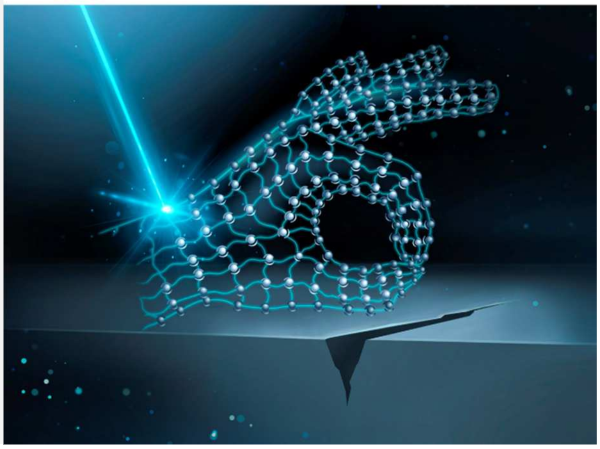
SUCCESS STORY

Chemitecture
Imparting new functions in digitalized polymers by bridging CHEMIstry with macroscopic archiTECTURE

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Module

Type of project: Project 1.03 - Self-healing and recycling of polymer networks, 2020-2023, multi-firm



©PCCL; Additive manufacturing of self-healable soft actuators

ADDITIVE MANUFACTURING OF SELF-HEALABLE POLYMERIC ACTUATORS

A NEW CATALYST HAS BEEN DISCOVERED ENABLING THE CUSTOMIZED FABRICATION OF SOFT ACTIVE DEVICES WITH SELF-HEALING FUNCTION.

Dynamic covalent bonds endow polymer networks with advanced functions such as self-healability, recyclability, malleability and shape memory. Currently, the most attractive dynamic networks are vitrimers, which rely on thermo-activated transesterification reactions. However, the introduction of these dynamic covalent bonds into 3D printable photopolymers is challenging, as commonly used transesterification catalysts are poorly soluble and compromise on cure rate and pot life of photocurable resins.

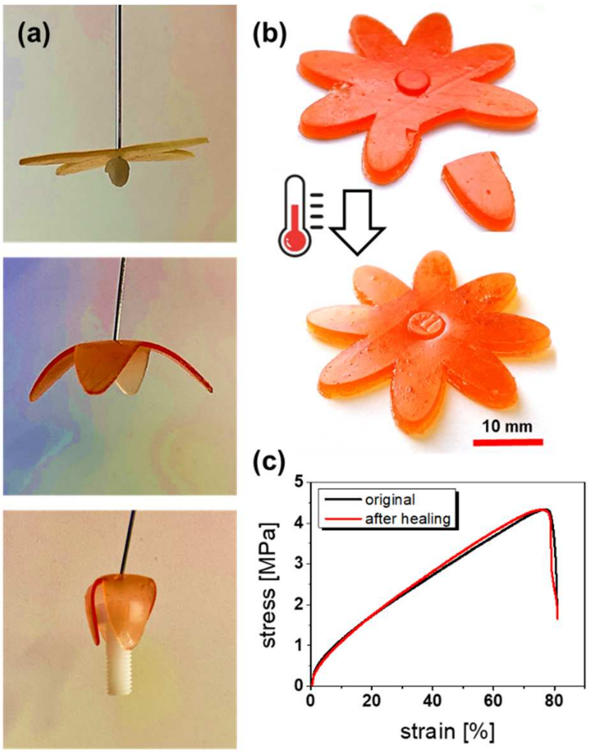
Within the COMET Module Project Chemitecture, we discovered organic phosphates as a new type of catalysts, which overcome these limitations and provide a step-change in the design of photocurable vitrimers. On the one hand, the catalyst does not compromise on cure kinetics and stability of acrylate and thiol-acrylate systems enabling a fast printing process. On the other hand, the catalyst efficiently induces bond exchange reactions at elevated temperature, which are crucial for the thermo-activated mending, recycling and reshaping of 3D printed parts.

The low viscosity together with the fast cure rates make the photopolymers ideal candidates for digital light processing (DLP) 3D printing techniques and 3D objects with feature sizes below 50 µm can be conveniently produced.

Impact and effects

The introduction of the new catalyst paves the way towards the personalized fabrication of soft active structures with additional functions. Due to their dynamic bonds, the printed structures feature triple shape memory, as they are capable to undergo a controlled and active macroscopic deformation upon heating and programming. The mechanical properties of the 3D printed parts are conveniently adapted by the choice of monomers. Soft structures with adequate stretchability are realized, which is crucial for achieving large shape changes in 3D printed devices. The structures are further characterized by a fast response time, which - combined with the freedom in design - makes these materials interesting candidates for the fabrication of customized active materials for soft actuators, soft robotics, biomedicine and electronics.

The dynamic nature of the bonds provides the soft active materials with additional functions such as thermal mendability and recyclability. Broken parts of 3D printed structures can be healed by a thermal treatment at 180 °C and the original tensile properties are fully recovered.



©PCCL; (a) DLP printed gripper showing the potential of this new class of material for the customized production of soft and fast acting actuators. (b) Thermally triggered healing of 3D printed test specimens. (c) Stress-strain curves of DLP printed test specimens prior to and after a thermal mending.

Project coordination (Story)
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- Rembrandtin Lack GmbH Nfg. KG, Österreich
- Siemens Mobility Austria GmbH, Österreich

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