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Nanofluidics with graphene and graphene-oxide membranes

Water and ions show curious behavior when constricted by two-dimensional materials at the scales of few nanometers or less – the phenomena include the edge-enhance ionic current in graphene nanopores [1,2], anomalous ionic flow in nanotubes, and frictionless water transport in graphene [3] and graphene-oxide (GO) nanochannels [4, 5]. Intimate understanding of such behavior would raise prospects in many applications, including filtration membranes, single-biomolecule analysis, supercapacitors, etc.

In this talk, I will present a systematic experimental investigation of the ionic flow in nanopores and nanochannels, as well as microscopic GO membranes. We investigated ionic flow in atomically-smooth graphene channels with height ranging from 0.7 – 3 nm and in chemically controllable GO channels. We identified several mechanisms that control ionic mobility in different systems: (a) mobility enhancement in smooth channels; (b) compression of the ionic hydration shell; (c) ionic electrostatic repulsion due to the membrane surface charge; and (d) chemically-specific interactions.

Armed with the insight into the physical mechanism governing the ionic flow, we are able to rationally engineer new membranes of desirable properties. With such tunability, we demonstrate a range of scaled-up membranes for desalination, electrodialysis and pervaporation, with properties matching or exceeding those of commercial membranes.

References

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Figures

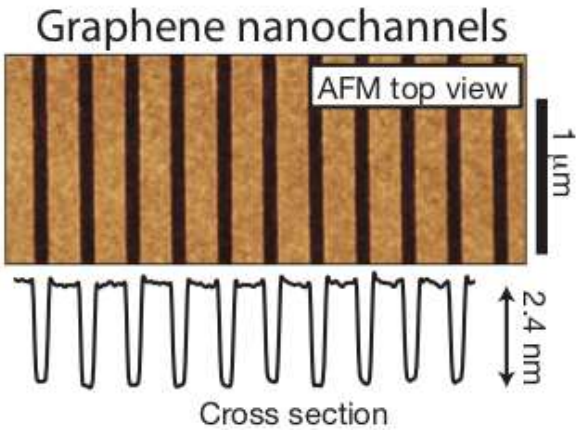

Figure 1: Atomic force microscopy of ultra-clean, atomically-smooth graphene nanochannels with height ranging from 0.7 – 3 nm, and micrometers long.