Quantitative Predictions of Shape Memory Effects (SME) in Polymers via Viscoelastic Length Transitions (VLTs)

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Abstract: Shape memory polymers are materials capable of recovering stored shapes from temporary geometrical arrangements upon application of stimuli. Among chemical and physical stimuli that trigger shape memory effects (SME) in polymers, the most common is thermal energy. These studies elucidate the origin of T_g-based shape memory behavior in thermosetting and thermoplastic polymers by utilizing dynamic mechanical analysis (DMA), which shows unique shape memory transitions. These transitions, termed viscoelastic length transitions (VLTs), are macroscopically manifested by directional extension and subsequent retraction of polymer networks back to their original shapes due to the release of stored energy. The extension is a result of viscous behavior of the network at the onset of the T_g, while the retraction is driven by conformational entropy. This behavior is quantified in terms of stored and released energy densities and the shape memory efficiency. Using this approach, shape memory in polymers can be predicted in a single DMA experiment.