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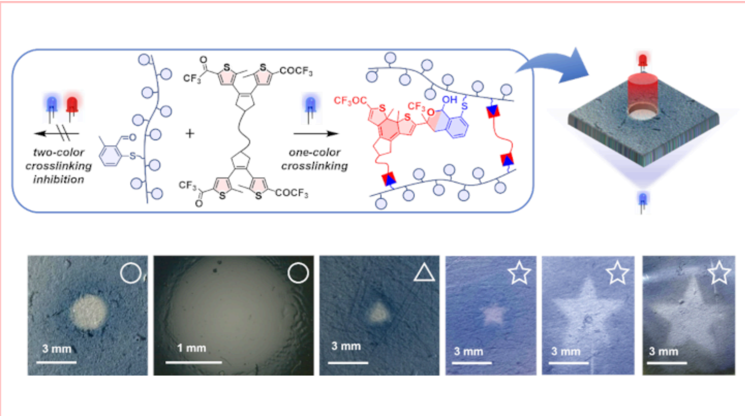
New light-induced polymer material formation method to improve 3D printing resolution



The lithographic and 3D printing techniques are limited by long printing times or low resolution, which prevents reaching micrometric scales. The Department of Chemistry takes part in the development of an alternative technique: polymer photocuring. This process enables the control of polymer formation through light irradiation to produce solid materials more quickly and with higher resolution.

3D printing is an increasingly widespread and accessible technology, typically involving the formation of solid polymeric materials in a specific region, either by extruding pre-formed polymers or by generating them *in situ* from their corresponding monomers. However, these techniques often suffer from several drawbacks, such as long printing times or low resolution, preventing the production of printed materials with micrometric dimensions. To address these issues, polymer formation through light irradiation could be a promising solution, as photopolymerization reactions tend to be faster and can be induced with precise spatiotemporal control.

Most light-induced polymer material formation processes occur under irradiation from a single light source, which limits their temporal and spatial precision. For example, some photoactivated reagents may diffuse beyond the illuminated zone, or their lifetime may exceed the irradiation time, thus limiting the spatiotemporal resolution of the photopolymerization process. Additionally, the maximum spatial resolution achievable with conventional optics is diffraction-limited, preventing such reactions from being confined to the nanometric scale. To overcome these challenges, controlling photopolymerization reactions using two different-colored light sources has been proposed, enabling the development of new lithographic and 3D printing techniques with enhanced capabilities. However, very few reactions of this type are currently known.

The researchers from the Department of Chemistry at UAB have collaborated in this study with Prof. Christopher Barner-Kowollik's group at Queensland University of Technology (Australia) to develop a new photopolymerization reaction controlled antagonistically by two different colors of light. Specifically, one light beam promotes the formation of the polymeric material, while another beam halts the reaction. This process involves photoinduced curing via an *oxo*-Diels–Alder cycloaddition between two reactants: prepolymers functionalized with dienes that are photoactivated by ultraviolet (UV) light and crosslinking agents containing photoconvertible dienophiles, which switch between a reactive and a non-reactive state upon UV and red-light irradiation. By employing light beams with distinct irradiation patterns, polymer resin curing occurs only in regions illuminated exclusively with UV light, while no solid material forms in areas exposed to both colors. This approach has enabled the fabrication of solid polymeric materials with controlled shapes. Currently, this photopolymerization methodology is being explored for 3D printing with micro- and submicrometric resolution.

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References

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