Dynamics of Stimulus Response of Swollen Nematic Elastomers

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1. Introduction

Nematic elastomers are rubbery polymer networks containing rigid mesogenic molecules. The nematic elastomers exhibit unique physical properties stemming from the strong coupling of rubber elasticity and liquid crystallinity.[1] We reported that the nematic elastomers swollen by solvents (nematic gels) showed the shape and volume variations upon temperature change (anisotropic swelling)[2], and that they exhibited the macroscopic deformation with a significant change in optical birefringence in fast response to electric fields (electro-opto-mechanical effect)[3]. In this talk, we present the dynamic aspects of these phenomena.

2. Dynamics of Temperature Response [4]

The nematic gels surrounded by nematic solvents vary their shape and volume depending on the nematic order of each nematogen: The gels swell largely in the totally isotropic or nematic states, but in the latter state they are elongated along the director; In the temperature region where the states inside and outside the gels are nematic and isotropic, respectively, the gels are considerably shrunken with an elongation along the director. We have observed the processes of shape and volume variations after the temperature-jumps with several combinations of initial and destination temperatures. The nematic gels show the complicated kinetics of swelling and shrinking: The dimension along or normal to the director exhibit overshoot or undershoot depending on the locations of the initial and destination temperatures in the phase diagram. We have revealed that the swelling kinetics of nematic gels is composed of the volume and shape variation modes with markedly different characteristic times.

3. Dynamics of Electric-Field Response [5]

We have evaluated the characteristic times for the optical and mechanical responses of nematic gels to the imposition and removal of electric fields. The gels exhibit the fast decay times (regarding the field removal) in the order of millisecond which are a few orders of magnitude smaller than that of the pure swelling nematic solvent (5CB) confined in a cell with the same thickness as the gel thickenss (ca. 20 μm). This indicates that the nematic solvents in the gels (solvent content: more than 70 vol%) move fast together with the nematic networks, and that the driving force for recovery is rubber elastic force instead of Frank elasticity. The rise times (regarding the field imposition) become smaller with increasing the field strength. We estimate the elastic and viscous parameters of the gels from the rise and decay times, and the threshold field-strengths for the onset of the responses.

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