Technical Information FL-TI 1

Solvent-borne and Solvent-free Floor Coatings

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Contents

Introduction

Across the world, increasing numbers of floors are being finished with liquid polymer coatings. They used to only be seen in warehouses and production sites, but now you'll come across them in shopping centers, schools, and hospitals. These coatings are now also available to end clients, whether they be for decorative purposes in bathrooms or to roll over the old screed in the garage.

Epoxy systems have the largest share in floor coatings. In commercial areas, the manufacture of the coatings is subject to increasingly tighter regulations, for example relating to volatile organic compounds.

For this reason, high-solid and solvent-free systems are growing ever more important. However, solvent-free systems are significantly more difficult to handle during manufacturing and application, which can be explained by their high inherent viscosity and reactivity.

Diverse additives are therefore now used which simplify system handling and make it possible to obtain more reproducible results.

Different Flooring Systems and their Properties

	Deep Sealer	Filling Primer to Even out Irregularities	Self-leveling Coating	Top Coat/Sealant (Clear Coat or Pigmented)
Coating Thickness	0.2–0.3 mm	1–6 mm	1–3 mm	0.06–0.1 mm
Coverage	≈ 0.4 kg/m² (dependent on substrate)	For 1 mm: 0.8–1.6 kg/m²	For 1 mm: ≈ 1.5 kg/m²	≈ 0.1–0.6 kg/m²
Application/ Function	Seals substrate, binds loose particles and improves the adhesion of subsequent coatings	Seals pores and levels the surface	Mechanical and chemical resistance, optical effect, conductivity, anti-static properties, anti-slip	Abrasion and scratch resistance, UV stability, optical effect, anti-slip
Systems Used	Low molecular weight epoxy systems	Solvent-free systems based on Epoxy and PU	- Solvent-free systems based on Epoxy and PU - Methacrylate systems - Aqueous epoxies	- Solvent-free systems based on Epoxy and PU - Methacrylate systems - Aqueous Epoxy or PU systems - Aqueous acrylate systems (one-pack)
Requirements	- Good substrate wetting - No foam bubbles	- Good substrate wetting - Low viscosity - Anti-settling - No foam bubbles - Good leveling	- Good substrate wetting - Low viscosity - No flooding/floating - Anti-settling - No foam bubbles - Good leveling	- Good substrate wetting - Low viscosity - No color separation - Anti-settling - No foam bubbles - Good leveling

Figure 1

Viscosity Reduction and Pigment Stabilization

As a result of their high solid content and high inherent viscosity, flooring systems tend to stabilize foam and have poor leveling properties. Many resins that are used in this area also have poor pigment-wetting properties, which frequently leads to flooding/floating, Bénard cells and color separation. Over large areas, Bénard cells in particular can be observed. These indicate poor pigment wetting and are produced as a result of turbulence, filler settling and increasing viscosity. Controlled flocculating and deflocculating wetting and dispersing additives are used to prevent this occurring.

The additives are primarily suited to highly filled primers and leveling primers. These coatings frequently contain many fillers and need good penetration properties.

Bénard Cells in a Self-leveling 2-Pack Epoxy System as a Result of Poor Pigment Stabilization

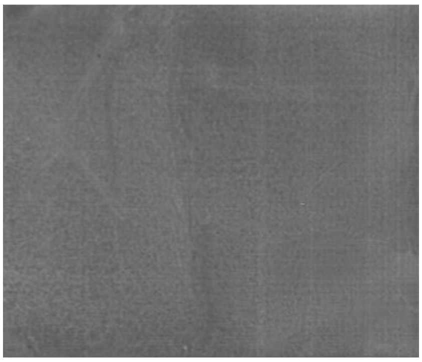


Figure 2

The Same System as in Figure 2, Stabilized with DISPERBYK-2152

Figure 3

BYK-P 104 S is suited to epoxy and polyurethane coatings.

They reduce the viscosity and also improve the anti-settling properties.

Highly filled self-leveling top coats and roller coatings also require excellent pigment stabilization of inorganic and organic pigments, as well as a high level of gloss.

Additives with aminic, pigment-affinic groups often give the best performance. However, these additives react with epoxy resins and are therefore unstable in these type of coatings.

BYK has developed an innovative additive in **DISPERBYK-2151** that is highly efficient as a result of its amine groups, but as the result of the encapsulation of these groups posess an outstanding storage stability in epoxy systems.

DISPERBYK-2152 is a product that contains solvents, yet contains the same active substance and therefore fulfills the German AgBB (Committee for the health-related evaluation of building products) specifications and the French VOC standard.

DISPERBYK-2155 and **BYK-9076** are the best choice for self-leveling polyurethane coatings.

BYK-9076 is particularly characterized by its great viscosity reduction, which is why it can also be used in primers. As a result of the strong amine character, the processing time should always be checked when using with aliphatic polyurethane systems.

The choice of wetting and dispersing agent is critical to be able to reproduce application results. The strong viscosity reduction makes defoaming easier and improves the leveling properties of flooring systems.

Anti-settling/Storage Stability

Flooring systems are especially difficult to stabilize against settling. The reason for this is the large proportion of fillers with high densities. The systems are also exposed to temperature fluctuations and shaking during transportation and storage, which can encourage settling. To prevent this, thickeners can be added to the system. However, parameters such as leveling and defoaming/air release must not be adversely affected.

To achieve this, products are used that give the systems pseudoplastic or thixotropic flow properties.

If a system possesses thixotropic flow properties, the total viscosity is already significantly reduced by low shear forces, resulting in the material displaying excellent application properties. Re-establishing the viscosity after application occurs slowly, which ensures good leveling of the coating and good air release.

Pseudoplastic products are also suitable for use in flooring systems. These are also shear-thinning, however the viscosity is re-established immediately after the shear forces have been removed. For this reason, their use requires a very low yield point as only then can sufficient air release and good leveling take place.

Ensuring good storage stability along with good defoaming and good leveling needs precise alignment with the type of additive used, and the rest of the formulation and additive components.

Good and Poor Air Release Using Different Rheology Additives

Good air release

Poor air release

Epoxy resin	42.0
Wetting and dispersing additive	0.3
Defoamer	1.0
Surface additive	0.2
Rheology additive	0.2
Quartz powder, d_{50} = 30 µm	27.0
Quartz powder, d_{50} = 20 µm	27.0

Tinting with pigment paste (carbon black/titanium dioxide), curing with cycloaliphatic polyamine

Figure 4

Liquid Rheology Additives

The BYK-410 family is based on modified ureas that are dissolved in various carriers. When being incorporated into the coating system, the additive usually precipitates within a few hours in a controlled manner forming fine, needle-shaped microcrystals. These build a three-dimensional network structure via hydrogen bonds, thereby giving the system thixotropic flow behavior. The additives in this category can be used irrespective of the chemical composition or solid composition, as long as the polarity of the system is aligned with that of the additive. By building the network structure, BYK-7410 ET prevents the settling of effect pigments, whereby their orientation in the coating can be significantly improved (Figure 5). The effectiveness is not impaired by the adding of amines.

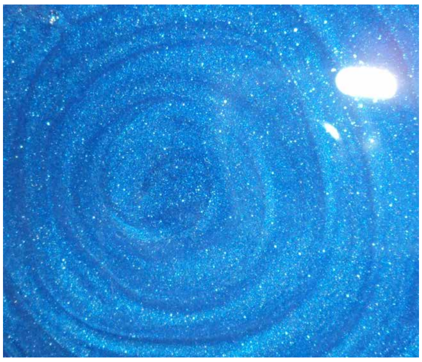
BYK-430 can also be used to prevent solids settling in highly filled systems. This urea-modified polyamide creates pseudoplastic flow behavior, which prevents solids settling during storage and following application.

Powdered Rheology Additives

Additives in this category consist of clay minerals, whose surfaces are modified in order to adapt them for use in systems of varying polarity. They are supplied as a powder and ideally converted into a pre-mixture (so-called "pre-gel") using a suitable carrier (e.g. solvent or reactive thinner), to deploy their full effectiveness. So-called "pre-activated" types also exist that can be directly incorporated. These additives include products from the **TIXOGEL** family. In the absence of shear forces, they form a three-dimensional network in the system, which increases the viscosity.

Influence of BYK-7410 ET on Effect Pigment Orientation

Without additive



With additive

Figure 5

This network can be disrupted by shear forces which causes a drop in viscosity. Once the shear forces are removed, the viscosity then slowly re-establishes.

Products from the GARAMITE family can always be incorporated directly into the formulation.

The "Mixed Mineral Technology" that forms the basis for these additives means that low shear forces and fewer additives are required during incorporation to achieve high efficiency. In addition to the ease of incorporation, GARAMITE additives are characterized by their low dusting tendency, high efficiency and high bulk densities.

Defoaming

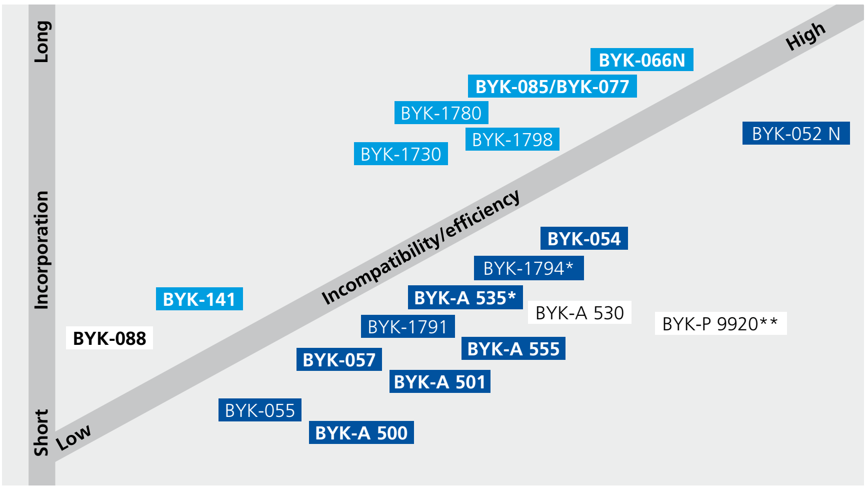
Often we refer to "defoamers" in general to describe the removal of gas bubbles from a liquid coating using an additive. However, we also frequently encounter the term "air release additive". The terminology goes hand in hand, as both mechanisms are necessary to release gas bubbles from a coating. "Air release" describes the foam bubbles contained in a liquid film fusing into larger foam bubbles. This increases their rate of ascent in accordance with Stokes' equation. We refer to defoaming once the bubbles have reached the surface, the lamella of the bubble is broken, and the bubble bursts.

In practice, it is not possible to precisely differentiate between "defoamers" and "air release additives" in the additive categories because generally both functions occur to a certain extent. For this reason and for simplicity, from now on we will only use the term **"defoamer"**.

Foam is one of the greatest challenges in flooring systems. There are many different reasons for this. Firstly, we often encounter high material viscosities that prevent the foam bubbles rising in the film. Secondly, air is introduced through high filler contents by adhering to the solid particles and sometimes being released from these too late as a result of poor dispersion, for example.

Solvent-free systems do not permit the use of solvents such as xylene to reduce viscosity or to support defoaming.

Overview of Defoamer Application



Polymer type/air release
Silicone type/defoaming
Polymer/silicone combination

Bold = First recommendation
*AgBB-compliant
**Product with reactive thinner

Figure 6

Often the foam bubbles only reach the surface when the viscosity is significantly increased and the foam bubbles can no longer burst, or once a bubble has burst it is not possible to ensure sufficient leveling.

This frequently results in self-leveling floor coatings, for example, appearing foam-free on the day of application, but a day later showing pinholes. Reaction foam in PUR systems is caused by the isocyanate reacting with water and becomes visible in the form of pinholes only after curing.

For this reason we recommend using the defoamer at an early stage in the millbase, even if the production is performed under vacuum. Frequently, the defoamer quantity is divided between different intermediate steps as the defoamer becomes too compatible in the system as a result of the powerful shear forces, thereby losing its effectiveness.

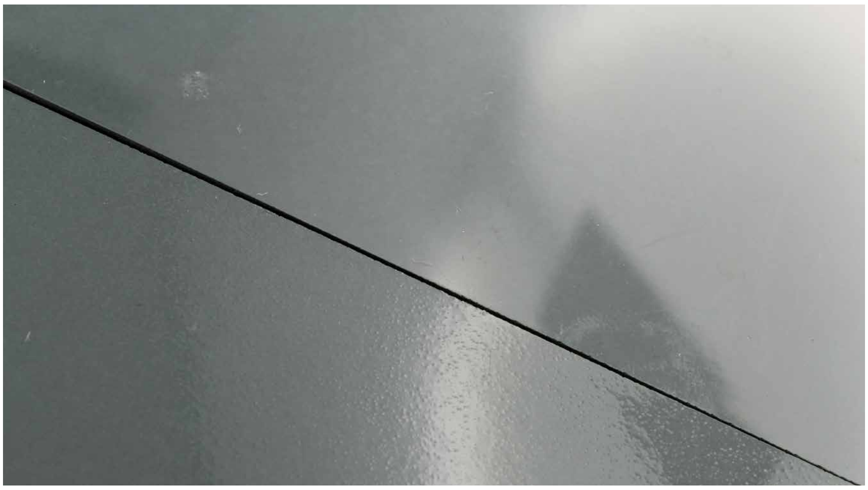
However, depending on the compatibility of the defoamers, sufficient incorporation time needs to be considered as otherwise undesirable effects such as cratering may occur.

The following summary table will help you select the right defoamer:

Selection Criteria for Defoamers

Requirement	Defoamer Selection
Pigment concentrate or co-grind	Moderately strong defoamer, silicone-free
Non-pigmented system	Compatible defoamer, based on silicone if possible (low tendency towards turbidity)
Primer (directly on concrete)	Primary effect of substrate wetting additives: the better the wetting, the quicker the air displacement/ defoaming
Roller coating	Low coating thickness, high air inclusion, therefore a medium-strength defoamer at a low dosage is recommended: Combination with BYK-3550 (reduces cratering caused by dust and foreign matter)

Figure 7



To continue achieving optimum results it is important to reduce foam-stabilizing substances (e.g. silicone leveling additives) to a minimum where possible or to avoid them entirely.

Surface Optimization

Surface defects that adversely affect the visual appearance and protective function frequently occur during and after applying a floor coating.

Typical **surface defects** are:
- Poor substrate wetting (contaminated concrete)
- Cratering
- Formation of Bénard cells, floating
- Trowel traces

A significant parameter for all defects of this kind is the varying surface tension of the materials involved and the resulting **surface tension** differences. These differences can be caused both by processes during curing (cross-linking reaction, filler settling) or be related to the application process (contaminated concrete or application equipment, dust, drips of sweat). Figure 8 illustrates common surface tension differences that may occur when using different floor coating systems.

Additives are used to avoid surface defects and to ensure adequate wetting, to selectively influence the surface tension of the coating system or to minimize differences in surface tension. Often, these products are additives based on **polysiloxanes** (silicones) and **polyacrylates** (acrylate additives).

Differences in Surface Tension of Common Flooring Raw Materials

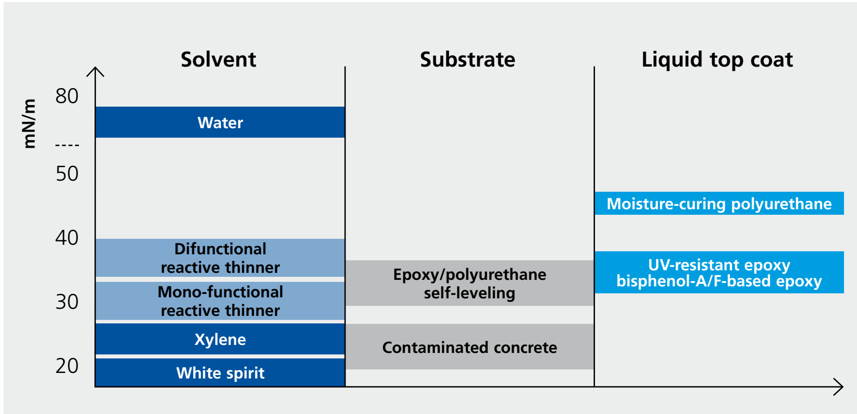


Figure 8

If large differences in the surface tension need to be balanced out between the coating system and the substrate, it is preferable to use **polysiloxanes**. They can highly reduce the surface tension of the liquid coating system and are therefore preferentially used to improve substrate wetting and as anti-cratering additives.

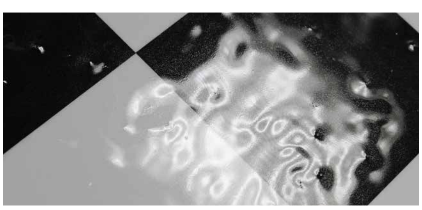
In flooring systems polysiloxane-based additives should preferably be used that have a high incompatibility with the coating system and therefore also have a defoaming effect (e.g. BYK-320).

Furthermore, silicone additives improve the surface slip of the cured coating film, which enables better cleaning and makes it more resistant to scratches.

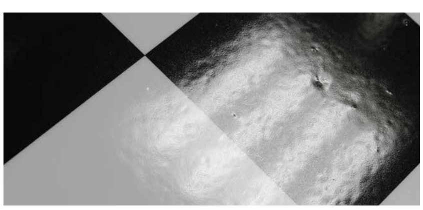
Additives from the polyacrylate category can also be used, which are able to balance out small differences in surface tension, however they only have a minimal effect on the total surface tension of the cured film and do not increase the surface slip in the cured system. For this reason they are primarily used to improve leveling.

The additive **BYK-3550** is especially recommended for floor coatings. Although it is structurally based on polyacrylate chemistry, it causes a great reduction in surface tension in the same way as a polysiloxane-based additive, however it has barely any effect on the surface slip in the cured film.

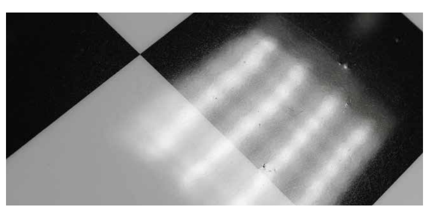
Alignment of Defoamer/Surface Additive



Control



With defoamer, surface additive incompatible



Optimum alignment of defoamer and surface additive

Figure 9

Floor Coating Glossary

Carbamate formation (amine blushing):
At low curing temperatures (below 10 °C), some curing agents tend to react chemically with the carbon dioxide and moisture in air and form carbamates, which are no longer involved in the curing reaction. In this case you can see a matt, sticky layer on the floor surface which does not adhere well to the next layer. These surface defects are sometimes like spots but can often occur as larger blemishes, particularly in the poorly ventilated or colder areas of the floor. In these cases, the suitability of the curing agent for use in cold surrounding temperatures should be checked. There are relevant curing agents that have a stronger tendency or much lower tendency to form carbamates. Surface additives that contain silicone (e.g. BYK-320, BYK-326 or BYK-333) can significantly reduce carbamate formation. It is likely that this happens as a result of a boundary layer forming on the surface, which slows down the diffusion of CO_2 into the coating.

Fish eyes:
Individually occurring, large, round, sometimes also ring-shaped spots. These are often caused by incompatible defoamers/air-release agents or by inadequate shear forces when incorporating these additives. More compatible defoamers/air-release agents or improved incorporation conditions for the defoamer can resolve the problem.

Trowel traces:
These are produced by local, varying surface tensions when working the system during curing. Often they are only visible after curing. They can be reduced by using products such as BYK-320 or BYK-3550.

Settling:
Fillers and pigments with high densities tend to sediment in all epoxy systems. Sometimes the phenomenon occurs only after adding the low-viscosity curing agent during the processing time. Additives based on modified ureas (e.g. BYK-410, BYK-7410 ET) can ensure effective anti-settling protection even at very low concentrations of 0.1–0.2 %. Specialist organophilic phyllosilicates such as GARAMITE-7305 can also solve the problem without any significant loss of gloss.

Leveling issues:
These may be produced as a result of inhomogeneity of the surface tension at the air interface or as a result of excessive pseudoplastic rheological behavior. In the first case, help is provided by surface additives that contain silicone such as BYK-320 or BYK-333, and polyacrylates such as BYK-354 or BYK-356. In the second case, viscosity-reducing wetting and dispersing additives (BYK-9076, BYK-220 S, DISPERBYK-111) can achieve significant improvement, particularly in highly filled systems. Some rheology additives (e.g. fumed silica, polyamides, hydrated castor oil derivatives, unmodified organophilic phyllosilicates) with a strong pseudoplastic character can also cause leveling problems at high dosages. In these cases we recommend using additives that are based on modified ureas (BYK-410, BYK-7410 ET) to adjust the rheological properties.

Floating/Bénard cells:
These phenomena are an indication of poor pigment stabilization. The pigments that are insufficiently dispersed then tend to separate horizontally or vertically. Controlled flocculating (BYK-P 104 S, BYK-220 S) or deflocculating wetting and dispersing additives (DISPERBYK-2152, BYK-9076) can effectively prevent these defects.

Reducing surface slip (anti-slip):
Floor coatings that offer a surface with too much slip can pose an accident risk. In these cases, high dosages of silicone additives should be avoided. Usually, the surface is interspersed with silica sand, carborundum or rubber granulate – however all these measures result in a highly textured surface. A homogeneous and not excessively smooth surface can be achieved using anti-slip wax additives such as CERAFLOUR 970.

For more information about our additives and instruments, as well as our additive sample orders please visit:

www.byk.com

Additives:

BYK-Chemie GmbH
P.O. Box 100245
46462 Wesel
Germany
Tel +49 281 670-0
Fax +49 281 65735

info@byk.com

Instruments:

BYK-Gardner GmbH
P.O. Box 970
82534 Geretsried
Germany
Tel +49 8171 3493-0
+49 800 427-3637
Fax +49 8171 3493-140

info.byk.gardner@altana.com

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