Hydrocarbon Contamination in Angström-scale Channels

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Abstract
Nanopores and nanochannels made of 2D materials play an important role both in fundamental studies of confined molecular transport [1] and mimicking biological channels. Nonspecific molecular adsorption like airborne contamination occurs on most surfaces including 2D materials and alters their properties. While the surface contamination is well studied, the effect of contamination in a confined system such as nanochannels/pores leading to their clogging is still lacking. We report a systematic investigation of hydrocarbon adsorption in the angstrom (Å) slit channels of varied heights where hexane is chosen to mimic the hydrocarbon contamination. A dynamic transition of the clogging and revival process is shown in sub-2 nm thin channels and long-term storage and stability of our Å-channels is demonstrated [2]. This study highlights the importance of the nanochannels' stability and demonstrates self-cleansing nature of sub-2 nm thin channels enabling a robust platform for molecular transport and separation studies. We provide a method to assess the cleanliness of the nanoporous membranes, vital for the practical applications of nanofluidics in various fields like molecular sensing, separation and power generation.

References

[1] L. Bocquet, Nat. Mater., 2020, 19, 254–256.
[2] R Sajja, Y You et al., Nanoscale, 2021, 13, 9553-9560.

Figures

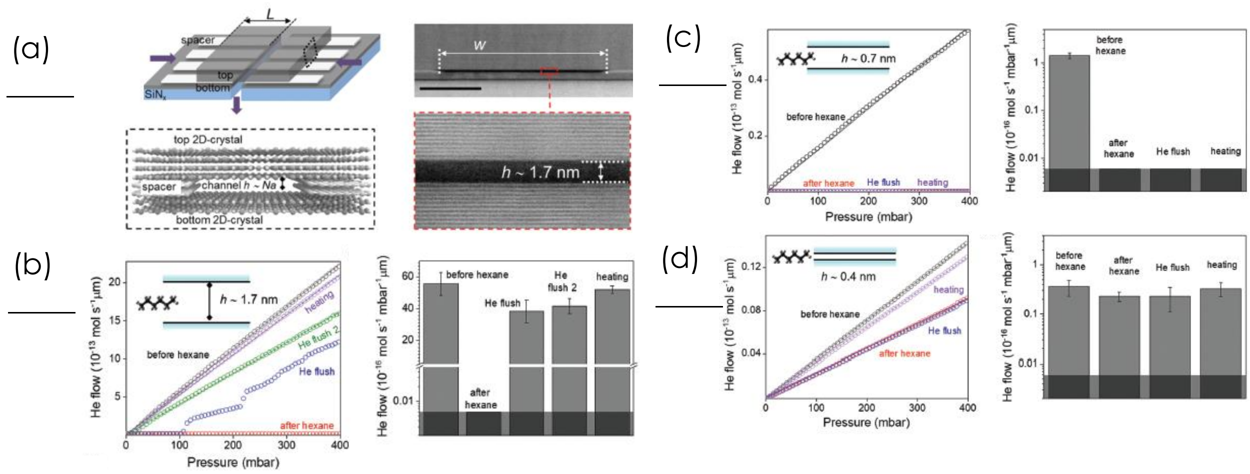

Figure 1: (a) Schematic of a device showing a silicon nitride (SiNx) membrane with angstrom slit channels on top and their length L is noted. Purple arrows indicate the flow directions of the gas through the device. The below inset shows a schematic representation of a channel displaying the top, bottom and spacer layers, with channel height h labelled. N is the number of layers of graphene spacer, and a is the interlayer distance in graphite. Cross-sectional TEM dark field image of a 5-layer channel, with a magnified view shown below. Horizontal bright lines represent individual layers of graphite, and the dark space is the Å-channel. Scale bar of the top image, 50 nm. (b, c, d) Comparison of helium leak rate before and after exposure to hexane through various graphite Å-channel devices with heights, (b h ~ 1.7 nm, (c) h ~ 0.7 nm, and (d) h ~ 0.4 nm. The insets show the schematics depicting the relative size of the hexane molecule to the channel in each case. The bar graphs in (b), (c), and (d) represent normalized He flow per unit pressure. Grey shaded area indicates the limit of detection. All the graphs represent the flows normalized per single channel and per μm length of the channel. Error bars are from two measurements on the same device, and where there was only measurement (e.g., He flush), it represents uncertainty in the best fit to the measured data.