Angstrom-scale capillaries: Ionic selectivity and dehydration

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Abstract

Understanding ion transport in nano/angstrom scale channels has practical relevance in applications such as membrane desalination, blue energy, supercapacitors and batteries, as well as in understanding ionic flow through biological channels. Synthetic Å-channels are now a reality with the emergence of several cutting-edge bottom-up and top-down fabrication methods. In particular, the use of atomically thin 2D-materials and nanotubes as components to build fluidic conduits has pushed the limits of fabrication to the Å-scale. In this talk, I will discuss about angstrom (Å)-scale capillaries, which can be dubbed as "2D-nothing". The Å-capillary is an antipode of graphene, created by what is left behind after extracting one-atomic layer out of a crystal [1]. What is intriguing here is, the dimensions of these channels being comparable to the size of a water molecule.

The Å-capillaries have helped probe several intriguing molecular-scale phenomena experimentally, including: water flow under extreme atomic-scale confinement [1] complete steric exclusion of ions [3,5], specular reflection and quantum effects in gas reflections off a surface [2,7], voltage gating of ion flows [4] translocation of DNA [6]. I will present ionic flows induced by stimuli (electric, pressure, concentration gradient) and discuss the importance of ionic parameters that are often overlooked in the selectivity between ions, along with ionic memory effects [8]. The mass production and the robustness of the nano/angstrofluidic devices for large-scale applications are still the main challenges. Toward the end of the talk, I will discuss strategies to scale the production of Å-capillaries.

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FIGURES

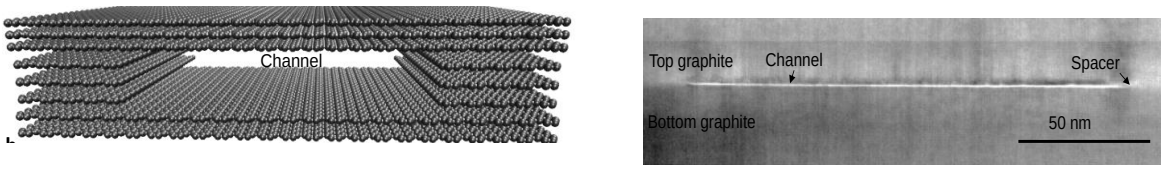

Figure 1: Left, General schematic of Graphene capillary device. Right, Cross-sectional bright field image of a bilayer capillary (h □ 7 Å) in a scanning transmission electron microscope.