Preprogramming materials to shape shift at a given time (w/ video)

September 28 2016, by Bob Yirka

(Phys.org)—A team of researchers with the University of North

Carolina at Chapel Hill and the University of Akron has devised a method to shape shift materials into a preconditioned state at a preprogrammed time. They have published a paper in the journal *Nature Communications* describing their materials and how they can be programmed and have created a video that shows the shape shifting in action.

Creating materials that can change shape under given conditions would be useful in a variety of applications, including space-based constructions, microstructures for delivering medications inside the human body or monitoring abilities. Up until now, however, such constructs have relied on an external stimulus to cause the change to occur, e.g. heat, light or even a change in pH level. In this new effort, the researchers have developed a material that can be caused to initiate shape shifting at a preprogrammed time.

The team created their materials by making use of two different types of chemical bonds—dynamic and permanent—using hydrogel polymers that were similar to human cartilage. The dynamic bonds control the change in state while the permanent bonds control the final state of the material after it has shape shifted. The energy that is stored due to folding is what ultimately drives the transformation. Preprogramming is done by adjusting the parameters that define the bonds such as location, strength and number. The team reports that they can control the shape shifting to within hours, minutes or even seconds.

The team also reports that they created many objects to test the materials. To demonstrate the effectiveness of their approach, they created a flower that blooms over time with different parts opening after others, just as occurs in nature. They filmed the action, speeded it up, and then posted a video of the results on YouTube. The team also notes that they believe such material could be used to deliver drugs in the body in a novel way—they would be transported to the site where they are needed and delivered when the material shape shifted, allowing the drug to be released.

More information: Xiaobo Hu et al. Programming temporal shapeshifting, *Nature Communications* (2016). DOI: 10.1038/ncomms12919

Abstract
Shapeshifting enables a wide range of engineering and biomedical applications, but until now transformations have required external triggers. This prerequisite limits viability in closed or inert systems and puts forward the challenge of developing materials with intrinsically encoded shape evolution. Herein we demonstrate programmable shape-memory materials that perform a sequence of encoded actuations under constant environment conditions without using an external trigger. We employ dual network hydrogels: in the first network, covalent crosslinks are introduced for elastic energy storage, and in the second one, temporary hydrogen-bonds regulate the energy release rate. Through strain-induced and time-dependent reorganization of the reversible hydrogen-bonds, this dual network allows for encoding both the rate and pathway of shape transformations on timescales from seconds to hours. This generic mechanism for programming trigger-free shapeshifting opens new ways to design autonomous actuators, drug-release systems and active implants.