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ナノポア狭小化による一本鎖ＤＮＡのナノポア通過速度への影響

Dependency of nanopore diameters on translocation speed of single-stranded DNA

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To slow the translocation of single-stranded (ss) DNA through a solid-state nanopore, a nanopore was narrowed, and the effect of the narrowing on DNA-translocation speed was investigated. For accurately measuring the speed, long (5.3 kb) ssDNA (namely, ss-poly(dA)) with uniform length (±0.4 kb) was synthesized. The diameters of nanopores fabricated by transmission electron microscope were controlled by atomic-layer deposition. Reducing nanopore diameter from 4.5 to 2.3 nm slowed down translocation of ssDNA more than 16 times (to 0.18 μs/base) when 300 mV was applied across the nanopore. It is speculated that the interaction between the nanopore and ssDNA dominates translocation speed. Unexpectedly, the translocation speed of ssDNA through the 4.5-nm nanopore is more than two orders of magnitude higher than that of double-stranded (ds) DNA through a nanopore with nearly the same size. The cause of such faster translocation of ssDNA can be explained by the weaker drag force inside the nanopore. Moreover, the measured translocation speeds of ssDNA and dsDNA agree well with those calculated by molecular-dynamics (MD) simulation. The MD simulation predicted that reducing nanopore diameter to almost the same as that of ssDNA (i.e., 1.4 nm) decreases translocation speed (to 1.4 μs/base). Narrowing the nanopore is thus an effective approach for accomplishing nanopore DNA sequencing.