Lower-Temperature Cure Catalysts for Epoxy Carboxy Coatings

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Norwalk, Connecticut
Epoxy Resins

• Commercially important in several key end use applications.
  – Coatings
  – Adhesives
  – Laminates
  – Castings
  – Encapsulations and moldings.

• Most relevant in the automotive clear coats and powder coating market segments.

• Versatile crosslinking chemistries
  – Acids
  – Anhydrides
  – Phenolics
  – DICY

• Provide superior end use properties
  – Acid etch resistance in automotive clear coats
  – Adhesion
Environmental Etch of Automotive Clearcoats

• Environmental etch induced field damages in automotive import storage areas.

• Environmental etch of Acrylic melamine based automotive Clearcoats
  
  – Clear coat appearance issue caused by acid rain from airborne pollutants in heavy industrial areas. Typical pH of acid rain at Jacksonville, Florida is about 3.5-4.5

  – Primarily the result of crosslink acid hydrolysis of acrylic melamine clearcoats and network fragmentation.

  – Primary mode of melamine crosslink degradation is due to hydrolysis of acetal linkages and subsequent formation of melamine sulfates

  – Results in localized loss of material and visible pitting of clear coat surface.
Mechanistic Pathway for Environmental etch of Acrylic Melamine Clearcoats

Several approaches were attempted to address this issue including

- Modifications of acrylic melamine with additional crosslinking with blocked NCO or silanes.
- Carbamate functional acrylics crosslinked with melamine resins result in a hydrolysis resistant urethane crosslink.

Technology using epoxy/acid, the most robust producing very powerful acid etch and scratch resistant coatings.

Can be formulated as either 1K or 2K Coatings

One component epoxy acid is the leading etch resistant clear coat technology used in Japan, and Korea with more than 80% of clear coat markets.
Epoxy Acid Powder Coatings

- Powder Coatings are an attractive alternate to conventional coatings.
  - High efficiency
  - Low environmental impact
  - Durability of finishes

- Major Crosslinking Chemistries
  - Esterification reaction-cure profile of 150°C-220°C (hydroxyalkylamide-Primid®)
  - Hydroxyl/blocked isocyanate reaction-cure profile of 140°C-160°C
  - Epoxy/acid or epoxy/anhydride-cure in the range of 120°C-140°C
  - Epoxy/phenolic or epoxy/DICY-cure profile of 110°C

- Higher curing temperatures not useful with heat sensitive substrates (plastics, wood etc.)

- Epoxy/phenolic systems and epoxy homo polymerizations provide lower temperature cure options but lack the desired UV resistance for outdoor applications.

- Polyester/epoxy hybrids more versatile
  - Lower cure temperature potential
  - Better external weatherability at lower cost
  - Industrial uses including furniture, appliance, information technology and telecom.
  - Fastest growth at a CAGR of 8.1% from 2016 to 2024 and will account for > 50% of powder coating markets by 2024.
Chemical Reaction of Resins Containing an Epoxy and a Carboxyl Group:

- Ring Opening Condensation Reaction
- Resulting in Stable Ester Linkages
- High Crosslink Density Capabilities
- Excellent Chemical Resistance Properties
Available Catalyst Technologies

- Basic amine catalysts are effective at lower temperatures but suffer from
  - Severe yellowing
  - Limited stability in 1K systems

- Quaternary Ammonium and phosphonium salts are effective 1K catalysts but suffer from
  - Problems with water permeability
  - Humidity resistance
  - Inadequate mar resistance

- Metal salts and Chelates are stable at higher temperatures and impart little yellowing, but suffer from
  - Inefficient cure at 120°C, though effective at 140°C
  - Divalent Zn can contribute to ionic crosslinking leading to storage instability, and gelation.
# Non-Metal Catalysts for Epoxy Resins

## High Active Catalyst for Epoxy/Acid Coatings

*Catalyst XC-2007*

## Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Clear Liquid</td>
</tr>
<tr>
<td>Active</td>
<td>80%</td>
</tr>
<tr>
<td>Volatile</td>
<td>Water</td>
</tr>
<tr>
<td>Specific Gravity (25°C)</td>
<td>1.068</td>
</tr>
</tbody>
</table>
Non-Metal Catalysts for Epoxy Resins

High Active Catalyst for Epoxy/Acid

Performance Attributes

• High Active Catalyst
• Capable of Significant Reductions in Bake Temperature
• Excellent MEK Resistance and Gloss
• Low Color & Viscosity of Neat Catalyst
• Great Color of Catalyzed Films
• Good Overbake Resistance
Non-Metal Catalysts for Epoxy Resins

High Active Catalyst for Epoxy/Acid

Recommendations

Application/Formulation

- 2K SB or WB Epoxy/Acid Clearcoats

Incorporation/Storage

- Fully Disperse and Store in Acid Component

- Capable of Being Added to Fully Formulated Powder Coatings System

- Add Catalyst Before or at the End of Extrusion Process, Depending on Catalyst Dosage and Extrusion Temperatures

- Epoxy/Acid Hybrid Powder Coatings
Relevant Control Catalysts

Octyldimethylamine
- ADMA-8
- Tertiary Amine
- 2K Epoxy
- 100% Solids
- Liquid

2-Ethylimidazole
- 2-EI
- Selective Catalyst
- 2K Epoxy
- 100% Solids
- Solid
Catalyst XC-2007 in 2K SB Epoxy/Acid Clearcoat Film Evaluation and Rheology Cure Study

Objective
Demonstrate Efficacy of Catalyst XC-2007 in a 2K SB Epoxy/Acid Formulation using GMA/Acrylic Hybrid Resin System
Solid Resins
Physical Properties

- **Carboxyl Functional Acrylic Resin:** White Powder/Flakes

<table>
<thead>
<tr>
<th>Resin</th>
<th>Acid EW (g/eq)</th>
<th>Softening Point (°C)</th>
<th>Tg (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic Resin 819</td>
<td>148</td>
<td>115</td>
<td>57</td>
</tr>
</tbody>
</table>

- **Glycidyl Methacrylate (GMA) Epoxy Resin:** White Powder/Flakes

<table>
<thead>
<tr>
<th>Resin</th>
<th>Epoxy EW (g/eq)</th>
<th>Melt Index (g/10min, 125°C)</th>
<th>Tg (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMA Epoxy AC 2710</td>
<td>300-350</td>
<td>100-120</td>
<td>~45</td>
</tr>
</tbody>
</table>
## Formulation

**2K SB Epoxy/Acid Clearcoat**

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component 1 - Acid Component</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrylic Resin 819</td>
<td>Carboxyl Functional Acrylic</td>
<td>31.1</td>
</tr>
<tr>
<td>Xylene</td>
<td>Solvent</td>
<td>15.1</td>
</tr>
<tr>
<td>PM Acetate</td>
<td>Solvent</td>
<td>15.1</td>
</tr>
<tr>
<td>n-Butyl Acetate</td>
<td>Solvent</td>
<td>7.5</td>
</tr>
<tr>
<td>BYK 310</td>
<td>Surface Additive</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Component 2 - Epoxy Component</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMA Epoxy AC 2710</td>
<td>Glycidyl Methacrylate (GMA)</td>
<td>14.0</td>
</tr>
<tr>
<td>Xylene</td>
<td>Solvent</td>
<td>6.8</td>
</tr>
<tr>
<td>PM Acetate</td>
<td>Solvent</td>
<td>6.8</td>
</tr>
<tr>
<td>n-Butyl Acetate</td>
<td>Solvent</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>100.0</td>
</tr>
<tr>
<td>% TRS</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Acrylic / GMA Solids</td>
<td></td>
<td>~ 70 / 30</td>
</tr>
<tr>
<td>Acid / Epoxide (molar ratio)</td>
<td></td>
<td>~ 1 / 1</td>
</tr>
</tbody>
</table>

**Catalyst XC-2007**

Dosage = 1% Solids on TRS

Dispersed and Stored in Acid Component

Epoxy Component Post-Added to Pre-Catalyzed Acid
### Pot Observations

**Dispersing Catalyst 2007 in a SB Epoxy/Acid System**

<table>
<thead>
<tr>
<th>System</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalyst XC-2007</td>
<td>Incorporating Catalyst into Acid Component</td>
</tr>
<tr>
<td></td>
<td>Clear Pot, Fully Dispersed</td>
</tr>
</tbody>
</table>

#### Implications

Aqueous Catalyst Fully Dispersible in SB System
**Rheology Studies**

**Oscillation Tests: Cure Profile**

**Terminology and Definitions for Rheology Studies Shown in Exp. I and Exp. III**

<table>
<thead>
<tr>
<th>Rheological Property</th>
<th>Typical Notation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Force</td>
<td>Normal Force</td>
<td>Perpendicular Force Applied to Sample By Rheometer</td>
</tr>
<tr>
<td></td>
<td>-or- N</td>
<td>Note: Studies Shown were Conducted with Fixed Gap</td>
</tr>
<tr>
<td>Storage (Elastic) Modulus</td>
<td>$G'$</td>
<td>Measures Elasticity or Ability to Store Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(i.e. properties of solids)</td>
</tr>
<tr>
<td>Loss (Viscous) Modulus</td>
<td>$G''$</td>
<td>Represents Viscous Region or Ability to Dissipate Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(i.e. properties of liquids)</td>
</tr>
<tr>
<td>Tan(delta)</td>
<td>$\tan(\delta)$</td>
<td>Ratio of $G''/G'$ – Measurement of “Viscous” to “Elastic” Portion of a Substance*</td>
</tr>
</tbody>
</table>

* $\tan(\delta) > 1 \rightarrow G'' > G' \rightarrow$ More Viscous $\rightarrow$ Behaving more-like Liquid
  $\tan(\delta) = 1 \rightarrow G'' = G' \rightarrow$ Viscoelastic $\rightarrow$ Gel Point
  $\tan(\delta) < 1 \rightarrow G'' < G' \rightarrow$ More Elastic $\rightarrow$ Behaving more-like Solid
# Rheology Studies

## Oscillation Tests: Cure Profile

<table>
<thead>
<tr>
<th>Pre-Exp. Step #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Place Sample on Peltier Plate at 25°C</td>
</tr>
<tr>
<td>1a</td>
<td>Immediately Bring Geometry to Zero-Gap (400 micron)</td>
</tr>
<tr>
<td>1b</td>
<td>Shear at 100 s⁻¹ / 1 min</td>
</tr>
<tr>
<td>1c</td>
<td>Raise Geometry and Allow Sample to rest at 25°C / 5 min</td>
</tr>
<tr>
<td>Step 2</td>
<td>Bring Geometry back to Zero-Gap (400 micron)</td>
</tr>
<tr>
<td>2a</td>
<td>Increase Temperature to 80°C</td>
</tr>
<tr>
<td>2b</td>
<td>Shear at 200 s⁻¹ Until Temperature Reaches 80°C</td>
</tr>
<tr>
<td>2c</td>
<td>Raise Geometry and Allow Sample to rest at 80°C / 5 min</td>
</tr>
<tr>
<td>2d</td>
<td>Equilibrate at 20°C / 1 min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exp. Step #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Temperature Ramp of 1°C/min from 20-140°C</td>
</tr>
</tbody>
</table>
Rheology Studies
Oscillation Tests: Cure Profile

- Oscillation Curve of Tan(δ) & Normal Force as a Function of Temperature
  - Heat Ramp: 1°C/min, 20-140°C
  - 0.5% Strain, Frequency = 2.0, 3.0, 4.0 .... 19, 20 Hz
  - 0% Catalyst vs. 1% Catalyst Solids on TRS
  - Catalyst XC-2007 Reduced Gel Time by ~20°C
Film Properties
Gloss, Hardness, and Cure

SB Clearcoats DTM over Bare CRS

- **Substrate:** Bare CRS
- **DFT:** 2.0-2.2 mil
- **Bake Schedule:** 100°C/30min

<table>
<thead>
<tr>
<th>System</th>
<th>Gloss 20°</th>
<th>Gloss 60°</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Catalyst</td>
<td>108</td>
<td>128</td>
</tr>
<tr>
<td>Catalyst XC-2007</td>
<td>106</td>
<td>125</td>
</tr>
</tbody>
</table>

**Good Cure at 100°C:**
1% Catalyst Solids on TRS
Film Properties
Overbake Resistance

Color Study—Yellowing and Total Color Change

- **Substrate:** Bare CRS
- **DFT:** 1.0-1.2 mil
- **Bake Schedule:** 100°C/30min
- **Overbake:** +100°C/30min

### Yellowing Resistance

<table>
<thead>
<tr>
<th>System</th>
<th>b\textsuperscript{o}</th>
<th>b\textsuperscript{f}</th>
<th>Δb\textsuperscript{*}</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Catalyst</td>
<td>0.24</td>
<td>0.25</td>
<td>0.01</td>
</tr>
<tr>
<td>Catalyst XC-2007</td>
<td>0.29</td>
<td>0.31</td>
<td>0.03</td>
</tr>
</tbody>
</table>

### Total Color Change

<table>
<thead>
<tr>
<th>System</th>
<th>ΔL\textsuperscript{*}</th>
<th>Δa\textsuperscript{*}</th>
<th>Δb\textsuperscript{*}</th>
<th>ΔE\textsuperscript{*}</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Catalyst</td>
<td>-0.07</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Catalyst XC-2007</td>
<td>-0.11</td>
<td>-0.03</td>
<td>0.03</td>
<td>0.12</td>
</tr>
</tbody>
</table>

- **Clearcoat Color Tested over White WB BC**
- Good Overbake Resistance with 1% Catalyst XC-2007 solids on TRS
- No Significant Increase in Color Versus Uncatalyzed Film
Objective
Compare Catalyst XC-2007 to 2-ethylimidazole and octydimethylamine in a 2K SB Epoxy/Acid Formulation using GMA Epoxy/Acrylic Hybrid
### Solid Resins

**Physical Properties**

#### Carboxyl Functional Acrylic Resin:
- Acrylic Resin 819
  - Acid EW (g/eq): 148
  - Softening Point (°C): 115
  - Tg (°C): 57

#### Glycidyl Methacrylate (GMA) Epoxy Resin:
- GMA Epoxy AC 2570
  - Epoxy EW (g/eq): 460-500
  - Melt Index (g/10min, 125°C): 35-45
  - Tg (°C): ~55
# Formulation

## 2K SB Epoxy/Acid Clearcoat

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component 1 - Acid Component</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrylic Resin 819</td>
<td>Carboxyl Functional Acrylic</td>
<td>27.0</td>
</tr>
<tr>
<td>Xylene</td>
<td>Solvent</td>
<td>13.2</td>
</tr>
<tr>
<td>PM Acetate</td>
<td>Solvent</td>
<td>13.2</td>
</tr>
<tr>
<td>n-Butyl Acetate</td>
<td>Solvent</td>
<td>6.5</td>
</tr>
<tr>
<td>BYK 310</td>
<td>Surface Additive</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Component 2 - Epoxy Component</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMA Epoxy AC 2570</td>
<td>Glycidyl Methacrylate (GMA)</td>
<td>18.0</td>
</tr>
<tr>
<td>Xylene</td>
<td>Solvent</td>
<td>8.8</td>
</tr>
<tr>
<td>PM Acetate</td>
<td>Solvent</td>
<td>8.8</td>
</tr>
<tr>
<td>n-Butyl Acetate</td>
<td>Solvent</td>
<td>4.3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>100.0</td>
</tr>
<tr>
<td>% TRS</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Acrylic / GMA Solids</td>
<td></td>
<td>~ 60 / 40</td>
</tr>
<tr>
<td>Acid / Epoxide (molar ratio)</td>
<td></td>
<td>~ 1 / 1</td>
</tr>
</tbody>
</table>

### Catalysts Tested

**Catalyst XC-2007**

- Octyldimethylamine (ADMA-8)
- 2-Ethylimidazole (2-EI)

**Dosage = 1% Solids on TRS**

Dispersed and Stored in Acid Component

Epoxy Component Post-Added to Pre-Catalyzed Acid
**Gloss and Hardness**

**100°C/30min**

*Bare Cold Roll Steel (Polished)*

<table>
<thead>
<tr>
<th>System</th>
<th>20°</th>
<th>60°</th>
<th>Pendulum</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMA-8</td>
<td>96.4</td>
<td>109</td>
<td>138</td>
</tr>
<tr>
<td>2-EI</td>
<td>95.8</td>
<td>109</td>
<td>143</td>
</tr>
<tr>
<td>Catalyst XC-2007</td>
<td>94.8</td>
<td>109</td>
<td>145</td>
</tr>
</tbody>
</table>

All Films Show Good Gloss and Hardness
(Not Necessarily Indicative of Cure Response)
Catalyst XC-2007 Provided Superior Cure Response
Better Mar Resistance after 100 MEK 2X
QUV Resistance: b* - 250 Hrs

SB Epoxy/Acid Clear over White WB Melamine Base Coat

**100°C/30 min**

*Bare Cold Roll Steel (Polished), ~1 mil DFT*

Catalyst XC-2007 Shows Lower Initial Color and Least Color Change
Crockmeter Testing
Borax Dry Method—10 Cycles—TIC Crockmeter Square (2x2)

100°C/30 min
Bare Cold Roll Steel (Polished), ~1 mil DFT

ADMA-8  2-EI  XC-2007

Catalyst XC-2007 Improved Resistance to Crockmeter Abrasion
Better Crosslink Density → Less Scratch and Mar → Less Change in Gloss
Crockmeter Testing
Borax Dry Method—10 Cycles—Crockmeter Square (2x2)

100°C/30 min
Bare Cold Roll Steel (Polished), ~1 mil DFT

Catalyst XC-2007 Improved Resistance to Crockmeter Abrasion
Better Crosslink Density → Less Scratch and Mar → Less Change in Gloss
## Overbake: Total Color Change

### 100°C/30 min

**Bare Cold Roll Steel (Polished), ~1 mil DFT**

**OVERBAKE: Additional 100°C/30min**

<table>
<thead>
<tr>
<th>System</th>
<th>ΔL*</th>
<th>Δa*</th>
<th>Δb*</th>
<th>ΔE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMA-8</td>
<td>-0.13</td>
<td>-0.01</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td>2-EI</td>
<td>-0.14</td>
<td>-0.01</td>
<td>0.17</td>
<td>0.22</td>
</tr>
<tr>
<td>Catalyst XC-2007</td>
<td>-0.11</td>
<td>-0.01</td>
<td>0.15</td>
<td>0.19</td>
</tr>
</tbody>
</table>

All Catalysts Show Low Change in Color with Overbake
Objective
Demonstrate Catalyst Cure Capabilities of Catalyst XC-2007 in a Powder Epoxy/Acid Formulation Based on GMA Epoxy/Acrylic Hybrid
## Solid Resins:
### Physical Properties

**Carboxyl Functional Acrylic Resin:** White Powder/Flakes

<table>
<thead>
<tr>
<th>Resin</th>
<th>Acid EW (g(eq))</th>
<th>Softening Point (°C)</th>
<th>Tg (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic Resin 819</td>
<td>148</td>
<td>115</td>
<td>57</td>
</tr>
</tbody>
</table>

**Glycidyl Methacrylate (GMA) Epoxy Resin:** White Powder/Flakes

<table>
<thead>
<tr>
<th>Resin</th>
<th>Epoxy EW (g(eq))</th>
<th>Melt Index (g/10min, 125°C)</th>
<th>Tg (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMA Epoxy AC 2710</td>
<td>300-350</td>
<td>100-120</td>
<td>~45</td>
</tr>
</tbody>
</table>
Formulation:
*Powder (No Solvent) Epoxy/Acid Clearcoat*

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic Resin 819</td>
<td>Carboxyl Functional Acrylic</td>
</tr>
<tr>
<td>GMA Epoxy AC 2710</td>
<td>Glycidyl Methacrylate (GMA)</td>
</tr>
<tr>
<td>% TRS</td>
<td>100</td>
</tr>
<tr>
<td>Acrylic / GMA Solids</td>
<td>~ 70 / 30</td>
</tr>
<tr>
<td>Acid / Epoxide (molar ratio)</td>
<td>~ 1 / 1</td>
</tr>
</tbody>
</table>

**Catalyst XC-2007**
**Dosage = 1% Solids on TRS**
Preparing Test Specimen For Rheology Study

GMA/Acrylic Hybrid Powder

1) Solid Grade GMA and Acrylic Resins Pulverized using Mortar and Pestle
2) Catalyst Post-Added to Fine Powder Mixture
3) Catalyzed Formulation Mixed Slowly in FlackTek Speed Mixer
4) Formulation Re-Pulverized using Mortar and Pestle

GMA/Acrylic Hybrid Formulation Pressed into Powder Disc to Test via Rheometer
Rheology Studies—Oscillation Tests: *Cure Profile*

- **Oscillation Curve of $G'$ & $G''$ as a Function of Temperature**
  - Heat Ramp: 1°C/min, 50-200°C
  - 0.25% Strain, Frequency = 1.0 Hz
  - 0% Catalyst vs. 1% Catalyst Solids on TRS
  - Catalyst XC-2007 Reduced Gel Time by ~20°C
Discussion:
Cure Capabilities of SB vs. Powder Epoxy/Acid

Final Conclusions
Discussion—Cure Capabilities: 2K SB vs. Powder
GMA / Acrylic Hybrid

Gel Time Comparison
Rheology – Oscillation Tests
\[ \tan(\delta) = \frac{G''}{G'} = 1 \]

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>No Catalyst</th>
<th>XC-2007</th>
<th>No Catalyst</th>
<th>XC-2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solventborne (2K)</td>
<td>114.1</td>
<td>93.2</td>
<td>145.0</td>
<td>123.6</td>
</tr>
<tr>
<td>Powder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

~ 70/30 Acrylic Resin 819/GMA Epoxy AC 2710  + 1% Catalyst XC-2007 Solids on TRS
Discussion— Cure Capabilities: 2K SB vs. Powder

GMA / Acrylic Hybrid

Gel Time Comparison

Rheology – Oscillation Tests

\( \tan(\delta) = \frac{G''}{G'} = 1 \)

~ 70/30 Acrylic Resin 819/GMA Epoxy AC 2710

+ 1% Catalyst XC-2007 Solids on TRS
Conclusions

Based on Studies in **Epoxy/Acid Hybrid** using **GMA/Acrylic** Resin System
+1% Catalyst XC-2007 Solids on TRS

**Catalyst Technology Validated as High Active Catalyst Capable of Promoting Epoxy/Acid Reaction at Lower Temperatures**

- Significant Reduction in Bake Temperature of Epoxy/Acid Hybrid Systems
- Capable of Lowering Cure Temperature by 20°C
- Potential for Achieving Good Cure at 100°C
- Minimal Change in Gloss with Good Lower Temperature Cure
- Low Color of Neat Catalyst
- Low Film Color with Good Overbake Resistance
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Based on Studies in Epoxy/Acid Hybrid using GMA/Acrylic Resin System +1% Catalyst XC-2007 Solids on TRS

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Strong Candidate for Replacing Imidazole or Amine Type Catalysts

- Significantly Less Heath and Physical Safety Hazards
- Superior Cure Response with Improved Mar Resistance (MEK 2X)
- Better UV Resistance (QUV)
- Enhanced Crockmeter Abrasion Resistance
Lower-Temperature Cure Catalysts for Epoxy Carboxy Coatings

Acknowledgements

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See you at King Industries Booth # 75