Functional Additives for Epoxy Adhesives

Additive Selection
BYK Chemie, Tobias Austermann  
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Improve Performance of Epoxy Applications
Additive selection

**Defoamers & Air Release Agents**
Reduce defects of the cured film and reduction of air incorporation during the mixing process.

**Wetting and Dispersing Additives**
Increase filler load and stabilization of fillers during storage time.

**Rheology Additives**
Influence on workability and sag resistance of vertical applications.
Additives for Epoxy Adhesives
Defoamers & Air Release Agents
The preparation of 2-pack and 1-pack epoxy based adhesives requires mixing. These shear forces lead to introduction of air.

While some small air voids are desirable (easy flow, insulation, flexibility), too much or large air voids are unwanted as they

- reduce density
- affect mechanical properties
- cause poor visual appearance / surface defects
- impact application properties (flowability)
- impair washability
Bubbles rise to the surface with a velocity dependent on the viscosity of the liquid. 

\[ V \sim \frac{r^2}{\eta} \]

- \( V \) = Velocity of rise
- \( r \) = Bubble radius
- \( \eta \) = Viscosity of liquid

Stroke's law
Minimization of foam
Test procedure
BYK-1796
High Performance Defoamer

100% 2-pack Epoxy Adhesives require an effective and fast defoaming process even at high viscosities.

High viscous resin and hardener components lead to foam building and foam stabilization in the production process and mixing for application.

Foam free applications are required even at high layer thicknesses.

Resin: Epikote 828
Hardener: Epikure 3140A

BYK-1796 is added to the resin component. Foam is evaluated directly after mixing the resin and hardener component and after curing of the formulation.

Left: control
Right: 0,5% BYK-1796
Polysiloxanes Based Defoamers

Additives for Epoxy Adhesives

Page 8
There are no compatible defoamers!
Defoamer selection
Mode of Action

Defoaming

Compatible / soluble

Incompatible / insoluble

Optimum

Defects

Foam stabilization

Additives for Epoxy Adhesives
Page 10
## Defoamer and Air Release Agents

### Recommendations

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Type</th>
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<tbody>
<tr>
<td>BYK-1796*</td>
<td>Silicone based</td>
</tr>
<tr>
<td>BYK-A 525</td>
<td></td>
</tr>
<tr>
<td>BYK-A 535*</td>
<td>Polymer (Silicone free)</td>
</tr>
<tr>
<td>BYK-A 501</td>
<td></td>
</tr>
<tr>
<td>BYK-1790*</td>
<td></td>
</tr>
<tr>
<td>BYK-530</td>
<td>Polymer/Silicone</td>
</tr>
</tbody>
</table>

* High solid additives
Additives for Epoxy Adhesives
Wetting and Dispersing Additives
Particle size versus specific surface area

<table>
<thead>
<tr>
<th>Particle</th>
<th>Surface area [m² / g]</th>
<th>Particle size [µm]</th>
<th>Strength of cohesive forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filler</td>
<td>&lt;1</td>
<td>10-250</td>
<td></td>
</tr>
<tr>
<td>Iron oxide red</td>
<td>12</td>
<td>0.250</td>
<td></td>
</tr>
<tr>
<td>Phthalocyanine blue</td>
<td>70</td>
<td>0.084</td>
<td></td>
</tr>
<tr>
<td>Carbon black</td>
<td>460</td>
<td>0.013</td>
<td></td>
</tr>
</tbody>
</table>

The larger the specific surface area, the more difficult to disperse the particles.
Wetting & Dispersing Additives
Basics

Polarity of organic and inorganic pigments / fillers

- **Organic** (i.e. Phthalocyanine blue)
  - Lower polar surface

- **Inorganic** (i.e. Titanium dioxide)
  - Higher polar surface
Wetting & Dispersing Process

Wetting

\[ \Delta \text{ in surface tension between filler / Filler and water} \]
- The higher the differences, the slower the wetting process
- Wetting & dispersing additives minimize the differences
Wetting and Dispersing Additives

Benefits

- All pigment/filler properties are based on primary particles
- Homogeneous distribution of particles will avoid defects
- Low viscosity
- No syneresis and settling of heavy fillers
- Good reproducibility of the rheology profile
- Better leveling and substrate wetting
- Uniform appearance by distribution of pigments

Easy incorporation and homogeneous distribution of solid fillers and pigments
### Stabilization Mechanisms

**Controlled Flocculation vs. Deflocculation**

**Flocculation**
- Undesired status
- Flocculates
- Settling

**Controlled flocculation**
- Anti-settling, anti-sagging
- For high film-built systems
- Pseudoplasticity, thixotropy

**Deflocculation**
- Low viscosity
- Newtonian flow behavior
- Enhances flow / leveling
## Solvent-borne & Reactive Systems

### Selection Criteria

<table>
<thead>
<tr>
<th>Fillers Inorganic particels</th>
<th>Organic fillers Carbon blacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity reduction</td>
<td>Viscosity reduction</td>
</tr>
<tr>
<td>Viscosity reduction + anti-settling</td>
<td>Anti-settling</td>
</tr>
<tr>
<td>Multifunctional, deflocculating</td>
<td>Multifunctional, controlled flocculating</td>
</tr>
<tr>
<td>Phosphoric Acid Esters</td>
<td>Polyurethanes Hyperbranched polymers Structured Polyacrylates</td>
</tr>
<tr>
<td>Fatty Acid Chemistry</td>
<td></td>
</tr>
</tbody>
</table>
Effect of Wetting and Dispersing Additives

Viscosity reduction

Control, no additive

Wetting and dispersing additives: viscosity reduction by BYK-W 9010

Wetting and dispersing additives: higher filler dosing possible by BYK-W 9010

Influence of wetting and dispersing additives in epoxy applications
Disperbyk-2152
Hyperbranched Wetting & Dispersing Additive

Reasons for product development
Epoxy-based systems represent an important market segment

Selection of wetting & dispersing additive is challenging
• 90% of all organic pigments are acidic in nature
  → Acid / base theory requires amine functional pigment anchoring groups

Epoxy can interact with amine functional anchoring groups
• Strong impact on long-term storage stability

[Image: Epoxy system after storage (4 weeks at 50°C)]
DISPERBYK-2152
Hyperbranched Structure

- Aminic pigment-affinic core
  - Can basically interact with epoxy resin

- “Camouflage structure”
  - Hyperbranched structure encapsulates amine
  - Very flexible
    - Pigment block under shear (milling) accessible

- Adjustment of polarity
  - Additional sterical hindrance
## Wetting and Dispersing Additives

### Recommendations

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYK-W 9010</td>
<td>Strong viscosity reduction</td>
</tr>
<tr>
<td>BYK-W 9011</td>
<td></td>
</tr>
<tr>
<td>DISPERBYK-2152</td>
<td></td>
</tr>
<tr>
<td>BYK-W 969</td>
<td></td>
</tr>
<tr>
<td>BYK-W 996</td>
<td></td>
</tr>
<tr>
<td>BYK-W 940</td>
<td>Viscosity reduction and anti settling properties</td>
</tr>
<tr>
<td>BYK-W 980</td>
<td></td>
</tr>
<tr>
<td>GARAMITE-1958</td>
<td>Rheology additives to combine with wetting and dispersing additives for anti-settling</td>
</tr>
<tr>
<td>GARAMITE-7305</td>
<td></td>
</tr>
<tr>
<td>BYK-7410 ET</td>
<td></td>
</tr>
</tbody>
</table>
Additives for Epoxy Adhesives
Rheology Additives
Rheology Additives
GARAMITE
Garamite 
Benefits

GARAMITE is a solid, powdery rheology additive to adjust the rheology profile of Epoxy Adhesives by targeted control.

GARAMITE is a combination of organoclays with tailored, organic modification for best efficiency in a wide range of different polarities.

By modification of 1-pack and 2-pack Epoxy Adhesives with GARAMITE-1958 and GARAMITE-7305 the rheological properties of the resin and hardener component can be optimized:

• Strong shear thinning effect
• Strong sag resistance
• Anti-settling of fillers
• Easy incorporation and low dust levels
• Improvement of efficiency by combination with Thixboosters
### Mixed Mineral Rheology Additive
**GARAMITE**

<table>
<thead>
<tr>
<th>Additive</th>
<th>Component Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPIKOTE 828</td>
<td>epoxy resin</td>
<td>25.0</td>
</tr>
<tr>
<td>Novacite 1250</td>
<td>Silica (quartz flour, average particle size 7-15 µm, 93%&lt;45µm)</td>
<td>43.0</td>
</tr>
<tr>
<td>Additive (GARAMITE-1958)</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>EPIKURE 3125 A</td>
<td>curing agent</td>
<td>10.0</td>
</tr>
<tr>
<td>Novacite 1250</td>
<td></td>
<td>22.0</td>
</tr>
</tbody>
</table>

Images:
- [no Additive](image1)
- [0.25% GARAMITE-1958](image2)
GARAMITE
Shear Thinning Effect

![Graph showing improved stability and low application viscosity with 0.1% GARAMITE-1958 compared to no additive.](image)

- Improved stability
- Low application viscosity

0.1% GARAMITE-1958

Easy Handling
GARAMITE
Sag Resistance

Applied as vertical joint filler

no Additive
– sag –

0.25% GARAMITE-1958
– stable –
Rheology Additives
Liquid Rheology Additives
By modification of 1-pack and 2-pack Epoxy Adhesives with liquid rheology additives (RHEOBYK-7410 ET) the rheological properties of the resin and hardener component can be optimized:

- Sag resistance
- Anti-settling of fillers
- Strong shear thinning effect
- Simple dosing
- Easy incorporation even after the production (post-adding)
Rheology Additives
Thixboosters
Rheology Boosters work only in combination with modified phyllosilicates (e.g. GARAMITE-7305) or hydrophilic pyrogenic silica.

They strengthen the three-dimensional network of the rheology additive and bring a significant increase in viscosity.

- Boosting the efficiency of solid rheology additives
- Replacement of hydrophobic by hydrophilic fumed silica
- Enabling vertical and over-head applications
- Easy incorporation
- Improvement of storage stability of hydrophilic fumed silica
Thixboosters for 2-pack Epoxy Adhesives
Boosting

To adjust a flowable formulation to a non sagging formulation

**Today's Standard**
- **Viscosity**
  - Resin hydrophobic FS
  - Hardener
  - Resin + Hardener

**BYK Advice**
- **Viscosity**
  - Resin hydrophilic FS
  - Hardener + BYK Thix-booster
  - Resin + Hardener incl. BYK Thix-booster

*Viscosity collapse when hardener is added*
*Boost effect*
Thixboosters for 2-pack Epoxy Adhesives
Influence on viscosity Part A

The viscosity of the resin component decreases significantly by replacing hydrophobic fumed silica + reactive diluent by hydrophilic fumed silica.

Significant advantage for mixing and pumping of the resin component.

![Viscosity curve 2 pack Epoxy - Part A -](image)

### Additives for Epoxy Adhesives

**Part A**

<table>
<thead>
<tr>
<th>Additive</th>
<th>Market Standard</th>
<th>BYK Advice</th>
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</thead>
<tbody>
<tr>
<td>Epon 828</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Reactive Diluent</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Filler</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Aerosil R 202</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Aerosil A 200</td>
<td></td>
<td>3</td>
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</table>
# Thixboosters for 2-pack Epoxy Adhesives

Comparison of Silica With Thixboosters

<table>
<thead>
<tr>
<th></th>
<th>Market Standard Hydrophobic FS</th>
<th>Control Hydrophilic FS</th>
<th>BYK recommendation Hydrophilic FS + BYK-P 2720</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day storage time</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>1 year storage time</td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Thixboosters for 2-pack Epoxy Adhesives
Mechanical Influence

Boosted formulations meet the same tensile strength performance as the market standard.

**Tensile Strength [MPa]**

<table>
<thead>
<tr>
<th></th>
<th>Test specimens:</th>
<th>Bond thickness:</th>
<th>Curing:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Standard</td>
<td>0.8 mm thickness sand blasted steel sheets</td>
<td>0.2 mm</td>
<td>Three days RT</td>
</tr>
<tr>
<td>Boosted BYK - R 607</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boosted BYK - P 2720</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Curing agent: EPIKURE 3140A
Thixboosters for 1-pack Epoxy Adhesives

Benefits

Thermally cured 1-pack epoxy adhesives must have high sag-resistance across the entire application process. The uncured adhesives are applied, the joined parts washed and the adhesive bond cured in the furnace.

- BYK-R 606 in combination with hydrophilic fumed silica to improve the sag resistance
- No loss of sag resistance during curing
- Easy incorporation
- Replacement of hydrophobic by hydrophilic fumed silica
Thixboosters for 1-pack Epoxy Adhesives
Comparison of Silica with Thixboosters

<table>
<thead>
<tr>
<th>Market Standard Hydrophobic FS</th>
<th>BYK-recommendation Hydrophilic FS + BYK-R 606</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>After application</strong></td>
<td><strong>After curing</strong></td>
</tr>
<tr>
<td>Cured @ 130°C, 30 min</td>
<td></td>
</tr>
</tbody>
</table>
The viscosity profile of 1-pack epoxy formulations can be specifically adjusted by combining hydrophilic silica with BYK-R 606.
Rheology Additives
Viscosity Control Technology
Viscosity Control Technology

We understand Viscosity Control Technology (VCT) as a new technology that is based on well-engineered processing additives to design the viscosity of 2-pack systems and their components to an optimum level for every single process step.

There is one additive for the resin system (Thixbreaker) and a matching one for the hardener component (Thixbooster).

The perfectly synchronized interaction of the two additives that comes into effect when the components are mixed together ensures that the final application viscosity is exactly as required.

Depending on application and system the Thixbooster can be used alone.

The concept of Viscosity Control Technology has a highly beneficial effect on the total value chain.
Viscosity Control Technology
Mode of Action Video

BYK Additives & Instruments
Product Information

Synergism with Fumed Silica or Clay

BYK thixboosters

Fumed silica or GARAMITE
Viscosity Control Technology for 2-pack Epoxy Systems
Comparison of Today’s Standard and BYK’s New Solution

To adjust the initial viscosities of the two components to the same level and end up in a high viscous application viscosity.

- **Component A**
  - Epoxy resin
  - Hydrophobic FS

- **Component B**
  - Curing Agent
  - Hydrophilic FS

- **Mixed System**
  - Epoxy resin
  - BYK-P 2710
  - Hydrophilic FS

- **Component A**
  - Curing Agent
  - BYK-P 2720

- **Component B**
  - Hydrophilic FS

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Additives for Epoxy Adhesives
Page 44
Thixbooster BYK-P 2720
The Thixbooster is added to the hardener component and can, if required, be combined with hydrophilic silica. After mixing the components, the Thixbooster brings about the development of the three-dimensional network, thereby creating a sag-resistant application.

Thixbreaker BYK-P 2710
The conventional hydrophobic silica in the resin component is replaced by hydrophilic silica. The Thixbreaker is added to the resin component and blocks the structural build up of the silica network – the viscosity of the resin component is low.

Viscosity Control Technology for 2-pack Epoxy Adhesives
Adjusting viscosities
Viscosity Control Technology for 2-pack Epoxy Adhesives
Optimization of the whole value chain

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Manufacture</th>
<th>Transportation</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different mixing viscosities of the resin and hardener components can be adapted precisely to one another. Cost-effective hydrophilic silica can be used as an alternative to hydrophobic silica.</td>
<td>VCT enables the use of the same apparatus for the resin and the hardener components. A simple dissolver can be used to produce the components.</td>
<td>Pumpable resin and hardener components can be transported in IBCs and drums. The low viscosity also enables pumping from pails and drums.</td>
<td>Mixing the two low-viscosity components results in a sag-resistant application. Low mixing viscosities simplify the dosage and processing of 2-pack systems.</td>
</tr>
</tbody>
</table>
Rheology Additives
Recommendations

<table>
<thead>
<tr>
<th></th>
<th>1-pack Epoxy</th>
<th>2-pack Epoxy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-settling</td>
<td>BYK-410</td>
<td>BYK-410</td>
</tr>
<tr>
<td></td>
<td>BYK-430</td>
<td>BYK-430</td>
</tr>
<tr>
<td></td>
<td>BYK-7410-ET</td>
<td>BYK-7410-ET</td>
</tr>
<tr>
<td></td>
<td>GARAMITE-1958</td>
<td>GARAMITE-1958</td>
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<tr>
<td></td>
<td>GARAMITE-7305</td>
<td>GARAMITE-7305</td>
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<td>Sag-resistance</td>
<td>GARAMITE-1958</td>
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<tr>
<td>Booster</td>
<td>BYK-R 606</td>
<td>BYK-P 2720</td>
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<td></td>
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<td>BYK-R 607</td>
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<tr>
<td>VCT</td>
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<td>BYK-P 2710</td>
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<tr>
<td></td>
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<td>BYK-P 2720</td>
</tr>
</tbody>
</table>
We support you – online and offline
With our comprehensive special service.

We remain in constant contact with you personally and through a variety of platforms.

Challenge us! Henkel.BYK@altana.com

Your exclusive Website: www.byk.com/Henkel
Thank you for your attention.