Green Bonding Processes

Global demand for sustainable bonding solutions is growing and is increasingly used for the production of furniture, construction elements or textiles. But how can industrial bonding applications be made more sustainable across the different sectors?

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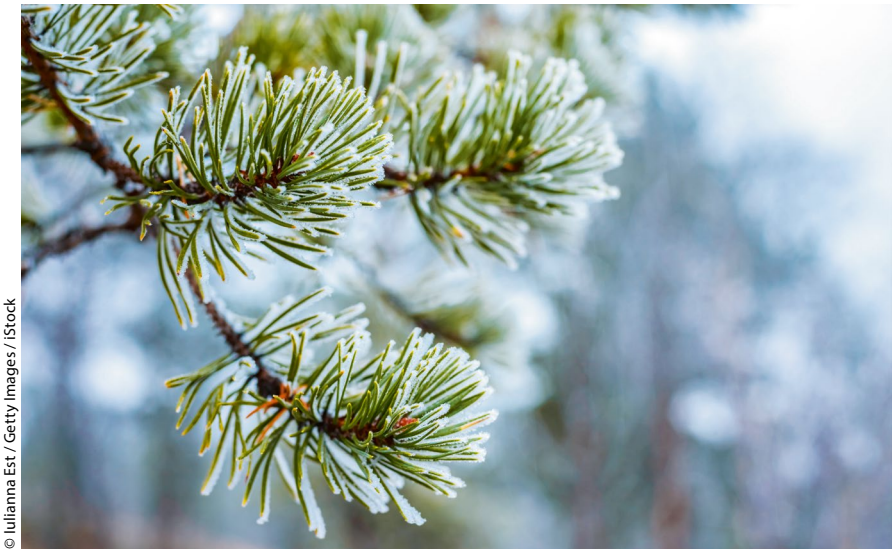
Increasing sustainability in adhesive bonding can only succeed by looking at different dimensions. The optimization of the adhesives themselves is particularly relevant here, but also the effects on the bonding processes associated with the products. For example, a biobased adhesive must not cause more intensive machine maintenance or disproportionately increase reject rates, as this would defeat the goal of sustainability. A sustainable adhesive must therefore meet equally high standards in terms of process reliability, bond quality and cost-effectiveness as a conventional fossil-based adhesive. The success of a sustainable and thus future-proof adhesive can be evaluated from various points of view (*Figure 1*): What is the raw material basis of the adhesive's formulation? What impact does the adhesive used have on consumers? What effects does its use have on the users in the bonding process? And what effects does it have on the process itself? The "Green Adhesives" developed by the adhesive manufacturer Jowat are designed to take these different aspects of sustainability into account and enable manufacturing companies to make bonding more responsible and resource-conserving, also with a view to employees and consumers.

Renewable raw materials

For companies that want to significantly increase the proportion of sustainable raw materials in their production, the use of adhesives based on biological or recycled materials is suitable. The selection of the appropriate adhesive should be made from a holistic perspective, as the substitution of fossil raw materials with renewable raw materials is not inherently sustainable. Thus, the use of biobased raw materials is only sensible if these raw materials can also be obtained in an environmentally friendly way at the same time. Biobased raw materials could counterproductively compete directly with their potential use as food or feed. The ecological benefit is equally questionable if additional agricultural land has to be created. In the optimum case, recycled raw materials or biological by-products from other processes, such as sugar molasses, are the basis for an environmentally friendly adhesive formulation. The aim is to replace as many components of the adhesive formulation as possible – for example, in the case of hot melt adhesives, resins, waxes, fillers, additives and polymers – with renewable alternatives. In biobased adhesives for the packaging industry, for example, Jowat uses tall

Figure 1 Aspects for evaluating a sustainable and future-proof adhesive



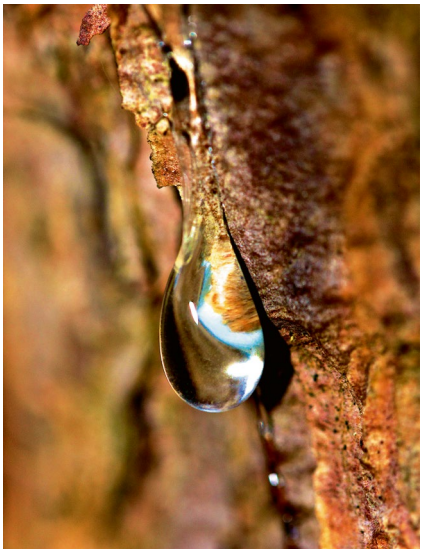


Figure 2 Directly obtained tree resins become raw materials for biobased adhesives

resins derived from pulp production residues. However, directly obtained tree resins (*Figure 2*) or terpene resins (*Figure 3*), which can be extracted from the peels of various citrus fruits, are also an option. Such biobased raw materials are often comparable to petroleum-based systems in terms of their availability and performance spectrum. Biobased adhesives established on the market, for example for packaging processes or textile lamination, offer biobased proportions of more than 50 % and at the same time enable maintenance-optimized and energy-saving bonding processes. The actual proportion of biobased raw materials in Jowatherm Grow hot melt adhesives is proven and certified according to DIN or USDA standards. The percentage of organic

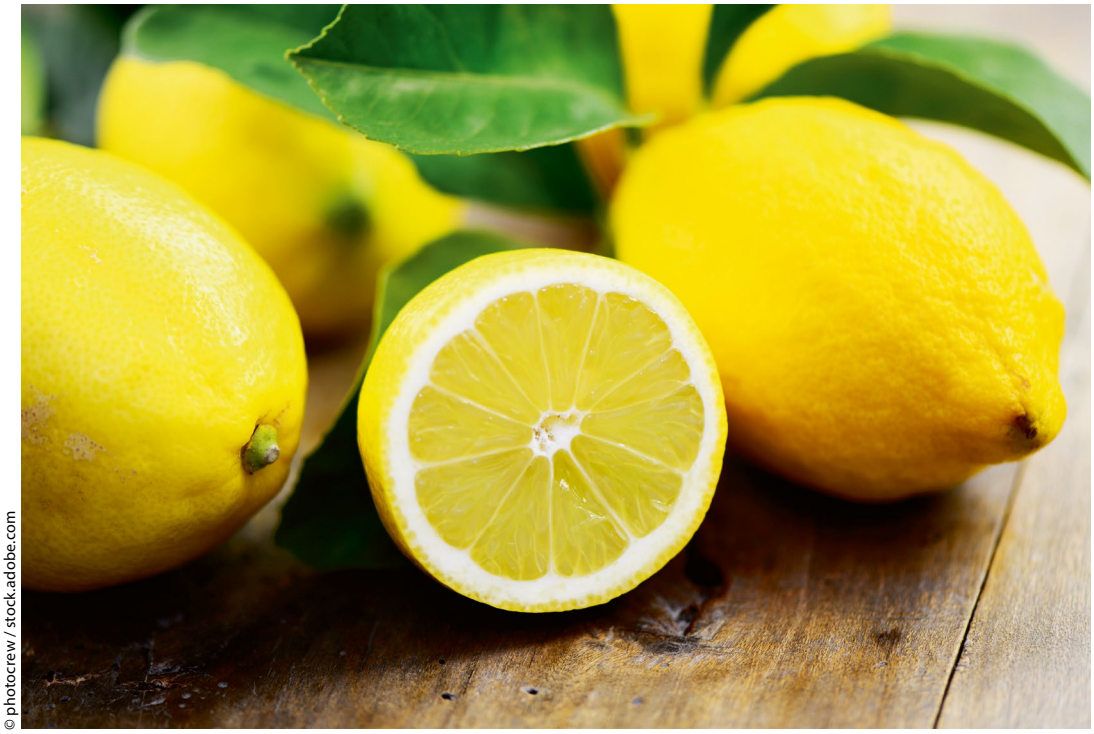


Figure 3 Terpene resins are extracted from the peels of various citrus fruits and are also suitable raw materials for biobased adhesives

substances is determined by the radiocarbon method, also known as the C14 method. This measurement method is based on the fact that the proportion of bound radioactive C14 atoms decreases in dead organisms, for example fossil raw materials, but remains almost identical in living organisms such as renewable raw materials. The use of the mass balance method is considered to be a promising long-term alternative to raw materials with directly measurable biological content. Today, monomers can be obtained from various biobased or non-biobased raw materials from primary or secondary production, which can be used to polymerize adhesive raw materials that do not differ from petroleum-based raw materials. These in turn can be used to produce more sustainable adhesives that have identical chemical and technical properties to their conventional counterparts. Renewable feedstock is added to the petroleum-based feedstock in the existing, continuously operated chemical production facilities. In the final product, the biogenic content is therefore not exactly measurable due to dilution effects. However, appropriate certification and verification systems ensure the traceability of the renewable content reported in the adhesive. The difference is therefore not in the product, but in the production method, similar to green electricity. There are no possible restrictions on the use of adhesives with this method, nor do new adhesive formulations have to be developed and tested. The mass balance method is therefore considered a key method for reducing the use of fossil raw materials in the chemical industry.

Consumer protection

End customers are attaching ever greater importance to a healthy environment: materials and objects in everyday use should be free of harmful substances as far as possible and thus harmless to humans. The development of green adhesives must therefore always take into account the aspects of health effects. Low-pollutant and low-emission adhesive solutions mean considerable relief in this respect: When used in the end customer's environment, they are advantageous in the long term due to their low content of substances that pose a health risk, such as formaldehyde and plasticizers. An optimized manufacturing process has made it possible to develop high-performance D3 and D4 dispersion adhesives whose formaldehyde emissions are 80 % lower than those of their predecessors. In the automotive industry, adhesives with reduced VOC and FOG levels, for example few volatile organic compounds and condensable substances, improve air quality and increase comfort in vehicle interiors. In food packaging, adhesives that are free from aromatic mineral oil hydrocarbons (MOAH) meet the stringent requirements of food legislation.

Occupational health and safety

Commitment to increased employee protection is also a hallmark of a company that wants to act sustainably and responsibly. Employers have a responsibility for the health and safety of their employees. By changing the adhesive they use, for example by switching to monomer-reduced PUR hot melt adhesives or to solvent-based adhesives with a high solids content, they can make a contribution to reducing the risk potential in the workplace and thus to improving occupational health and safety. Monomer-reduced PUR hot melt adhesives have a very low content of monomeric diisocyanate (MDI) of less than 0.1 % and therefore do not require hazard labeling. In addition, from August 24, 2023, at the latest, there will be a further advantage: from this date, the legal obligation to provide training for all users of products containing MDI in the European Union will come into force. With mon-

omer-reduced products, the training obligation will no longer apply, and thus also the resources that are required for this.

Conserving resources

The use of high-yield or low-temperature hot melt adhesives also supports the design of energy-efficient production processes. Conventional hot melt adhesives, depending on their composition and the area of application intended for them, are usually melted and applied at high temperatures. Temperatures of 160 °C and significantly more are often the rule. Under these conditions, heating the adhesives in the bonding process involves a high energy input. Low-temperature hot melt adhesives, on the other hand, can be melted and processed at significantly lower temperatures, in some cases below 100 °C. This leads to a significant reduction in energy consumption and a resource-saving bonding process with lower risks of burns for processors. Another advantage of the temperature reduction during processing is the lower thermal load on the adhesives used. This minimizes the formation of oxidative residues, which can otherwise result in increased maintenance and downtime of the equipment. For universal use in the bonding of edgebands in furniture construction with an optical zero joint, there is a high-yield, unfilled PUR adhesive that can be processed from 100 °C. It offers a high initial strength and can be processed cleanly and without stringing. Such adhesives ensure high bonding strengths with reduced material consumption. In addition, their clean application can simultaneously reduce contamination of machine parts and products.

Conclusions

Green adhesives are elementary building blocks on the way to sustainable industrial bonding. What does not lead to the fulfilment of sustainability goals is the redesign of the overall process at the expense of higher renewable raw material proportions in the adhesive if this is less resource-efficient overall, less compatible with health and the environment, or possibly even uneconomical. In terms of a holistic approach, resource efficiency in the adhesive process, user protection and end-user health are also relevant. //

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