Tuning salt rejection and water permeation in support based novel single layer nanoporous graphene membranes for water desalination

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Abstract

Among promising novel membrane materials for enhancing desalination performance, graphene has been realized as a high potential candidate due to its unique properties [1]. However, large area graphene membrane, dominantly available through wet transfer and assistance of polymers, has inevitable features like defects, holes and cracks that could limit the realistic prospects for industrial-scale production of desalination membranes [2]. Here, using hole arrays in silicon as a secondary and a fine mesh grid as an initial support, we experimentally designed a mobile nanoporous graphene membrane with tunable salt rejection and water permeation by favorobaly limiting the undesired effects of defects and holes on the graphene [3]. A model is also presented to support the experiments and give more insight into the possible superpositions (i.e. motifs) that occur by movements of graphene/grid over silicon hole arrays. Using the moveable assembly of graphene/grid/hole arrays and the consequent motifs, a range of high permeation ($4.34e^{7}$-$5.90e^{7}$ $Lm^{-2}h^{-1}bar^{-1}$) and NaCl rejection (58%-100%) values were obtained. The moveable assembly of graphene/grid on fixed silicon hole arrays opens possibilities of fabrication of scalable atomically thin membranes for water desalination and can be applied for many other separation purposes specifically ion selectivity and filteration of multivalent ions or larger molecules [4]. Si with different array of holes was fabricated here at a research level, however, for realistic desalination plants, it may not be an ideal support but the idea of a fixed secondary porous support can be envisaged with candidates such as thin nickel foil (≤ 50 µm).

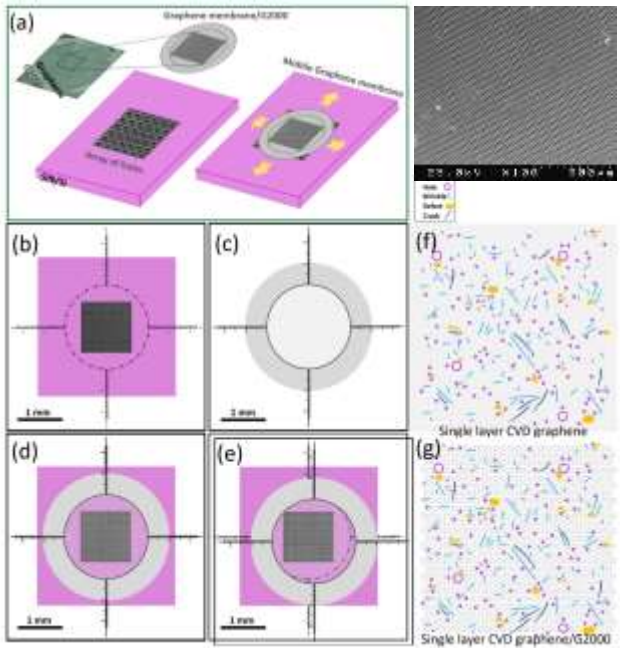

Figure 1: (a-e) Schematics of overlaying and movement of (G/G2000) on an array of holes on SiN/Si substrate, (f) A model of randomly distributed features, i.e., holes, wrinkles, defects and cracks, from wet transfer of single layer CVD graphene. (g) The transferred single layer graphene in (f) on G2000.

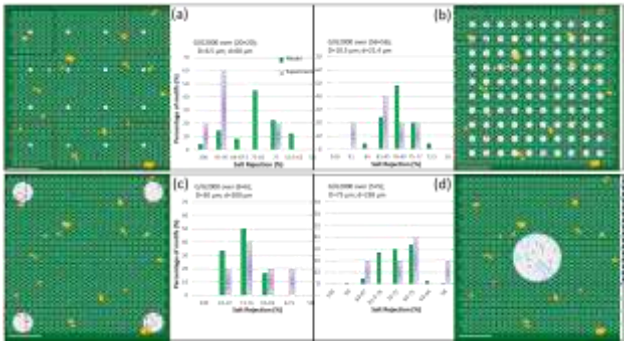

Figure 2: (a-d) Models of G/G2000 overlaid on SiN/Si hole arrays and the corresponding experimental and theoretical salt rejection ranges obtained.

References

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