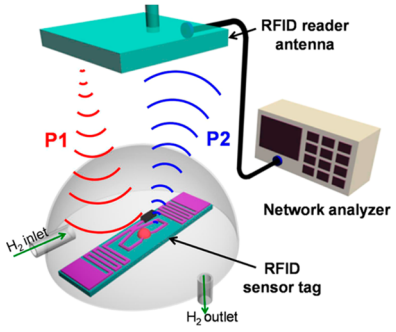
The Smart Way To Sense Hydrogen

Hydrogen has played a longstanding role in a variety of industrial applications, including in fossil fuel production, chemical compound synthesis, power plant operation, and the aerospace and automotive industries. As hydrogen-based zero-carbon-emission vehicles move closer to fruition, hydrogen will play an even more common role in everyday life. However, hydrogen is highly flammable yet odorless and colorless, making the ability to monitor its presence effectively an important priority. In addition, as the use of hydrogen grows, having ways to monitor large areas such as cities using wireless networks will be important for its safe application.

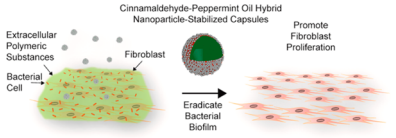
Toward these goals, Lee *et al.* (DOI: 10.1021/acsnano.5b02024) developed a radio frequency identification (RFID)-based wireless smart-sensor system to detect hydrogen. The researchers constructed the RFID sensor by spin-coating platinum onto reduced graphene oxide and incorporated these sensors into tags containing wireless antennas. When hydrogen adsorbs to the platinum decorating this sensor, its electrical resistance increases, leading to a shift in the reflectance of the RFID tag. Tests show excellent sensitivity to hydrogen gas at concentrations as low as 1 ppm at room temperature and rapid response and recovery times, a response that was reversible and reproducible. These tags were flexible under bending deformation and operated without a battery using backscattering communication, promoting a long lifetimes. The authors suggest that RFID sensors such as these could find use in hydrogen monitoring on both small and large scales.



Nanoparticle-Stabilized Capsules Break through Biofilms

Biofilms—microbial communities that exude extrapolymeric substances that create a thick, sticky film—have become significant clinical challenges. These robust collections of microorganisms grow on living or dead tissue, causing infections including endocarditis, otitis media, and chronic wounds. They also frequently occur on synthetic implants and indwelling medical devices, negatively impacting their function. A biofilm's matrix gives it high resistance to host immune responses and limits antibiotic penetration; when combined with growing antibiotic resistance, these factors severely restrict treatment options. Although phytochemicals have emerged as promising alternatives to traditional antibiotics, delivering them within biofilms has been difficult.

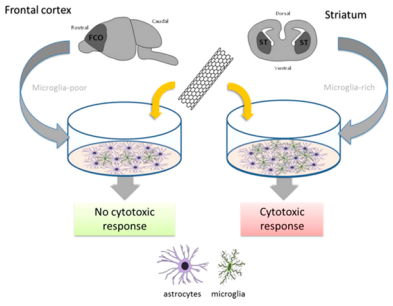
To overcome these issues, Duncan *et al.* (DOI: 10.1021/acsnano.5b01696) developed Pickering emulsions stabilized with nanoparticles that enclose a multifunctional core. The researchers chose SiO_2 cationic amine-functionalized nanoparticles with an average diameter of 150 nm for biocompatibility in both materials and size. Mixing a water solution containing these nanoparticles with either peppermint oil or a mixture of peppermint oil and cinnamaldehyde, the nanoparticles self-assembled into capsules with oil cores at the oil/water interface. Tests showed that these capsules readily penetrated biofilms of *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Enterobacter cloacae*. Both the peppermint oil and oil/cinnamaldehyde mixtures demonstrated effective antimicrobial activity, with cinnamaldehyde mixtures also encouraging the growth of fibroblasts, giving them additional potential for wound-healing applications. The authors suggest that these phytochemical capsules offer a promising delivery vehicle to combat biofilms.



Microglia as Sentinels for Carbon Nanotube Toxicity

The brain is far from homogeneous in composition, with different regions displaying specific cell compositions. Although researchers have made significant advances in bypassing the blood–brain barrier to gain access to this organ, targeting specific brain regions remains a challenge. Recent studies suggest that nanosized constructs, including functionalized carbon nanotubes (*f*-CNTs), could overcome these difficulties. However, other research has prompted concern around their safety profile, showing that *f*-CNTs can induce various toxic responses including oxidative stress, free radical production, peroxidative product accumulation, DNA damage, and/or inflammatory responses. Additional studies have shown that some cell populations are more vulnerable to these effects than others.

To investigate the toxicological impact of *f*-CNTs, Bussy *et al.* (DOI: 10.1021/acsnano.5b02358) examined the effects of both pristine and various functionalized multiwalled carbon nanotubes (*f*-MWNTs) on neuronal and glial cells isolated from two brain regions, the striatum and the frontal cortex. They studied three different primary cell culture types: neuron-enriched, mixed glial, and microglia-enriched. A modified lactate dehydrogenase assay showed that neurons from either brain region were generally unaffected by exposure to any of the MWNTs.



However, the mixed glia cultures' viability was significantly reduced in the striatum-derived cells but not in the frontal-cortex-derived cells. Further examination showed that microglia, which are more prevalent in the striatum-derived culture, displayed a unique sensitivity to the MWNTs and had a more efficient MWNT update than did frontal-cortex-derived cultures. These microglia-enriched cultures also released more NO, a marker of nitrosative stress. The authors suggest that these differences between brain regions must be thoroughly investigated when designing MWNTs for medical devices or delivery systems.

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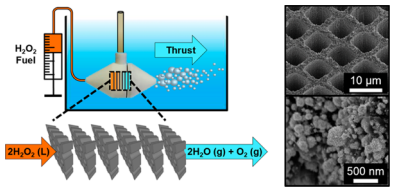
Carbon Nanotubes, Pt Nanoparticle Urchins Go for a Swim

Micro underwater vehicles (MUVs), unmanned underwater vehicles between 1 and 50 cm in length, could have unique utility in exploring confined spaces such as shipwrecks and submerged oil pipelines. In recent years, researchers have developed a variety of designs for MUVs, with the locomotion of most of these vehicles controlled by propeller-based systems. Although these systems are useful for long-endurance missions, they limit the agility of the vehicles by restricting maneuvers that require burst propulsion. Such motions, including tight radius turns, burst-driven docking, and low-speed course corrections, typically require energy-dense fuels such as H_2O_2.

In a new study, Marr *et al.* (DOI: 10.1021/acsnano.5b02124) developed a system to generate thrust for MUVs by using multiwalled carbon nanotube microarray membranes decorated with urchin-like platinum nanoparticles. The researchers constructed high aspect ratio, vertically

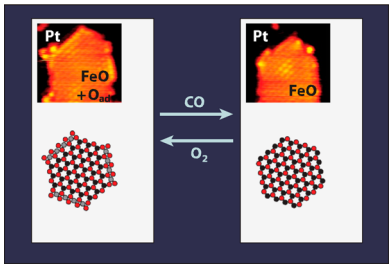


aligned carbon nanotube forests in close-packed diamond-shaped channels, then infiltrated these forests with a mixture of graphitic and amorphous carbon to create membranes. They then decorated these membranes with the urchin-shaped platinum nanoparticles, a desirable morphology that encourages H_2O_2 decomposition with these catalysts. To test the viability of this system, the researchers used three-dimensional printing to create a MUV test submersible that housed eight of these decorated membranes. When H_2O_2 was fed into the MUV through tubing, the vehicle demonstrated a maximum thrust of 0.209 N. The authors suggest that future work could identify ways to increase this thrust, increasing the MUV's underwater agility.

Viewing Catalysis in Action

Finding the active sites in heterogeneous catalysts is critical for gaining better understanding of reaction mechanism, a key toward improving the properties of industrial catalysts. Although researchers have been able to identify these catalytically active sites conclusively using high-resolution scanning tunneling microscopy (STM) to visualize reactions occurring on flat surfaces directly, such results have been difficult to achieve for heterogeneous catalyst systems because it is difficult to image the interfaces between the support and catalytically relevant features, such as islands or atomic step edges.

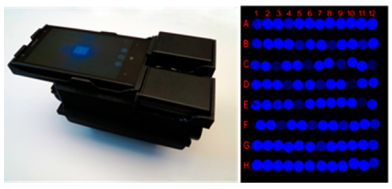
In a new study, Kudernatsch *et al.* (DOI: 10.1021/acsnano.5b02339) achieve this goal for the CO oxidation reaction at the interface between ultrathin FeO islands and a Pt(111) support by *in situ* STM combined with density functional theory (DFT) calculations. The researchers exposed this FeO/Pt surface to alternating doses of CO and O_2, scanning the surface at room temperature in a tip state that distinguished original Fe edges and oxidized Fe edges on the basis of their apparent STM heights. Using this technique, the researchers saw that the appearance of the Fe edges was reversible depending on whether the surface was exposed to O_2 or CO, suggesting that CO oxidation occurred at the oxidized Fe edges. Conversely, no sign of a reaction was detected at the O edges of the FeO islands. The authors suggest that these results represent direct visualizations of catalysis occurring at interfaces in heterogeneous catalysts.



Reading Enzyme-Linked Immunosorbent Assays? There Is an App for That

Enzyme-linked immunosorbent assays (ELISA) that take place in a standard 96-well plate format are widely used for high-throughput and accurate antibody or antigen recognition for the diagnosis of many important infectious diseases, including herpes simplex virus (HSV), and for vaccine effectiveness surveillance for re-emerging diseases such as measles and mumps. This multiwall plate batched analysis significantly reduces costs per patient compared to other test formats. However, this setup typically requires laboratories with large, integrated infrastructures. Although some research has focused on developing hand-held ELISA readers, creating devices with a wide field of view and minimal optical aberrations that are compact, lightweight, and cost-effective remains a challenge.

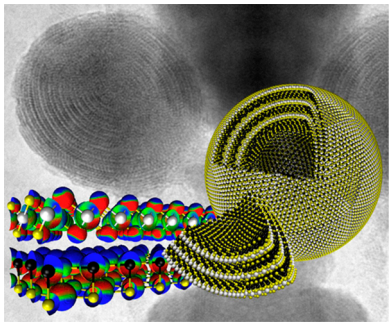
In a new study, Berg *et al.* (DOI: 10.1021/acsnano.5b03203) report the development of a hand-held microplate reader that clips onto a cell phone. Using three-dimensional printing, the researchers created an attachment for a Windows-based smartphone with a chamber to accommodate a 96-well plate. Inside was a light-emitting diode array that transmitted light through each well, which was then collected through 96 individual optical fibers. To analyze data from the images, the researchers created a custom app that processes the images on their servers using a machine-learning algorithm and delivers results to the user within about 1 min per plate. As proof of principle, they show the utility of this device for accurately detecting mumps IgG, measles IgG, and herpes simplex virus 1 and 2 IgG. The authors suggest that this device could offer a simple and cost-effective way to read ELISA results without cumbersome laboratory setups.



Misfits Find Their Place in the Sun

Transition metal dichalcogenide compounds, such as SnS_2, crystallize in layered nanosheet structures much like those of carbon or hexagonal BN. Because the dangling bonds on the rims of these layers are reactive, these structures can fold under high temperatures and create seams, producing hollow closed-cage architectures including inorganic fullerene-like (IF) structures and inorganic nanotubes (INT). Recent research suggests that, after laser ablation, SnS_2 not only forms IF and INT, but these structures are actually misfit layered compounds (MLCs) composed of alternating layers of SnS and SnS_2 with different periodicities. Other MLCs have also been reported to form closed-cage nanostructures, encouraged by the relaxation of the mismatch between the two sublattices in addition to the dangling bonds on their rims.

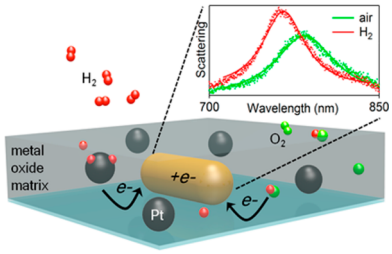
In a new study, Brontvein *et al.* (DOI: 10.1021/acsnano.5b02412) report the synthesis of a new MLC nanoparticle formed by alternating layers of PbS and SnS_2 that form into a fullerene-like ball. A key to this synthesis is the use of a solar furnace that produces target temperatures above 2000 °C. By irradiating a mixed powder of Pb, SnS_2, and graphite in this furnace, the researchers produced these MLC nanoparticles with reproducible yields of about 10%. Microscopy shows that these superstructures are not hollow, suggesting an inside-out growth mechanism. Further computational analysis suggests a counterintuitive charge-transfer pathway from the SnS_2 layers to the PbS layers, indicating that polar forces play just as important a role in stabilizing these superstructures as do van der Waals forces. The authors suggest that future studies might focus on theoretical predictions for the synthesis of other unusual MLC nanostructures that could then be verified through experiments.



No Crying over Hydrogen Spillover with Single-Particle Surface Plasmon Spectroscopy

The first step in heterogeneous gas catalysis is typically the adsorption of a reactant onto the catalyst surface. One prominent example is dissociative H_2 adsorption, which occurs on transition metal surfaces and produces mobile adsorbed H atoms. These H_2 atoms may then migrate from the metal to the support matrix and then potentially undergo further chemical reactions, depending on the nature of the support and the presence of other adsorbed species, a phenomenon pivotal for catalysis. This process, dubbed hydrogen spillover, has been studied by a variety of techniques including product analysis, electrical conductivity, and a variety of spectroscopic methods including infrared, nuclear magnetic resonance, electronic paramagnetic resonance, and X-ray absorption. However, because these methods do not allow hydrogen spillover to be observed directly, much about it remains a mystery.

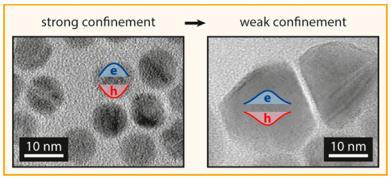
Seeking a more straightforward view of hydrogen spillover, Collins *et al.* (DOI: 10.1021/acsnano.5b02970) used single-particle surface plasmon spectroscopy (SPS), a technique recently exploited to study the chemisorption of gases on metal nanocrystal surfaces. The researchers took advantage of this method to study the dissociation of hydrogen on single Au nanorods on a variety of surfaces and in the presence of Pt nanoparticles. After exposing the Au nanorods to repeated cycles alternating N_2 or air with H_2, the researchers found that hydrogen did not dissociate from the nanorods when in contact with silica, but it did migrate from Pt nanoparticles to Au nanoparticles through metal oxide supports including TiO_2 and ZnO. These results suggest that SPS offers a viable way to observe hydrogen spillover, the authors say, providing a way to better understand this phenomenon at the single-particle level.



Quantum Confinement in Nanocrystals Small and Large

Colloidal semiconductor nanocrystals have attracted increasing attention over the past three decades due to the possibility of tuning their optoelectronic properties by controlling size, shape, and composition. Investigators have mainly focused on understanding the strong spatial quantum confinement that can occur in these particles when the nanocrystal radius is smaller than the exciton Bohr radius. Although this phenomenon has been well studied in small colloidal nanocrystals, investigations on larger colloidal nanocrystals showing marginal quantum confinement have been lacking. Because these larger nanocrystals provide a bulk-like crystal environment for excitons while limiting the long-distance diffusion that can occur in the true bulk material, they provide an alternative platform for studying the photoluminescence of bulk-like excitons.

In a new study, Tilchin *et al.* (DOI: 10.1021/acsnano.5b02597) explored individual CdTe nanocrystals passivated with a thin shell



of CdSe using microphotoluminescence spectroscopy. Because these nanocrystals ranged in diameter from 9 to 25.5 nm, they provided an opportunity to study intermediate-to-weak quantum confinement. By determining values for the biexciton binding energy, diamagnetic shift constant, and Lande *g*-factor, the researchers show that the exciton properties for these nanocrystals are size dependent, with properties for the larger nanocrystals approaching those of bulk CdTe. The authors suggest that colloidal nanocrystals of various sizes might offer additional insight into how the exciton fine structure changes gradually with the degree of quantum confinement, ranging from strong confinement regimes to those governed primarily by Coulomb attraction.