Advanced Materials

Optimizing cure control and latency

Quarter 1, 2015
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# Latent hardeners for epoxy resins

## Product selection

<table>
<thead>
<tr>
<th>Product</th>
<th>Latency / reactivity</th>
<th>Impact on mechanical properties</th>
<th>Chemical nature / form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aradur® 1571</td>
<td>Good latency at RT - curing above 120°C</td>
<td>Standard modulus</td>
<td>Dispersion of DICY in epoxy resin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium Tg</td>
<td></td>
</tr>
<tr>
<td>Aradur® 9506</td>
<td>Outstanding latency at RT - snap cure</td>
<td>Standard modulus</td>
<td>Fine yellow powder easily dispersible</td>
</tr>
<tr>
<td></td>
<td>type behaviour above 70-80°C</td>
<td>Medium Tg</td>
<td></td>
</tr>
<tr>
<td>XB 3473</td>
<td>Good latency at RT - curing above 140°C</td>
<td>Standard modulus</td>
<td>Liquid aromatic amine (~ 100 mPas)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High Tg</td>
<td></td>
</tr>
<tr>
<td>Aradur® 9664-1</td>
<td>Very latent at RT</td>
<td>Standard modulus</td>
<td>4,4’-DDS</td>
</tr>
<tr>
<td></td>
<td>Curing above 180°C</td>
<td>Very high Tg</td>
<td>Solid: fine powder easily dispersible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Softening point 176 - 185°C</td>
</tr>
<tr>
<td>Aradur® 9719-1</td>
<td>Latent at RT</td>
<td>Highest modulus</td>
<td>3,3’-DDS</td>
</tr>
<tr>
<td></td>
<td>Curing above 180°C</td>
<td>Very high Tg</td>
<td>Solid: fine powder easily dispersible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Softening point 170 - 180°C</td>
</tr>
</tbody>
</table>
Latent hardeners for epoxy resins

Kinetics

Gel time at different temperature

100 parts Araldite® MY 790 + 40 parts Aradur® 9506 or 25 parts Aradur® 1571 / 3 parts accelerator 1573 or 25 parts hardener XB 3473

Gel time measured with Gelnorm©
Latent hardeners for epoxy resins

Kinetics
Time to reach 90% conversion at different temperature

100 parts Araldite® MY 790 + 40 parts Aradur® 9506 or 25 parts Aradur® 1571 / 3 parts accelerator 1573
Conversion measured with DSC (isotherm)
Latent hardeners for epoxy resins

Kinetics

Conversion and Tg versus time of cure at 110°C

100 parts Araldite® MY 790 + 40 parts Aradur® 9506 or 25 parts Aradur® 1571 / 3 parts accelerator 1573

Tg onset measured via DSC
Latent hardeners for epoxy resins

Kinetics
Time to reach 90% conversion at 120°C and 180°C

Araldite® GY 250 (BisA-diglycidyl ether) + hardener mixed at stoichiometry
Conversion measured with DSC (isotherm)

Aradur® 9664-1
Aradur® 9719-1
XB 3473
Latent hardeners for epoxy resins

Thermo-mechanical properties
Modulus and Tg

Araldite® GY 250 (BisA-diglycidyl ether) + hardener mixed at stoichiometry
Cure profile: 2h at 150°C + 4h at 180°C + 2h at 200°C - Tg measured via DMA (Tan delta Peak)
# Latent accelerators for epoxy resins

## Product selection

<table>
<thead>
<tr>
<th>Product</th>
<th>Latency / reactivity</th>
<th>Impact on mechanical properties</th>
<th>Form / processability</th>
<th>EHS status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aradur® 1167</td>
<td>Outstanding latency at 80°C</td>
<td>Standard modulus</td>
<td>Solid: easy to incorporate</td>
<td>Not classified</td>
</tr>
<tr>
<td></td>
<td>Lower reactivity than TDI-uron at 120°C</td>
<td>High Tg</td>
<td>Softening point: 95°C</td>
<td></td>
</tr>
<tr>
<td>Aradur® 1573</td>
<td>Good latency</td>
<td>Similar to TDI-uron</td>
<td>Paste (75 000 mPa.s): easy to incorporate</td>
<td>!</td>
</tr>
<tr>
<td></td>
<td>Lower reactivity than TDI-uron at 120°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aradur® 3123</td>
<td>Slightly lower latency</td>
<td>Standard modulus</td>
<td>Solid: to be dispersed</td>
<td>!</td>
</tr>
<tr>
<td></td>
<td>Faster reactivity than TDI-uron at 120°C</td>
<td>High Tg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerator DY 9577</td>
<td>Good latency up to 80°C</td>
<td>Standard modulus</td>
<td>Solid: easy to incorporate</td>
<td>Not classified</td>
</tr>
<tr>
<td></td>
<td>High reactivity above 120°C</td>
<td>High Tg</td>
<td>Melting point: 25-30°C</td>
<td></td>
</tr>
</tbody>
</table>
Latent accelerators for epoxy resins

DICY cure
Time to reach 90% conversion at different temperature

100 parts Araldite® GY 250 (BisA-diglycidyl ether) + 25 parts Aradur® 1571 (DICY paste) + 6 parts accelerator
Conversion measured with DSC (isotherm)
Latent accelerators for epoxy resins

DICY cure

Gel time measured at 80°C

Gel time at 80°C (min)
- Aradur® 1167
- TDI-Uron

Araldite® PY 306
Araldite® MY 790
Araldite® EPN 1179
Tactix® 556
Araldite® EPN 1180
Araldite® MY 0610
Araldite® MY 0510
Araldite® MY 721

Stoichiometric cure with DICY hardener / TDI-Uron or DICY hardener / Aradur® 1167 (100/46 pbw)
Gel time measured with Gelnorm®
Latent accelerators for epoxy resins

DICY cure
Gel time measured at 120°C

Stoichiometric cure with DICY hardener / TDI-Uron or DICY hardener / Aradur® 1167 (100/46 pbw)
Gel time measured with Gelnorm®
Latent accelerators for epoxy resins

DICY cure
Tg and flexural modulus

Stoichiometric cure with DICY hardener / TDI-Uron or DICY hardener / Aradur® 1167 (100/46 pbw)
Cure profile: 2h at 100°C + 2h at 150°C + 2h at 220°C - Tg measured via DMA (G' Onset)
Latent accelerators for epoxy resins

Anhydride cure
Latency comparison vs. methyl imidazole - Viscosity build-up, time to reach 1 000 Pa.s

100 parts Araldite® GY 250 (BisA-diglycidyl ether) + 90 parts Aradur® 917 (MTHPA) + 3 parts accelerator
Viscosity build-up measured with plate / plate dynamic viscosimeter
Latent accelerators for epoxy resins

Accelerator for homopolymerization
Reactivity - Time to reach 90% conversion at different curing temperature

6.0 pbw of Aradur® 3123 in 100 parts of epoxy resin
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