WATER-BORNE REMOVABLE PRESSURE SENSITIVE ADHESIVES – CHALLENGES AND NOVEL TECHNICAL CONCEPTS

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1. Introduction

Today solvent-borne adhesives still play a major role in removable PSA markets. However, ecological and toxicological concerns as well as cost pressure (price increase of organic solvents) make water-borne adhesives become more and more attractive. In this paper novel technical concepts will be discussed that boost the performance of water-borne PSA to the level of solvent-borne removable adhesives.

2. Removable PSA for filmic carriers – graphic arts

In the graphic arts industry removable adhesives have shown an explicit growth in recent years, e.g. for short term advertising applications of self-adhesive printed PVC films.

Fig. 1: Typical graphic arts application

Important technical demands for easily removable graphic arts adhesives are:

- Little or no whitening, if the adhesive film is getting into contact with water
- A high resistance to monomeric phthalates, which are used to plasticize the PVC films; no severe reduction of adhesion and cohesion by the action of plasticizer
- Peel strength on glass after 1 min, 20 min and 24 h should be in the range of 0.45 – 1.35 lb/inch (adhesive coated at 0.8 mil on monomer phthalate plasticized PVC film)

2.1. Water whitening of films formed by aqueous emulsions

The water whitening phenomenon of aqueous adhesives, which is sometimes called blushing, is one of the reasons why solvent-borne systems still dominate this market. Fig.2 illustrates what makes a film formed by a common polymer dispersion turn white if it comes into contact with water.

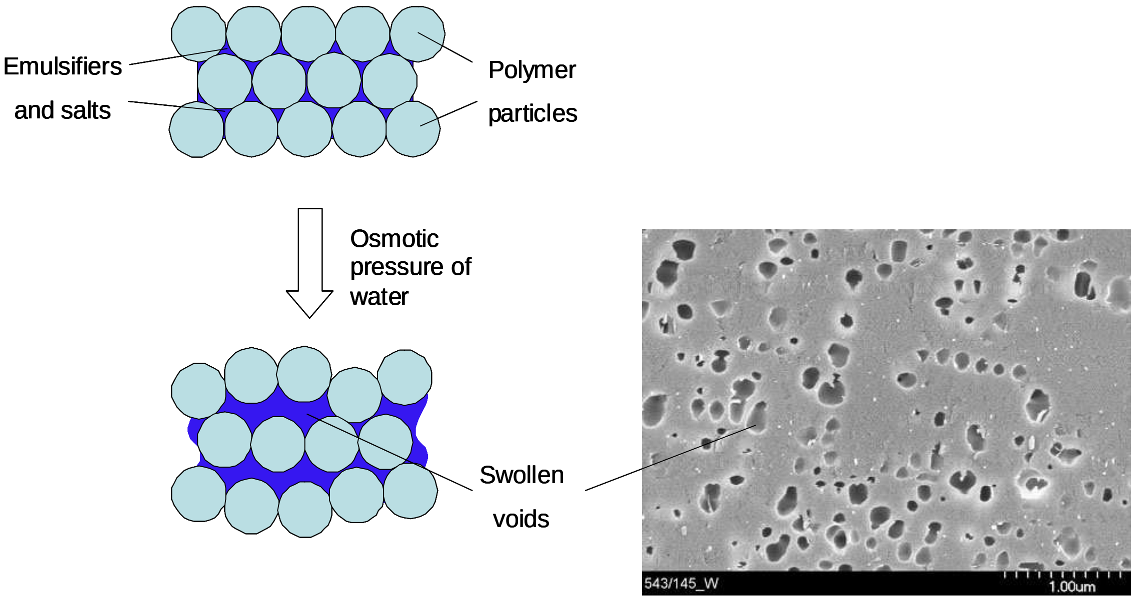

Fig. 2: Water-whitening of films formed by common aqueous dispersions

Aqueous polymer dispersions contain hydrophilic ingredients, e.g. emulsifiers and inorganic salts, which are necessary to produce the dispersion. In the film forming process these hydrophilic components stay in voids between the cooalesing polymer particles. These voids swell when they come into contact with water. If the swollen voids reach light scattering size, a white color will become visible as the refractive index of the voids is different from that of the polymer. In the picture on the right hand side of Fig. 2 which had been taken by electron microscopy, the swollen voids have reached such a dimension that this film looks white.

To reduce water-whitening we followed two strategies: The first is to control the particle size distribution of the dispersion so that the size of the hydrophilic voids between the polymer particles are minimized, in order to keep their dimension below light scattering size after swelling with water.

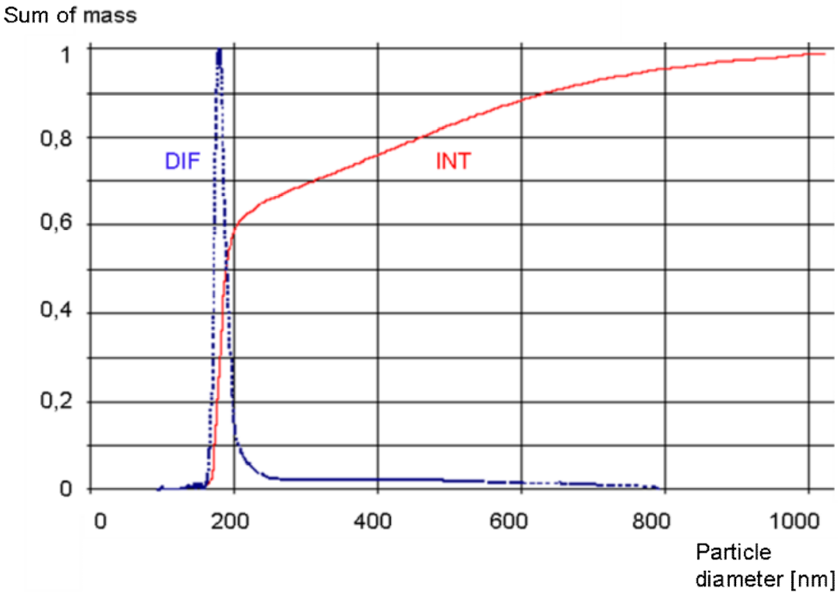

Fig. 3: Particle size distribution of emulsion-based PSA for graphic arts

The second strategy we applied was to copolymerize special hydrophilic monomers to minimize the difference between the refractive indices in the transition range hydrophilic void / polymer.

By following these strategies we are able to offer water-borne adhesives to the graphic arts industry, with a water whitening behavior that comes very close to the high performance level of solvent-based adhesives:

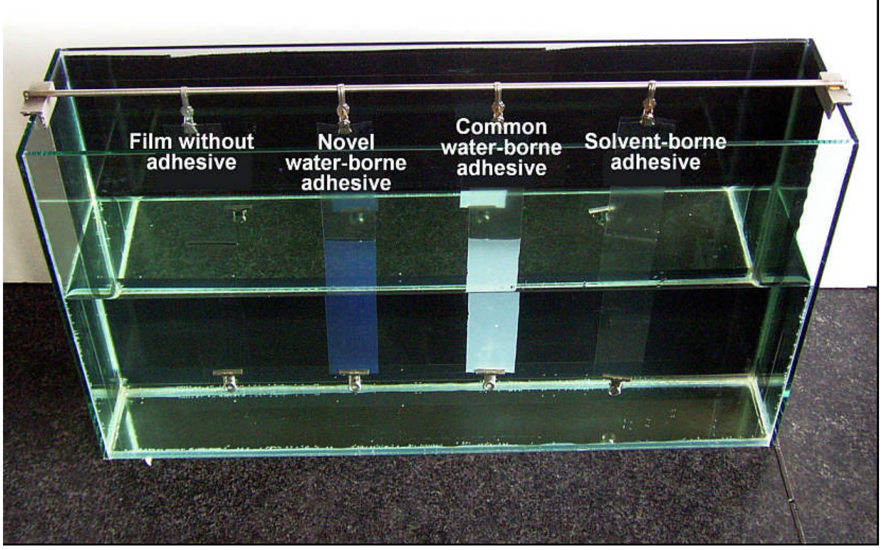

Fig. 4: Water whitening test after 24 h immersion

2.2 Plasticizer resistance / good removability

The second challenge to meet for successful removable graphic arts applications is an excellent plasticizer resistance of the aqueous adhesive. Typically the PVC films contain low molecular weight plasticizers like di-butyl- or di-octylphthalate. As illustrated in Fig. 5 the plasticizer can migrate from the PVC face material into the adhesive and may damage the anchorage of the adhesive (I) to the PVC, the adhesion of the PSA (II) or its cohesion (III).

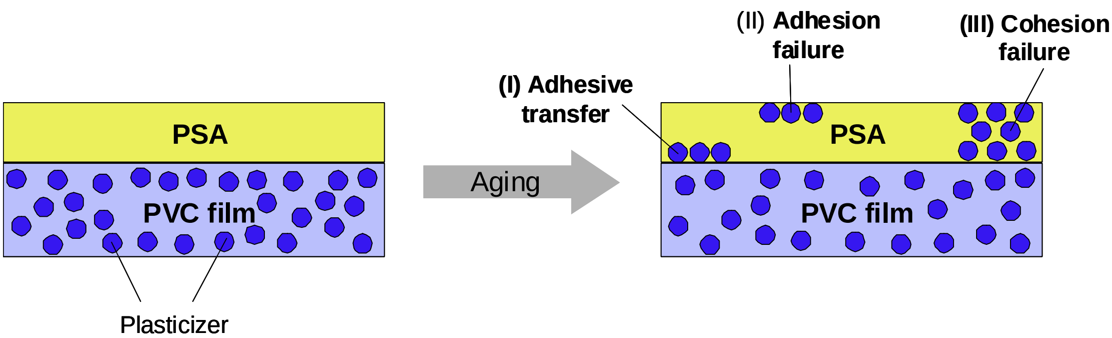

Fig. 5: Threats of plasticizer to PSA performance

As it is not realistic to prevent the plasticizer from migrating completely into the adhesive, our strategy has been to modify the acrylic adhesive in such a way that in spite of plasticizer being present in the adhesive, there is no considerable decline of anchorage, adhesion or cohesion.

We achieved this by copolymerizing special monomers that produced a specific type of crosslinked chemical structures in the adhesive, and they helped to reduce the migration of plasticizer into the adhesive film.

In Fig. 6 we have compared the quickstick and the peel values of our novel aqueous PSA with those of common solvent- and water-based adhesives. The good plasticizer resistance of our removable adhesive becomes visible: There is only a slight drop of peel strength after the laminate has been aged for three days at 70°C and then adhered to the test plate. After aging the applied PVC film for 1 week at 60°C, only a slight increase of the peel value is noticed, and a clean removability including critical surfaces is demonstrated.

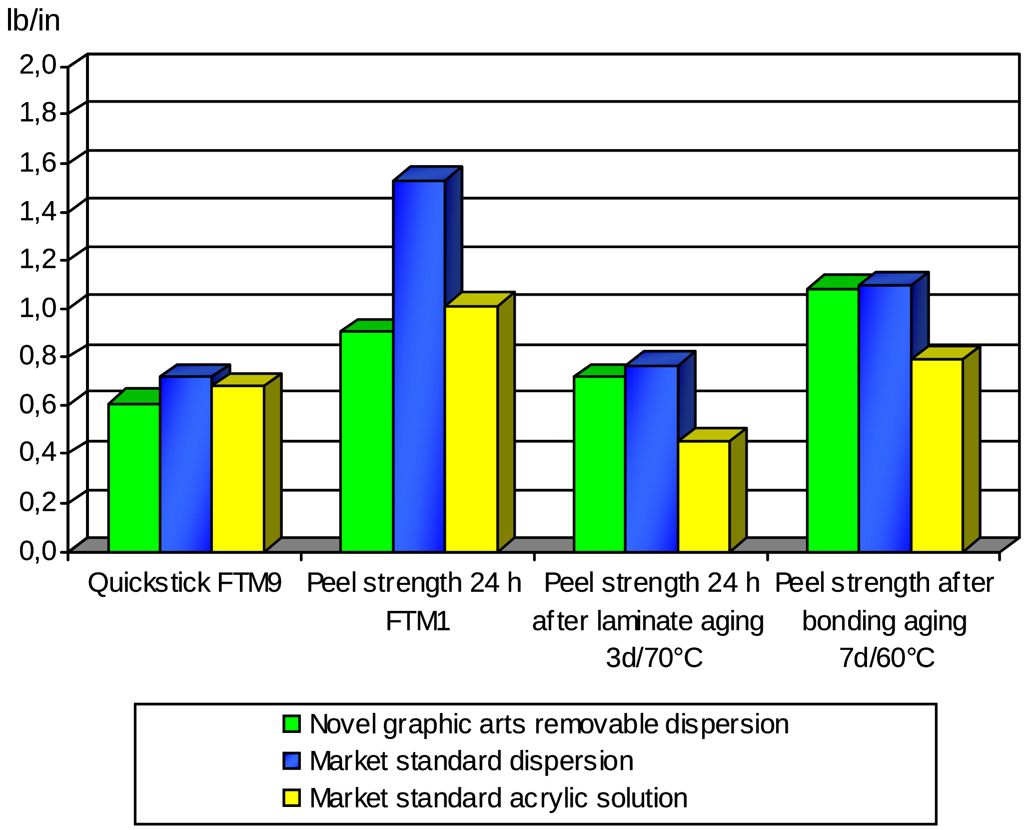

Fig. 6: Quickstick and peel values of new PSA for graphic arts application

3. Removable PSA for paper face materials

Although aqueous emulsions have become a standard technology for removable self-adhesive paper labels solvent-based adhesives are still very common especially in regions outside Europe. For critical applications, e.g. a clean removability from sensitive surfaces like many book covers, until today solvent-based adhesives offer a higher security than water-borne systems. Therefore our development goal was to overcome this lack of water-borne performance, and the following list of technical demands had been defined:

- Applicable on non-primered papers (cost advantage!)
- Very good removability from various surfaces (only slight peel increase by aging)
- Plasticizer-free ➔ no danger for paper recycling processes
- Very low label paper penetration (good staining performance)
- Medium quickstick for easy low pressure applications
- FDA 175.105 and EG 1935/2004 compliance
- Extractable residues very low ⇒ direct contact to dry, wet and fatty food possible

3.1. Challenge anchorage

A real challenge for the development of a good removable adhesive is to produce an excellent anchorage of the adhesive polymer to the rough surface of the face paper.

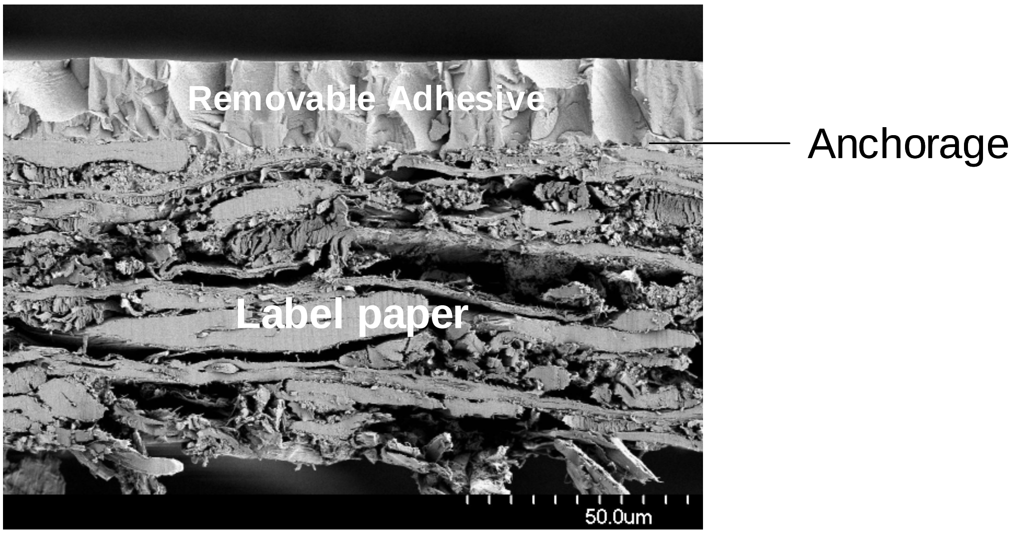

Fig. 7: Cross-section of a removable adhesive on a paper carrier

Typically a self-adhesive paper material is produced in a transfer coating process: The aqueous adhesive is coated on a siliconized carrier material, dried and then the face material is calendared to the dry adhesive film.

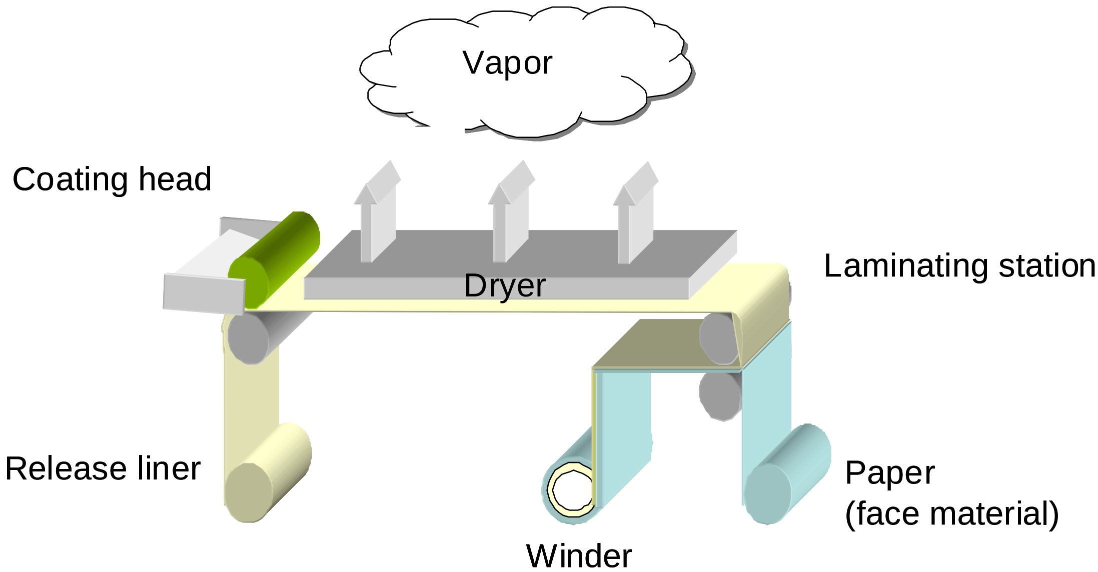

Fig.8: Transfer coating of PSA

In its final application the material has to be easily removable from any surface without leaving any residues. This means that the adhesion of the adhesive to the face paper has to be much better than its adhesion to the surface it is adhered onto.

In order to achieve such a good adhesion to the face material (anchorage) the flow properties of the pressure sensitive adhesive have to be optimized. This is necessary to make the dry adhesive film flow easily onto the rough paper surface in order to produce a maximum of contact area for strong adhesive interactions between adhesive and paper.
Our key to an optimized anchorage was to combine a very low glass transition temperture of the aqueous adhesive with a special way of production technology. By this we generate excellent flow-out without losing too much cohesion. This is necessary for a complete removability of the adhesive as well as for good converting properties of the laminate.

3.2. Benefits of the new technology

As our new dispersion for removable paper carrier applications is phthalate plasticizer-free, there are several benefits derived of it: It can be applied on non-primered papers, e.g. common machine coated label papers. It is not necessary to put a primer or a barrier coating on the paper to prevent any plasticizer from migrating to the surface of the face paper. This saves money.
There are no printing problems on the face paper, even if it had been in stock for a longer time. This has been a problem for many common water-based adhesives. Another advantage of the new technology is that thermo paper prints do not lose their color by the action of migrating ingredients from the adhesive. This usually happened with plasticizer containing adhesives.
Traditionally removable PSA contain plasticizers like DOP or DiBP to produce a soft peel at a moderate peel level to guarantee removability. This may be a problem in paper recycling processes, as some phthalate plasticizers are suspected of being harmful for health.

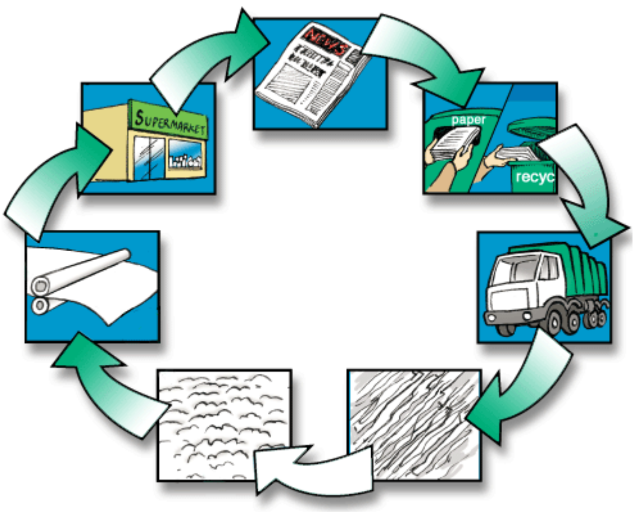

Fig.9: Recycling process including paper based self-adhesive articles

Self-adhesive articles with the new adhesive do not bring any phthalate plasticizer into the paper recycling process, which is an ecological benefit of the new technology.

An excellent removability from difficult surfaces after aging is one of the key benefits of the new water-borne adhesive. Regardless of the surface that the new PSA is adhered to an excellent removability without leaving any residues is ensured. Compared to water-borne market standards, peel build-up after aging is very low, including difficult surfaces like glossy and other printed papers, as being used for book covers and calendars. In this respect the new dispersion meets the performance of solvent-based rubber adhesives, which still dominate these kinds of difficult applications.

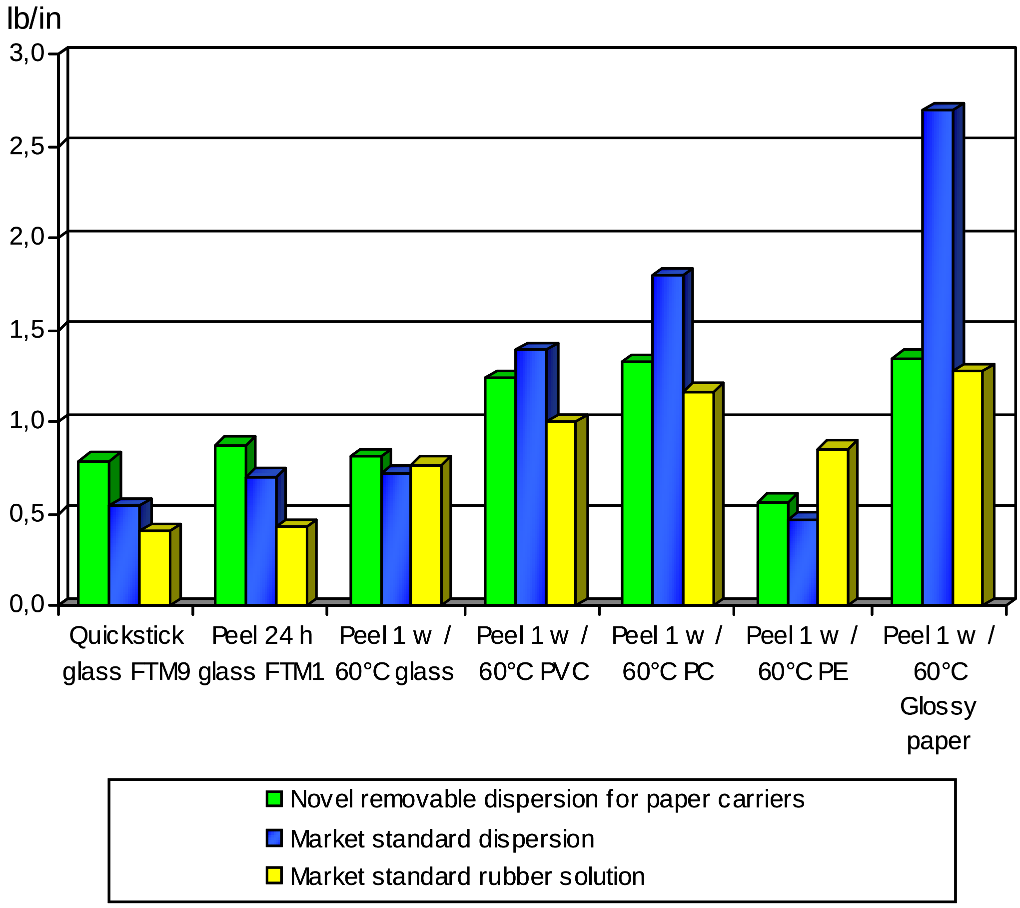

Fig.10: Quickstick and peel values of new PSA for removable paper applications

4. Acknowledgements

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