Water desalination with atomically precise nanoporous graphene membranes

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Abstract

Filtration is a critical process across various industries, including water treatment, chemical processing, and biomedical applications. The efficiency of filtration systems largely depends on the materials employed. Recent advancements have highlighted atomically precise nanoporous graphene (NPG), synthesized via a bottom-up scientific method[1], as a promising candidate due to its exceptional mechanical strength, chemical stability, and well-defined pore architecture. Unlike pristine graphene, which is impermeable to all molecules, this bottom-up synthesized NPG intrinsically contains uniformly distributed sub-nanometer pores that enable selective molecular transport, making it highly suitable for desalination applications. In this study, we report the development and evaluation of a NPG-based membrane system for efficient desalination of saline water. The membranes were fabricated through on-surface synthesis, a bottom-up "Lego chemistry" approach in which molecular building blocks self-assemble to form atomically precise nanoporous graphene with uniformly distributed pores. The size, density, morphology, and chemical composition of these pores are controlled through the rational design of molecular precursors. The structural integrity of the resulting nanoporous graphene and the formation of the pore network were characterized using scanning tunneling microscopy (STM) and Raman spectroscopy. The synthesized nanoporous graphene was subsequently transferred onto silicon nitride (SiN) support membranes with a pore size of 300 nm to fabricate the final filtration membrane. The resulting system will be used to evaluate molecular transport across the nanoporous graphene layer using saline water solutions as model systems. These experiments aim to assess the membrane's salt rejection behavior, permeability, and structural stability under filtration conditions. This study provides a framework for exploring the use of bottom-up synthesized nanoporous graphene as a model platform for next-generation filtration membranes with atomically defined pore architectures.

References

[1] Moreno, César, Manuel Vilas-Varela, Bernhard Kretz, Aran Garcia-Lekue, Marius V. Costache, Markos Paradinas, Mirko Panighel et al. Science 360.6385 (2018): 199-203