

Colloquium

Dr. Ting Ge

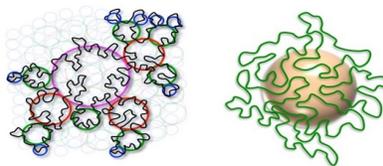
(Duke University)

Rheology and Nanorheology of Entangled Melts of Non-Concatenated Ring Polymers

Friday, February 1, 2019

2:30pm—3:30pm

210 Robeson Hall



Rheology is the branch of science that studies how matter deforms and flows. Rheology of polymers is characterized by viscoelasticity that exhibits both solid-like elastic and liquid-like viscous features depending on the relevant time scales. Understanding and controlling the macromolecular dynamics underlying the viscoelastic response of polymers is one of the great challenges in polymer science. Complementary to experiments, theoretical and computational approaches provide deep physical insight into polymer dynamics. We use scaling theory and molecular dynamics simulation to study the rheology of non-concatenated ring polymers [1], a prominent example of polymers with non-linear architectures. The study of ring polymers sheds light on the effects of polymer architecture on polymer dynamics and rheology. Additionally, the melt of non-concatenated ring polymers serves as a good model for the de-swollen polymer network that possesses super-elasticity and for the organization of chromosomes critical to the gene expression and regulation in cell nucleus. Unlike their linear counterparts, ring polymers do not form long-lived entanglement network. Their viscoelastic response is characterized by a power-law stress relaxation prior to terminal viscous flow. The theoretical description and simulation results agree with each other and are in consistence with experimental observations of ring polymers. We further use molecular simulations to study nanorheology, which employs embedded nanoparticles to explore local viscoelasticity of polymers [2]. Nanorheology is important to the processing of nanoparticle polymer composites and the design of particle-based drug delivery systems in living cells as well. We find that the motion of large nanoparticles is not strongly suppressed in ring polymers as in linear polymers, because there is no long-lived entanglement network that traps nanoparticles. With increasing nanoparticle size, the local viscoelasticity experienced by the particle approaches the bulk viscoelasticity of ring polymers. We estimate that the bulk viscoelasticity is reached for nanoparticle size about twice the average spanning size of ring polymers.

References

- [1]. “Self-Similar Conformations and Dynamics in Entangled Melts and Solutions of Nonconcatenated Ring Polymers”, T. Ge, S. Panyukov, and M. Rubinstein, *Macromolecules* 49, 708 (2016)
- [2]. “Nanorheology of Entangled Polymer melts”, T. Ge, G. S. Grest, and M. Rubinstein, *Phys. Rev. Lett.* 120, 057801 (2018)

