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Direct observation of polymer dynamics in semi-dilute solutions

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University of Illinois at Urbana Champaign — In this work, we use single molecule techniques to study polymer dynamics in semi-dilute solutions. Here, we study the steady state extension and relaxation time dynamics of polymer molecules in semi-dilute DNA solutions in extensional flow. Polymer chain dynamics are complicated in semi-dilute solutions due to chain overlap, hydrodynamic interactions, and excluded volume interactions. We use single molecule fluorescence microscopy and a microfluidic-based hydrodynamic trap to directly observe the dynamics of polymers in non-dilute solutions. We report the scaling of polymer relaxation time as a function of polymer concentration, and we observe a crossover in chain behavior from the dilute to semi-dilute regime. Interestingly, we observe a pronounced center-of-mass drift of single polymer chains in directions orthogonal to flow in semi-dilute solutions, which is characterized as a function of concentration and flow rate. By using the automated hydrodynamic trap coupled with a piezoelectric stage, we are able to track the 3-D position of single polymer molecules and deduce the relationship between strain rate and polymer extension. Overall, our work reports on a key advance in the field of polymer dynamics via direct observation of dynamics in semi-dilute solutions in strong flows

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