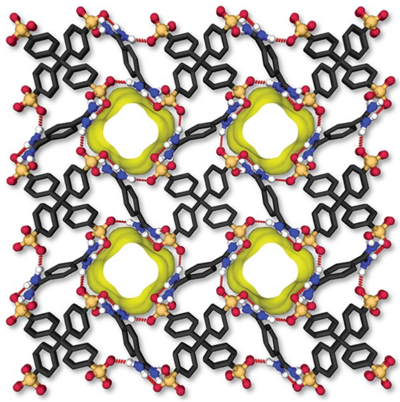
POROUS MATERIALS

A carbon dioxide screw

Chem. Sci. https://doi.org/10.1039/c8sc04376k (2018)



Credit: Royal Society of Chemistry

Permanent porous materials can be designed from molecular building blocks and their pores made to have a defined size and chemical functionalization. These materials have been used for gas sorption and separation applications, but a common challenge is to achieve a high enough selectivity for quantitative separations. Now, Xing et al. describe a porous material that shows high selectivity for carbon dioxide versus nitrogen and that is capable of siphoning CO_2 molecules with a mechanism analogous to that of small molecules moving through certain transmembrane channels.

The researchers start by assembling the porous material using molecules consisting of tetrasulfonate anions and diaminium cations. The channels are subnanometre-size and perfectly fit for CO_2 sorption. The positive and negative charges of the ionic building blocks that face the inside of the pores generate a strong electrostatic interaction with the electric dipoles of a CO_2 molecule. As a result, the selectivity of the material for CO_2 versus N_2 is greater than 500-fold at room temperature. Interestingly, Xing et al. were also able to elucidate the dynamics of CO_2 permeation through the channels. Using temperature-dependent ^{13}C nuclear magnetic resonance, they find that full rotation of CO_2 on the spot is sterically hindered; rather, the molecule can move from one adsorption site to the next by a 90° rotation at a rate of 10^6 steps per second, in a screw-like fashion. *AM*

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ANTIMICROBIALS

Piercing the biofilm

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Biofilms forming around bacterial colonies interfere with the diffusion and penetration of antibiotics within the bacterial cell layers, leading to decreased antimicrobial efficiency and increased resistance. Although pharmacological treatments have been used to disturb biofilm integrity, these are targeted to specific bacterial species. Physical disruption of biofilms might represent a generally applicable alternative.

In their recent paper, Teirlinck and colleagues incubate bacterial biofilms with gold nanoparticles and show that the heat produced on laser irradiation of the nanoparticle causes water within the biofilm to evaporate and form vapour nanobubbles. The nanobubbles can locally disrupt the integrity of the biofilm and enlarge the space between the cells in the bacterial community, increasing its permeability to small molecules. As a result of the treatment, three different Gram-positive and Gram-negative bacteria displayed increased susceptibility to the antibiotic tobramycin. By using the localized effect of laser irradiation, the approach reduces side effects and promises to be valuable for the care of superficial wounds and infections, owing to its low toxicity and negligible heat transfer to the surrounding environment. *CP*

https://doi.org/10.1038/s41565-018-0334-5

NANO-OPTICS

Photons gauge ångstroms

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Although there are optical methods such as stimulated emission depletion microscopy that circumvent the diffraction limit, common sense tells that position determination at ångstrom precision is not possible with visible light. Nevertheless, with the help of precisely tailored laser light and a spherical silicon nanoparticle, Bag et al. have now been able to measure the displacement of this nanoantenna with sub-ångstrom precision.

The researchers base their work on an effect known as Kerker scattering. An incoming wave that simultaneously excites electric and magnetic dipoles of a dielectric particle is scattered asymmetrically, with reduced or enhanced transverse scattering. Earlier, the same group proposed the use of radially polarized light focused on the nanoparticle. The interference of the scattering transverse to the light's propagation direction then produces an intensity distribution in the far field that contains information about the position of the scatterer. Now, they have designed an analytical model taking into account not only the particle but also the interface to its support. Their model can simulate the effects of various parameters, such as particle size and shape or the wavelength of the light, for the most sensitive position determination. With an optimized wavelength and a well-focused laser, the researchers were then able to follow the displacement of a single nanoantenna by a couple of ångstrom with sub-ångstrom precision. *BH*

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NEUROMORPHIC COMPUTING

Artificial neurons à la carte

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Neuromorphic networks built from artificial neurons offer a new form of energy-efficient brain-like computing. So far, however, the demonstrations of artificial neurons have been limited to integrate-and-fire behaviours falling far behind the capabilities of biological neurons in terms of computational complexity and dynamics. Now, Yi et al. report neuron circuits emulating single tonic, phasic and mixed-mode excitabilities and experimentally observe 23 types of biological neuron spiking behaviours.

As a first step, the researchers develop a scalable electroforming-free active memristor made of VO_2 on a SiN_x-coated silicon substrate, with high endurance and low device-to-device variation. Apart from the VO_2 active memristors, the basic circuit topology of the artificial neuron consists of other two circuit elements — a capacitor and a load resistor. By customizing the passive circuit components and operation parameters, they can achieve all three classes of spiking behaviour, including tonic, mixed-mode and phasic spiking. In particular, the newly demonstrated phasic excitability can be realized simply by replacing the load resistor with a capacitor. Finally, the neurons exhibit input-noise-sensitive stochastically phase-locked firing, the behaviour commonly observed in biological neurons. *OB*

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