RHEOLOGY MODIFICATION OF POLYMERIC NETWORKS VIA LOOP THREADING

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ABSTRACT

Tailoring the rheological properties of soft composites at molecular level has been a thematic at the forefront of engineering research. A formidable challenge is understanding the role of macromolecular architecture on topological constraints and the resulting network dynamics. Ring polymers represent a unique case because of the absence of free ends that mediate conformational arrangements in a topological entanglement network. It has been shown that these macromolecules exhibit a power-law stress relaxation, in the absence of entanglement plateau. Here, we discuss the rheology of these loopy structures. We show that they exhibit unusual nonlinear response in shear and, especially, in extension because of loop interlocking. Adding small amounts of ring polymers to entangled linear matrices yields a reinforcement effect, which can be understood by invoking the (coherent) constraint release processes on the rings due to the escape (unthreading) of linear chains. The ring-linear molecular weight asymmetry is important and examined in this work. We also consider the addition of a few single chain nanoparticles, which are also (crosslinked) loopy structures, on linear matrices and show that, indeed they exhibit a qualitatively similar reinforcement effect, because of the action of loop threading. The punchline is the emerging ability to selectively tailor the rheological properties of a wide range of polymeric networks with loops and, at the same time, provide insights on the physics of the constraint release process.

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