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Mechanics of polymer brush based soft active materials– theory and experiments

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Abstract

A brush-like structure emerges from stretching of long polymer chains, densely grafted on to the surface of an impermeable substrate. The structure arises due to the competition between conformational entropic elasticity of polymer chains and excluded volume interactions leading to intra and interchain monomer repulsions. Recently, soft materials based on stimuli responsive polymer brushes have been developed to produce controllable and reversible large bending deformation of the host substrates. To understand such systems and improve their functional properties, we study the stress distribution in a brush, and develop surface stress-curvature relation for an elastic beam of a soft material grafted with a neutral polymer brush. In the strongly stretched brush regime, we combine mean field theory from polymer physics with a continuum mechanics model and show that the residual stress variation in a brush is a quartic function of distance from the grafting surface, with a maximum occurring at the grafting surface. By idealizing a brush as a continuum elastic surface layer with residual stress,

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