Active twisting for adaptive droplet collection

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Abstract

Many xeric plant leaves exhibit bending and twisting morphology, which may contribute to their important biological and physical functions adapted to drought and desert conditions. Revealing the relationships between various morphologies and functionalities can inspire device designs for meeting increasingly stringent environmental requirements. Here, demonstrated on the biomimetic bilayer ribbons made of liquid crystal elastomers (LCE), we reveal that the stimuli-induced morphological evolution of bending, spiraling, twisting as well as various coupling states among them can be selectively achieved and precisely tuned by designing the orientations of director in LCE bilayers. The mathematical models and analytical solutions are developed to quantify the morphology selection and phase transition of these liquid crystal elastomer ribbons for material design, as confirmed by experiments. Moreover, we show that under activation and control of external stimuli, twisting configuration can be harnessed to effectively collect and guide transportation of droplets, and enhance structural stiffness for resisting wind blow and rain falling to realize optimal configuration for water collection. Our results uncover the interesting functions correlated with bending, spiralling and twisting morphologies widely existed in natural world, with providing fundamental insights into their shape transformation and controlling factors, and also demonstrate potential application with integrating morphogenesis - environment interactions into devices or equipments.

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