Conformations and cryo-force spectroscopy of spray-deposited single-strand DNA on gold

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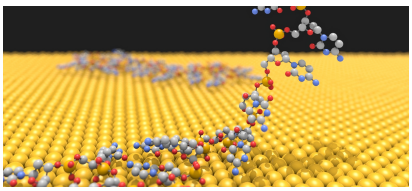
Cryo-electron microscopy has become a valuable tool to determine the structure of biological matter in vitrified liquids. So far, however, mechanical properties of biomolecules, including elasticity and adhesion, have mainly been probed at room temperature using tens of pico-newton forces. Their detection is then limited by entropic fluctuations causing unfolding-refolding events. Here, we combine scanning probe microscopy, force spectroscopy and computer simulations in cryogenic conditions to quantify intra-molecular properties of spray–deposited single–strand DNA oligomers on Au(111). Images with sub–nanometer resolution reveal their folding conformations further confirmed in detail by molecular dynamics simulations. Single-chain lifting shows a progressive decay of the sequential peeling and detachment of single nucleotides. An intra-molecular stiffness of 30-35 N.m −1 per stretched ssDNA repeat unit is obtained in the nano-newton range.



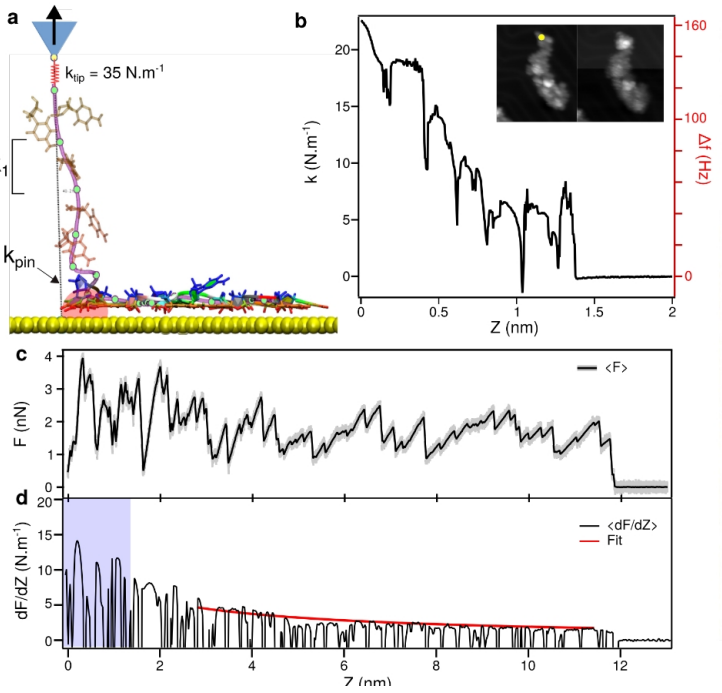


Figure: **(top)** Illustration of the peeling process of ssDNA/Au. **(right)** Mechanical response while lifting a ssDNA oligomer from gold. (**a)** Schematic of the lifting simulations. (**b)** Experimental retraction trace, Δf(Z)∝k(Z) recorded at 4.8 K. (**c)** Force-distance curve F (Z) obtained from MD, **(d)** and the corresponding computed stiffness k(Z). The blue area shows the Z-range accessed by the experiment.