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Switching Shape of Nematic Elastomers

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Nematic elastomers (NEs) are a novel class of materials. NEs possess both the elastic properties of rubbers and the orientational properties of liquid crystals. The combination of these two properties makes the shape of NEs very sensitive to external stimuli. We focus on the thermally induced deformation of the NE films inherently possessing the two types of inhomogeneous director alignments, i.e., hybrid and twist alignments. In the NEs with hybrid alignments (HNEs), the director continuously changes by 90 degree from planar alignment to vertical alignment between the top and bottom surfaces. In the twist NEs, the director parallel to the surfaces smoothly rotates by 90 degree around the thickness axis, and the director at the mid-plane is parallel to the long or short axis of the film. In the HNEs and TNEs, the director change along the normal of the films causes the planes at different depth to respond differently to temperature variation, and the films are thus expected to change shape. We experimentally demonstrate that (i) depending on the width/thickness ratio, the TNE ribbons form the spiral ribbons or helicoids whose spiral or helical pitch markedly depends on temperature [1], and (ii) the HNE ribbons exhibit giant bending in response to temperature variation [2]. We theoretically interpret these experimental observations on the basis of the elastic models with the data of thermally induced uniaxial deformation of the corresponding NEs with globally planar alignment.

[1] Sawa, Ye, Urayama, Takigawa, Gimenez-Pinto, Selinger, R., Selinger, J., Proc. Natl. Acad. Sci., USA, 108, 6364 (2011).
[2] Sawa, Urayama, Takigawa, DeSimone, Teresi, Macromolecules, 43, 4362 (2010).