Ionic Transport Across Graphene Membranes

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By studying the concentration driven diffusion of positive and negative ions across porous 2D membranes of graphene and hexagonal Boron Nitride (h-BN) we demonstrate cation selectivity. Using the current-voltage characteristics of graphene and h-BN monolayers separating reservoirs of different salt concentrations we use the reversal potential to determine selectivity. We demonstrate that negative surface charge gives rise to cation selectivity by tuning the Debye screening length. Surprisingly, h-BN and graphene membranes show similar characteristics strongly suggesting a common origin of selectivity in aqueous solvents. We also demonstrate that the cation flux can be increased by using ozone to create additional pores in graphene whilst maintaining excellent selectivity and we show how the selectivity can be tuned to work towards anion selectivity. We discuss opportunities to exploit our 2D membranes for applications including osmotic power conversion.

References

1. Walker, M. I., Weatherup, R. S., Bell, N. A. W., Hofmann, S. & Keyser, U. F. Free-standing graphene membranes on glass nanopores for ionic current measurements. Appl. Phys. Lett. 106, 23119 (2015).
2. Walker, M. I., Braeuninger-weimar, P., Weatherup, R. S., Hofmann, S. & Keyser, U. F. Measuring the Proton Selectivity of Graphene Membranes. Appl. Phys. Lett. 107, 213104 (2015).

Figures

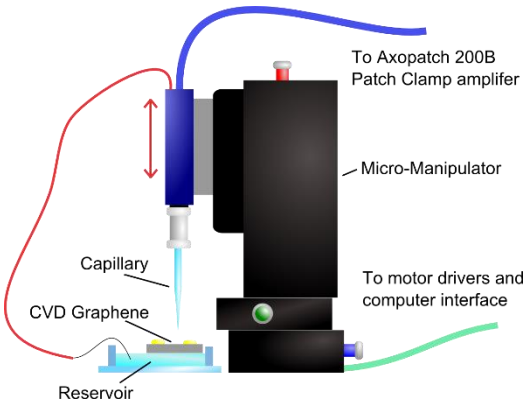

Figure 1: Experimental set up used to seal graphene membranes across the tips of glass nanocapillaries.

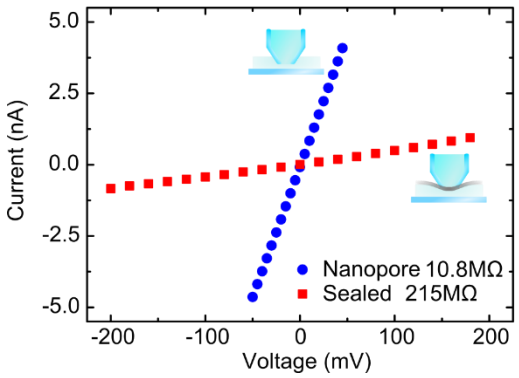

Figure 2: Current – voltage curves for a bare capillary and a capillary sealed with a graphene membrane (180nm capillary, 1M NaCl)