ADVANCED FUNCTIONAL MATERIALS

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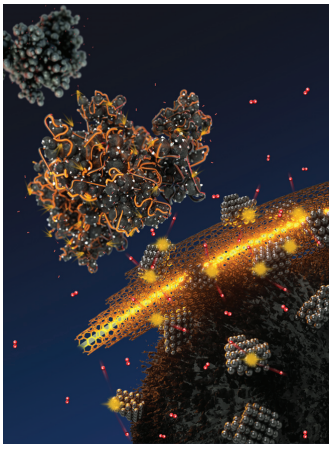
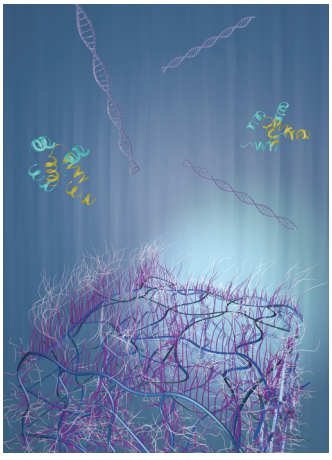


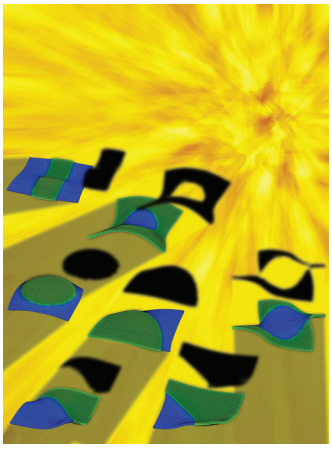
Fuel Cells

On page 4585, D. E. Morse and co-workers report a biologically inspired, kinetically controlled, catalytic approach to synthesizing a new family of nanocrystalline platinum-based catalysts. A novel composite of multiwalled carbon nanotubes and carbon black serves as the matrix for the in situ nucleation and growth of the Pt nanocrystals, providing access to new combinations of porosity, mesoscale morphology, conductivity, and electrochemical activity for hydrogen oxidation.

Stimuli-Responsive Materials

A self-healing, long-lasting, antifouling coating is made by S. Minko and co-workers from antifouling polymers grafted to the surface and inside a polymer network film. On page 4593, they show how, if the grafted polymers are detached from the surface in the course of aging, the antifouling effect is spontaneously recovered by the rearrangement of the internally grafted polymers at the interface. 3D-grafted structures demonstrate four-fold longer stability than 2D surface grafted structures. Cover image courtesy of Ella Marushchenko.





Polymer Gels

O. Kuksenok and A. C. Balazs perform computational studies on photoresponsive polymer gels functionalized with spirobenzopyran chromophores. On page 4601, they these materials undergo 3D shape changes under nonuniform illumination. The repeated motion of the light along the gel results in well-controlled, directed sample movement. These results point to a robust method for controllably reconfiguring the morphology of polymer gels and driving the self-organization of multiple reconfigurable pieces into complex architectures. This image was designed by Mr. Nicholas Moellers.

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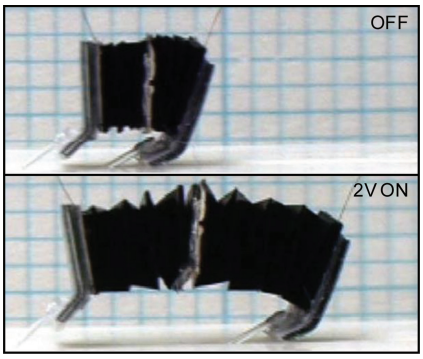
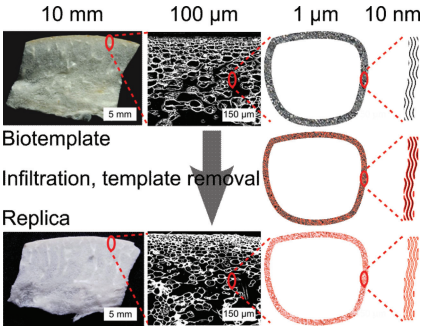
Humidity-Sensitive Actuators



Humidity-sensitive polypyrrole films can provide an insight to the development of an origami robot fabricated by folding the polypyrrole film. The principle lies in the electrically induced changes in the elastic modulus caused by desorption of water vapor due to Joule heating, which is responsible for amplifying a contraction of the film to more than a 100-fold expansion.

Biotemplating



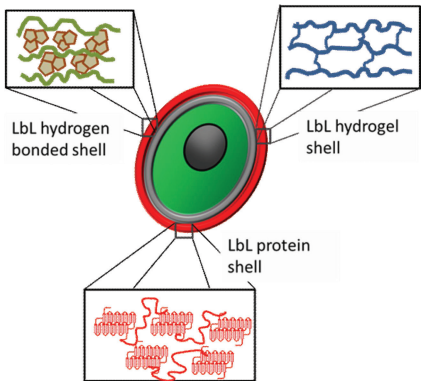
Biotemplating combines the hierarchical structure of natural materials with a broad range of available constituent materials by using biological tissues as scaffolds or casting molds for the synthesis of inorganic porous materials or composites. The replication of the entire hierarchical structure of biological materials down to nanometer length scales requires several important steps such as the thermal or chemical preparation of the template, its infiltration with the precursor, the subsequent transformation to a solid, and finally the template removal.

Biomimetics

Load bearing materials in biology and in engineering differ markedly in their microstructural design. While biological materials exhibit highly heterogeneous microstructures (left), their synthetic counterparts are often designed to be homogeneous and isotropic (middle). Creating heterogeneous architectures with properties locally tuned to match non-uniform loading conditions should lead to bioinspired composites with extended durability using bioresorbable or environmental-friendly building blocks (right).

FEATURE ARTICLES

Biologically inspired materials with tailored properties have proven to increase stability of encapsulated cells in a hostile environment, and hence can expand applicability for biomedical, biotechnology, and bioelectronics applications. This Feature Article addresses some of the recent studies of inorganic and organic gels, polymeric and biomolecular microgels, and ultrathin conformal shells from polymers and proteins for efficient cell protection.

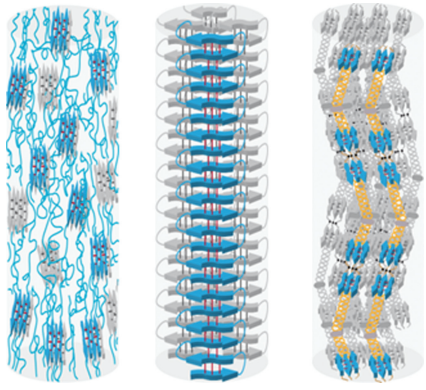


Biomimetics

Investigation of the structural organization of chitinous materials—the second most abundant organic material on earth—leads to understanding of the principles of natural materials design. These designs are beginning to be harnessed to fabricate bioinspired composites with tunable properties that mimic living materials, which might provide useful for environmental challenges, as well as medical applications.

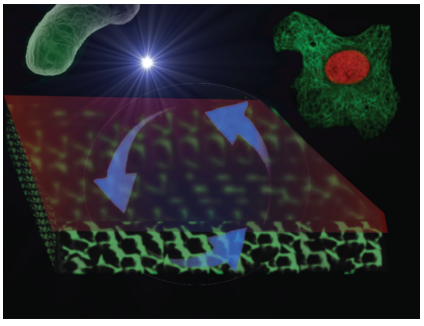
Biomimetics

Spider dragline, lacewing egg stalk and mussel byssus: three extraordinary protein fibers with similar sequence motifs but widely differing mechanical properties and a wealth of potential uses as biomaterials.



Fibers

Significant advances in surface nanoarchitecture for bio-applications such as biocompatible surfaces, antifouling systems, implantation, stem cell research, organ-on-chip, and lab-on-chip are reviewed. The design of intelligent surfaces with both space- and time-dependent functionality requires selected materials, methodology used for nanostructuring, an active cell surface interface, patterning, drug depots in the substrate, and stimuli response (including multi-trigger response of system and self-regulation).



Biosurfaces

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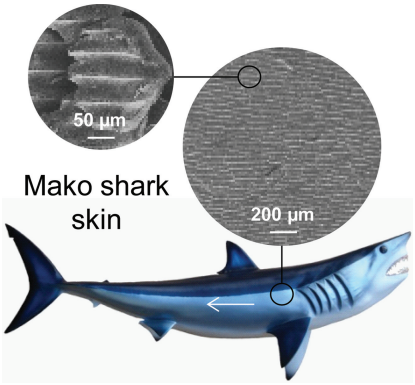
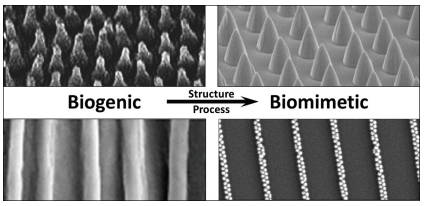
FEATURE ARTICLES

Bioinspired Materials



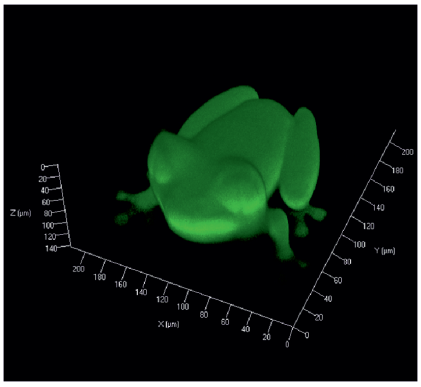
Engineering marvels found throughout living nature provide inspiration to researchers solving technical challenges. For example, the skin from fast-swimming sharks intrigues researchers because its riblet microstructure leads to low drag, self-cleaning, and antifouling properties. An overview of shark skin related studies that have been conducted in both open and closed channel flow experiments is presented. Adapted with permission.[24] Copyright 2012, Royal Society of Chemistry.

Self-Assembly

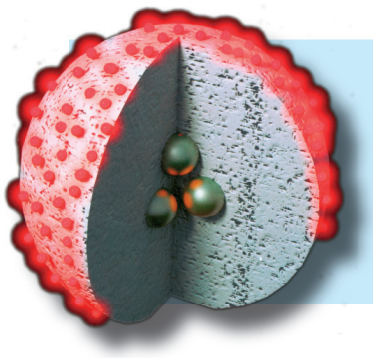


Particle-based routes to microstructure surfaces are discussed and two biomimetic approaches are reviewed: the fabrication of surface structures that are inspired by biogenic examples and the development of fabrication processes that are inspired by biological processes. Both strategies yield surfaces which mimic functional aspects of biological models or go beyond.

Hydrogels



Advances in the fabrication of hydrogel structures via two-photon polymerization are presented. Biocompatible synthetic and naturally derived hydrogel precursors polymerizable with water-soluble two-photon photoinitiators are discussed. Hydrogel constructs can be fabricated in situ, in the presence of cells and tissues mimicking key elements of the natural extracellular matrix. The potential of two-photon polymerization for exploring cell–cell and cell–extracellular matrix interactions is shown.



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FEATURE ARTICLE

FULL PAPERS

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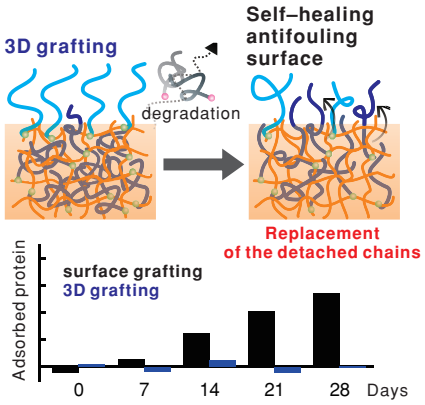
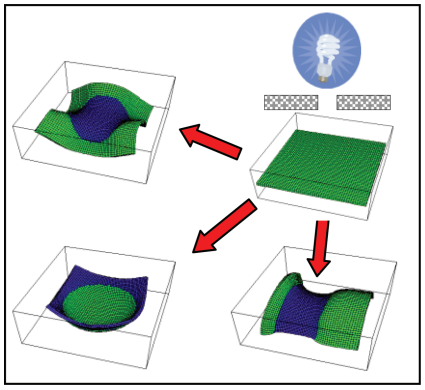
FULL PAPERS

Stimuli-Responsive Materials



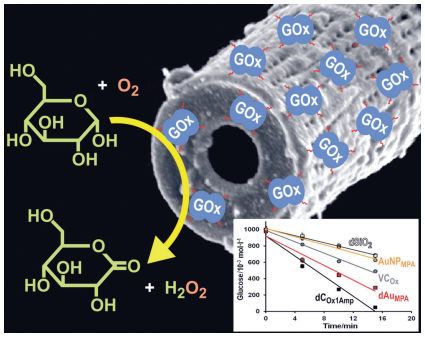
The self-healing long-lasting antifouling coating is developed using 3D polymer-grafting when antifouling polymers are grafted to the surface and inside the polymer network film. If the grafted polymers are detached from the surface in the course of aging, the antifouling effect is spontaneously recovered by the rearrangement of the internally grafted polymers at the interface. 3D grafted structures demonstrate 4-fold longer stability than 2D surface grafting.

Polymer Gels



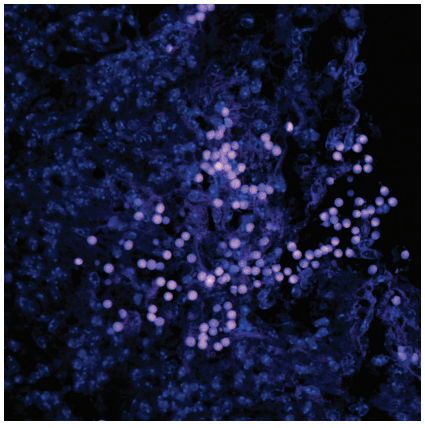
Computer simulations of polymer gels containing spirobenzopyran chromophores show that these materials can undergo both 3D shape changes and directed motion under non-uniform illumination. By illuminating the samples through photomasks, these gels can be molded remotely and reversibly into a variety of shapes. Furthermore, repeated motion of light in a specific direction results in the directed motion of the samples.

Biocatalysis



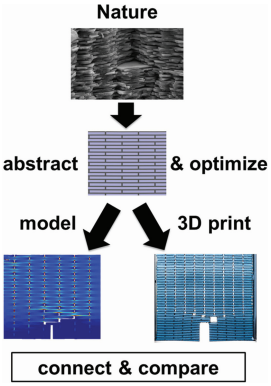
Electrically conductive microparticles possessing the hollow, hierarchically-porous architectures of diatom frustules can be attractive as enzyme supports. Freestanding, high-specific-surface-area carbon and gold-bearing frustule replicas (generated via shape-preserving conversion of diatom silica) functionalized with a high loading of glucose oxidase (GOx) exhibit rates of flow-through catalysis more than 80% greater than for GOx-bearing carbon black and gold nanoparticles.

Immunotherapy



Macroporous poly(lactide-*co*-glycolide) (PLG) matrices mimic inflammatory environments by producing gradients of inflammatory cytokines. Controlled, in vivo presentation of GM-CSF, Flt3L, and CCl20 recruits a unique distribution of dendritic cells (DCs) that infiltrate the pores of the PLG extracellular matrix. The coordination of cell mobilization caused by these systems may be exploited for the design of vaccines and other immunotherapies.

Tough composites with bioinspired topologies and microscale features are designed, 3D printed and mechanically tested. Discrete simulation methods are used to identify fracture resistant composite topologies. Subsequently, additive manufacturing is used for rapid fabrication of the computationally conceived composites. In agreement with the simulation predictions the 3D printed composites exhibit fracture resistance far superior to their individual constituents.



Composites