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Solvated Block Copolymers as a Novel Class of Electroactive Nanostructured Polymers

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Microphase-ordered block copolymers serve as model systems to elucidate the potential of molecular self-assembly and organic templates to fabricate functionalized polymer materials. Both aspects are related to the incorporation of secondary species such as low-molar-mass compounds or nanoparticles within copolymer matrices. Since the resulting properties of such functionalized copolymers depend on the morphology of the blend or composite, the nonrandom distribution of such inclusions within the copolymer matrix must be understood. Using a self-consistent field theoretical approach, we first evaluate the segregation and interfacial excess of low-molar-mass and nanoscale species in ordered triblock copolymers as functions of block selectivity and inclusion size. The predictions are found to agree with the morphology observed in a model triblock copolymer/nanoparticle composite, suggesting a wide correspondence in the structure-forming effect of molecular and nanoscale inclusions that will have implications in the design of functional nanostructured polymers such as conformable electroactive actuators. Such responsive materials, stimulated by electric fields, are required for emergent technologies such as microrobotics, micro air vehicles and responsive prosthetics. High actuation strains (>50%) are currently afforded by dielectric elastomers at relatively high electric fields (>50 V/μm). In this work, we demonstrate that incorporation of a low-volatility solvent into a triblock copolymer yields physical networks that exhibit excellent displacement under an external field. Ultrahigh actuation strains (>200%) accompanied by low cyclic hysteresis are realized at significantly reduced electric fields (<40 V/μm). Use of nanostructured polymers whose properties can be tailored by varying copolymer characteristics or blend composition represents an innovative and tunable avenue to reduced-field actuation for advanced engineering, biomimetic and biomedical applications.