Hydrogen adsorption

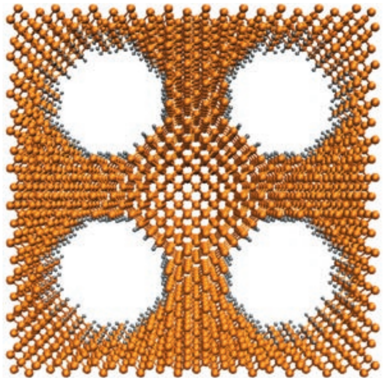
Chem. Mater. doi:10.1021/cm802157r (2008)
High-surface-area materials such as porous carbon, polymers and metal–organic frameworks have high hydrogen storage capabilities at cryogenic temperature. The small hydrogen adsorption enthalpies of these materials have so far limited their applications at room temperature.

Jean Frechet and colleagues have now prepared nanoporous size-selective hypercrosslinked polymer networks with well-controlled pore size formed by linking aromatic rings through a trivalent nitrogen atom. These polymers contain a large number of pores small enough for hydrogen adsorption but too small for nitrogen penetration, leading to size discrimination between nitrogen and hydrogen molecules. The selectivity of these lightweight polymers is based on thermodynamic characteristics and the enthalpies of adsorption for hydrogen are high enough to be considered for hydrogen storage at room temperature. The authors believe that in order for these polymers to meet thermodynamic and capacity requirements, fast crosslinking reactions should be used to increase both pore volume and surface area.

Protein detection

Nature Biotechnol. doi:10.1038/nbt.1501 (2008)
Fluorescence-based assays used for the detection of biomolecules in both research and clinical settings have the advantage of allowing high-throughput analysis, but their sensitivity is limited by background interference and increased fluorescence from molecular sources other than the target fluorophore. Now, Hongjie Dai and colleagues have reported an improvement of three orders of magnitude in sensitivity, compared with fluorescence-based systems, by using single-walled carbon nanotubes as Raman labels. The nanotubes are attached to antibodies and these conjugates are used to analyse protein arrays. This method, coupled with the use of surface-enhanced Raman scattering substrates, results in protein detection of femtomolar sensitivity. Carbon nanotubes are well suited to this application because of their sharp, strong and background-free Raman signals. In addition, the Raman labels are not susceptible to photobleaching or quenching. Isotopic carbon nanotubes with different antibodies attached allow multiplexed two-colour protein detection. The Stanford team apply this new technology to the detection of an autoimmune disease biomarker present in high dilution in human serum.

Porous thermoelectrics



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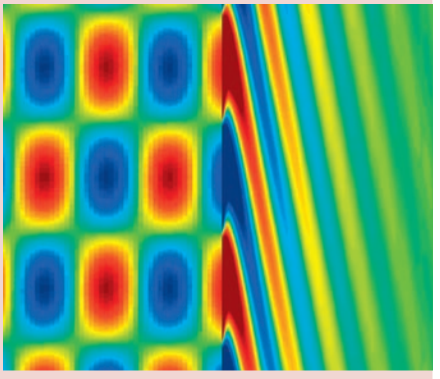
An efficient thermoelectric material, capable of transforming wasted heat into electricity, needs to be good at conducting charges while showing very low thermal conductivity. This combination is usually found in complex compounds that are difficult and expensive to synthesize in large quantities. A promising alternative is to modify the shape and structure of more standard materials in a way that leaves the electrical properties unchanged while degrading the thermal transport. This is precisely what Joo-Hyoung Lee and colleagues have demonstrated for silicon. They used numerical calculations to predict the thermal conductivity of a nanoporous silicon structure with an ordered arrangement of circular or square pores. By varying the size and spacing of the pores, they were able to predict a thermal conductivity up to two orders of magnitude lower than for bulk silicon at room temperature, leaving the electrical transport properties unvaried. This corresponds to a thermoelectric efficiency comparable to materials currently used, but on a material much easier to handle.

Really motoring

Angew. Chem. Int. Ed. doi:10.1002/anie.200803841
The ability to synthesize nanoscale motors that move through fluids could lead to numerous nanoscale devices. Potential applications include delivering drugs in the body, and finding and destroying pollutants in water. Recently attention has turned to bimetal nanowires such as Au–Pt and Au–Ni, where motion is generated by the electrocatalytic decomposition of hydrogen peroxide fuel. These nanomotors typically have speeds of 10–20 μm s^{-1}, thought to be related to the mixed potential difference of the segments. Now Joseph Wang and co-workers have devised a bi-segment metal nanomotor that can run at speeds of up to 150 μm s^{-1} (close to that of efficient biomotors). Replacing gold with a Ag–Au alloy in a Au–Pt nanowire increases the potential difference and this is mirrored by the increase in speed of the nanomotor. By varying the composition of the alloy the speed can be controlled, opening up opportunities to design nanowire barcodes that use motion as a new mode of identification.

True negative refraction

Opt. Expr. **16,** 19001–19017 (2008)
A common misconception is that negative refraction is only possible for materials with a negative refractive index, such as metamaterials. Under certain circumstances, however, negative refraction is possible in a number of systems, whereas a negative refractive index is far more difficult to realize. For example, when negative refraction in the visible was recently reported for plasmon waveguides, it raised the question of whether such systems could have a true negative refractive index. This issue has now been addressed by Jennifer Dionne and colleagues. In their computational study they show that metal–insulator–metal waveguides made from materials such as silver and GaP in particular can indeed support a negative refractive index. In the case of these structures, competing light modes are suppressed. Therefore, the calculated figure of merit is very high,



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suggesting low propagation losses. Based on these findings, the development of plasmon waveguides with a negative refractive index seems a realistic alternative to current metamaterial designs. In particular, it promises ease of integration into optoelectronic circuits and may even lead to new three-dimensional geometries.