Bigger is not necessarily better -- in hydrogen storage

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University of Nottingham scientists have made a breakthrough which could help in the development of the next generation of environmentally-friendly cars. Their latest findings on hydrogen storage could be crucial in the development of hydrogen-powered vehicles that are a viable alternative to the petrol and diesel-powered vehicles of today.

In research published in the journal *Angewandte Chemie*, and featured in *Nature* and *Chemistry World*, they studied materials that have a porous sponge-like structure in which to store hydrogen — and found that bigger is not necessarily better. Bigger pores, they found, don't necessarily store the most hydrogen fuel.

The work gives a boost to attempts to cram hydrogen into a small space so that it can be used practically as a fuel. Fuel cells, which run on hydrogen and oxygen, are a potentially environmentally friendly way to power vehicles, producing only water as a waste product.

But hydrogen fuel needs to overcome a number of stumbling blocks before it can replace our oil-based economy. Not the least of these is how to safely store enough hydrogen fuel for cars to cover a reasonable distance before their supplies must be replenished.

One possible solution is to pack hydrogen into porous materials, which soak up the gas like a sponge. Professor Martin Schröder and his colleagues, Professor Neil Champness and Dr Hubberstey from the School of Chemistry, with Dr Gavin Walker from the School of

Mechanical, Materials and Manufacturing Engineering at The University of Nottingham, have been investigating so-called metal organic frameworks (MOFs) — molecular scaffolding filled with tiny cylindrical pores that hydrogen gas can be forced into.

Professor Schröder said: "The idea up to this point has been to increase the pore volume, so as to fit in more gas."

That makes intuitive sense: the bigger the cylinders, the more their capacity, and the greater the inside surface area available for hydrogen to attach to. But now the painstaking University of Nottingham study has quantified the amount of hydrogen that can be put into three MOFs made of identical material but with different pore sizes. Surprisingly, the study showed that the middle-sized pores could hold the highest density of hydrogen.

Professor Schröder added: "In a very small tube, the hydrogen gas molecules all see the wall and interact with it. But in a larger tube, the molecules see less of the wall and more of each other: that interaction is weaker, so they don't pack together as closely."

The researchers conclude that there is an optimum pore size for any given material.

The US Department of Energy (DoE) has set a series of advisable targets that a hydrogen-fuelled vehicle should meet in order to be economically viable: by 2010, the storage system's capacity will need to be greater than six per cent hydrogen by weight, for example.

Schröder's team shows that their frameworks reach this requirement, and come close to the DoE's volume-density target of 45 grams per litre. In fact they have achieved the highest percentage hydrogen uptake of any such material thus far reported.

He added: "MOFs appear to be a viable alternative technology to other materials currently being investigated for hydrogen storage since they can show excellent reversible uptake-release characteristics and appropriate capacities."

Source: University of Nottingham

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