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Anomalous dynamics of polymer translocation[1]

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We study the passage times of a translocating polymer of length N in three dimensions, while it passes through a narrow pore. We show that the behavior of the polymer stems from the polymer dynamics at the immediate vicinity of the pore — in particular, the memory effects in the polymer chain tension imbalance across the pore. We take as a reaction coordinate the number s of the monomer residing in the pore. in the case of unbiased translocation, these memory effects cause the mobility of s to be anomalous diffusion for times up to the Rouse time $N \sim N^{1+2\nu}$ or Zimm time $N \sim N^{3\nu}$, without or with hydrodynamics, respectively. Here, ν is the Flory exponent. Beyond this time, the dynamics becomes ordinary diffusion. As a consequence, the pore blockade time scales with length as $\tau_d \sim N^{2+\nu}$. If a force of sufficient strength is pulling on one end, the pore blockade time scales as $\tau_d \sim N^2$ in the absence of hydrodynamics. If a voltage is applied across the pore, which drives the charged polymer, the pore blockade time scales as $\tau_d \sim N^{(1+2\nu)/(1+\nu)}$ without, and $\tau_d \sim N^{3\nu/(1+\nu)}$ with hydrodynamics. In these cases, the pore blockade time decreases inversely with force and field strength, respectively. Our theoretical framework is substantiated with high-precision computer simulations. We will show that memory effects similar to those governing translocation, also play a role in the dynamics of dense polymer solutions and polymer melts.

[1]in collaboration with D. Panja