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Adhesive with memory

At the Leibniz Institute for Catalysis, LIKAT, waste from wood and paper production was used to produce a building block for a polymer that can assemble components and has a kind of memory function. The catalytic process for this was developed by LIKAT chemist Bernhard Stadler as part of his PhD thesis. Researchers at the industrial and consumer goods company Henkel are currently investigating the potential of the biobased material on the market, for example in the adhesives industry. The work is part of the EU "GreenSolRes" project, which is investigating the use of renewable resources for the production of biochemicals.

The long-term goal of "GreenSolRes" is the conversion of chemical processes from oil and natural gas based processes to renewable resources. Experts assume that there are about a dozen so-called platform chemicals that can be produced biobased and are thus suitable to replace petrochemicals. These include levulinic acid. It is produced in high yields when, for example, wood waste is heated to 200 degrees with water and diluted sulphuric acid. This chemical reaction has been known for a hundred years.

Bernhard Stadler's task in the "GreenSolRes" project is to refine derivatives of levulinic acid into innovative materials. Therefore the chemist is using catalysts as well as hydrogen and cross-linking agents in addition to levulinic acid. First of all, an intermediate product is created, a so-called diol (1,4-pentanediol), which in a further step combines to form a polyester. The end product is a clear, viscous liquid that is suitable as an adhesive. When cured, the material behaves like a rubber.

In cooperation with researchers from Henkel it was possible to produce a polymer based on 1,4-pentanediol that has a surprising shape memory (ChemSusChem 2020, 13, 556, DOI: 10.1002/cssc.201902988). It can be rolled up and keeps this shape below nine degrees Celsius. As soon as it warms up again to room temperature, it unrolls into its original shape. Shape memory polymers are well known, but the effect can be seen at certain temperatures, often between 60 and 70°C. With these effects, however, it is desirable to set switching temperatures as flexibly as possible - depending on its use, e.g. in the range of body temperature or typical cooling temperatures. This enables potential applications in medicine and logistics for the cooling of goods. Since it is possible to set different switching temperatures with bio-based 1,4-pentanediol in polymers, 1,4-pentanediol could become a central bio-based building block.

"The industry," says Bernhard Stadler, "feels a growing awareness of climate and environmental issues in the market and is opening up to bio-based products. However, these are not simply intended to replace fossil resources, but to provide an additional performance advantage with new properties". The adhesive based on levulinic acid can provide this desired benefit. It is the result of close cooperation with Henkel's development department, as the researcher points out. Both partners have filed a joint patent application for the material and the process. Henkel already manufactures the product on a kilogram scale for sample purposes.

"GreenSolRes" runs from 2017 until the end of 2020 and is funded with 7.45 million Euros. It is connecting together six partners from industry and science from four countries. This international consortium is coordinated by RWTH Aachen University. In addition, a plant for the production of levulinic acid is being optimized at RWTH Aachen University in cooperation with industrial partners. The Aachen-based company is also responsible for the lifecycle assessment. This is because the "green process" should be based as completely as possible on renewable raw materials. This is not yet the case, says Bernhard Stadler, but in principle it is possible.

Bernhard Stadler, Wissenschaftler am LIKAT, entwickelt katalytische Verfahren, um biobasierte Lävulinsäure zu innovativen Materialien zu veredeln (Nordlicht/LIKAT)

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