Nested metal-organic frameworks as possible novel hydrogen storage materials

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The success of hydrogen technology for driving vehicles depends on the storage of hydrogen, for which a truly satisfying solution has yet to be found. A team of scientists from the University of North Carolina and the United States Department of Energy has now developed a metal-organic material whose cavities keep hydrogen molecules "trapped"-this may be a new prototype for the design of new storage media.

The team led by Wenbin Lin works with compounds of the metal zinc and special organic molecules with six to eight aromatic six-membered rings as their central structural element. Aromatic rings are important because they strongly attract hydrogen molecules.

It turns out that these metal-organic building blocks crystallize in the form of a three-dimensional grid with very large cubic cavities. What is unusual in this case is that four of these grids are partially pushed into each other, which causes them to overlap. The cubic cavities thus get correspondingly smaller. These tiny "caves" are accessible from the outside by means of open channels. When the crystal is freshly formed, the cavities are first unevenly occupied by solvent molecules. These "guests" can easily be completely removed without causing the framework to collapse.

The empty cavities can take up hydrogen molecules. At a pressure of 48 bar, it was possible to store 1.12 (for the compound with six rings) to 0.98 (compound with eight rings) percent by weight of hydrogen-and to release it. This storage capacity is about equivalent to that of carbon nanotubes, another material being considered for hydrogen storage. In comparison with record holders in their own class of metal-organic porous frameworks, the two newcomers are only slightly inferior. The best of the class owe their superiority to their five- to ten-fold higher interior surface area.

How is it that these two new metal-organic frameworks can store hydrogen so well, without an especially high surface area or a particularly large pore volume? Because of the multiple nested grids, the hydrogen molecules in the cavities come into contact with a larger number of aromatic rings than they do in pores of ordinary single grids. The hydrogen is well and truly trapped. "The trapping mechanism of our highly aromatic, strongly interlocking grid structure," says Lin," could point to a new path for the development of effective metal-organic hydrogen storage materials."

Source: University of North Carolina