



Technical Information AS-TI 5

Additives for 1-pack and 2-pack Epoxy Adhesives and Sealants

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About BYK

Using an adhesive as a binder is indispensable for most modern industry sectors such as automotive or electrical. As an innovative joining process, it is increasingly replacing classic methods such as welding, screwing or riveting. Adhesives also offer ecological advantages in aircraft construction or wind turbine construction where modern high-performance adhesives can reduce weight and save energy.

Particularly in the construction sector, considerable requirements are placed on VOC-free products so that flooring adhesives can be provided with the "Blauer Engel" or the Ecodecode seal.

BYK is your technology partner when it comes to improving the properties of your adhesives and sealants.

BYK offers additives for all kinds of adhesive systems, from aqueous dispersion additives to solvent-borne systems or solvent-free reactive systems such as polyurethanes, epoxides, acrylates and silane-terminated polymers. In addition, BYK is continuously expanding its additive range in the area of hot-melt adhesives.

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Introduction

Compared with other joining processes, the use of adhesives to join and seal material components allows considerable versatility and various application possibilities. The adhesive process is often superior to other production processes, and it fulfills the requirements of a multitude of high-performance applications.

Epoxy adhesives and sealants offer equally diverse application possibilities, and are preferred in aviation or construction, automotive and electrical industries. They have considerable strength, provide a good adhesion even on the most difficult of substrates, and are highly chemically resistant.

However, in order to exploit the full potential, these products must be manufactured using the utmost care and technical expertise. Alongside an optimum coordination of the raw materials, additives play a major role in the production and optimization of epoxy adhesives and sealants, e.g.:

- Ensuring producibility and quality consistency
- Improving properties such as substrate wetting, defoaming and application parameters, and thereby simplifying the application and increasing the efficiency
- Increasing the storage stability

BYK offers a multitude of additives for 2-pack and hot-cured-pack epoxy systems that guarantee and improve the efficiency of these adhesive technologies.



Defoamers and Air Release Agents for 1-pack and 2-pack Epoxy Adhesives and Sealants

Trapped air bubbles and the formation of foam represent a major challenge in the production and application processes of epoxy formulations, especially with thick layers and sophisticated viscosity profiles.

The use of defoamers and air release agents prevents or destroys the foam

bubbles, resulting in improved processing, perfect surface properties and, in turn, optimized efficiency.

In doing so, air release agents help to transport any trapped air to the surface. The subsequent destruction of the foam bubbles at the surface is referred to as defoaming and is achieved by using the

appropriate defoamer. Despite the different terms, to a certain extent both products bring about the same effects, which means that an air release agent also has a defoaming effect, and a defoamer can also contribute towards the release of air.

Effect of Air Release Agents and Defoamers

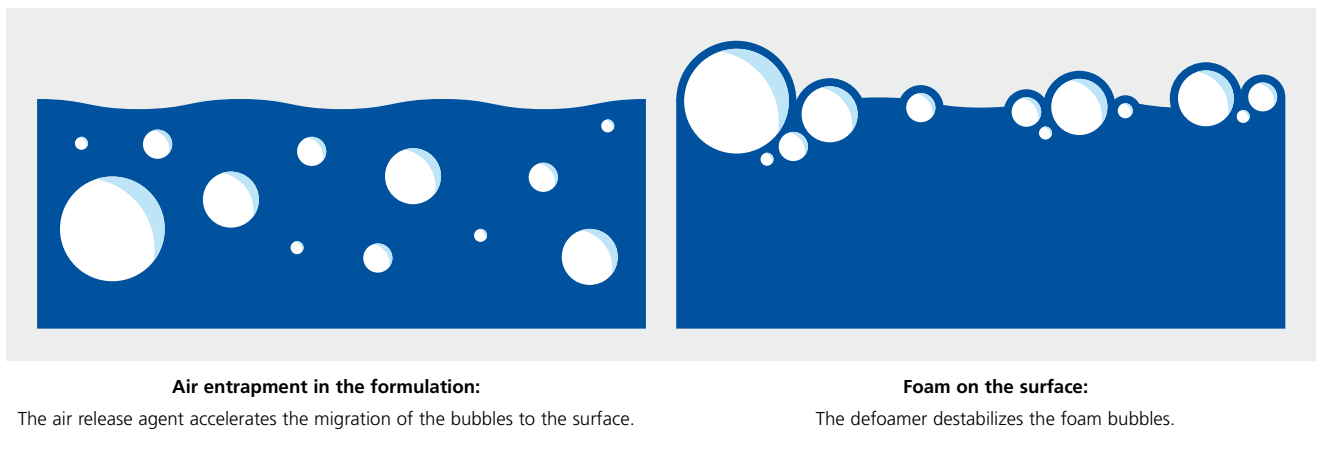


Figure 1



The efficiency of the defoamer and air release agent depends on its compatibility in the adhesive or in the resin and hardener components. For good efficiency, the additive must have a specific incompatibility with the matrix. When selecting these additives, it is necessary to consider a good balance between compatibility and efficiency.

Defoamers and air release agents in 1-pack and 2-pack epoxy systems can be divided into:

- Modified polysiloxanes
- Silicone-free polymer defoamers
- Silicone modified polymer defoamers

Air release agents and defoamers are added to and incorporated into the respective components at the start of production. This ensures the efficiency of these additives throughout the production process, i.e. during the production as well as during the transportation, the mixing process and the application.

Effect of a Defoamer in a 2-pack Epoxy System



Reference

Air release agent used in resin components

Taken after hardening.

Figure 2

Part A: Bisphenol A resin, Part B: Polyamide hardener

Defoamer/Air Release Agent Recommendations for 1-pack and 2-pack Epoxy Formulations

Defoamer/air release agent base	
Silicone	BYK-1796
	BYK-A 525
	BYK-A 530
Polymer (silicone-free)	BYK-1790
	BYK-A 501
	BYK-A 535
Polymer/silicone	BYK-A 530

Figure 3



Rheology Additives for 1-pack and 2-pack Epoxy Adhesives and Sealants

The rheological behavior of epoxy systems is a key parameter. For example, a high viscosity is required in order to increase the sag-resistance and stabilization of fillers, while the manufacturing properties, miscibility and air release are positively influenced by a low viscosity. BYK offers a variety of different rheology additives in order to tailor the rheological profile of the epoxy systems to the application. These include:

- Solid rheology additives
- Liquid rheology additives
- Rheology boosters

GARAMITE for 1-pack and 2-pack Epoxy Systems

GARAMITE is a solid, powdered rheology additive which specifically influences the rheology profile of the epoxy system. It comprises a combination of phyllosilicates, the surfaces of which have been organically modified. These modifications control the efficiency in varying polarities and in different systems. The high bulk density of GARAMITE reduces the formation of dust and simplifies the processing. The advantages of using GARAMITE:

- Strong shear thinning viscosity profile
- Prevents the settling of solids
- Highly efficient

- High stability and very good ridge formation
- Easy application of the adhesive and sealant from cartridges and dosing units
- High bulk density, low dusting
- Easy incorporation, no special activation required
- Increased efficiency with boosters, as needed

GARAMITE-1958 and GARAMITE-7305 are products which have been specially developed for epoxy systems which influence the flow behavior of both the resin and the hardener components.

Composition of GARAMITE

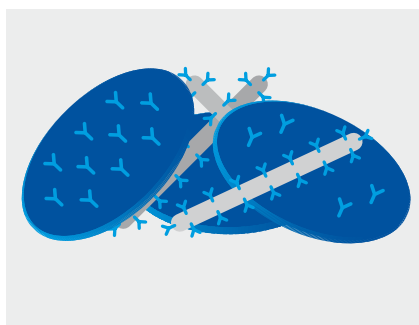
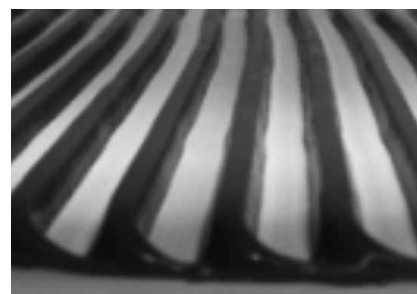


Figure 4

Improving Sag-Resistance when Applying a 2-pack Epoxy System



Without additive



0.25 % GARAMITE-1958 in resin

2-pack epoxy system, (bisphenol A resin + amido-amine hardener)

Figure 5

Liquid Rheology Additives for 1-pack and 2-pack Epoxy Systems

Liquid rheology additives in epoxy systems can be used in both the resin and the hardener components. They form a three-dimensional network, thus optimizing the settling of fillers and the anti-sag properties of components when applied. Their advantage lies in the simple dosing and the possibility to incorporate the additives even after the production (post-adding).

RHEOBYK-410 and RHEOBYK-7410 ET are urea-based rheology additives that prevent the formation of sedimentation in filled epoxy systems, and improve the sag-resistance. The products increase the viscosity especially at low shear rates, and barely influence the viscosity in the high-shear range.

RHEOBYK-430 is based on a urea-modified, medium polarity polyamide. The settling behavior, especially in filled amine hardener components, can be improved due to the additive's impact on the pseudoplastic flow behavior.

Rheology Control – Rheology Boosters and Viscosity Control Technology

2-pack epoxy systems are used in high-performance applications in the automotive, aviation and construction industries. One of the most important parameters is the stability of the reactive mixture after application. It is only a sufficiently high sag-resistance after mixing the components that permits vertical or above-head applications.

However, when you consider the process steps of the production, mixing and the application of the system, a significantly lower viscosity is preferred: production is facilitated, the components are easy to pump, they mix easier and more thoroughly, and can be applied using less pressure.

At first this contrast appears to be impossible to resolve, as such strong shear thinning effects and viscosity increases cannot be achieved using conventional rheology additives.

With the options of rheology boosters and “viscosity control technology”, the viscosity can be influenced in precisely the correct process steps: during the production and the processing, low viscosities are possible, and then only after mixing will the viscosity increase immediately, thereby resulting in outstanding sag-resistance.

Furthermore, the storage stability is improved, and the use of hydrophilic instead of hydrophobic silica enable the production costs to be reduced too.

Rheology Boosters for 2-pack Epoxy Systems

Rheology boosters work in combination with modified phyllosilicates (e.g. GARAMITE-7305) or pyrogenic silicas. They are added to the hardener and only when mixed are they combined with the solid thixotropic agents which

are located in the A component. Here, they strengthen the three-dimensional network of the rheology additive and bring about a significant increase in viscosity compared with a formulation that does not contain a booster.

Booster Effect

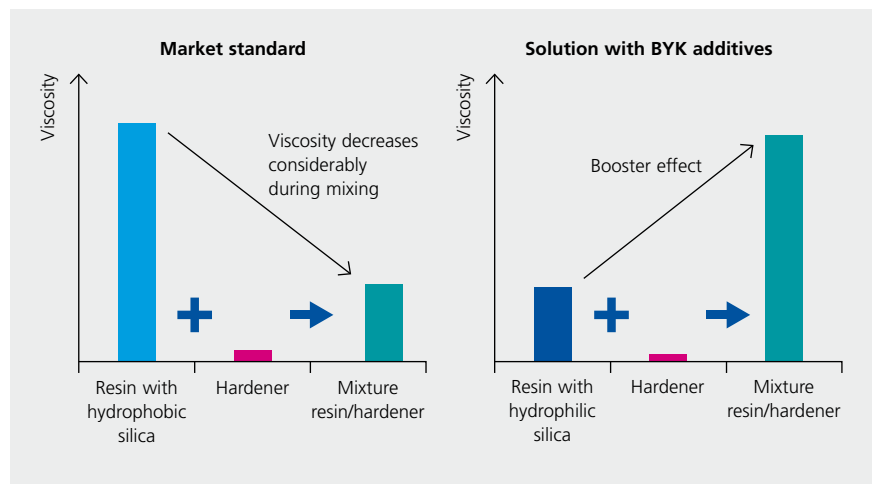


Figure 6

Working Principle of Thixboosters

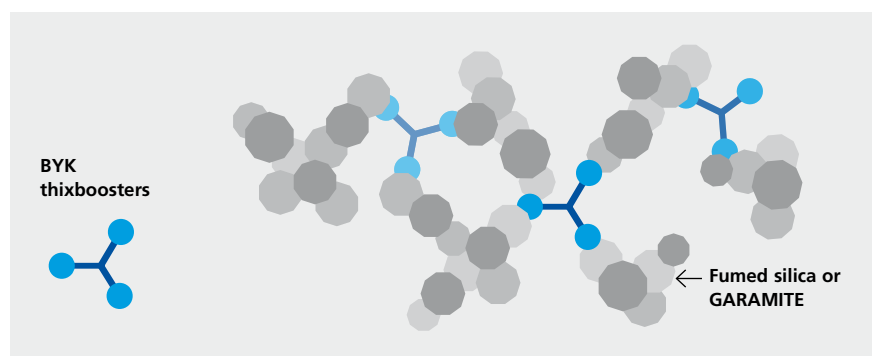


Figure 7

› Rheology Additives for 1-pack and 2-pack Epoxy Adhesives and Sealants

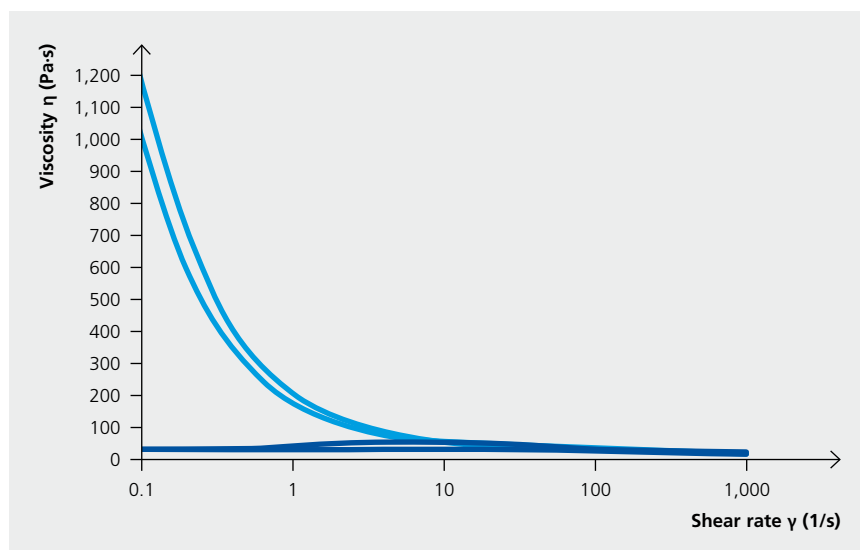
Benefits

Generally speaking, the use of a booster increases the efficiency of fumed silica or phyllosilicates as soon as the solid rheology additive and the booster come into contact by mixing together the A and the B components. This enables hydrophobic silica to be replaced with hydrophilic silica. The lower efficiency of hydrophilic silica reduces the viscosity of the resin components and improves the mixing and application properties. After mixing, the booster increases the efficiency and the viscosity rises, which results in an outstanding sag resistance.

Advantage of Storage Stability

In many cases, epoxy formulations with (hydrophilic) silica are not storage-stable. The combination of hydrophilic silica with BYK rheology boosters prevents the loss in efficiency during storage so that the individual components can be used to create sag-resistant applications, even after a long period of storage.

Viscosity Comparison of a Resin with Hydrophobic and Hydrophilic Silica



Part A	Market standard	Formulation with BYK
Bisphenol A resin	65	65
Hydrophobic silica	3	
Hydrophilic silica		3

■ Market standard ■ Formulation with BYK

Figure 8

Comparison of Silicas With Thixboosters

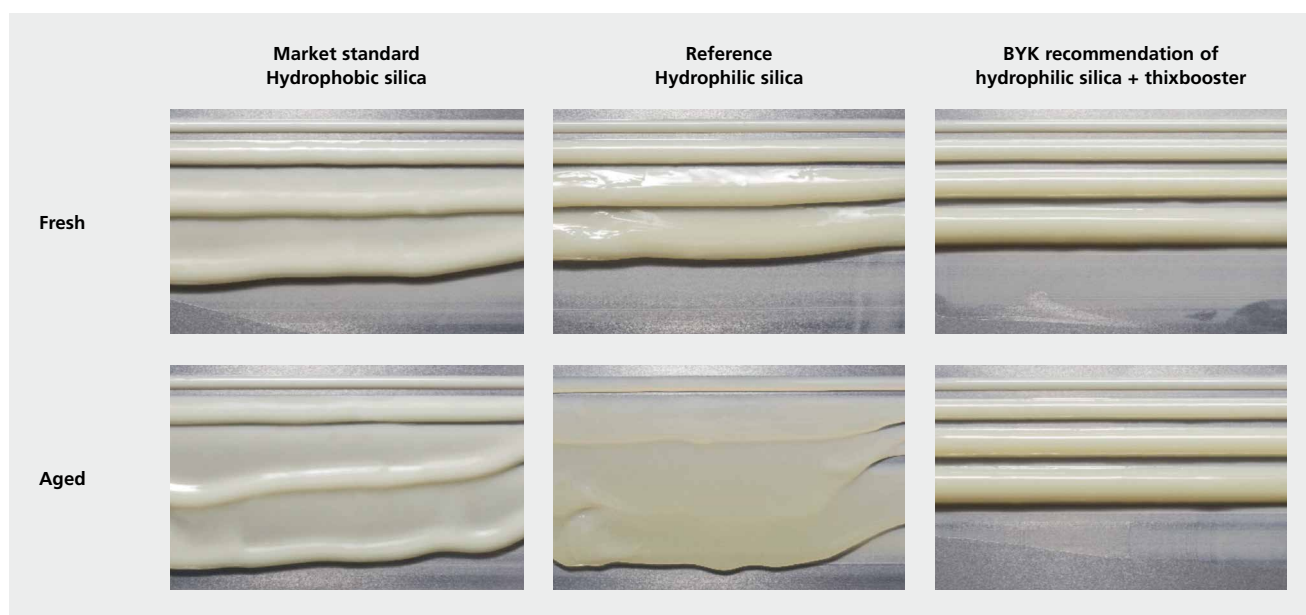


Figure 9

Mechanics

The use of BYK rheology boosters in 2-pack epoxy adhesives has no measurable influence on the mechanical properties of the systems. The tensile strength of overlapping, bonded steel test specimens is comparable with the market standard.

Sag-resistance when Curing 1-pack Epoxy Systems

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.

The combination of hydrophilic silica with the rheology booster RHEOBYK-R 606 enables the application of sag-resistant 1-pack epoxy systems without the loss of sag-resistance during curing.

Tensile Strength

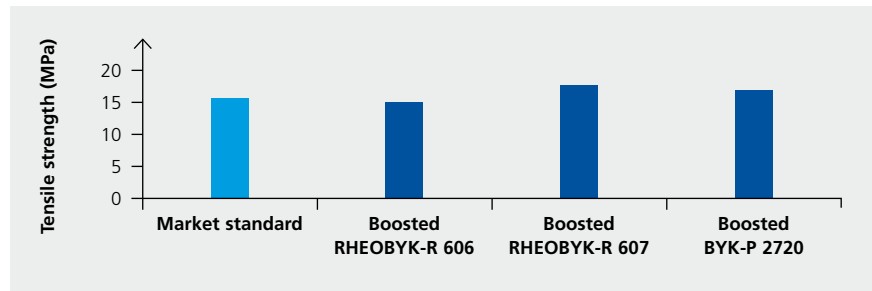


Figure 10

1-pack Epoxy Adhesive Formulation

Raw material	Market standard (%)	BYK recommendation (%)
Bisphenol – A resin	100	100
Filler	150	150
Hydrophobic silica	3	
Hydrophilic silica		3
Thixbooster RHEOBYK-R 606		20
Hardener	6	6
Accelerator	2	2

Figure 11

Application and Sag-resistance

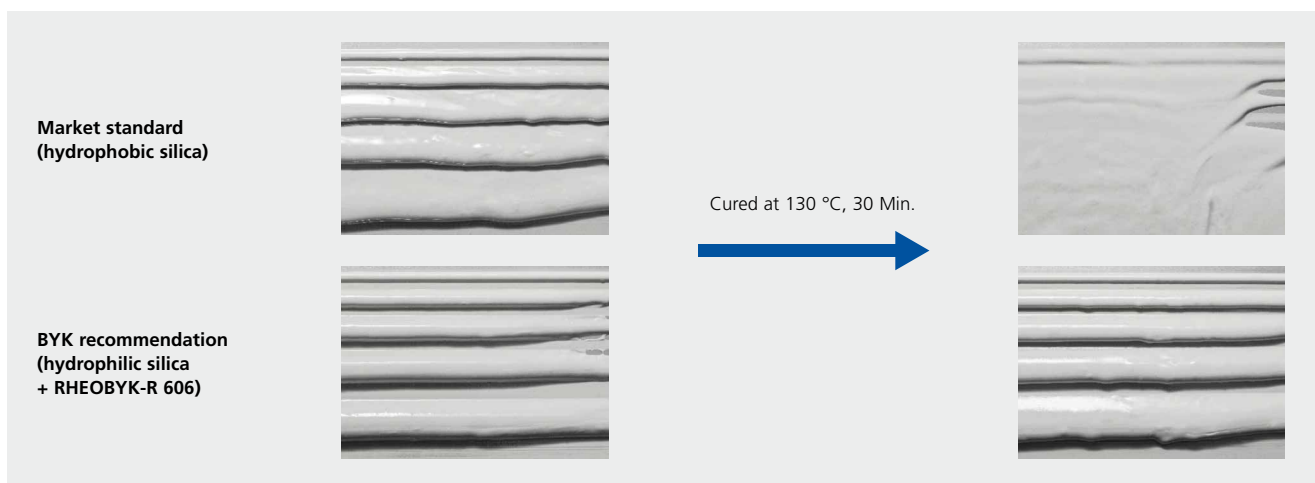


Figure 12

› Rheology Additives for 1-pack and 2-pack Epoxy Adhesives and Sealants

Mechanics

The mechanics of the thermally cured 1-pack epoxy adhesives are not influenced by the modification with BYK boosters. The tensile strength of overlapping, adhered steel test specimens is comparable with the market standard.

Tensile Strength

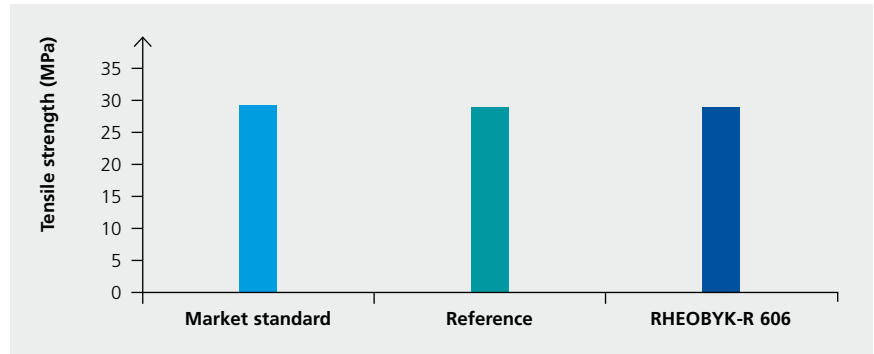
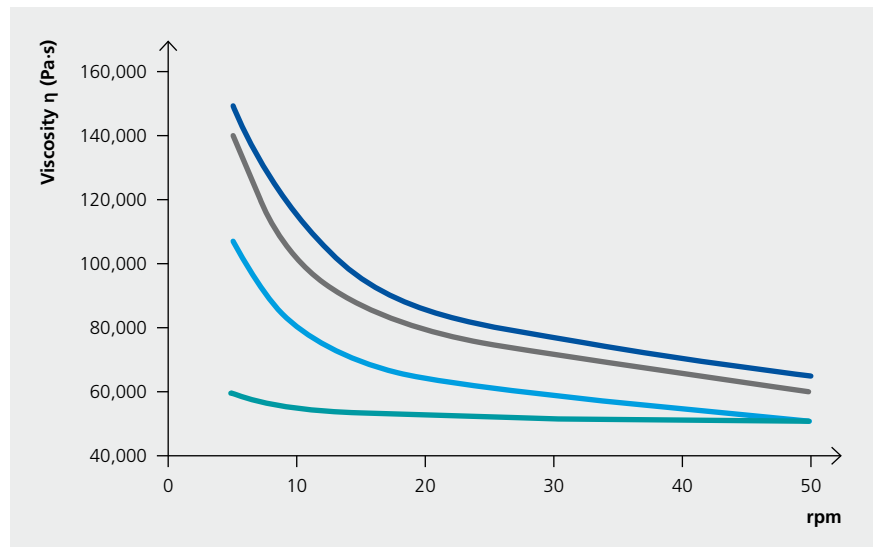


Figure 13

Viscosity

The viscosity profile of 1-pack epoxy formulations can be specifically adjusted by combining hydrophilic silica with RHEOBYK-R 606.

Comparison of Different Rheology Profiles



- 1.2 % hydrophilic silica + RHEOBYK-R 606
- 1.2 % hydrophobic silica
- 0.6 % hydrophilic silica + RHEOBYK-R 606
- 3 % hydrophilic silica

Figure 13

Viscosity control technology (VCT) for 2-pack epoxides

The “viscosity control technology” (VCT) is a new technology which is based on a combination of two process additives which are specially aligned with each other. With their help it is possible to adjust both the viscosity of the A and the B components. There

is an additive for the resin system (Thixbreaker) and an additive that has been developed for the hardener (Thixbooster). The Thixbreaker has the task of reducing the viscosity of the resin component to a desired extent. The Thixbooster is used in the hardener and doesn't change the viscosity provided there is no silica present.

Adding silica at this point can increase the efficiency. When the components meet, the interaction of the VCT additive brings about a significant increase in the viscosity (Figure 14). This new concept of “viscosity control technology” has very broad uses across the entire value chain (Figure 17).

Comparison of Market Standard and BYK Solution with VCT

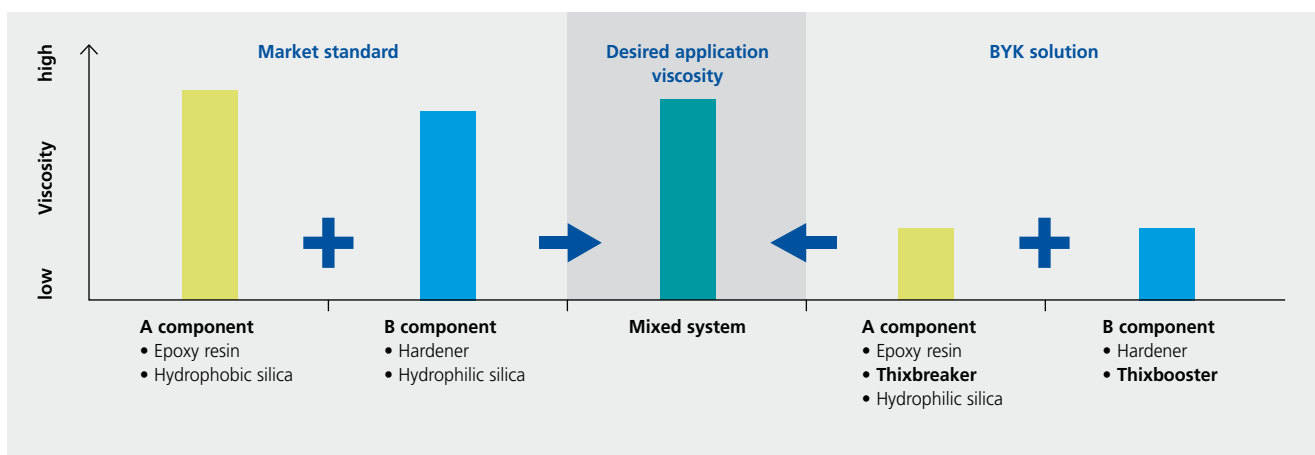


Figure 14

Thixbreaker – Use in the Resin Component

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.

Adapting the Resin to the Hardener Viscosity Using BYK-P 2710

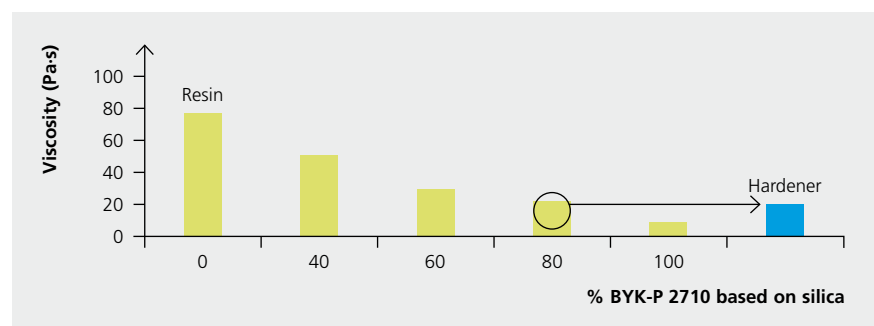


Figure 15

› Rheology Additives for 1-pack and 2-pack Epoxy Adhesives and Sealants

Thixbooster – Use in the Hardener Component

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.

Adapting the Hardener to the Resin Viscosity Using BYK-P 2720

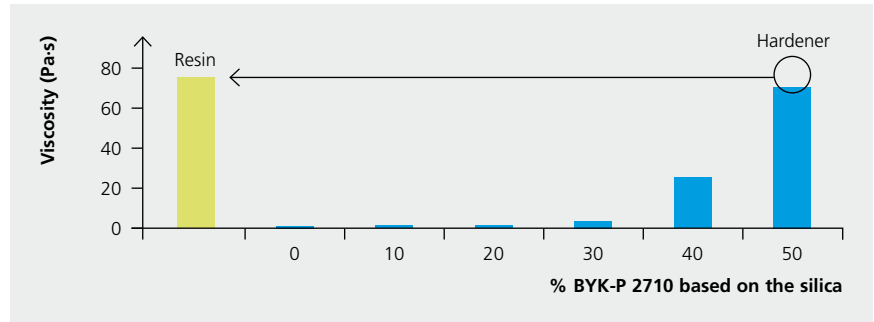


Figure 16

Value Chain



Figure 17

Formulation

Different mixing viscosities of the resin and hardener components can be adapted precisely to one another.

Manufacture

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. Cost-effective hydrophilic silica can be used as an alternative to hydrophobic silica.

Transportation

Pumpable resin and hardener components can be transported in IBCs and bulk containers. The low viscosity also enables pumping from pails and drums.

Application

Mixing the two low-viscosity components results in a sag-resistant application. Low mixing viscosities simplify the dosage and processing of 2-pack systems.

Miscibility and Application of a System Optimized with VCT

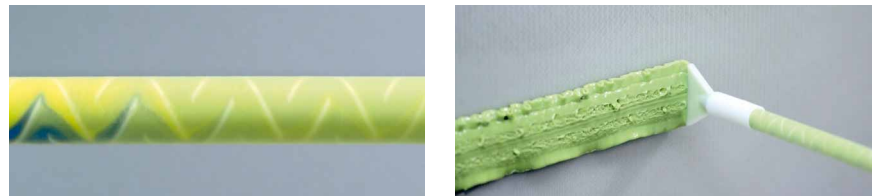


Figure 18

Recommended Rheology Additives, Boosters and VCT for 1-pack and 2-pack Epoxy Systems

	1-pack Epoxy	2-pack Epoxy
Anti-settling	RHEOBYK-410 RHEOBYK-430 RHEOBYK-7410 ET GARAMITE-1958 GARAMITE-7305	RHEOBYK-410 RHEOBYK-430 RHEOBYK-7410 ET GARAMITE-1958 GARAMITE-7305
Sag-resistance	GARAMITE-1958 GARAMITE-7305	GARAMITE-1958 GARAMITE-7305
Booster	RHEOBYK-R 606	BYK-P 2720 RHEOBYK-R 607
VCT		BYK-P 2710 BYK-P 2720

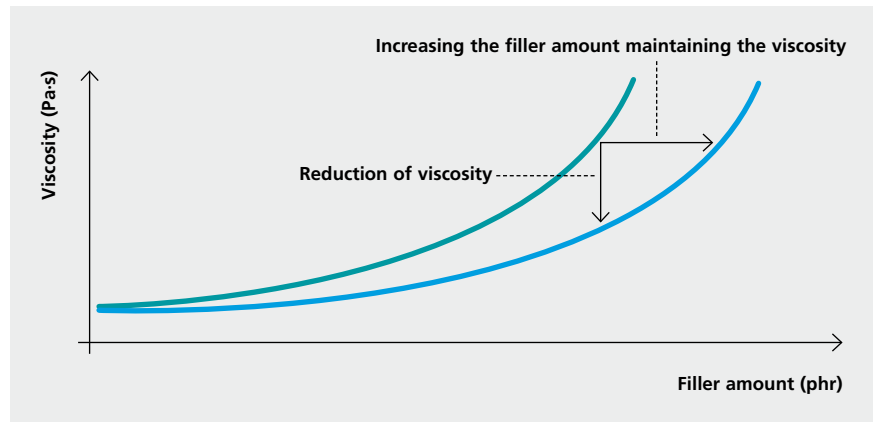
Figure 19

Wetting and Dispersing Additives for 1-pack and 2-pack Epoxy Adhesives and Sealants

When formulating 1-pack and 2-pack epoxy adhesives and sealants, the easy incorporation and even distribution of solid fillers and pigments in the liquid or highly viscous resin and hardener matrix is essential. This is the only way to ensure an optimized and fast production, and a consistent quality and performance.

The use of wetting and dispersing additives also enables the viscosity to be reduced. This can achieve either a better processing or an increase of filler amount while maintaining the viscosity. However, the lower viscosities can also intensify the settling, which is countered with the use of rheology additives. Alternatively, it is possible to use controlled flocculating wetting and dispersing additives, which prevent the settling by network formation.

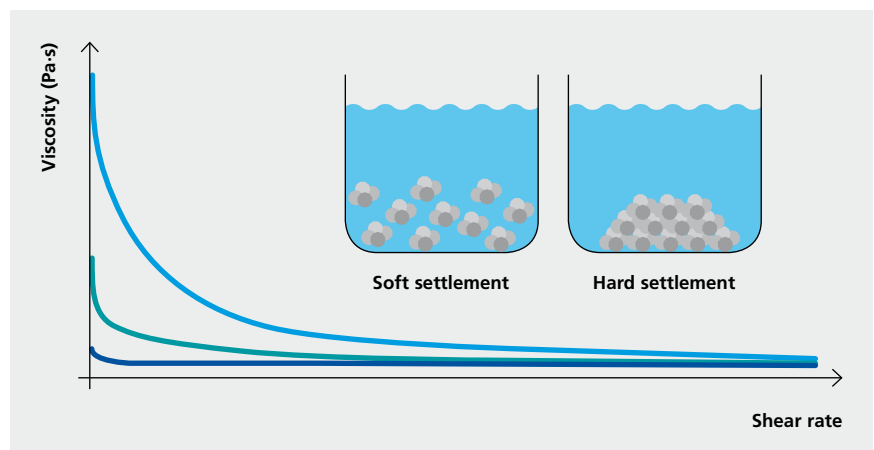
Optimizing an Epoxy System: Lower Viscosity or Greater Filler Amount



■ Reference ■ Wetting and dispersing additive

Figure 20

Influence of Wetting and Dispersing Additives on the Viscosity



■ Controlled flocculating
 ■ Flocculating
 ■ Deflocculating

Figure 21

Wetting and Dispersing Additives for 1-pack and 2-pack Epoxy Adhesives and Sealants

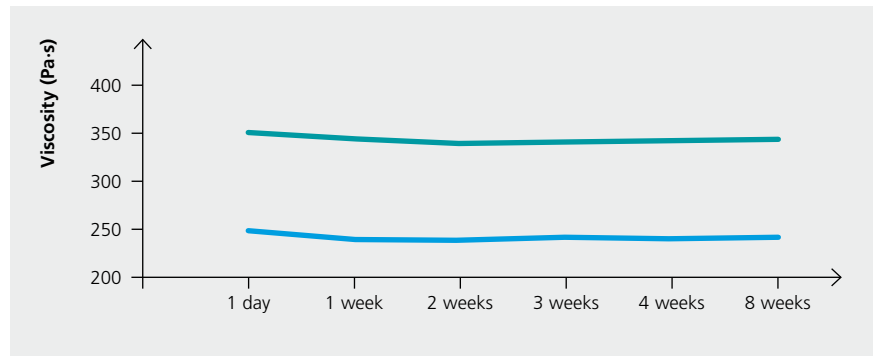
Optimizing an Epoxy System: Lower Viscosity or Higher Filler Amount



Figure 22

When selecting wetting and dispersing additives, you must be mindful of any reactivity of the additive with the epoxy system. BYK offers special wetting and dispersing additives which are stable in epoxy systems and therefore have no influence on the storage stability of the formulated components.

Storage Stability



■ Reference ■ Wetting and dispersing additive

Figure 23

Wetting and Dispersing Additive Recommendations for 1-pack and 2-pack Epoxy Adhesives and Sealants

Strong viscosity reduction	BYK-W 969 BYK-W 996 BYK-W 9010 BYK-W 9011 DISPERBYK-2152
Viscosity reduction and anti-settling	BYK-W 940 BYK-W 980
Rheology additives that can be combined with wetting and dispersing additives – anti-settling	RHEOBYK-7410 ET GARAMITE-1958 GARAMITE-7305

Figure 24

Overview

Defoamer/Air Release Agent Recommendations for 1-pack and 2-pack Epoxy Formulations

Defoamer/air release agent base	
Silicone	BYK-1796 BYK-A 525 BYK-A 530
Polymer (silicone-free)	BYK-1790 BYK-A 501 BYK-A 535
Polymer/silicone	BYK-A 530

Figure 25

Recommended Rheology Additives, Boosters and VCT for 1-pack and 2-pack Epoxy Systems

	1-pack Epoxy	2-pack Epoxy
Anti-settling	RHEOBYK-410 RHEOBYK-430 RHEOBYK-7410 ET GARAMITE-1958 GARAMITE-7305	RHEOBYK-410 RHEOBYK-430 RHEOBYK-7410 ET GARAMITE-1958 GARAMITE-7305
Sag-resistance	GARAMITE-1958 GARAMITE-7305	GARAMITE-1958 GARAMITE-7305
Booster	RHEOBYK-R 606	BYK-P 2720 RHEOBYK-R 607
VCT		BYK-P 2710 BYK-P 2720

Figure 26

Wetting and Dispersing Additive Recommendations for 1-pack and 2-pack Epoxy Adhesives and Sealants

Strong viscosity reduction	BYK-W 969 BYK-W 996 BYK-W 9010 BYK-W 9011 DISPERBYK-2152
Viscosity reduction and anti-settling	BYK-W 940 BYK-W 980
Rheology additives that can be combined with wetting and dispersing additives – anti-settling	RHEOBYK-7410 ET GARAMITE-1958 GARAMITE-7305

Figure 27

Detailed information
about our additives and
sample orders can be
found at:

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