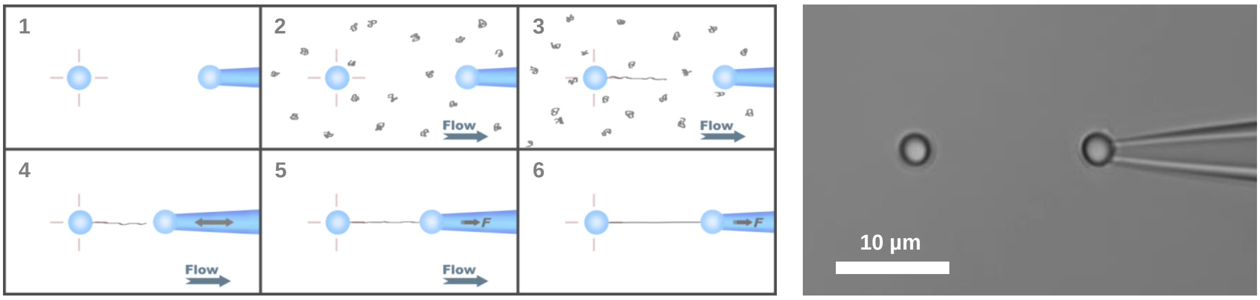
Single Molecules and DNA Elasticity

IonoVation PicoTweezers

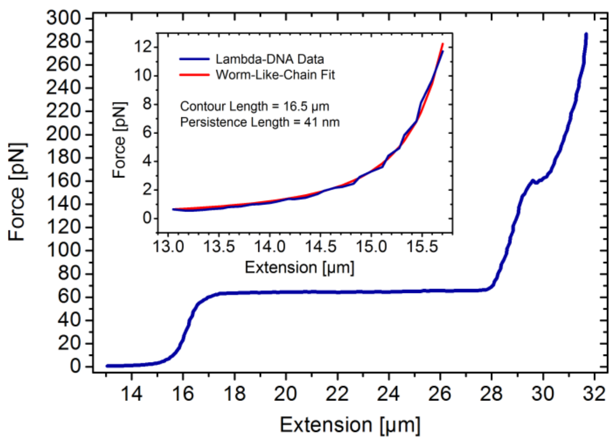
PicoTweezers Application Note 02

The elastic properties of a single DNA-strand in absence or in presence of binding ligands can be scrutinized with optical tweezers. Theoretical polymer models that are fitted to the results deliver parameters, which characterize the polymer elasticity and the kinetics of the respective binding ligands.



Procedure of how a single DNA strand is immobilized between two microbeads. 1: One functionalized bead is optically trapped, the second one is attached to the tip of a micropipette. 2: A solution of functionalized DNA molecules flows into the sample chamber. 3: One DNA molecule binds to the trapped bead and extends. 4: Buffer solution is flowed into the sample chamber and the second bead approaches the DNA. 5: The DNA binds to the second bead. 6: The buffer flow is stopped.

A controlled mechanical tension to a single, immobilized DNA can be applied by increasing the distance between the two beads. As a response, the force-extension curve exhibits characteristic mechanical properties, such as entropic elasticity, an overstretching plateau and a melting transition region.



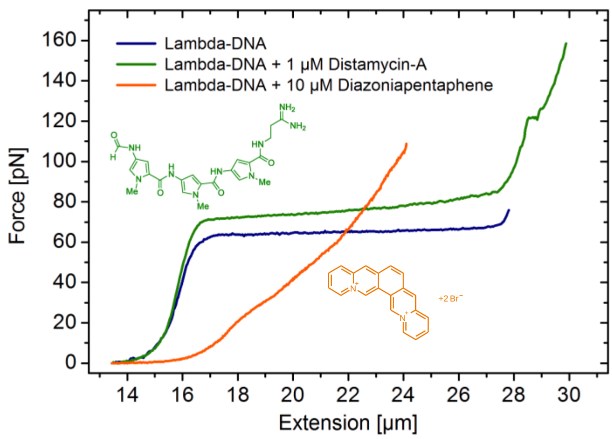
Force response of a single 48502 base pair long DNA molecule of bacteriophage lambda. In the force range up to 10 pN the entropic regime determines the elastic behavior of the molecule, whereas around 65 pN the characteristic overstretching transition occurs. The nature of this phenomena remains controversial, as well as for a less pronounced transition at 160 pN.

Inset: Fitting the Worm-like-chain model to the entropic regime yields two intrinsic elasticity parameters. For example, the persistence length strongly depends on ion concentration and on the presence of DNA-binding ligands.

DNA as a Sensor for Ligands

The DNA strand can serve as a host for a variety of different molecules, such as small intercalators, groove-binders, proteins, enzymes or molecular motors.

The binding event of a single or a multitude of ligands change the elastic response more or less significantly. As an example, the force curve of a DNA is shown in presence of the antibiotic distamycin-A that attaches to the minor groove of the DNA strand while stabilizing it and helping to resist the overstretching. On the other hand, diazoniapentaphene as an intercalator increases both contour and persistence length and renders the overstretching plateau to disappear.



Variations in the elastic response of a DNA-molecule in the presence of binding ligands can easily be distinguished.

See also: A. Sischka et al., *Molecular mechanisms and kinetics between DNA and DNA binding ligands*; Biophysical Journal, **88**, 404 (2005)

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