Say ‘no’ to biofouling: Slippery coatings that resist adhesion of biological matter

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Living organisms and biological substances are among the most difficult and persistent sources of surface fouling, particularly in medical and marine settings. The ability of organisms to adapt, move, cooperate, evolve on short timescales, and modify surfaces by secreting proteins and other molecules enables them to colonize even state-of-the-art antifouling coatings, and small surface defects can trigger protein aggregation and blood clotting. Attempts to combat these issues are further hindered by conflicting requirements at different size scales and across different species. Our recently developed concept of Slippery, Liquid-Infused Porous Surfaces (SLIPS) provides a defect-free, dynamic liquid interface that overcomes many of these problems at once. A single surface is able to prevent adhesion of a broad range of genetically diverse bacteria, including many pathogenic species that underlie widespread hospital-acquired infections, as well as marine algae. The same approach resists adhesion of proteins, cells, and blood, preventing clogging and thrombus formation inside medical tubing and catheters. At a larger scale, the slippery interface repels insects, barnacles and mussels, which slide off and actively avoid the coated surface. We are currently developing this strategy to solve long-standing fouling issues in a wide range of medical, marine, and other settings.
Dynamic structures that respond reversibly to changes in their environment are central to self-regulating thermal and lighting systems, targeted drug delivery, sensors, and self-propelled locomotion. Since an adaptive change requires energy input, an ideal strategy would be to design materials that harvest energy directly from the environment and use it to drive an appropriate response. This lecture will present the design of a novel class of reconfigurable materials that use surfaces bearing arrays of nanostructures put in motion by environment-responsive gels. Their unique hybrid architecture, and chemical and mechanical properties can be optimized to confer a wide range of adaptive behaviors. Using both experimental and modeling approaches, we are developing these hydrogel-actuated integrated responsive systems (HAIRS) as new materials with reversible optical and wetting properties, as a multifunctional platform for controlling cell differentiation and function, and as a first homeostatic system with autonomous self-regulation.