Investigation of the Effectiveness of Graphene for Water Purification

COLLEGE ENRICHMENT PROGRAM

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First Year Research Experience

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Introduction

- The goal of the experiment is to use IR spectroscopy to determine salt and PAH species after filtration with graphene and THF.
- Understanding the interactions of graphene and THF with NaCl and PAHs will allow great insight into new techniques of water filtration that is more efficient and cost effective.

Water Scarcity

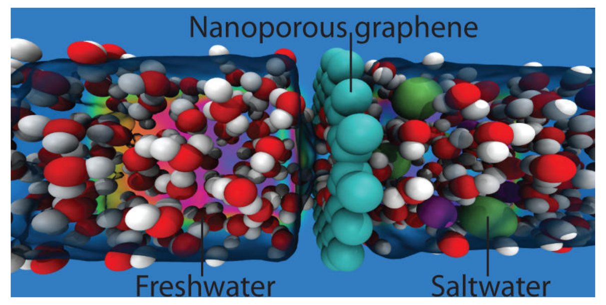
Only 3% of the Earth's seemingly bountiful water is suitable to be used by humans. Of this 3%, 7.7 billion humans currently consume 4000 km3 annually per person, a rate well in excess of the annual 39% precipitation that is not evaporated vapor transpired by forests and other natural landscapes replenishing quantity of 48400 km3.

Oil Spills

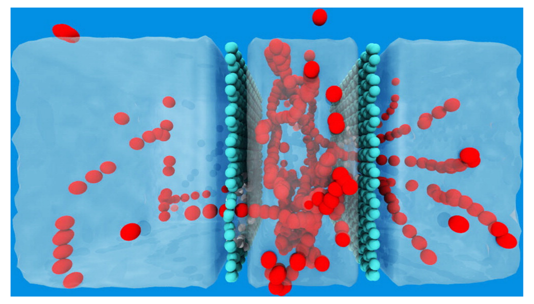
The use, transportation, extraction and natural seepage of oil endanger aquatic and human lives when carcinogenic polycyclic aromatic hydrocarbons settle within the ocean long after contamination. With prior emphasis of removing PAHs from the ambient air, the exploration of filtration in water as an alternative to eliminating these organic compounds is essential.

Techniques of Water Desalination

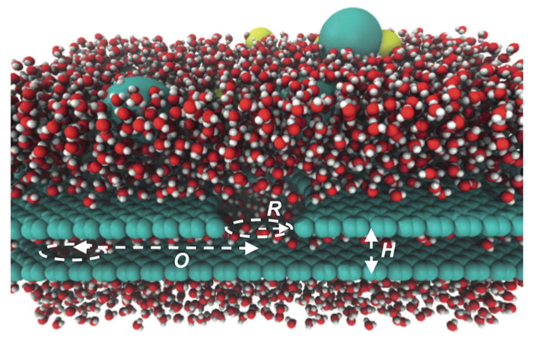
- Thermal distillation desalination heats saltwater until the point of evaporation then forces the fresh water to condense. This method produces around 85% of the world's desalinated water.
- Reverse osmosis desalination forces water drawn from intake pipes below the seafloor through membrane sheets at 600 to 1000 psi which separates the salt from the fresh water.
- Nanoporous graphene platelet desalination is similar to reverse osmosis; however the membrane is replaced with a sheet of graphene layered with epoxy resin which is held in place by the pressure of the water.



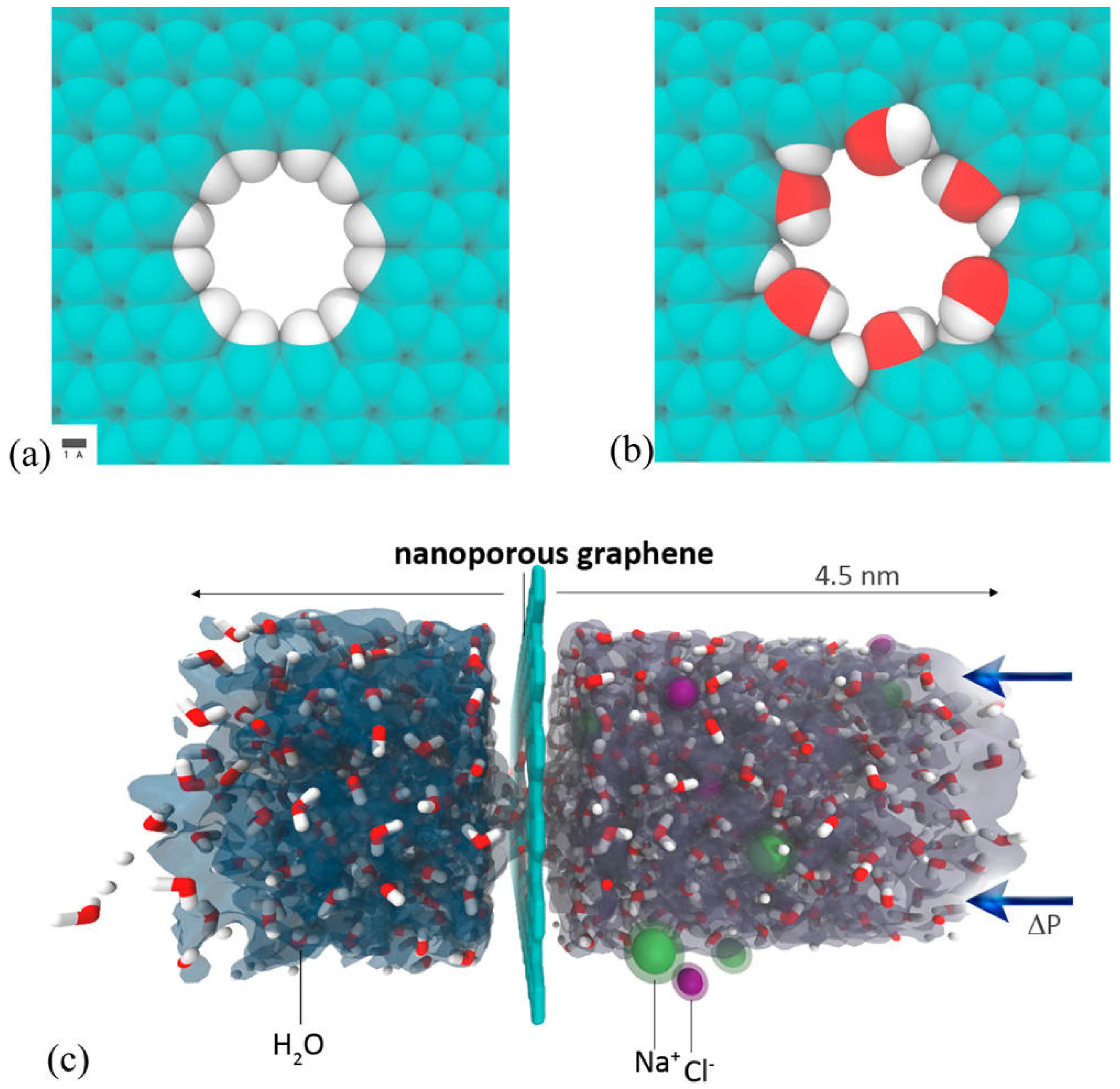
Nanometer-scale pores in single-layer freestanding graphene



Multilayer nanoporous graphene membranes



Key parameters for multilayer NPG filtration: P - feed pressure, O - offset between nanopores (upstream and downstream layers), H - spacing between graphene layers



(a) Hydrogenated graphene pores (b) hydroxylated graphene (c) side view of computational system

References

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Methodology and Techniques of Analysis

- External standards calibration curve of sodium chloride (NaCl), naphthalene (C10H8), pyrene (C16H10) and perylene (C20H12)
- Infrared spectroscopy to determine the residual composition of solution
- Number of filter layers varied to determine the purification capacity per layer

Water Desalination across Nanoporous Graphene

- Cohen Tanugi -

The NaCl molecules that are filtered depends on pore size. The number of graphene layers does not determine sufficient filtration. Applied pressure and chemical functionalization were more influential. The hydrophilic qualities of hydroxyl groups in solution rather than bonded to the graphene increased product.

Multilayer Nanoporous Graphene Membranes for Water Desalination

- Cohen Tanugi -

The performance of multilayer membranes was essentially equal to single layer membrane after pore alignment and layer separation were manipulated. Ultimately, it is more economical to produce multilayer membranes rather than single layer product.

We expect that orienting these filters in a spiral, to take advantage of each graphene ring's surrounding electron clouds, will limit the size of debris capable of passing through the filter.

The Potential Graphene has in Water Purification

- Desalination is a promising solution to the restricted quantity of freshwater and the ability to attract and remove dangerous PAHs from ocean water could save aquatic life around the world.
- Synthesizing a device that reduces toxicity and salinity attributes in seawater could revolutionize the water filtration industry.
- The durability and nanoporous nature of graphene may hold promise for desalination and purification with a single filter.