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ABSTRACT

Tunable Ion Transport in Graphene Membranes for Advanced Nanofiltration

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Two-dimensional crystals (2DCs), such as graphene, are poised to revolutionize membrane technology due to their exceptional chemical stability, mechanical robustness, and atomic-scale permeability control. However, angstrom-scale confinement alone offers size-dependent selectivity without sharp ionic cut-off, making geometry insufficient for high ionic discrimination [1]. Additionally, translating lab-scale nanofiltration properties into industrial membranes requires sustainable and scalable production. While graphene oxide (GO) has attracted attention, its swelling in aqueous environments limits its use in ion sieving and desalination [2]. In contrast, graphene membranes produced via liquid-phase exfoliation (LPE) offer a promising alternative due to their structural integrity, narrow interlayer spacing, and scalable fabrication. Here, we present recent advancements in the eco-friendly production of graphene membranes via LPE in water-based [3] and bio-derived solvents [4]. The membranes show excellent long-term aqueous stability, confirmed by morphological analyses and immersion tests.

In terms of nanofiltration performance, the ionic transport is governed by both chargeand size-selective mechanisms, as demonstrated by concentration-dependent conductance and ion rejection studies under drift and diffusion conditions [5]. We applied selected functionalization strategies to modulate the surface charge and spacing of the nanochannels. Zeta potential analysis confirmed successful surface tuning, suggesting possible pathways to influence ion selectivity beyond steric exclusion.

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