A squishy Rubik's Cube that chemists built from polymers holds promise for data storage

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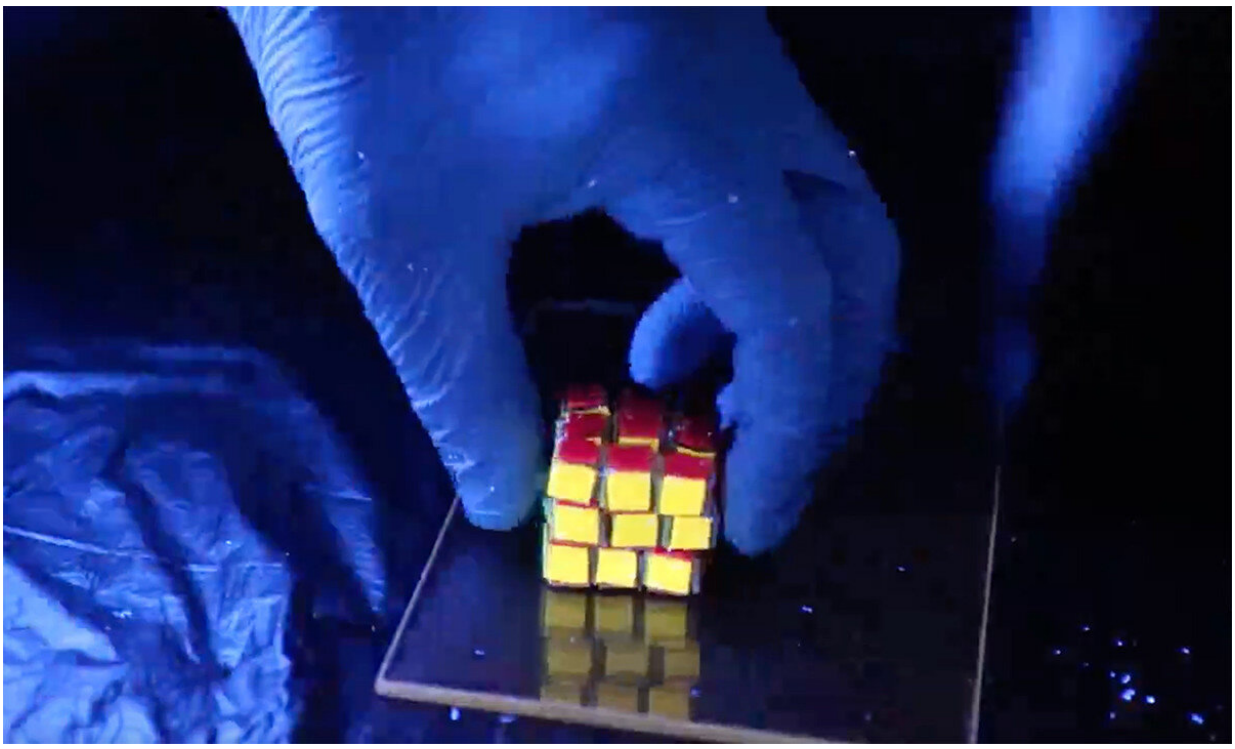

A new Rubik's Cube-like structure made of a self-healing hydrogel might inspire new ways to store information and possibly help patients monitor their medical conditions. Credit: Xiaofan Ji

A team of chemists from the U.S. and China have constructed a cube of colored, hydrogel blocks, which looks and acts much like a Rubik's

Cube. The researchers say their work is more than just fun to play with: it might inspire new ways to store and detect information, and possibly even help patients monitor their medical conditions.

Just like the toy, the new structure contains rotatable individual rows and columns; manipulating these changes the color pattern on the cube's six faces. But unlike the rigid plastic of a Rubik's Cube, this new structure is made of a self-healing hydrogel, a squishy polymer material that can absorb large amounts of water and form new chemical bonds when old bonds break.

The team came up with the structure as part of a larger effort to find new ways to encode information into physical objects.

"Think of QR codes, which are patterns of black and white pixels on a two-dimensional surface used to store information," said Jonathan Sessler, a professor of chemistry at The University of Texas at Austin and co-author of a study published today in the journal *Advanced Materials*. "We're exploring ways to encode information in patterns of color and in three dimensions, theoretically leading to a much higher information density."

Mathematicians estimate that there are roughly 43 quintillion—that's 43 times 10 to 18th power—unique configurations of a Rubik's Cube, suggesting one cube could store a vast amount of information.

"Over a short time, you can manipulate the interactions between the little blocks," Sessler said. "It's sticky, but they aren't getting stuck. Then over a longer time, say 24 hours, the structure locks into place."

The 27 building blocks in the cube were colored using a revolutionary new class of fluorescent dots invented by Ben Zhong Tang, a chemist at the Hong Kong University of Science and Technology, and the project

was led by Xiaofan Ji, a former postdoctoral researcher at UT Austin, now working in Tang's lab.

When parts of a self-healing hydrogel are torn apart and then reattached in a different orientation, new chemical bonds form to hold it in the new configuration. One of the challenges with making the new squishy Rubik's Cube was to make the bonds weak enough that rows could be easily rotated by hand, yet strong enough for the whole structure to retain its shape.

Further development will be needed before the innovation can be applied to data storage, or for other applications, such as in wearable sensors monitoring a patient's chemical changes, for example, in someone with diabetes.

In the 1980s, in the days before solutions to all of life's problems were just a quick Internet search away, Sessler used mathematics to find different series of rotations that could be used to rearrange color patterns on a Rubik's Cube in a controlled way. With enough time, he could take a scrambled cube and restore it to its original condition, with solid colors on each face.

"I'd be at a party and somebody would throw me a Rubik's Cube," Sessler recalled. "And I'd go off in the corner and solve it in a socially acceptable amount of time—something like 10 or 20 minutes."

"Now," said Sessler, "with this new Rubik's Cube, all we have to do is pull it apart and stick the blocks back together where we want. We can solve the problem in seconds by using the power of chemistry to cheat."

More information: Xiaofan Ji et al. A Functioning Macroscopic "Rubik's Cube" Assembled via Controllable Dynamic Covalent Interactions, *Advanced Materials* (2019). DOI:

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