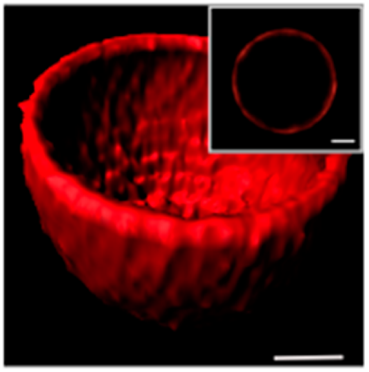
Amyloids for Health, Not Disease

Amyloid fibrils were originally identified for their roles in the pathology of a variety of diseases, including Alzheimer's disease, atherosclerosis, and transmissible spongiform encephalopathy. However, these structures have recently been found to serve as key functional components for biological materials in organisms ranging from bacteria to humans. Their remarkable properties, including a high Young's modulus, tensile strength, and the ability to self-assemble under mild conditions in aqueous solutions, have made them a model for artificial materials currently being investigated as cell culture scaffolds and drug delivery vehicles. However, applications for amyloid protein scaffolds are limited by challenges in overcoming their innate micron-scale morphology to move beyond spatially uniform gels.

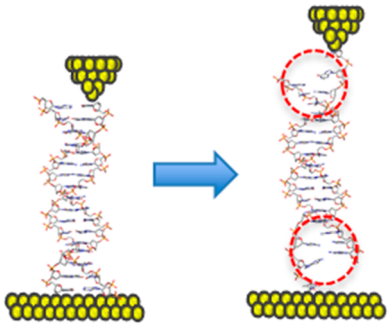
In a new study, Shimanovich *et al.* (DOI: 10.1021/nn504869d) combined amyloid fibrils' inherent nanoscale self-assembly process with micron-scale structuring provided by droplet microfluidics, producing a class of microgels based on nanofibril-forming proteins. Using the abundant natural protein lysozyme, the researchers combined soluble protein and preformed seed fibrils in a water–oil emulsion, forming a nanofibril gel by incubating the microemulsion at 65 °C. This fabrication process could be tuned to create either dense microgels or hollow gel shells with varying particle size, surface roughness, and internal structure. Experiments showed that these protein microgels could act as carriers for dyes or antibiotics, with a high encapsulation efficiency and varying release kinetics. The antibiotic-loaded gels showed significantly higher antibacterial activity than free drugs but were nontoxic to human cells. The authors suggest that these protein nanofibril microgels could find use in a variety of biomedical applications.



Not a Stretch To Change DNA's Conductance

Developing better understanding of charge transport in DNA is key to explaining many biological processes and using this natural material in electronic devices. Research has shown that charge transport in double-stranded DNA (dsDNA) is mediated by π-stacking interactions between neighboring base pairs. These interactions are strongly affected by structural changes in dsDNA molecules, such as mechanically stretching them. Although the effects of these structural changes on DNA's mechanical properties have been intensely studied, little is known about how mechanically stretching dsDNA affects its charge transport.

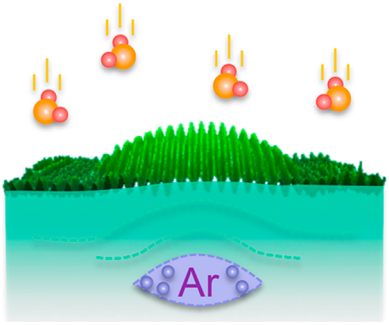
To investigate, Bruot *et al.* (DOI: 10.1021/nn506280t) developed a method to stretch DNA mechanically that allows them to study its charge transport properties at various levels of strain. Using dsDNA of lengths varying from 6 to 26 base pairs, the researchers terminated these molecules with alkanethiol linkers that allowed them to bridge between a gold scanning tunneling microscope (STM) tip and gold electrodes on a substrate. By moving the STM tip, the researchers stretched the dsDNA molecule while continuously measuring its conductance. Results showed that the dsDNA resistance increased linearly with length, consistent with a thermally activated hopping transport mechanism. The charge transport proved to be highly sensitive to mechanical stretching, with conductance abruptly decreasing at very short stretching distances. The authors suggest that this decrease is likely due to hydrogen bonds breaking at base pairs near the molecules' terminal ends. These findings, they add, provide new insight into dsDNA's charge transport properties that could prove valuable for future applications.



Custom Catalysis, Bubbling at the Surface

Researchers have long known that strain has the potential to change chemical and electronic properties in materials. For example, lattice strain in epitaxial silicon can increase charge carrier mobility, and surface strain can significantly alter adsorption and dissociation of molecular adsorbates on metal surfaces. Although these systems have been well studied, researchers still know little about the role of strain in altering chemisorption in heteroreactive systems, including catalytic substrates. This research area has been stymied largely by the lack of systemic approaches for inducing high levels of strain in these materials.

In a new study, Li *et al.* (DOI: 10.1021/nn506150m) use a technique they recently developed that creates patches of high strain in TiO_2 that are ideal for comparing differences in surface reactivity with unstrained surfaces on the same material. By bombarding this catalytic substrate with low-energy argon ions at elevated temperature, the researchers induced nanoscale areas of highly pressurized argon clusters 6 to 20 monolayers below the surface. Consequently, these clusters protruded outward to form blister-like protrusions with localized high strain. Scanning tunneling microscopy and continuum mechanics modeling showed that this strain causes the surface bridge-bonded oxygen vacancies typically present on the surface to be absent, generating defect-free regions. Additionally, experiments in which this surface was dosed with water vapor showed that the adsorption energy of hydrogen binding to oxygen on these strained regions was significantly reduced. The authors suggest that these findings provide direct evidence that strain greatly influences surface reactions in this material, results that could help guide future research in catalyst material design.



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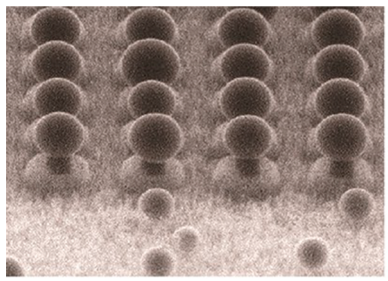
Condensation Inspired by Beetles' Backs

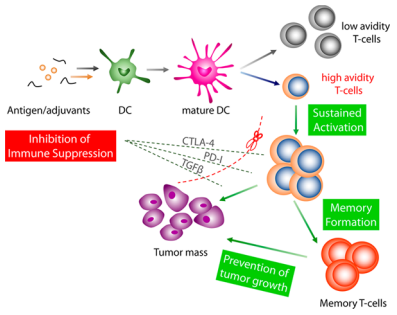
Various industrial applications depend on vapor condensation, including thermal management, power generation, water desalination, and water harvesting systems. Having a way to generate condensation efficiently in these applications is essential for their energy efficiency, security, and environmental protection. How condensation takes place typically depends strongly on the physiochemical properties of the condenser surface. For example, hydrophilic surfaces usually condense liquid in a filmwise fashion, accumulating an immobile layer. Filmwise condensation comes with the drawback of a low heat transfer coefficient. Conversely, hydrophobic surfaces condense liquids in a dropwise fashion. Most efforts to enhance condensation heat transfer have focused on improving superhydrophobic surfaces rather than hydrophilic ones. However, for the best droplet nucleation density, lowest droplet departure size, and smallest thermal barrier, researchers will need aspects of both types of surfaces.

In a new study, Hou *et al.* (DOI: 10.1021/nn505716b) report the design of a novel hybrid surface that provides both filmwise and dropwise condensation modeled on the back of the Namib desert beetle, which utilizes hydrophilic and hydrophobic patches on its shell to condense and to collect water droplets. The researchers' novel surface was composed of nanopillars topped with hydrophilic patches surrounded by hydrophobic nanograss. Experiments showed that water vapor tended to nucleate and to spread on the hydrophilic patches, eventually transitioning to isolated spherical droplets that contacted neighboring droplets, sweeping off several at once. Besides acting as an effective condenser, the hybrid surface had a significantly larger heat transfer coefficient than a flat hydrophobic surface. The authors suggest that this novel surface holds promise for many applications such as water harvesting, desalination, and anti-icing.



The Current State of Nanoparticles for Cancer Immunotherapy

The immune system, with its innate and adaptive arms, is the body's police force, continually working to identify and to destroy pathogens in healthy individuals. It is been long known that the immune system not only fights foreign invaders but also cancers, pathogens that arise from within one's own body, by distinguishing cancer cells from healthy cells. However, tumors can engage the immune system in a biological arms race, utilizing a variety of strategies to evade detection and destruction, such as disguise, developing a resistance to killing tactics, and actively suppressing immunity. Although researchers have developed various approaches to overcome these evasive moves, such as a therapeutic vaccines, none offer the perfect solution to stimulating anticancer immunity.

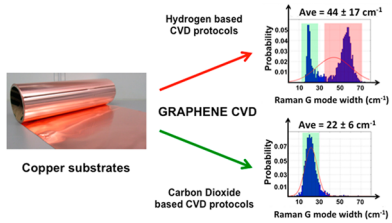


In a new review article, Shao *et al.* (DOI: 10.1021/nn5062029) provide an overview of recent research that takes advantage of nanoparticles as novel tools for prompting an anticancer immune response. Nanoparticles have numerous advantages for this purpose, including longer circulation times than many other carriers and preferential collection in tumors due to their "leaky" circulation, enhanced permeability and retention, and impaired lympathic drainage. The review showcases several developments that take advantage of these benefits, including direct delivery of antigens, delivering dendritic cell stimulatory molecules to tumor-draining lymph nodes, codelivering antigens and adjuvants, and directly triggering the activation of antigen-specific T-cells without the need for cellular intermediaries. The authors note that although nanoparticle-based tumor immunotherapy is still early in development, it holds tremendous potential for future anticancer therapies.

CO_2 for Better Graphene?

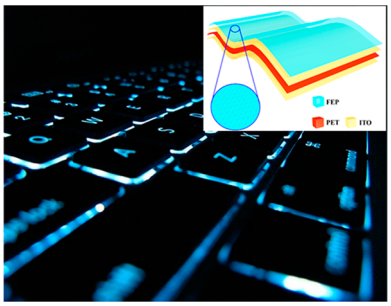
Chemical vapor deposition (CVD) has thus far been the best candidate for supplying the increasing demand for high-quality graphene films that will likely serve pivotal roles in next-generation electronics. However, challenges remain in producing high-quality, preferably single-crystal graphene, in a consistent and scalable manner. These challenges include commercial growth substrates that lack uniformity and homogeneity, leading to graphene of variable quality.

In a new study, Strudwick *et al.* (DOI: 10.1021/nn504822m) developed a method for CVD that produces high-quality graphene on copper foil by using CO_2 both to pretreat the growth substrate and as the atmosphere during the growth phase instead of H_2. Results showed that CO_2 acted as a mild oxidant and chemical reactant that rid the copper surface of unwanted carbon, which can lead to uncontrolled graphene nucleation that negatively affects final graphene quality. Molecular hydrogen on its own did not have this effect. Similarly, incorporating CO_2 rather than H_2 into the atmosphere during the growth phase improved graphene quality, leading to a product with fewer defects. Raman maps comparing graphene samples grown with the two protocols show that the CO_2 method leads to a product with a significantly lower G-band than the traditional H_2 method. Additionally, the CO_2 protocol produced graphene with higher charge-carrier mobilities and lower resistance than graphene produced with the H_2 method. The authors suggest that incorporating CO_2 rather than H_2 into graphene CVD protocols could offer the consistency and scalability necessary to produce this material for next-generation electronics applications.



Better Computer Security, At Your Fingertips

Computers have become essential to many people worldwide, improving the quality, efficiency, and pleasure of work and life. Despite best efforts at securing these machines, conventional security measures still focus on passwords, personal identification numbers, or similar tools, each of which offer only limited protection and are susceptible to being misused or stolen by others. As society moves toward paperless work and communication, better ways to secure computing systems must be developed.

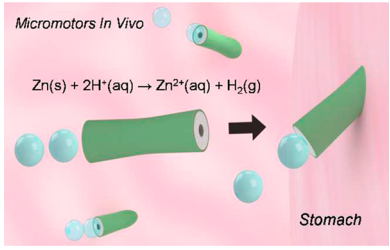


In a new study, Chen *et al.* (DOI: 10.1021/nn506832w) offer a novel way to safeguard against unauthorized access to computers through a keyboard that can accurately gage the particulars of an individual's typing habits, which are mostly unique to each person and are hard to replicate by imposters. The key functional element of this new keyboard is vertically stacked transparent thin film materials designed to produce contact electrification through generating triboelectric charges. This device is then set on top of a commercial keyboard. When a human finger touches the keys, it generates a unique electrical signal that differs based on manner and rhythm of the keystroke, typing habit, finger size, individual bioelectricity, and typing force. The authors show in a test of 104 volunteers that the novel keyboard can distinguish well between individuals with low error rates. Additionally, the keyboard is self-powered and self-cleaning. The authors suggest that this technology can be applied to a variety of keyboards, including those on cash registers and automated banking machines.

Micromotors Go Live

Very small-scale synthetic motors that convert energy into movement and forces have made significant progress over the past decade, leading to a variety of micro- and nanomotors with different propulsion mechanisms and design principles. These tiny motors have been proposed for a variety of biomedical applications, including directed drug delivery, diagnostics, nanosurgery, and biopsy. Although researchers have shown their utility through numerous examples *in vitro*, no reports thus far have illustrated and examined their operation and behavior *in vivo*.

In a new study, Gao *et al.* (DOI: 10.1021/nn507097k) demonstrated the use of small-scale synthetic motors in live mice. The authors used tube-shaped zinc-based micromotors, which release hydrogen microbubbles from one end when exposed to acid, propelling them at a speed of about 60 μm/s. By delivering them orally to mice, the researchers tested their utility in the stomach of live animals, the ideal environment for these tiny machines. Results showed that the micromotors were retained significantly longer than similar devices that do not move. Additionally, when loaded with Au nanoparticle cargo, the animals' stomachs retained three times as many nanoparticles compared to an analogous number of nanoparticles delivered orally. These machines eventually degraded naturally, with no toxicity to the mice. Although the researchers suggest further *in vivo* examinations are necessary to evaluate a wider variety of micro- and nanomotors, the authors say that their findings are a significant step in advancing these machines toward use in medicine and other fields.



Thermoresponsive NanoVelcro Sticks It to Cancer

Solid tumors regularly shed bits of themselves into the bloodstream, generating circulating tumor cells (CTCs). Although these CTCs are responsible for metastasis, they also offer information on the prognosis of a patient's disease and could provide additional insights into tumor biology with molecular and functional analyses. Enabling these possibilities requires capturing CTCs from the bloodstream with low contamination from white blood cells (WBC) and minimal detriment to their viability. To accomplish this feat, researchers have developed a variety of capture methods, including developing nanostructured materials combined with capture agents. One such material, called NanoVelcro, has demonstrated success in oncology clinics, and has continued to improve in combination with microfluidics for CTC detection, counting, genomic sequencing, and mutational analysis.

In another advance for NanoVelcro, Ke *et al.* (DOI: 10.1021/nn5056282), who developed this material, have made it thermoresponsive, allowing more efficient capture and release of CTCs. The researchers attached vertically aligned silicon nanowires to a silicon wafer, covalently grafting thermoresponsive poly(*N*-isopropyl-acrylamide) (PIPAAm) brushes onto this substrate. They then conjugated this to a capture agent specific for nonsmall-cell lung cancer cells (NSCLC). The resulting thermoresponsive NanoVelcro effectively captured these cells at 37 °C, then released them at 4 °C, temperatures that had minimal effect on cell viability. Using this method, the researchers captured NSCLC from several late-stage cancer patients, using follow-up mutational analysis to identify mutations that could affect their course of treatment. The authors suggest that this tool could have significant value in managing NSCLC and other forms of cancer.