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PROCEEDINGS

Ion dynamics and Manipulation Under Extreme Confinement

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ABSTRACT

Ion dynamics and precise control in nanochannels play key roles in biological systems, energy conversation, and environmental engineering. However, the mechanics behaviors of ions and their manipulation mechanism under extreme confinement remain largely unexplored. Biological ion channels acting as life's transistors can gate simultaneously fast and selective ion transport through atomic-scale filters to maintain vital life functions. This biological inspiration motivates the quest for artificial structures with simultaneous functions of ion selectivity, fast transport and electrical gating at the atomic scale. Here, we experimentally investigate the ion dynamics and electrical manipulation in graphene channels of 3 angstrom size and report an atomic-scale ion transistor exhibiting simultaneously ultrafast and highly selective ion transport controlled by electrical gating, where the ion diffusion coefficient reaches two orders of magnitude higher than that in bulk water. We observe the atomic-scale ion transport has a threshold behavior due to the critical energy barrier for hydrated ion insertion, similar to that in biological channels. Our in situ optical measurements suggest ultrafast ion transport likely originates from highly dense packing of ions and their concerted movement inside the graphene channels. This mechanism is analogous with that of "Newton's cradle" [1]. This discovery opens a door to both fundamental understanding of ion transport and applications such as water desalination, mineral ion extraction, and medical dialysis.

KEYWORDS

Ion dynamics; electrical control; ion channels; ion transistors; nonconfinement

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