

Expanding the limits for solvent free UV-curable acrylic Hot Melt PSA's

Introduction

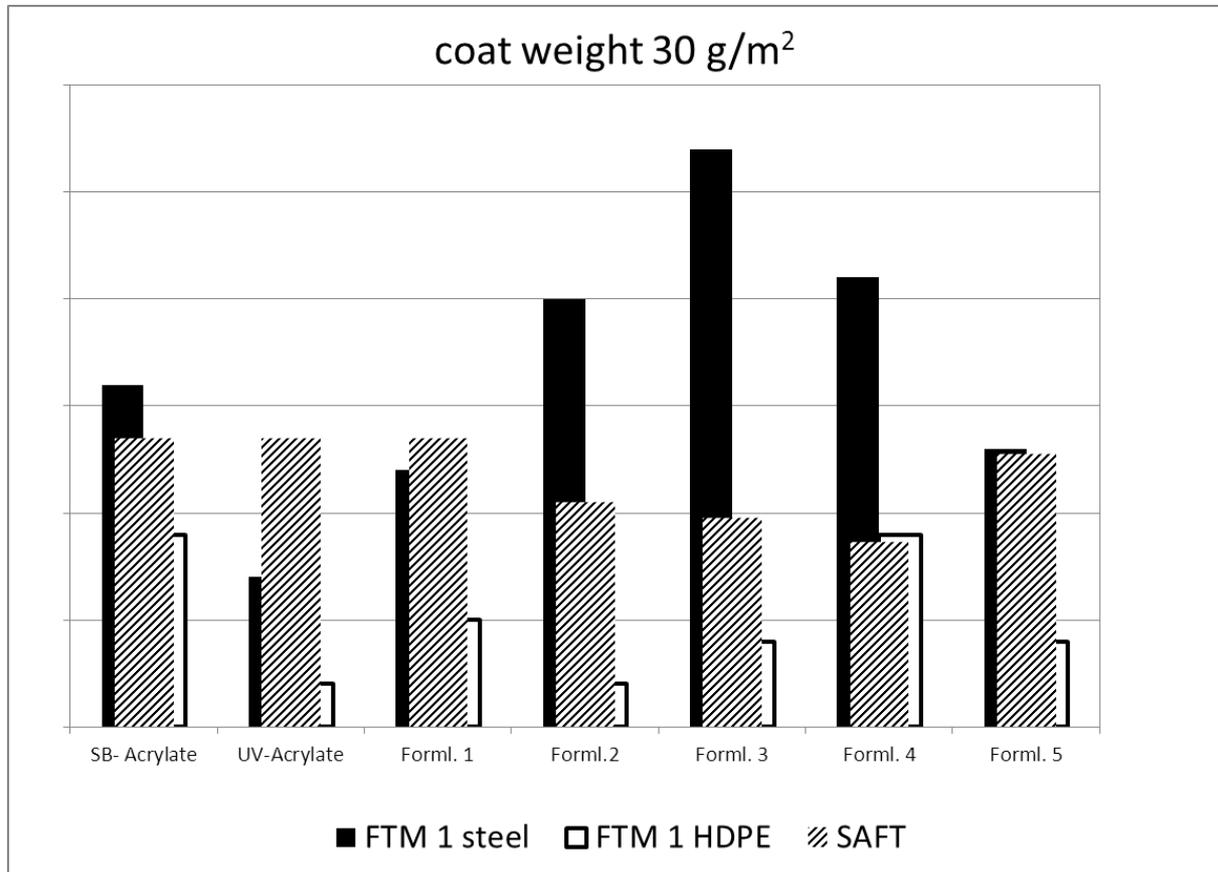
Solvent free UV-curable acrylics entered the market in the mid-nineties with the goal of replacing solvent based acrylic PSA systems. Drivers for the development of this system were on the one hand increased government regulations for running solvent coating equipment as well as environmental concerns. Furthermore there is a cost saving potential by eliminating the drying process and the recapturing and/or thermo treatment of the evaporated solvent. By eliminating the drying tunnels, thus reducing the size of the needed equipment and the possibility to integrate UV-lamps in existing hot melt coaters, small or medium size coating facilities became able to coat acrylic adhesives themselves. We, as a supplier of UV-curable adhesive formulations, can provide individually adjusted adhesives, which are used in the production of high value labels and tapes. Here the similarities of UV-curable acrylics and solvent based acrylics come into play, as there is high transparency, stability towards UV-radiation, and good resistance to chemicals. In the area of no label look labels for beverages and cosmetics the UV-curable acrylics have captured a stable share of the market. In combination with the right substrates UV-acrylics are well suited for wash off labels, which are increasingly used on beer bottles. Due to their good resistance to a wide range of chemicals UV-acrylics are also used in the construction of re-sealable lids for wet wipe bags. Typically we can find the optimal solution for each application with the right adhesion profile by formulating the appropriate base polymer.

There are, however, certain limitations to formulating of the base polymers. First there are only four different UV-curable polymers available on the market. These four polymers have only limited compatibility with tackifiers, a fact that reduces our options. The formulation or mixing of the base polymers with a tackifier also results in a loss of shear and temperature resistance. Since shear resistance is the result of a cross linking reaction of the incorporated photoinitiator with neighboring polymer chains the dilution of the system with relatively low molecular weight components obviously leads to a lower overall molecular weight and thus to poor cohesion. A possible absorption of UV-radiation by the tackifier can also result in a lower curing rate respectively lower crosslinking density.

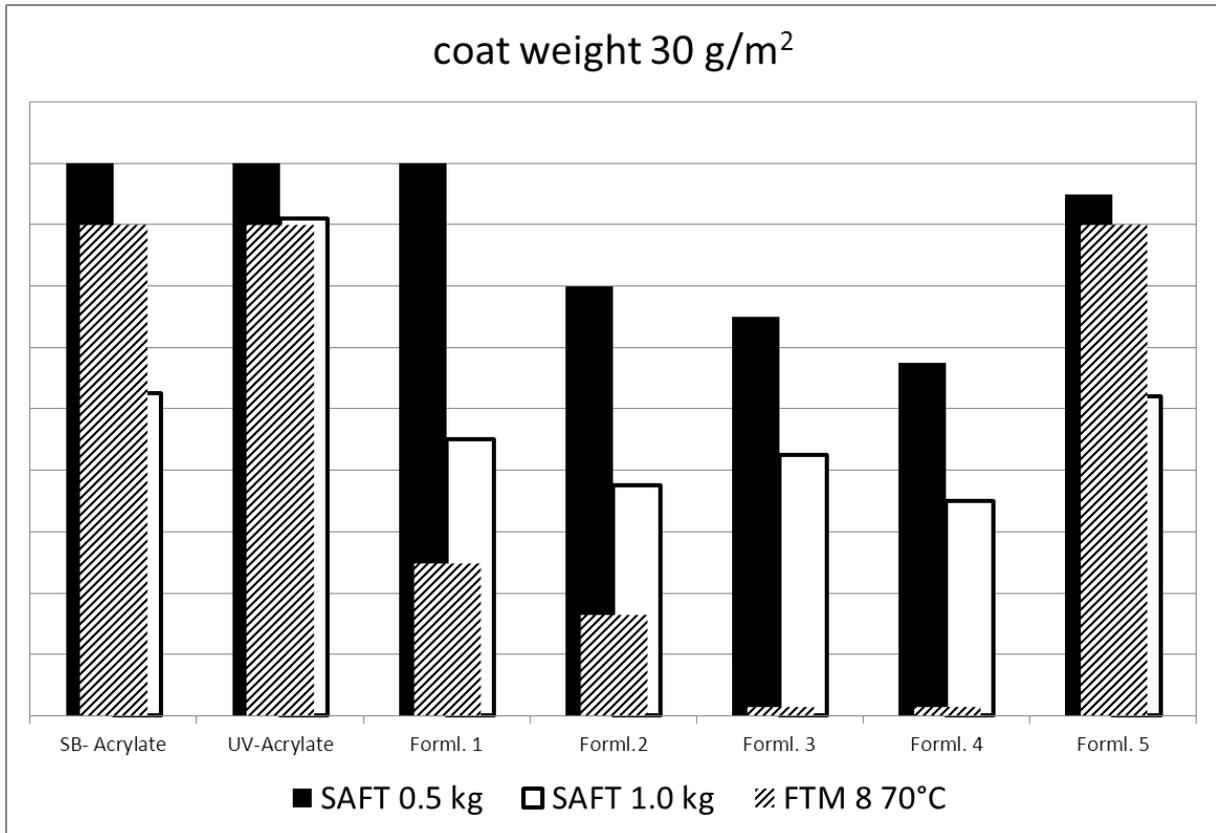
Durable labels

Due to the aforementioned reasons UV-curable acrylics are mostly used for applications with low or medium shear and temperature stress. In the production of the so called durable labels for the permanent labeling of appliances or automotive parts solvent based acrylics are preferred to UV-acrylics, whose limited shear resistance and the lower adhesion to nonpolar surfaces seem to make them inferior.

Nevertheless, the following chart comparing a solvent based acrylic adhesive with pure and formulated UV-acrylics shows possibilities for using UV-systems in this area.



Formulated UV-acrylics can have higher adhesion to steel than the shown solvent based adhesive. On HDPE we can match the adhesion of the solvent based adhesive with formulation four, but the rest of the UV-acrylics have lower adhesion than the reference. By taking a look at the SAFT values it becomes obvious that we have to pay for the improved adhesion on steel and/or HDPE with a loss in cohesion. This is even more obvious when we take a look at the shear performance at 70 °C.

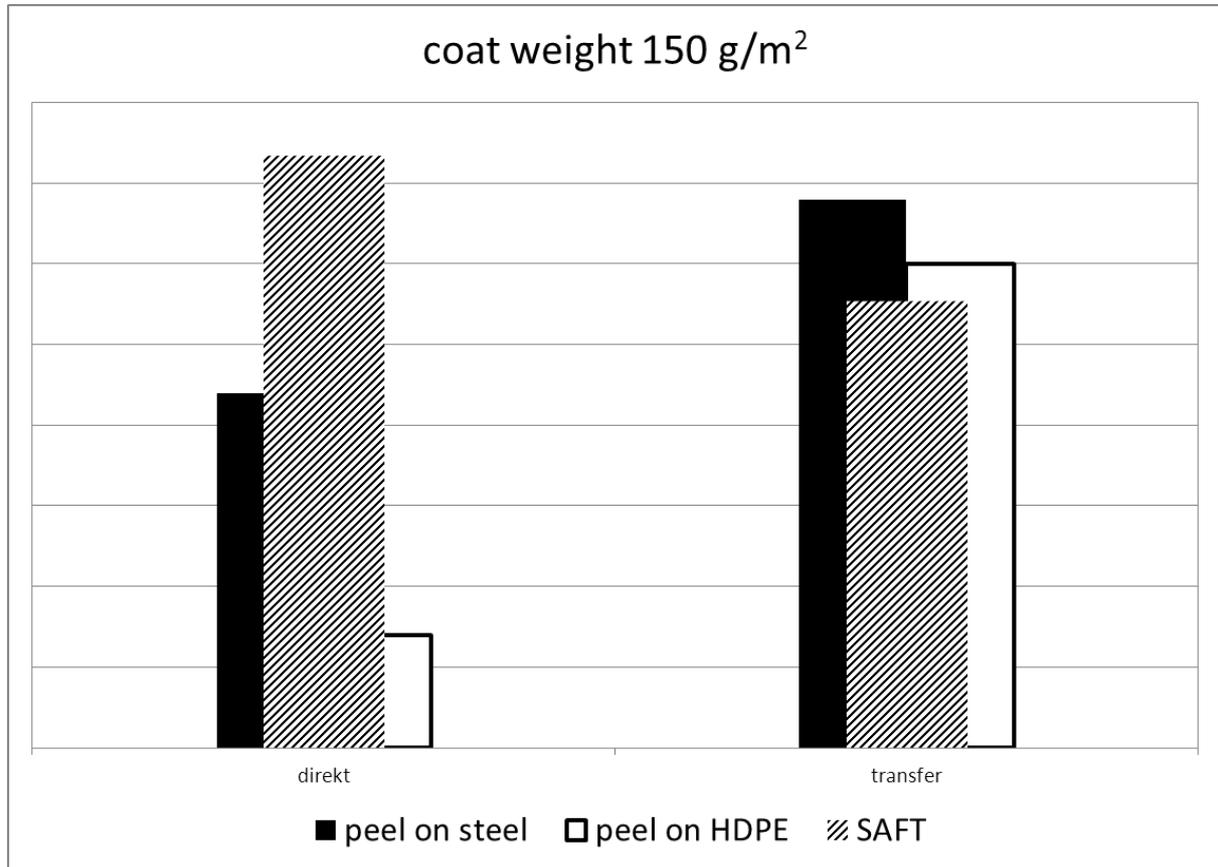


If one focuses on high temperature resistance, formulation five is a good choice for the replacement of the solvent based PSA. It is on par with the adhesion profile of the reference, except for the adhesion to HDPE. Nevertheless, it has twice the adhesion to the non-polar surface than the pure UV-acrylic. The data shows that if we are willing to sacrifice either high temperature/shear resistance or good adhesion to non-polar substrates, UV-acrylics open up a lot of opportunities for replacing solvent based systems. Since in most cases the combination of high shear resistance and good adhesion to non-polar substrates is not required and we can achieve one or the other with the presented formulations, it is possible to find solutions for many different applications with UV-acrylics. In the past solvent based PSA's were used habitually, although the user respectively the label producer could also have fully enjoyed the benefits of solvent free UV-acrylics.

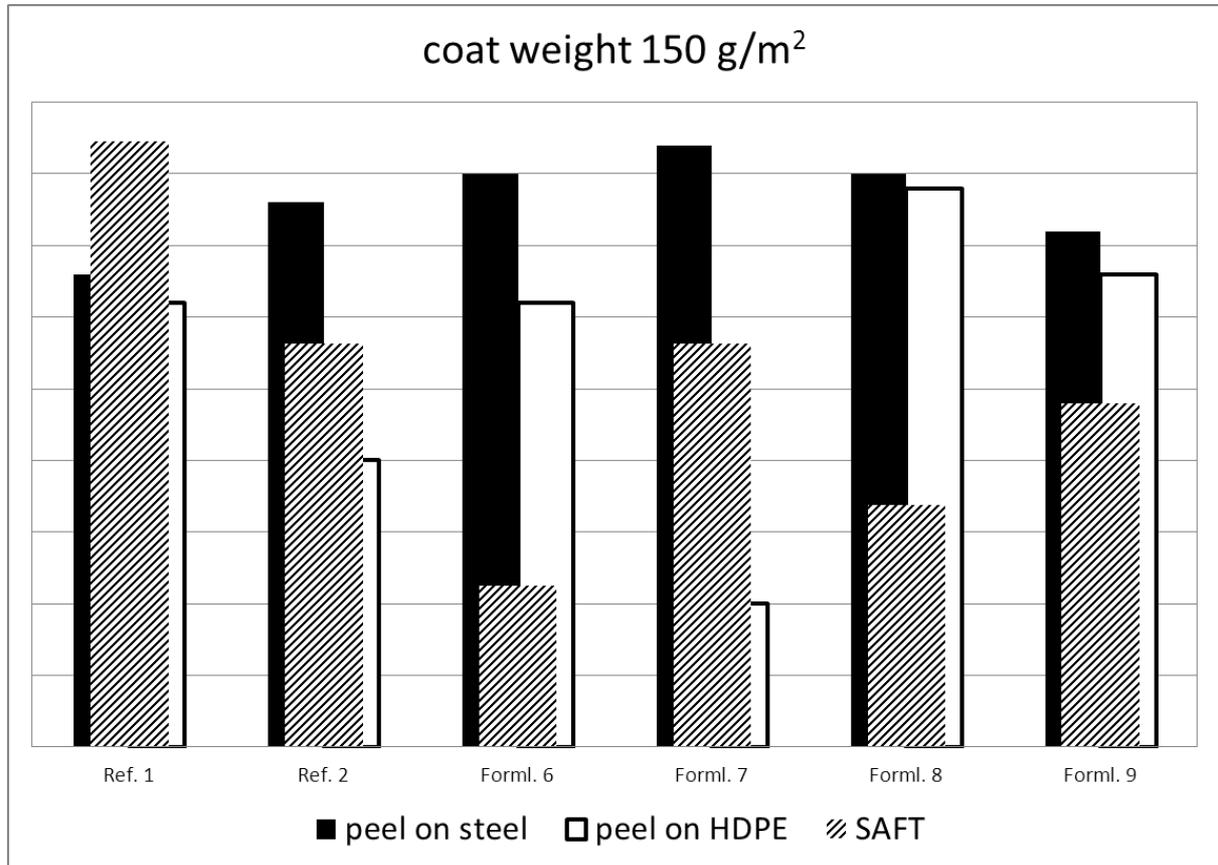
Tape applications with higher coating weights

In the tape sector UV-acrylics come into play if there is a need for a - compared to rubber based adhesives – higher resistance to temperature and chemicals, e.g. wire harnesses in the automotive industry. According to the producer of the base polymers one can realize coating weights up to 100 g/m² respectively layers of approximately 100 µm. Above 100 µm the cross linking is incomplete. For applications on rough and dusty or dirty surfaces higher coating weights are desirable.

In layers above 100 µm the cross linking gradient has a decisive influence on the properties of the cured adhesive. Since less UV-C radiation reaches the bottom layers of the coating, the top layer has a higher cross linking density than the bottom layer. The influence of the cross linking gradient is illustrated by the following scheme:

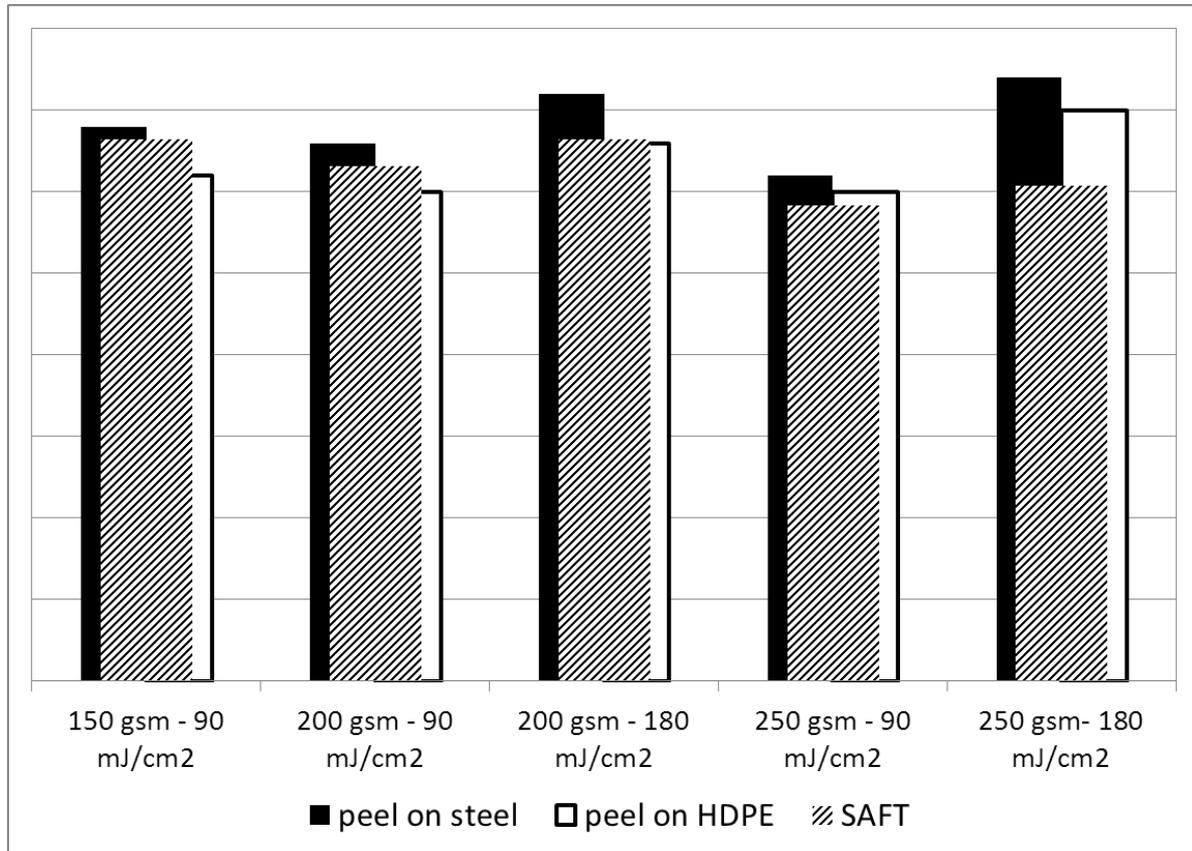


The directly coated sample, in which the lamp side of the coating is applied on the test panel, shows better cohesion than the transfer coated sample having the “under-cured” side attached to the panel. Adhesion of the directly coated sample, especially to HDPE surfaces, is significantly lower than with a transfer coated sample. A higher degree of cross linking results in a harder surface, which complicates the wet out on to the HDPE panel and the development of adhesion. The fact that there is a cross linking gradient could be regarded as a disadvantage, but one can also take the difference of direct and transfer coating as an additional degree of freedom in adjusting the adhesion properties of UV-acrylics.



We want to take a look at the possibilities of UV-acrylics with high coating weights in comparison to two solvent based references. With our formulations we can easily match or exceed the adhesion of the references on steel and HDPE. The shear resistance of formulation seven is on par with reference two but in general the shear resistance level of UV-acrylics is well below the level of the solvent based adhesives. Especially high adhesion on HDPE is accompanied with low shear strength. The good wet out to the non-polar surface is achieved with a soft formulation with a low cross linking density thus being low in cohesion. Formulation nine represents a good trade-off between shear resistance and adhesion. The adhesion to steel and HDPE is on par with the references and the SAFT is increased by 33% respectively 100% compared to formulation eight and six, which have slightly higher adhesion to steel and HDPE. Out of our formulations, nine exhibits the most well-balanced adhesion profile.

As a final example I'd like to present the adhesion profile of formulation nine at different coat weights and UV-C doses.



We observe a slight tendency of increased peel adhesion towards higher coating weights and higher UV dose. There is only a slight decrease in SAFT value going from a 150 g/m² to a 250 g/m² coating. If there is a need for higher coating weights due to difficult surfaces we can readily increase the coating weight without experiencing a dramatic loss in shear resistance. In contrast to previous UV-formulations we can achieve good adhesion and medium shear resistance at coat weights up to 250 g/m², thus making applications possible for UV-acrylics, which were reserved for other adhesive systems.

Outlook and conclusion

As shown, UV-acrylics can readily replace solvent based acrylics in a number of applications bringing the aforementioned benefits of a solvent free system to bear. For labels there are solutions for nearly all applications. Only applications with a need for high adhesion to non-polar surfaces and high temperature resistance remain an unmet challenge. A thorough analysis of the application will show that in most cases this is not necessary and we can achieve excellent results using the formulations presented here. In the tape sector with high coating weights we can get adhesion comparable to the solvent based PSA's. In terms of cohesion respectively shear and temperature resistance an increase remains desirable. We can achieve good results with UV curable acrylics, but the results of solvent based acrylics cannot be met, yet. Nevertheless we have taken another step to closing the gap between solvent based and UV-acrylics by developing a formulation, which exhibits a well-balanced adhesion profile at coating weights up to 250 g/m².

At this point it is also part of the manufacturers of the UV-curable polymers to develop new and better base polymers, which will enable us to finally close the gap between solvent based and UV-acrylics. So far the new systems suffer from the same shortcomings as the existing UV-curable adhesives.

With this short overview of the existing possibilities I hope to have awakened your interest in UV-acrylics. If so, you are welcome to contact us for further discussions or trials at our facilities. Of course commercial samples of the presented formulations are available.