2D Nanoconfined Fluidic Channels and its Application

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Abstract

Nanoconfined electrical double layers have attracted significant attention due to their potential benefits in environmental and biomedical applications by facilitating ion-selective mass transport. [1] Our research explores the ion selectivity of nanoconfined fluidic channels under chemical potentials using interplanar nanochannels created by stacking two-dimensional (2D) nanosheets such as metal carbide and nitride (MXene) or graphene oxides in an ordered manner. [2-5] The overlapped electrical double layers between neighbouring 2D sheets allow for selective ion transport while maintaining a consistent interlayer distance. Our investigations demonstrate the potential of subnanometer-scale channels derived from a lamellar structure for ion-exchange membranes, salinity-gradient energy harvesting, and sensory transduction. Specifically, MXene-based membranes have exceptional salinity-gradient energy harvesting capabilities, achieving an output power density of up to 54 $W{\cdot}m^{-2}$ by regulating surface charges and ionic mobility. [3] We have also proposed a new type of lamellar membrane constructed by holey 2D nanosheets, which exhibits simultaneous enhancement in permeability and ion selectivity beyond their inherent trade-off. [4] The perforated nanopores on the plane lower the energy barrier for cation passage, thereby boosting preferential ion diffusion across the membrane. Additionally, we have demonstrated how MXene-based ion conducting channels can be utilized for a photothermal sensory transduction system, which converts light-driven thermochemical potential to active ion transport.[5]

References

[1] Hong, S. et al., ACS Mater. Lett. (2023) 5, 341-356
[2] Hong, S. et al., Nano Lett. (2017) 17, 728-732
[3] Hong, S. et al., ACS Nano (2019) 13, 8917-8925
[4] Hong, S. et al., ACS Nano (2022)16, 792-800
[5] Hong, S. et al., ACS Nano (2020)14, 9042-9049

Figures

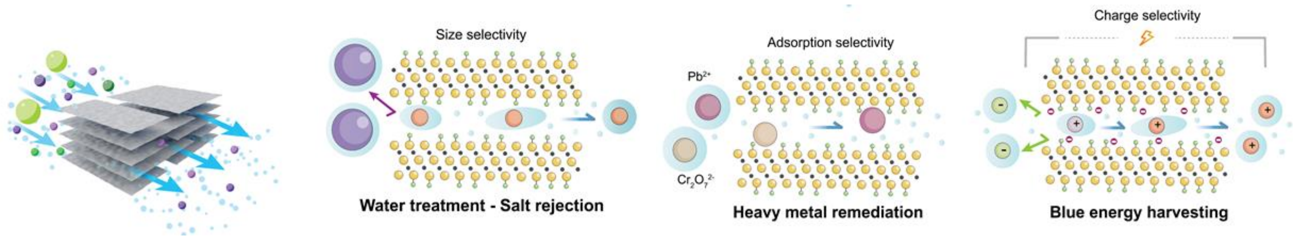

Figure 1: 2D Nanoconfined fluidic channels and its applications for selective separation [1]