

Polymer Chemistry | Materials Science and Engineering | Surface Engineering | Technology Offer

# Bio-based, non-isocyanate shape memory polyhydroxyurethanes (SMPHUs) with programmable and switchable shapes

## Field of application

So-called Shape Memory Polymers (SMPs) are materials with the ability to undergo predefined shape changes in response to external stimuli. They are able to memorize their original shape and return from a deformed state (temporarily induced shape) to their original (permanent) shape. The synthesis route is free from hazardous and water-sensitive isocyanates and thereby offers a facile and 'green' alternative to common shape memory polyurethanes while maintaining their stimulus-responsive properties.

These shape memory polyhydroxyurethanes (SMPHU) can be used for a wide range of applications – from moldings, coatings and fibers to films, actuators and components used in medical engineering

## State of the art

Conventional, stimulus-responsive polyurethanes are made from toxic and phosgene-derived isocyanates. These substances are likely to cause allergies, skin irritations and are suspected to cause cancer. In addition, if aromatic isocyanates are used, toxic aromatic amines will be generated as degradation products.

## Innovation

As part of a project funded by the Baden-Wuerttemberg Stiftung gGmbH, scientists at the University of Freiburg succeeded in developing an innovative, relatively simple process that enables sustainable, less dangerous and preferably solvent-free production of smart poly(beta-hydroxy)urethanes (PHUs) using bio-based components. These PHUs are generated by means of polyaddition of di- or polyfunctional, preferably five-membered, cyclic carbonates with di- or polyfunctional amines. The carbonates can thereby be obtained via chemical fixation of carbon dioxide to epoxides and thus also combine the chemical and biological carbon dioxide fixation.

The semi-crystalline polyurethane materials or multi-layer systems related to this invention can change their shape in a precisely defined, programmed manner (shape memory effect) through heating and cooling or water absorption.

## Your benefits at a glance

- ✓ Comparatively simple synthesis of 'green' poly (beta-hydroxy)urethanes
- ✓ Free from isocyanates
- ✓ Use of bio-based components
- ✓ Solvent-free
- ✓ Moisture-resistant monomers
- ✓ Possibility of using additives, which can refine the properties of the PHUs
- ✓ 'Triple shape memory' behavior feasible
- ✓ Reversible 'two-way shape memory'
- ✓ Wide range of applications of the PHUs brought about by the invention

## Technology transfer

TLB GmbH manages inventions until they are marketable and offers companies opportunities for license and collaboration agreements.

## Patent portfolio

A German patent application (DE102017001.393.4) is pending.

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## Publications

„Triple-Shape Memory Materials via Thermoresponsive Behavior of Nanocrystalline Non-Isocyanate Polyhydroxyurethanes“ - Vitalij Schimpf, Barbara Heck, Günter Reiter, and Rolf Mülhaupt, *Macromolecules* 2017 50 (9), 3598-3606

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