SUCCESS STORY

Repairtecture
Innovative repair concepts for polymer-based materials and components along their life-time

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Module

Type of project: Project 1.02 - Fast repairable dynamic covalent polymer networks without creep for a circular economy of crosslinked polymer components, 2024-2027, multi-firm

Repairtecture

NEW REPAIR CONCEPTS FOR HIGHLY CROSSLINKED POLYMERS

A NEW REVERSIBLE CATALYST HAS BEEN DISCOVERED ENABLING THE REPAIR OF HIGHLY CROSSLINKED POLYMERS.

Dynamic covalent bonds endow polymer networks with unique functions such as reparability, healability or recyclability. The current focus of research is geared towards dynamic polymer networks - so-called vitrimers - which are based on thermally activated transesterification. However, the use of this new class of materials in technically relevant applications (e.g., repair of coatings) is difficult, as the dynamic bonds reduce the creep resistance of the materials.

In the COMET module project *Repairtecture*, a new group of catalysts was discovered in a collaboration with the University of Innsbruck and the University of Münster, which enables the reversible switching “on” and “off” of the repair function in the material. By irradiation with light, the activity of the corresponding catalyst is controlled by the color of the light (visible light or ultraviolet light). The work was published in the journal *Advanced Materials* (https://doi.org/10.1002/adma.202411307).

Impact and effects

In the non-activated state of the catalyst, the material behaves like a classic thermoset and is characterized by a high creep resistance (even at higher temperatures). In the case of a repair, the catalyst can be activated in a controlled manner by irradiation

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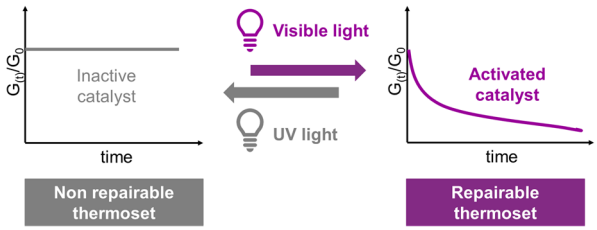
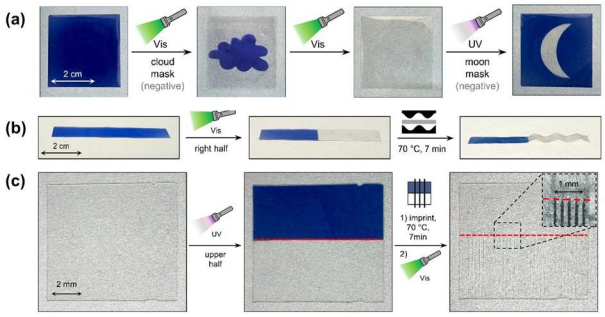
with visible light. At elevated temperature, the catalyzed exchange reactions lead to a viscoelastic material flow, which seals and repairs the defect accordingly. Once the repair is complete, the catalyst is deactivated by irradiation with UV light and the material behaves like a typical thermoset again.



© PCCL, Principle of reversible activation of the new catalysts for the repair of thermosets with high creep resistance.

In addition, the activation of the catalyst by light enables localized control so that defects can be repaired precisely without affecting the surrounding material. This represents significant step-change in the development of repairable coatings.

The new catalysts also pave the way for the production of soft structures with additional functions. The versatility of the new materials enables, among other things, reversible writing and erasing by light, as well as the reversible patterning of microstructures by imprint lithography. This allows the implementation of new manufacturing processes for microfluidics and electronics applications.



© PCCL, local and reversible (a) writing with light, (b) reshaping of soft polymer materials and (c) formation of micropatterns by imprint lithography.

Project coordination (Story)
Priv.-Doz. Dr. Sandra Schlögl
Division Manager
Polymer Competence Center Leoben GmbH

sandra.schloegl@pccl.at

PCCL GmbH
Sauraugasse 1
8700 Leoben
T +43 (0) 3842 42962-0
office@pccl.at
www.pccl.at

Projektpartner

- Mitsui Chemicals Europe GmbH, Germany
- eologix sensor technology gmbH; Austria
- Graz University of Technology, Austria
- Montanuniversitaet Leoben, Austria
- University of New South Wales, Australia

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Österreichische
Forschungsförderungsgesellschaft mbH
Sensengasse 1, A-1090 Wien
T +43 (0) 5 77 55 - 0
office@ffg.at
www.ffg.at