MAR06-2005-004049

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

Pressure-driven DNA polymer transport in microfluidic and nanofluidic channels

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The transport of DNA and proteins within micro- and nanofluidic channels is of central importance to "lab-on-a-chip" bioanalysis technology. As fluidic devices shrink, a new regime is encountered where critical device dimensions approach the molecular scale, and the behavior of polymers often departs significantly from the bulk. Here, we present a study of the pressure-driven transport of individual DNA molecules in 175 nm – 3.8 μm high silica channels. Two distinct transport regimes were observed: The pressure-driven mobility of DNA increased with molecular length in channels higher than a few times the molecular radius of gyration, whereas DNA mobility was practically independent of molecular length in thin channels. In addition, both the Taylor dispersion and the self-diffusion of DNA molecules were observed to decrease significantly in confined channels, each obeying a power-law scaling relationship. These unusual transport properties are shown to be rooted in the statistical nature of DNA polymer coils. Our results show that simple fluidic channels can be engineered to achieve either hydrodynamic DNA length separation or uniform transport with minimal dispersion using pressure-driven flows.