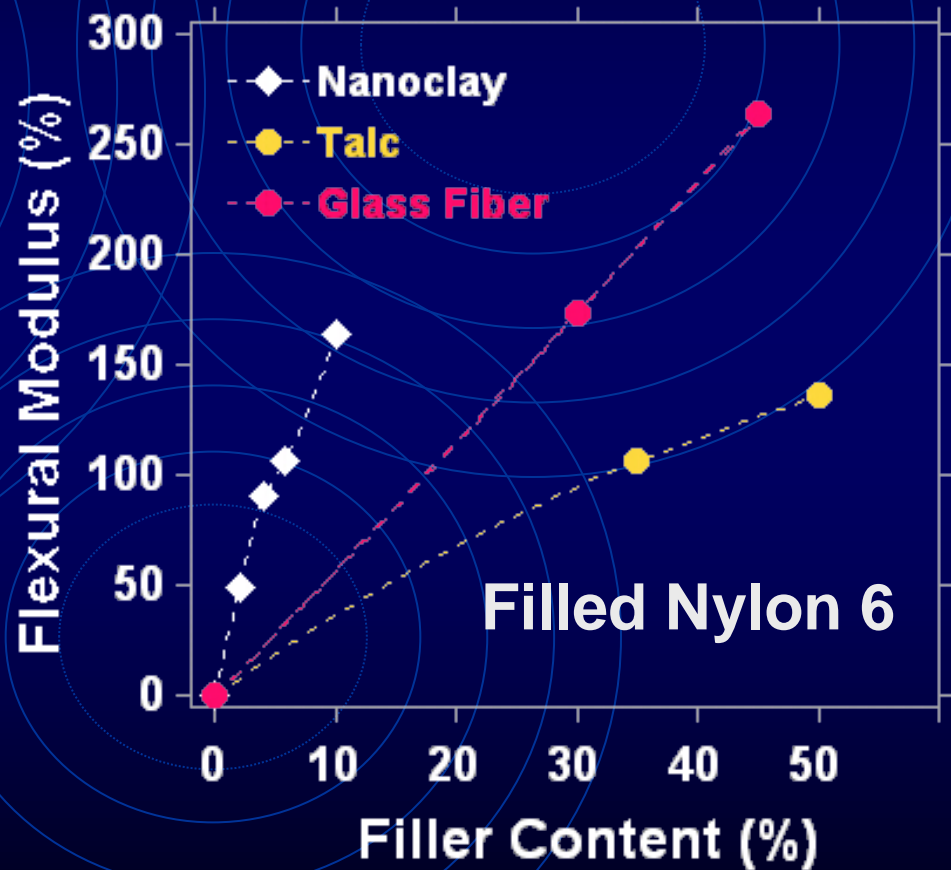
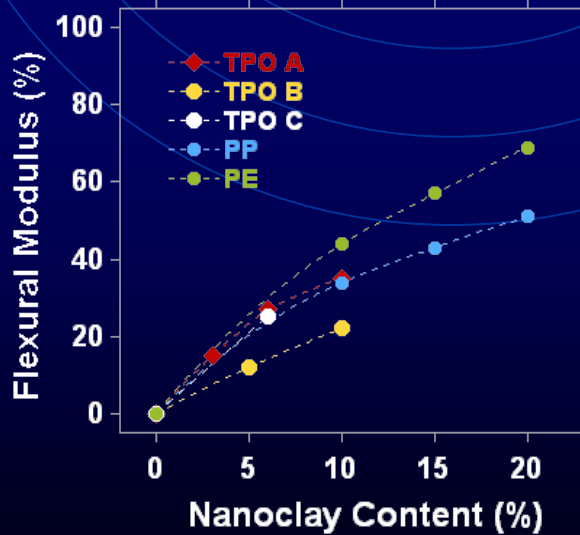
- If the platelets end up in the elastomeric phase then the thermal growth and shrinkage properties are reduced
- If the platelets end up in the polypropylene matrix then the Flexural Modulus or stiffness is increased
- By balancing where the clay nanocomposites end up, the material characteristics can be adjusted

Nanocomposite Effect on Flexural Modulus

- ISO 178, 1 mm/min, 23 °C

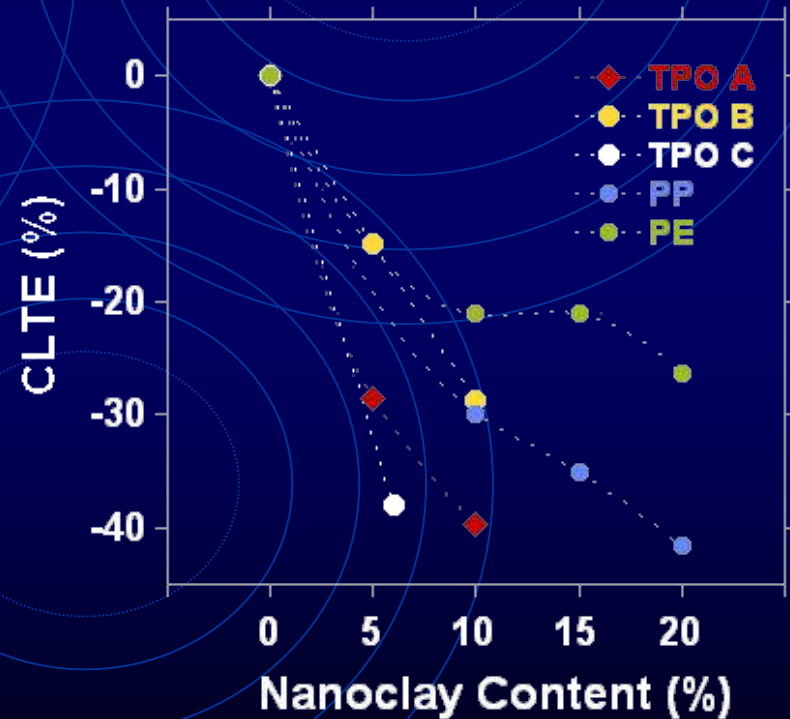
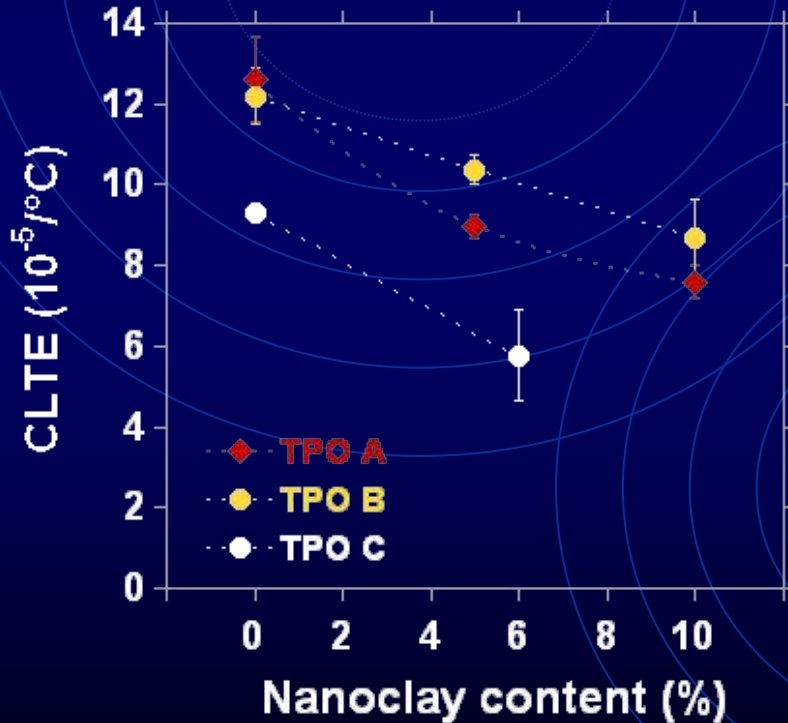


Various Fillers Effect on Flexural Modulus of Nylon



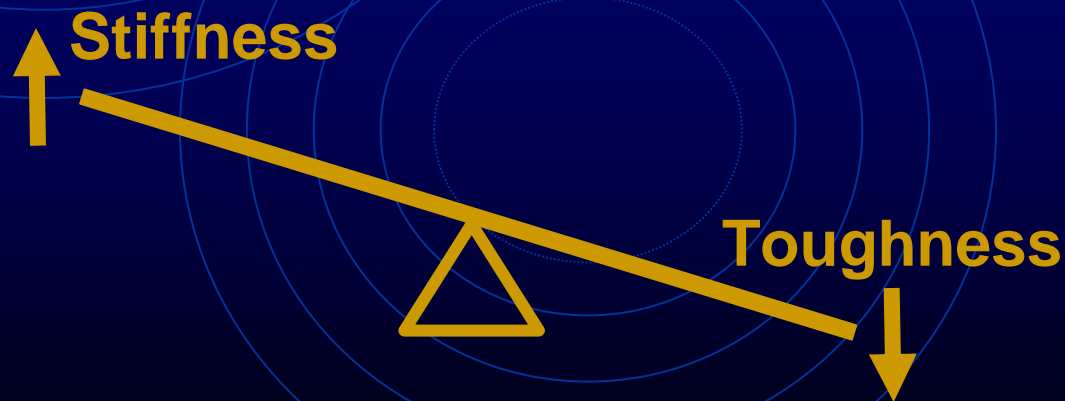
Thermal Expansion

• ASTM E831



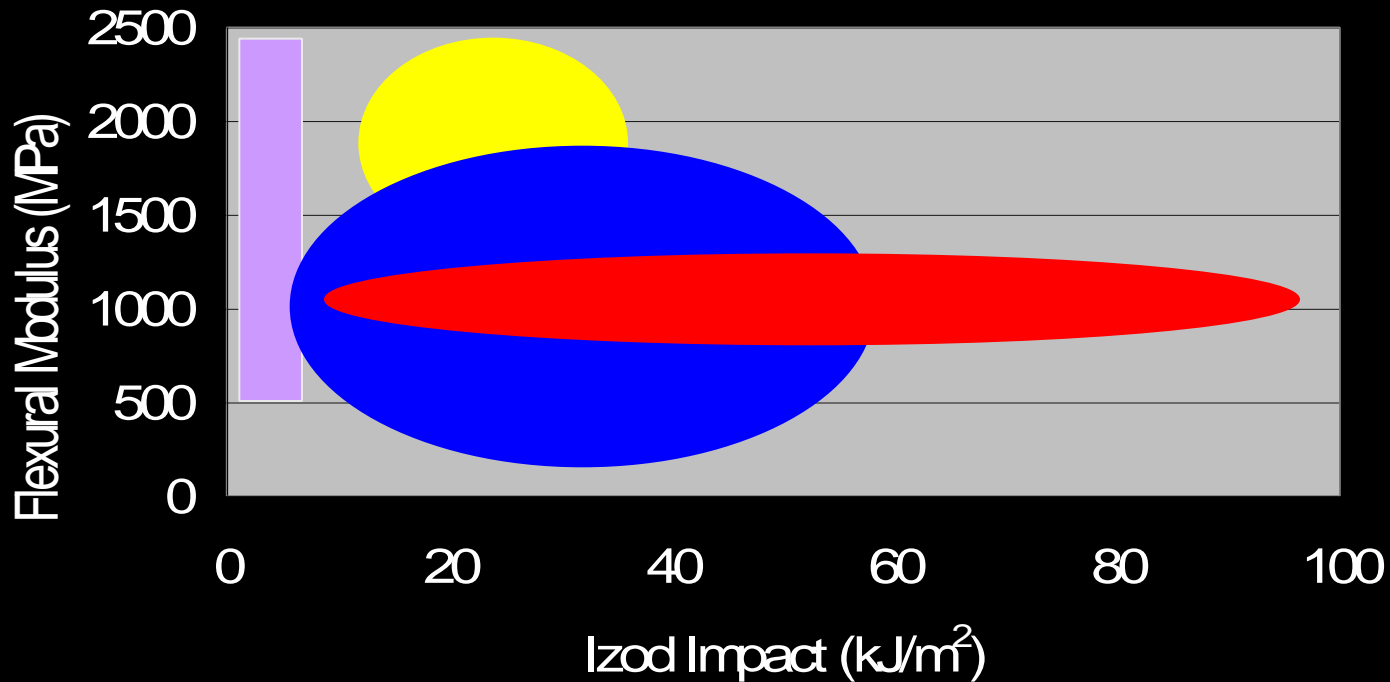
Improve Stiffness-Toughness Balance

- In addition to balancing stiffness and CLTE, there are other properties to balance...
- When you add typical fillers the stiffness goes up but the toughness (impact properties) are reduced.



Room Temperature Comparison of Stiffness and Izod

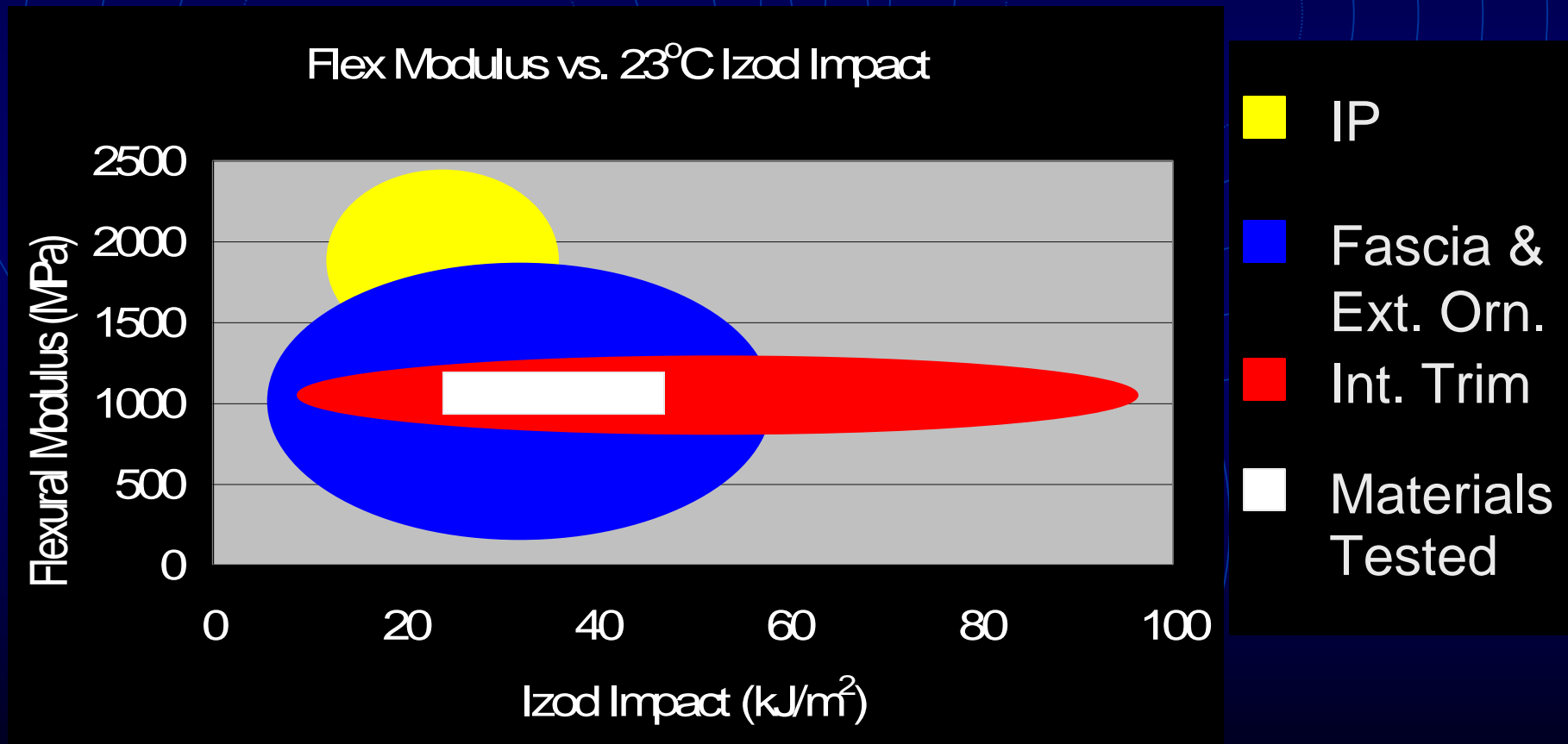
Flex Modulus vs. 23°C Izod Impact



- IP
- Fascia & Ext. Orn.
- Int. Trim
- Cold Impact

Materials

- The studied materials are shown below



Impact Performance

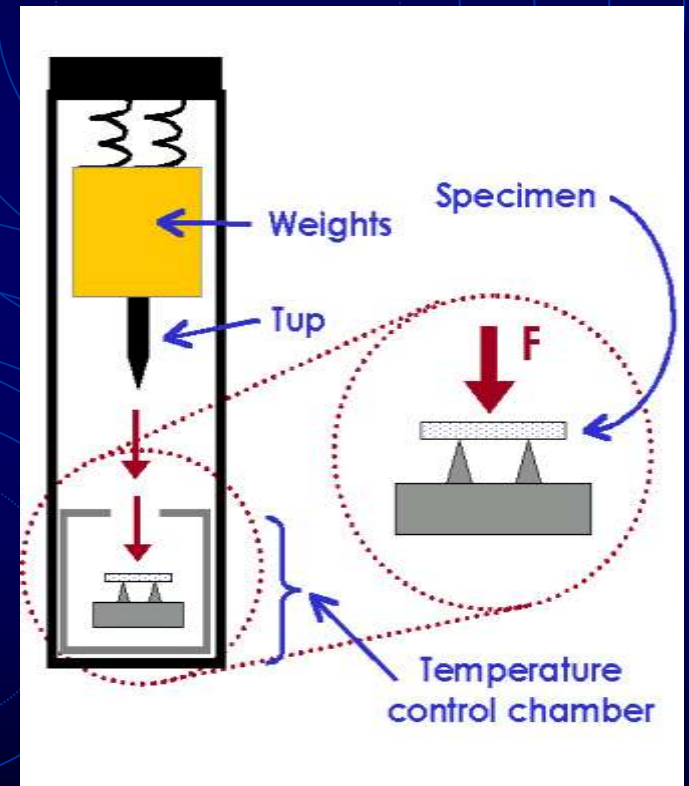
- Izod does not accurately represent the performance of painted materials
- Izod notch size and radius contributes to large variability in the data
- Multi-axial testing is not representative of component failures
- Experimental Method: ASTM D790 Three Point Bend, Flexural Impact
- Using this method provides data on the subtle differences between materials

Impact Performance

- **Experimental Method**

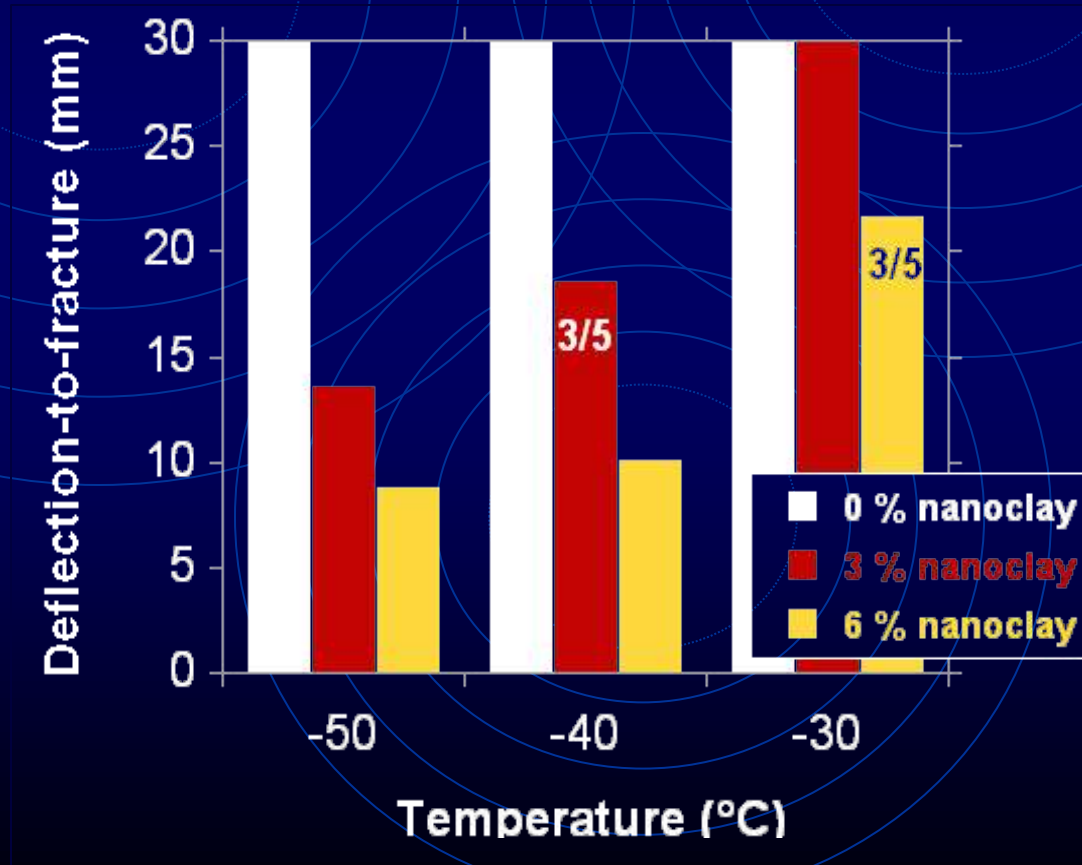
- **Three-point bend (ASTM D790)**

- Impact speeds:
 - 10^{-5} to 20 mph
 - Approximate (tensile) elastic strain rate:
 - 10^{-4} to 10^2 /s
 - Temperatures:
 - -50 to 300 °C



Impact Performance

- Flexural Impact at low temperatures

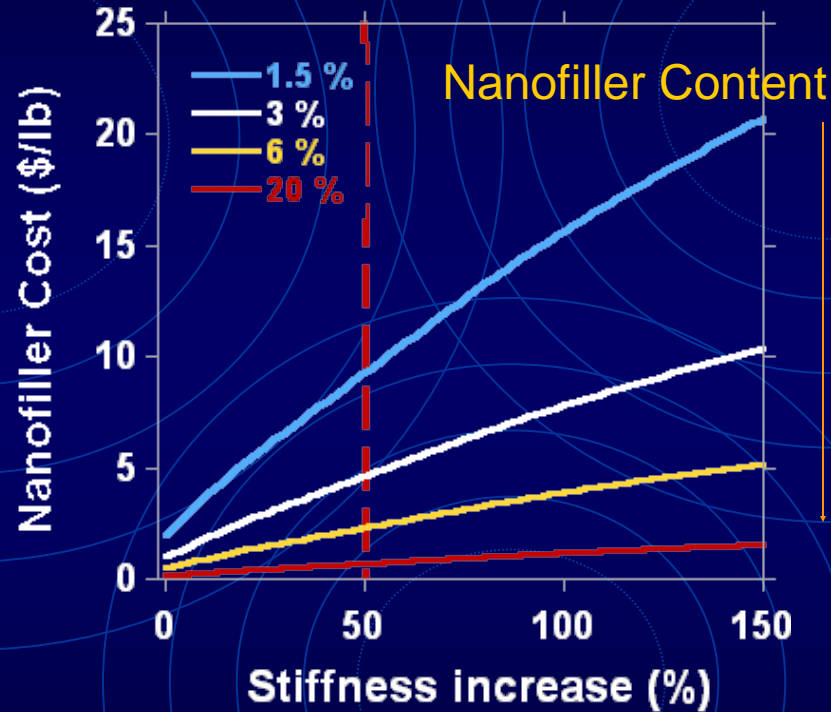


TPO
2.2 m/s

Business Case 1: Reducing Part Thickness

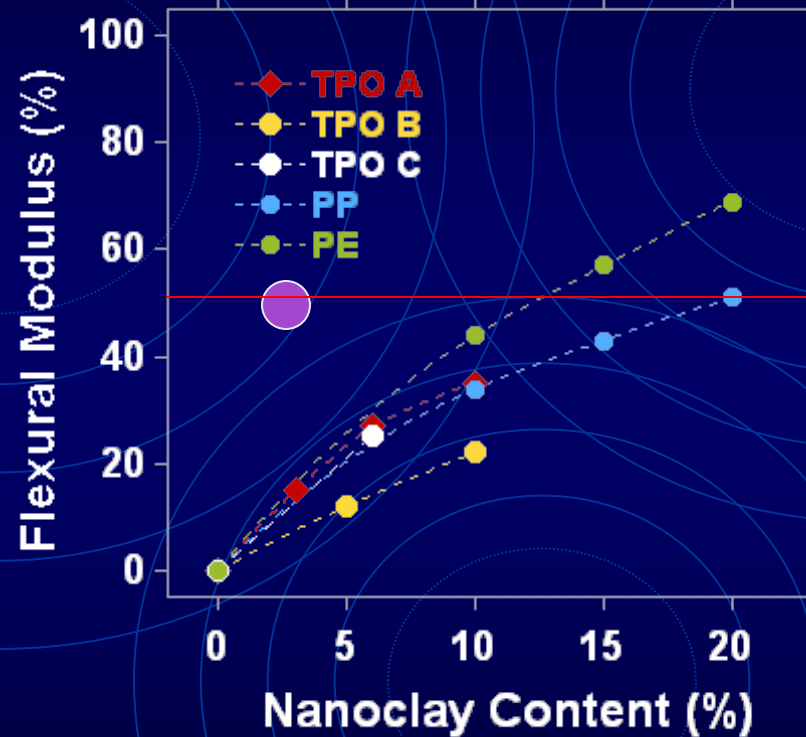
- Assumptions:
 - Reactor grade of TPO
 - Add Nanocomposite to improve stiffness
 - 50% stiffness improvement
 - Reduce part thickness by 10%
 - Nanocomposite filler does not affect impact

Business Case 1: Reducing Part Thickness



However adding more than 3% nanocomposite does adversely affect impact properties...

Business Case 1: Reducing Part Thickness



None of the commercially available grades of nanocomposites meet these requirements

Business Case 2: Reducing Talc & Rubber

- Assumptions:
 - Compounded grade of TPO
 - Remove the talc filler & add Nanocomposite
 - Reduce the rubber component
 - Equivalent impact with less rubber
 - 3% Nanocomposite with acceptable impact
 - Reducing 10% rubber by weight

Business Case 2: Reducing Talc & Rubber

- Content of TPO for Bumper Fascias

- 60% (wt.) Polypropylene

- 15 % Atactic homopolymer

- 15 % Isotactic homopolymer

- 30 % Copolymer

.50-.80 \$/lb*

- 30% Elastomer (EPDM)

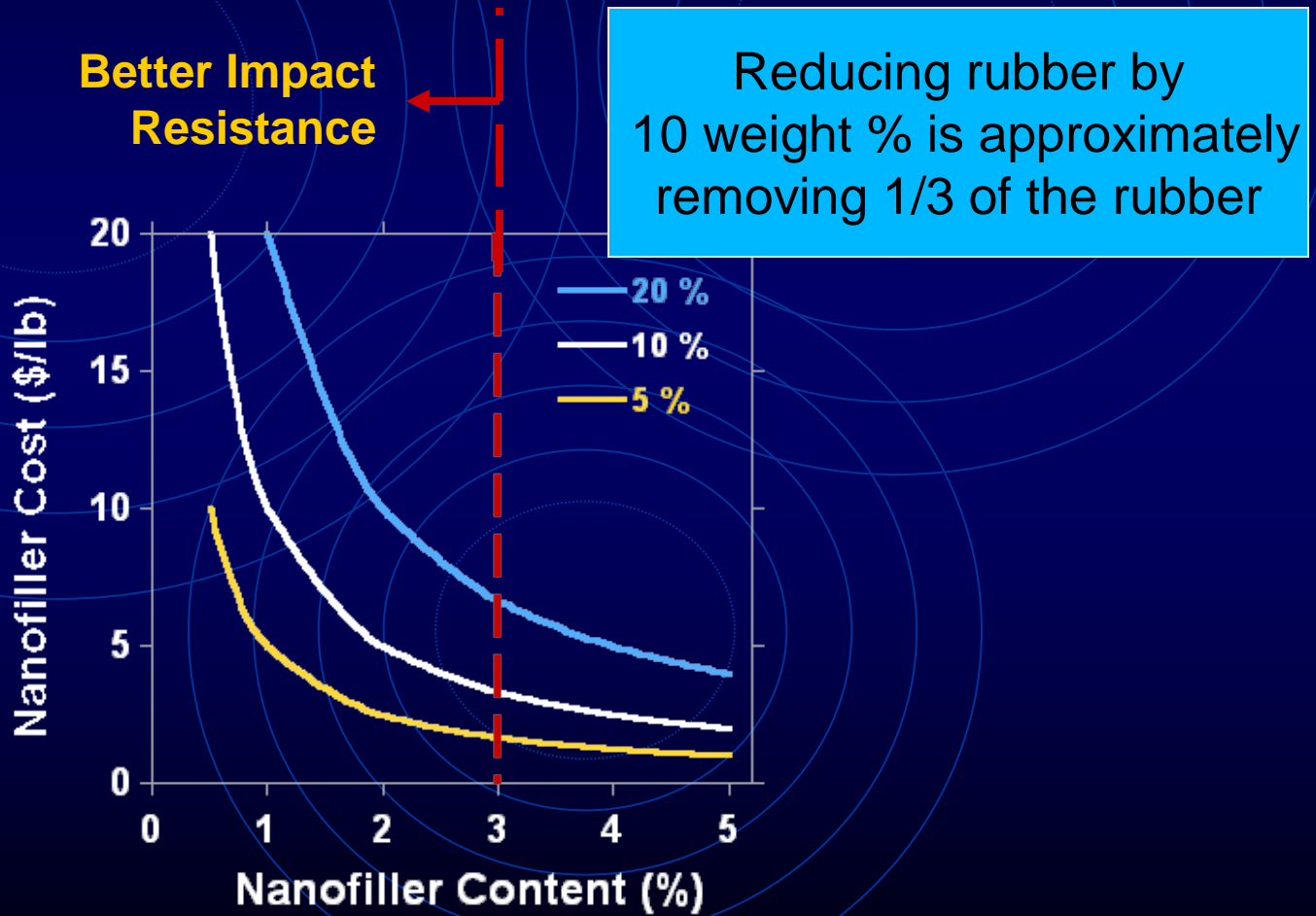
1.50 \$/lb*

- 10% Talc

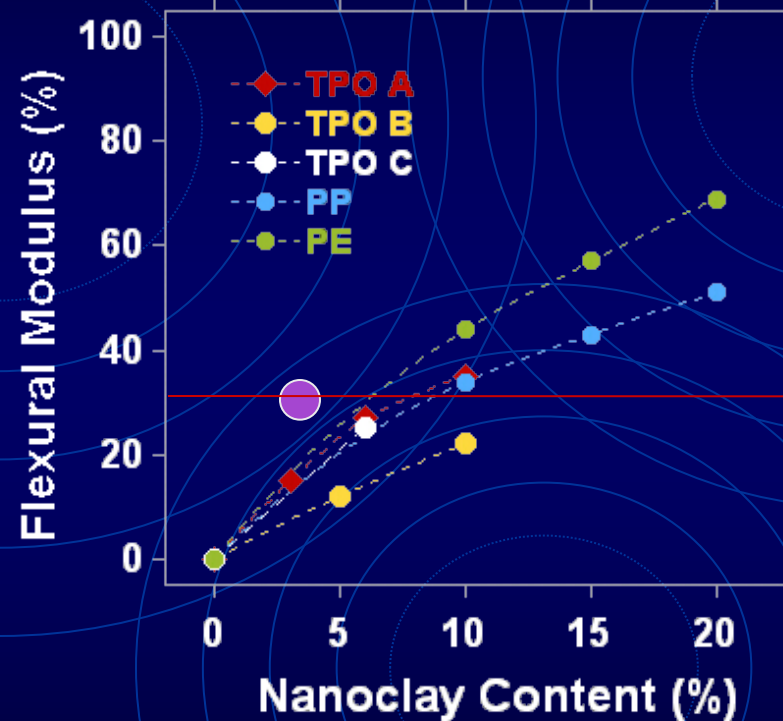
.15 \$/lb*

** Plastics News*

Business Case 2: Reducing Talc & Rubber



Business Case 2: Reducing Talc & Rubber



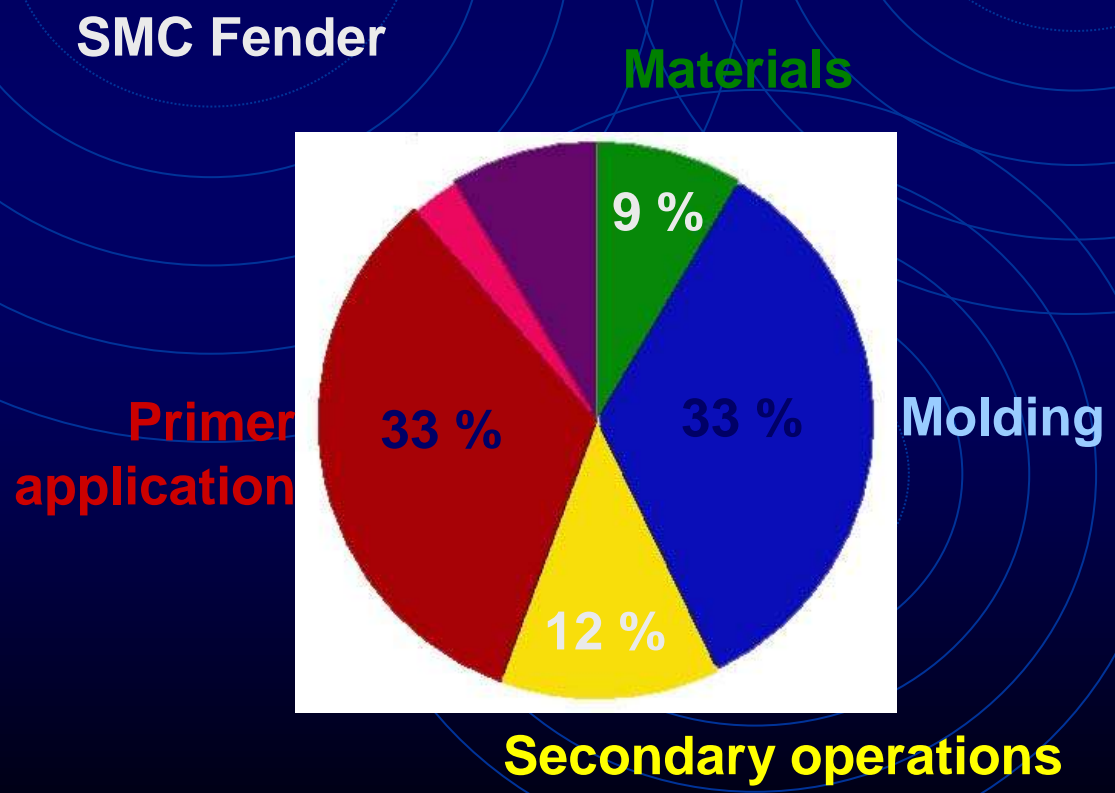
Need improved stiffness (Flexural Modulus) with better compatibility/dispersion than current commercial offerings

Business Case 3: Improving Charge Dissipation

- Assumptions:
 - Sheet Molded Compound (SMC) Body Panels
 - Add Carbon Nanofiber for electrostatic painting - elimination of conductive priming of parts at the supplier
 - Retain Class “A” surface quality
 - Additional opportunity with carbon nanofibers to reduce calcium carbonate for improved toughness and thinner panels (lighter weight).

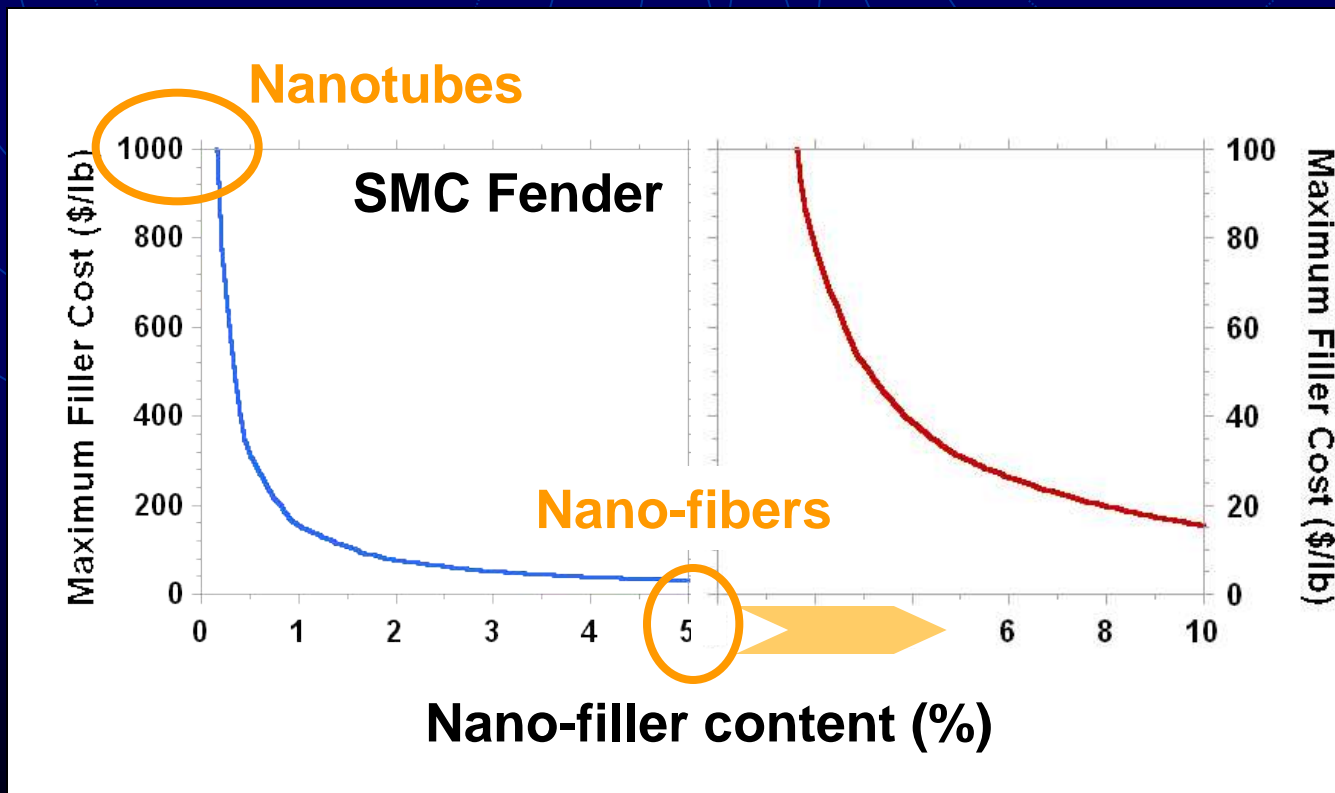
Business Case 3: Improving Charge Dissipation

- Conductive priming is 1/3 the cost of producing a SMC Fender



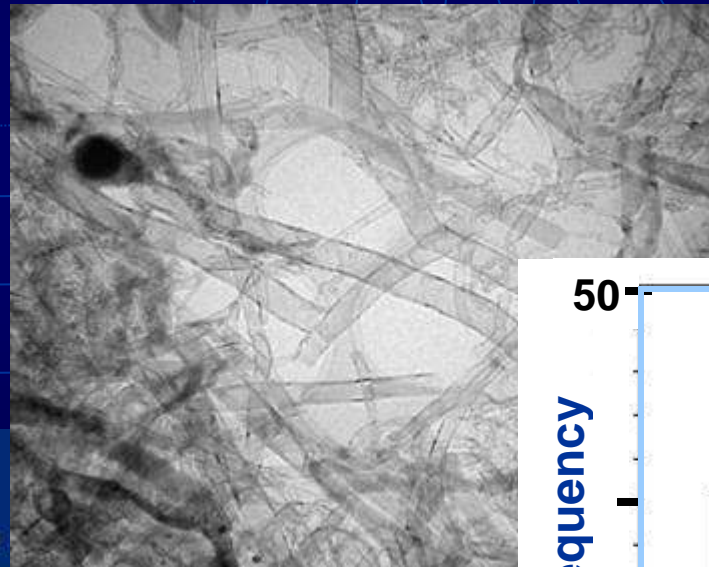
Business Case 3: Improving Charge Dissipation

- Carbon Nanofiber opportunity with elimination of conductive priming operation



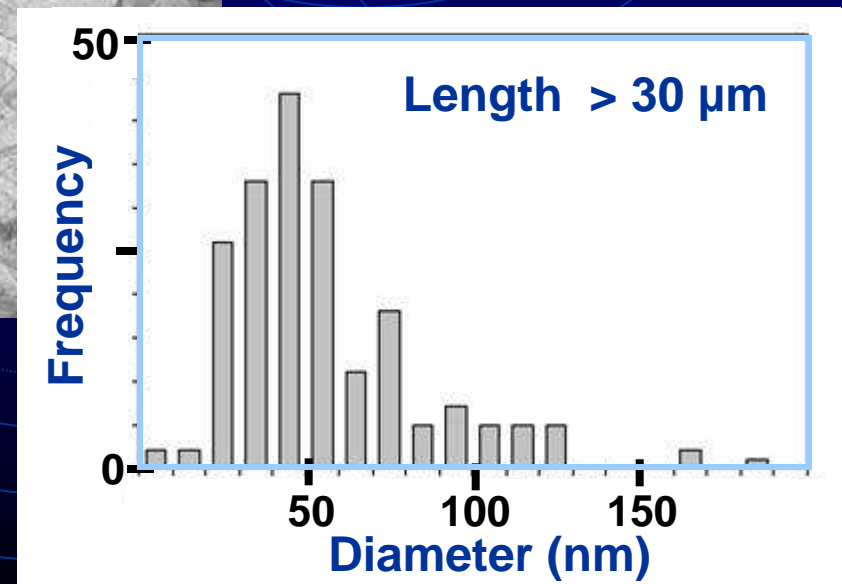
Business Case 3: Improving Charge Dissipation

- Ford is working with carbon nanofibers



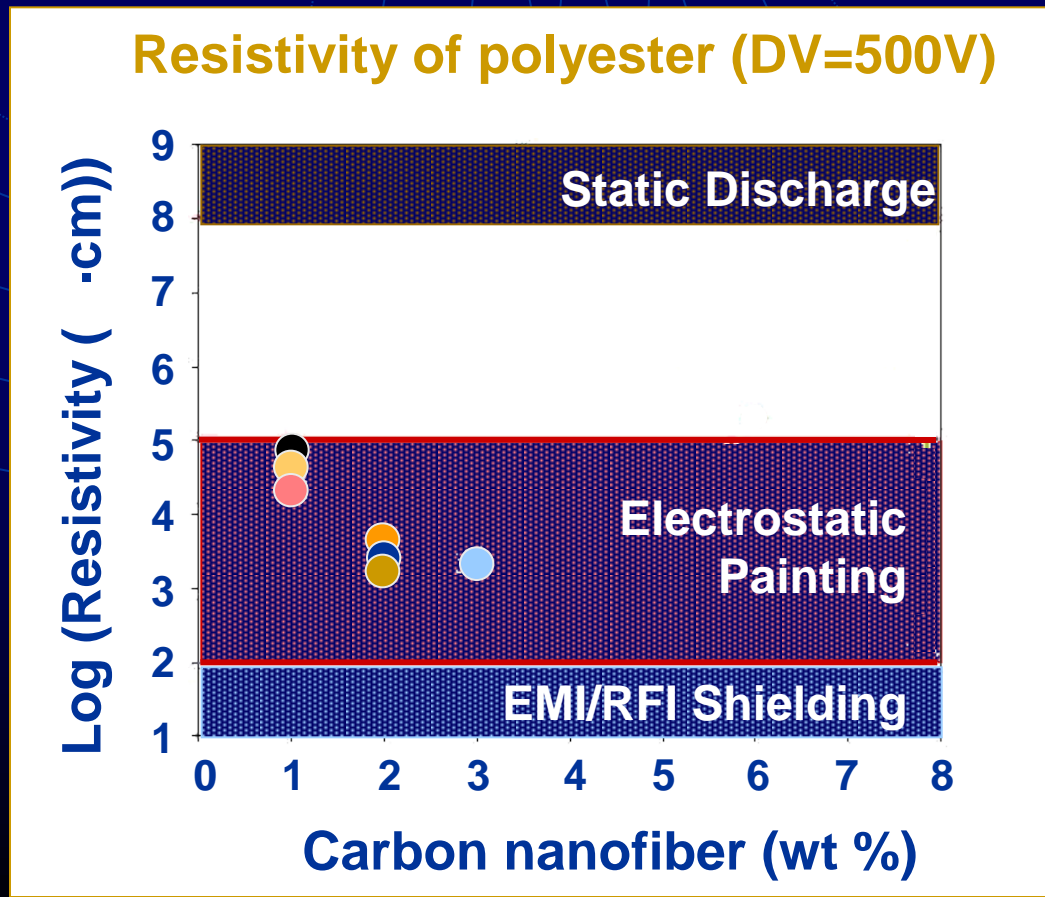
Carbon Nano-fibers

20 - 80 nm Diameter
> 70% Graphitization



Business Case 3: Improving Charge Dissipation

- Very low loading provides dissipation of charge for electrostatic painting



Business Case Summary

- Clay nanocomposites are harder to make a robust case
 - 3% nanocomposite filler provides acceptable impact characteristics
 - Case 1 and 2 require further improvements to the flexural stiffness characteristics in order to be viable
- Carbon nanocomposites are easier to make a robust case

Summary

- The balance between flexural stiffness and toughness is key for exterior components with clay nanocomposites.
- The possibility of eliminating conductive priming on SMC body panels is a significant opportunity with carbon nanocomposites.

The compatibility of the matrix and the filler can provide dramatically different properties for unique applications.

Acknowledgements

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