BYK
Additives & Instruments

Technical Information AS-TI 3

Wetting and Dispersing Additives for Adhesives and Sealants

Wetting and Dispersing Additives for Adhesives and Sealants

Contents

Why use Wetting and Dispersing Additives?

One of the most important steps in generating filled systems is to ensure the fine and uniform distribution of the **solid** particles/fillers in the **liquid** phase. Non-optimal dispersing can lead to numerous defects such as:

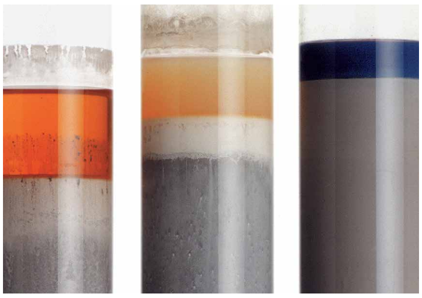
- Flocculation
- Agglomerates
- Flooding/floating
- Sedimentation

Properties relating to the **rheology** of the systems such as:

- Sagging
- Leveling

may also be negatively impacted (see figure 1).
Dispersing involves the breakdown of agglomerates. Ideally, this process progresses down to the primary particles. **Agglomerates** are collections of several particles with air and moisture trapped in between. The individual particles are in contact with each other only at the corners and edges. The forces acting between the particles are relatively weak, so they can be overcome with standard dispersion equipment. (**Aggregates,** on the other hand, are more compact in structure, have surface-to-surface contact and are much more difficult to break down into primary particles).
During **dispersing** (figure 2), energy is introduced into the system, generating smaller particles that have a larger interface with the binder.
The system strives to transition from a state of high energy back to a state of lower energy: the finely distributed particles cluster back together to form flocculates. This manifests itself, for example, by flooding/floating, sedimentation and altered rheology. These **flocculates** are very similar in structure to the agglomerates. The interstices between the particles, however, are filled with binder instead of air.

Possible Defects


Sedimentation

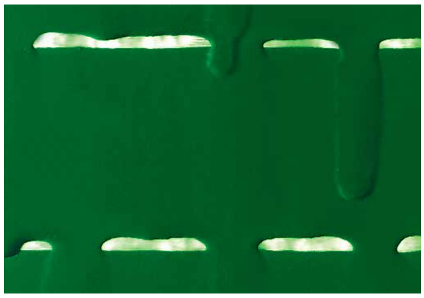

Sagging

figure 1

Pigment Dispersing

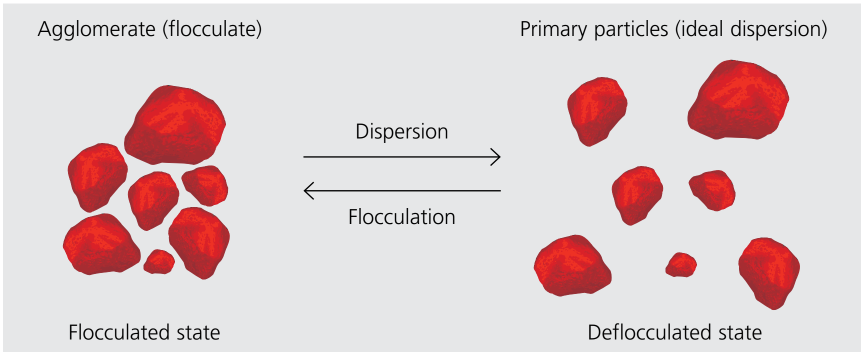


figure 2

The Dispersing Process

Wetting and Dispersing Process

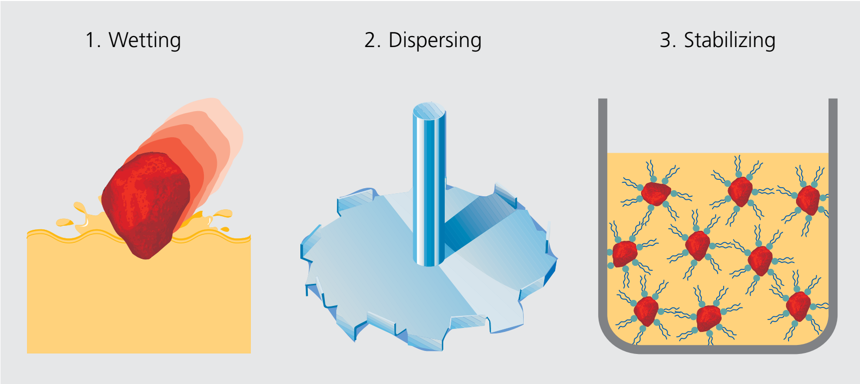


figure 3

The dispersing process can be divided into three phases (figure 3): In **Step 1,** the air and moisture on the surface of the particles are displaced and replaced by the binder. The solid/gas interface (particle/air) is converted into a solid/liquid interface (particle/binder). For this purpose, the binder must penetrate into the interstices of the agglomerate. The actual dispersing of the particles occurs in **Step 2.** By introducing mechanical energy (impact and shear forces), the agglomerates are broken up to reduce their particle size. In the final **Step 3,** the particle/filler dispersion must be **stabilized** to prevent uncontrolled flocculation. By utilizing suitable methods described in further detail below, the individual particles can be kept apart, so that they do not cluster together. Stabilization of the deflocculated state is the ideal approach for most applications. In some cases, however, particle dispersion may also be stabilized by controlled flocculation, as described further below. Step 1 (wetting) and step 3 (stabilizing) can be influenced by additives. **Wetting additives** accelerate the binder wetting of the agglomerates. **Dispersing additives** improve the stabilization of the particle dispersion. In many cases, one and the same product acts both as a wetting and a dispersing additive.

Dispersing Additives

Dispersing additives adsorb to the surface of the solid/filler, keep the particles apart by **electrostatic** repulsion and/or **steric stabilization,** and therefore reduce the tendency for uncontrolled flocculation. Both stabilization methods will be discussed in more detail below.

Electrostatic Repulsion

The particles in the liquid adhesive carry electric charges on their surfaces. Additives enable these charges to be **augmented** and ensure that all particles have **like** charges. Counterions concentrate near the particle surface in the liquid phase, resulting in the formation of an **electrical double layer** (figure 4). The thicker this layer, the better the stabilizing effect. This stabilization mechanism based on electrostatic repulsion forces between the individual particles is particularly used in aqueous dispersion systems. The dispersing additives used in this case are polyelectrolytes, in a chemical sense. In other words, they are high molecular weight compounds with multiple electrical charges in their side chains. Due to their chemical structure, the wetting properties of these additives are usually limited. This is why they are combined with wetting additives as needed.

Steric Stabilization

Dispersing additives that have steric stabilization properties are characterized by two distinct structural features: The first feature of these products consists of one or several so-called **"particle-affinic groups"**, which are anchor or adhesive groups that enable firm and long-lasting adsorption to the particle surface. The second distinct feature consists of **binder-compatible chains** (hydrocarbon groups) that protrude as far as possible from the particle after the additive adsorbs to the particle surface and extend into the surrounding binder. This layer, consisting of the adsorbed additive molecules with the protruding chain groups, prevents the particles from coming in direct contact with each other, and therefore effectively impedes flocculation. This effect is known as steric or entropic stabilization (figure 5). Stabilization is further enhanced by the fact that the polymer segments of the additive molecules interact with the polymers of the binder and, in doing so, enlarge the particle surface coat even more. In addition to perfect stabilization, the use of dispersing additives significantly reduces viscosity.

Controlled Flocculation

If the particle-affinic groups are not exclusively limited to a tightly confined area within the molecule, but are properly distributed across the molecule, they can function as a bridge between distinct particles. The additive may be used in this case to build three-dimensional networks: **particle flocculates**. The size and stability of these flocculates is determined by the additive, that is, by the additive-additive and additive-particle interactions. This therefore represents a type of flocculation **controlled** by the additive, in which the degree of flocculation is determined by the chemical structure and the dosage of the additive. In this structure the individual particles also remain separated from each other (by additive molecules). This type of stabilization leads to properties that are distinct from the solid particles deflocculating. The mechanism of action via the three-dimensional network results in particle stabilization and thereby prevents the sedimentation of the heavy filler/solid particles.

Electrostatic Repulsion

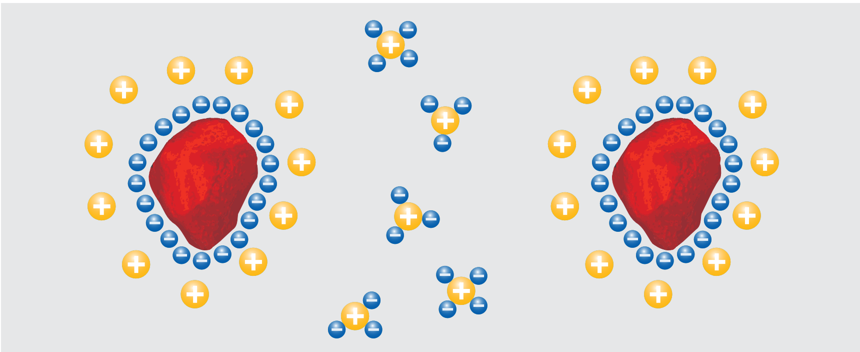


figure 4

Particle Stabilization by Steric Stabilization

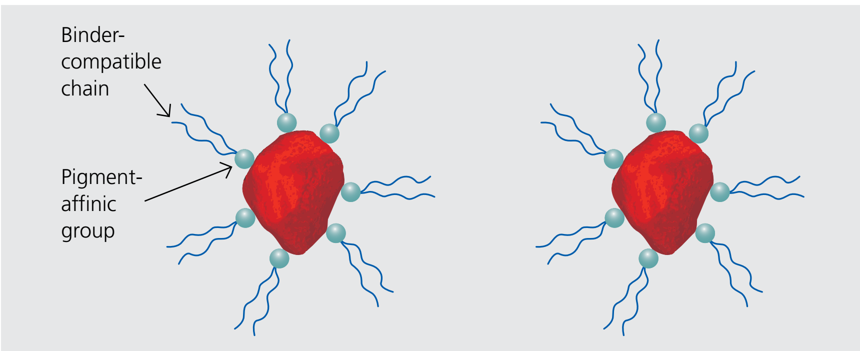
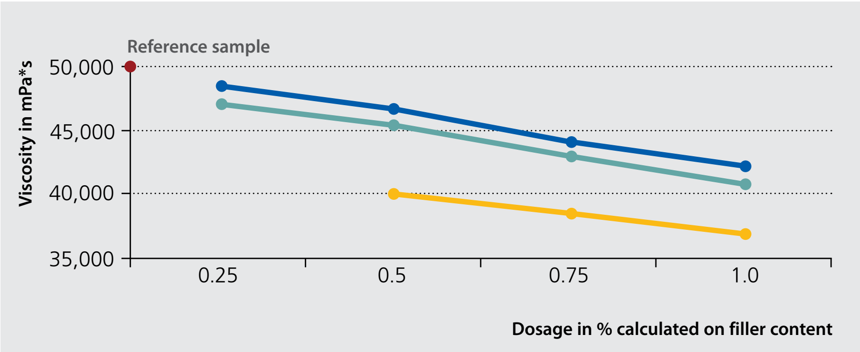


figure 5

Why use Dispersing Additives in Adhesive Formulations?

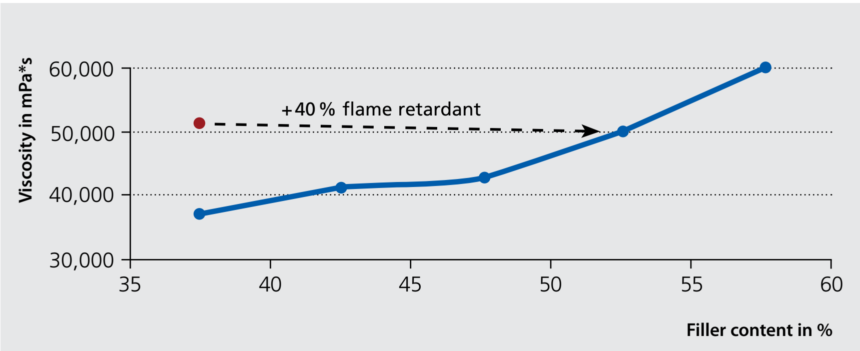
Pronounced Reduction in Viscosity in Mineral Filled, Reactive 2-K Epoxy Resin Adhesive



BYK-W 995 BYK-W 996 BYK-W 985 Reference sample, no additive figure 5

Filler: Calcium carbonate, 5 µm
Binder type: DGEBA, Epikote 828
Brookfield Viscosimeter, 20 rpm

Increase of the Proportion of Flame Retardant at the Same Viscosity



Wetting and dispersing additive included Reference sample, no additive figure 6

Dosage: 2 % BYK-W 996 calculated on filler content
Binder type: DGEBA, Epikote 828
Brookfield Viscosimeter, 20 rpm

Many adhesive systems use fillers and also pigments. Mineral fillers have the tendency to sediment due to their high density. They must therefore be sufficiently protected from reagglomeration and sedimentation.

The following are typical fillers/ pigments used in adhesives:
- Calcium carbonate
- Aluminum trihydroxide
- Silicic acids
- Metal oxide powder
- Carbon blacks

High filler and pigment contents in formulations result in high viscosities that hamper subsequent processing (e.g. pumps) and the application of the adhesive. Without the correct additive, phase separation occurs during storage, that is, a hard precipitate forms that shortens the shelf-life of the finished adhesive product.
This is where wetting and dispersing additives make a difference. They optimally disperse and stabilize the solids while reducing the viscosity.

Advantages of Using Wetting and Dispersing Additives in Reactive Adhesives

Reduction of Viscosity

The use of additives can significantly reduce the viscosity of filled adhesive systems. Viscosity can typically be reduced by roughly 30-50 % (see figure 5). Some formulations must have a high filler content or contain very fine particles for performance or cost reasons. The implementation fails in this case due to excessive viscosity, since the adhesive or sealant cannot be processed or applied. In this case, wetting and dispersing additives enable new types of adhesives or sealants to be formed.

Increased Filler Content at the same Viscosity

An additional advantage of additives is the technological improvement in adhesive properties by increasing the content of filler while maintaining the same viscosity. The decreased viscosity from the first step opens up the possibility of significantly increasing the content of filler while maintaining the same viscosity (see figure 6). Examples of performance advancements include:

- improved flame retardant properties due to higher flame retardent content, e.g. ATH
- improved thermal conductivity due to higher content of metal oxide powder content, e.g. Al_2O_3
- improved mechanical properties due to higher content of reinforcing filler content

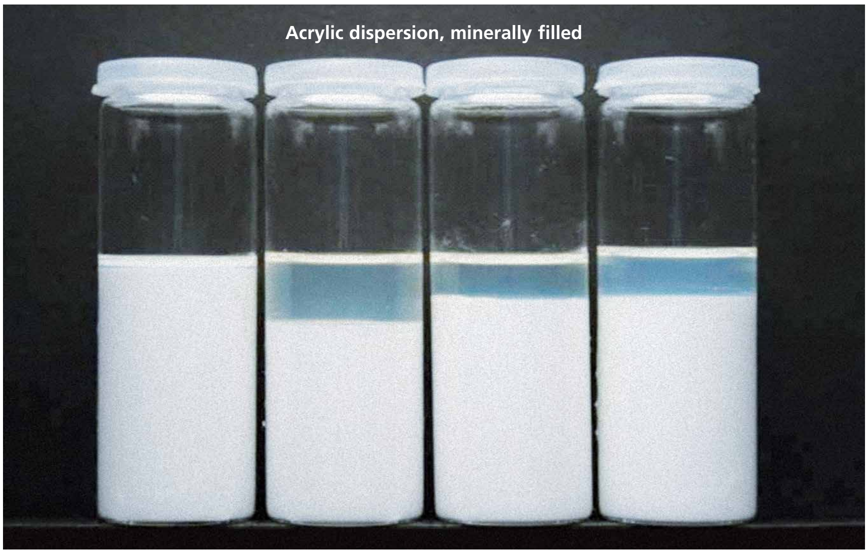
Improved Storage Stability and Easier Handling

Filled systems have a tendency to settle or separate into phases during storage. Optimum dispersion and stabilization can prevent settling and phase separation (see figure 7). Additives causing controlled flocculation create a three-dimensional structure that stabilizes the particles. This results in improved storage properties and a longer shelf-life. The adhesive is more user-friendly since it no longer has to be stirred and homogenized prior to use. Figure 8 provides an overview of recommendations on wetting and dispersing additives for reactive adhesives and sealants.

Wetting and Dispersing Additives for Aqueous Adhesives

The additives available for aqueous adhesives and sealants are similar to those discussed for reactive adhesives. BYK-154 and DISPERBYK-199 are the first choices for targeted viscosity reduction. ANTI-TERRA-250 is recommended if a slight reduction in viscosity is desired while preventing settling at the same time. This product leads to the generation of a three-dimensional network by controlled flocculation, which stabilizes the filler particles and prevents the formation of a hard precipitate (see figure 9).

Outstanding Anti-settling Properties in Aqueous Adhesive Systems



ANTI-TERRA-250 | Deflocculating additive | Na^+ Polyacrylate | NH_4^+ Polyacrylate

figure 7

Recommendation Table – Wetting and Dispersing Additives for Reactive Systems

	Viscosity Reduction	Viscosity Reduction and Anti-settling	Anti-settling
PUR	**BYK-W 969** **BYK-W 985** BYK-9076* DISPERBYK-118 DISPERBYK-2152*	**BYK-W 980** BYK-W 966	**BYK-W 961** BYK-P 105*
Epoxide	**BYK-W 985** BYK-W 969 BYK-W 996 BYK-W 9010* DISPERBYK-118 DISPERBYK-2152*	**BYK-W 980** BYK-W 966	**BYK-W 940**
Acrylates	**BYK-W 969**	**BYK-W 980** BYK-W 966	**BYK-P 105*** BYK-W 940

	Inorganic Fillers and Pigments	Organic Pigments and Carbon Black
UV-Systems	**BYK-W 9010***	**DISPERBYK-168** BYK-9077* DISPERBYK-2008*

* >94 % non-volatile components

First recommendation Second recommendation

figure 8

Recommendation Table – Wetting and Dispersing Additives for Aqueous Systems

Inorganic Fillers and Pigments:

Viscosity Reduction	Viscosity Reduction and Anti-settling
BYK-154 **DISPERBYK-199** DISPERBYK-2015	**ANTI-TERRA-250**

Organic Pigments and Carbon Black:

DISPERBYK-191* DISPERBYK-2015

* >94 % non-volatile componentse

First recommendation Second recommendation

figure 9

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

www.byk.com

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