Transport of ions and biomolecules through single asymmetric nanopores in polymer films

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Single conical nanopores in polymer foils show 'rectifying' diode-like current–voltage (*I*–*V*) characteristics, with preferential cation flow in the direction from the narrow to the wide opening [*P. Apel, Y.E. Korchev, Z. Siwy, R. Spohr, M. Yoshida, Nucl. Instr. and Meth. B 184 (2001) 337–346, Z. Siwy, D. Dobrev, R. Neumann, C. Trautmann, K. Voss, Appl. Phys. A 76 (2003) 781–785*].To produce single-pore membranes, we irradiated polymer films (polyethylene terephthalate and polyimide) with single heavy ions (using kinetic energies in the GeV range) and subsequently performed asymmetric chemical track-etching. The resulting conical pores had narrow openings of 4–20 nm.

The *I*–*V* curves of these pores were measured in aqueous KCl solutions of various concentrations and pH values, and it was found that both parameters influence the rectification properties of the pores. For decreasing concentrations, down to 0.1 M, the degree of rectification increases, as predicted by a recently proposed model [*Z. Siwy, A. Fulinski, Phys. Rev. Lett. 89 (2002) 198103*], however, as the concentration decreases further, the rectification unexpectedly begins to decrease again. We suspect that this is due to conformation changes occurring in the pore.

Also, our results have shown that the pores exhibit a non-classical conductance versus electrolyte concentration characteristic, having elevated conductances at low concentrations, for which we propose an explanation based on surface conductivity.

Finally, we present an application of the polyimide conical nanopores as single-molecule DNA sensors, with results demonstrating their ability to detect individual plasmid DNA molecules.