Water-based adhesives for flexible packaging

A response to the market requirements of today: immediate processing and high toxicological safety

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Flexible packages like pouches and bags are gaining market share and increasingly replace the traditional means of packaging, namely cans, containers and bottles. Their advantages are lower weight, less required storage space, lower shipping costs and increased customisability. Furthermore, they offer more options for packaging designers. A large part of flexible packaging is not made of a single polymer film but instead a combination of various films and therefore different material properties. The result is a customised multi-layer laminate structure which fulfils the desired packaging specification in the most efficient way.

Two-component reactive PU adhesives

Such adhesives still dominate the European market for adhesives for flexible packaging. Typically adhesives are involved when it comes to the manufacture of such multi-layer laminates. Polyurethane (PU) systems, applied either as organic solution (solvent-based adhesives) or by mixing a polyol component with an isocyanate as a 100% system (solvent-less adhesives), are usually used in Europe.

Solvent-based and solvent-less laminating adhesives are mostly applied as two-component systems. The laminate producer mixes a base with a hardener component, which usually has a significantly lower medium molecular weight than the base component. Base and hardener components are functionalised with isocyanate or with hydroxy groups. After coating the two-component PU adhesive on the first film (and in the case of a solvent-based adhesive after removal of the solvent), this film is laminated with the second film under heat and pressure. Now the chemical reaction to build up the molecular weight and thus the final bond strength takes place between the two films at the converters facility.

Conventional PU adhesives

Low green strength slows down the production process

The strength of a bonding depends to a large extent on the molecular weight of the adhesive – the higher, the better. A challenge for the currently used PU adhesives is that the build up of molecular weight between the films requires some time. Within this time, the laminate is vulnerable to mechanical stress. This is especially true when using solventless adhesives which typically start with a very low molecular weight. Hence, slitting, rewinding and sealing of the laminates are only possible after several hours, which prevents efficient production. Furthermore, the risk of telescoping rolls, i.e. the movement of the laminated films relative to each other, and the therewith connected additional costs are omnipresent.

Technology inherent toxicological risks cause long leadtimes

In addition to the limited green strength (i.e. the ability of an adhesive to withstand handling before it is completely cured), users of two-component solvent-based and solvent-less PU adhesives are confronted with another problem: the risk of contaminating the packaging content with toxic components. Usually, these types of adhesives contain a percentage of monomeric aromatic isocyanates like MDI (Methylene Diphenyl Disocyanate), which enable a rapid build-up of molecular weight and thus adhesive strength due to its high chemical reactivity. If some unreacted aromatic isocyanate remains in the adhesive layer, the isocyanate can migrate through the inner laminate film into e.g. the packaged food and hydrolyse to an aromatic amine (figure 1).

Such aromatic amines are suspected of causing cancer and must not be detected in the food. Hence, the produced laminates have to be stored for several days until the aromatic isocyanate in the adhesive layer has completely been incorporated into the polymer network of the adhesive and can’t cause any damage anymore.

In the last few years, this waiting time has been significantly reduced for solventless adhesives by chemical innovations, however, it is, even today, generally at least a few days.

Water-based lamination adhesives

High toxicological safety

Water-based lamination adhesives, i.e. aqueous PU or acrylic dispersions, are fully reacted systems which are characterised by a high molecular weight. The polymerisation reaction takes place in the reactor vessels of the chemical industry and not between the films at the converters as with solvent-based and solvent-less adhesives. Dispersions have a medium molecular weight of 50,000 Daltons and BASF SE, Ludwigshafen am Rhein/D.

Figure 1: Migration of aromatic isocyanates into food and their hydrolysis to aromatic amines.
With regard to the toxicological risks, especially the adhesive components with a molecular weight of <1000 Daltons (1E+03) are critical. They are considered to be particularly migratable and therefore require special attention. As figure 2 shows, water-based adhesives (i.e. Polyurethane and acrylic dispersions) have significantly lower shares of these critical low molecular weight components that may migrate into the packaging content (e.g. food) than the solvent-based and solventless adhesives.

Generally, water-based lamination adhesives are used as one-component systems. For high performance applications, the thermal and chemical resistance of the adhesive can be improved by adding aliphatic crosslinkers in the range of <5%. These crosslinkers do not contain any aromatic isocyanates. Hence, there is no risk of aromatic amines. The high toxicological safety of the aqueous systems is not negatively affected by this kind of chemical crosslinking.

Aqueous laminating adhesives can be processed on existing solvent-based adhesive coaters with gravure coating heads. Their solids content lies between 44-48%. If the system does not operate in the reverse gravure mode, the installation of a smoothing bar is recommended. Coating speeds of up to 800 m/min (2625 fpm) are no problem with modern equipment. After coating, the machinery can be cleaned easily with just plain water.

Summary

Continuously changing consumer trends and the customers’ constant seeking for variety require brand owners to modify their packaging within increasingly shorter time cycles. Hence, packaging is produced in smaller lots and packaging manufacturers need to be able to react quickly to new market demands. Furthermore, there is an increased focus on the safety and potential toxicological risks of packaging materials.

Water-based lamination adhesives support these two trends by helping to significantly shorten the lead times and minimising the toxicological risks of the adhesive layer (figure 4). Lamination and delivery within a day become a reality with aqueous adhesives and can bring a significant competitive advantage to the producer of flexible packaging by speeding up the whole process chain.