CONTROLLED CHARGE TRANSPORT MEASUREMENTS THROUGH SHORT DSDNA USING CONDUCTIVE AFM

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Complementary, single-strands of DNA (ssDNA), one bound to an ultra flat gold electrode and the other to a gold nanoparticle (GNP) were hybridized on the surface to form a double stranded (ds)DNA bridge between the two gold electrodes. The adsorption of a ssDNA monolayer at each gold interface eliminates non-specific interactions of the dsDNA with the surface, allowing bridge formation only upon hybridization. The technique used, in addition to providing a good electrical contact, offers topographical contrast between the GNP and the non-hybridized surface and enables accurate location of the bridge for the electrical measurements[1].

Electrical measurements, as well as topography images, were performed using conductive Atomic Force Microscope system (C-AFM). Generally**,** the tip is approached to the nanoparticle and then current-voltage (IV) measurement is performed. Previously, we reported currents of up to 220 nA flowing through the dsDNA at a bias voltage of 2 V, while the surrounding ssDNA monolayer was found to be insulating at a bias voltages up to 2.5V and even at 4 V.[2,3,4]

In the present work we report the results of additional and highly controlled measurements of the same system. We have developed the experimental measurement method, using special codes that were incorporated with the measurements system to enable full control over the measurement parameters. This control allows following and verifying all the measurement parameters at all measurement stages. In particular the codes we developed enable us to monitor the tip deflection and the current simultaneously at all the measurement stages and to perform measurements with a wide range of action sequences and parameters, e.g., times and repetitions.

Here we report the results of two measurement methods. In the first method (Method I) we form a contact between the AFM tip and the GNP, and then measure I-V every 0.5 nm of withdrawal while monitoring the deflection. In the second method (Method II) we form a contact between the AFM tip and the GNP, and then ramp the bias and withdraw the tip at fixed bias voltage while monitoring the current and deflection. Using Method I we show that significant currents flows through the dsDNA when the GNP is raised 2-3 nm above the ssDNA monolayer while the monolayer itself is insulating. Using Method II we show that almost no current is measured up to a bias of ~2 V, while at a bias of 2-2.5 V the current first rises and then falls upon withdrawal of the tip from the surface. Both methods show that the current peaks when raising the GNP to 2-3 nm above the ssDNA monolayer (possibly improving the dsDNA configuration).

In conclusion, we reconfirm, in a controlled way, that short dsDNA is able to transport electrical charge, while the ssDNA monolayer is insulating at bias voltages of up to 2.5V. Additionally, we find that the GNP raising has an effect on the conductivity, and the conductance peaks at a ramp of 2-3 nm. We believe that these measurement methods will enable us to get further important information on the electrical properties of dsDNA and on the relation between the measured current and the mechanical properties of the DNA.

References:

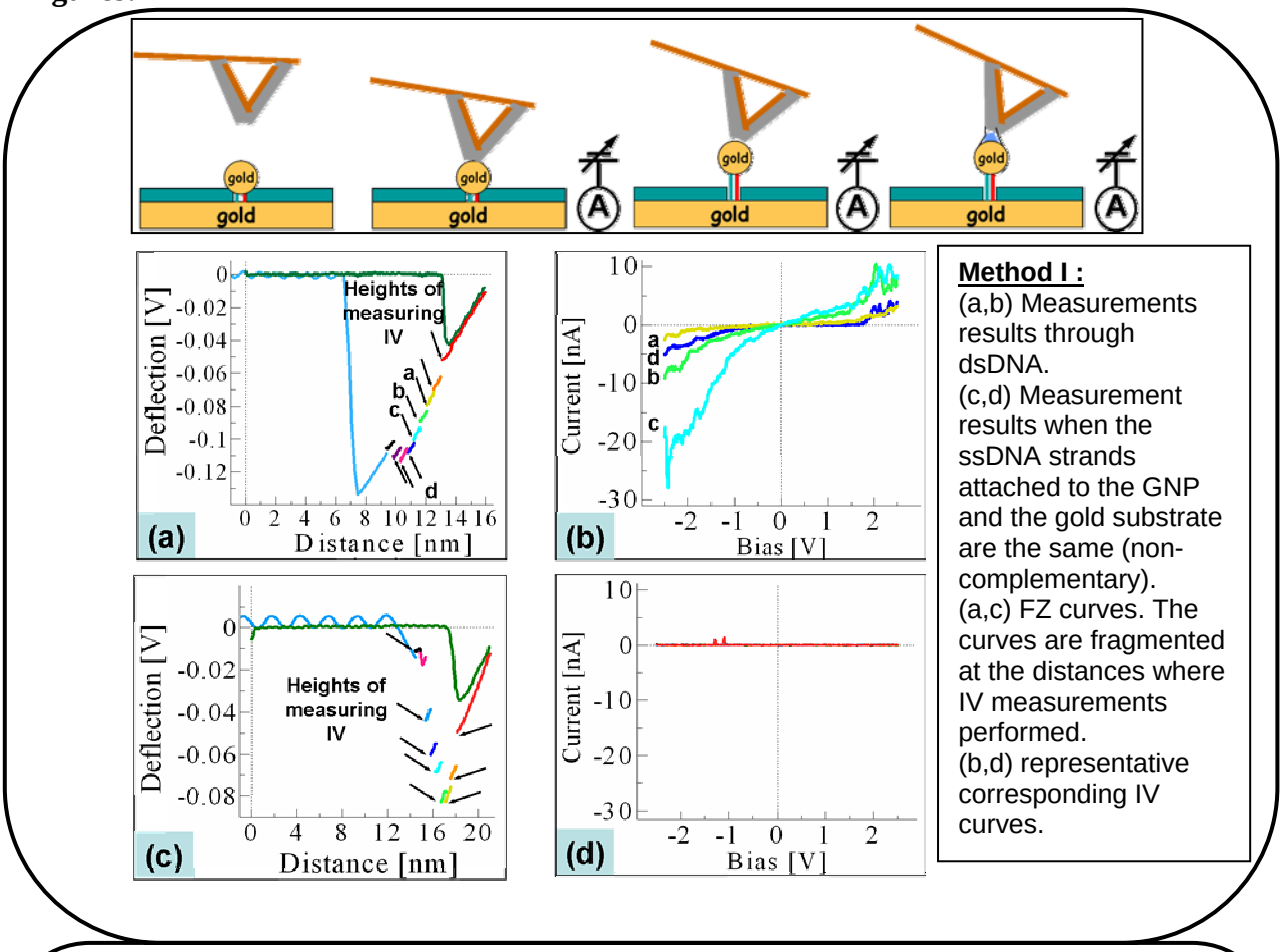
[1] Nogues C., Cohen S.R., Daube S.S. & Naaman R., Phys.Chem.Chem.Phys. 6, ***Electrical properties of short DNA oligomers characterized by conducting atomic force microscopy*** (2004) 4459–4466

[2] Cohen H., Nogues C., Naaman R., Porath D., Proc. Nat. Acad. Sci. USA 102, ***Direct measurement of electrical transport through single DNA molecules of complex sequence*** (2005) 11589.

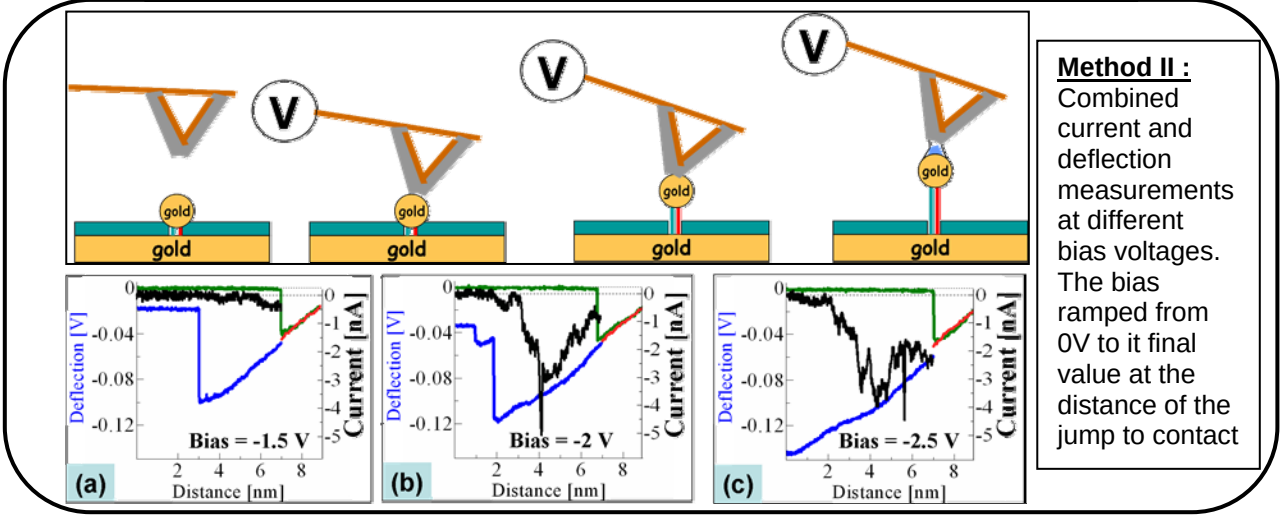
[3] Cohen H., Nogues C., Ullien D., Daube S., Naaman R., Porath D., Faraday Discussions 131, ***Electrical characterization of self-assembled single- and double-stranded DNA monolayers using conductive AFM*** (2006) 367

[4] Ullien D., Cohen H., Porath D., Nanotechnology 18, ***The effect of the number of parallel DNA molecules on electric charge transport through 'standing DNA'*** (2007) 424015

Figures:



Method I :
(a,b) Measurements results through dsDNA.
(c,d) Measurement results when the ssDNA strands attached to the GNP and the gold substrate are the same (non-complementary).
(a,c) FZ curves. The curves are fragmented at the distances where IV measurements performed.
(b,d) representative corresponding IV curves.



Method II :
Combined current and deflection measurements at different bias voltages. The bias ramped from 0V to it final value at the distance of the jump to contact