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Pillar[5]arene-based sorbents for efficient and scalable aqueous PFAS removal

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Motivation

PFAS (per- and polyfluoroalkyl substances) are a global problem for water quality and safety, considering the persistent risk PFAS pose to human health. Therefore, authorities are decreasing the acceptable PFAS levels in the environment and drinking water, pushing the need for an effective PFAS-removing technology. Granular activated carbon adsorption is the standard method applied in water treatment to remove organic pollutants, but is inefficient for removing PFAS. Consequently, alternatives like anion-exchange resins and clays are being explored, giving better results. However, small perfluoroalkyl acids, like perfluorobutanoic acid, still cause early failure of the adsorbent[1]. Recently, certain cationic pillar[5]arene derivatives (P5) (**Figure 1**) have proven to be promising adsorbents that offer a new approach for removal. P5 immobilized on resin beads has unique affinity, selectivity and capacity for the capture of perfluoro alkyl acids/sulfonic acids such as PFOA and PFOS in continuous-flow systems[2]. Some interactions between P5 and PFAS that might play a role are shown in **Figure 2**.

Technological challenge

The promising results of P5-resin encourage the development of P5-based adsorbents or other methods into a real-world applicable system. Broadening P5 application first requires research into appropriate materials to immobilize P5. The functionalized material as a whole must be stable to increase its potential for regeneration. Thereafter, suitable P5-functionalized materials must be tested on a small scale to elucidate the kinetics of the P5-PFAS binding mechanism and robustness against salt and fouling by natural organic matter. Regeneration is important to optimize, because reusability of the material is paramount for cost-efficiency. Lastly, a P5-based method, selected according to performance in small-scale tests, will have to be scaled up. At this step, it is expected that pre-treatment and operational parameters are the major focus. In the case of a packed-bed adsorbent, channeling and pressure drop are important to address[3].

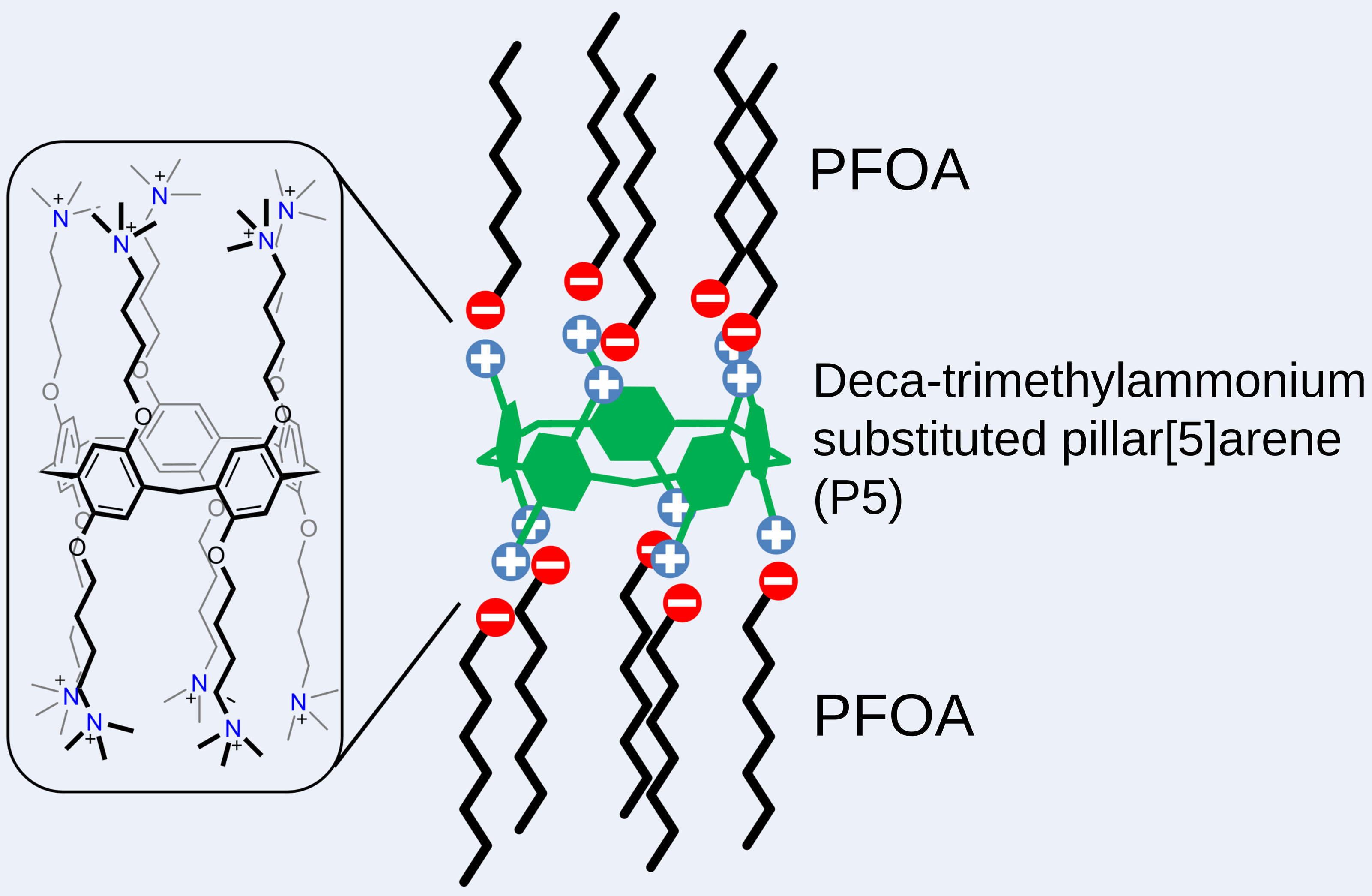

Fig 1. P5 forming a complex with 10 PFOA molecules.

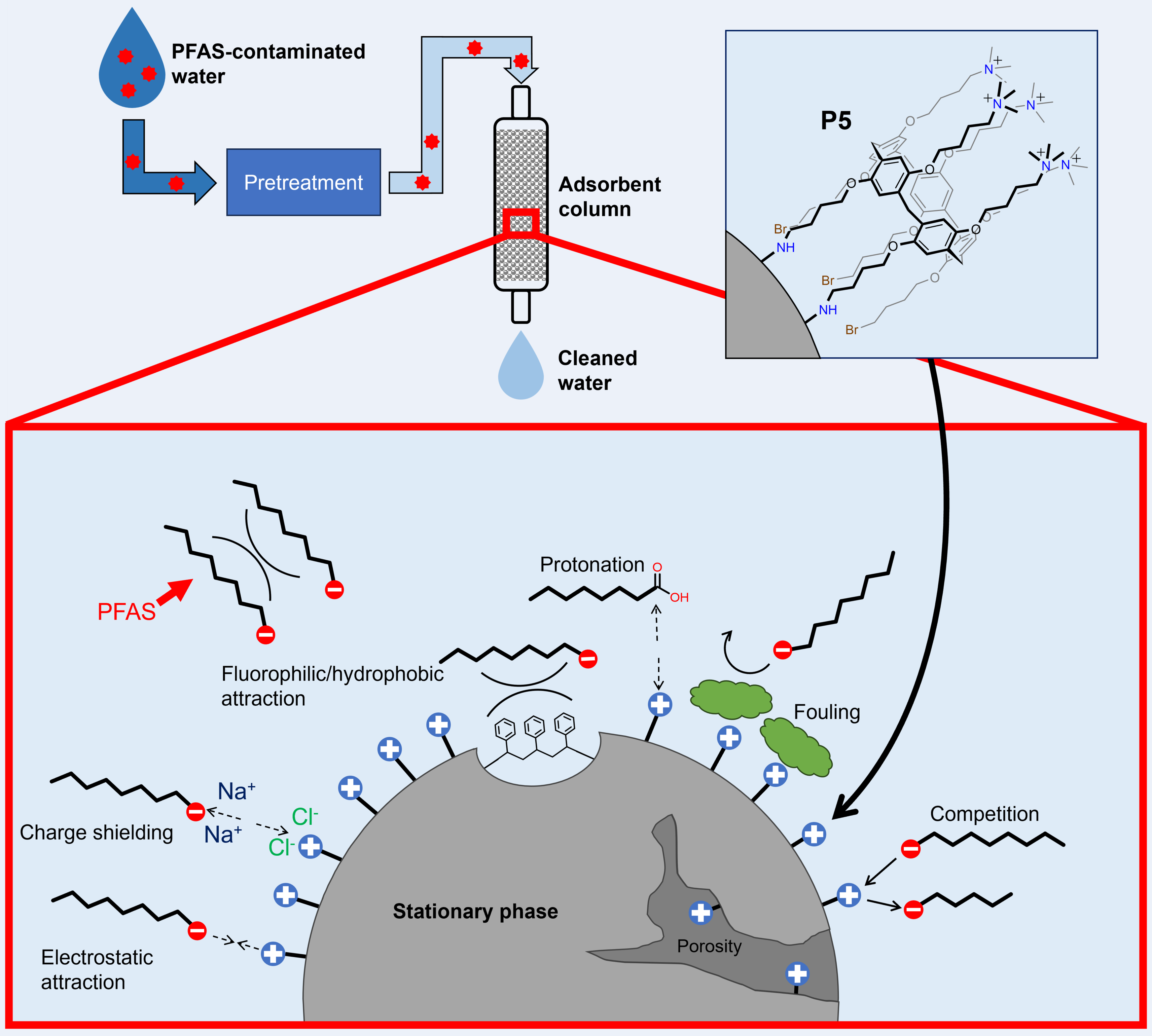

Fig 2. Different kind of interactions and properties that may be at play in a P5-modified resin packed-bed column tested in prior research [2].

Research goals

This project aims to deepen the understanding of P5-based adsorbents in PFAS removal and enhance their performance through investigation of:

1) a range of materials and (adsorption) methods, such as packed-bed resins and other adsorbents, for their compatibility as a base for immobilization of P5 in a flowing system;

2) the efficiency of such regenerable P5-based systems for PFAS capture on a small scale;

3) the requirements for scaling up the best-performing P5-based system to efficiently reduce PFAS levels in water to acceptable levels.

References

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