Thermomechanical functionalization of conventional rubber

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The method of dispersing additional material into a polymer network can enhance or introduce new properties to elastic materials, thus broadening its applicability and adaptability to various industrial needs. We have therefore adopted this idea to introduce a novel method of thermomechanically functionalizing conventional rubber. By producing a composite material consisting of magnetically oriented liquid crystal elastomer particles incorporated in a cured PDMS matrix, we have transferred thermomechanical properties from the particles onto the composite, meaning that the material experiences reversible contraction in the particle's alignment direction upon thermal activation. Such composites, termed polymer-dispersed liquid crystal elastomers or PDLCE's [1], are no longer restricted by the limitations of the 2-step LCE synthesis procedure [2] so they can be molded into arbitrary shapes and sizes. By spatially modulating the particle's director orientation throughout the specimen using an external magnetic field, it is also possible to achieve complex reversible thermomechanical deformations (Figure 1).

The amount of thermomechanical deformation of PDLCE's strongly depends on the particle's concentration and elastic moduli of PDLCE constituents, as well as on the degree of particle's orientational order, which we successfully assessed by means of deuterium perturbed ^{2}H-NMR. By controlling these parameters, the PDLCE's thermomechanical and elastic properties can be custom tailored to user's preferences, while the lack of mechanical manipulation of the specimen and the liquid nature of the pre-polymerized PDLCD melt, makes the material well suited for implementation into additive manufacturing techniques, such as 3D-printing.
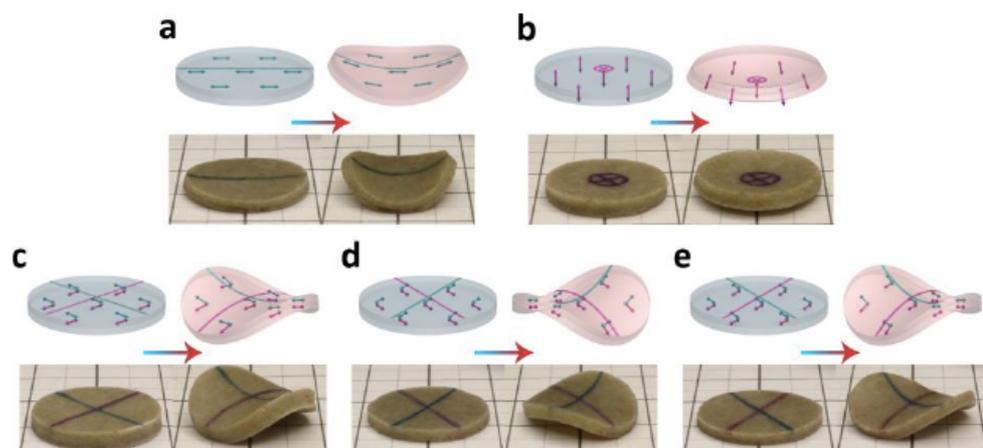

Figure 1: Determined PDLCE's orientational order parameter.

References

[1]   A. Rešetič, J. Milavec, B. Zupančič, V. Domenici, B. Zalar, Nat. Commun. 7 (2016) 13140.

[2]   J. Küpfer and H. Finkelmann, Makromol. Chem., Rapid Commun. 12, 717 (1991).

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