ADVANCED FUNCTIONAL MATERIALS

Supporting Information

for *Adv. Funct. Mater.,* DOI: 10.1002/adfm.201403719

Slowing DNA Transport Using Graphene–DNA Interactions

Shouvik Banerjee, James Wilson, Jiwook Shim, Manish Shankla, Elise A. Corbin, Aleksei Aksimentiev, and Rashid Bashir**

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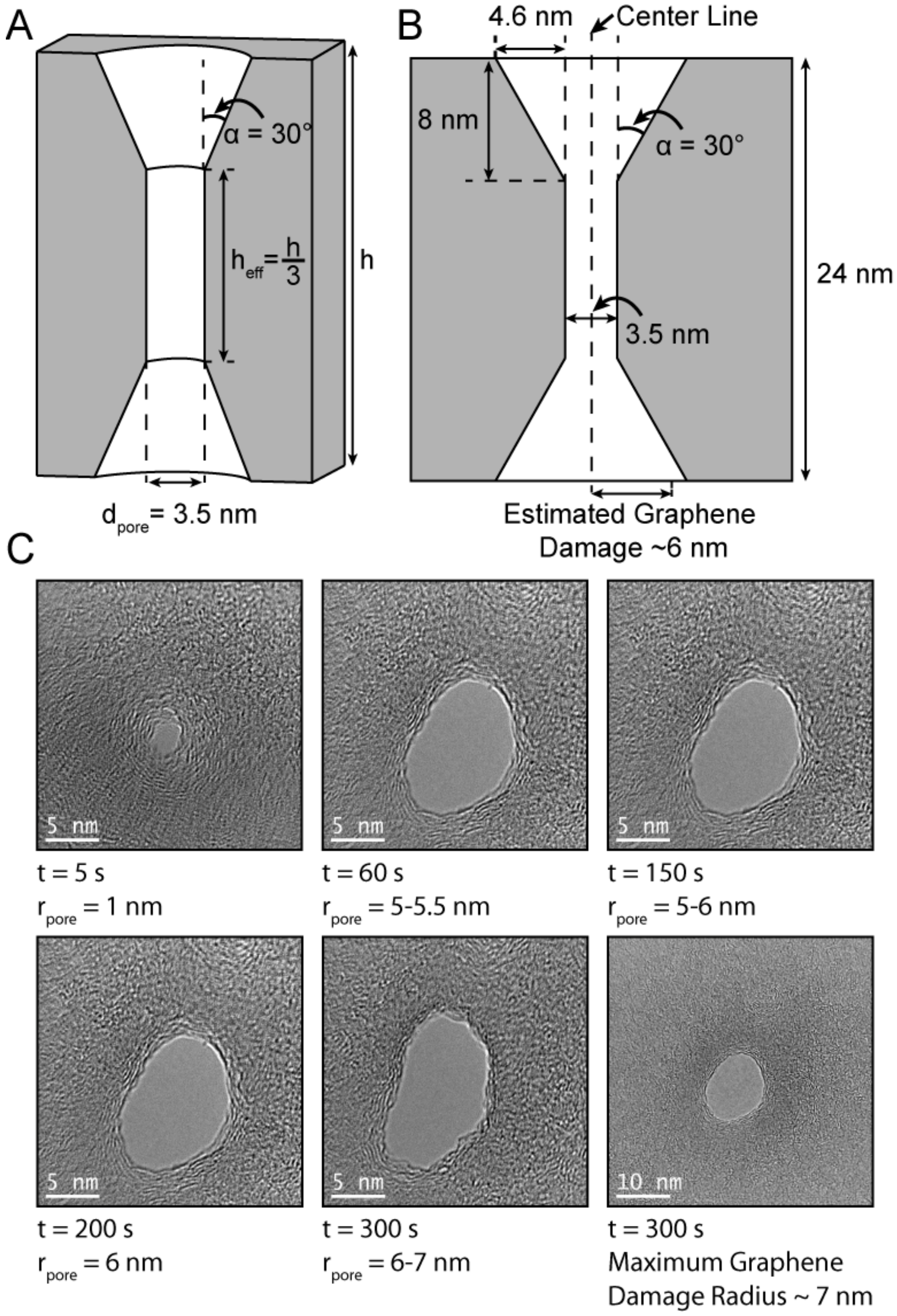


Figure S1. A-B) Schematics of the expected nanopore shape indicating different dimensions of the nanopore. C) Characterization of graphene damage by the convergent electron beam exposure. The pore nucleates very quickly but growth saturates for exposure time longer than 60 seconds. The further enlargement is mainly attributed to beam drift which is manifested in the asymmetric growth of the nanopore. As can be clearly seen from the images there is still sufficient material around the pore for the DNA molecules to interact with.

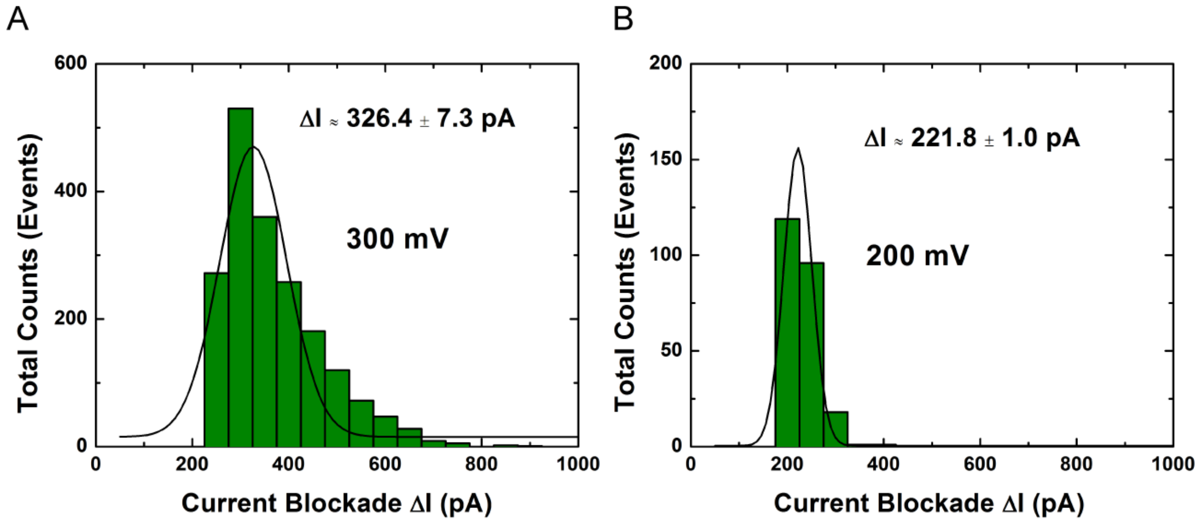


Figure S2. A-B) Current blockade histograms at 300 mV and 200 mV respectively corresponding to the translocations of 100 nt ssDNA through a 3.5 nm pore in a graphene-dielectric-graphene membrane showing the reduction of blockade levels with applied voltage as expected. The blockade levels (ΔI values provided in the insets) also correspond very closely to expected levels for a nanopore of this diameter and conductance level. The experiment was performed in 1 M KCl, 10 mM Tris, 1 mM EDTA at pH 7.6.

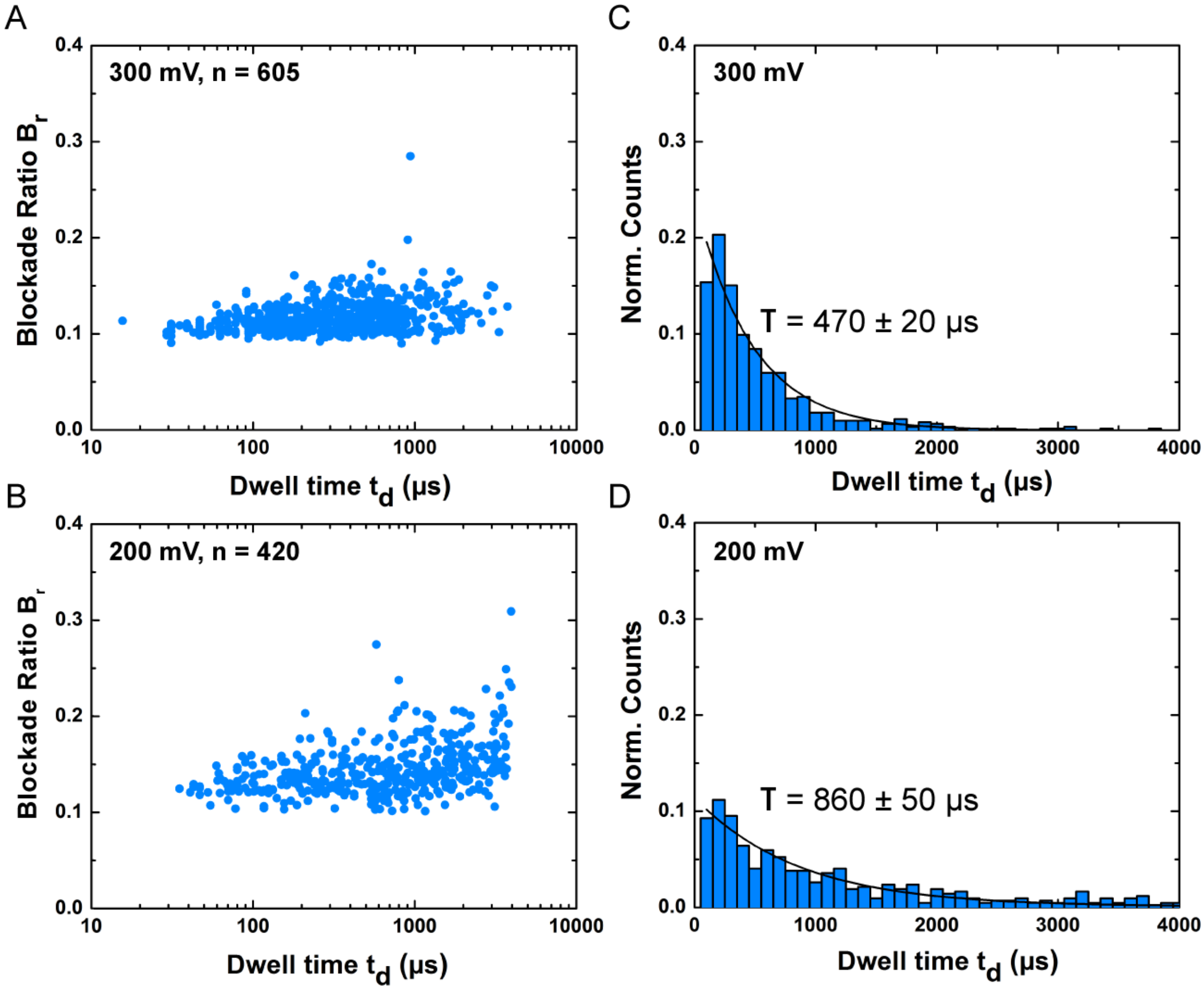


Figure S3. Scatter diagrams and translocation time histograms for a 4.0 nm nanopore in graphene-dielectric membrane at 300 mV and 200 mV used for 100nt ssDNA translocation experiments. The decreased translocation time at higher voltage (300 mV) indicates translocations of DNA molecules and not random collisions contributing to the data. All experiments were done in 1 M KCl, 10 mM Tris, 1 mM EDTA at pH 7.6.

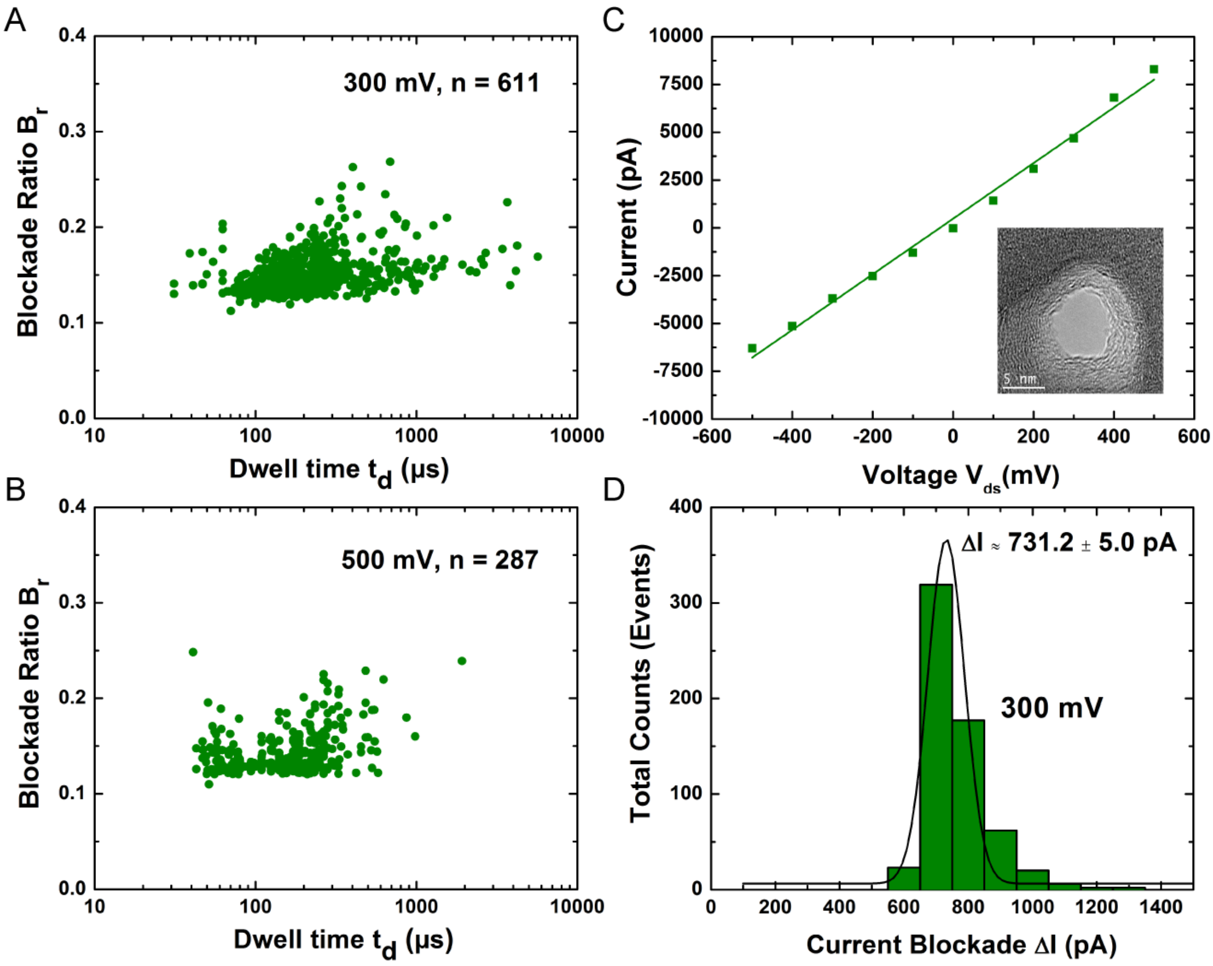


Figure S4. A-B) Scatter diagrams for translocation experiments in graphene-dielectric-graphene membrane at 300 mV and 500 mV used for 850bp dsDNA translocation experiments. The decreased translocation time at higher voltage (500 mV) indicate translocations of DNA molecules and not random collisions contributing to the data. All experiments were done in 1 M KCl, 10 mM Tris, 1 mM EDTA at pH 7. C) IV curve for the 6 nm pore (image: inset) used for dsDNA translocation study. D) Current blockade histograms at 300 mV corresponding to the translocations of 850bp dsDNA through a 6 nm pore in a graphene-dielectric-graphene membrane. The blockade levels (ΔI values provided in the insets) also correspond very closely to expected levels for a nanopore of this diameter and conductance level.

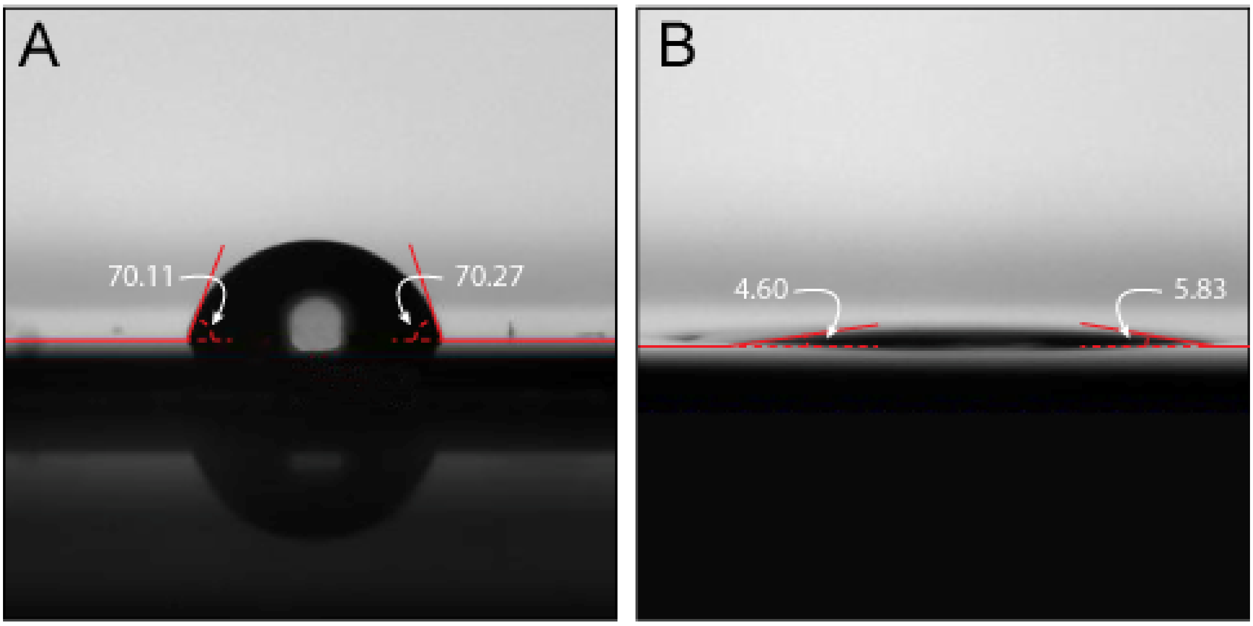


Figure S5. Contact angle measurements with 1M KCl, 10mM Tris, 1mM EDTA at pH 7.6 solution. Contact angle values (insets) of graphene (A) is observed to be much higher than that of dielectric Al_2O_3 (B).

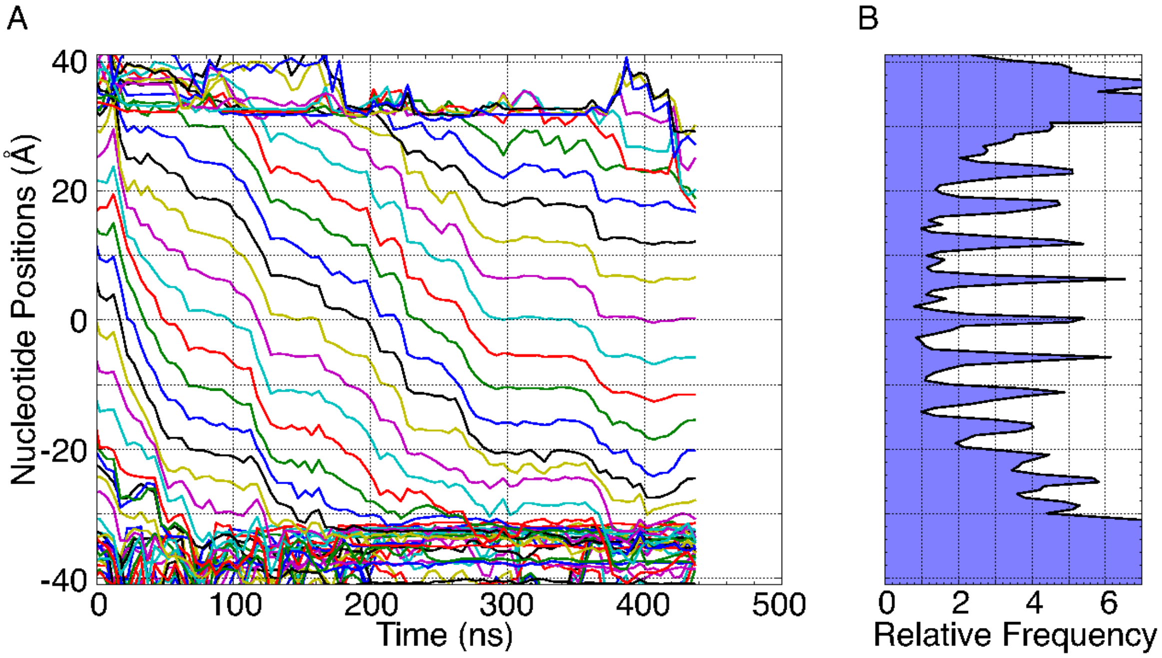
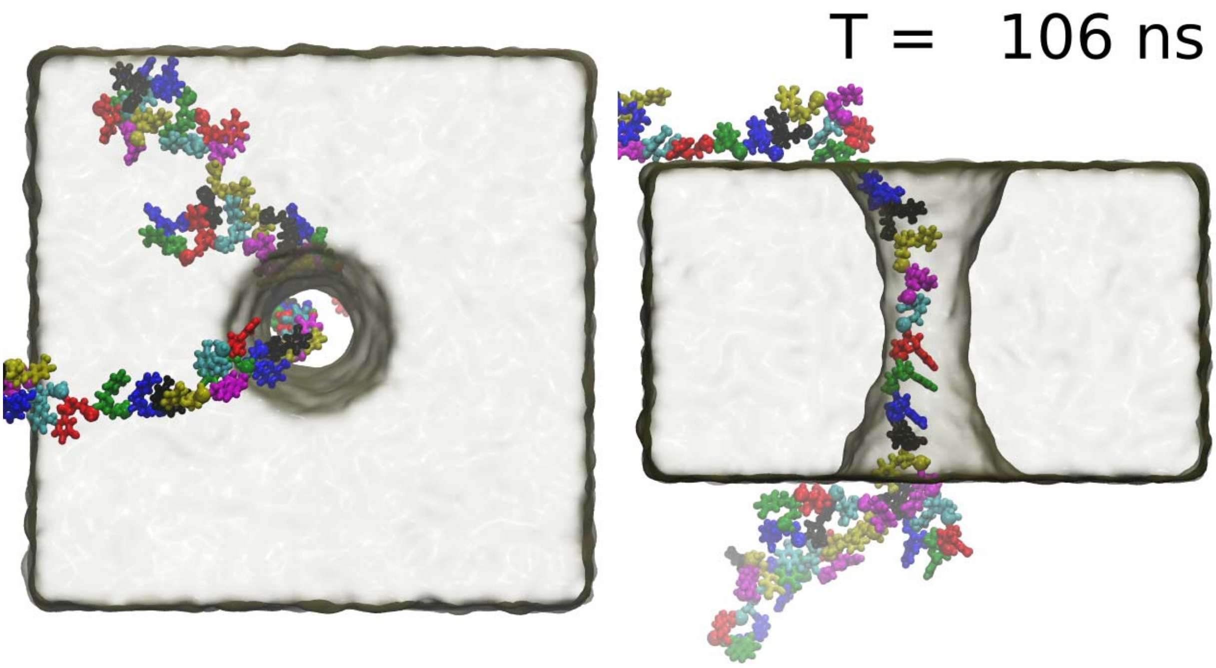
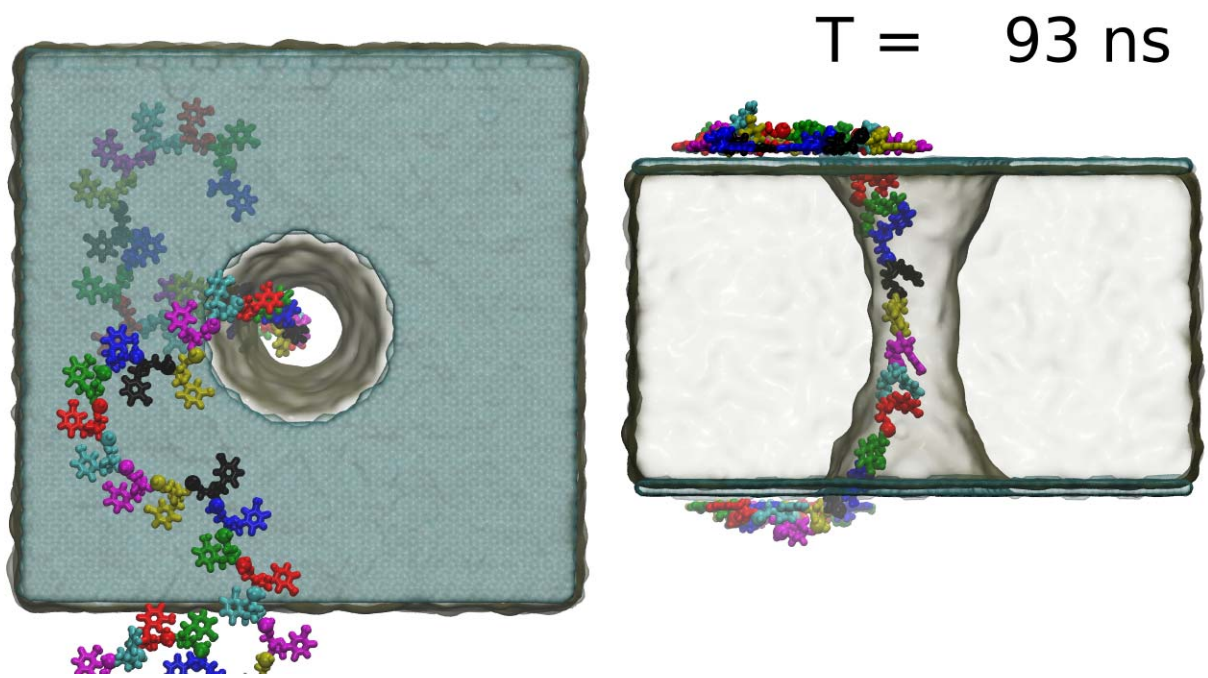


Figure S6. A) Positions of each nucleotide (calculated from the center of mass of the backbone) within the silica pore region over time. The color of each nucleotide trace corresponds to the color of the nucleotide in animation M0. B) Histogram of the positions of the nucleotides (calculated from the center of mass of the backbone) within the silica pore region over time. Traces show some periods of very little motion and some short quick movements. This stepwise behavior is also shown by the relative frequency of finding a nucleotide at a specific vertical position shown far right in blue. The sharp peaks in the graph of relative frequency suggest an affinity for a nucleotide to be found in specific vertical positions within the pore.



Animation M1. The dynamics of a poly(dT)$_{50}$ strand threaded through a nanopore in a silica membrane. The DNA is shown using a representation that shows the interatomic bonds, the phosphorous atoms are shown with spheres. Each nucleotide is shown with a color corresponding to the colors in the traces of Fig S6. The membrane is shown using a transparent tan color. A transmembrane bias of 500 mV is applied throughout the simulation. The movie covers 455 ns of continuous MD simulation.



Animation M2. The dynamics of a poly(dT)$_{50}$ strand threaded through a nanopore in a stacked graphene-silica-graphene membrane. The DNA is shown using a representation that shows the interatomic bonds, the phosphorous atoms are shown with spheres. Each nucleotide is shown with a color corresponding to the colors in the traces of Figure 5. The silica is shown using a transparent tan color showing the molecular surface, and the graphene sheets are shown using a transparent cyan color showing the molecular surface. A transmembrane bias of 500 mV is applied throughout the simulation. The movie covers 943 ns of continuous MD simulation.