FEICA The European voice of the adhesive and sealant industry

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Terminology and definitions to be used in the context of adhesives in the recycling of packaging

FEICA, the Association of the European Adhesive & Sealant Industry, is a multinational association representing the European adhesive and sealant industry. Today's membership stands at 15 National Association Members, 24 Direct Company Members and 19 Affiliate Company Members. The European market for adhesives and sealants is currently worth almost 17 billion euros. With the support of its national associations and several direct and affiliated members, FEICA coordinates, represents and advocates the common interests of our industry throughout Europe. In this regard, FEICA works with all relevant stakeholders to create a mutually beneficial economic and legislative environment.

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Background and objective of the document

FEICA is aware of several different stakeholders publishing guidelines on recycling, including requirements for adhesives in recycling. Divergent terminology is used in these guidance papers, and this terminology also often differs from what is used in the adhesives industry and by users of adhesives.

Therefore, FEICA would like to assist stakeholders in furthering a common understanding of adhesives and the requirements that are important for adhesives in recycling. A common language and technically sound definitions will help to ensure a better understanding amongst stakeholders and an easier exchange of expertise.

Classification of adhesives used in packaging

Adhesives can be classified by their chemistries as well as by their function. In packaging, the following adhesives chemistries and functions can be found:

Adhesive chemistries used in or on packaging

Polyurethane adhesives

Polyurethane adhesives are based in reactive chemistry where isocyanates react with polyols and /or water. The high thermal resistance of polyurethanes, including the ability to withstand retort processes, results from chemical crosslinking. This crosslinking is achieved by either using a **two-component liquid polyurethane** adhesive system or through moisture curing of a one-component **reactive polyurethane adhesive**. In the case of liquid adhesive systems, solvent can be added to one or both components to reduce their viscosity. One-component polyurethane adhesives can be liquid adhesives or (reactive) hotmelt adhesives.

(Non-reactive) Water-based adhesives

Water-based adhesives can be dispersions or solutions. Polymer dispersions are two-phasic systems in which polymer particles are dispersed in water. In the case of solutions, the polymers are dissolved in water and the system is a single phase (the product is a clear liquid).

Water-based adhesives are applied as liquids at room temperature or at slightly elevated temperatures and bond by evaporation of the water and/or absorption (penetration) of water into the substrate.[1]

Water-based adhesives based on natural polymers

Adhesives based on natural polymers are derived from either animal or plant materials.

In the case of animal sources, the polymeric substances are typically proteins, such as casein. In the case of plant sources, they are generally carbohydrates, such as starch. Adhesives can also contain mixtures of animal- and plant-based polymers, combined with synthetic polymers as well.

1 Note that a fully dried layer of water-based adhesive cannot automatically be assumed to be soluble or dispersible again in water.

As natural polymers are typically hydrophilic, they are generally dissolved in water in the form of so-called colloidal solutions[2]. A special case is natural rubber latex, which is not hydrophilic and forms a dispersion in water. The setting of the adhesive occurs, in either case, by evaporation of water.

Water-based adhesives based on synthetic polymers

Polyvinyl acetate (PVA) dispersions have beneficial handling and application properties for a wide range of applications on paper, both for paper-to-paper as well as for paper-to-plastic bonding.

Dispersions based on acrylic resins (polymers) offer high initial bond strength. The softness of acrylic dispersions can be widely adapted, thereby creating both pressure sensitive as well as non-pressure sensitive adhesives.

In addition to the dispersion form, acrylic polymers can also be produced as water-based solutions.

Polyolefin- / EVA-based hotmelt adhesives

Polyolefins as wells as ethylene vinyl acetate copolymers (EVA) are thermoplastic polymers that are employed in (non-reactive) hotmelt adhesives.

(Non-reactive) Hotmelt adhesives

Non-reactive hotmelts adhesives belong to the group of physically setting adhesives, where the setting takes place without any chemical change to the polymer. Before application, the adhesive is heated and starts to melt, typically at temperatures above 100 °C. The adhesive is then applied in liquid (molten) form to the substrate. A physical setting takes place during cooling, which turns the hotmelt back into a crystalline or amorphous solid.

Non-reactive solvent-based adhesives

A range of non-reactive, non-crosslinked polymers can be fully dissolved in organic solvents. Such solutions can be used to lay down coatings on paper and more typically plastic substrates by a coating and subsequent drying step. Such coatings can function as adhesives under specific conditions.

Rubber-based pressure-sensitive hotmelt adhesives

Rubber based hotmelts are typically based on styrene block copolymer rubbers that are compounded with a suitable tackifier to form pressure sensitive (non-reactive) hotmelts. The applied adhesive remains permanently in a tacky state.

Reactive adhesives

Reactive adhesives do not rely on a purely physical bonding process. They contain reactive groups that participate in chemical reactions within the adhesive, in certain cases also with the substrate surface, leading to very resistant final adhesive applications. Once cured[3], reactive adhesives can generally not be dissolved in water or be substantially softened by increased temperatures.

2 A mixture that has particles ranging between 1 and 1000 nanometres in diameter yet still able to remain evenly distributed throughout the solution.

3 The process of 'hardening' of reactive adhesives is called 'curing'. For non-reactive adhesives, the term 'setting' is used.

UV curing acrylic adhesives

UV curing adhesives are typically acrylic polymers and are commonly used for pressure sensitive applications. In contrast to water-based acrylic dispersions, UV curable acrylics do not typically contain water. They can be liquid adhesives which are directly applied or hotmelts that are applied in molten form. In both cases, the applied adhesive is cured by exposing it to UV light.

Reactive acrylic dispersion adhesives

To increase the thermal and chemical resistance of acrylic dispersions, they can be crosslinked with isocyanates.

Functions of adhesives in or on packaging

Labelling (not self-adhesive)

Most rigid packaging uses labels to present marketing and legal information on the product. Labelling provides multiple benefits over direct printing, such as greater flexibility in production and the ability to reuse or recycle the container more readily after the removal of the label.

A wide range of adhesives is used for labelling. In the case of paper labels, water-based adhesives such as acrylic dispersions or, more traditionally, adhesives based on natural polymers are used. For attaching non-absorbent label materials, i.e., plastic labels, non-reactive hotmelt adhesives are typically used.

Pressure sensitive applications

Pressure sensitive applications are used in the production of self-adhesive labels. Adhesion can be permanent, or the label can be designed to be (easily) peelable by hand. Pressure sensitive applications are also used for re-closable food packs and re-closable lids.

Commonly, acrylic dispersions are used to produce pressure sensitive adhesives. In certain cases, non-reactive hotmelt chemistry and UV curing acrylic adhesives can also be used.

Lamination

Most flexible packaging is composed of two or more layers, each fulfilling a specific function, such as sealability, product protection, and tear or puncture resistance. These layers need to be bonded together by adhesives.

The most common technology in use is polyurethane laminating adhesives as they exhibit excellent resistance to filling goods and thermal stress as well as low migration potential due to their reactive nature. Acrylic dispersions can also be used to produce multi-layer lamination for flexible packaging.

Cold seal applications

Cold seal adhesive applications are used to seal the edges of packaging made from a wide range of different substrates such as paper and polypropylene PP or polyethylene PE films.

In pressure-activated systems, no heating is required to obtain the seal: two cold seal coated sides must be pressed together. Cold seals are typically sealed within a temperature range of 15 to 25 °C, and the

absence of heat makes them ideal for packaging temperature-sensitive foodstuff such as ice cream, chocolate or biscuits.

Cold seals typically contain a blend of natural rubber latex and acrylic dispersions.

Heat seal applications

Heat sealing refers to the combining of two substrates via heat and pressure. This process is predominantly used for lidding applications, where paper, aluminium or plastic lids are bound to paper or plastic food containers, for example, in the packaging of dairy products; for plastic trays for convenience food and meat and for instant noodle cups. Heat seals are also used for the sealing of medical packaging.

Heat seal adhesives are in most cases non-reactive solvent-based products or based on acrylic dispersions, which are applied and dried on one or both substrates that will later be sealed together. In some cases, non-reactive hotmelts can also be used as heat seals.

Adhesive applications in fibre-based package production

In contrast to plastic packaging, which can be shaped by injection moulding, blow moulding or thermoforming, most fibre-based packaging is held in shape by adhesive applications. Often, a single sheet of paper or cardboard adheres to itself after folding or shaping.

For most fibre-based packaging applications, such as corrugating, box making, side seaming[4] and cross- and bottom pasting of sacks, non-reactive water-based adhesives are used.

Polyolefin- / EVA-based hotmelt adhesives are very commonly used for the closing of cardboard boxes on production lines (‚end-of-line application').

Table I summarises typical utilisation of adhesives for packaging by relating function to chemistry

Chemistry/ Function	**Fibre-based packaging**	**Labelling**	**Pressure sensitive application**	**Lamination**	**Cold seal**	**Heat seal**
Polyurethane	**x**			**X**		
Acrylic resin dispersion/ emulsion		**X**	**X**	**X**	**X**	**X**
Natural polymer-based adhesives	**X**	**X**			**X**	
Polyolefin/EVA hotmelt	**X**	**X**	**X**			**X**
Non-reactive solvent-based adhesives						**X**
Rubber-based pressure-sensitive hotmelt adhesives	**X**		**X**			
UV curing acrylic adhesives			**X**			

4Side seaming is used to create paper pouches, bags and sacs from flat sheets/reels of paper by overlapping and bonding the paper in the seams.

PVA	**X**					

Table I: Correlation between adhesive chemistry and function.

Relevant characteristics of adhesives in the recycling process

Regardless of the chemistry or method of application, adhesive applications in recyclable packaging (whether used in the packaging itself or on the label) must possess certain characteristics to ensure they do not interfere with the recycling process under consideration. Several stakeholders have published guidance documents that help packaging producers make the right basic choices.

Each class of adhesive has its own behaviour, and adhesive manufacturers should be involved in the creation and update of guidelines and the evaluation of recycling options.

Terminology related to adhesive behaviour can differ between value chain actors and create misunderstandings. FEICA would like to contribute to establishing a common language and common understanding, thus making communication between the different actors easier.

FEICA therefore proposes the following definitions for adhesive behaviour during recycling:

Water-soluble / alkali-soluble adhesive application

Any applied adhesive capable of dissolving in water or alkali in the recycling process.

The dissolved adhesive is transferred into the process water and remains in solution until the washing liquid undergoes a recovery or cleaning step.

Releasable adhesive application

Any applied adhesive capable of releasing on at least one side of its bond under the specified conditions in the recycling process.

After releasing, the adhesive remains on one or on both substrates. The process water does not accumulate adhesives (it isn't recommended to recycle the washing solution).

- **Water releasable**: any applied adhesive capable of releasing on at least one side of its bond in water under the specified conditions in the recycling process.
- **Alkali releasable**: any applied adhesive capable of releasing on at least one side of its bond in alkali under the specified conditions in the recycling process.

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