

Kane Ace MX[®]

Core-Shell Rubber (CSR) Toughener for
Thermosetting Resin Systems

Overview

- ✓ Introduction
- ✓ Core Shell Technology
- ✓ Introduction to the Kane Ace MX technology
- ✓ Highlights of Mechanical Performance in Thermoset systems
- ✓ Summary

Why do Thermoset resins need toughening?

- ✓ Many thermoset resins (like epoxies) cure to form hard rigid compositions
- ✓ Epoxy resins have very low impact resistance
- ✓ Epoxy resins by themselves have very low elongation characteristics.

Common Methods for Toughening

- ✓ Vegetable Oils
 - ✓ Polyamide or Polysulfide Curing agents
 - ✓ Long chain Polyglycols
 - ✓ Reactive Rubber (CTBN)
- ✓ All of these methods adversely affect the mechanical properties and chemical resistance of the polymer.

Why Core-Shell Rubber?



Over the last fifty years CSR have been successfully used to toughen items ranging from plastic packaging to automobile parts to building products. Employed primarily in thermoplastic resins (PVC, styrenics, engineering plastics) global production of CSR today is estimated in excess of 1 billion pounds.



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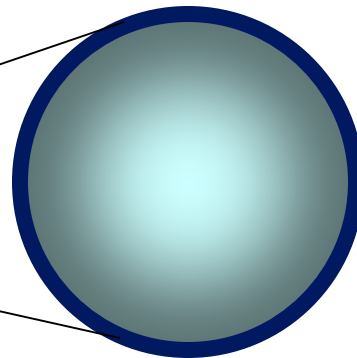
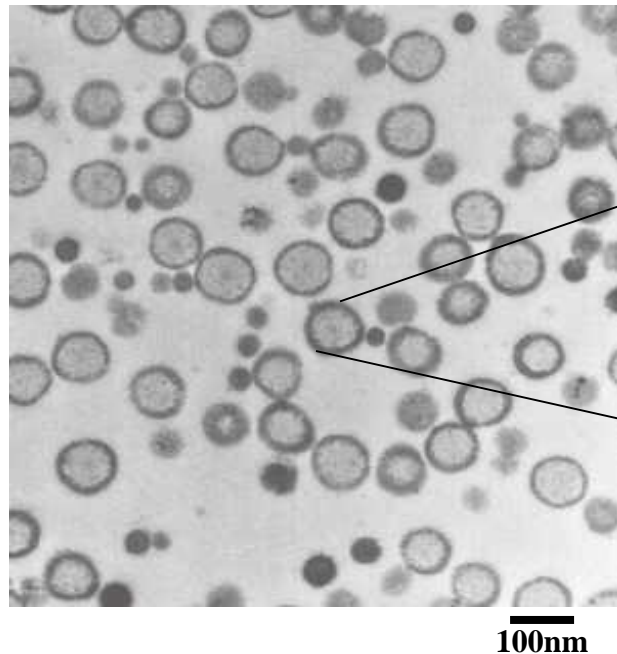
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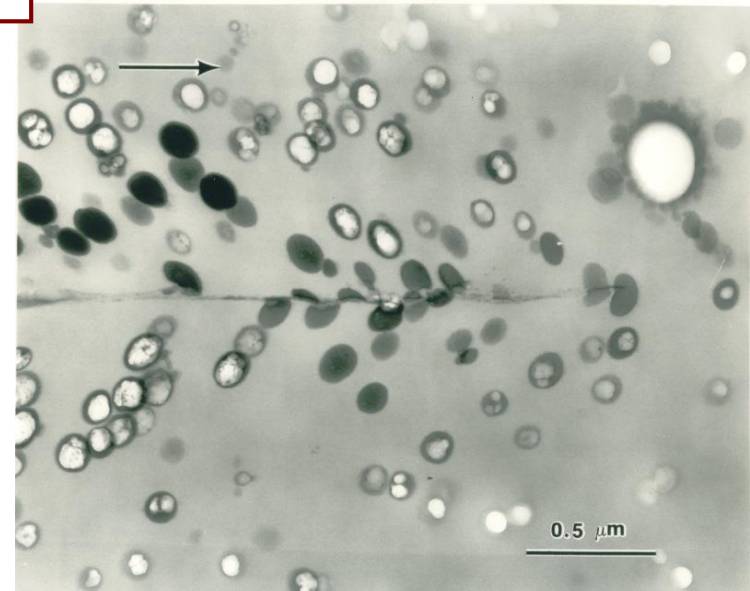
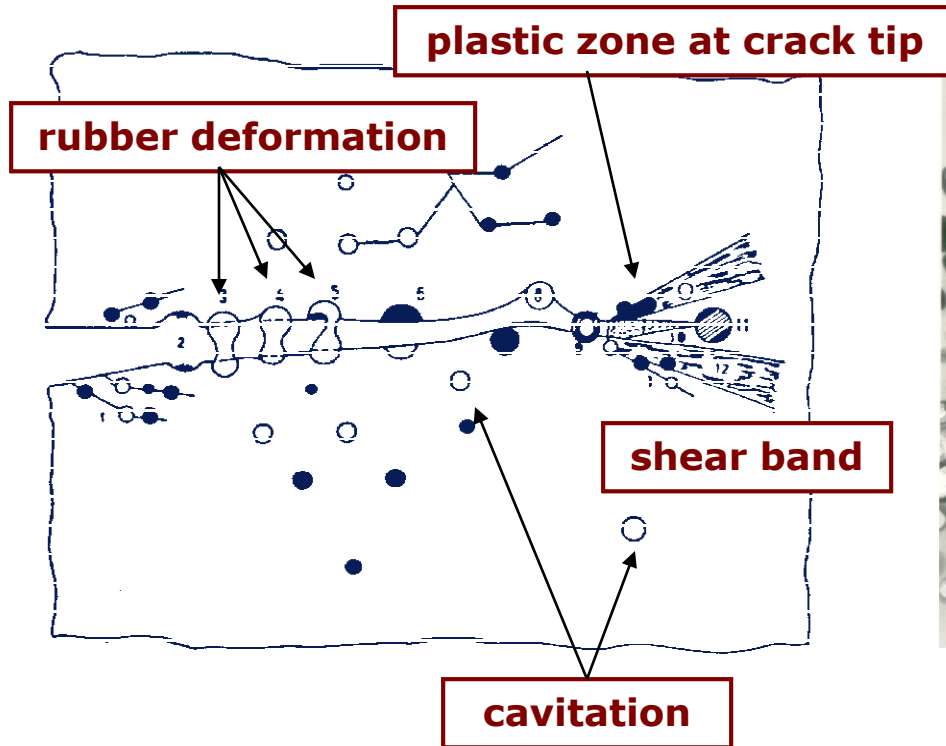
What is Core-Shell Rubber (CSR)?

The structure of a core-shell rubber particle consists of a cross-linked rubber core encased by a hard “glassy” shell.



Performance can be optimized by tailoring the structure, chemistry, particle size and distribution, as well as shell functionality.

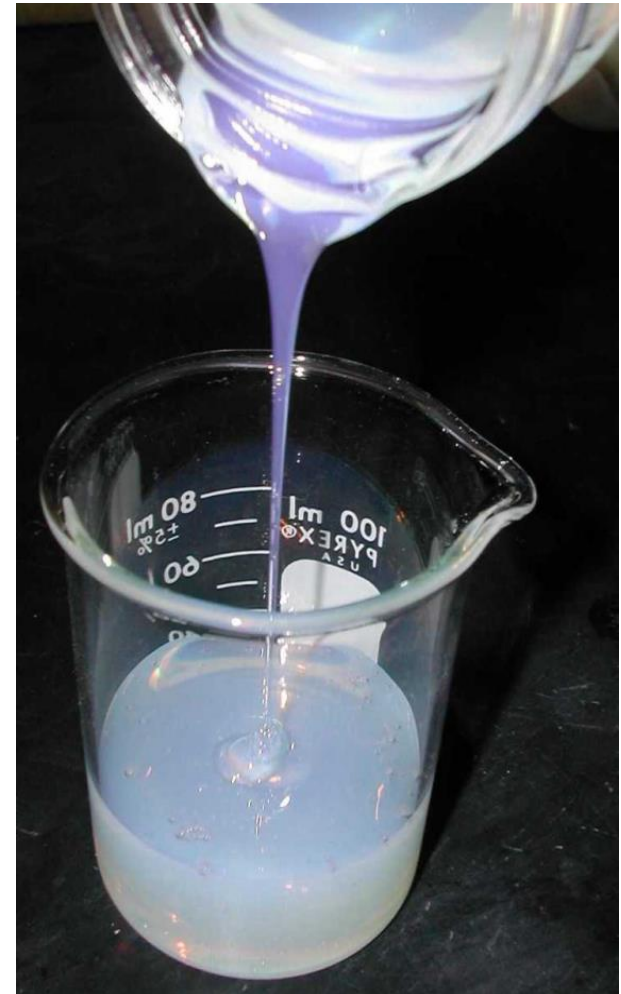
How Does CSR Toughen?



**Rubber Cavitation and Shear Yielding
(epoxy resin/CSR)**

What is Kane Ace[®] MX?

Kane Ace[®] MX is a family of user-friendly concentrates comprised of proprietary core-shell rubber (CSR) particles pre-dispersed into thermosetting resins or other liquid media.



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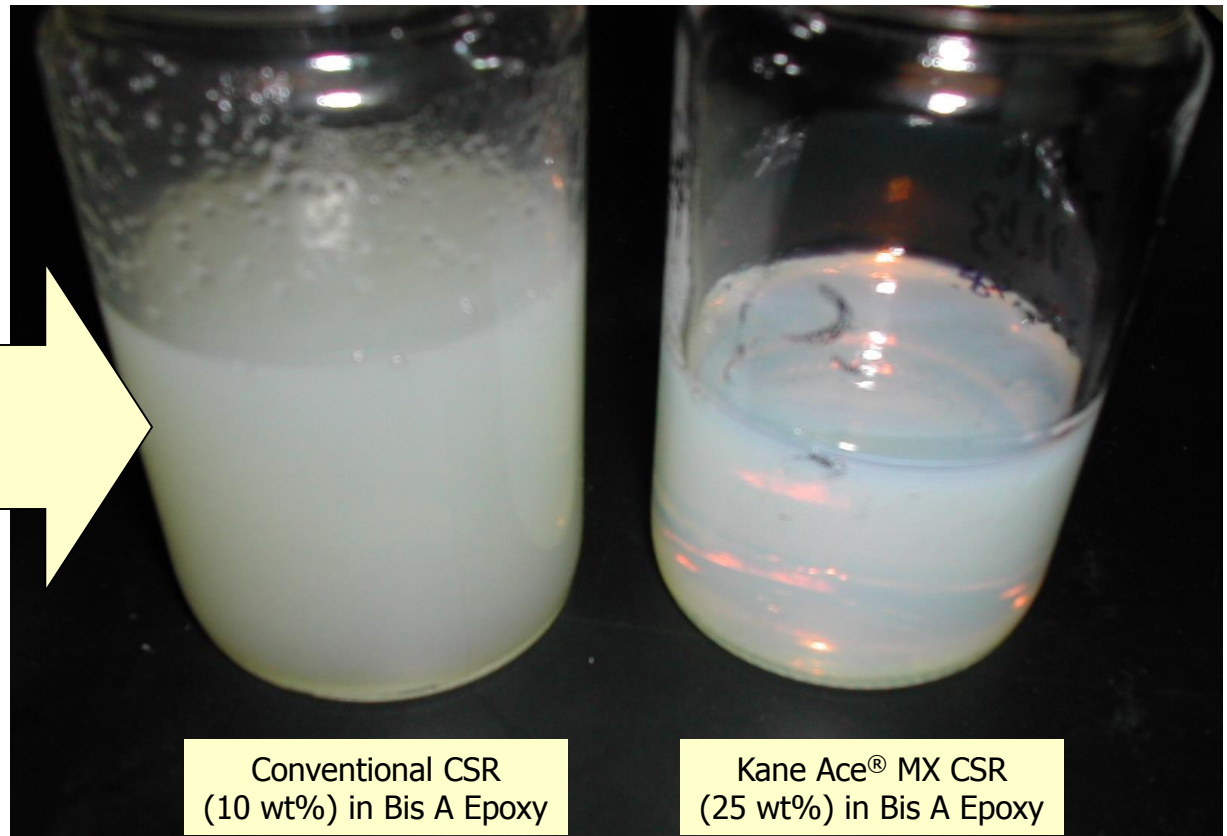
Formulating With Kane Ace™ MX

Standard Recipe	MX Modified Recipe
<p><u>Part A:</u> 70 parts liquid Bis A resin 20 parts epoxy resin Bis-F 10 parts reactive diluent</p> <p><u>Part B:</u> 30 parts Part B- Curative</p> <p><u>Mix Ratio Part A to B:</u> 100/30</p> <p><u>Core Shell Concentration:</u> 0%</p>	<p><u>Part A:</u> 52 parts liquid Bis A resin 20 parts epoxy resin B 10 parts reactive diluent 24 parts MX 125</p> <p><u>Part B:</u> 30 parts Part B-Curative</p> <p><u>Mix Ratio Part A to B:</u> 106:30</p> <p><u>Core Shell Concentration:</u> 4.4%</p>

Replacing 18 parts of epoxy with 24 parts of MX-125 is an easy way to add a modest amount of CSR without affecting the ratio of epoxy to curing agent

Benefits of Kane Ace[®] MX

Conventional tougheners can be difficult and messy to disperse, and often result in blends that are inconsistent.

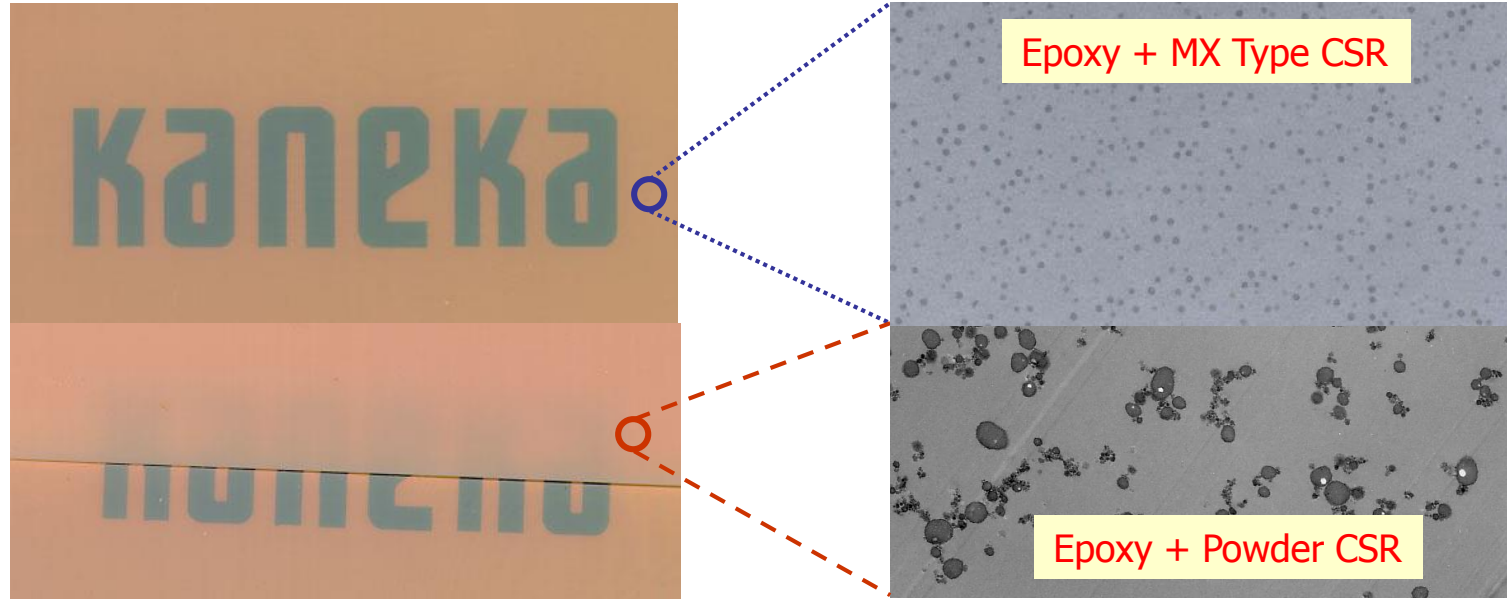


Benefits of Using Kane Ace[®] MX

- ✓ Enhanced **Mechanical Properties**
 - Fracture, Fatigue, Abrasion, Crack, Peel, Scratch
- ✓ Improved **Chemical Properties**
 - Corrosion, Acid Resistance, Shrinkage Reduction
- ✓ **Consistent and User Friendly** Performance
 - Very Clean, Long Shelf Life, Simple to Use
- ✓ No Change to **Curing Dynamics**
 - Won't Sacrifice of Tg, Not Curing Agent Specific

Benefits of Kane Ace[®] MX

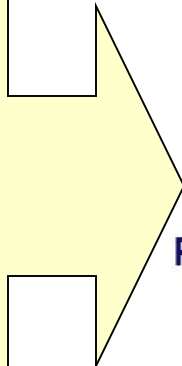
DISPERSION is the key to improvement of mechanical properties!



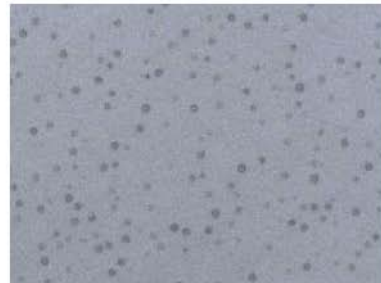
TEM analysis shows complete dispersion of CSR particles via MX while conventional tougheners suffer from agglomeration issues.

Benefits of Kane Ace[®] MX

Kane Ace[®] MX can be used with common curing agents regardless of usage level, without sacrificing dispersion of the CSR particles.

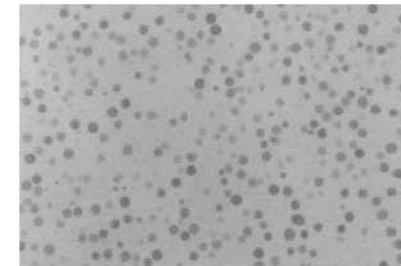


Amine Cure at 200°C (CSR 5%)



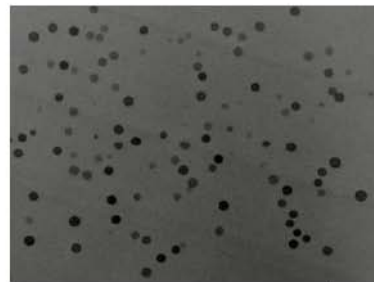
0.5µm

Amine Cure at 60°C (CSR 15%)



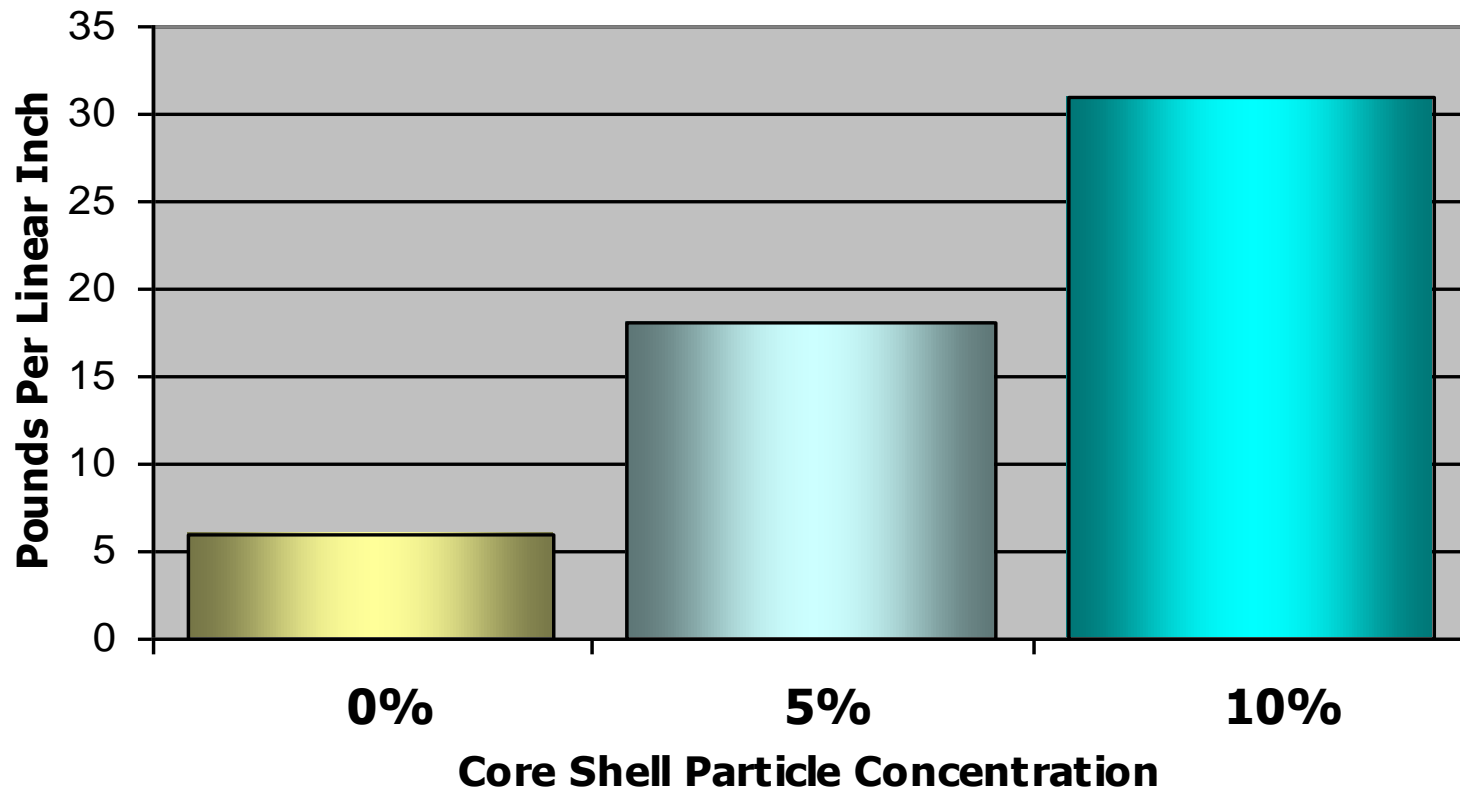
0.5µm

Phenolic cure at 190°C (CSR 3%)



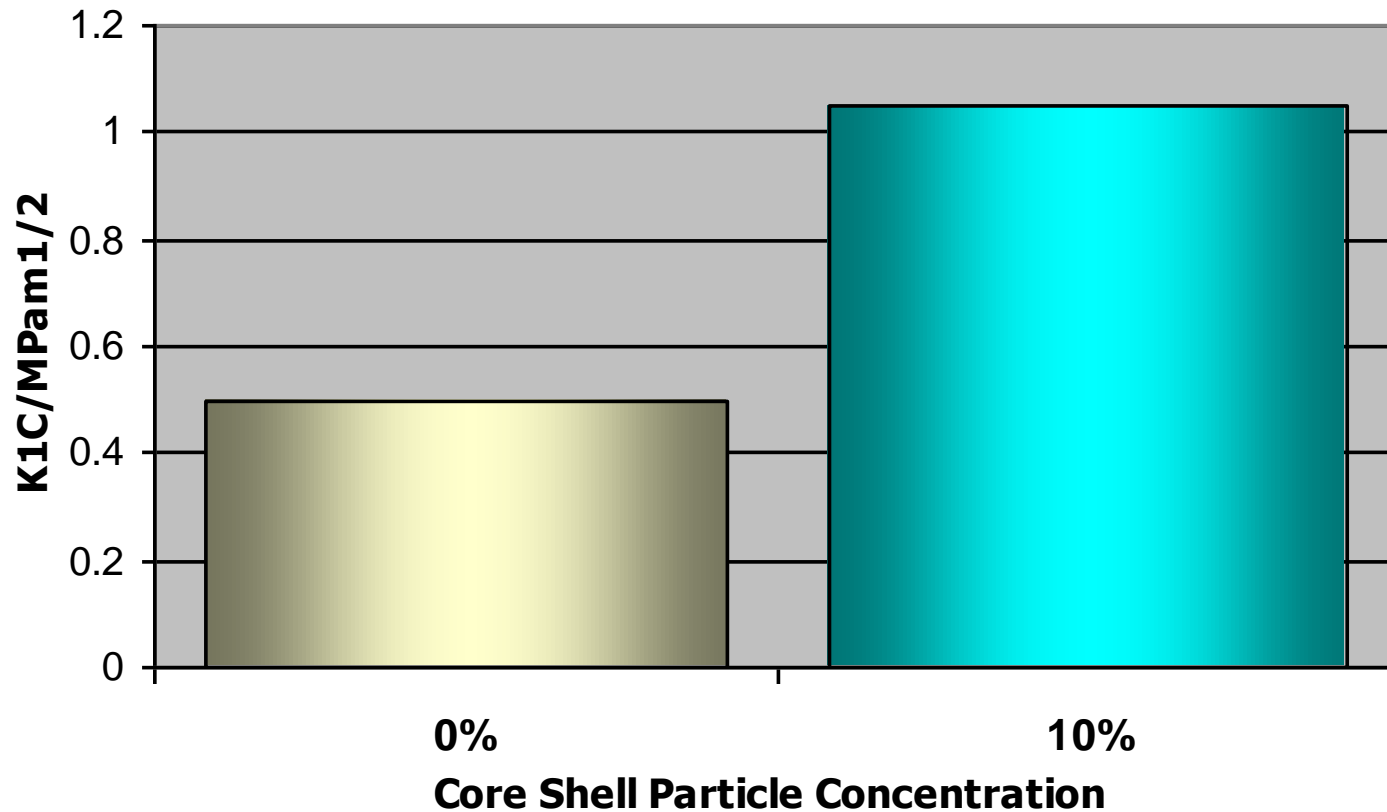
0.5µm

Benefits: Increased Peel Strength



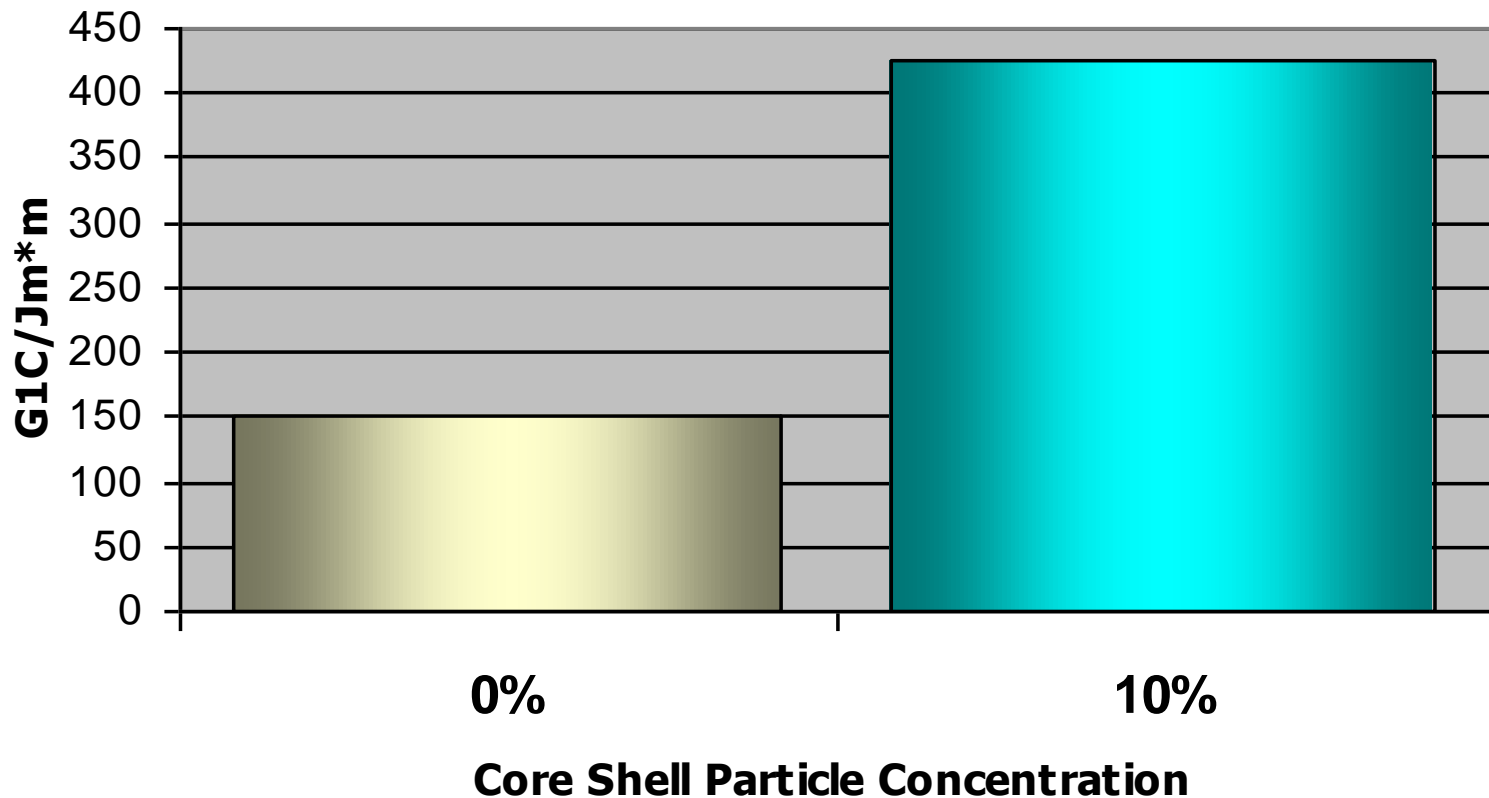
(Recipe: Bis A Epoxy + Curing Agent + MX)

Benefits: Fracture Toughness (K_{1C})



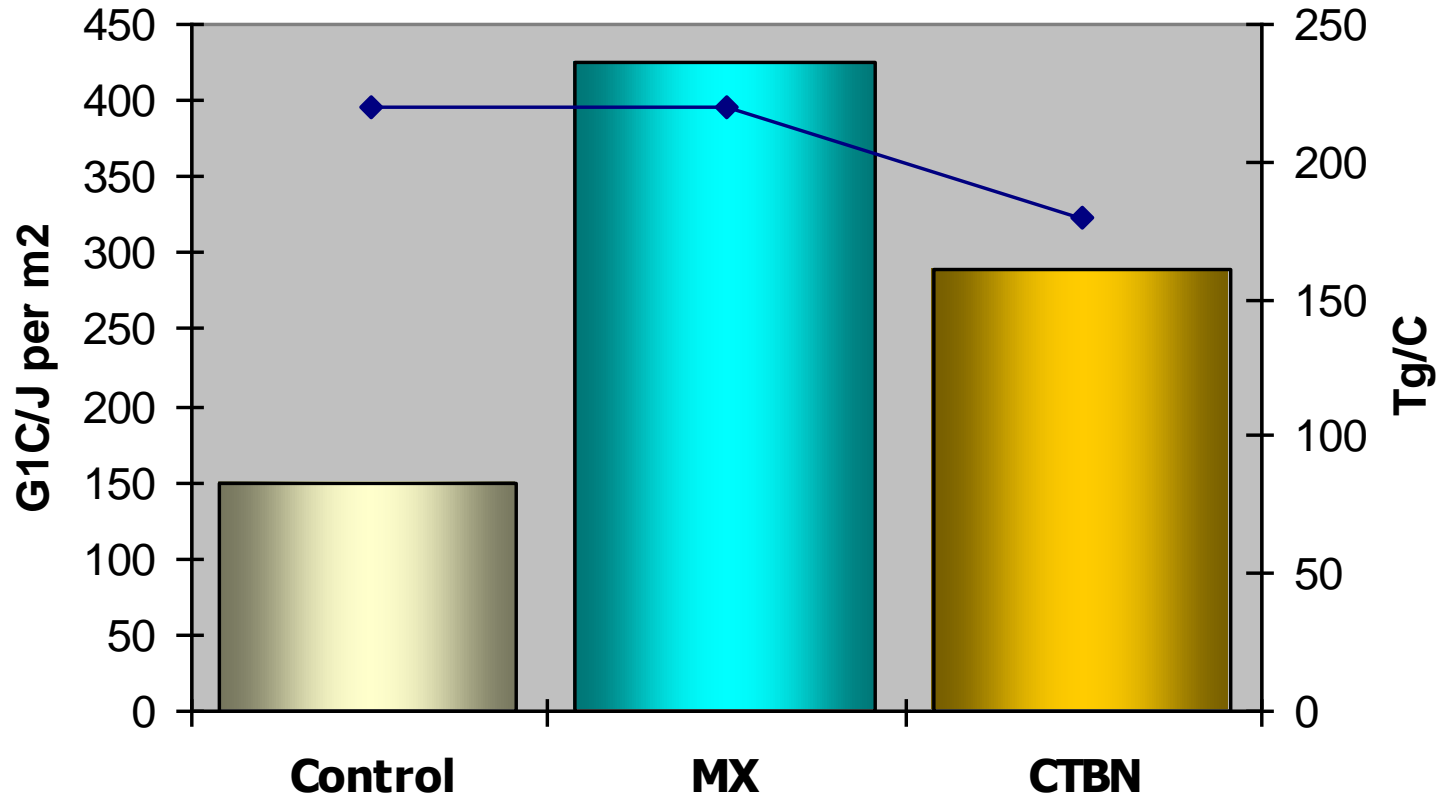
(Recipe: Bis A Epoxy + Curing Agent + MX)

Benefits: Fracture Toughness (G_{1C})



(Recipe: Bis A Epoxy + Curing Agent + MX)

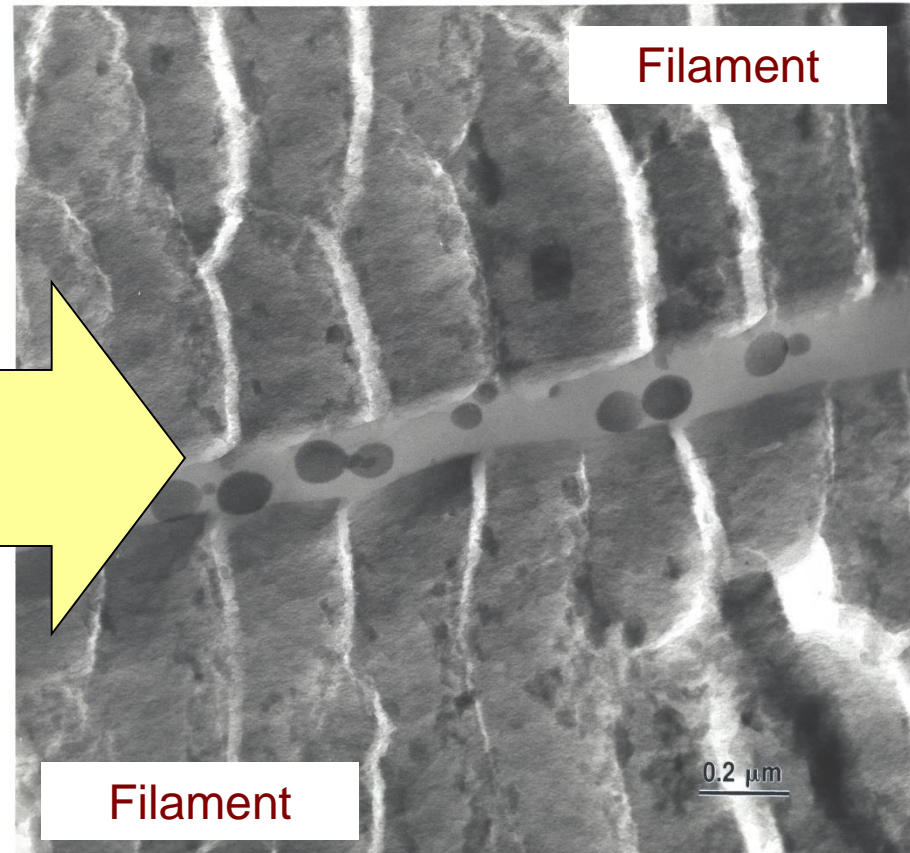
Benefits: Toughness versus T_g



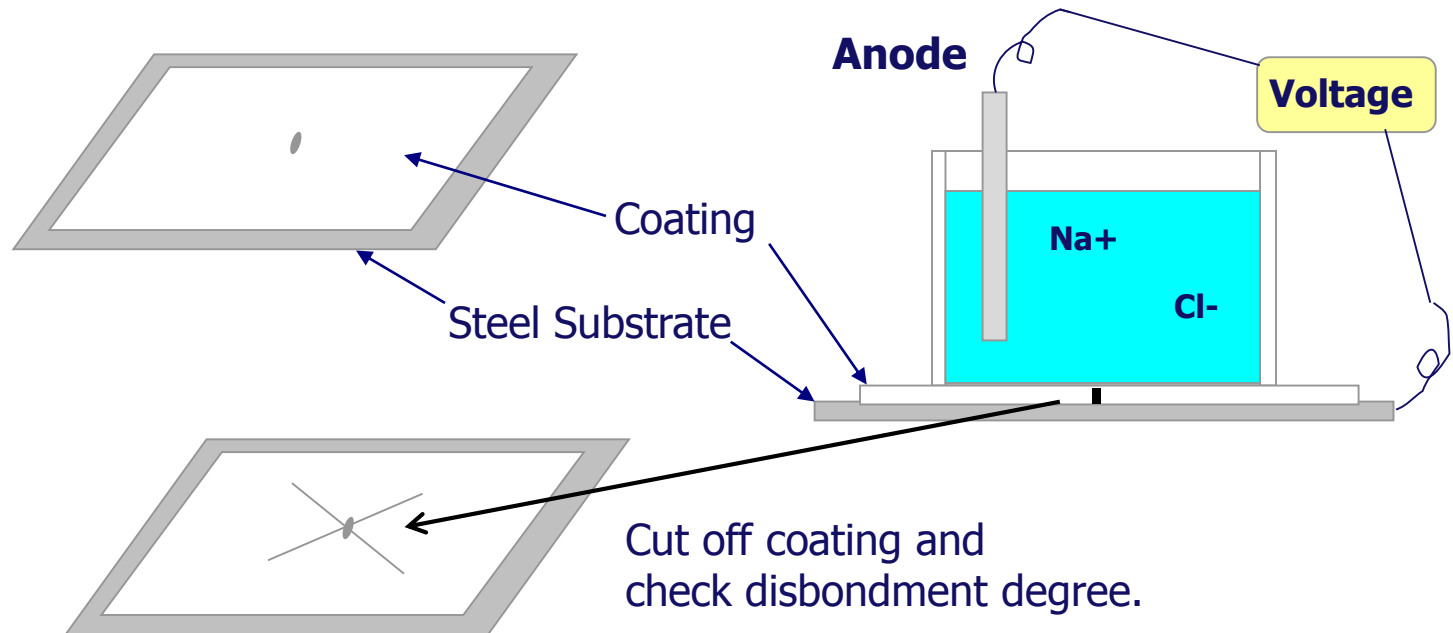
(Recipe: Bis A Epoxy + Curing Agent + MX)

Benefits: Fiber Reinforced Systems

The technology associated with the production of Kane Ace™ MX avoids agglomeration of CSR particles. As a result fibers (such as carbon or glass) do not filter out the CSR particles, allowing them to toughen even the resin-rich area between single filaments.



Cathodic Disbondment Testing



To evaluate cathodic disbondment, the coating is scribed at a point 45 degrees from the edge of the hole. The radius of disbondment area is then determined by inserting a knife point under the coating to "flick" the coating until a definite resistance to this action can be noted.

Benefits: Corrosion Resistance



Huntsman "Zero VOC" White Epoxy
High-Gloss topcoat (WEHGT)



Resolution Waterborne #1609

Cathodic Disbondment Test: NACE method RP0394-94
measured in mm after 24 hours at 66°C @3.5 DCV

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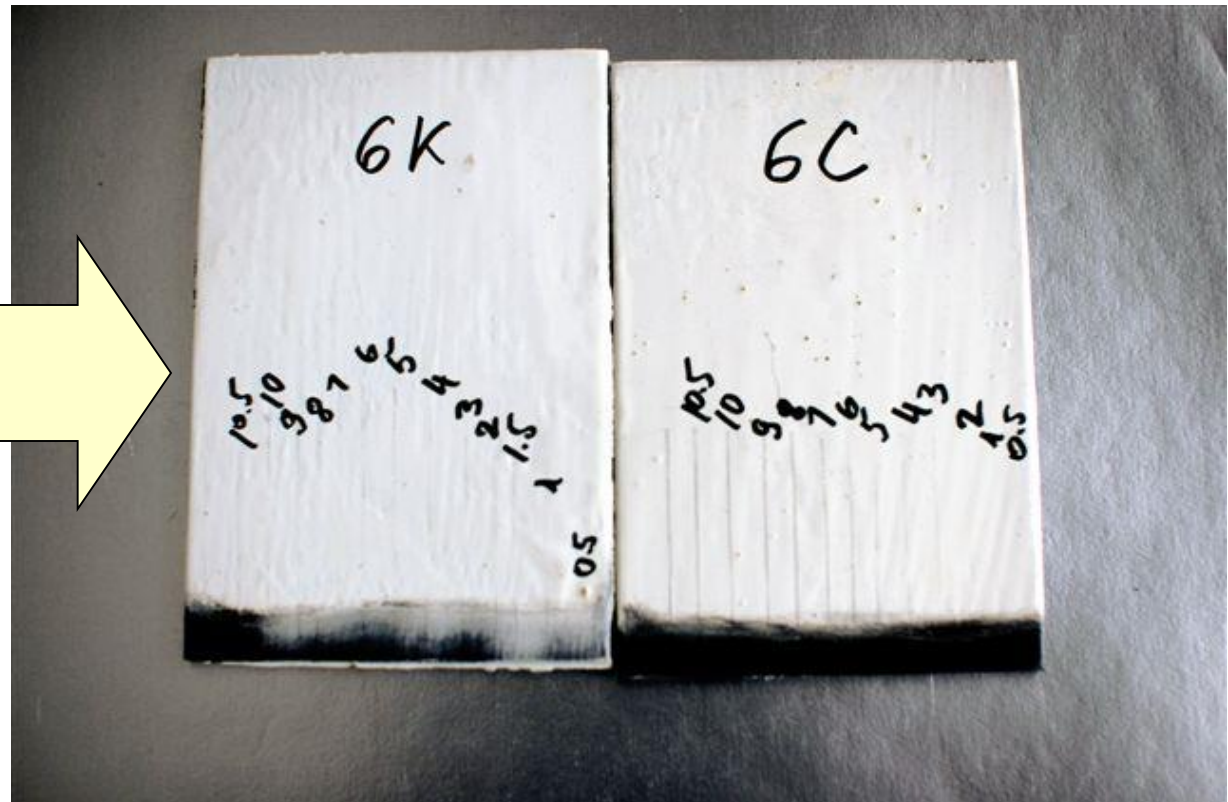
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28 Day Cathodic Disbondment



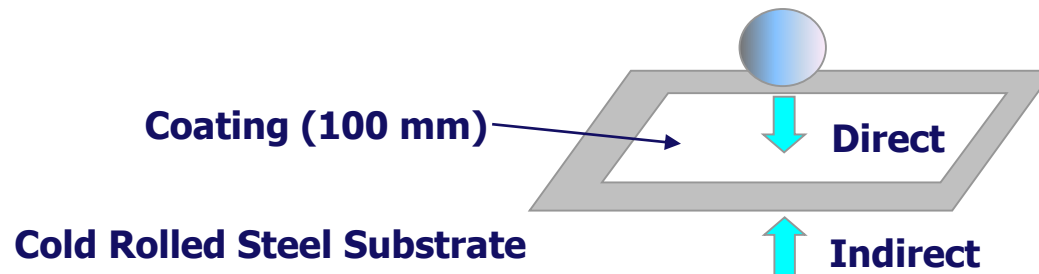
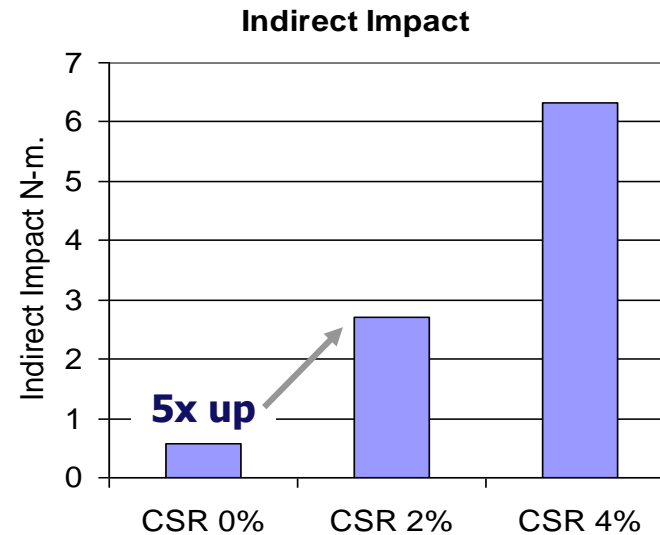
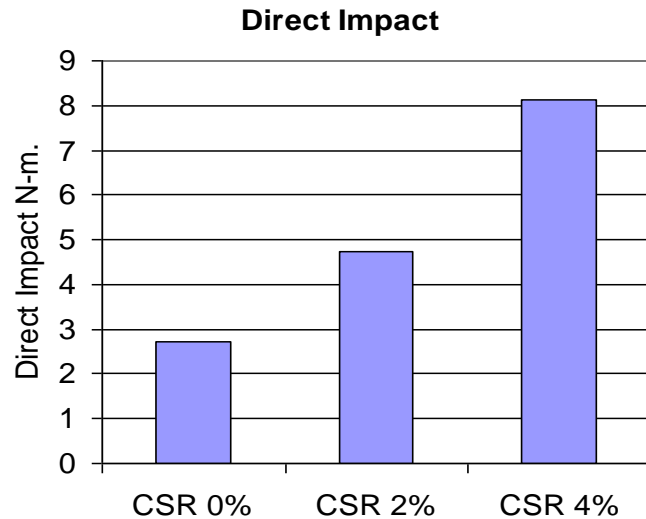
Benefits: Mar & Scratch Resistance

Kane Ace® MX can provide improvements to mar/scratch and abrasion resistance of thermosetting materials.



Huntsman "Zero VOC" White Epoxy High-Gloss topcoat (WEHGT)

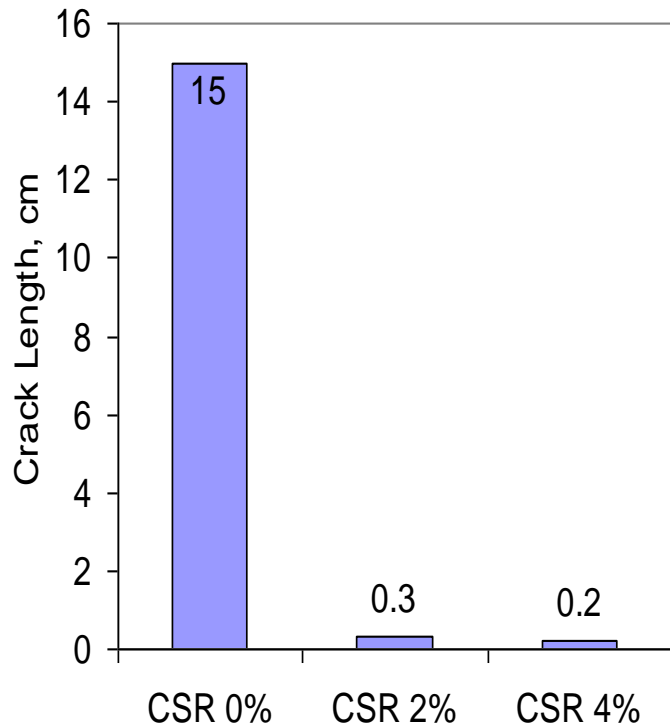
Gardner Impact



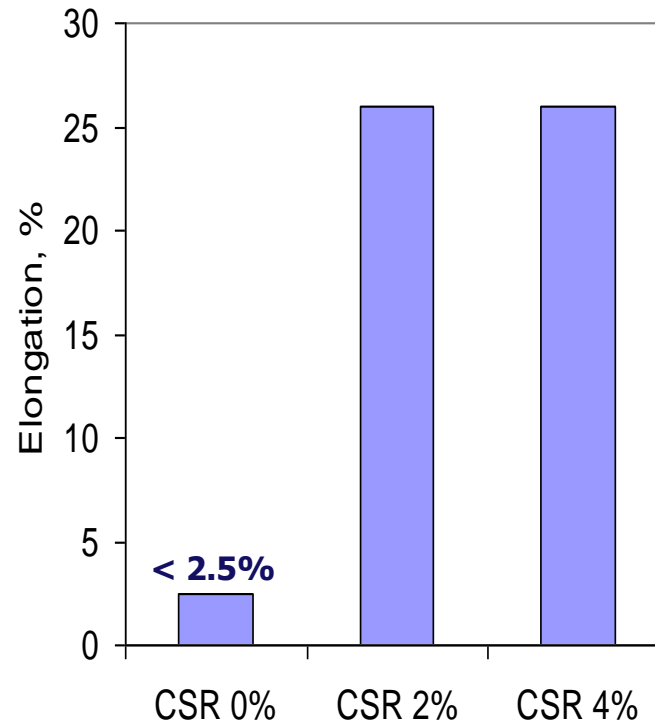
Test temperature 23°C
ASTM D-2794

Mandrel Bend Testing

Crack Length



Estimated Elongation



ASTM D-522

Products

Kane Ace MX products are available in a variety of carrier resins including:

Bis-A epoxy

Bis-F epoxy

Phenol Novolac epoxy

Multi-functional epoxy

Polyol for Urethane systems

Polyaspartic

Vinyl ester and UPE compatible

Acrylic system for UV curable applications

Summary

The Kane Ace MX[®] family tougheners offer formulators consistently high level performance in an easy-to-use form.

The technology associated with Kane Ace MX[®] allows for the “perfect” dispersion of CSR particles in thermosetting media, thereby providing enhancements properties such as impact, peel, mar & scratch resistance, fatigue, shrinkage, and chemical resistance.

A wide variety of Kane Ace MX[®] grades are now available. These materials can improve the performance many different types of thermosetting resins.

Questions??

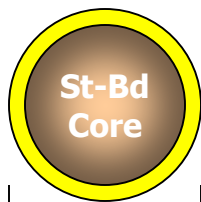
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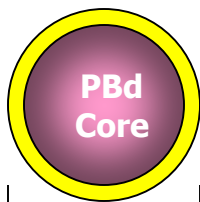
CSR Options For Kane Ace MX[®]

Four basic CSR species have been incorporated into the Kane Ace MX product line

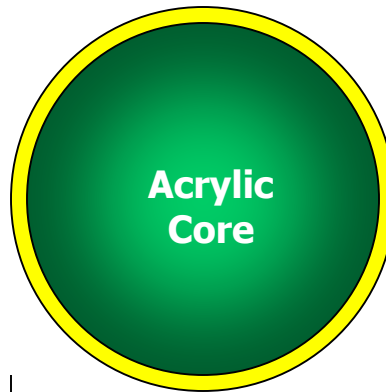
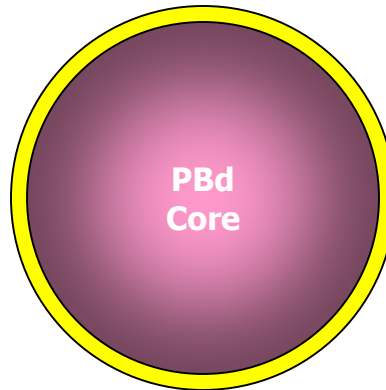
Shell composition and functionality (type) can be tailored to optimize performance and compatibility with the matrix.



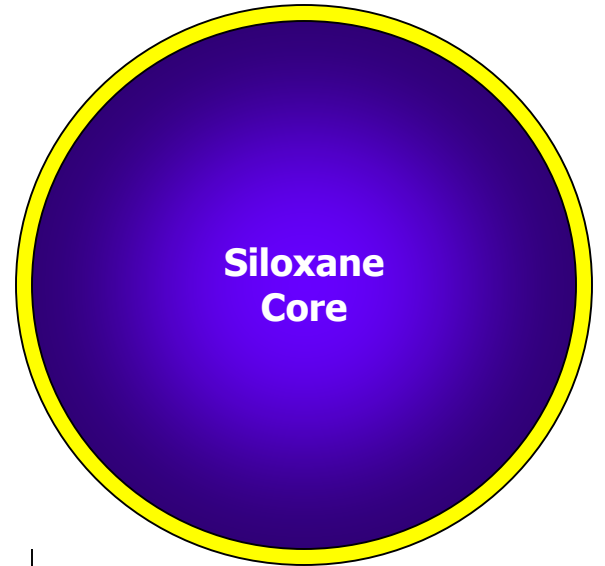
100 nm



100 nm



200 nm



300 nm