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Strategic Integration of Electrospinning and Additive Processing for Smart and Sustainable Nanostructures

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Electrospinning is an effective and versatile technique applied to fabricate porous structures ranging from submicron to nanometer dimensions. Using a variety of high-performance polymers and blends, several porous structure configurations have become possible for applications in tactile sensing, energy harvesting, filtration, and biomedical applications, however, the structures lack mechanical complexity, conformity, and desired three-dimensional single/multi-material constructs necessary to mimic desired structures. A simple, yet versatile, strategy is through employing digitally controlled fabrication of shape-morphing by combining two promising technologies, viz., combinatorial electrospinning and 3D printing/additive processing. Using synergistic integration of configurations, elaborate shapes, and patterns are printed with mesostructured stimuli-responsive electrospun membranes, allowing for in-plane-modulations, and internal interlayer stresses induced by swelling/shrinkage or mismatch, thus guiding morphing behaviors of electrospun membranes to adapt to changes of the environment. Recent progress in 3D/4D printing/additive processing includes materials and scaffold constructs for tactile and wearable sensors, filtration structures, sensors for structural health monitoring, biomedical scaffolds, tissue engineering, and optical patterning, among many other applications to support the vision of synthetically prepared smart material designs that mimic the structural aspects with digital precision. A novel technology called 3D jet writing was recently reported that propels electrospinning to adaptive technologies for the manufacturing of scaffolds according to user-defined specifications of the shape and size of both the pores and the overall geometric footprint. This presentation reviews the hierarchical synergy between electrospinning and 3D printing as part of the precision and rapid prototyping of smart, sustainable, and biomedical structures that are likely to evolve next-generation structures into reality.