Scaled-down 'memory' polymer holds key to stronger and smarter mesoscopic materials

April 23 2013

A team of researchers headed by Director Susumu Kitagawa, at Kyoto University Institute for Integrated Cell-Material Sciences (iCeMS), has found that small porous materials increase in memory shape function as they get smaller. The study, published in *Science*, could have potential medical and engineering implications.

Memory shape materials are porous coordination polymers (PCPs) that have the ability to exchange gas molecules and alternate shapes depending on whether they are empty or loaded, like a duffle bag would if clothes were stored inside of it. When unoccupied, the polymer maintains a collapsed state but, when molecules are loaded into it, the material changes its physical appearance and fills out like a stuffed duffle bag. The memory shape function comes into play when gas molecules are removed, PCPs have the ability to retain their filled out shape and will only return to their original form when heated to a high temperature of 200 degrees Celsius.

Kitagawa's group reduced the size of copper-based PCPs into crystals of varying mesoscopic sizes, a realm that lies between a few nanometers and one micrometer, and found that the stability of the memory shape function increased as the crystals decreased in size. Larger crystals tended to lose their ability to keep an occupied state as soon as the contents were removed. Another important finding was that the smaller PCPs were robust and could undergo 20 cycles of change without losing any structural integrity. Finding an optimal crystal size for increasing a material's memory capacity is novel.

"The properties of the smaller crystals actually made them more resistant to physically returning to their original shape," said iCeMS Associate Professor Shuhei Furukawa, one of the lead scientists in the study.

The researchers are hoping that this memory material could be used for numerous applications such as making environmentally responsive medical devices.

"The fact that reduced mesoscopic porous coordination polymers retain memory more efficiently will allow us to construct higher quality materials," stated Kitagawa.

It is not yet known if and how this material could be mass-produced at a reasonable cost, however the knowledge gained from this study provides a stepping stone for creating new products which can be stronger and more easily manipulated.

More information: Sakata, Y., et al. Shape-Memory Nanopores Induced in Coordination Frameworks by Crystal Downsizing, *Science* 339, 6116, 193-196. Published 11 January 2013. DOI: 10.1126/science.1231451

Provided by Kyoto University