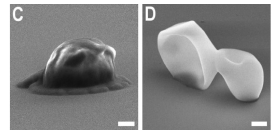
Putting Bio into Nano

Incorporating whole cells into three-dimensional (3D) matrices could prove useful for a variety of applications, such as controlled drug delivery, tissue engineering, or early warning systems for bioterrorist attacks. However, designing the right encapsulation matrix has proved to be a challenge. Such a system would need to allow encapsulated cells to interact with their environment, protect them from mechanical or chemical stresses, allow them access to oxygen and nutrients, and provide an outlet for eliminating metabolic wastes. Some studies have shown the potential of silica sol−gel systems for this use, but traditional sol−gel processing techniques can be toxic to cells.

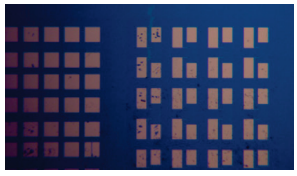
Seeking a new system for creating encapsulated cells, Harper *et al.* (p 5539) devised a novel approach in which cells direct their own integration into the 3D matrix material. The researchers synthesized a weakly condensed lipid−silica mesophase film, then deposited an aqueous suspension of yeast cells onto the film using a pipet or aerosol. The droplets containing the yeast partially dissolved the film and, as they evaporated,



concentrated the cells, lipid, and soluble silica. Viable cells then produced a locally high pH gradient, which catalyzed silica condensation. This effect integrated the cells into 3D lipid−silica nanostructures bound to the underlying film. Tests showed that the cells remained viable and culturable for several days following integration into the matrix, an effect that the researchers were able to extend by adding an antidessication compound to the lipid−silica precursor solution. The researchers suggest that this system could be useful for creating bio/nano interfaces, which could serve as platforms for medical and other applications.

For Graphene, New Way To Peel Back the Layers

Researchers continue to be intrigued by the single-atomic-layer form of carbon known as graphene due to its unusual electronic, optical, mechanical, and thermal properties. Most studies on this material's uses have relied on graphene derived from bulk pieces of graphite through poorly controlled processes, often resulting in unpredictable quality and thickness. Some research has focused on better ways to derive graphene of higher quality and single-sheet thickness. One recent study showed that single-sheet graphene can be peeled from silicon carbide (SiC) substrates using Au as an adhesive and a polymeric layer as a support. However, this method limits the total area of graphene derived because of Au's moderate adhesion.

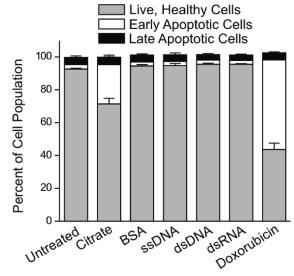


To improve this method, Unarunotai *et al.* (p 5591) substituted Pd, which has stronger adhesive capabilities with graphene, for Au. The researchers grew multiple layers of graphene on SiC substrates, then deposited a layer of Pd, topped with a coating of polyimide (PI). They were then able to peel back the Pd/PI layer manually with an attached sheet of graphene and place it on a target substrate. Removing the Pd/PI layer left only the transferred graphene, which microscopy showed to be of high quality and single-sheet thickness and about 1 cm^2 in area. The same method was able to transfer up to 6 sheets of graphene from the same SiC substrate. Tests showed that the sheet resistance was about 2 kΩ, comparable to single-sheet graphene derived from other sources. The authors note that this method represents a new way to fabricate large-area graphene suitable for a variety of applications.

Surface Chemistry Makes Deep Difference for Nanoparticles in Cells

Nanomaterials are quickly becoming useful tools for a variety of therapeutic and diagnostic applications. However, beyond limited data on toxicity, researchers know little about how the uptake of nanoparticles affects cellular function. In particular, few studies have addressed the effects of various nanoparticle surface chemistry modifications on cell biocompatibility. Characterizing these effects will be necessary before nanoparticles can reach their full potential in medical applications.

To help further this knowledge, Massich *et al.* (p 5641) investigated the effects of gold nanoparticles with various surface chemistries on HeLa cells. The 15 nm nanoparticles were either stabilized with electrostatically bound citrate or were functionalized with covalently bound single-stranded DNA, double-stranded DNA, double-stranded RNA, or coated with bovine serum albumin. To understand how these various surface chemistries affected the cells, the researchers incubated the cells with each of the various nanoparticle types, then did genome-wide expression profiling to look for changes in gene expression. Results showed that the citrate-stabilized nanoparticles induced significant changes in gene expression, but nanoparticles functionalized with either the nucleic acids or protein had little effect on the cells' gene expression profile. Similarly, further experiments showed that the citrate-stabilized nanoparticles affected cell-cycle progression and significantly induced apoptosis, but the nucleic acid and protein-functionalized nanoparticles had no effect on either of these cellular phenomena. The authors suggest that small surface changes on nanoparticles can have significant effects on the cells they interact with and should be taken into account when designing medical applications.



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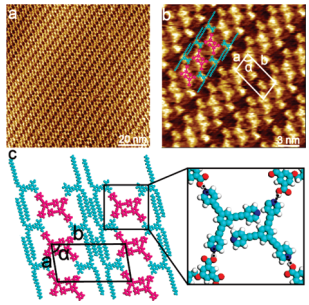
Hosting Guests with Hydrogen Bonds

Patterning molecules on surfaces has been proposed as a useful base for many applications in and of nanotechnology. As such, researchers continue to search for new ways to control patterning and the accompanying function of these assembled nanostructures. One method that has been explored for creating functional, patterned surfaces is laying down a host molecule network as a template to attach functional guest molecules in controlled positions, orientations, and distances from each other. Many of the systems demonstrated thus far have used rigid two-dimensional templates that limit flexibility in attaching different types of guest molecules.

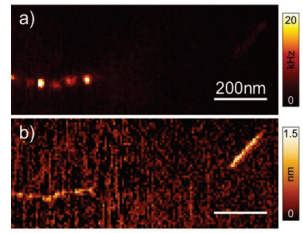


In an effort to create a more versatile host−guest assembly, Zhang *et al.* (p 5685) developed a system that relies on hydrogen bonding between the template and attached molecules. The team laid down a layer of 5-(benzyloxy)-isophthalic acid (BIC) on highly oriented pyrolytic graphite, which formed a linear template. After depositing a solution containing a simple linear pyridylethynyl derivative, scanning tunneling microscopy images showed distinct ribbon structures with the attached guest molecules. Separate experiments with five other different pyridylethylnyl derivatives of varying shapes, including triangular and four-pointed stars, attached similarly well to the BIC template, demonstrating its versatility. Each of these assemblies was possible due to the ability of the pyridylethynyl molecules to serve as hydrogen-bond acceptors because of their pyridyl rings and the BIC molecules' ability to serve as hydrogen-bond donors because of their carboxyl groups. The authors suggest that even more assemblies of interesting host−guest molecules, such as those with useful electrical properties, are possible using the same principle.

A Bright Spot for Carbon Nanotubes

Carbon nanotubes' unique properties continue to earn this material considerable attention from researchers across a wide range of fields. Of particular interest are carbon nanotubes' optical properties, which could be useful in potential applications ranging from optoelectronics to biosensing. Optically exciting semiconducting single-walled carbon nanotubes (SWNTs) can generate excitons of high binding energies. These excitons can be spatially confined due to potential energy fluctuations along the nanotube length, which can influence the nanotubes' optical properties. Thus far, such exciton localization has been observed only indirectly because conventional confocal microscopy cannot access length scales below 100 nm, far above the range at which such local exciton confinement occurs.

To probe this phenomenon, Georgi *et al.* (p 5914) used tip-enhanced near-field optical microscopy (TENOM) to view exciton localization. This tool is able to image the photoluminescence intensity and energy along SWNTs at ~15 nm resolution. The researchers applied TENOM on DNA-wrapped semiconducting SWNTs on a mica substrate, finding localized photoluminescent emission spots in about 5−10% of the investigated nanotubes. The researchers propose that these bright spots are the result of local exciton trapping due to non-uniform wrapping of DNA along the nanotubes. Further experiments showed that localization appeared to be produced by confined energy minima of more than 15 meV and lateral energy gradients of more than 2 meV/nm. Numerical simulations added further support to these findings. The authors suggest that this work could shed light on other phenomena that involve exciton mobility, such as quenching by local defects and exciton−exciton annihilation.



Bringing DNA Origami into the Fold

Researchers have long known that human topoisomerase 1 (hTopo1B), which unwinds DNA by introducing transient single-stranded breaks, shows a strong preference for acting on supercoiled DNA compared to relaxed DNA. One potential reason for this preference is the presence of an unknown secondary DNA binding site in the enzyme. This would make activation more likely in supercoiled DNA, which contains more double-strand DNA crossovers. Another possibility is that complexes of this enzyme with bound DNA may bind to each other through protein−protein interactions. No platform has existed to test whether either of these schemes represents the correct mechanism for hTopo1B's preference.

Seeking a new way to investigate this phenomenon, Subramani *et al.* (p 5969) relied on DNA origami, a technique that folds single-stranded DNA into distinct conformations at the nanoscale, holding these shapes together with the use of oligonucleotide staple strands. The researchers constructed a conformation of DNA that left a small section of protruding DNA as a "bait" for the enzyme and attached this DNA origami onto a mica surface. They then added purified hTopo1B−DNA cleavage complexes. After a short incubation, atomic force microscopy showed that a high percentage of the hTopo1B−DNA complexes had bound to the bait DNA. When the researchers tried a similar experiment with the bait DNA already complexed to hTopo1B, the frequency of interactions with free hTopo1B−DNA complexes was low. These results suggest that the scenario of hTopo1B having a second DNA binding site was more likely, say the authors, and highlights the power of DNA origami as a useful tool for understanding similar biological phenomena at the nanoscale.