

ADDITIVES IN ADHESIVE FORMULATIONS

Wetting Agents – boon or bane?

Although additives are the smallest component of an adhesive formulation, they have a significant influence on its overall properties. The impact of additives is often in inverse proportion to the amount of additive used. Whether an additive is boon or bane depends primarily on the overall formulation of the adhesive in question. In order to find out in more detail about the effect of additives and, in this case, wetting agents in particular, extensive studies were carried out using water-based pressure-sensitive adhesives.

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Pressure-sensitive adhesives or PSAs are traditionally used on labels, including paper labels and clear labels, Figure 1, which are made from plastic film. Other important uses for PSAs include adhesive tapes and a wide range of graphical applications.

One factor that all these applications have in common is a specific requirement relating to the end performance of the adhesive system, which is determined to a large extent by the polymer used, but also by the choice of additives. In order to use additives effectively, extensive expertise and in-depth knowledge of adhesive formulation is needed. This helps to ensure that the properties of the additive are a boon and not a bane.

The classic additives for PSAs include defoamers, wetting agents, thickeners, UV stabilisers and antioxidants. To find out more about the influence of wetting agents on the different properties of adhesives, a study was carried out into general properties, such as foaming ten-



Figure 1: Pressure-sensitive adhesives are traditionally used on labels, including paper labels and clear labels made from plastic film.

dency, water resistance and wettability, together with specific adhesive properties, such as adhesion, cohesion and tackiness.

The important question for all PSA manufacturers with regard to wetting agents is whether they have a negative impact on adhesive strength. For example, in the production of transfer labels, good wetting on a silicone-coated substrate is required. However, if the bond with the substrate to which the label is being applied is not sufficiently strong,

then the supposed boon quickly becomes bane.

What are wetting agents?

Wetting agents are surface-active substances, which, in simple terms, consist of a hydrophilic and a hydrophobic segment, Figure 2.

For the purposes of the study, the wetting agents were divided into four different groups, on the basis of the chemical classification of the products and the structural differences between them, Figure 3.

Wetting Agent	Surface tension 0.1% in water [mN/m]	
	Static	Dynamic
Sulphosuccinate	32	51
Alcohol-alkoxyolate	29	42
Organommodified siloxane	21	54
Gemini surfactant	20	51

Table 1: Surface tension of the surfactant groups used

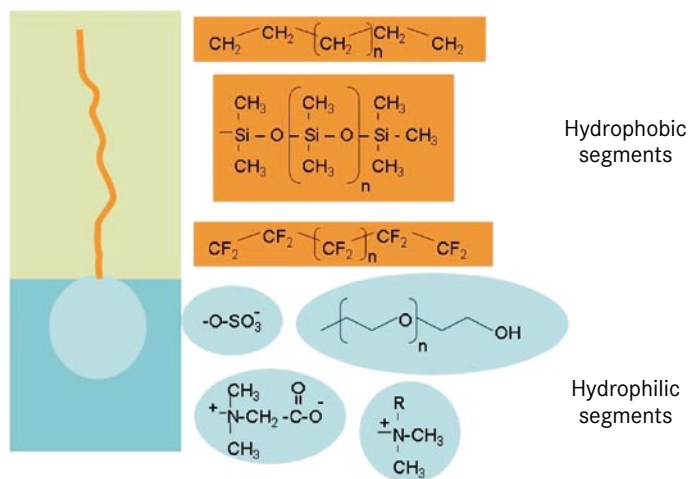


Figure 2: General surfactant structures

General properties

As a part of an initial general study, the influence of the above-mentioned groups of wetting agents on the wettability, foaming behaviour and water resistance of adhesives was investigated, Figures 4 to 6.

Sulphosuccinates are a type of surfactant that is cost-effective and widely used in PSAs. Frequently, substances of this kind are used not only in the adhesive formulation, but also in the production of the adhesive dispersions. Therefore, in many cases, sulphosuccinates are already present in the dispersions in the form of emulsifiers, for example. The wetting behaviour of these products in formulations is satisfactory, provided that the requirements on the adhesive are not too demanding. For example, on machinery that operates at high speed, the pronounced foaming behaviour of sulphosuccinates can result in problems with the adhesive application. In addition, adhesive films which use sulphosuccinate additives often have very low levels of water resistance.

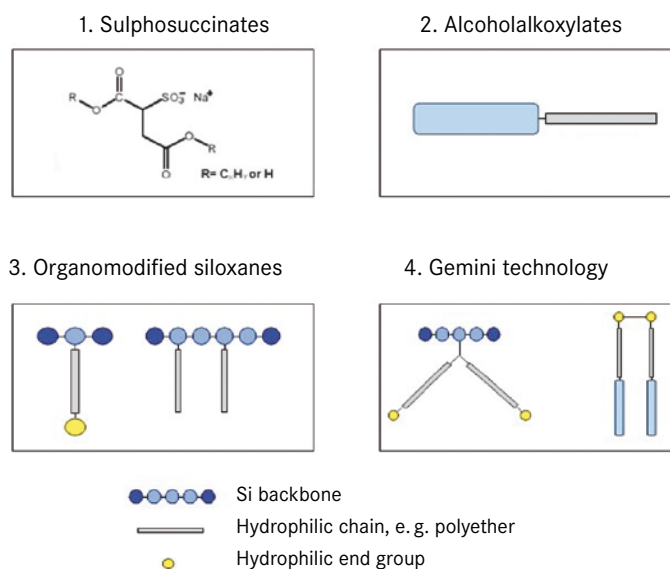


Figure 3: Classification of the wetting agents used

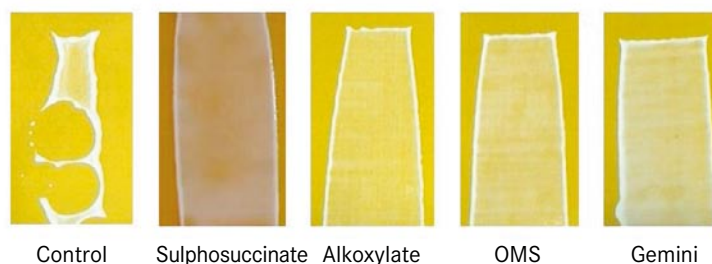


Figure 4: Wetting behaviour on silicone-coated surfaces (coating thickness: 50 μm , wetting agent concentration: 0.6 %)

In contrast, alcoholalkoxylates with an optimized structure form hardly any foam and have no impact on the water resistance of the adhesive. They also show good wetting behaviour. Another characteristic feature of these surfactants is the steady decrease in dynamic surface tension, Table 1. This means that, even in the case of systems that rapidly form new surfaces, such as curtain coatings, these products offer significant benefits.

Organommodified siloxanes, like alkoxyates, have only a limited influence on the water resistance of water-based adhesive formations and show only a moderate tendency to produce foam. Their major advantage is the very significant reduction in surface tension, which makes them particularly suited to wetting low-surface-energy substrates. Using organommodified siloxanes, static surface tension can be reduced to levels as low as 21 mN/m.

Gemini surfactants are not a special chemical class of wetting agents. Instead, the term is used to describe a specific surfactant structure, which is like that of a pair of twins, with two identical parts. This type of product has very good wetting behaviour and does not affect the water resistance of the adhesive. With regard to foam formation, Gemini surfactants are also referred to as foam-suppressing surfactants. As a result, these products offer 2-in-1 performance, with wetting properties on the one hand and defoaming properties on the other.

One further property of Gemini surfactants that has already been described in the relevant literature is their low critical micelle concentration (CMC), which is the result of their special structure. A low CMC means that these products can be used at very low concentrations with high levels of effectiveness. They therefore have a very good price/performance ratio.

An overall consideration of the wetting and foaming behaviour and the impact on water resistance of each class of

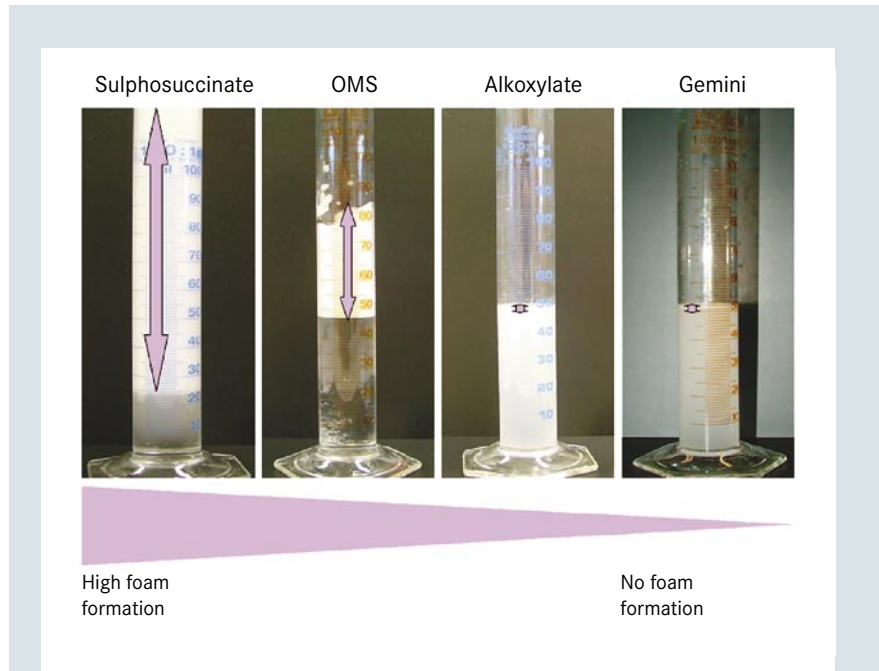


Figure 5: Foaming behaviour of the wetting agents in water (wetting agent concentration: 0.6 %)

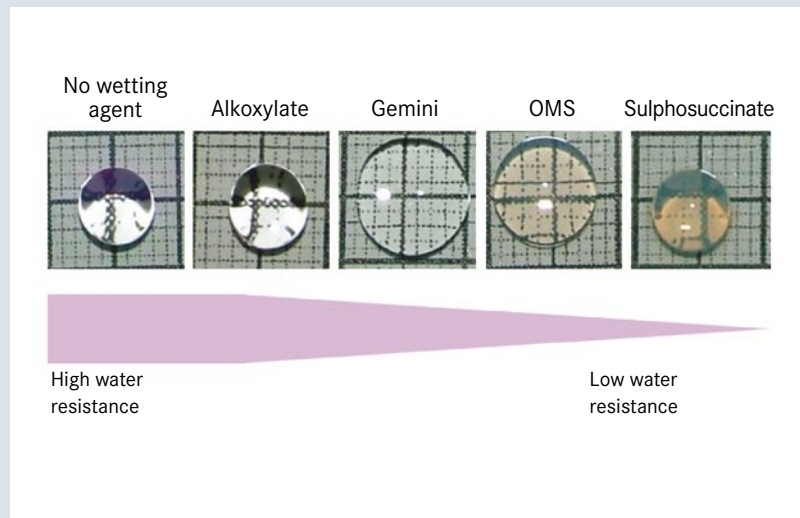


Figure 6: Water resistance of adhesive films with 0.6 % wetting agent

surfactant allows suitable products with an ideal property profile to be identified in each class of wetting agents for a wide range of applications.

Impact on adhesive strength

The next step is to consider the influence of the individual wetting agents on the strength of the adhesive.

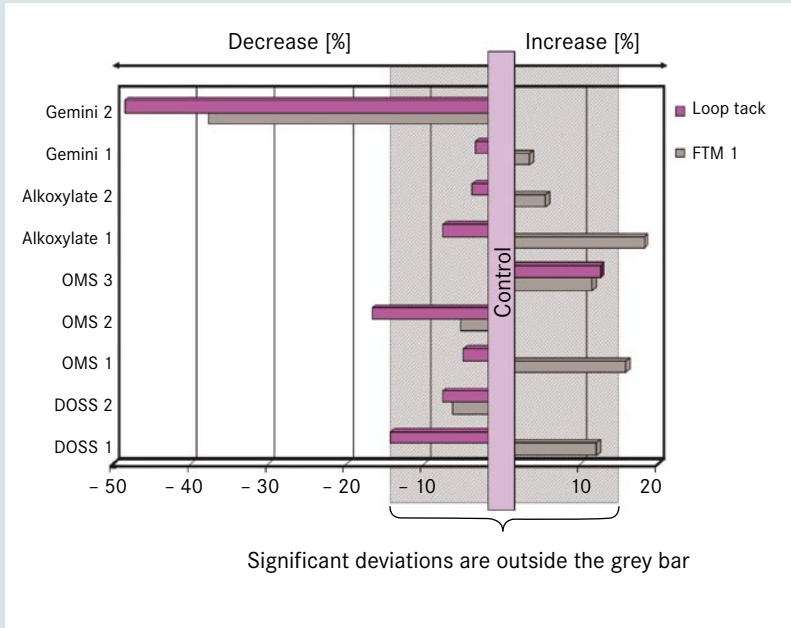


Figure 7: Influence on the adhesive strength of a paper label adhesive without tackifiers. Deviations shown in [%] of the blank value.

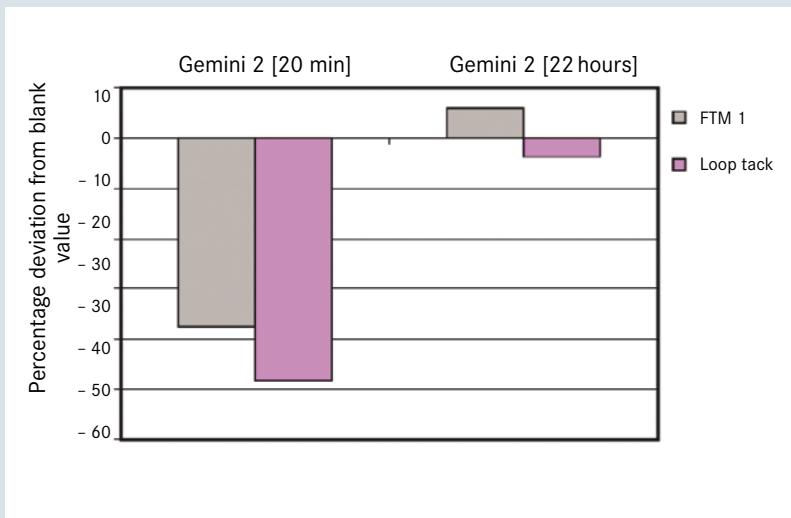


Figure 8: Influence on the adhesive strength using Gemini 2 after 20 minutes and 24 hours.

sive, initially without added tackifiers, was mixed using 0.6% of the above-mentioned wetting agents. The bond was then measured using FTM 1, 8 and 9. In the case of the adhesive dispersion without tackifiers, Figure 7, the majority of the additives only have a minor influence on the adhesive strength. In this system, none of the additives have any impact on the cohesion. Alkoxylate 1 and OMS 1 bring a significant increase in adhesion. This is the result of improved wetting in the microstructure area, because all of the adhesive films had the same appearance. Gemini surfactant 2 caused a reduction in adhesive strength. The measurements were made after 20 minutes storage time following the bonding of the labels onto glass. When the same measurement was made after a storage time of 24 hours, the effect could no longer be identified, which means that there was no remaining impact on the adhesive strength, Figure 8. A short-term effect of this kind is a positive feature in the case of repositionable labels or protective films.

PSA dispersions generally include tackifiers added in order to increase the tackiness of the systems. In many cases, tackifiers are used in dispersions that also contain surfactants and wetting agents. What effect does the combination of a tackifier and the added wetting agents have on the adhesive strength?

Figures 9 and 10 show that generally where there is a combination of adhesive dispersion and tackifier, the wetting agents can have an influence on the adhesive strength in terms of loop tack and adhesion. However, it is important to note that simply replacing the tackifier can give completely different results. It is therefore not possible to say in general terms that wetting agents have a negative impact on the adhesion or the loop tack. The correct conclusion to draw is that by carefully choosing the combination of wetting agent and tacki-

The best water-resistant adhesive is worse than useless if the label does not remain stuck to the shampoo bottle. FI-NAT test methods (FTM) 1 for adhesion, 8

for cohesion and 9 for tackiness were used to investigate the adhesive strength.

One example of this is the result of using a paper label adhesive. The adhe-

fier, it is possible to achieve the required adhesive strength.

The effects shown in Figures 9 and 10 can be explained by the fact that the wetting agents, depending on the surfactant composition of a PSA dispersion, are arranged differently in the dried film of adhesive and therefore result in different loop tack and adhesion figures.

When this is compared with the influence on the cohesion, some highly interesting positive changes can be observed, Figure 11.

Cohesion can be significantly increased by the use of tackifiers and the choice of the appropriate wetting agent. This is demonstrated, for example, by the use of OMS 1 in combination with both tackifiers. It is also interesting to note that the same wetting agent in the same dispersion can produce completely different results when used with different tackifiers. This is clear from the two sulphosuccinates (DOSS 1 and DOSS 2) in Figure 11. It is once again evident that the influence on the adhesive strength is the result of the interaction of the different surfactants. This interaction affects the film formation behaviour and therefore the corresponding values for adhesion, cohesion and tackiness. A thorough knowledge of the way in which wetting agents and surfactants work and the opportunity to make the appropriate measurements will allow the best wetting agent for a particular application to be identified.

Summary

In many cases, the use of wetting agents in adhesive formulations is avoided wherever possible. However, the need to process PSA dispersions with machines that operate at increasing speeds makes the use of wetting agents essential. It is very important to ensure that this has no impact on the fundamental properties of the adhesive dispersion, such as its water resistance or foaming behaviour. However, the crucial point is

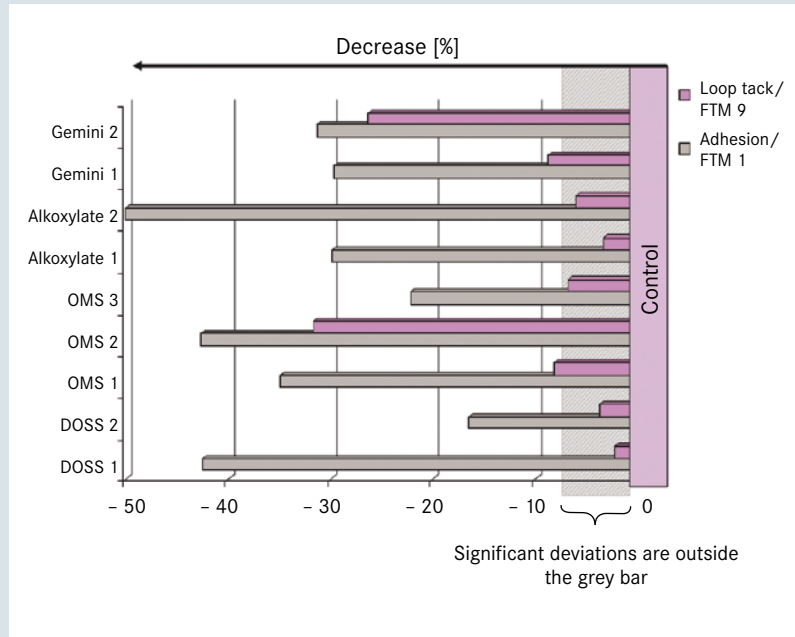


Figure 9: Influence on the adhesive strength of a paper label adhesive using tackifier no. 1. Deviations shown in [%] of the blank value.

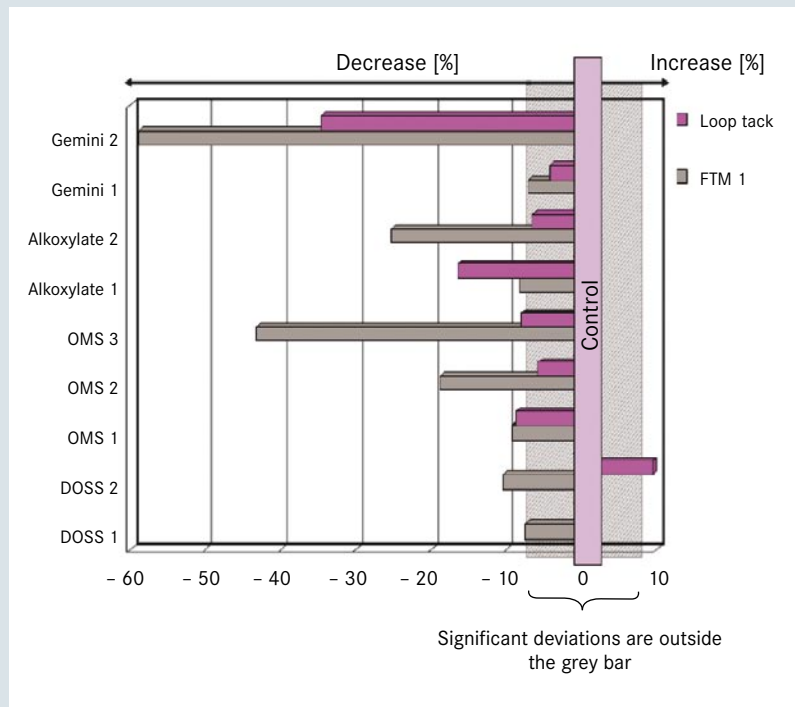


Figure 10: Influence on the adhesive strength of a paper label adhesive using tackifier no. 2. Deviations shown in [%] of the blank value.

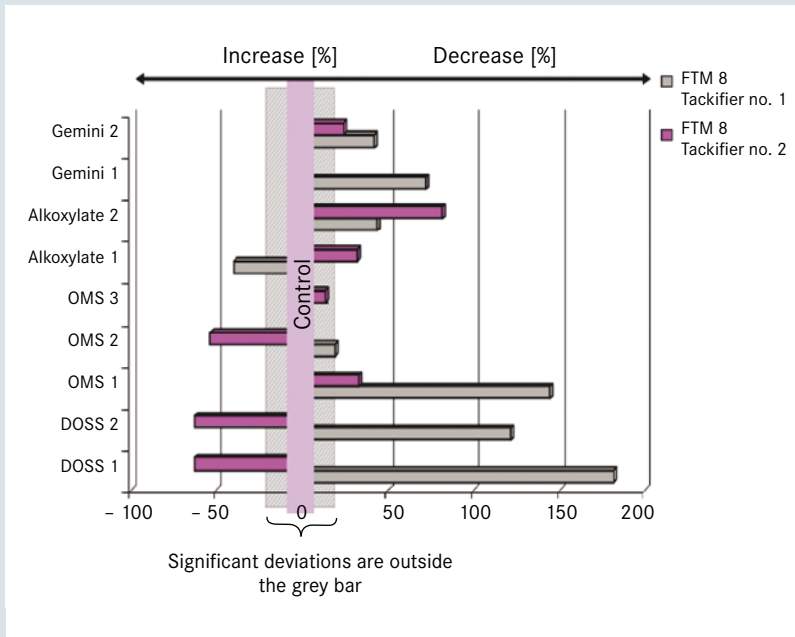


Figure 11: Influence on the cohesion of a paper label adhesive using tackifier no. 1 and no. 2. Deviations shown in [%] of the blank value.

that the wetting agent must not influence the adhesive properties, in other words the adhesion, cohesion and tackiness.

The studies clearly showed that wetting agent classes such as Gemini surfactants or organomodified siloxanes in particular have very interesting property profiles because of their specific structures. Alongside their excellent wetting properties, they also produce very little foam. The Gemini surfactants even have foam-suppressing properties. Even classic organic surfactants, such as alcoholalkoxylates, have a number of potential uses in particular in the case of difficult application methods, for example, curtain coating.

These investigations prove that wetting agents do not have a negative influence on adhesion, cohesion and tackiness. It is possible to choose a suitable wetting agent for a particular application from among the different

product groups. However, there is unfortunately no single surfactant that represents the perfect solution for every dispersion.

Overall, it is important to realise that none of the classes of surfactants should be assumed to be unsuitable for adhesive dispersions. By contrast, the choice of the right surfactant will allow any adhesive formulation to be adapted to meet the requirements in question. ■

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