Upcycling and recycling of commercial water filters using graphene derivatives

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Commercial water filters use often hollow fibers (HF) made of polymers, typically polyethersulfone (PES), for microfiltration. Each filter typically includes hundreds of sub-millimeter diameter fibers (e.g. 300 μm) with nanometric pores that define the module cut-off (ca. 150 nm). The feed solution flows inside the fiber, and purified water exits through the lateral pores.
Graphene oxide (GO) has gained attention as a leading material for creating advanced membranes for water filtration and desalinization. These can be made by filtering GO nanosheets in water on porous substrates, resulting in organized membranes with nanochannels. However, GO-based membranes have been limited to lab use due to difficulties in producing larger, uniform filters necessary for real-world applications like water purification.
In past years we demonstrated the possibility to use together commercial filters and nano-materials, coating PES fibers with GO to obtain a composite bilayer membrane.[1-3] This membrane retains the microfiltration properties of PES-HF while also enabling the adsorption of small ions and molecules. This year, we used the same approach to recycle scraps deriving from industrial production of commercial filters.[4] Hollow fibers were cut in small granular particles and upcycled as sorbents of several classes of emerging and standard water contaminants, such as drugs, heavy metal ions, and a mixture of per- and poly-fluoroalkyl substances (PFASs). The millimetric sized granules outperformed granular activated carbon (GAC), the industrial sorbent benchmark, in the adsorption of lead, diclofenac, and PFOA from tap water.

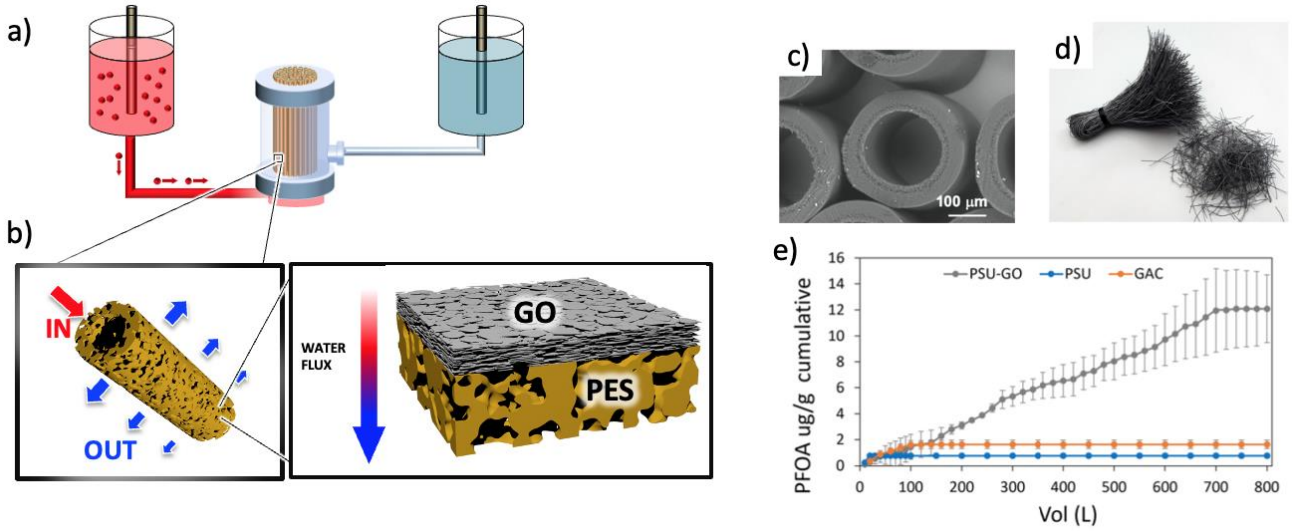

Figure 1: a) cartoon showing hollow fiber filtration. c,d) SEM and photo of typical hollow fibers. e) Cumulative performance of removing perfluorooctanoic acid pollution from water upon filtration of >800 L, as compared to Benchmark.

1.Lancellotti, L., et al., *Selective ion transport in large-area graphene oxide membrane filters driven by the ionic radius and electrostatic interactions.* NANOSCALE, 2024. **16**(14): p. 7123-7133.
2.Moro, G., et al., *Amino acid modified graphene oxide for the simultaneous capture and electrochemical detection of glyphosate.* MATERIALS TODAY CHEMISTRY, 2024. **36**.
3.Tunioli, F., et al., *Chemical Tailoring of β-Cyclodextrin-Graphene Oxide for Enhanced Per- and Polyfluoroalkyl Substances (PFAS) Adsorption from Drinking Water.* CHEMISTRY-A EUROPEAN JOURNAL, 2023. **29**(60).
4.Khaliha, S., et al., *Upcycling of plastic membrane industrial scraps and reuse as sorbent for emerging contaminants in water.* ENVIRONMENTAL SCIENCE-WATER RESEARCH & TECHNOLOGY, 2024. **10**(5).