Turning up the heat on shape-shifting gels

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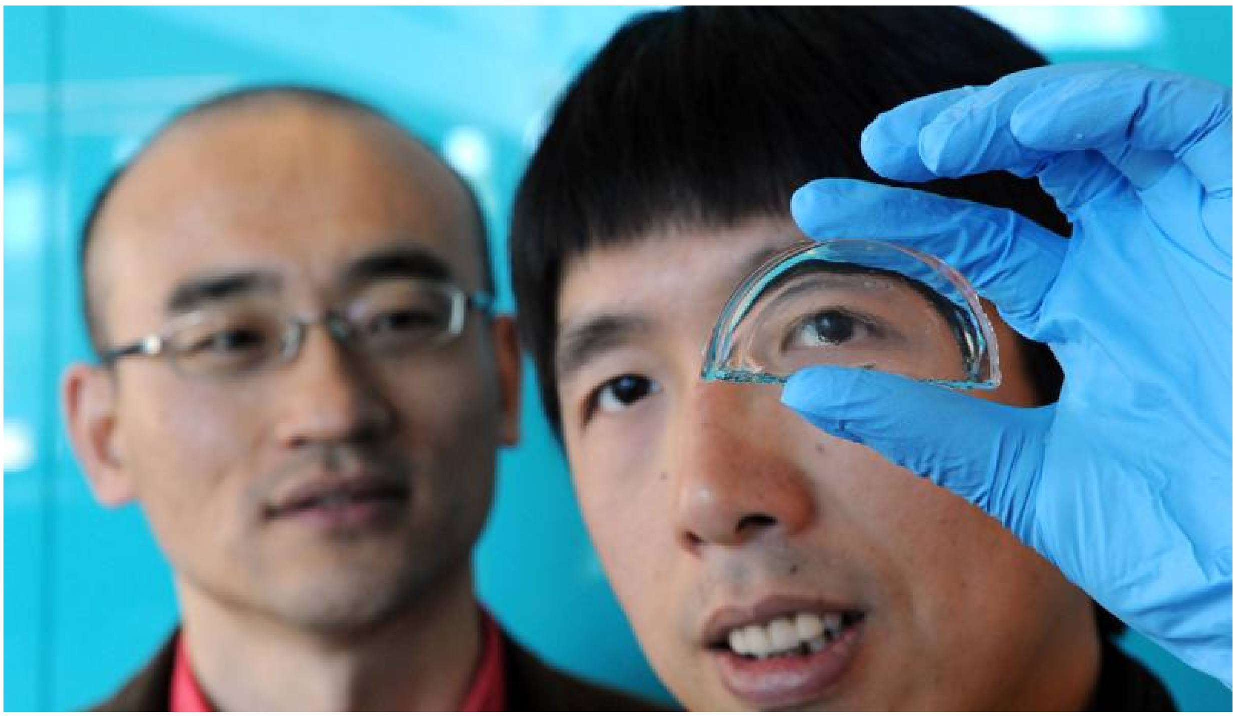

Using steam to control complex chemistry heralds the next generation of heat sensitive smart gels for medicine.

Researchers at the University of Wollongong's (UOW) Institute for Superconducting and Electronic Materials (ISEM) have developed a simple and effective method to turn up the response of temperature-sensitive hydrogels.

Temperature-sensitive hydrogels are a class of materials that consist mainly of water, producing a soft, squishy and wet material with properties similar to human tissue. They are highly sensitive to changes in temperature: shrinking when heated and expand to original size when cooled.

This property makes hydrogels an ideal candidate for temperature-controlled processes, including drug delivery and various types of smart systems, such as valves that expands and closes at certain temperatures.

"The effectiveness of these applications is highly dependent on the hydrogel's response to changes in temperature. In most cases it needs to be very fast. The problem is that the heat does not spread rapidly through the gel," lead researcher Dr Zhenguo Huang explained.

The solution is to add boron nitride, a material with the same atomic arrangement as graphene but with boron and nitrogen replacing carbon atoms alternatively. These atomic-think boron nitride sheets have outstanding thermal conductivity.

"A second challenge was that boron nitride is hard to functionalise for applications because it is chemically and thermally stable. Without functionalisation it is impossible to disperse the boron nitride sheets uniformly through the hydrogel. " Dr Huang said.

The researchers developed a method using just water steam to build atom-thick boron nitride sheets that are then added to the hydrogel. Uniformity of the boron nitride sheets creates a continuous pathway for rapid and even heat dispersion through the hydrogels.

The boron nitride nanosheets, which are now simple to make, low cost, and free of harsh chemicals, proved to enhance the hydrogel's thermal conductivity without compromising its mechanical strength.

"A simple test for temperature response is to look for changes in the material's opacity. A fast change in opacity indicates a quicker response to change in temperature and in this case the hydrogel with the boron nitride nanosheets additive was fivefold faster than a comparison gel without it," Dr Huang said.

Once quick temperature response was confirmed, further lab tests showed the hydrogel boron nitride mix was almost 50 per cent more thermally conductive than the hydrogel without additives.

Boron nitride is non-toxic and biocompatible. A dye test was used to simulate drug delivery. As the temperature rises, the the hydrogel changes shape rapidly and and squeeze out the dye, or drug molecules.

"The key features of shape change and the dye release show this material is really promising for use in medical applications such as drug delivery as well as soft robotics that change shape in soft environments, eliminating the need for mechanical contact."

The research was published recently in the journal *Advanced Materials*.

More information: Feng Xiao et al. Edge-Hydroxylated Boron Nitride Nanosheets as an Effective Additive to Improve the Thermal Response of Hydrogels, *Advanced Materials* (2015). DOI: 10.1002/adma.201502803

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