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Additives & Instruments

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Application Information CC-A1

Additives for Polyurethane Applications

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Additives for Polyurethane Applications

Content

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.

Surface Defects

Surface defects often occur during and after the application of a polyurethane system. These defects degrade both the optical properties of the final part and the mechanical properties.

Typical defects are:
- air entrapment or foam formation
- pinholes
- poor substrate wetting
- crater formation
- non-optimal flow/leveling

Silicone-based as well as silicone-free polymeric additives are available. BYK-A 535 is especially recommended for air release if these systems are formulated with MDI or TDI prepolymers. BYK-A 535 fully meets all requirements of the European Union for "articles and materials intended to come in contact with foodstuffs" (incl. drinking water).

For details, please refer to the relevant documents on our website: **www.byk.com/foodcontact** or e-mail: **foodcontact.byk@altana.com**.

BYK-067 A and BYK-088 are good starters to evaluate in PUR lining, flooring, and casting applications.

Additives to Prevent Surface Defects

	Air Entrapment, Foam, Pinholes	Substrate Wetting, Anti-cratering, Leveling
Silicone-based	BYK-067 A BYK-141	BYK-306
Silicone-free polymer	BYK-A 535	
Silicone/polymer combination	BYK-088	
Recommended dosage (on total formulation)	0.1-1.5 %	0.1-0.5 %

figure 1

2-pack PUR System – MDI Prepolymer

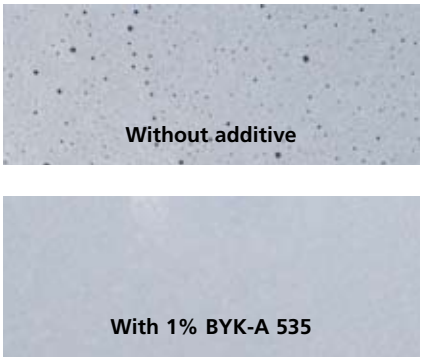


figure 2

Filler Stabilization

In order to achieve the desired mechanical properties or other benefits (such as compound cost reduction) in RIM, casting, and other application areas within the PUR industry, formulators often utilize large amounts of filler in the polyol. These fillers can be calcium carbonate, barium sulfate, hollow glass spheres, and others.

Filler particles that are not properly wetted, dispersed, and stabilized tend to:
- create a high compound viscosity
- cause the filled polyol to be improperly mixed with the isocyanate
- exhibit poor compound flow behavior

BYK-W 969 is a wetting and dispersing additive that provides the following benefits:
- higher filler loading
- better cost-performance ratio
- improved compound flow (figure 4)
- filled polyol homogeneously mixed with iscocyanate

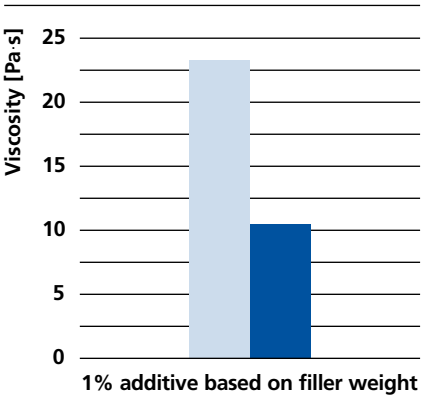
The OH-functionality of BYK-W 969 means it also performs well in applications where fogging and emissions are critical issues (like automotive).
Due to the chemical nature of wetting and dispersing additives, it is generally important to check the influence on the system's reactivity.

Wetting and Dispersing Additive for Filler Stabilization

	Type of additive	Recommended dosage
BYK-W 969	OH-reactive copolymer	0.5-1.5 % on filler weight

figure 3

Viscosity of a Polyether Polyol with 150 phr $CaCO_3$



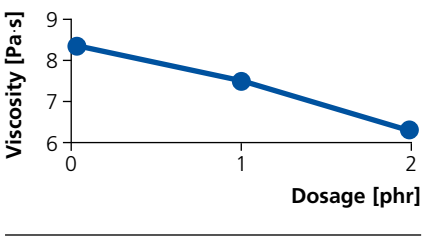
Brookfield RVT DVII, Spindle No. 5, @ 5 rpm, 40°C/140°F after 60 min.

figure 4

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 reinforcement such as mica or wollastonite is used.
BYK-P 9915 is an OH-functional viscosity depressant which becomes part of the polymer chain during curing. It is thus specifically recommended for all applications where migration is an issue.

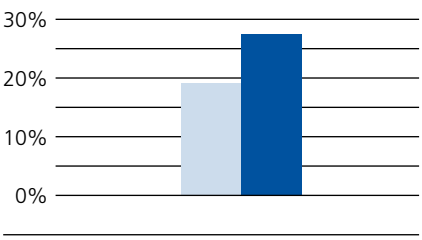
Polymer Polyol 45% SAN



BYK-P 9915

figure 5

Low OH PIR Polyol



1 phr 2 phr BYK-P 9915

figure 6

Viscosity Depressants

	Recommended for	Recommended dosage
BYK-P 9915	OH-reactive polyoxyalkylene derivatives	0.5-5 % on polyol
VISCOBYK-4015	Aliphatic hydrocarbons	1-10 % on polyol

figure 7

Anti-settling/Anti-floating

Filler particles that have a fairly high density (calcium carbonate, melamine powder) tend to settle during storage, whereas low density particles (ground PU powder, polyethylene powder) may float. The rheological behavior of the system must be optimized to prevent these issues.

Anti-settling/Anti-floating in PO-based Conventional Polyol (after 24 hours)

- **no flotation of light-weight filler (15% polyethylene powder)**
- **no sedimentation of heavier melamine (30%)**

control **with BYK-D 410** **0.1 phr** **0.3 phr** **control** **with BYK-D 410** **0.5 phr**

figure 8

Anti-settling/Anti-floating Additives

	Additive type	Recommended dosage
BYK-D 410	Modified urea	0.1-1 % on polyol
BYK-R 605	Polyhydroxycarboxylic acid amides	20% on filler
BYK-W 961	Solution of an alkylammonium salt of a polycarboxylic acid	0.5-2 % on filler

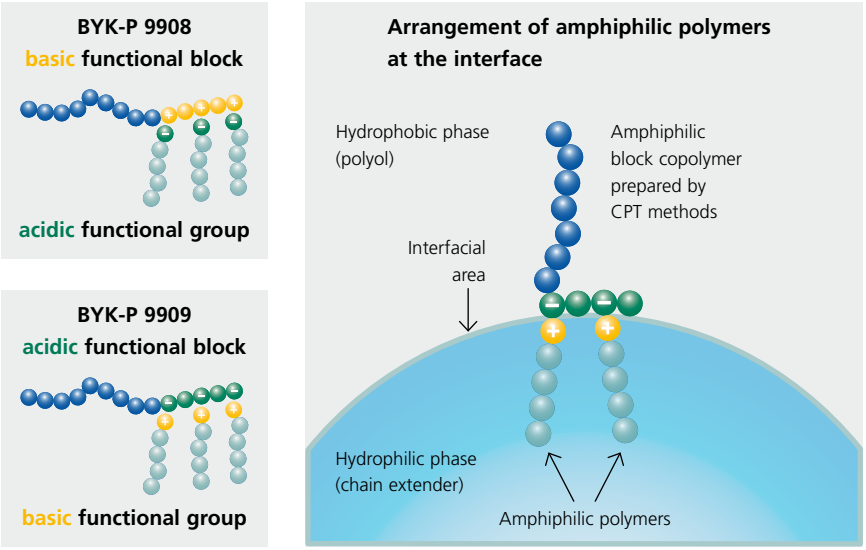
figure 9

To ensure ease of application, the viscosity of the filled system should be as low as possible, but, on the other hand, high enough that the particles will not settle or float. Such flow properties can be achieved by using specially developed additives such as BYK-D 410 and BYK-R 605, which adsorb onto the particle surface, build a network in the system, and create thixotropy. Controlled flocculating wetting and dispersing additives such as the multi-functional BYK-W 961 work in a similar way. This additive brings the dispersed particles together into loose structures, which sometimes leads to even higher viscosities and good anti-settling properties. Pseudoplasticity and thixotropy are enhanced which also improves sag stability.

When humidity is present in isocyanate-based systems, it will easily react with the isocyanate and the resulting carbon dioxide creates a foam problem. Zeolites are micro-porous solids (molecular sieves) that are often used to absorb any traces of water and thus prevent this problem. The disadvantage of zeolites is their strong tendency to form a hard sediment in the systems they are supposed to protect. BYK-R 605 is very effective in improving the situation: slight settling will still occur, but the additive makes the sediment soft and easy to reincorporate.

Improved Compatibility

Twin Amphiphilic Polymeric Emulsifiers (T.A.P.E.)



neutral block basic group/block acidic group/block polymer chain figure 10

Processing Additives

	Additive type	Recommended 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

figure 11

Compatibilizers for Polyol Blends

	Polyester polyol	Polyether polyol
BYK-P 9904	■	■
BYK-P 9908	□	□

■ recommended □ suitable figure 12

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 (figure 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.

Stabilization of Butanediol in Polyol

figure 13

Compatibilizers for Polyol/Chain Extender Blends

	Polyols		Chain extenders		
	Polyester	**Polyether**	**PTMEG**	**1,4-Butanediol**	**Hydrophilic glycols**
BYK-P 9904	□	□		□	
BYK-P 9908	■	■	■	■	
BYK-P 9909	□	■			■

■ recommended □ suitable figure 14

Application Examples

1. Electrical Insulation

The main requirements are:
- dielectrical properties
- low viscosity
- no filler sedimentation
- good substrate wetting

Air in the system has a tremendous impact on the dielectrical properties. Air release additives can help improve these properties by improving the deaeration of the system after application or even at production. Surface additives can support the dielectrical properties as well. They improve substrate wetting especially if combinations of substrates are used, e.g. high surface tension (metal) and low surface tension (plastic). The casting (potting) application requires a low application viscosity especially if complex designed parts have to be insulated.

Wetting and dispersing additives such as BYK-W 969 with viscosity reducing properties help cast this kind of part. These additives reduce the interfacial forces between the filler particles so that the viscosity is reduced and a higher filler content is possible. Wetting and dispersing additives such as BYK-W 961 prevent filler sedimentation during storage. Formulating a thixotropic flow behavior is another way to improve the application and the settling properties. These systems show high viscosities at low shear rates (storage) and low viscosities at high shear rates (application). The liquid rheology additive BYK-D 410 can be used in this case. Depending on the dosage, the additive exhibits good anti-sedimentation properties without affecting the application properties.

2-pack PUR Casting System – Electrical Insulation

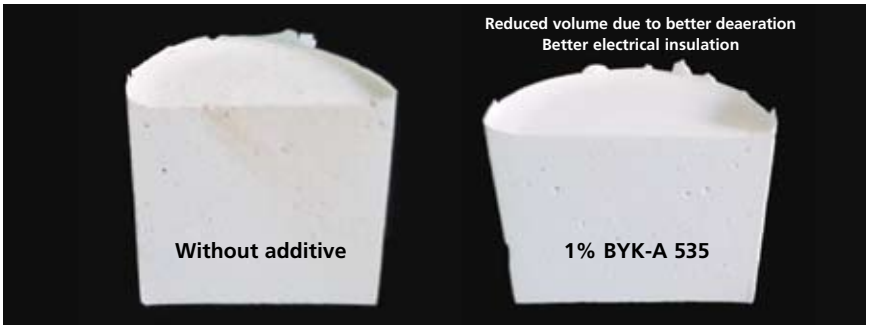


figure 15

2. Flooring

PU flooring systems combine optical appearance with excellent mechanical properties. These systems are therefore used for industrial and decorative applications. Low viscosities are required with respect to good application properties as well as good filler or pigment stabilization regarding handling. Additives such as BYK-W 969 meet these requirements. They reduce the viscosity and prevent filler sedimentation. DISPERBYK additives are also used for color stabilization in decorative applications. VISCOBYK-4015 is used to reduce viscosity in transparent systems. Additives such as BYK-088 or BYK-A 535 are the right choice to prevent air from being incorporated during the production process and to improve the deaeration after application. Leveling additives such as BYK-306 can cover the surface, which not only prevents the isocyanate from reacting with humidity but also improves the optical appearance.

3. Stable Polyol/Chain Extender Blends for Easier Processing

Polyol systems containing chain extenders are often seriously affected by insufficient stability against phase separation. This is because incompatible raw materials are used. Today's process on a construction site is therefore as follows (figure 16): Polyol, chain extender, and crosslinker are delivered separately. The first step on site is for the polyol to be mixed with the chain extender; this mixture is stable for 24 hours. In a second step, this polyol blend is mixed with the crosslinker (isocyanate).

Today's Process

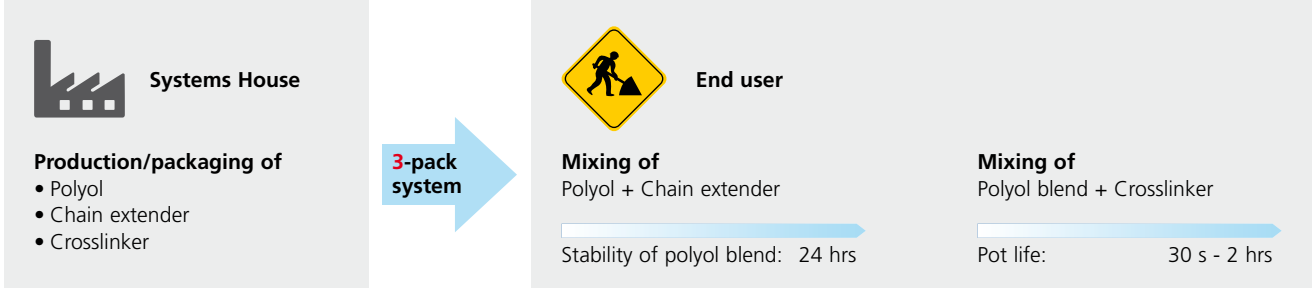


figure 16

With new processing additives, BYK-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 (figure 17). 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.

New Process with Stable Polyol/Chain Extender Blend

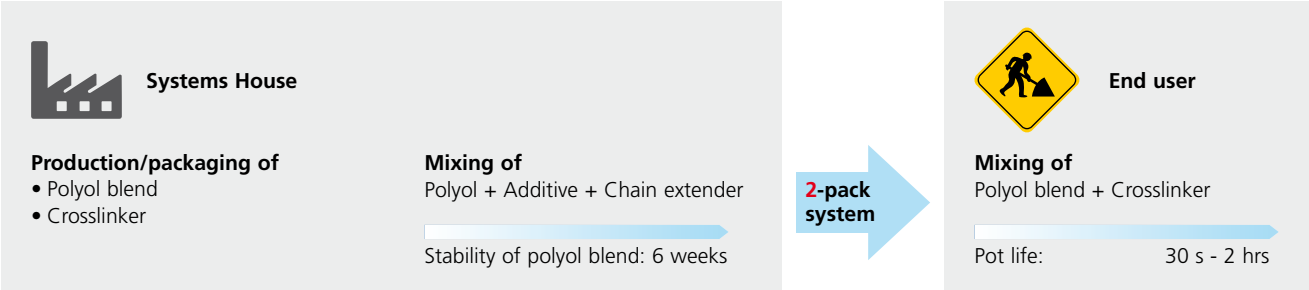


figure 17

Summary of Additive Recommendations

Additive Recommendations for Polyurethane Applications

		First recommendation	Second recommendation
Flooring/Lining	Air release	**BYK-088** **BYK-A 535**	BYK-067 A
	Viscosity reduction	**VISCOBYK-4015**	
	Flow/leveling, anti-cratering	**BYK-306**	
	Anti-settling, anti-floating	**BYK-D 410** **BYK-W 961**	BYK-R 605
	Compatibilizer	**BYK-P 9908**	BYK-P 9904
Casting systems/Electrical casting	Air release	**BYK-141**	BYK-088
	Filler stabilization	**BYK-W 969**	
	Anti-settling, anti-floating	**BYK-D 410** **BYK-W 961**	BYK-R 605
	Viscosity reduction	**BYK-P 9915**	VISCOBYK-4015
Foams	Compatibilizer	**BYK-P 9904** **BYK-P 9909**	BYK-P 9908
	Viscosity reduction	**BYK-P 9915**	

figure 18

Products and Applications

BYK Additives

Product Range Additives:

- Additives to improve surface slip, leveling, and substrate wetting
- Adhesion promoters
- Defoamers and air release agents
- Processing additives
- Rheological additives
- UV absorbers
- Viscosity depressants
- Wax additives
- Wetting and dispersing additives for pigments and extenders

Application Areas:

Coatings Industry
- Architectural Coatings
- Automotive Coatings
- Industrial Coatings
- Can Coatings
- Coil Coatings
- Wood & Furniture Coatings
- Powder Coatings
- Leather Finishes
- Protective & Marine Coatings

Plastics Industry
- Ambient Curing Systems
- PVC Plastisols
- SMC/BMC
- Thermoplastics

Printing Ink Industry
- Flexo Inks
- Gravure Inks
- Inkjet Inks
- Silk Screen Inks
- Offset Inks
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