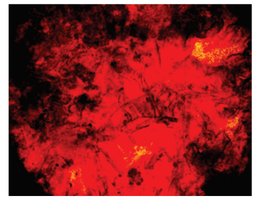
Photoacoustic Effect Bones Up Stem Cells

Mesenchymal stromal cells (MSCs) are multipotent stem cells found in marrow that can differentiate into tissue types including bone, cartilage, and adipose. Since this versatility imbues them with a variety of potential biomedical applications, researchers have sought to develop ways to effectively direct their differentiation into specific tissue types using environmental cues. Previous studies have identified several influences which can steer the cells' differentiation toward osteoblasts, including laser-induced optical stimulation and low-intensity pulsed ultrasound. However, the effects of photoacoustic stimulation (PA) had not yet been explored.

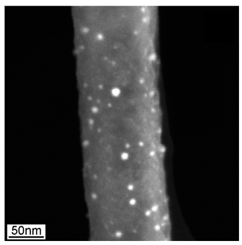
To investigate, Green *et al.* (p 2065) exposed MSCs grown without osteogenic culture supplements to daily 10-min rounds of nanosecond pulse laser-induced PA, facilitated in cell cultures by single-walled carbon nanotubes or gold nanoparticles. They compared these cells to cells grown the more conventional way, without PA and with the supplements. The researchers found that the cultures



exposed to PA and seeded with nanotubes had a 612% increase in calcium, an indication of differentiation toward osteoblasts. In addition, these cells had nearly twice as much calcium content as PA-stimulated cells without the nanotubes. The results suggest that PA is an effective way to stimulate differentiation toward osteoblasts, a method with important implications for bone regeneration.

Interior—and Exterior—Decorating of Nanotubes

Carbon nanotubes possess a variety of interesting mechanical, thermal, and electronic properties, some of which are enhanced with chemical modifications to their surface through doping or grafting. Consequently, many research teams have developed techniques to decorate nanotube surfaces with multifunctional agents including nanoparticles, which are of particular interest for catalysis applications. However, these techniques do not distinguish



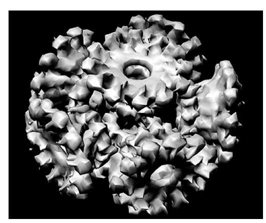
between decorating the inner and outer surfaces of the nanotubes, which can affect the catalytic properties of the nanoparticles.

Seeking a new way to localize the deposition of nanoparticles on nanotubes, Tessionnier *et al.* (p 2081) developed a method that selectively directs them to the inner or outer surfaces of nanotubes based on the difference in interface energies of organic and aqueous solvents with the nanotube surface. The experiments show that an ethanol solvent better wets and penetrates the nanotubes, depositing Ni nanoparticles on the inner surface, while a distilled water solution better deposits Ni nanoparticles on the outer surface. Imaging the resulting products with electron microscopy shows that this technique has ~75% selectivity for localizing the nanoparticles inside nanotubes and 85% selectivity for depositing nanoparticles on the outer surface. The authors suggest that such selective deposition could make it possible to create new hybrid materials for catalysis, magnetism, and electronics.

Bacteriophage Motor Proteins, Salvaged for Parts

Researchers are increasingly using rational design to develop new nanoparticles derived from biological building blocks. So far, scientists have successfully crafted nanoparticles based on biomolecules including DNA, RNA, viral proteins, bacterial S-layer proteins, peptides, and peptidomimetics. Central to each of these applications is a thorough understanding of the characteristics and self-assembly mechanism of these molecules.

In an effort to design a new biomimetic nanoparticle, Xiao *et al.* (p 2163) chose as their starting point the connector protein from the well-studied bacteriophage phi29. This protein is part of a unique molecular motor that phi29 uses to package its 19.3 kb genome into a preformed procapsid. The native crystal structure of the protein is a 12-fold symmetric dodecamer that forms a truncated cone. Re-engineering this protein by extending its N-terminus with a removable 22-residue peptide, the researchers generated ellipsoid nanoparticles using 7 dodecamer units. Using electron microscopy and analytical ultracentrifugation, the researchers found that the synthetic particles measured 20 × 30 nm and contained 84 connector protein subunits. The scientists were able to reversibly convert this nanoparticle to its individual dodecamer

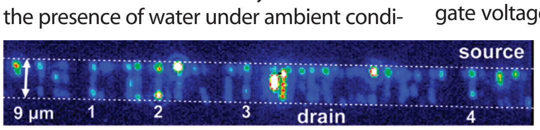


subunits by cleaving the N-terminus extension with a protease. The authors note that conjugating the nanoparticle's 84 C-termini with a streptavidin binding particle made it amenable to incorporating markers for enhanced signaling, which could extend its applications to pathogen detection and disease diagnosis.

Using Electrolytes to Generate Electric Light

Recent studies have documented a range of interesting optoelectric effects from field-effect transistors (FETs) based on single-walled carbon nanotubes, including near-infrared electroluminescence from excitons produced by the recombination of holes and electrons injected from the source and drain electrodes. However, external quantum efficiencies from these devices were generally low. Many nanotube-based FETs also suffered from current hysteresis from the presence of water under ambient conditions and the high voltages required for sufficient injection of holes and electrons.

Seeking to improve performance, Zaumseil *et al.* (p 2225) developed ambipolar FETs using large-scale, parallel arrays of carbon nanotubes grown by chemical vapor deposition. However, rather than using traditional oxide dielectrics, the researchers gated these FETs with electrolytes to facilitate injection and accumulation of high densities of holes and electrons at very low gate voltages with minimal current hysteresis. These devices generated electroluminescence from numerous emission spots corresponding to individual nanotubes in the array. Adding a thin layer of TiO_2 or HfO_2 to these FETs resulted in a significant increase in the dielectric constant of the nanotubes without drastically altering the overall device and emission characteristics. The authors suggest that efficiency might be further improved by increasing the ratio of semiconducting to metallic nanotubes and by gaining better control over the chirality and diameter distribution.



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