Hierarchical Multi-Step Folding of Polymer Bilayers

Abstract

A highly complex multi-step folding of isotropic stimuli-responsive polymer bilayers resulting in a variety of 2D and 3D structures is reported. Experimental observations allow determination of empirical rules, which can be used to direct the folding of polymer fi lms in a predictable manner. In particular, it is demonstrated that these rules can be used for the design of a 3D pyramid. The understanding and know-how attained in this study allow the very simple design of highly complex, self-folding 3D objects and open new horizons for 3D patterning, important for the design of microfluidic devices, biomaterials, and soft electronics.

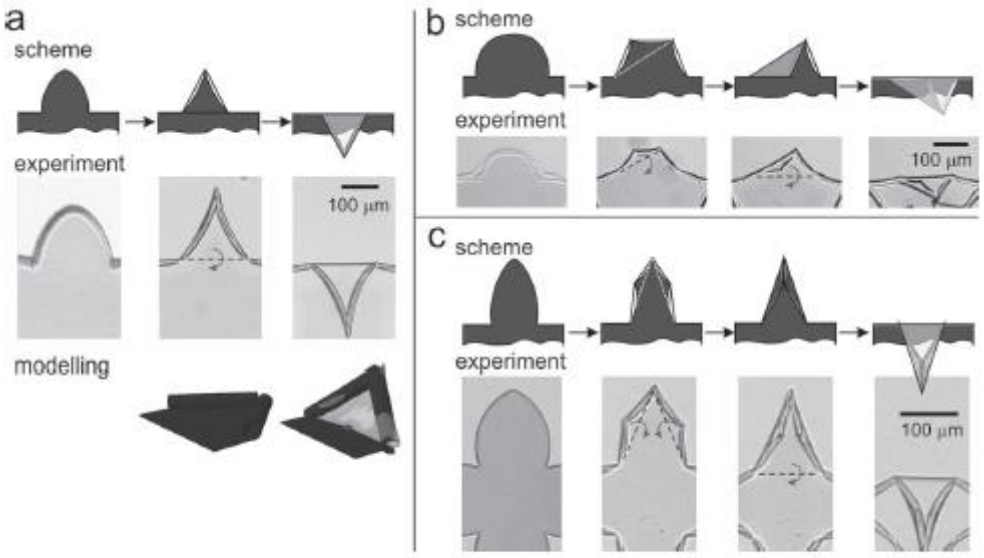

Figure 3. Schematic illustration, experimental observation, and modeling of the second step of folding of the elliptical arms depending on their shape. a) $H_{(PNIPAM\text{-}AA)}$ = 1200 nm, H_{PMMA} = 170 nm; b) ($H_{(PNIPAM\text{-}AA)}$ = 1200 nm, H_{PMMA} = 400 nm; c) $H_{(PNIPAM\text{-}AA)}$ = 900 nm, H_{PMMA} = 170 nm.