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DNA Dynamics in Nanoconfinement and Electric Fields

PATRICK DOYLE, Massachusetts Institute of Technology

Controlled stretching of DNA molecules is critical for single molecule genomic and polymer physics studies. To date, most devices have relied on hydrodynamic flows to stretch DNA in an unconfined environment. In contrast, we employ electric field gradients to electrophoretically deform DNA. The purely elongational nature of electric field allows us to use very thin nanofluidic channels and thus explore how nanoconfinement can affect stretching. Here we experimentally study DNA stretching dynamics in a nano-slit cross-slot device. We measure three steady-state quantities at varying strain rates: the average extension, the magnitude of extension fluctuations, and the average orientation of the DNA molecules in the electric field. By comparison with the unconfined case, we show that the presence of the nanoconfinement results in a highly-modified coil-stretch transition of the DNA. We develop a model to demonstrate that these experimental observations are directly related to the fact that the confinement alters the conformational energy landscape of the DNA molecules.