Researchers develop first-of-its-kind woven material made entirely from flexible organic crystals

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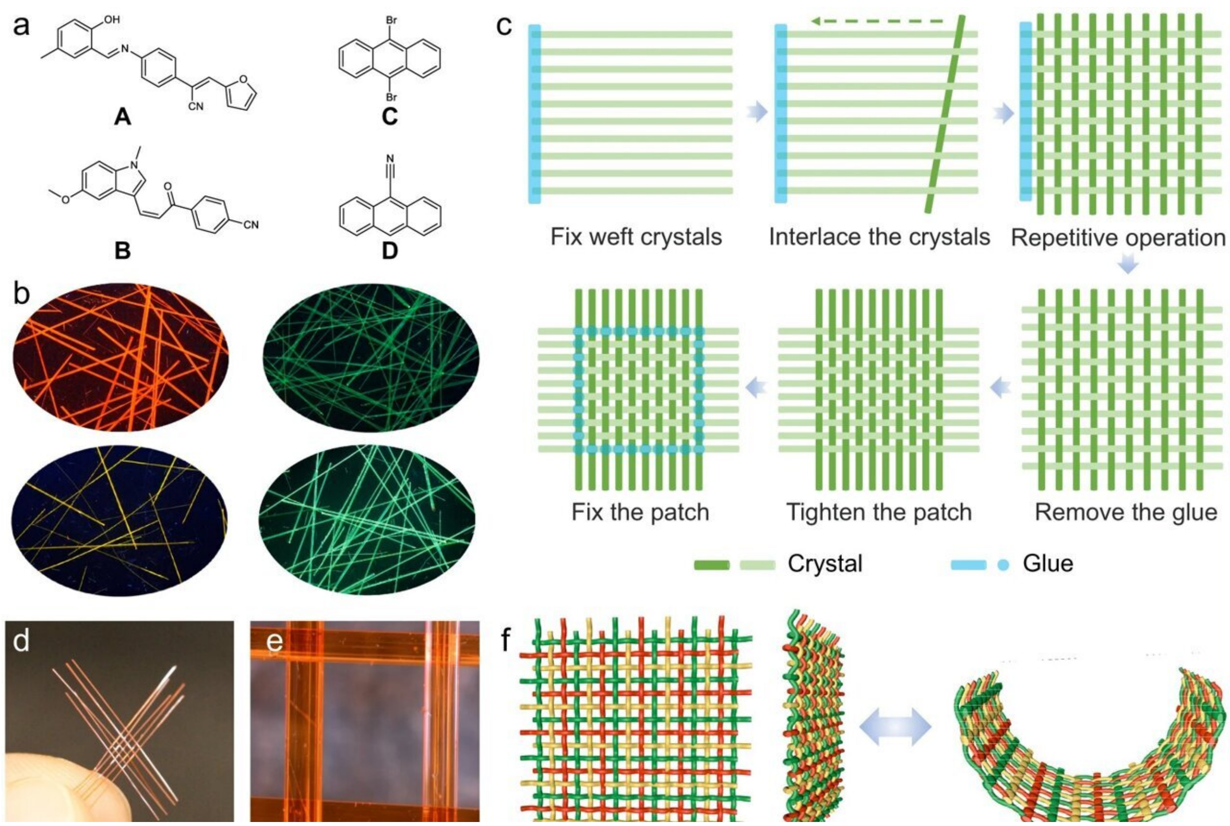

a Chemical structures of compounds **A–D** used to weave the crystalline patches. **b** Photographs of crystals of **A–D** recorded under UV light for contrast against a black background. **c** The method used to weave the crystals. The weft, which is composed of quasiparallel crystals, is set first, followed by interlacing crystals normal to the first set that act as a warp. The weft is then released from the base, the patch is tightened, and the outermost crystals are affixed with glue at the interlacing points to prevent the patch from disassembling. **d**, **e** Photographs of a crystalline patch of **A** (5 × 5) held between fingers (**d**) and a zoomed image of one cell with a hole in its grid (**e**). The scale lengths are 2 mm in panel **d** and 200 μm in panel **e**. **f** Schematic showing the curling of the crystalline patches. **g** A larger woven crystalline patch of **A** (20 × 18) in daylight (left) and under UV light (right). **h** Side view of the crystalline patch in daylight (top) and under UV light (bottom). The scale lengths in panels **g**, **i**, and **j** are 1 cm. **i**, **j** Bending and unbending of the patch of woven **A** supported by the palm (**i**) or by a piece of black paper (**j**). Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-43084-7

Applying simple, ancient weaving techniques to newly recognized properties of organic crystals, researchers with the Smart Materials Lab (SML) and the Center for Smart Engineering Materials (CSEM) at NYU Abu Dhabi (NYUAD) have, for the first time, developed a unique form of woven "textile." These new fabric patches expand one-dimensional crystals into flexible, integrated, two-dimensional planar structures that are incredibly strong—some 20 times stronger than the original crystals—and resistant to low temperatures.

These traits give them a host of exciting potential applications, including in flexible electronics that range from sensing devices to optical arrays, as well as in extreme conditions such as low temperatures encountered in space exploration.

In the paper titled "Woven Organic Crystals" published in the journal *Nature Communications*, Panče Naumov, NYUAD Professor of Chemistry and Director of the CSEM, and colleagues from Jilin University demonstrate that organic crystal can be simply woven into flexible and robust patches with plain, twill, and satin textures.

Because the organic crystals are inherently flexible materials, the researchers found that the patches are not only light in weight but also robust to mechanical impact. They are more than 15 times more resilient to failure than the individual crystals, reflecting the enhanced collective action in response to bending or other impacts on these entangled structural elements.

The researchers also report that the thermal stability of the new "crystalline fabric" is another impressive asset of the flexible crystals. While the thermal stability depends on the actual crystals used in the weaving, crystalline patches of some of these crystals, remain flexible over a temperature range of about 350 ^{o}C, between –196 ^{o}C and 150 ^{o}C, which is superior to many polymers or elastomers that normally become brittle below their glass transition temperature.

The new fabric remains optically transmissive, providing the opportunity to construct networks of optical waveguides that can perform logic operations by selective laser excitation of the component crystals. The researchers report optical arrays of woven crystals that can perform simple logic functions to demonstrate that characteristic.

When organic crystals have the appropriate aspect ratio, they can be exceedingly mechanically compliant and either bent, curled, or twisted. This counter-intuitive flexibility of organic crystals is likely rooted in their weak intermolecular interactions which can sustain large stress without fracture.

"For thousands of years, weaving has been used to produce a range of textiles that are flexible, yet stronger than their component materials, resistant to abrasion and wear, and remarkably durable," said Dr. Naumov.

"Until recently, organic crystals were considered to be stiff and brittle; however, the realization that they can have extraordinary elastic properties has changed that paradigm, not only adding a new facet to their unique set of properties but also revealing an unexplored new direction in materials science. Our new concept of using crystals as the basis for a woven fabric opens up an exciting range of opportunities to combine these woven crystals with other materials for an untold number of technological applications."

More information: Linfeng Lan et al, Woven organic crystals, *Nature Communications* (2023). DOI: 10.1038/s41467-023-43084-7

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