Stress Relaxation in Ring-Linear Polymer Blends

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An essential characteristic associated with the mechanism of motion of linear polymers is the presence of free-ends[1]. Ring polymers without chain ends exhibit a very different behavior characterized by a power-law stress relaxation[2,3], no entanglement plateau and lower viscosity compared to their linear counterparts. A natural question is what happens when linear and ring polymers are blended. We show, by means of rheological experiments with well-characterized polymers, that the addition of rings to an entangled linear polymer melt gives rise to a nonmonotonic variation of the viscosity as a function of the ring polymer fraction. Interestingly, the viscosity of the blend can even reach values up to three times higher than the pure linear polymer chains because of threading effects of the latter on rings. By adopting the self-consistent model of constraint release in polymer chains[4] and accounting for the coherent constraint release of ring polymers mediated by the reptation of linear chains, we show how to describe the linear viscoelasticity of the linear-ring polymer blends in the region of small fraction of rings. In the limit of very large fractions of rings the rheology is extremely sensitive to the presence of linear chains (contaminants), as also confirmed by simulations[5]. These results contribute toward the development of a generic picture of polymer blend dynamics and suggest ways for tailoring the rheology of polymers.

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