VOLUME CHANGES OF V-SHAPED CROSS-LINKING LIQUID CRYSTAL ELASTOMERS

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We experimentally investigated the volume changes of V-shaped cross-linking liquid crystal elastomers (LCEs) with different concentration of cross-linking agents as a function of temperature. We found that there is cross-linking concentrations dependence to the volume and the shape changes.

Introduction

LCEs consist of the cross-linked polymer chain networks and the liquid crystalline ordering of side chain mesogenic groups. There are two kind of the cross-linking agents used in LCEs, i.e. bifunctional and trifunctional cross-linking [1]. In the previous studies, the bifunctional cross-linking LCEs have been investigated in detail. A drastic shape change is observed at nematic-isotropic transition temperature (T_{NI}) [2,3]. In present study we will report the volume and shape changes of trifunctional cross-linking LCEs, namely V-shaped LCEs as a function of temperature. Here, we used three kinds of V-shaped LCEs with different concentration of cross-linking agents, i.e. 3.3%, 5%, 7% of cross-linking. The V-shaped LCEs materials studied here were originally invented and developed by Finkelmann and co-workers.

Experimental

V-shaped LCEs consist of cross-linking (1,3,5-tris-undec-10-enoxy-benzene), polymer backbones and mesogenic units (4-(3-butenoxy) benzoic acid−(4-methoxy) phenylester). The concentrations of cross-linking are 3.3% (LCE1), 5% (LCE2) and 7% (LCE3). The LCEs sample is made by mechanical stretching after gelation to obtain the direction orientation, n, parallel to the stretching direction. To measure the volume changes of V-shaped LCEs during the variation of temperature, we prepared two types of rectangular V-shaped LCE samples with different bulk director orientation n. One is obtained by slicing parallel to n (planar sample) and another by slicing perpendicular to n (homeotropic sample). The V-shaped LCE films have the thickness of ~ 400μm and the area of ~ 0.7mm × 0.5mm. The sample is observed by a polarizing microscope (Nikon) equipped with a hot stage (Mettler Toledo FP90 Central Processor) as a temperature controller.

Result and Discussion

To quantify the volume changes of V-shaped LCEs, at first we measured the relative length changes as the ratio of expansion shrinkage length to the initial length in nematic phase(T = 30°C). Increasing temperature at the elevation rate of about 0.5 K/min, each samples shrank
slowly perpendicular to \( \mathbf{n} \) with a somewhat faster decrease in the vicinity of \( T_{\mathrm{NI}}^{\mathrm{LCE1}} \sim 78^\circ \mathrm{C} \), \( T_{\mathrm{NI}}^{\mathrm{LCE2}} \sim 67^\circ \mathrm{C} \), and \( T_{\mathrm{NI}}^{\mathrm{LCE3}} \sim 62^\circ \mathrm{C} \), the apparent nematic-isotropic phase transition temperatures of the V-shaped LCE1, LCE2 and LCE3, respectively.

![Graph](image1.png) ![Graph](image2.png)

**Fig.1.** Concentration of cross-linking dependence of the maximum contraction of V-shaped LCEs.

**Fig.2.** Concentration of cross-linking dependence of volume changes of V-shaped LCEs.

In Fig.1, the maximum contraction of V-shaped LCEs increases with increasing the cross-linking concentrations. In case of LCE3 (7%) sample, reaches its maximum contraction of 20%. Fig. 2 shows that volume changes decrease with increasing cross-linking concentrations measured in isotropic phase \( (T = 100^\circ \mathrm{C}) \). In case of LCE1 (3.3%) and LCE2 (5%) samples, the volume increased about 3.5% and 1%, respectively. However, LCE3 (7%) sample decreases about 1.5% from its initial volume in nematic phase.

**Conclusion**

We discussed the volume changes of V-shaped LCEs with different cross-linking concentrations as a function of temperature. We found that the contraction of V-shaped LCEs increases with increasing cross-linking concentrations, and the change of volume decreases with increasing cross-linking concentrations.

**Reference**