Selective sensing using a solid-state nanopore

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Solid-state nanopores are powerful tools to detect DNA configurations,[1] protein size[2] and conformation,[3,4] nanoparticles[5] and virus.[6] The nanometric diameter of solid-state nanopores can be tuned to fit the analyte size. Moreover, they present better chemical and mechanical stability than the biological ones.[7,8] However, the interactions between nanoparticles to be detected and the nanopore remain poorly controlled, while the membrane supporting the nanopore has a short lifetime attributed to a high surface energy.[3] To overcome these drawbacks, we have proposed a polymer functionalization to better control the pore size, to passivate the membrane. Hence avoiding nonspecific interactions of nanoparticles, by manipulating the chemical and physical surface properties.[9] Furthermore, to increase the specificity, a receptor can be grafted on the nanopore surface to specifically capture the target molecules,[6] leading to an active sensor. The nanopore chip was inserted into a microfluidic device to facilitate its handling and ease the change of buffers. The proof of concept was done using the streptavidin-biotin complex, where the streptavidin was captured by the grafted biotin inside the nanopore.[10,11] We plan to use this approach for biomarker detection.[12,13]

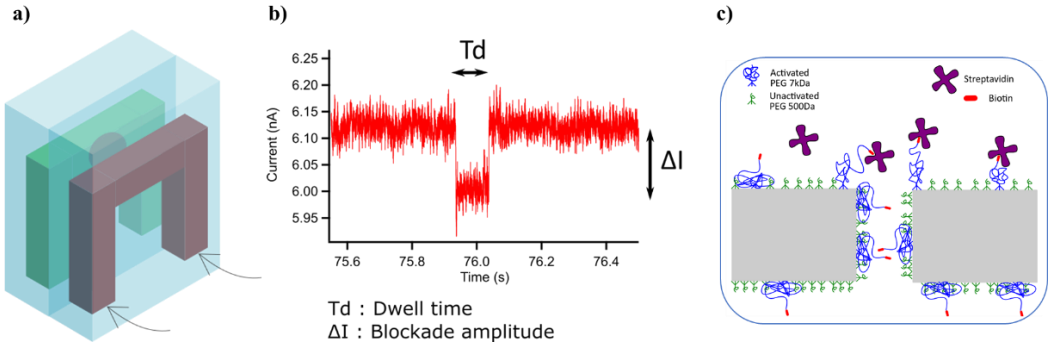

Fig. 1 a) Microfluidic device with a nanopore chip placed on it. b) Current blockade when a streptavidin molecule transiently resides inside a functionalized nanopore. c) Streptavidin interactions with a nanopore grafted with short and biotinylated long polymer (PEG) chains.

1 J. L. Li, M. Gershow, D. Stein, E. Brandin and J. A. Golovchenko, *Nat. Mater.*, 2003, **2**, 611–615.
2 E. C. Yusko, B. R. Bruhn, O. M. Eggenberger, J. Houghtaling, R. C. Rollings, N. C. Walsh, S. Nandivada, M. Pindrus, A. R. Hall, D. Sept, J. Li, D. S. Kalonia and M. Mayer, *Nature Nanotech*, 2017, **12**, 360–367.
3 A. Oukhaled, B. Cressiot, L. Bacri, M. Pastoriza-Gallego, J.-M. Betton, E. Bourhis, R. Jede, J. Gierak, L. Auvray and J. Pelta, *ACS Nano*, 2011, **5**, 3628–3638.
4 P. Waduge, R. Hu, P. Bandarkar, H. Yamazaki, B. Cressiot, Q. Zhao, P. C. Whitford and M. Wanunu, *ACS Nano*, 2017, **11**, 5706–5716.
5 L. Bacri, A. G. Oukhaled, B. Schiedt, G. Patriarche, E. Bourhis, J. Gierak, J. Pelta and L. Auvray, *J. Phys. Chem. B*, 2011, **115**, 2890–2898.
6 A. Arima, I. H. Harlisa, T. Yoshida, M. Tsutsui, M. Tanaka, K. Yokota, W. Tonomura, J. Yasuda, M. Taniguchi, T. Washio, M. Okochi and T. Kawai, *J. Am. Chem. Soc.*, 2018, **140**, 16834–16841.
7 J. Roman, N. Jarroux, G. Patriarche, O. Français, J. Pelta, B. Le Piouffle and L. Bacri, *ACS Appl. Mater. Interfaces*, 2017, **9**, 41634–41640.
8 N. Giamblanco, D. Coglitore, J.-M. Janot, P. E. Coulon, B. Charlot and S. Balme, *Sensors and Actuators B: Chemical*, 2018, **260**, 736–745.
9 J. Roman, O. Français, N. Jarroux, G. Patriarche, J. Pelta, L. Bacri and B. Le Piouffle, *ACS Sens.*, 2018, **3**, 2129–2137.
10 M. Lepoitevin, M. Bechelany, E. Balanzat, J.-M. Janot and S. Balme, *Electrochim. Acta*, 2016, **211**, 611–618.
11 I. M. Fujinami Tanimoto, B. Cressiot, N. Jarroux, J. Roman, G. Patriarche, B. Le Piouffle, J. Pelta and L. Bacri, *Biosensors and Bioelectronics*, 2021, **183**, 113195.
12 L. Reynaud, A. Bouchet-Spinelli, J.-M. Janot, A. Buhot, S. Balme and C. Raillon, *Anal. Chem.*, , DOI:10.1021/acs.analchem.1c00461.
13 N. Meyer, J.-M. Janot, J. Torrent and S. Balme, *ACS Cent. Sci.*, , DOI:10.1021/acscentsci.1c01404.