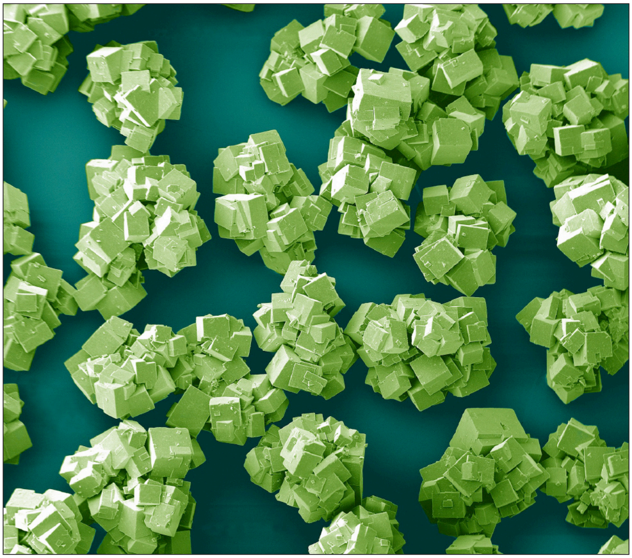
How nanocubes can run your laptop

Dr Who's Tardis may not have been quite so far-fetched after all. A canister filled with newly developed "nanocubes" is able to hold several times more gas than an empty one. These crystals were created by scientists working for chemical giant BASF as part of an effort to generate clean energy. Just a thimbleful has the surface area of a football pitch. What's more, they are formed in a reaction so simple it could be done in a school chemistry lab. The crystals represent part of the company's commitment to the emerging field of nanotechnology – materials on the scale of a billionth of a meter. In the case of these nanocubes, it is only the pores that are nano-scale – the crystals themselves are the size of salt grains.

The big hope for nanocubes is that they could help build a "hydrogen economy". Hydrogen burns efficiently and gives off only water as a waste-product. It is thus an ideal fuel to use, as it yields a lot of energy and produces no pollution. A "fuel cell" reacts the hydrogen with oxygen in a controlled way to generate electricity efficiently. Ideally, all cars, trucks and buses will soon be electric, powered by hydrogen-fed fuel cells.

But aside from cleanly producing hydrogen in the first place, the main difficulty lies in storing and transporting it. Hydrogen is the lightest element, and so to store it effectively as a liquid it must be cooled to extremely low temperatures, or else crammed into reinforced containers at very high pressure. Nanocubes represent a different strategy.



Shaping up: nanocubes could help build a hydrogen economy

Hydrogen is absorbed on to the structure of the crystal, and the high surface area means that large volumes can be stored, even at a relatively low pressure and temperature. Other materials, such as zeolites and activated carbon, can also absorb gases, but have a much lower capacity and can require higher pressures and temperatures.

The safer operating conditions of nanocubes mean that they could also store hydrogen for fuel cells in smaller electronic appliances. Within a few years, nanocubes could be providing much longer battery life for your mobile phone, laptop computer or personal stereo. Instead of plugging your phone into the mains to recharge, you would simply exchange the depleted nanocube cartridge for a new one full of hydrogen.

Aside from fuel cells, nanocubes have many other potential applications. Different gases are absorbed on to the crystal at particular rates, and so nanocubes can be used as "molecular sieves". The nanocubes selectively hold on to one gas, filtering it out of a mixture blown through the crystal. This could be used by hospitals to extract pure oxygen very cheaply from the air, or as an atmospheric scrubber to keep the air fresh aboard submarines or the space station. Scuba diving is another area that might be revolutionised by nanocubes. To hold an equivalent volume, the air tank would need less heavy reinforcement for the pressure and would also be much smaller. However, the differential gas absorption of nanocubes means that nitrogen and oxygen would need to be stored in separate compartments and remixed before breathing.

The molecular structure of a nanocube is a "metal-organic framework" – a grid-like lattice. The corners of this cubic network are clusters of zinc atoms, linked by long organic acids forming the uprights and crossbars. Most of the crystal is therefore empty space, and so nanocubes are extremely lightweight – they are only a few times more dense than a Styrofoam coffee cup. These large pores also mean that gas can be pumped in and out of the crystal with ease.

But it is the metal-organic framework itself that the gas molecules bind to, and scientists are keen to increase its absorption. The situation is analogous to a room in a library with shelves full of books lining the walls. One way of fitting more books into the library would be to build rows of bookcases in the middle of the room as well. Similarly, the storage capacity of nanocubes could be improved even further by introducing struts through the middle of each pore. BASF, and its scientific collaborator, Prof Omar Yaghi at University of Michigan, are working hard to do just this.

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*The author, who is at University College London, came second in the older age group of the latest BASF/*Daily Telegraph *science writer competition. The competition has been launched again and the closing date for entries from 16 to 28 year olds is April 30. For more information, email enquiries@science-writer.co.uk, ring 0870 1267 458 or see www.science-writer.co.uk*