



## Supporting Information

for *Small*, DOI: 10.1002/smll.201703327

### Osmotic Effects in Track-Etched Nanopores

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## **Supporting Information**

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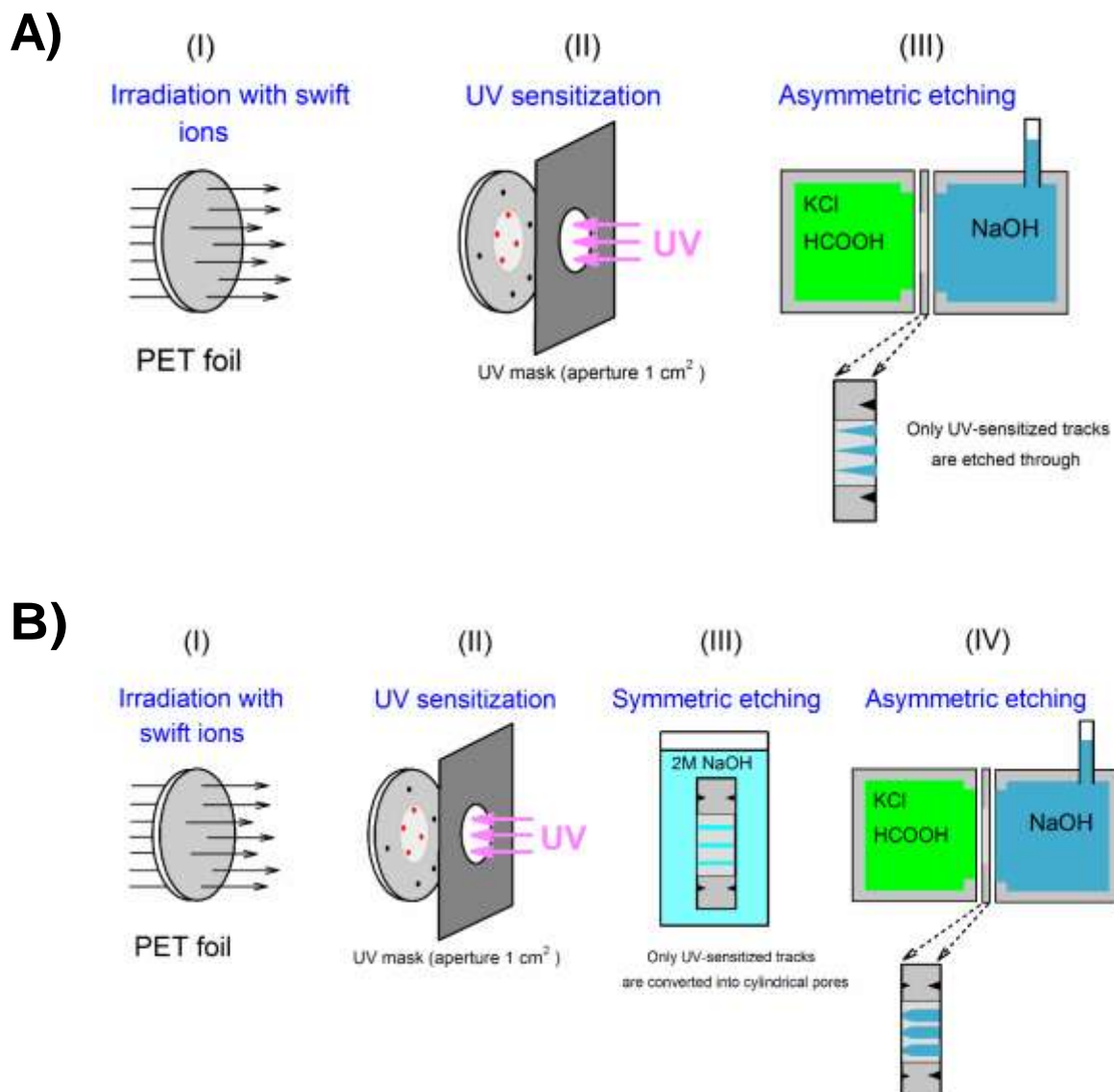
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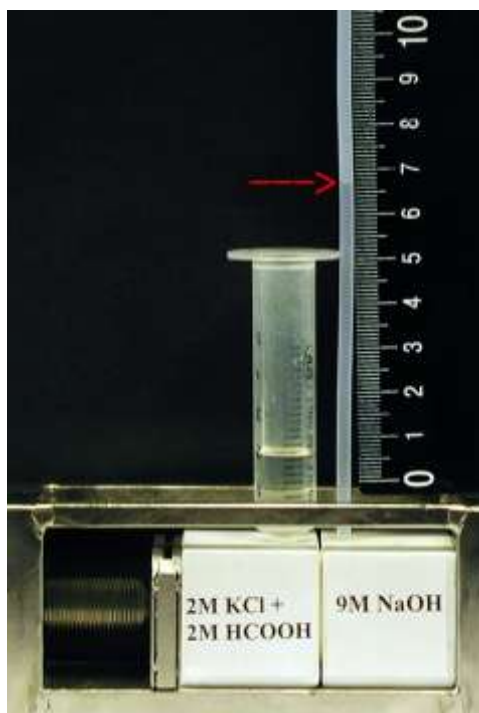
## 1. Experimental procedure



**Figure S1.** Schematic of experimental procedure.

A) PET samples are irradiated with swift heavy ions (I). The ion-irradiated samples are exposed to ultraviolet radiation through a mask with 1 cm<sup>2</sup> aperture (II). PET samples with UV-sensitized ion tracks are etched from one side in two-compartment cell; level of etching solution in the capillary is measured (III).

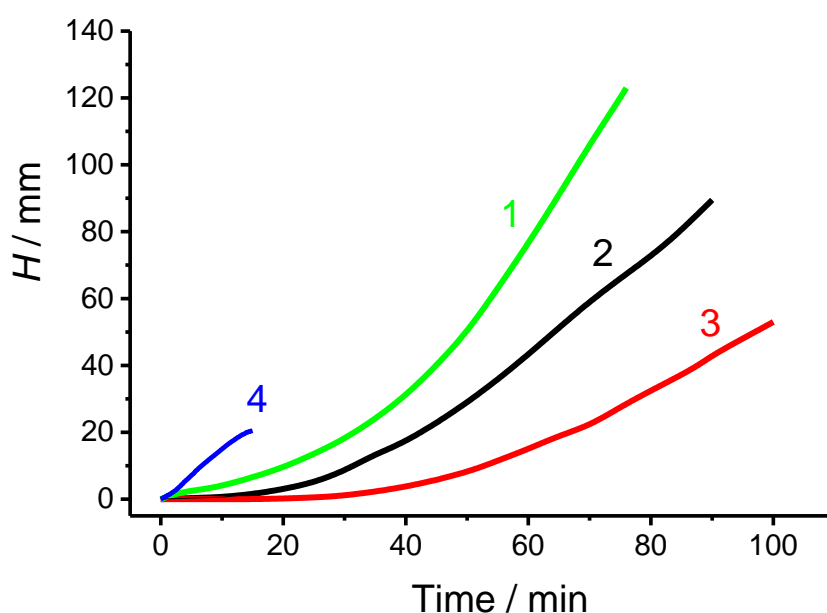
B) PET samples are irradiated with swift heavy ions (I). The ion-irradiated samples are exposed to ultraviolet radiation through a mask with 1 cm<sup>2</sup> aperture (I). PET samples with UV-sensitized ion tracks are etched from two sides in a beaker at 60 °C to produce cylindrical pores (III). Sample with cylindrical pores is etched asymmetrically and the level of etching solution in the capillary is measured (IV).



**Figure S2.** Teflon cell for observation of osmotic flow during asymmetric etching.<sup>[1]</sup> Scale units in cm. The etchant solution level in the capillary is indicated with a red arrow.

## 2. Osmotic flow through pre-etched cylindrical pores using different stopping solutions

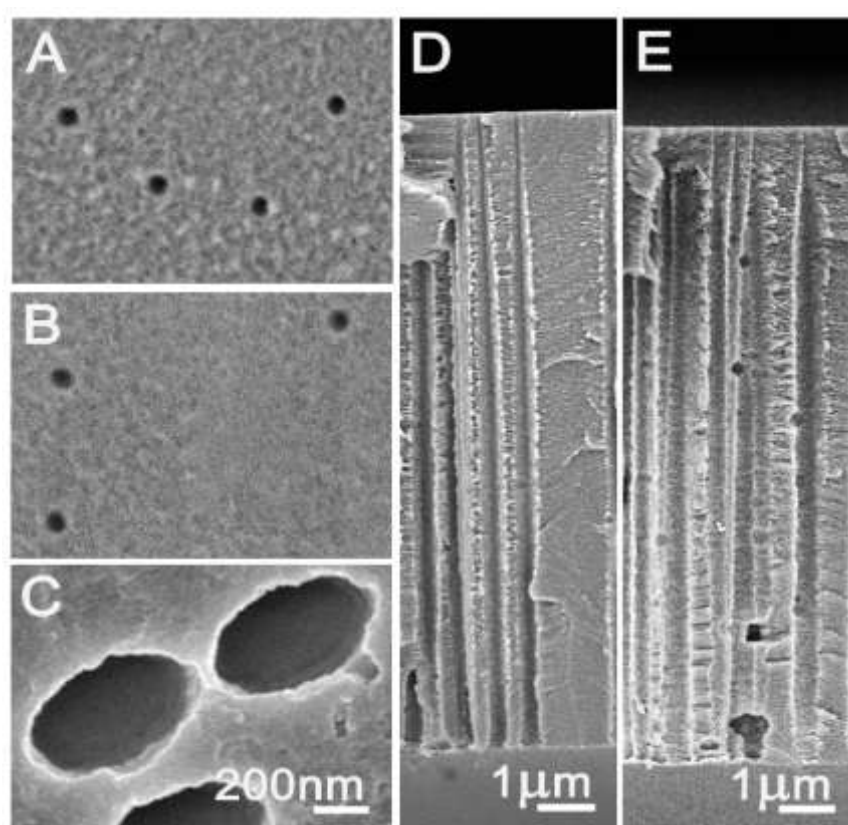
Multi-track samples with pre-etched cylindrical pores, as shown in **Figure S1B**, were etched in a Teflon cell presented in **Figure S2**. Three different stopping solutions were used: 1 m KCl/1 m HCOOH, 1 m HCOOH, and pure water. Each diagram in **Figure S3** shows the build-up of the solution level  $H$  in the alkaline compartment of the cell as a function of time under asymmetric etching. The membrane with  $10^9$  pores of 62 nm in diameter lost its integrity after 18 min due to excessive porosity (curve 4 in Figure S3).



**Figure S3.** Build-up of the level  $H$  of the etching solution in the capillary as a function of time under asymmetric etching in 9 m NaOH. Stopping solution: 1 m KCl/1 m HCOOH (1,4); 1 m KCl (2); H<sub>2</sub>O (3). Total number of cylindrical pores is  $\cdot 10^8$  (1, 2, 3) and  $10^9$  (4), with effective pore diameter of 32 nm (1, 2, 3) and 62 nm (4). Surface area of etched PET foils is 1 cm<sup>2</sup>. Temperature 23 °C.

After the osmotic flux measurements and completing the etching, the samples were rinsed, dried, embrittled by extensive UV exposure for FESEM observation. Fractured samples were

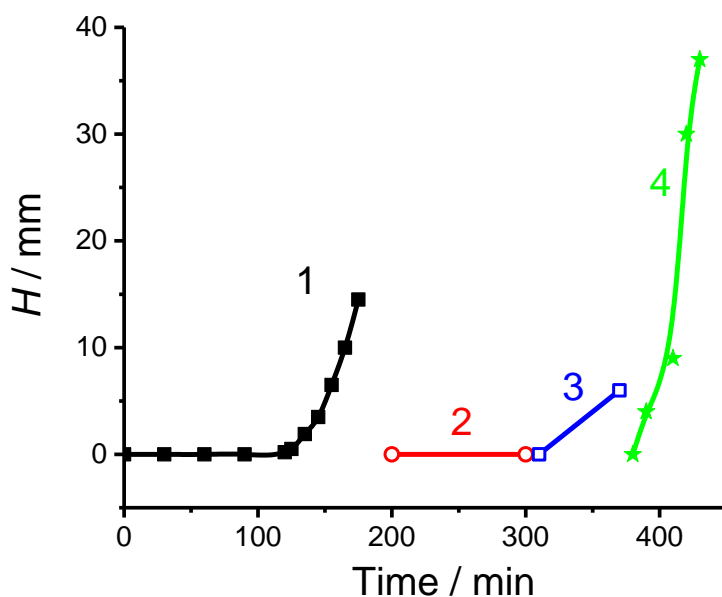
coated with a thin (10 nm) layer of chromium and examined using a Hitachi SU8020 instrument. Representative images of pore channels broken along their axis are presented in **Figure S4**. The pore channels consist of long cylindrical parts evolving into conical tips. The length of the conical parts is 2-3  $\mu\text{m}$ . The pore diameter on the surface that was in contact with the stopping solution did practically not change during asymmetric etching (compare images A and B in Figure S4).



**Figure S4.** Representative FESEM images of pre-etched membranes with cylindrical pores subjected to asymmetric etching for 75 and 120 min. (A) surface of the initial membrane with effective pore diameter of 32 nm. (B) top and (C) bottom surfaces of membrane after 75-minute asymmetric etching (sample corresponds to curve 2 in Figure S3). Fractured cross-section of membranes etched for (D) 75 min and (E) 120 min (corresponding to curves 2 and 3 in Figure S3). Images A and B were obtained on non-metal-coated specimens to measure true dimensions of pore openings.

### 3. Osmotic flow through asymmetric nanopores with NaCl draw solutions

**Figure S5** shows attempts to measure the osmotic flow with draw solutions containing different quantities of sodium chloride. The PET foil irradiated with  $10^8$  Au-ions  $\text{cm}^{-2}$  was etched from one side with 9 m NaOH at room temperature. Water served as stopping solution.



**Figure S5.** Solution level  $H$  in the capillary as a function of time for different draw solutions. In all cases, deionized water served as feed solution. The membrane was a PET foil with  $\sim 10^8$  ion tracks. (Black curve 1) Asymmetric etching (etchant: 9 m NaOH, stopping solution:  $\text{H}_2\text{O}$ ). Etching was stopped at 175 min followed by careful rinsing of both cell compartments with deionized water. (Red curve 2) One compartment of cell was filled with 25 g/L NaCl serving as draw solution. (Blue curve 3) Draw solution was 45 g/L NaCl. (Green curve 4) Draw solution was 300 g/L NaCl. Temperature 23 °C.

A well-pronounced osmotic flux developed during etching after a time period of 125 min (curve 1 in figure S5). Then the etchant was removed from the cell and both cell halves were carefully rinsed with deionized water. In a next step, the cell compartment equipped with the capillary was filled with a NaCl solution (25 g/L), the other compartment was filled with water. During 100 minutes no measurable rise of the solution in the capillary was observed (curve 2 in figure S5). When increasing the concentration of the draw solution to 45 g/L

NaCl, we measured a significant rise of the osmotic flux during the following 75 minutes (curve 3 in Figure S5). Finally, the 45 g/L solution was replaced with a 300 g/L NaCl solution (curve 4 in Figure S5). The measured osmotic flux is even higher than the flux measured with 9 m NaOH as draw solution (curve 1). This can be explained by the fact that the viscosity of sodium chloride solutions is significantly lower than the viscosity of the strong alkaline NaOH solution and, therefore, the resistance of the membrane to convective flow is lower.

## References

1. P. Y. Apel, I. V. Blonskaya, N. E. Lizunov, O. L. Orelovitch, C. Trautmann, *Phys. Chem. Chem. Phys.* **2016**, 18, 25421-25433.