Strain Dependent Relaxation of Main-Chain Liquid Crystal Elastomer†

S. Dey,1 D. Agra-Kooijman,1,* W. Ren,2 P. McMullan,2
A. Griffin,2 and Satyendra Kumar1

1 Department of Physics, Kent State University, Kent, OH, USA
2 School of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, GA 30332

Two polydomain SmC main-chain liquid crystal elastomers[1] I and II were studied using synchrotron x-ray diffraction to determine how microscopic structural changes relate to the macroscopic changes in their physical properties and elastic behavior at room temperature to understand their shape recovery. LC elastomer I mainly contains end-on mesogenic attachment along the main chain while II has 20% side-on mesogen attachment.

Changes in their molecular organization were measured and analyzed at different stages of elastic deformation by uniaxial strain, strain retention under zero external stress, and the thermal shape recovery process. At low strains, i.e. ε < 0.8, the smectic layer-normals are found to be distributed in a plane perpendicular to the stretch direction. The system relaxes relatively slowly (τlow strain ~ 45 minutes) as determined mostly by the flow properties of the liquid crystalline phase. At strains ε > 0.8, this relaxation mechanism is replaced by a second faster relaxation process (τhigh strain ~ 4 - 8 minutes) determined by the polymer’s properties in the soft elasticity regime. The chevron microstructure formed at high strains shows strong dependence on the strain as the system finally assumes an optically monodomain structure. Global orientational order parameter S for the mesogenic part of LC elastomer I gradually increases[2] from ~ 0.15 to ~ 0.7. Upon thermal annealing, chevron structure melts via a different path to the initial polydomain structure. Similar results were observed for LC elastomer II.

References:
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* presenting author; E-mail: dagrako@kent.edu