APPLICATION INFORMATION

ADDITIVES FOR POLYURETHANE APPLICATIONS

Contents

Introduction to polyurethane applications

The polyurethane industry is a diversified area with many different applications and their related formulations. Polyurethane parts can be small or large, solid or foamed, flexible or rigid.

Technically, a polyurethane can be any polymer with a urethane linkage in its backbone chain. Various problems related to the application type and formulation often exist for polyurethanes because of their chemical complexity and wide range of uses.

This application information offers an overview of additives designed to help the fabricator or processor deal with:

- Air entrapment, pinholes, and foam formation
- Flow and leveling as well as substrate wetting problems
- Viscosity reduction in filled and non-filled systems
- Sedimentation and floating of solid particles in filled systems
- Viscosity differences between polyols and isocyanates
- Separation of liquid components (polyols and chain extender)

The additives listed in this guide are applicable for rigid and elastomeric systems such as: casting, lining, flooring, reaction injection molding (RIM), syntactic foam, spray application (i.e. coatings and decking), foam applications, and adhesives and pigment concentrates.

For additional information on additives and technical topics, please contact us:
Thermosets.BYK@altana.com

Note

To ensure the best appearance and full functionality, please open in Adobe Acrobat.

Air release additives

Entrapped air bubbles are a common challenge in manufacturing or applying polyurethane based systems. They are difficult to remove, especially in highly thixotropic and pseudoplastic formulations or high wet film thickness. These same air bubbles ultimately develop into pinholes, which increases porosity and dramatically reduces the overall performance of the final part. Defoamers as well as air release additives can prevent:

- Blisters
- Pinholes
- Loss of insulation properties in electrical casting systems
- Weakening of the composite structure
- Poor appearance
- Porosity

of the final part.

Air release additives work in three steps

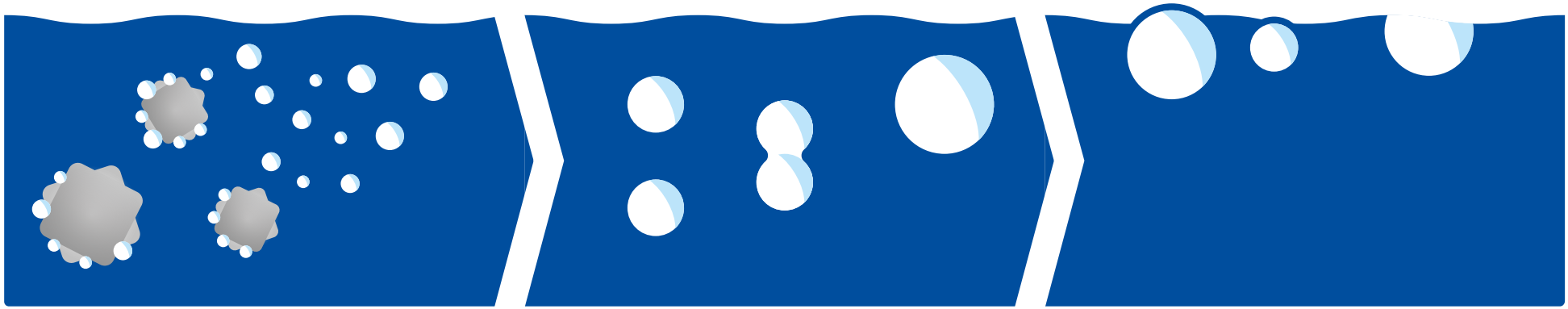
1. Displacing air from filler and reinforcement materials
By reducing the interfacial tension between resin and filler/reinforcement materials, the trapped air is displaced into the resin.

2. Smaller bubbles coalesce to form large bubbles
Bubble-stabilizing substances are displaced by the air release additive. Smaller bubbles coalesce to form larger bubbles, which rise to the surface faster because of their higher buoyancy (Stokes' law).

3. Bubbles burst on the surface
Bubble-stabilizing substances are displaced and the bubbles burst.

Air release additives work in three steps

Step 1 **Step 2** **Step 3**



Air release additives can be based on (modified) polysiloxanes, silicon-free polymers, or a combination of both. Whether or not a particular polymer can destroy foam bubbles depends on the product compatibility and solubility in the liquid medium. All defoamers and air release additives must have some degree of incompatibility – managing that delicate balance between compatibility and incompatibility. This is achieved by adjusting the molecular weight and/or polarity of the polymeric structures.

Some additives are especially designed for specific requirements, e.g. potable water, AgBB, high voltage, etc. As regulations can change, please refer to the relevant documents on our website or contact our product safety department.

Optimized dosage

BYK air release additives achieve excellent deaeration even at small dosage levels.

Recommendations for air release additives

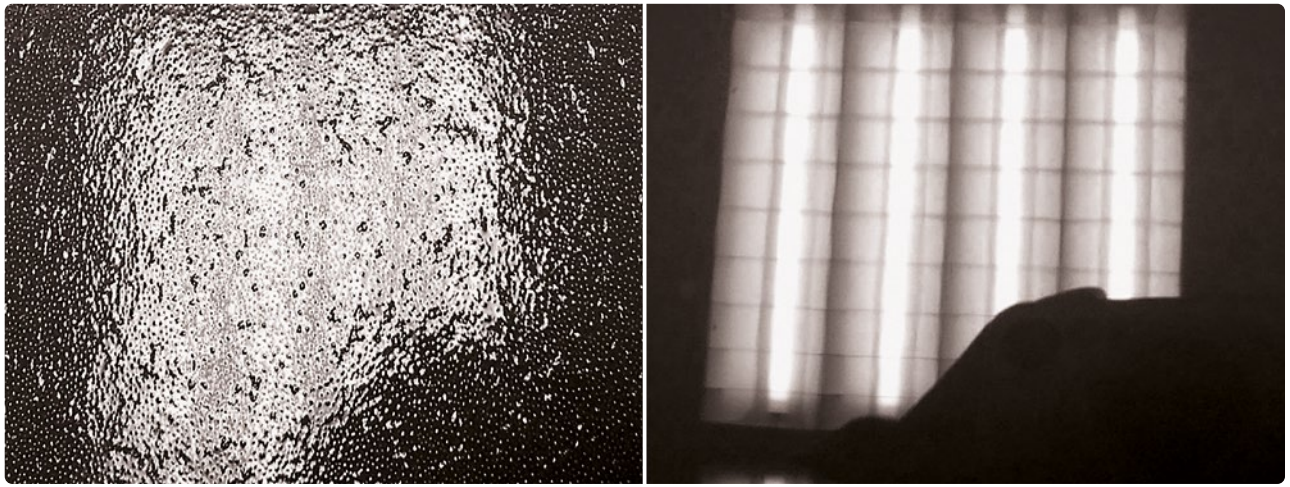
System	Product	Remarks
Silicone-based	BYK-141	Universal air release additive
	BYK-1796	Very effective, solvent-free
Silicone-free, polymer-based	BYK-A 535	Low polar, solvent-free for food contact*
	BYK-1790	Very effective, solvent-free air release additive
Silicone/polymer combination	BYK-088	Very effective, universal air release additive

* For details on food contact use, please refer to the food contact sheet available on www.byk.com/en/service/regulatory-affairs/food-contact.

T. 01

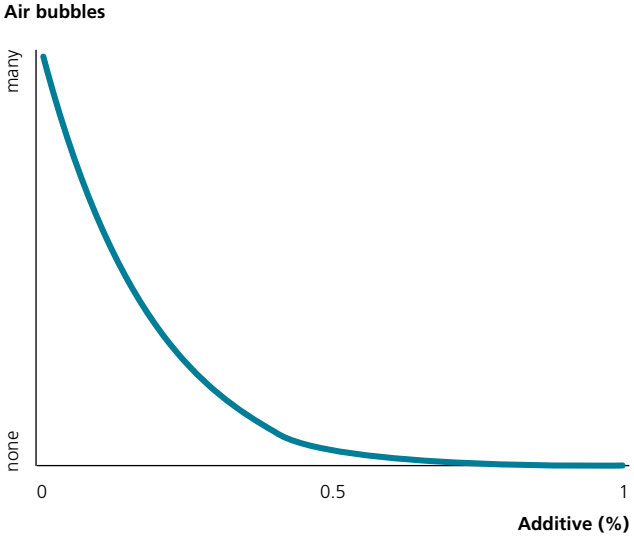
Air release in a 2-pack polyurethane system

Without additive **0.5 % BYK-088**



G. 02

BYK air release additives



G. 03

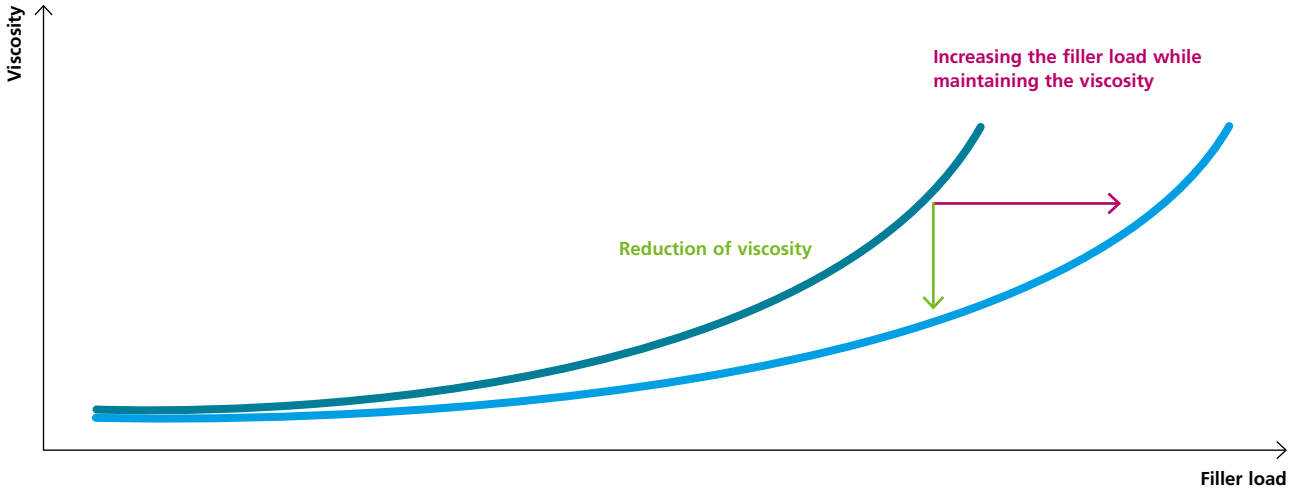
Wetting and dispersing

One of the most important steps in producing filled or pigmented polyurethane systems is the homogeneous distribution of the solid pigments and fillers within the liquid resin solution. If this step (grinding) is not optimized, a wide range of defects such as flocculation, flooding and floating (pigment separation), and settling can occur as well as poor flow behavior during application. Wetting and dispersing additives are added prior to the incorporation of the filler/ pigment.

They will accelerate the wetting of solid particles, stabilize them, and can provide the following benefits:

- Viscosity reduction
- Improved flow
- Increased filler load
- Reduced filler sedimentation
- Color homogeneity

Wetting and dispersing additive: lower viscosity or higher filler load



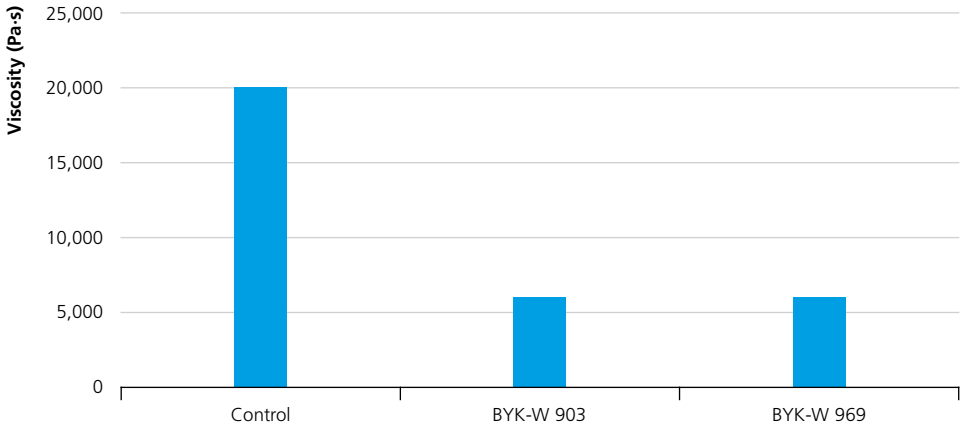
Reference Formulation including wetting and dispersing additive

G.04

By using wetting and dispersing additives, a lower viscosity can be obtained. When the viscosity is reduced, the choice between better flow or an increase of filler load can be made (G. 04). Selecting the correct additive is dependent on the application requirements and the raw materials. A combination of wetting and dispersing additives with air release additives will improve the final result.

Depending on the structure of the wetting and dispersing additive, it can reduce the viscosity or stabilize the system against sedimentation.

Viscosity reduction ATH in polyol (60:40)



G. 05

Recommendations for wetting and dispersing additives

Product	Remarks
BYK-W 903	Universal, for viscosity reduction
BYK-W 940	Universal, anti-settling
BYK-W 961	Strong anti-settling
BYK-W 969	Universal, for viscosity reduction
BYK-W 980	Stabilization and viscosity reduction
BYK-W 9010	Universal, for viscosity reduction, solvent free

T. 02

Rheology

Rheology is impacting many properties of polyurethane resin systems, e.g. flow behavior, air release, or sagging and settling issues. Furthermore, the rheological profile is considerably affected after mixing polyol with hardener due to the mixing ratio and polarities of the components. Higher viscosity at low shear in combination with a high yield point can substantially reduce both sedimentation and sagging. This results in a longer shelf life with less settling and better sag resistance during application. During storage, pigments and fillers in a system can settle and form sediments that are difficult to re-disperse. This effect depends on the filler load, type of filler, and the storage conditions (e.g. temperature). During application on inclined and vertical surfaces, running and sagging frequently occur at higher film thicknesses.

To adjust rheology, BYK offers different types of rheological additives:
- Liquid rheology additives
- Solid rheology additives
- Thixotropy Booster

All of them modify the sagging and/or settling properties.

Liquid rheology additive

Liquid rheology additives are used to adjust anti-settling and anti-sagging properties. They can be added to the polyol. Examples for this additive family are RHEOBYK-7410 ET and RHEOBYK-410.

These products are based on modified urea that forms strong, three-dimensional network structures, thereby creating thixotropy.

Solid rheology additives

Solid thixotrope additives are mainly used for anti-settling. They build up a network between the single particles and are easy to incorporate. In the correct combination with a thixotropy booster (e.g. RHEOBYK-R 605, RHEOBYK-R 607), they also show an excellent sag resistance.

GARAMITE-1958 is a solid thixotrope based on the Mixed Mineral Technology (MMT) and can be easily incorporated into the polyol.

Thixotropy booster

Optimum processability coupled with high sag resistance requires a perfectly adjusted rheology profile, and often mixed minerals or fumed silica are used for this. However, if the hardener is added, the viscosity spontaneously drops. A combination of modified solid thixotropes, especially GARAMITE-1958, or hydrophilic fumed silica in the polyol and RHEOBYK-R 607 or RHEOBYK-R 605 can prevent this.

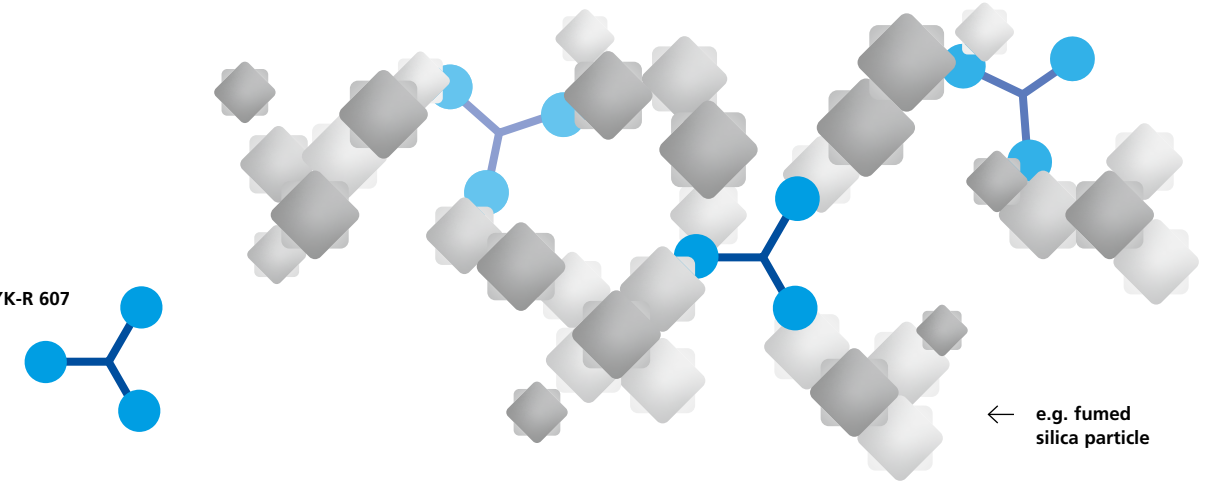
RHEOBYK-R 607 enhances the network of the solid thixotrope and leads to a very strong sag resistance (G. 07).

Recommendations for rheology additives

Product type	Product	Remarks
Liquid rheology additives	RHEOBYK-410	Anti-sagging and anti-settling
	RHEOBYK-7410 ET	
Thixotropy booster	RHEOBYK-R 605	Anti-sagging and anti-settling in combination with GARAMITE or fumed silica
	RHEOBYK-R 607	
Solid thixotropes	GARAMITE-1958	Best in combination with RHEOBYK-R 605 or RHEOBYK-R 607

T. 03

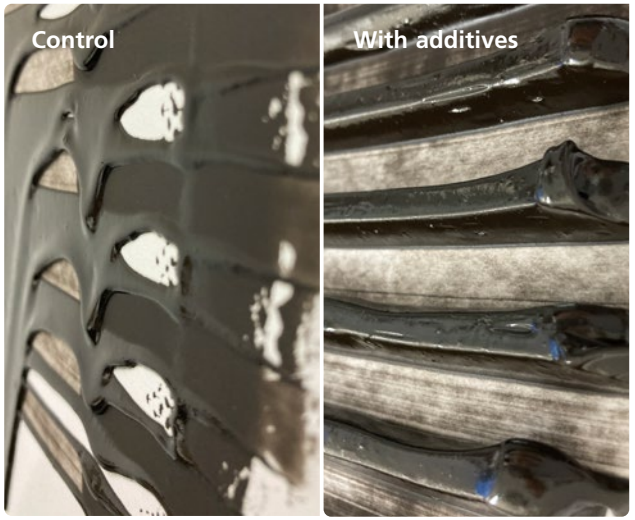
RHEOBYK-R 607 – mode of action



Multiple functional groups effectively enhance the solid thixotropic network.

G. 06

Higher sag resistance with RHEOBYK-R 607 and an additive based on mixed mineral technology (MMT)

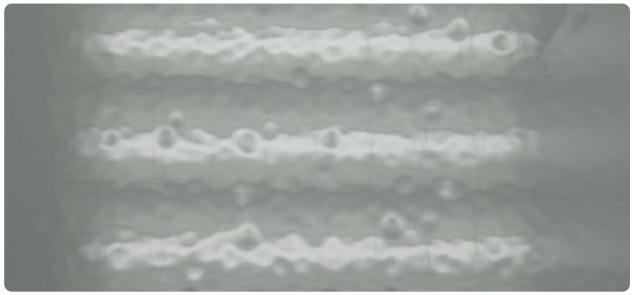


G. 07

Surface additives

Whenever a polyurethane is applied in a certain layer on a substrate, defects such as craters, Bénard cells, pinholes, orange peel, and others can appear on the surface. One very significant parameter that has an impact on all these defects is the surface tension, or more specifically, the surface tension differences. The following additives could be used to prevent or minimize these differences in surface tension.

Cratering and poor leveling



G. 08

Recommendations for surface additives

Product	Remarks
BYK-306	Strong surface tension reduction, anti-cratering
BYK-330	
BYK-361 N	Improved leveling
BYK-S 706	

T. 04

Processing additives

BYK-P 9912 – processing additive with mold release properties

Composite materials made of polyurethane resins and reinforcing fibers such as glass fibers or carbon fibers are used in various applications. Especially in the automotive industry which require short cycle times, these systems are processed by RTM or HP-RTM techniques. To ensure a good demolding after curing, both internal as well as external release agents are used in combination. The reapplication of the external mold release agent after each part is one step of the total cycle. BYK-P 9912 was developed in order to reduce the cycle time and accelerate the process. The processing additive with internal release properties is designed for polyurethane systems to increase the production speed. The number of parts that can be demolded without reapplication of the mold release agent is increased and results in an improved potential output of the production process by a reduced cycle time.

BYK-P 9912 has no negative impact on the processing parameters of the polyurethane system, such as viscosity and reactivity. Another important feature is the excellent surface quality directly after demolding and the power wash process no longer being required prior to coating. No negative influence on the mechanical properties of the finished part has been observed. The process additive can be incorporated in both the polyol as well as the isocyanate components.

Viscosity reduction

In some non-filled applications, mixing problems occur when the polyol is too viscous to be properly mixed with the low viscous isocyanate. In this case, viscosity depressants VISCOBYK-4015 and BYK-P 9915 provide an opportunity to reduce the viscosity of the unfilled polyol and improve its flowability during the process. VISCOBYK-4015 is also suitable in filled systems when the filler load is low (< 30 % filler) or when a reinforcement such as mica or wollastonite is used.

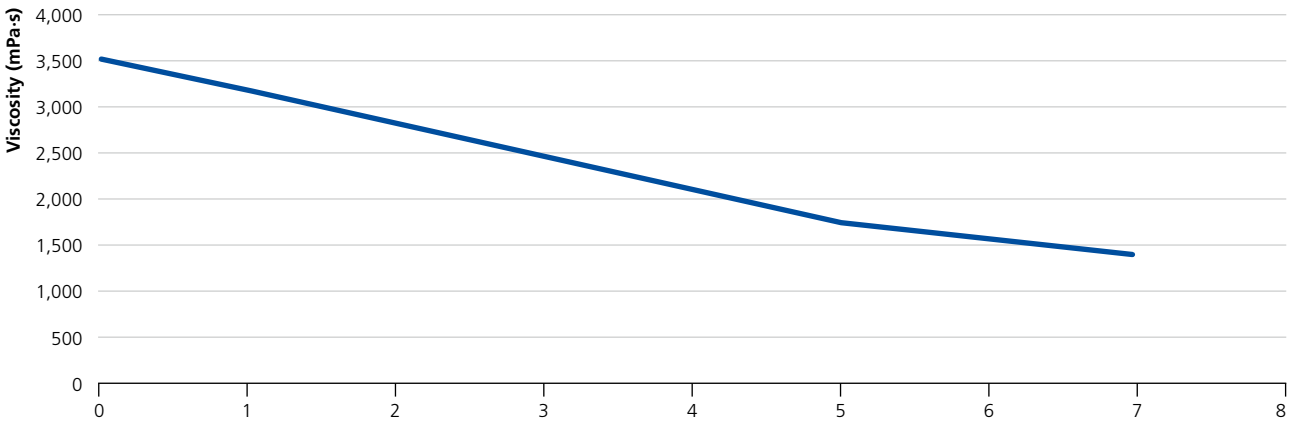
BYK-P 9915 is an OH-functional viscosity depressant that becomes part of the polymer chain during curing. It is thus specifically recommended for all applications where migration is an issue.

Recommendations for viscosity reduction

Product	Product type	Dosage
BYK-P 9915	OH-reactive polyalkylene derivatives	0.5–5 % on polyol
VISCOBYK-4015	Aliphatic hydrocarbons	1–10 % on polyol

T. 05

Viscosity reduction of a polyol



G. 09

Processing additives for improved compatibility

Polyurethane elastomers and foams utilize liquid components such as polyol mixtures, butanediol (chain extender), and cyclopentane (blowing agent). Mixtures of these materials often exhibit phase separation because of their insufficient compatibility. This instability may become obvious immediately after mixing or over time.

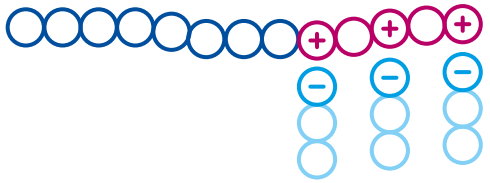
There are a number of compatibilizers that have been specially developed for polyurethane systems in order to overcome this liquid/liquid separation issue.

BYK-P 9904, BYK-P 9908, and BYK-P 9909 have different molecule structures in order to meet the requirements of components with greatly varying polarities. BYK-P 9904 is a block copolymer with alternating polar and non-polar groups, and electrical charges along the backbone. BYK-P 9908 and BYK-P 9909 are based on the innovative T.A.P.E. technology. The twin amphiphilic structure enables the additives to cover a wide range of polarities (G. 10).

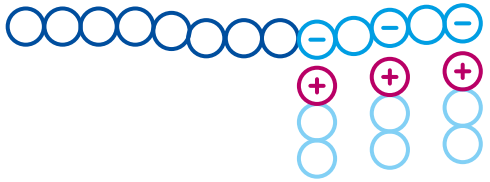
BYK-P 9904 is mainly used in straight polyol blends (polyether, polyester), whereas BYK-P 9908 and BYK-P 9909 are primarily recommended for mixtures of polyols (or polyol blends) with chain extenders.

Twin amphiphilic polymeric emulsifiers (T.A.P.E.)

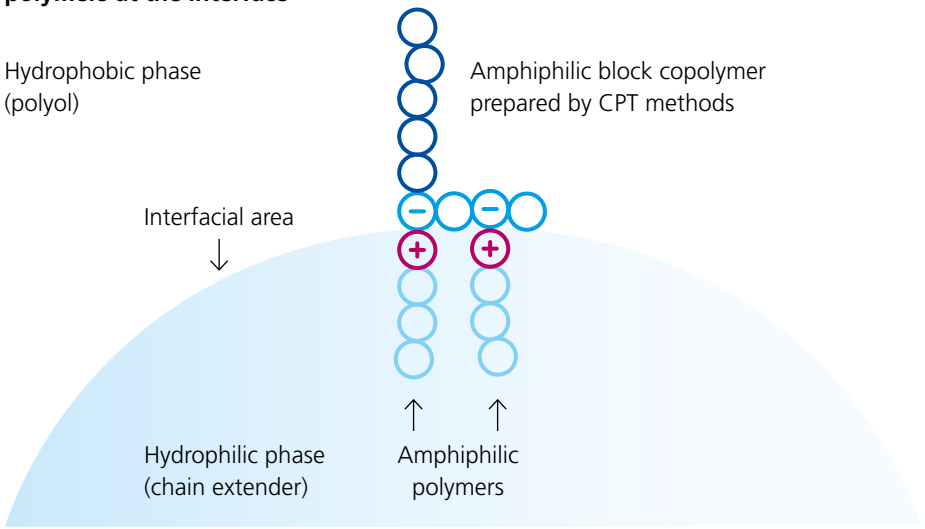
BYK-P 9908
basic functional block
acidic functional group



BYK-P 9909
acidic functional block
basic functional group



Arrangement of amphiphilic polymers at the interface



Neutral block · Basic group/block · Acidic group/block · Polymer chain

Stabilization of butanediol in polyol

G. 11

Processing additives

Product	Product type	Dosage
BYK-P 9904	Solution of a high molecular weight block copolymer with pigment affinic groups	0.2–2 % on polyol blend
BYK-P 9908	Solution of an acrylate copolymer	1–3 % on total formulation
BYK-P 9909	Solution of an ammonium salt of an acrylic acid polymer	0.2–3 % on total formulation

T. 06

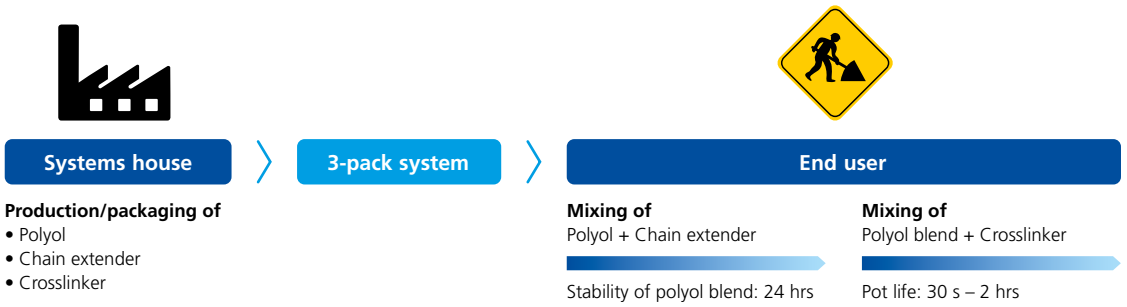
Compatibilizers for polyol/chain extender blends

Product	Polyols		Chain extenders		
	Polyester	Polyether	PTMEG	1,4-Butanediol	Hydrophilic glycols
BYK-P 9904	○	○		○	
BYK-P 9908	●	●	●	●	
BYK-P 9909	○	●			●

● Recommended ○ Suitable

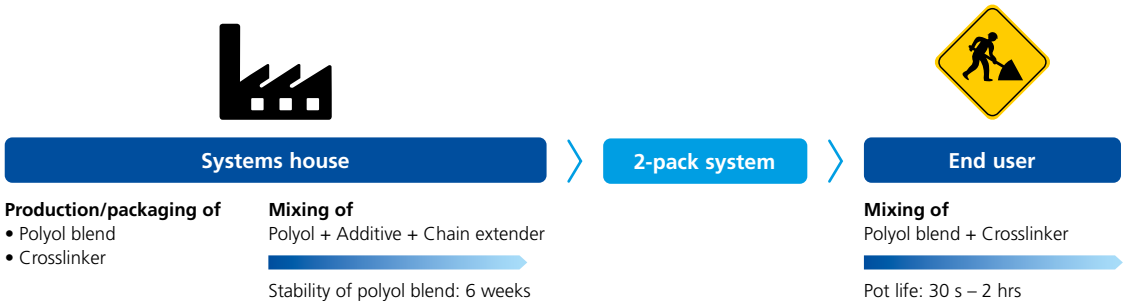
T. 07

Today's process



G. 12

New process with stable polyol/chain extender blend



G. 13

With the new process additives BYP-P 9908 and BYK-P 9909, this process can now be simplified. Both additives enable stable polyol/chain extender blends to be formulated, which makes it possible for the first mixing step (polyol + chain extender) to be accomplished in the systems house. Therefore, the only on-site step necessary is for the polyol blend to be mixed with the crosslinker (G. 10). Storage-stable polyol blends, including the chain extenders, allow systems houses to offer more innovative 2-pack systems compared to traditional 3-pack systems.

Another important factor to consider is the benefit the additives have on the production of the polyol blends themselves: Some polyol systems start to separate minutes after mixing. This distinct incompatibility means that the blends have to be continuously mixed while they are in storage or day tanks. Processing conditions and timing require special care, especially when breaks or weekends are at odds with production schedules. BYK processing additives offer considerable advantages. Emulsions that are stable for many days or even weeks can be produced and stored without the need for continuous mixing. Moreover, using processing additives leads to improved homogeneity in the reaction mix and consequently may improve the quality of the finished part as well.

Summary of additive recommendations

Additive recommendations for polyurethane applications

Product type	Product	Remarks
Air release, silicone-containing	BYK-141	Universal
	BYK-1796	Very effective, solvent-free
Air release, silicone-free	BYK-088	Very effective, universal
	BYK-1790	Very effective, solvent-free, for food contact
	BYK-A 535	Low polar, solvent-free, for food contact
Wetting and dispersing	BYK-W 903	Univeral, for viscosity reduction
	BYK-W 940	Universal, anti-settling
	BYK-W 961	Strong anti-settling
	BYK-W 969	Univeral, for viscosity reduction
	BYK-W 980	Stabilization, viscosity reduction
	BYK-W 9010	Universal, for viscosity reduction, solvent free
Liquid rheology additives	RHEOBYK-410	Anti-settling, anti-sagging
	RHEOBYK-7410 ET	
Thixotropy booster	RHEOBYK-R 605	Anti-sagging and anti-settling in combination with GARAMITE or fumed silica
	RHEOBYK-R 607	
Solid rheology additive	GARAMITE-1958	Best in combination with RHEOBYK-R 605 or RHEOBYK-R 607

Product type	Product	Remarks
Surface additives, silicone-containing	BYK-306	Strong surface tension reduction, anti-cratering
	BYK-330	
Surface additives, silicone-free	BYK-361 N	Improved leveling
	BYK-S 706	
Processing	BYK-P 9904	Compatibilizer
	BYK-P 9908	
	BYK-P 9909	
	BYK-P 9912	Processing with mold release properties
	BYK-P 9915	Reactive viscosity reducer
	VISCOBYK-4015	Non-reactive viscosity reducer

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BYK-Chemie GmbH
P.O. Box 10 02 45
46462 Wesel
Germany
Tel +49 281 670-0
Fax +49 281 65735

info@byk.com
www.byk.com

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