ICMES-2024 / 7th International Conference on Materials & Environmental Science, June 6-9, 2024, Saïdia – Morocco

Graphene-based sorbents and membranes for water nanofiltration

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Abstract

In this talk, we review our research on the development of next-generation nanofiltration membranes [1] and sorbents [2] for water purification based on few-layer graphene.

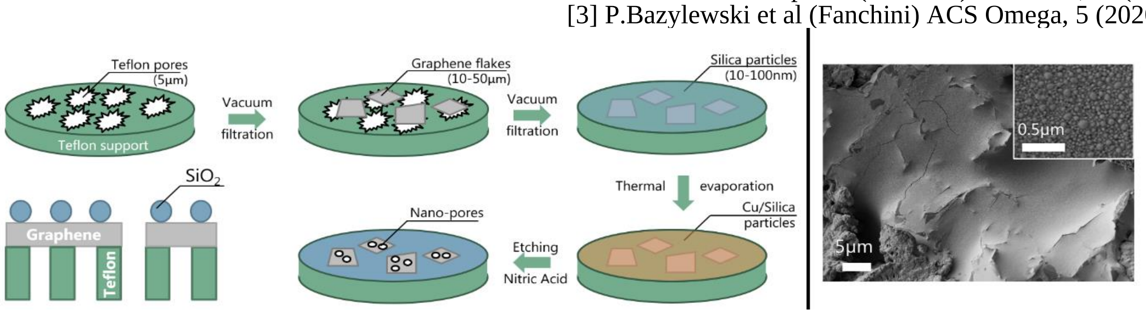
As far as nanofiltration is concerned, we present a fabrication process in which sonochemically exfoliated few-layer graphene flakes are utilized to fabricate a continuous membrane, in which leaks between juxtaposed flakes are sealed by colloidal silica, in a treatment that precedes opening of the pores through the flakes. Copper nanoparticles are subsequently deposited on the membrane and their removal by nitric acid etching ensures the opening of nanopores of the diameter of the removed nanoparticles (i.e., 5-50 nm) without compromising the membrane continuity and making them leak-free. Our nanofiltration system thus combines the advantages of graphene bored membranes (suitable to differential pressures as low as ~10 KPa) with those of graphene oxide (thus offering large areas and scalability). We focus on water purification from metal ions and demonstrate that our membranes offer superior retention of common ions, including Mn(II) and Fe(II).

As far as sorbents are concerned, we report how multilayer graphene exfoliated from graphite at sufficiently low point-defect density, and intercalated by poly(ethylene glycol)-block-poly(propylene glycol)-block-poly (ethylene glycol) (PEG-PPG-PEG) block copolymer of appropriate chain length, functions as an integrated sorbent and detector for cadmium dications in water. Cd(II) remains trapped within the graphene interlayers, thus also changing the device's electrical resistivity. This system can be incorporated into gap-cell chemiresistors assembled onto microporous supports, and the resulting devices are nanoporous and can be inserted in-line in water filtration systems.[2]

Collectively, our work demonstrates the outstanding capabilities of graphene-based materials in water filtration. Solutions making use of 2D materials other than graphene [3] will also be presented, and their pros and cons in terms of performance will be discussed with reference to their graphene-based counterparts.

References

[1] J.Park et al (Fanchini) Nanoscale, 8 (2016) 9563
[2] S.Van Middelkoop et al (Fanchini) FlatChem, 17 (2019) 100118
[3] P.Bazylewski et al (Fanchini) ACS Omega, 5 (2020) 643.



Biography

Dr. Giovanni Fanchini is Full Professor at Western University, Canada, where he has held the Canada Research Chair in Carbon-based nanomaterials and nano-optoelectronics. An experimental condensed matter physicist, he has been working for more than a decade on different types of carbon materials, including carbon nitrides, boron carbide, carbon nanotubes, blends of fullerenes and photoactive polymers, and graphene thin films. Before joining Western, he has worked as a solar cell scientist at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia, towards the development of flexible and printable photovoltaics from small polyaromatic molecules and carbon nanotubes, and towards the investigation of their nano-optical photophysics. For his work, he has received an Ontario Early Researcher Award and a Petro-Canada Young Innovator Award. His h-index is 33 on Scopus.

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