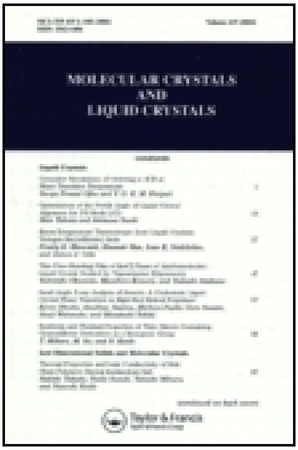

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BOOK REVIEW

"Liquid Crystal Elastomers" by M. Warner and E. M. Terentjev, Oxford University Press, 2003. $124.50 cloth.

This text masterfully interfaces the subjects of elastic polymers and liquid crystals (LCs), making the topic of LC elastomers accessible to chemists, physicists, engineers, and applied mathematicians. According to the authors, it considers three aspects of soft matter: *orientational order*—spontaneous liquid crystalline order exhibited by LC molecules (mesogens); *responsive molecular shape*—how elastic forces couple to the orientational order; and *quenched topological constraints*—the implications of polymer chain entanglements and covalent junctions (cross-links).

Liquid Crystal Elastomers is not a text for undergraduates, nor should it be relegated to the reference shelf. Rather, it is aimed at established liquid crystallographers and newcomers to this intriguing field. It could be used as a text in advanced courses on ordered soft matter. There are more options as well: for example, chapter 2, "Liquid Crystals," could serve as a rather complete outline of an advanced undergraduate or graduate course on LCs. "Polymers, Elastomers and Rubber Elasticity" (chapter 3) could be used in the same way, as this chapter is a thorough and succinct summary of classical rubber elasticity. It also includes the potential for elastic shape responses to photoinitiated isomerization—photoinduced changes in a polymer chain's dimensions in response to the contraction of individual chain segments—and contemporary aspects of rubber elasticity (e.g., entanglements and the "tube model"). Chapter 4, "Classical Elasticity," is a summary introduction to distortion and strain tensors and invariance with an eye towards rubbery materials. Molecular structures are introduced in chapter 5, "Nematic Elastomers." For the most part, LC elastomers are of the "side chain" type, with anisometric mesogens covalently appended to the polymer backbone. (Main-chain LC elastomers with the mesogens incorporated into the contour of the chain are rare.) This chapter also introduces the unusual physical phenomena exhibited by this class of materials. These phenomena and their physical descriptions form the core of the text.

The thermally and photoinduced spontaneous distortions observed in nematic rubbers are explained in chapter 6; the influence of external strains on nematic order is also considered here, and the reader can infer the potential for, and limitations of, these materials in transducer applications. In a chapter 7, provocatively titled "Soft Ela [sic]," perhaps the most tantalizing aspect of LC elastomers is introduced: the so-called "soft elasticity." Incredibly liquid-like, energetically cheap (very low storage modulus), deformation modes can be exhibited by nematic elastomers. These modes involve director reorientations—as opposed to deformed polymer chain distributions—that accommodate an external strain. The associated reduction in the elastic energy resulting from director rotations in response to a deformation makes these materials, in the words of the authors, "unlike any other solid." Chapter 8 considers the more complex consequences associated with situations where the soft elasticity is encumbered by sample boundary conditions.

Molecular chirality imposes a unidirectional supramolecular twist in nematics, i.e., a cholesteric phase. Chapter 9 describes how the helicoidal director distribution in cholesteric elastomers is affected by external deformations, leading to unique mechanical effects: color changes (tunable lasing) and the appearance of photonic bandgaps as the helix pitch contracts or elongates. The authors also consider that chiral LC elastomers may also serve as imprinted substrates for chiral recognition in separations of optical isomers.

The lower resolution continuum description of nematics (chapter 10) emphasizes the universal nature of nematic elastomers and provides a preface to the dynamical aspects of these materials (chapter 11). The latter show, for example, that there is a dynamical analogue of soft elasticity: at high frequencies behavior is reminiscent of ordinary polymer networks and melts, but at lower frequencies, when director rotations are involved, the dynamics are much more complex. Smectic elastomers—translationally stratified phases—are considered in the final chapter. Therein, a variety of chain topologies consonant with the lamellar structure influence the elastic response of this curious semisolid.

I had difficulty merely skimming this text—I found myself stopping to read sections in detail. It is the kind of overview of intriguing and unique phenomena exhibited by polymeric mesophases that can only be described by scientists intimately versed in the subject. Both authors have contributed to the theoretical and physical underpinnings of this unusual class of soft materials. The text is replete with judiciously chosen problems (and solutions) inserted at key points to facilitate the appreciation of subtle points. *Liquid Crystal Elastomers* is a major contribution to soft materials science, ranking with benchmark texts like P.-G. de Gennes' 1974 text, *The Physics of Liquid Crystals*.

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