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Green Deal Challenge: Adhesives as Problem Solvers in the Packaging Industry

Adhesives are used in multi-layer packaging systems to combine various functional materials. They may, in the future, play a significant role when it comes to the development of sustainable and recyclable packaging systems. What matters above all is that all parties involved in a product's life cycle work together within the value chain.

Kresimir Cule

Are you used to potato chips that are still crispy after one year or cold meat and cheese that still taste fresh after four weeks? What every consumer takes for granted, does not happen naturally. It is the result of complex multi-layer packaging systems that we cannot imagine doing without in today's markets.

Each layer of such a system fulfils a certain function. An essential role is played by the barrier function that protects food against moisture and oxygen. An ideal example is a bag of potato chips and its complex multi-layer packaging material, which often consists of two films that are laminated together, a metalized one and transparent one, which is printed on the inside in order to protect the printed image (*Figure 1*).

The metalized layer provides the barrier function making sure that the chips remain crunchy. In addition, the metalized film features a sealable layer on the inside that allows airtight sealing.

Plastic trays made of polyethylene terephthalate/polyethylene (PET/PE) have a similar multi-layer structure (*Figure 2*). While the PET film provides shape, stability and functions as an oxygen barrier, the PE film strengthens the water vapour barrier and enhances sealability. This combination extends the shelf life of cold meat and cheese. To close the tray, the manufacturers use a PET/PE lidding film that is thinner and heat sealable.

Both of these multi-layer packaging items are a perfect example of the importance of such systems for the shelf life of food. Whilst the consumer in the supermarket is blissfully unaware of it, a great deal of thinking has gone into the packaging, which is highly functional and incredibly important for supply chains in the food industry.

Figure 1 A bag of potato chips – an example to illustrate the structure of multi-layer packaging

The Green Deal – a challenge for the packaging industry

The Green Deal action plan was approved by the EU at the end of 2019. Its aim is to reach climate neutrality by 2050. As a first step, greenhouse gas emissions are to be reduced by at least 55 % by 2030 compared with 1990 levels. The plan is, among other things, to create a pollutant-free circular economy. This means that in future all products and articles placed on the market need to be recyclable; the plan also stipulates that the materials that we are left with at the end of a product's life cycle must be of one type only as well as free from hazardous substances.

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Figure 2 Cheese packaging – an example to illustrate the structure of multi-layer items

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Figure 3 An essential component of the Green Deal concept stipulates that, as of 2030, packaging must reach a certain minimum level of recyclability throughout the EU.

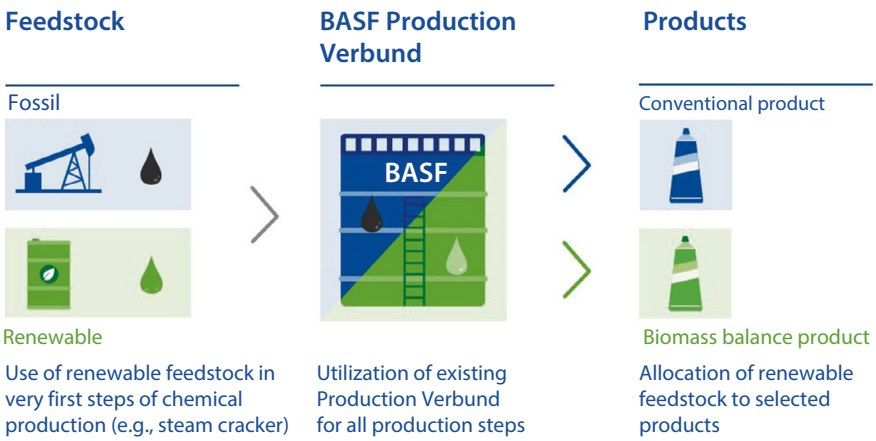

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Figure 4 The bio-mass balance approach and how it works

As pointed out before, multi-functional packaging extends the shelf life of food. It also helps prevent waste and, at the same time, improves availability. As far as sustainability is concerned, packaging plays an important role in the food value chain. Due to its complex structure, however, recycling is more difficult. Hence, fulfilling the new sustainability requirements of the Green Deal is a real challenge. The Packaging and Packaging Waste Regulation (PPWR), an essential component of the Green Deal concept, does for instance stipulate that all packaging used throughout the EU must reach a certain minimum level of recyclability as of 2030 (*Figure 3*). Up to now, multi-layer packaging systems, which consist of different types of plastic, have been considered unsuitable for raw material processing. It is argued that the material mix used for such packaging can no longer be separated, which in turn would be necessary to ensure recycling by type. On the other hand, we cannot do without the functionality of such packaging systems. This means that the entire industry is faced with a major challenge. Irrespective of that, another aspect that the packaging industry is confronted with concerns the chemicals strategy of the Green Deal, which requires that any material classified as critical must gradually be eliminated from material cycles.
Therefore, the demand for sustainable and recycling-friendly packaging is huge. BASF is looking at various options that involve the use of adhesives to achieve sustainable packaging solutions.

Sustainability through the reduction of carbon emissions

The goal of the Green Deal is to use all technologies and approaches available to minimize carbon emissions. One such option is the biomass balance approach (*Figure 4*) with the help of which customers can order products made with renewable raw material in line with the certification procedure. This approach allows fossil fuels to be replaced by biogas and bio-naphtha derived from sustainable sources. The bio-based feedstock amount is then allocated to specific products sold by means of the certified method.
This would lead to a more sparing use of fossil resources and a reduction of greenhouse emissions. The independent REDcert² and ISCC PLUS systems are used to ascertain and certify that the amounts of fossil resources required for the sold biomass balances products are replaced with renewable feedstock.

Sustainability through water-based raw material

The exclusive focus on the development of water-based adhesive systems alone illustrates the strive for sustainability as water-based adhesives are per se intrinsically safe systems and lend themselves to the

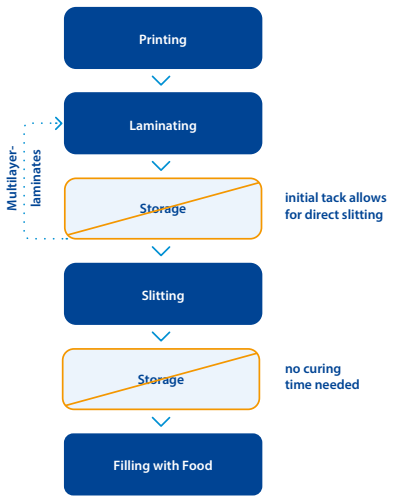

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Figure 5 The steps in packaging production: intermediate storage (warehouse) required to ensure complete curing of adhesives is no longer necessary; products can therefore be processed straight afterwards.

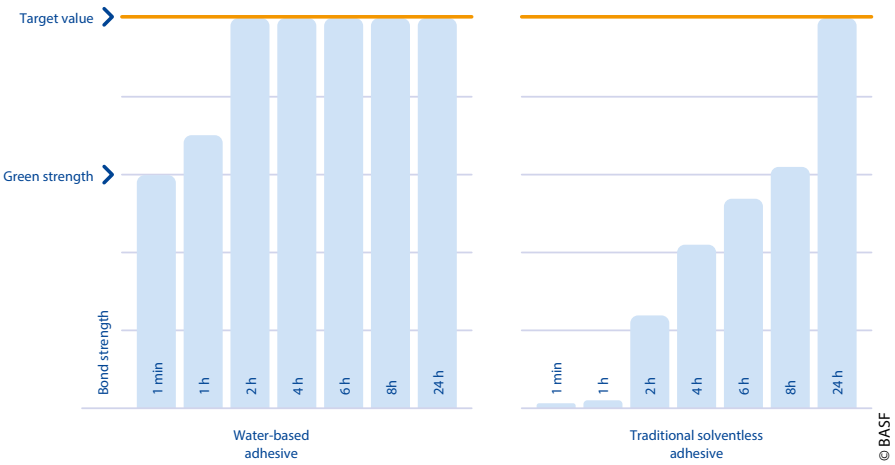

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Figure 6 Water-based adhesive systems: The diagram shows peel strength as a function of time. It only takes two hours until the water-based system has reached the required peel strength of 5 Newtons (N) per 15 millimeters.

use in food packaging. They constitute a sustainable alternative to solvent-based and solvent-free PU lamination adhesives (*Figure 5* and *Figure 6*).

Professor Thomas Schiele, Vice President of Adhesives, Fiberbonding & Paper Coating Chemicals states: "Initial skepticism about the performance of such systems has long been a thing of the past in many industries and applications and, in the meantime, we have been supplying various sectors with sustainable water-based solutions for diverse applications involving adhesives. We also offer customers the opportunity to see for themselves, at our Adhesive Coating Center in Ludwigshafen, what water-based systems can achieve and work with us to find a suitable sustainable solution for individual coating requirements" (*Figure 7*).

In the field of flexible packaging, it is possible to implement a very wide range of applications using water-based lamination adhesives. These days, manufacturers can even meet the very high standards of retort packaging, which, for example, is used for cat and dog food. In the field of medium-performance applications, lamination in the form of 1C-systems is feasible without the use of additional cross-linkers. Even as far as the coating technology based on aqueous systems is concerned, a great deal has been happening over the last few years. In conjunction with the producers of lamination facilities and based on many test runs, companies have been able to prove that aqueous systems are fit for purpose, and have developed a high level of coating knowhow.

Sustainability through development of new adhesive products

BASF is working on a range of options to enable sustainable and recyclable packaging through the use of innovative adhesive systems.

Debonding

The fact that recycling of multilayer composites is possible in principle is shown by Sulayr, for example, with a process in which the PET fraction is separated from

The main benefits of water-based lamination adhesives

- no organic solvents
- low levels of volatile organic compounds (VOCs)
- no primary aromatic amines (PAAs) derived from aromatic isocyanates
- no silane coupling agents (GLYMO-free)
- low residual odor
- time saving due to high initial adhesion: direct further processing possible
- increased flexibility and cost reduction

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Figure 7 The Adhesive Coating Center in Ludwigshafen

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Figure 8 Closed recycling loop for PET-based multi-layer packaging

composite packaging on an industrial scale and returned to the material cycle as a raw material for new packaging.

Forming a strategic partnership with Sulayr, the machine tool manufacturer Bobst and the film producer Evertis, BASF has trialed a recycling concept for PET/PE trays (*Figure 8*). During the process it emerged that, apart from process parameters such as temperature, shearing or the use of additives, it is above all the adhesive used that matters. It must have the best possible adhesive strength when required. When the package has reached the end of its useful life, the adhesive is to facilitate the simple separation of the two layers because swift delamination is important to make the recycling process economical. The cooperation showed that water-based acrylate adhesives have an advantage as they are easier to separate than, for example, 2C PU adhesives. Even if, according to some "Design-for-Recycling" (D4R) guidelines, PET/PE trays are still considered to be non-recyclable, it should be noted that these days companies such as Sulayr do commercially recycle PET/PE laminates by separating the two plastic layers.

BASF is using the expertise gained in this project to develop a lamination adhesive that is specifically utilized for "debonding" purposes. It is meant to facilitate the separation of multi-layer packaging under the conditions commonly applied to PET bottle recycling. Proof of technical feasibility has already been produced at laboratory level. Now, as part of a joint collaborative effort beyond the value chain, the company is working with partners on upscaling the approach. The aim is to show that it is indeed possible to recycle multi-layer packaging with existing infrastructure. The intention is to stimulate discussions and produce sustainable solutions.

Before such novel concepts can be included in the D4R guidelines, there are still some issues that require clarification. When it comes to PET packaging that, following recycling, is to be reused in the food industry, adhesives and other impurities must be completely removed before it can be fed into the regranulation process. Looking at processing temperatures of between 200 to 270 °C that are commonly used for plastic material, it is to be assumed that certain types of compounds may disintegrate or decompose into their smaller molecules. Concerning the recycling of polyolefin, however, one must take into consideration that, based on the currently used processes, adhesives as well as printing inks or barrier layers remain part of the recycled product. Furthermore, the chemical structure of the adhesives affects the quality of the recycled product in many ways. For example, aromatic polyurethane adhesives have a tendency to split back at temperatures above 150 °C. The data situation still needs to be improved here. Apart from the impact on the mechanical and optical properties of the recycled polymer, the D4R guidelines should also pay attention to the potential production of critical substances.

Paper trays

In the case of paper-based solutions that replace conventional tray packaging, two different types of paper are laminated together. This makes the paper thermoformable. What matters is that the adhesive does not affect the subsequent recycling process; this may, for example be certified by the "Papiertechnische Stiftung" (Paper Technology Foundation).

Compostable packaging

Another option are lamination adhesives that are industrial- and home-compostable. As in the case of paper-based solutions, the adhesive is also independently certified. Combinations with the corresponding packaging materials such as paper and biopolymers enable fully compostable packaging.

Barrier for mono-material

There is another system, which is still undergoing tests, that uses a two-component barrier technology in order to effectively keep atmospheric oxygen away from food. This extends the field of application of mono-material packaging.

Chemcycling

Another recycling option is Chemcycling. The procedure lends itself to plastic waste that, for technological, economic, or ecological reasons, cannot be recycled mechanically. Its molecules are broken down with the help of pyrolysis and processed into pyrolysis oil, which can be fed into composite production as a raw material at the beginning of the value chain.

Conclusions

The packaging industry is facing huge challenges and needs to urgently rethink its approach to reach the goals set by the Green Deal. These days there is no doubt that only sustainable food packaging is future-proof, above all where recycling is concerned. Sustainable change can however only be achieved if those developing new solutions look at the entire life cycle of a product. To close the loop and implement future-proof sustainable solutions in practice, all parties involved in the value chain must work together as closely as possible. //

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