Novel method for curing of epoxy resins uses local UV flashes to initiate a chemical cascade

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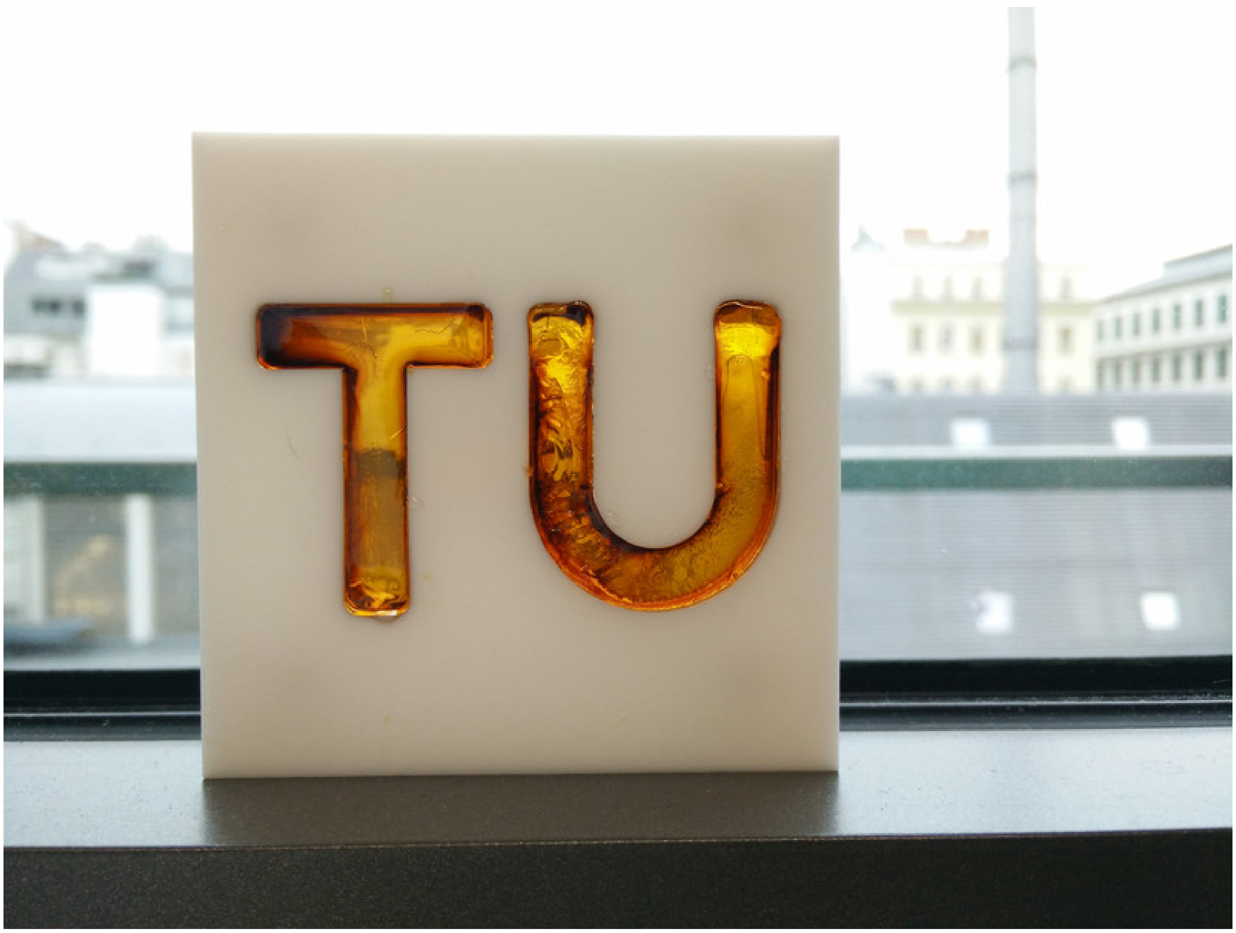

Epoxy resin - hardened with UV light. Credit: Vienna University of Technology

It may appear to be a nondescript, transparent, viscous liquid, but all you have to do is irradiate any part of it briefly with UV light and it changes completely. The new special resin formulation developed at TU Wien solidifies in seconds. This effect continues to spread outwards until the resin is completely solid, which takes a matter of seconds or minutes, regardless of its previous shape. This is referred to as frontal polymerisation. This reaction can be started at any point on the material and spreads automatically from there. The possible applications range from repair kits for car bodywork and moulded parts for aerospace, to wind turbines and high-tech electronics.

Versatile synthetic resin

Epoxy resins are currently used in a wide variety of sectors: in high-tech applications, for example, to insulate electrical components or fix components firmly in electric motors, for load-bearing parts in aeroplanes, as well as for the manufacture of boat hulls. They are also frequently used for repairs, for instance to permanently mend cracks.

Epoxy resins can be poured as required in their viscous state. They are often combined with fibreglass mats or carbon fibre to form high-performance composite materials. There are currently various different curing methods available depending on the type of resin used. "Nowadays, curing is often carried out in large ovens, in which the resin is heated to a high temperature," says Prof. Robert Liska from the Institute of Applied Synthetic Chemistry at TU Wien. This is extremely difficult with bulky objects, such as rotor blades for wind turbines, however. Large ovens are required for this, which is extremely intensive in terms of both time and energy. It also means that the parts must not contain any heat-sensitive supplementary materials. Other resin systems consist of two different highly reactive components that need to be mixed in the right proportions before being used and then solidify by themselves within a short period of time. This is not only more timeconsuming but is also more difficult to control during processing.

Credit: Vienna University of Technology

Other epoxy resins that can be selectively cured using UV light do exist, however. It is these types of materials that Robert Liska is working on with his team. "These materials are already in use today. However, as UV light cannot penetrate particularly deep into the material, this method has so far mainly been used to produce thin decorative coatings or protective coatings," explains Liska.

The new epoxy resin formulation that has now been developed at TU Wien is capable of much more though: "The UV light starts a chemical reaction at a specific point, which temporarily produces a local temperature of up to 200°C. The heat spreads and sets off the curing reaction in the adjacent regions of the resin as well. A chemical cascade is initiated, which then keeps running automatically until all of the resin has been cured," explains Daniel Bomze, a doctoral student on this project.

High quality

The resulting end product has the best possible quality: "It surpasses the materials used to date in terms of both its thermal and mechanical properties," says Patrick Knaack, Senior Scientist at the Institute of Applied Synthetic Chemistry. Another benefit of the new technology is that it does not use harmful heavy metals. Knaack sees numerous possible applications for this technology. It could be used for repair kits and the malleable mass could be manipulated for any length of time before being converted to a solid state using UV light. It would also be possible to cure resin that has a complicated geometric shape, for example coatings on electronic components that cannot be irradiated from all sides. "Thin inaccessible coatings such as these pose a challenge due to the heat loss. We were able to solve this problem too in cooperation with the University of Freiburg," explains Robert Liska.

More information: Daniel Bomze et al. Radical induced cationic frontal polymerization as a versatile tool for epoxy curing and composite production, *Journal of Polymer Science Part A: Polymer Chemistry* (2016). DOI: 10.1002/pola.28274

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