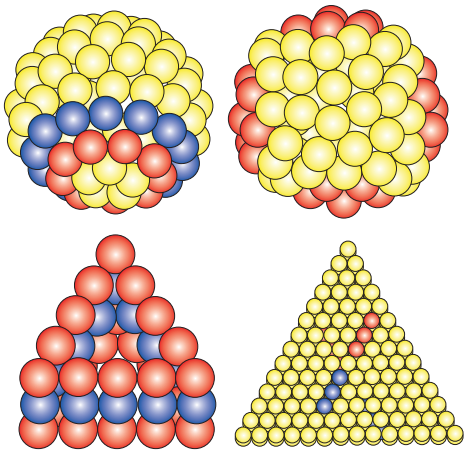
Patchy particles



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The next generation of materials and devices for molecular electronics, photonics, drug delivery and sensing rely on the self-assembly of synthetic nanostructures with the precision of biological organization processes. But despite tremendous advances in the fabrication of a wide range of organic and inorganic nanoscale building blocks of various sizes and shapes, control over their assembly into ordered structures remains the main obstacle to the bottom-up fabrication of these novel materials and devices. Now Zhenli Zhang and Sharon Glotzer at the University of Michigan propose a model to study the self-assembly of nanoparticles with discrete, attractive interaction sites — 'patches' — at prescribed locations on the surface of particles. Their simulations show that specific arrangements of weakly interactive and highly directional patches (see figure) may be used to direct the organization of particles from a disordered state into unique complex structures such as sheets, rings, square pyramids and chains. These results suggest that this strategy could provide a universal route for the rational self-assembly of particles into precise and predictable structures.

MOLECULAR RECOGNITION USING AFM

When a gene mutates, this mutation affects the behaviour of all other genes in the system. To study these effects, researchers need to be able to see these systems function in real time. Atomic force microscopy (AFM) is an ideal technique for this purpose, as reported by Dave Allison and colleagues at the Microscopy & Microanalysis conference in Savannah, Georgia, USA (1–5 August 2004). The researchers studied molecular interactions in a number of bacterial systems using a previously developed molecular imaging AFM that is capable of generating both topographical and molecular recognition images. In it, an antibody — for example, biotin — is attached to the AFM tip, and the corresponding antigen, in this case, avidin, is immobilized in liquid on a mica surface. An attractive force is registered whenever the AFM tip passes over an avidin molecule. This AFM force recognition system can be used as a tool to study structural and functional relationships at the molecular level in live cells.

Dendrimer drugs reduce scars

Scar tissue is the result of inflammation and formation of new blood vessels that trigger the proliferation of fibroblasts — the cells that produce the fibrous tissue of scars. Using new synthetic macromolecules a group of researchers in the UK has proved that it is possible to reduce scarring significantly and promote better healing of skin wounds (Shaunak, S. *et al. Nature Biotechnology* **22**, 977–984; 2004). The successful macromolecules are hyperbranched star-shaped dendrimers that are water soluble and non-toxic. Attached to the periphery of these macromolecules are glucosamine and glucosamine-6-sulphate moieties — the first keeps inflammation at bay and the second inhibits the formation of new blood vessels. The net effect of injecting this combination of dendrimers both locally and systemically is minimal scar formation. Moreover, animal experiments showed a remarkable improvement in the success rate of glaucoma filtration surgery — failure of which is ascribed to excessive post-surgical scarring. Because inflammation and blood-vessel formation are processes involved in many diseases, such as shock-related ones, the authors speculate that the therapeutic utility of these functionalized dendrimers may extend further than just preventing scarring.

Timed delivery

Gene therapy involves the delivery of specific genes into the machinery of living cells where they can promote the production of proteins required to treat a given disease. Increasing the likelihood of success of such therapies often relies on being able to target the delivery of genes to cells in a localized area of tissue, such as that surrounding a biomedical implant. To this end, David Lynn and colleagues (*Langmuir* http://dx.doi.org/10.1021/la048888) have developed a multilayer thin-film polyelectrolyte gene-delivery system consisting of alternating layers of a degradable synthetic polymer (in this case a polyamine) and the sequences of DNA intended for delivery (in this case plasmid DNA encoded for the expression of a green fluorescent protein). When placed in solution, the degradation of successive layers of the polymer causes the interspersed DNA to be released in a slow and sustainable way. More importantly, the authors find that these DNA segments are transcriptionally active — that is, they are ready to start the expression of proteins once they enter the targeted living cells.

Tailored for entanglement

Quantum entanglement is vital to the development of quantum-information processing technologies for high-performance computation and secure telecommunications. The use of entangled photons for such technologies has particular benefits owing to their relatively weak interaction with their environment, and ability to be transmitted over long distances. One way of generating entangled photon pairs is by splitting them from single photons of half their wavelength using a nonlinear optical material such as lithium niobate. However, this requires that the net phase of the generated photon pairs is equal to that of the original photons. Satisfying this 'phase matching' condition whilst maintaining or improving a materials' nonlinear optical properties is difficult, as changing one usually affects the other. Writing in *Physical Review Letters* (93, 040504; 2004), Michiel de Dood and colleagues propose that these difficulties could be overcome through the use of photonic crystals. This allows nonlinear optical properties to be controlled by constructing a photonic crystal from materials of appropriately high nonlinear optical susceptibility, and phase matching to be engineered independently through its structure.