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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Professor, James Economy Professor of Materials Science and Engineering

Attend virtually: https://udel.zoom.us/j/91314568641

SINGLE POLYMER DYNAMICS OF RING-LINEAR BLENDS AND ENTANGLED SOLUTIONS

Single polymer dynamics provides a powerful window to directly view the nonequilibrium behavior of polymer molecules in flow. In recent years, single polymer techniques have been used to uncover fascinating and unexpected phenomena in molecular rheology, including the importance of molecular individualism, dynamic heterogeneity, and molecular subpopulations that underlie the dynamic behavior of materials. In this talk, I will discuss our group's recent work in extending the field of single polymer dynamics to architecturally complex polymers such as rings and combs, in addition to entangled solutions of linear chains in flow. In the first part of the talk, I will focus on the nonequilibrium dynamics of ring polymers and ring-linear blends in flow. Ring polymers are a unique class of macromolecules that lack free ends and show qualitatively different dynamics compared to linear polymers. In dilute solution, ring polymers undergo a coil-to-stretch transition in extensional flow that is different than linear polymers due to a coupling between chain architecture and hydrodynamic interactions (HI), resulting in an 'open loop' conformation in flow. We further study the dynamics of rings in shear flow using a custom flow-gradient shear device for fluorescence microscopy. Single rings undergo end-over-end tumbling events and tank-treading-like motion in shear flow that is markedly different compared to linear chains. Upon increasing polymer concentration, we also study the dynamics of rings in semi-dilute solutions consisting of pure linear chains or blends of ring-linear chains. Surprisingly, the relaxation dynamics of rings in semi-dilute solutions reveals the emergence of multiple molecular sub-populations, which is qualitatively similar to the relaxation of linear chains in the entangled regime, but starkly contrasts with the relaxation of linear chains in dilute solution or semi-dilute unentangled solutions. Finally, we study the nonequilibrium stretching dynamics of rings in semi-dilute blends of ring-linear polymers in extensional flow, which reveals unexpected fluctuations in chain extension in extensional flow, even at so-called 'steady-state'. Brownian dynamics simulations are used to complement single molecule experiments, which show that ring extension fluctuations arise due to a combination of intermolecular HI effects and threading of linear polymers through open ring polymer chains in flow. Overall, our work shows that molecular behavior is markedly heterogeneous in non-dilute polymer solutions and is directly impacted by non-linear polymer architectures, which showcases the power in using single molecule analysis to understand the nonequilibrium dynamics of soft materials.

ABOUT THE SPEAKER

Charles Schroeder is the James Economy Professor of Materials Science and Engineering and Professor of Chemical & Biomolecular Engineering at the University of Illinois at Urbana-Champaign. He is Co-Chair of the Molecular Science and Engineering Theme in the Beckman Institute for Advanced Science and Technology and holds affiliate status in the Departments of Chemistry, Bioengineering, Biophysics, the Institute for Genomic Biology, and the Materials Research Lab. He previously served as Associate Head in ChBE at Illinois. Dr. Schroeder received his B.S. in Chemical Engineering from Carnegie Mellon University in 1999, followed by an M.S. in 2001 and Ph.D. in 2005 in Chemical Engineering from Stanford University under the supervision of Professors Eric Shaqfeh and Steve Chu. Before joining Illinois in 2008, he was a postdoctoral fellow in the Department of Chemistry and Chemical Biology at Harvard University. Professor Schroeder has received several awards, including a Packard Fellowship, a Camille Dreyfus Teacher-Scholar Award, an NSF CAREER Award, the Arthur B. Metzner Award from the Society of Rheology, the Dean's Award for Excellence in Research at Illinois, and an NIH Pathway to Independence Award (K99/R00).