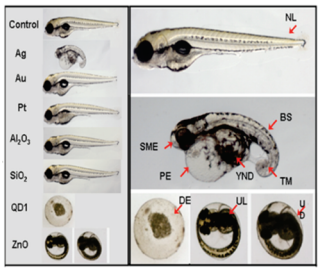
A New Way To Fish for Engineered Nanomaterial Risks

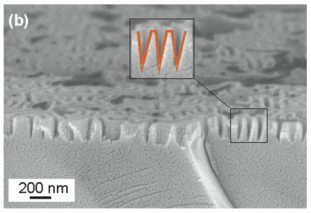
More than 1000 consumer products currently contain engineered nanomaterials (ENMs), and this number is expected to grow exponentially over the next decade. As various ENMs crowd the market, researchers are turning more vigilant attention to the safety of these materials. Though some of them have been evaluated using traditional toxicology methods, the sheer number of new products and their novel properties are expected to make typical assessment protocols unfeasible. Consequently, some researchers have suggested turning to high-throughput screening approaches similar to those used to test the effects of potential pharmaceuticals.



To test the feasibility of this approach, George *et al.* (DOI: 10.1021/nn102734s) used high-throughput screening to test the effects of six metal or metal-oxide nanoparticles and three types of quantum dots on mammalian cells *in vitro*, comparing the results to *in vivo* tests on zebrafish embryos. By adding various dyes to cells treated with ENMs in 384-well plates, the researchers were able to use an automated system to assess for a range of hazardous biological effects, such as mitochondrial depolarization, a rise in intracellular calcium flux, or damage from reactive oxygen species. The results allowed the researchers to rank the nanoparticles from most to least toxic and to group the ENMs by similarities in toxic effects. With a single exception—the effects of Ag ENM, which appear to be species specific—the *in vitro* and *in vivo* results closely matched. The authors note that future assessments could be improved by adding more cellular stress parameters to the assays.

Do Not Reflect on This: Antireflective Coatings from Block Copolymers

Antireflective surfaces have a variety of applications in devices where stray light can be detrimental to optical performance, such as in lenses, solar cells, detectors, and displays. Consequently, various antireflective coatings are typically layered onto optical surfaces to reduce glare and to enhance transmission. These surfaces are usually vacuum-deposited dielectric coatings that work by using thin-film interference to dampen reflected light waves. However, these coatings have a number of drawbacks, including expense, fragility, and often a lack of coverage in the UV range. Patterning subwavelength grating structures is another option for creating antireflective surfaces, but these can be expensive and difficult to place over large or curved surfaces.

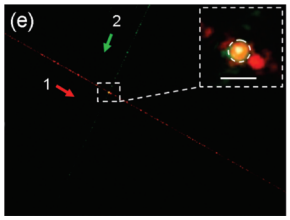


Seeking a new way to produce antireflective coatings without these drawbacks, Päivänranta *et al.* (DOI: 10.1021/nn103361d) looked to nanopatterning surfaces using self-assembling block copolymers. The researchers used different combinations of polystyrene and polymethyl methacrylate to create patterns of varying periodicities on fused silica substrates, then transferred the patterns into these substrates with plasma etching. Spectroscopic measurements showed that reflectivity was reduced over a broad wavelength range by a factor of 10. Further tests showed that the antireflective properties could be tuned by choosing the optimal block copolymer period and varying the etching time. By combining these experimental results with simulations based on rigorous diffraction theory, the researchers showed that the tapered shape of the etched troughs is responsible for the surfaces' broad-band reflective behavior. They suggest that selective etching could further enhance the performance of these antireflective coatings.

Bright Lights, Small Wires

A variety of consumer electronics contain electrically driven liquid-crystal displays. More efficient technologies, such as displays based on electrophoretic ink and electrowetting, are expected on the market soon. For the next stage in display advancement, some researchers are pursuing optically controlled full-color displays. This new technology is expected to require novel materials. One set of possibilities is based on polymers such as poly(trimethylene terephthalate) (PTT), a highly flexible and low-cost material with relatively large refractive index and good transparency.

In a new study, Yu *et al.* (DOI: 10.1021/nn1034185) took the first step toward creating full-color displays made of PTT nanowires. The researchers synthesized the nanowires by drawing them from a PTT melt and manipulated them into a cross on a glass substrate. They then introduced silica fiber tapers that carried red, blue, or green wavelengths of light into these structures. At the apex of the crossed nanowires, the researchers observed spots of light that differed in color based on the combinations of the color inputs and the power of the light sources. For example, combining red and green light led to a mixed yellowish-green spot in one power combination and a greenish-yellow spot with another. They successfully produced other colors with different inputs, such as orange, reddish-orange, blue-green, or purplish-red. By crossing more nanowires in 2 × 2 or 2 × 6 grids, the researchers were able to produce multiple colored spots at each nanowire cross apex. The authors suggest that assembling more nanowires into the grid and introducing a logic circuit to control power input will eventually result in a tunable, all-optical, full-color display with higher efficiency than electrically driven displays.



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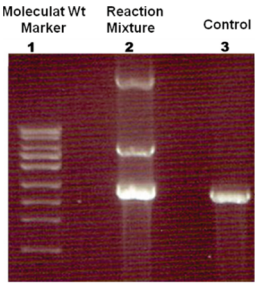
Bringing DNA and Organic Molecules Together

DNA's novel properties, such as its highly specific molecular recognition, tailorable end-functional moieties, and rigid, negatively charged backbone, have led researchers to investigate many uses for this molecule besides its traditional role as a carrier of genetic information. One of its most promising potential roles is serving as a template for building new nanostructures. Incorporating organic molecules into DNA structures could imbue them with more functional qualities that could make them into promising molecular-scale building blocks. However, investigators have run into numerous problems creating DNA–organic molecule hybrids, such as poor solubility in organic solvents, complex electrostatic interactions, and steric hindrance contributing to low reactivities of end-functional groups in pieces of long DNA.

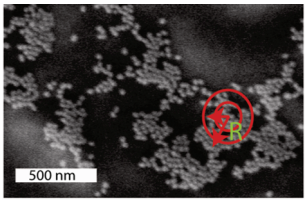


To gain a better understanding of the best way to build these hybrid molecules, Lee *et al.* (DOI: 10.1021/nn1032455) undertook a systematic investigation of various ways to synthesize DNA–organic molecule building blocks and to lengthen these structures into micrometer-sized pieces. The researchers focused their investigations on three common cross-coupling reactions: amide coupling, isothiourea bond formation, and "click" chemistry, which mimics reactions in nature. By varying conditions, the researchers identified the optimal reactions to join three different organic molecules (poly(ethylene glycol), poly(*p*-phenylene ethynylene), and benzenetricarboxylate) between short segments of single-stranded DNA. They successfully created linear DNA–organic molecule hybrid building blocks as well as tribranched structures. Additionally, the investigators used DNA hybridization, followed by ligation, to elongate these structures into micrometer lengths. They note that these findings could eventually aid in constructing nanoscale two- and three-terminal DNA-based electronic devices.

Networking for Cancer Diagnostics

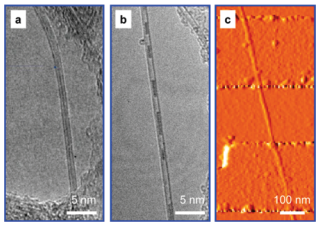
Finding accurate and easily interpretable ways to identify cell surface markers would be a boon for cancer diagnostics and subsequent treatment. Many of these markers give potent clues about the cells' invasive and metastatic potential. Some of the latest methods developed to detect cell surface markers include hyperspectral surface plasmon resonance imaging (SPR) and surface-enhanced Raman scattering (SERS) of gold nanoparticles. However, using single particles has several drawbacks, including the potential for nonspecific binding, aggregation that could lead to undefined SPR peaks, and uptake by cells.

Looking for a way around these difficulties, Lee *et al.* (DOI: 10.1021/nn1030862) developed a new cell phenotyping approach in which gold nanoparticles aggregate into networks surrounding cell surface markers. The researchers created "pointer" particles functionalized with antibodies to the markers and single-stranded DNA, as well as "enhancer" particles functionalized with Raman dyes and single-stranded DNA complementary to that in the pointer particles. When the two particles specific for CD44 or CD24 antigens were added to cells that displayed these markers, the particles formed fractal-like networks on the cells' surfaces. When added to cells without these markers, no networks were visible, and the particles were easily rinsed off. The researchers confirmed that the networks were viable and easily detectable using both SERS and localized SPR in scattering. While such a diagnostic system would be advantageous on its own, the authors also suggest that the nanoparticle networks could eventually play a role in therapeutics, allowing selective heating of cells carrying particular markers for gene release or specific tumor cell ablation.



The Attraction of Trapped Magnetic Particles in Nanotubes

Researchers continue to pave the way toward spintronic devices, emerging technologies that take advantage of both the spin of electrons and their associated magnetic moment in low-dimensional systems. Some investigators have focused on carbon nanotubes as components for these devices because these materials possess unusually rich transport properties. Carbon nanotubes might act to manipulate and to detect electron spins at the molecular scale in hybrid spintronic devices. These materials might be further enhanced by trapping nanometer-sized magnetic objects inside single-walled carbon nanotubes, a possibility realized experimentally in recent years after motivation by numerous theoretical studies. However, despite these investigations, few studies have focused on measuring electrical transport in these hybrid materials.



To expand the knowledge base surrounding these materials, Cleuziou *et al.* (DOI: 10.1021/nn2000349) created single-walled carbon nanotubes (SWNTs) partially filled with cobalt nanoparticles. They fabricated these devices by filling SWNTs with CoI_2 nanowires, then reducing the wires into cobalt nanoparticles that remained trapped within the nanotube walls. The researchers then connected these hybrid nanotubes with source and drain Pd electrodes and placed the devices on top of oxidized doped silicon substrates, which served as back gates. Ramping up and down the magnetic field showed that the nanotubes' conductance was highly sensitive to the magnetization reversal of the cobalt nanoparticles, which retained their magnetic properties while encased within the SWNTs. Measurements showed unusual magnetic anisotropy, causing the magnetization of the nanoparticles to be perpendicular to the encapsulating nanotube. The authors suggest that these devices could eventually act as powerful magnetometers, providing readouts of the activity of nanoscale magnets.