research highlights

Buckled shapes of shells

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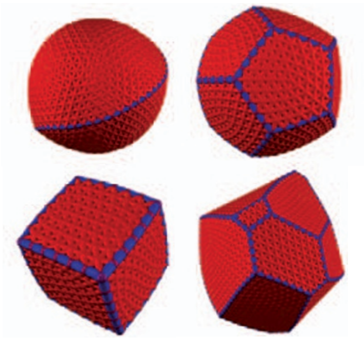

In buckled crystalline shells, curvature (and the corresponding elastic energy) concentrates on the edges and vertices instead of being distributed uniformly over a spherical surface. Buckling into regular polyhedral shapes minimizes the overall elastic energy; this is why most virus capsids are icosahedrons — the polyhedron with the highest possible symmetry. Less symmetrical buckled structures have been observed — for instance in bacterial microcompartments — but this has not been investigated theoretically. Now, Vernizzi and colleagues show that buckling into various polyhedrons of differing regularity can occur spontaneously in inhomogeneous shells. By using Monte Carlo simulations of a two-component lattice model of the shells, they explored the energy-minimizing configurations as a function of the components' area fraction. They also find that the component with low bending rigidity segregates to the edges and vertices of the polyhedrons, and that edges also appear on spherical shells highly rich in the component that does not favour buckling. Surface patterns on buckled shells could be exploited for the design of shape-specific functional microcontainers.

Setting the bar

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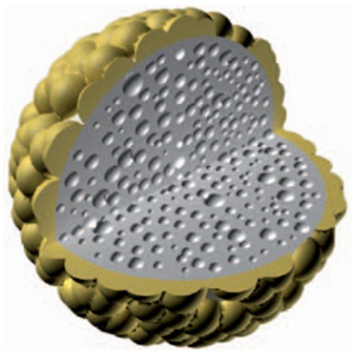
Azobenzenes are known to change geometry under the influence of light. On exposure to UV radiation, *trans*-azobenzene — in which two phenyl rings are arranged on opposite sides of an azo group — readily isomerizes to the more compact *cis* form. The energetically lower *trans* state can be recovered by exposure to visible light or by thermal excitation. Usually, the photoisomerization of azobenzene is quenched in the vicinity of metal surfaces. The molecule can, however, be modified such that the effect persists in self-assembled monolayers. Crivillers and co-workers now show that a monolayer of thiolated biphenyl azobenzene retains its switching capability when covered by a film of organic semiconductor. They fabricated an organic field-effect transistor in which the source–drain electrodes were functionalized with such a monolayer. On exposure to UV radiation and recovery in the dark, the current in the device can be reversibly modulated by 10%. Higher currents were observed for the *cis* state, which the authors attribute to a thinner tunnelling barrier at the electrodes, rather than a work function modulation.

Locate and kill

Angew. Chem. Int. Ed. doi:10.1002/anie201008286 (2011)



Combining diagnostic techniques with providing the optimum therapy — termed theranostics — has obvious advantages in the treatment of various diseases, especially cancer. Now, Zhifei Dai and colleagues have fabricated gold-nanoshelled polymer microcapsules that show promising *in vivo* behaviour as theranostic agents. The polymer microcapsules are coated with gold nanoparticles by electrostatic adsorption and, using a surface-seeding method, the gold nanoshells are formed. The gold-nanoshelled microcapsules detect the location and size of tumours using ultrasound imaging, and kill cancer cells via photothermal ablation therapy. The microcapsules are of such a size that they can cross pulmonary capillaries and show systemic enhancement. When irradiated with near-infrared radiation, the microcapsules raise the local temperature such that cancer cells are killed whilst surrounding healthy tissue remains unharmed. Following photothermal treatment, the ultrasound-imaging step could be repeated to establish the effectiveness of the treatment. During these processes, the theranostic agents do not elicit arrhythmia or other side effects, and show no signs of acute toxicity.

From all viewpoints

Nature **470,** 374–377 (2011)

Electron microscopists have made great improvements in imaging ever smaller structures with continuously improving spatial resolution. It is already possible to achieve a resolution of 50 pm, which is usually smaller than the distance between atoms. In contrast, electron tomography can only reconstruct three-dimensional structures with a resolution of 1 nm. A dream of many experts in the field has been to transfer the atomic resolution of electron microscopy to 3D imaging, and Sandra Van Aert and colleagues have now succeeded. They studied Ag nanoclusters embedded in an Al matrix and reconstructed the structure from only two planar images obtained from different directions with high-angle annular dark-field-imaging scanning transmission microscopy. The fundamental ingredient was the application of a recent technique that allows determination, from each of the two images, of the number of atoms in each visualized column. From the 3D reconstructed clusters the team was able to calculate the projection along various directions, which were then compared with experimental images, confirming the validity of the approach.

Bouncing fluids

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Similar to their photonic counterparts, phononic crystals modify the propagation of acoustic waves through a periodic structure with different elastic properties. Jonathan Cooper and colleagues from the University of Glasgow in the UK have now shown that phononic crystals provide a very efficient control over the shape of liquids flowing along planar surfaces. Previously the shaping of droplets on the surface of piezoelectric materials has been achieved through surface acoustic waves (SAW). These shapes can be quite unusual, and include liquid jets projected perpendicular to the sample surface. In their work, Cooper and colleagues now enhance the function of SAW by placing a phononic crystal on top of the piezoelectric substrate to achieve a much more versatile control over these jets. The phononic crystal contains a conical structure free from the period array of holes etched elsewhere into the silicon. Depending on the frequency of the SAW induced by the piezoelectric substrate, water jets of different shape and length form at a resonance point within the conical structure, which could be used to dispense droplets of a defined volume in a predetermined direction away from the surface.