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.
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?

- Plastic zone at crack tip
- Rubber deformation
- Shear band
- Cavitation

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.
# Formulating With Kane Ace™ MX

<table>
<thead>
<tr>
<th>Standard Recipe</th>
<th>MX Modified Recipe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part A:</strong></td>
<td><strong>Part A:</strong></td>
</tr>
<tr>
<td>70 parts liquid Bis A resin</td>
<td>52 parts liquid Bis A resin</td>
</tr>
<tr>
<td>20 parts epoxy resin Bis-F</td>
<td>20 parts epoxy resin B</td>
</tr>
<tr>
<td>10 parts reactive diluent</td>
<td>10 parts reactive diluent</td>
</tr>
<tr>
<td><strong>Part B:</strong></td>
<td><strong>Part B:</strong></td>
</tr>
<tr>
<td>30 parts Part B- Curative</td>
<td>30 parts Part B-Curative</td>
</tr>
<tr>
<td><strong>Mix Ratio Part A to B:</strong></td>
<td><strong>Mix Ratio Part A to B:</strong></td>
</tr>
<tr>
<td>100/30</td>
<td>106:30</td>
</tr>
<tr>
<td><strong>Core Shell Concentration:</strong></td>
<td><strong>Core Shell Concentration:</strong></td>
</tr>
<tr>
<td>0%</td>
<td>4.4%</td>
</tr>
</tbody>
</table>

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.

Conventional CSR (10 wt%) in Bis A Epoxy
Kane Ace® MX CSR (25 wt%) in Bis A Epoxy
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
TEM analysis shows complete dispersion of CSR particles via MX while conventional tougheners suffer from agglomeration issues.

DISPERSION is the key to improvement of mechanical properties!
Kane Ace® MX can be used with common curing agents regardless of usage level, without sacrificing dispersion of the CSR particles.
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)
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.
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. Cut off coating and check disbondment degree.
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 66ºC @3.5 DCV
28 Day Cathodic Disbondment
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

Direct Impact

Indirect Impact

Coating (100 mm)

Cold Rolled Steel Substrate

Test temperature 23°C
ASTM D-2794
Mandrel Bend Testing

Crack Length

<table>
<thead>
<tr>
<th>CSR 0%</th>
<th>CSR 2%</th>
<th>CSR 4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0.3</td>
<td>0.2</td>
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</tbody>
</table>

Estimated Elongation

<table>
<thead>
<tr>
<th>CSR 0%</th>
<th>CSR 2%</th>
<th>CSR 4%</th>
</tr>
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<tbody>
<tr>
<td>&lt; 2.5%</td>
<td></td>
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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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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.