High-throughput membrane adsorbers for selective PFAS removal

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Motivation

Per- and polyfluoroalkyl substances (PFAS), often referred to as “forever chemicals” due to their extreme persistence in the environment, pose potential health risks to humans and animals. Recent research reported that 69% of global groundwater samples exceed drinking water safety standards without a known source of contamination[1]. Providing safe drinking and irrigation water therefore requires effective removal of PFAS. Adsorption (e.g. activated carbon or ion exchange resins) in packed beds is a common PFAS treatment. However, packed beds are often limited by slow diffusive mass transfer, flow channelling and high pressure drops[2].

This research presents membrane adsorbers designed to overcome existing limitations through direct convective flow, allowing higher throughput operation. Direct mass transfer reduces the time needed for PFAS molecules to reach active sites, thereby increasing adsorptive efficiency. In polymer membrane adsorbers, adsorbent particles are embedded within the membrane or the membrane itself serves as the adsorptive material with specific functional groups [3]. These membranes are arranged in a column forming hierarchical structures to capture PFAS based components (Figure 1).

Technological challenges

Developing membrane adsorbers presents several challenges:

- Current membrane adsorbers have low surface area-to-volume ratio and large pore size distribution.
- Replacement of commonly used petroleum-derived aprotic toxic solvents for green alternatives.
- Integrating developed membranes into modules to enable scale-up to industrial applications.

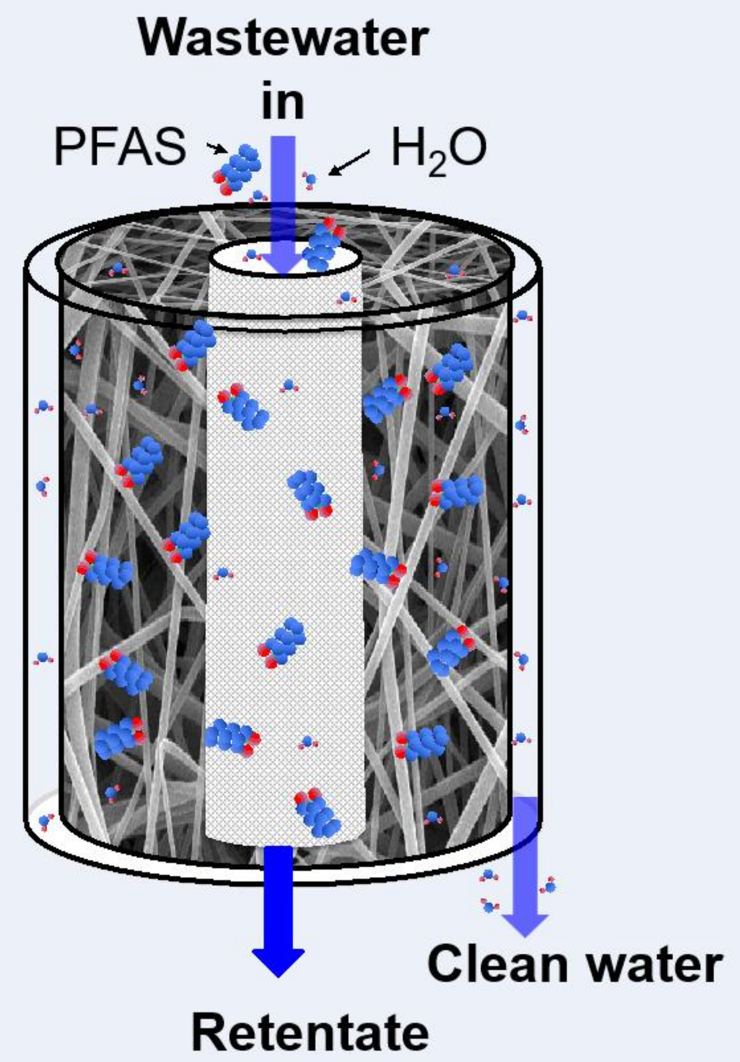

Fig 1. Schematic of radial membrane adsorber module for selective capture of PFAS. The flat-sheet electrospun mat is coiled around a porous tube.

Research goals

The main goal of this research is to develop high-throughput membrane adsorbers to capture PFAS compounds from aqueous streams. The objectives are as follows:

1. Develop membrane adsorbers via electrospinning (Figure 2) under varying process parameters and functionalisation.
2. Explore green and sustainable methods for developing membrane adsorbers.
3. Characterize the morphology and/or functionality of prepared membranes and evaluate their PFAS separation performance.
4. Design and assemble membrane adsorbers into axial or radial modules.

References

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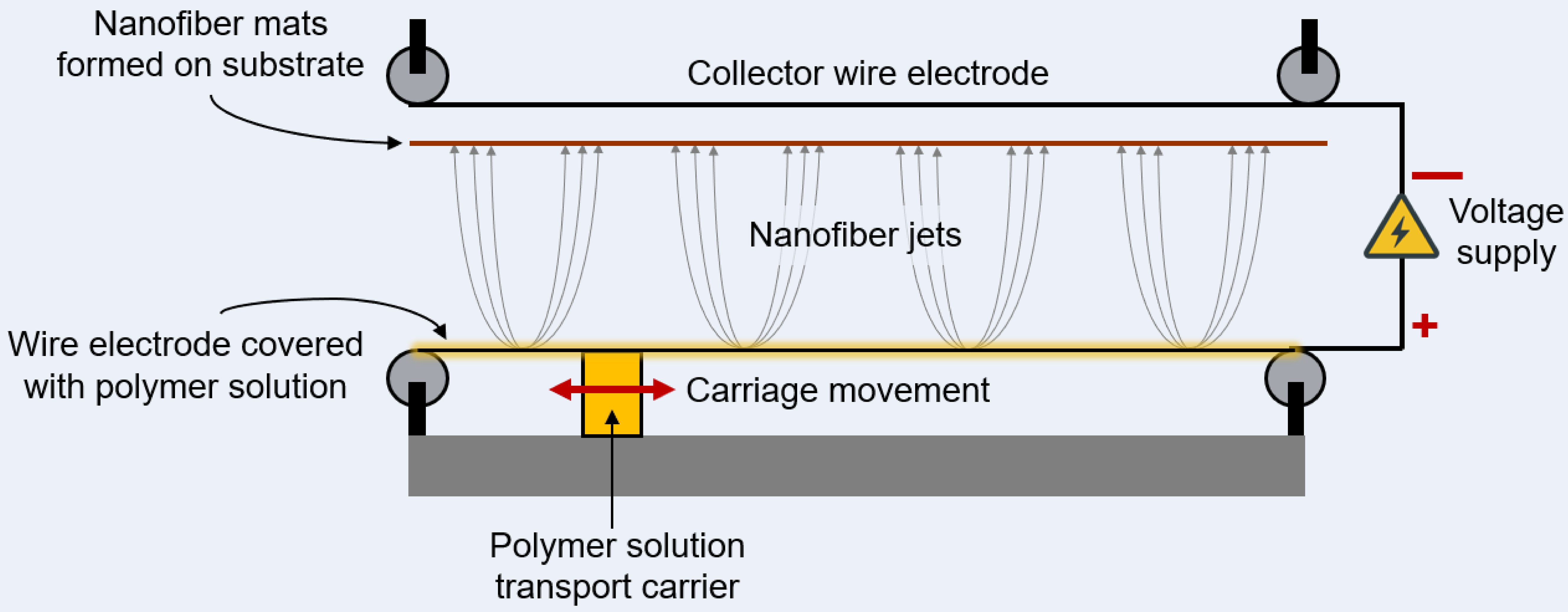

Fig 2. Schematic of wire electrospinning setup for nanofibrous mat development. High voltage overcomes the surface tension of the polymer solution on the wire electrode, forming nanofiber jets. A carrier holding the polymer solution moves to coat the wire through an interchangeable aperture.

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