MOLECULAR TRANSISTORS

Another gate opens

Nature **462,** 1039–1043 (2009)

In a conventional field-effect transistor, a voltage is applied to a gate electrode to control the flow of charge from a source electrode to a drain electrode through a semiconducting channel. One goal in nanoelectronics is to make a field-effect-transistor-like device in which a single molecule acts as the channel. Single-molecule transistors have been made before, but the flow of charge in these devices has been controlled by non-molecular mechanisms — the Coulomb blockade and Kondo effects — rather than by changing the properties of the molecule. Now Takhee Lee and co-workers at Gwangju Institute of Science and Technology, Hanyang University and Yale University have demonstrated molecular-orbital gating in a single-molecule transistor.

Lee and colleagues patterned gold nanowires on an aluminium surface, coated them with the molecules and then broke the nanowires. Sometimes a single molecule bridged the gap between the two ends of the nanowire, which acted as the source and drain electrodes. By measuring the current through the device as a function of the voltage across it for different values of the gate voltage, Lee and colleagues were able to observe transistor characteristics in 35 of the 418 devices that they fabricated. Moreover, electron tunnelling spectroscopy confirmed that the electronic structure of the molecules was being changed by the electric field from the gate, and that the coupling between the gate voltage and the molecular orbitals was surprisingly strong.

NANOPARTICLE CATALYSTS

Two-faced

Science **327,** 68–72 (2009)

When a catalyst is in the same phase as the reacting molecules, separating it from the products can be a considerable challenge. Mixtures of two immiscible solvents, such as water and a hydrophobic organic liquid, can be used to help recover catalysts by exploiting the differing solubilities of the reactants, products and catalyst in the two liquid phases. As well as simplifying separation, such emulsions can also allow products formed in one solvent to transfer to the other so as to avoid further reaction. Surfactant molecules can be used in these mixtures to increase the interfacial surface area and aid the transfer of molecules between the two phases. However, these surfactants can also be difficult to separate from the final product mixtures. Daniel Resasco and colleagues at the University of Oklahoma have now developed solid nanoparticles that can simultaneously stabilize water–oil emulsions and catalyse significant organic reactions.

The researchers synthesized inorganic oxide nanoparticles that were decorated with carbon nanotubes. By combining hydrophobic nanotubes and hydrophilic oxides, the solid particles can seek out the interface between organic and aqueous phases, and by depositing palladium clusters onto the hybrid material, the nanoparticles can also catalyse reactions in both liquid phases. As the catalyst is a solid, it can be recovered simply by filtration.

The Oklahoma team use their nanoparticles to catalyse reactions important in the upgrading of biomass to fuels, in which small organic molecules are added together and oxygenated groups are removed.

CARBON NANOTUBES

Prodigious pores

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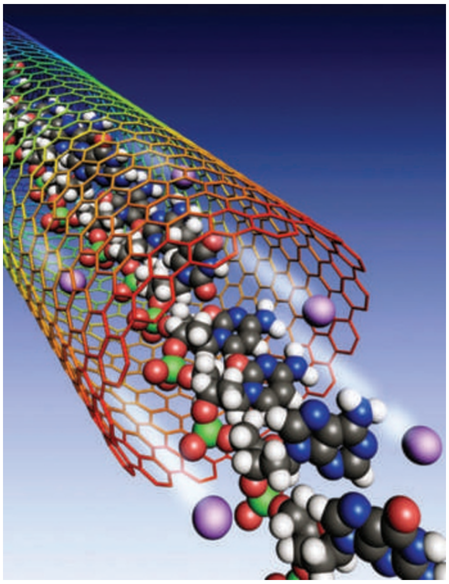

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Nanoscale pores can be used as DNA sequencers and single-molecule counters, and can be made from carbon nanotubes. Gas, water, ions and DNA have all been made to pass through carbon nanotube pores. Now Colin Nuckolls and colleagues at Columbia University, Arizona State University and Oak Ridge National Laboratory have discovered that carbon nanotube pores can pass anomalously high ionic currents.

The researchers measured the ionic current driven by an applied voltage between two fluid reservoirs connected by an individual single-walled carbon nanotube. They found that ionic conductivities ranged over four orders of magnitude for different tubes, with the highest values exceeding expected values by an order of magnitude or more. The high-conductivity tubes were also able to transport single-stranded DNA between the reservoirs. Because DNA is negatively charged, the transport event was accompanied by ionic conduction. Surprisingly, the magnitude of this conduction was orders of magnitude greater than expected given the quantity of DNA transported.

The high ionic conductivities could be due to net-charge imbalances inside the nanotubes, leading to electroosmotic current and large changes in the polarization of the buffer outside the tubes. Nuckolls and colleagues also suggest that the results could be exploited to fabricate a DNA sequencer in which a metallic nanotube serves both as a pore and an integrated electrode.

SELF-ASSEMBLY

Recipe for antibodies

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Synthetic peptides, which are useful as antigens for the production of well-defined antibodies for vaccines, are themselves not reactive and require a substance (known as an adjuvant) to evoke an immune response. Because adjuvants such as oil emulsions and other biological materials are heterogeneous and poorly defined, characterizing and understanding their mechanisms is a challenge. Researchers at the University of Chicago and Illinois Institute of Technology have now shown that a self-assembling peptide can act as an immune adjuvant.

Joel Collier and colleagues attached a short ovalbumin peptide obtained from a chicken egg to a short fibril-forming peptide, and allowed the construct to self-assemble into micron-long fibrils that are soluble in water. The fibrils containing the ovalbumin antigen evoked an immune response in mice, whereas fibrils without the antigen did not. The response was similar to when ovalbumin peptide alone was administered with a conventional adjuvant, suggesting that the self-assembled fibrils can act as an adjuvant. Experiments with unconjugated mixtures of the ovalbumin and fibril-forming peptides completely abolished the immune response, further suggesting that covalent coupling between the peptides and self-assembly are important.

Although the mechanisms remain unclear, and definitive long-term studies need to be carried out, self-assembling peptides represent a simple way to enhance antibody responses towards antigenic peptides.