Combined One-Way and Two-Way Shape Memory in a Glass-Forming Nematic Network

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Supporting Information

Supplemental Movies. Real time movies of the tandem recovery of P5tB-LCN are shown. Before the movies were taken, the sample was first heated to above 200 °C on a hot stage and then elongated through its T_{NI} transition (deformation I). Then, at 100 °C, the sample was further bent (unbend_then_shrink.avi) or twisted (untwist_then_shrink.avi) through the mechanism of the one way shape memory (deformation II). After cooling to room temperature, both deformations were fixed. During the videos, the sample first unbent/untwist itself when heated to 100 °C on the hot stage, recovering the deformation II rapidly in about 3.6 s. However, deformation I does not recover at 100 °C even when the sample was annealed for a considerable period of time. After the sample was moved onto the hot stage of 200 °C, the sample shrank to its original length in 3.6 seconds, recovering the deformation I. The original length of the sample in both videos is about 20 mm.

In the inset of Figure 5, the plot of *first recovery* (ε_{R1}) versus the *second deformation* (ε_{D2}) clearly shows a negative intercept. This can be explained by the tensile stress-strain curve, shown schematically in Figure S1. In Figure S1, the red annotations indicate strain and stress limits for the soft elasticity plateau while the black annotations represent stresses and strains from the experiments performed. With a *preload stress* (σ_{D1}) less than σ_{cII}, applied during cooling to the nematic phase, the strain will not reach the full capacity for soft elasticity: ε_{cII}. As a result, ε_{D2}, which is brought on by the "secondary stress", will be composed of both region II strain (ε_{II}) and the region III strain (ε_{III}), as depicted in the following equation:

$$\varepsilon_{D2} = \varepsilon_{II} + \varepsilon_{III}$$

Only the portion of the strain in region III (ε_{III}) will recover at the first stage (as ε_{R1}) when the sample is heating through T_g. That is:

$$\varepsilon_{R1} = \varepsilon_{III} = \varepsilon_{D2} - \varepsilon_{II}$$

Consequently, for *preload stresses* (σ_{D1}) less than σ_{cII}, the recovery strain will be less than ε_{DII} by the amount ε_{II} and a negative intercept is expected for a plot of ε_{R1} against ε_{D2}.

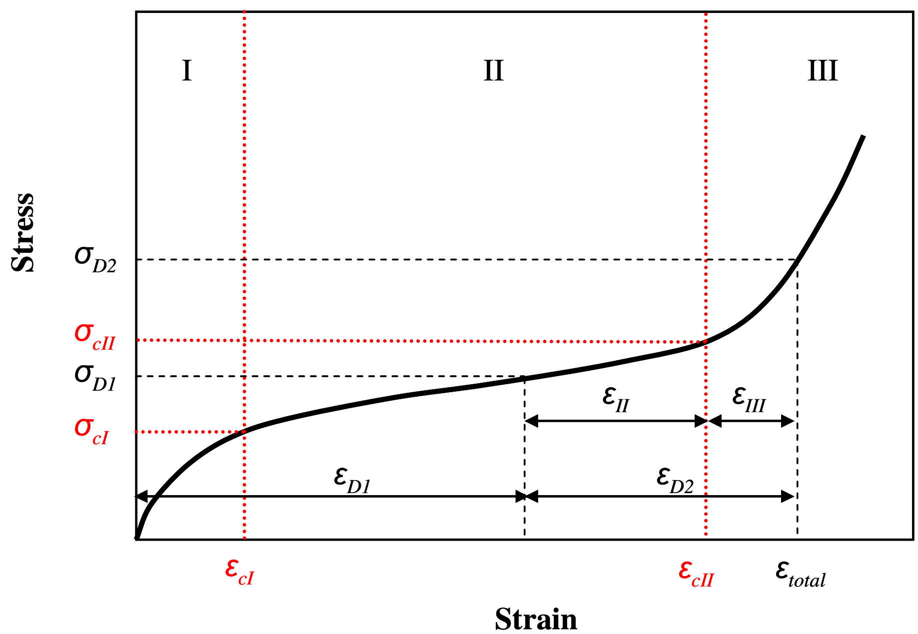

FIGURE S1. Schematic stress-strain curve of liquid crystalline thermosets with soft elasticity plateau. Above the first threshold stress σ_{cI}, the strain can increase with few stress increment until a specific value of strain, ε_{cII}, is reached. Afterward, the stress increases again with the strain. By the strain ε_{cI} and ε_{cII}, three regions, I, II and III are defined.