

Jan Lenz, BYK Additives & Instruments, discusses how reactive adhesives and sealants by means of wetting and dispersing additives can be technically improved

Improving the performance of reactive adhesives

Reactive adhesives and sealants cover a wide range of chemistries, such as epoxy, polyurethane, acrylic, silicones and silane-terminated polymers, to mention only a few important examples. Their usage ranges from transportation, building and construction to assembly operations. In other words, the reactive adhesives and sealants can be found in a broad chemical variety and in a lot of different applications. Because of their 'solvent-free' or '100%' character, these systems are gaining increasing importance nowadays. Joining different components by means of reactive adhesives has become an integral part of today's modern industry. This innovative way of bonding elements is increasingly taking the place of the classic methods, such as welding, screwing or riveting.

Besides all their differences described above, what all of the reactive adhesives and sealants have in common is that their formulations do contain some kind of inorganic filler or particle. These inorganic materials might include classical calcium carbonate as a filler, different kinds of silicas such as fumed silica or quartz, flame retardants such as aluminium trihydroxide, metal powders or carbon black.

All these fillers need to be dispersed in the first phase but in a second phase they also need to be sufficiently stabilised against reagglomeration and sedimentation.

In some cases the formulator wants to add a high amount of functional filler to achieve a specific performance such as flame retardancy or thermal conductivity. The addition level of the functional filler is often limited by the strong increase in viscosity, as shown in **figure 1**. At the necessary dosage level of the filler, the adhesive is so high in viscosity that it cannot be processed or applied.

The use of wetting and dispersing additives will lead to

reduced viscosity, with easier handling and processing. This will enable the formulator to improve the technical performance of his adhesive. A higher content of, for example, flame retardants to achieve a better fire classification or silica to acquire mechanical properties is possible. Cost benefits can also be achieved by adding more filler at the same viscosity level.

Phase separation or filler sedimentation is an issue, which regularly arises in filled systems. This causes handling problems because customers need to mix the product again before they can use the adhesive. The storage stability is often reduced, which results in a reduced shelf life. The right choice of wetting and dispersing additives achieves a perfect stabilised system without separation or sedimentation problems.

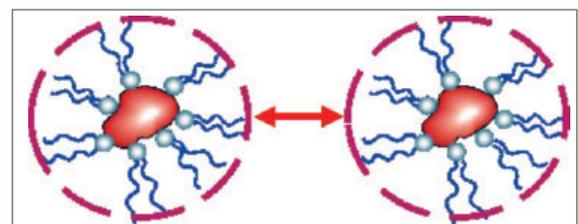
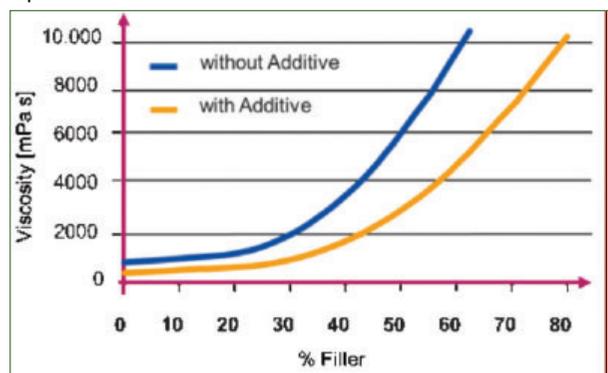
WORKING MECHANISM OF WETTING AND DISPERSING ADDITIVES

Wetting and dispersing additives can be differentiated based on their working mechanism. There are deflocculating additives, which lead to a strong reduction in viscosity. These additives are linear in structure and have a filler or pigment affinic group and a resin compatible group. For most of the inorganic materials used in adhesives and sealants, an acidic group is very suitable as a filler affinic part. The resin compatible group can be chosen from alkyl, polyurethane, polyether or polyester. The additive keeps the filler particles at a distance and reduces the interactive forces between different particles. This results in a lower viscosity of the system. **Figure 2**.

With regard to anti-settling properties, the molecular structure of the additives is different. The additives have not just one filler affinic group but are multifunctional. As a consequence, the additive builds up a network structure with other additive molecules and this leads to a controlled flocculated state to create anti-settling properties. **Figure 3**.

Fig 1. Below left: The amount of functional filler is limited by the increase in viscosity

Fig 2. Below right: The additive keeps filler particles at a distance and reduces interactive forces between different particles



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Additives

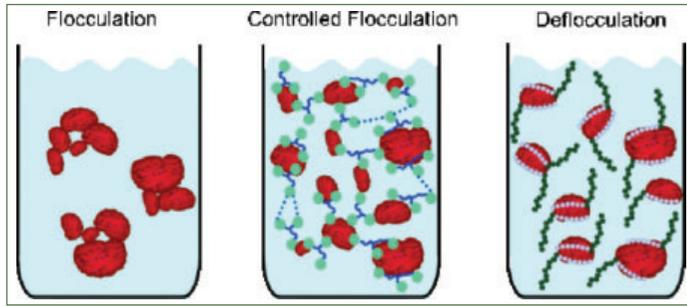


Fig 3. The additive builds up a network structure with other additive molecules, which leads to a controlled flocculated state

Fig 4. A viscosity reduction of about 40% was possible following the addition of 1% wetting and dispersing additive

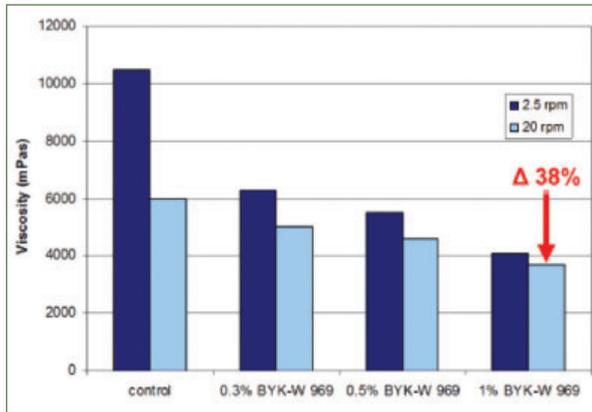


Above: Standard formulation
Below: With BYK-W 961 (1% based on filler)



Fig 5. Below: The dosage of the wetting and dispersing additives is based on the filler amount

Fig 6. Below right: Using wetting and dispersing additives, it is possible to add 40% more ATH filler and keep viscosity constant



VISCOSITY REDUCTION

The following examples are giving an overview of the results that are achievable in terms of viscosity reduction for reactive adhesives and sealants.

The first example is a calcium-carbonate-filled polyurethane adhesive. The filler dosage was 40% of Omycarb 5GU added to the polyol. The dosage of the wetting and dispersing additives in figure 4 is based on the filler amount. Viscosity was measured by Brookfield viscometer.

By adding 1% of wetting and dispersing additive based on the filler, a viscosity reduction of about 40% was possible. This reduction is a typical value and most of the additives work with a large variety of inorganic fillers, such as calcium carbonate, quartz or aluminium trihydroxide (ATH).

The second example is a Bisphenol A Epoxy (Epikote 828) filled with a very fine aluminium trihydroxide filler. Viscosity was again measured by Brookfield.

The control without any wetting and dispersing additive is close to 50,000mPa*s. The dosage of 2% wetting and dispersing additive calculated on the amount of ATH gives a vis-

cosity of around 33,000mPa*s, which is 35% lower. Figure 5.

As described above, often it is necessary to add more flame retardant to achieve a better performance. To answer the question 'How much more can you add without increasing the viscosity?', we took the above test system and the most efficient wetting and dispersing additive. The starting point was 37,5 parts of ATH to 100 parts Epikote 828. The next step was to add the wetting and dispersing additive which reduces the viscosity. We then increased the amount of ATH gradually to return to a viscosity level exhibited by the initial sample without additive.

As a result of the use of wetting and dispersing additives, it is possible to add 40% more ATH filler and keep the viscosity constant, figure 6. The higher content of flame retardant will improve the final performance of the system. This benefit can be transferred to other systems, such as metal powder for thermal conductivity or filler for cost reasons.

ANTI-SETTLING

Due to the high density of the inorganic filler there is a strong tendency for sedimentation. In this case the focus is to stabilize the filler particles and avoid the settling.

As an example, we cite a 2K PUR adhesive where the polyol is filled with about 50% of an Omycarb 5GU. The sample without additive shows a strong tendency for phase separation after storage.

This is often a problem, especially in bigger containers, and customers would need to mix the container before they can use the adhesive. By adding a controlled flocculating wetting and dispersing additive it is possible to avoid the phase separation and settlement of the filler. This gives the formulator more freedom and improves the handling and processing of the adhesive at customer level.

CONCLUSION

The use of wetting and dispersing additives in reactive adhesives and sealants gives more freedom to the formulator. The technical performance of adhesives can be improved by adding more functional filler and keeping the viscosity constant. Cost benefits can be achieved with higher filler loadings. Furthermore, the controlled flocculating wetting and dispersing additives provide anti-settling properties and avoid filler sedimentation or phase separation. This eases the handling and application of adhesives.

