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Diffusion and Segmental Dynamics of Double-Stranded DNA

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Understanding dynamics of double-stranded DNA (dsDNA) in solution is important not only for obtaining quantitative information on the properties of this important molecule, but also for quantitative verification of theories of polymer dynamics. This task requires detailed information on both the translational diffusion of individual polymer molecules and dynamics of the segmental motion within a polymer coil.

Fluorescence correlation spectroscopy (FCS) [1] is a single-molecule experimental technique which can be effectively applied to study polymer dynamics in solution, simultaneously providing quantitative information on segmental dynamics and translational Brownian motion of the macromolecule.

Several years ago, by applying the FCS technique to single-end fluorescently labeled monodisperse dsDNA fragments with the lengths ranging from 100 bp to 20000 bp, we experimentally demonstrated [2] that double-stranded dsDNA in solution behaves as a semiflexible polymer with strong hydrodynamic interactions, in agreement with theory [3]. Thus, our results [2] questioned the validity of the previous experimental study [4] claiming that dsDNA in solution behaves as a Rouse polymer.

Recently, a new thorough theoretical study [5] of semiflexible polymer dynamics with hydrodynamic interactions has been published. Here we show that our experimental data on diffusion and segmental dynamics of dsDNA [2] are in excellent agreement with both the previous [3] and new theoretical results [5] within the full time range from microseconds to seconds. This unambiguously demonstrates that dsDNA behaves as a semiflexible polymer whose segmental dynamics is controlled by hydrodynamic interactions.

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