BYK

TECHNICAL INFORMATION

ADDITIVES FOR 1-PACK AND 2-PACK EPOXY ADHESIVES AND SEALANTS

AS-TI 5

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Contents

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, construction, automotive and electrical industries. They have considerable strength, provide good adhesion even on the most difficult of substrates, and are highly chemically resistant.

However, in order to exploit their full potential, these products must be manufactured using the utmost care and technical expertise. Alongside an optimum combination of 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 application and increasing efficiency
- Increasing storage stability

BYK offers a multitude of additives for 2-pack and hot-cured 1-pack epoxy systems that guarantee and improve the efficiency of these adhesive technologies.

Note

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Defoamers/air release agents

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.

The efficiency of the defoamer and air release agent depends on its compatibility with the adhesive or with 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

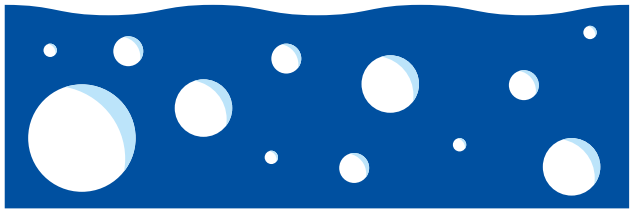
Air release agents and defoamers are added to and incorporated into the respective components at the start of production. This ensures the efficiency of these additives throughout the production process, i.e. during production as well as during transportation, the mixing process and application.

Defoamer/air release agent recommendations for 1-pack and 2-pack epoxy formulations

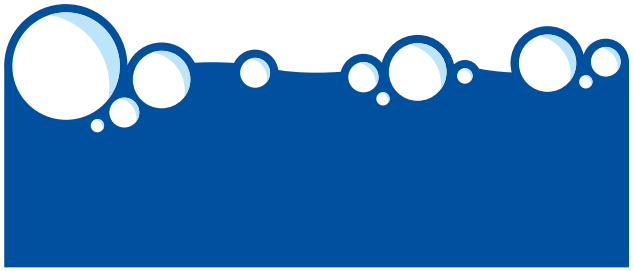
Defoamer/air release agent base	Recommendation
Silicone	BYK-1796 BYK-A 525 BYK-A 530
Polymer (silicone-free)	BYK-1790 BYK-A 501 BYK-A 535 BYK-A 550
Polymer/silicone	BYK-A 530

T. 01

Effect of air release agents and defoamers



Air entrapment in the formulation:
The air release agent accelerates the migration of the bubbles to the surface.



Foam on the surface:
The defoamer destabilizes the foam bubbles.

G. 01

Effect of a defoamer in a 2-pack epoxy system

Reference **Air release agent used in resin components**

G. 02

Rheology additives

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

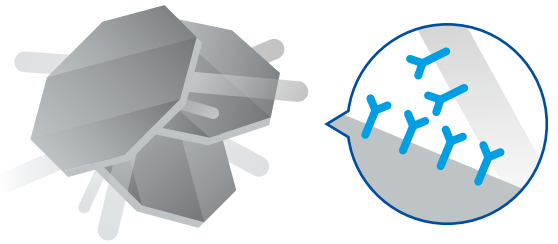
GARAMITE is a solid, powdered rheology additive which specifically influences the rheology profile of the epoxy system. It comprises a combination of phyllosilicates, the surfaces of which have been organically modified. These modifications control the efficiency in varying polarities and in different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

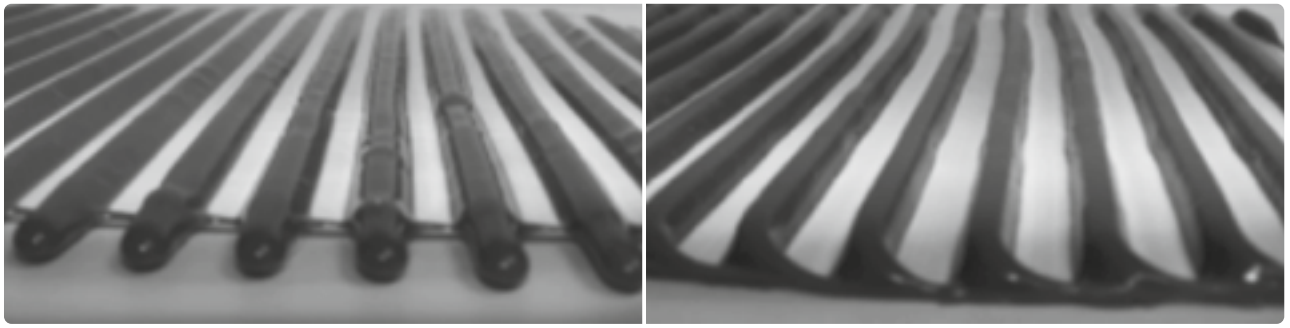
GARAMITE-1958 and GARAMITE-7305 are products which have been specially developed for epoxy systems which influence the flow behavior of both the resin and the hardener components.

Composition of GARAMITE



G.03

Improving sag resistance when applying a 2-pack epoxy system



Without additive **GARAMITE used in resin component**

2-pack epoxy system, (bisphenol A resin + amido-amine hardener) G.04

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 simple dosing and the possibility to incorporate the additives even after 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.

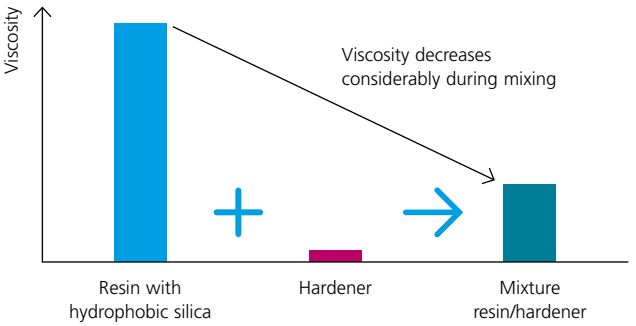
RHEOBYK-430 is based on a urea-modified, medium polarity polyamide. The settling behavior, especially in filled aminic hardener components, can be improved due to the additive's impact on the pseudoplastic flow behavior.

Rheology control – rheology boosters and viscosity control technology

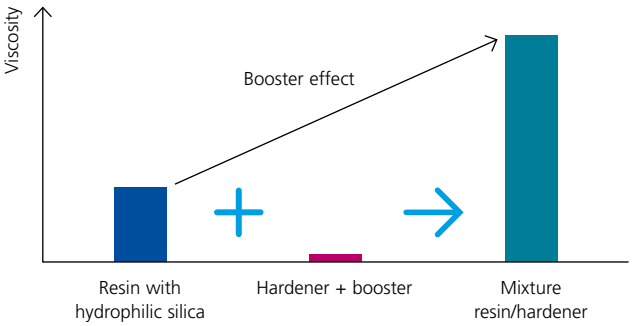
2-pack epoxy systems are used in high-performance applications in the automotive, aviation and construction industries. One of the most important parameters is the stability of the reactive mixture after application. It is only a sufficiently high sag resistance after mixing the components that permits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

Booster effect

Market standard



Solution with BYK additives



G.05

However, when you consider the process steps of the production, mixing and application of the system, a significantly lower viscosity is preferred: production is facilitated, the components are easy to pump, they mix more easily 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 production and 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 resin 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.

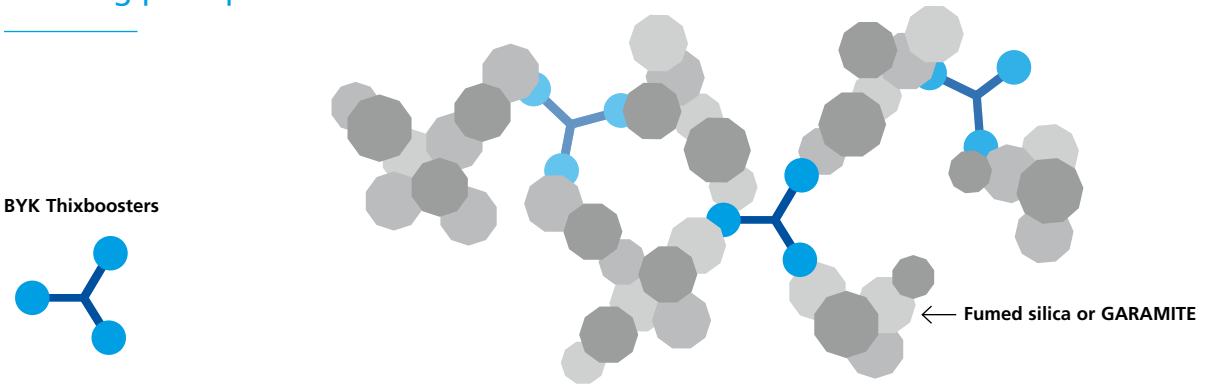
Benefits

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

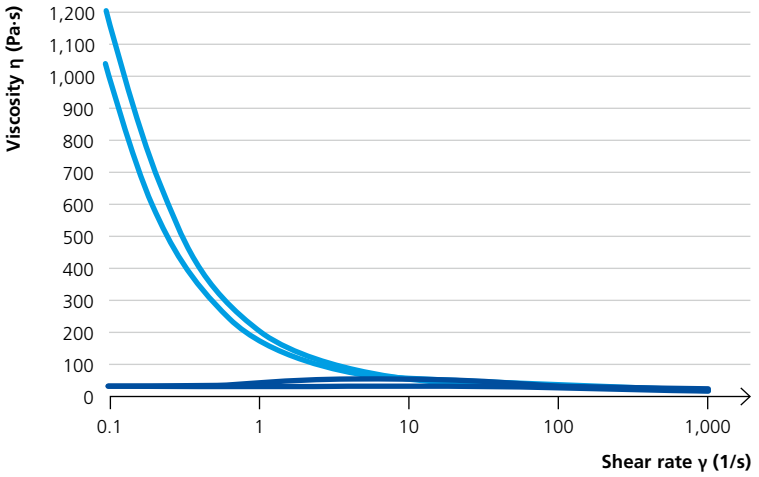
In many cases, epoxy formulations with (hydrophilic) silica are not storage-stable. The combination of hydrophilic silica with BYK rheology boosters prevents the loss in efficiency during storage so that the individual components can be used to create sag resistant applications, even after a long period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

Working principle of Thixboosters



G.06

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

G.07

Comparison of silicas with Thixboosters

	Market standard hydrophobic silica	**Reference hydrophilic silica**	**BYK recommendation of hydrophilic silica + Thixbooster**
Fresh			
Aged			

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.

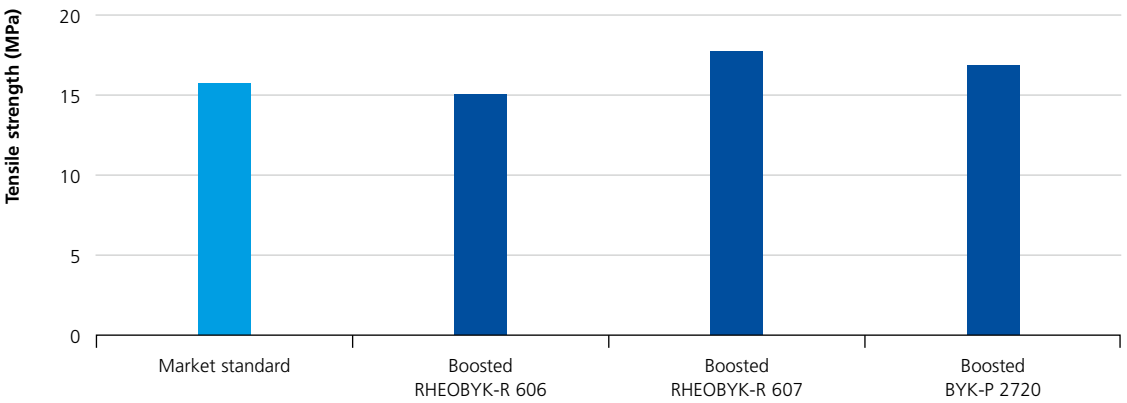
The combination of hydrophilic silica with the rheology booster RHEOBYK-R 606 enables the application of sag resistant 1-pack epoxy systems without the loss of sag resistance during curing.

1-Pack epoxy adhesive formulation

Raw material	Market standard (parts)	BYK recommendation (parts)
Bisphenol – A resin	100	100
Filler	150	150
Hydrophobic silica	3	
Hydrophilic silica		3
Thixbooster RHEOBYK-R 606		0.6 (20 % on fumed silica)
Hardener	6	6
Accelerator	2	2

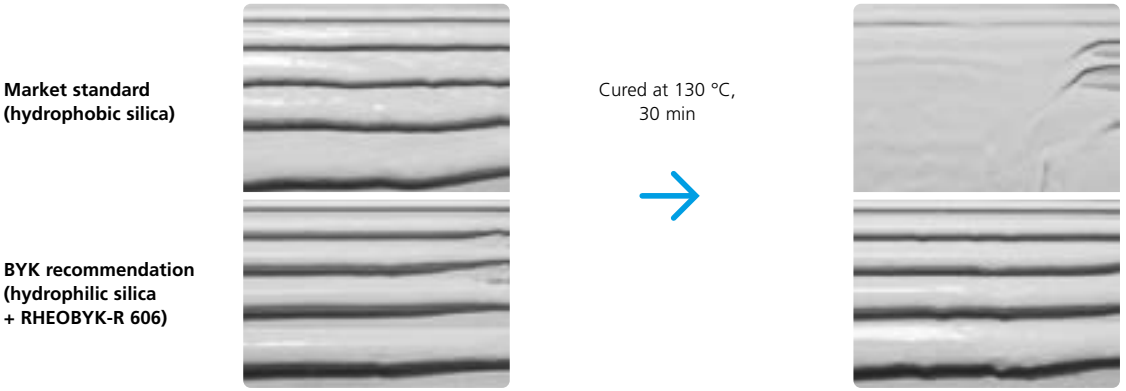
T. 02

Tensile strength



G. 09

Application and sag resistance



G. 10

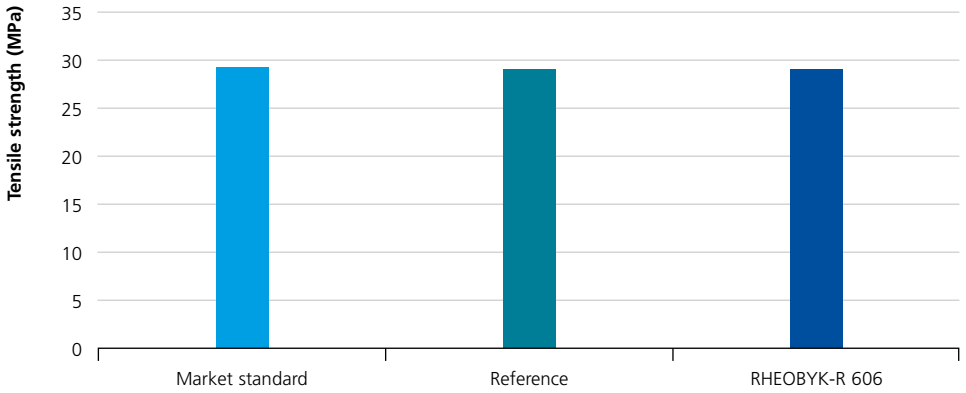
Mechanics

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.

Viscosity

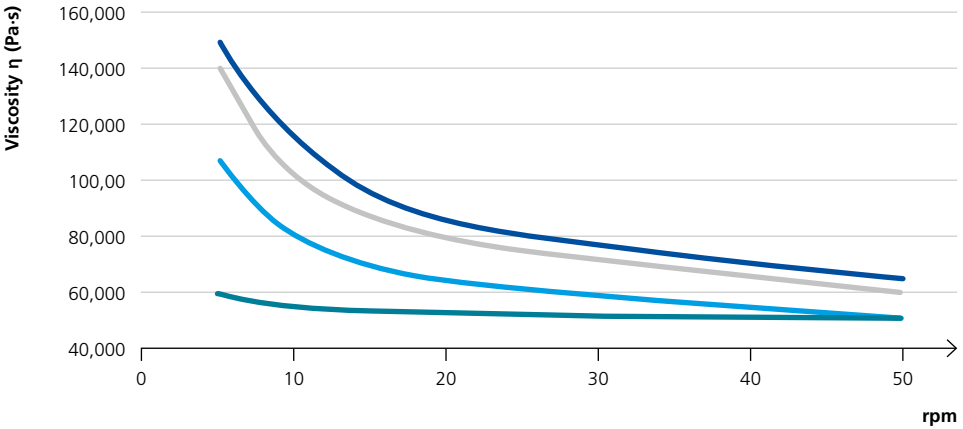
The viscosity profile of 1-pack epoxy formulations can be specifically adjusted by combining hydrophilic silica with RHEOBYK-R 606.

Tensile strength



G. 11

Comparison of different rheology profiles



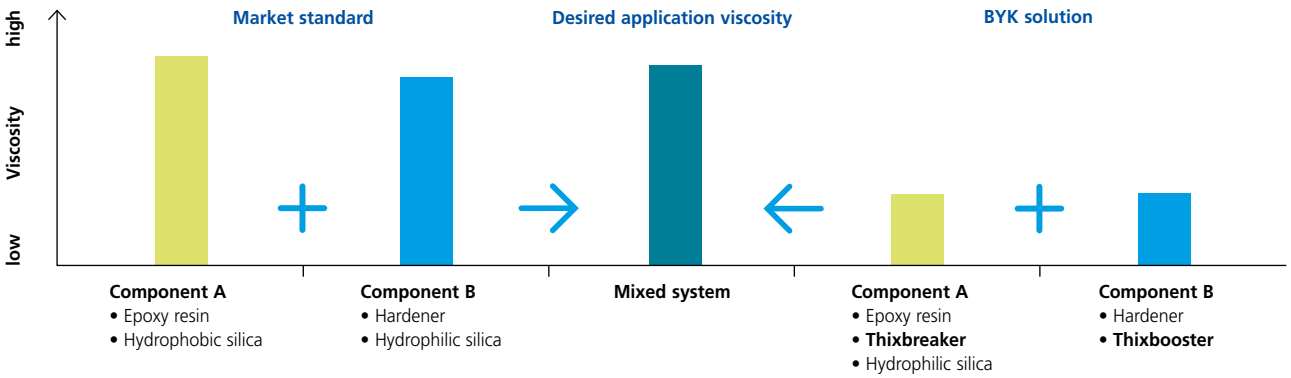
- 1.2 % hydrophilic silica + RHEOBYK-R 606
- 1.2 % hydrophobic silica
- 0.6 % hydrophilic silica + RHEOBYK-R 606
- 3 % hydrophilic silica

G. 12

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 (G. 13). This new concept of "viscosity control technology" has very broad uses across the entire value chain (G. 18).

Comparison of market standard and BYK solution with VCT



G. 13

Viscosity in production

G. 14

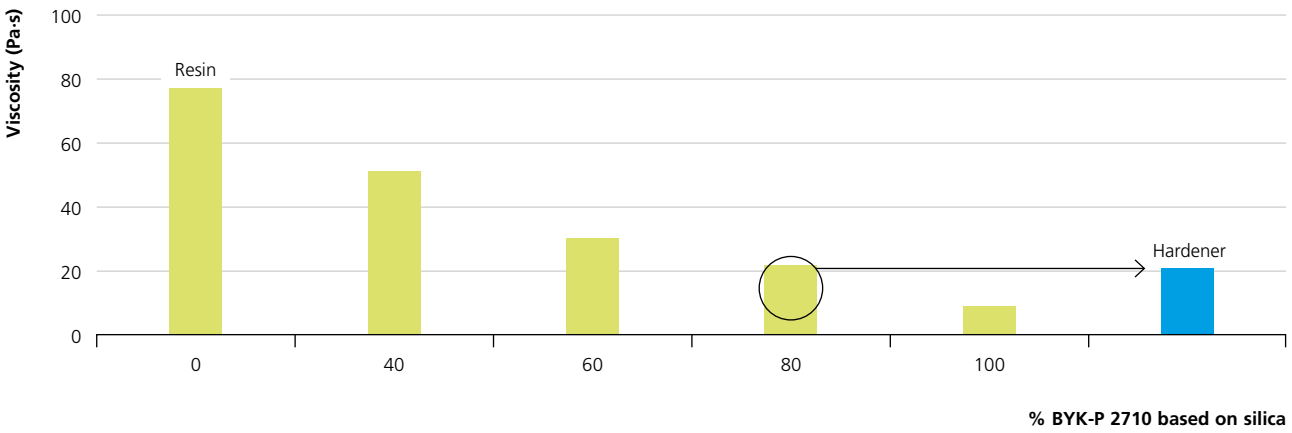
Viscosity at application

G. 15

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

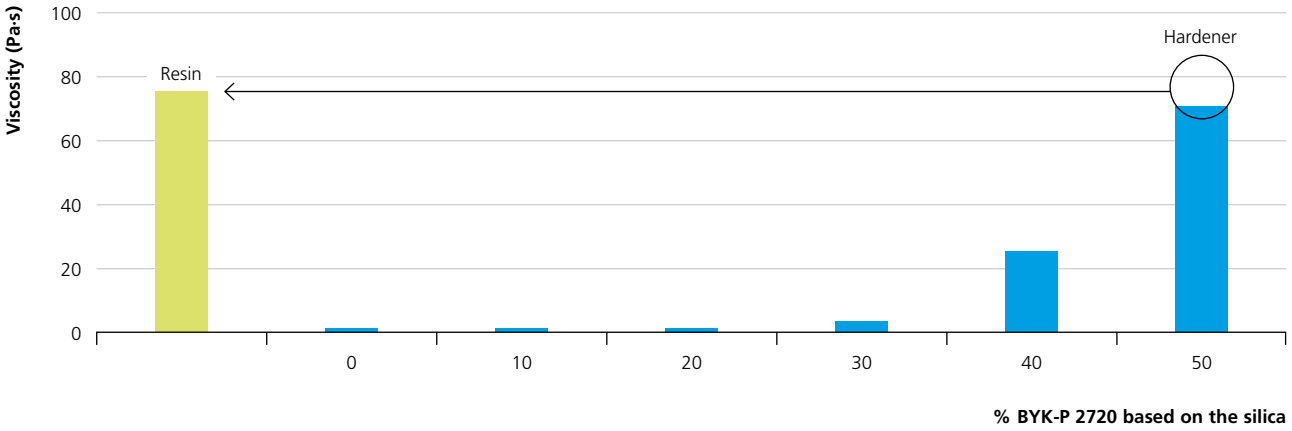


G. 16

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 2710



G. 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.

Value chain

G. 18

Recommended rheology additives, boosters and VCT for 1-pack and 2-pack epoxy systems

Application	1-pack epoxy	2-pack epoxy
Anti-settling	CLAYTONE-40 GARAMITE-1958 GARAMITE-7305 RHEOBYK-430 RHEOBYK-7410 ET RHEOBYK-D 410	CLAYTONE-40 GARAMITE-1958 GARAMITE-7305 RHEOBYK-430 RHEOBYK-7410 ET RHEOBYK-D 410
Sag resistance	CLAYTONE-40 GARAMITE-1958 GARAMITE-7305 RHEOBYK-100 RHEOBYK-7590	CLAYTONE-40 GARAMITE-1958 GARAMITE-7305 RHEOBYK-100 RHEOBYK-7590
Booster	RHEOBYK-R 606	BYK-P 2720 RHEOBYK-7405 RHEOBYK-R 607
VCT	-	BYK-P 2710 BYK-P 2720

T. 03

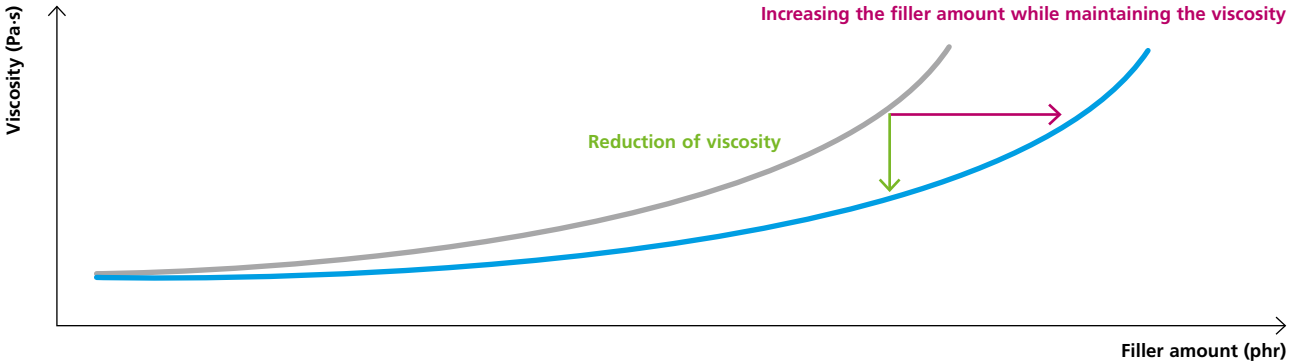
Wetting and dispersing additives

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 optimized and fast production, and consistent quality and performance.

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

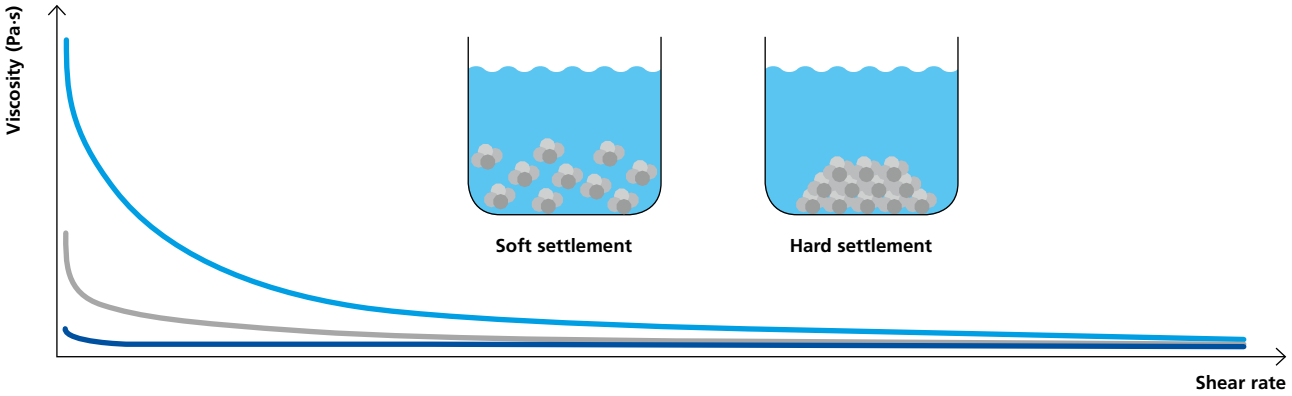
When selecting wetting and dispersing additives, you must be mindful of any reactivity of the additive with the epoxy system. BYK offers special wetting and dispersing additives which are stable in epoxy systems and therefore have no influence on the storage stability of the formulated components (G. 22).

Optimizing an epoxy system: lower viscosity or greater filler amount



Reference Wetting and dispersing additive G. 19

Influence of wetting and dispersing additives on the viscosity



Controlled flocculating Flocculating Deflocculating G. 20

Optimizing an epoxy system: lower viscosity or higher filler amount

Control – no additive

Viscosity reduction by using wetting and dispersing additives

Increasing the filler amount by using wetting and dispersing additives

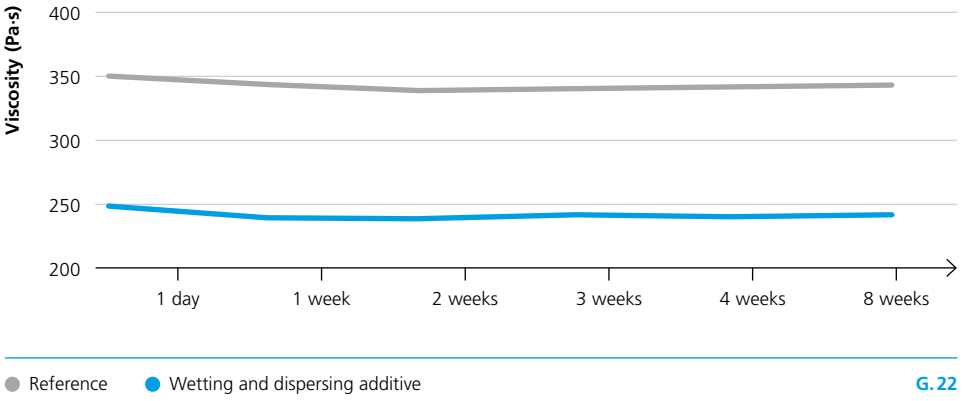
G.21

Wetting and dispersing additive recommendations for 1-pack and 2-pack epoxy adhesives and sealants

Application	Recommendation
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 966 BYK-W 980
Rheology additives that can be combined with wetting and dispersing additives – anti-settling	RHEOBYK-7410 ET GARAMITE-1958 GARAMITE-7305

T.03

Storage stability



G.22

AS-TI 5 07/2022

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