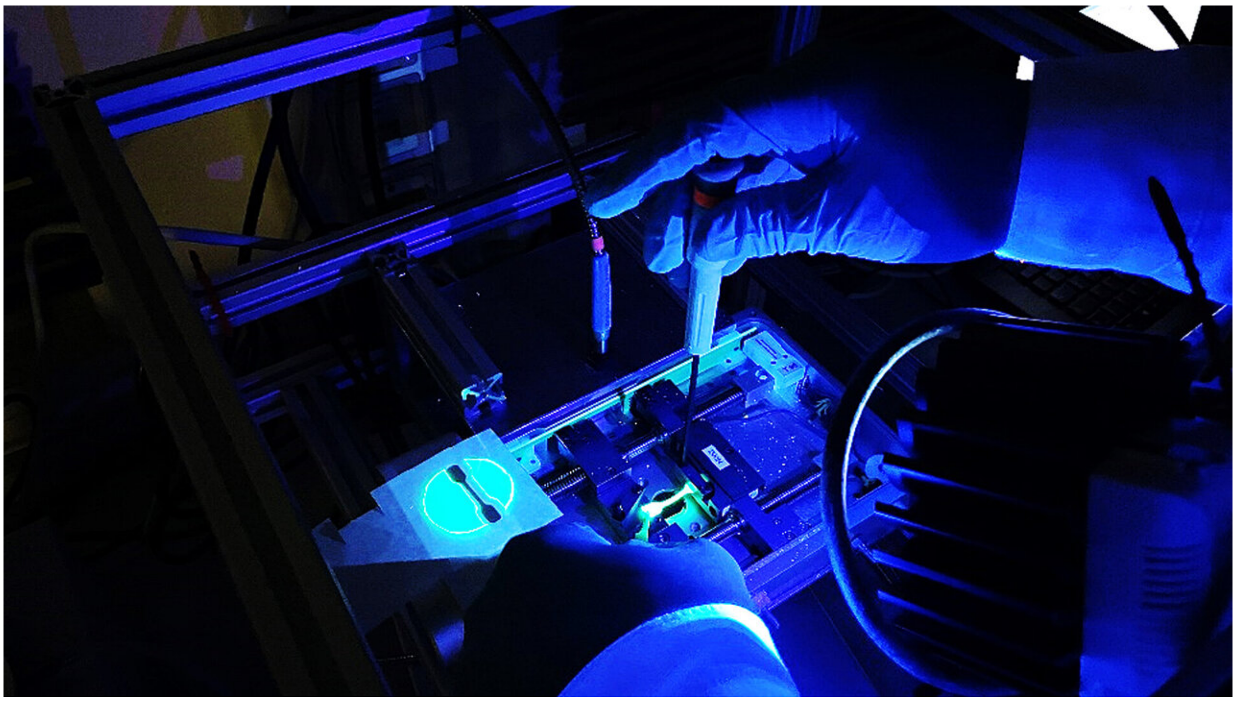
Visualizing stress in plastics

August 4 2021



The developed dye shows stress of different magnitude in plastic components. Whether this works was investigated using mechanical experiments on test specimens containing the dye. Credit: Maximilian Raisch

A research team led by Prof. Dr. Michael Sommer, Professorship of Polymer Chemistry at Chemnitz University of Technology, and PD Dr. Michael Walter, project leader at the Cluster Of Excellence Living, Adaptive, and Energy-autonomous Materials Systems (livMatS) at the University of Freiburg, has succeeded in constructing a new dye molecule from the area of so-called mechanophores.

Thanks to this molecule, stress of different magnitude in plastic components can be visualized continuously by color changes. The concept of such dyes is not new, but most previous mechanophores were able to only indicate the presence or absence of stress in plastics. The current research now enables to differentiate between stresses of different magnitude. This adds up great advantages whenever it is important to map stress distributions in macroscopic plastic components to monitor integrity of the material at all times. The research team is now one step further to developing this effective form of deformation and damage analysis, bringing it closer to practical applications.

The results of the study were published in the journal *Nature Communications* on July 9, 2021.

Molecular spring shows the strength of the load in terms of color

As the researchers report in their publication, by combining a molecularly designed dye with a suitable and, above all, non-brittle plastic, macroscopic forces can now be brought down to the molecular scale. These acting forces can be, for example, external pressure or tension.

The dye molecule thus "feels" the force acting within the plastic components and continues to indicate changes in force by increasing changes in color. If the external load is taken off, the dye molecule returns into its original state. This is why this dye is termed a "molecular spring"—it stretches and "springs"—depending on external tension.

Compared to existing molecular switches that translate stress in plastics by changing color, the advantages here clearly lie in the stepless mapping of forces of different magnitudes as well as the spring-like behavior of the molecule, which can thus be used again and again.

Better mechanical properties—better understanding and applying damping

"This is a bold step towards directly visualizing external residual stresses of plastics with simple analytical methods, which is of great help for the further development of materials with improved mechanical properties made by, for example, 3D printing," summarizes Prof. Michael Sommer.

But it could also allow a more fundamental understanding of damping properties of synthetic materials and natural systems: For example, there are large and heavy fruits that fall from trees from large heights but remain undamaged. Nature serves as a model here, and molecular springs could help to better understand and imitate such systems.

Future efforts will therefore focus on adapting molecular force springs for use in various plastics. This will require joint efforts with other research groups and the use of computer-assisted methods.

More information: Maximilian Raisch et al, A mechanochromic donor-acceptor torsional spring, *Nature Communications* (2021). DOI: 10.1038/s41467-021-24501-1

Provided by Chemnitz University of Technology