**Response and Applications 2:** 10:45 - 11:05 a.m.

# NECKING INSTABILITY IN POLYDOMAIN MAIN-CHAIN SMECTIC ELASTOMERS

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Recent efforts in our group have focused on understanding the molecular factors governing the static and dynamic mechanical response of smectic polydomain elastomers at both low and high strains.1-3 During uniaxial elongation, polydomain smectic elastomers are well known to undergo a polydomain-monodomain (P-M) transition, though the mechanism for the transition has been debated. Recent studies of main-chain smectic elastomers suggest a three-stage deformation process. At low strains, elongation proceeds by local director rotations within smectic regions, which slightly favor the anomalous (perpendicular) alignment of chain axes with respect to the draw direction. In addition, any amorphous (non-smectic) regions deform elastically (if present). At intermediate strains, disordering of smectic microdomains via unfolding of hairpinned elastic chains becomes the dominant mechanism for elongation, and chain axes become oriented predominantly parallel to the draw direction. At very high strains, an upturn in the nominal stress is observed due to the finite extensibility of elastic chains and due to the neck reaching the clamps. Layer buckling is observed at high strains under certain conditions of temperature and strain rate. During uniaxial elongation at a constant strain rate, a yield stress is sometimes observed. Yielding coincides with formation of a necking (Considére) instability, which initiates via conformational rearrangements within hairpinned smectic microdomains. The P-M transition occurs in a spatially localized fashion within a narrow boundary region between the necked and non-necked regions. The magnitude of the observed yield stress increases as temperature decreases below the smectic-isotropic clearing temperature. The yield stress also generally increases as strain rate increases at constant temperature. In addition, the boundary region is narrower and the neck is geometrically better defined at lower temperatures and higher strain rates. The relaxation time associated with local director rotations increases with decreasing temperature. The magnitude of the yield stress may be dependent upon the ratio between the time scale for domain rotation and the time scale for the applied deformation. The net orientation of chain axes immediately prior to the onset of the P-M transition, which depends upon this ratio, may be a key factor that impacts the geometry of the neck.

References

1. H. P. Patil, D.M. Lentz, and R. C. Hedden, " Necking Instability during Polydomain-Monodomain Transition in a Smectic Main-Chain Elastomer." *Macromolecules* **2009**, In Press.
2. H. P. Patil, J. Liao, and R. C. Hedden, "Smectic Ordering in Main-Chain Siloxane Polymers and Elastomers Containing *p*-Phenyleneterephthalate Mesogens." *Macromolecules* **2007**, *40*, 6206-6216.
3. H.P. Patil and R. C. Hedden. "Effects of Structural Imperfections on the Dynamic Mechanical Response of Main-Chain Smectic Elastomers." *J. Polym. Sci. B: Polym. Phys.* **2007**, 3267-3276.

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