NOVEL SORBENTS FOR PFAS WATER REMEDIATION

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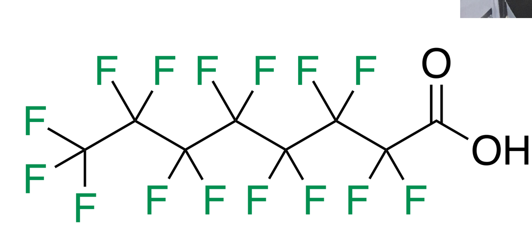
BACKGROUND

Per- and polyfluorinated alkyl substances (PFAS) are a broad class of synthetic organic compounds, possessing desirable chemical properties that enable a broad range of applications and contribute to their environmental persistence in groundwater, surface water, and finished drinking water systems. Water contamination is the most common pathway for human exposure, giving way to adverse health effects such as altered liver function, elevated cholesterol, and some cancers.[1] Mini-rapid small-scale column tests (RSSCT), loaded with ionic fluorogel (IF) resin, demonstrated an effective approach for PFAS removal from water systems via selective fluorophilic sorption and targeted ion exchange mechanisms.

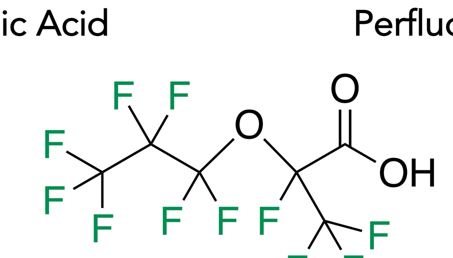
MOTIVATION

PFAS, the "forever chemicals," are heavily integrated into the daily lives of consumers. These chemicals are used as surfactants, possessing hydrophobic and oleophobic properties, making them useful in water/stain resistant products such as aqueous film forming foams, water and stain resistant fabrics, and more.[2] Because of widespread application, PFAS are increasingly disposed and detected in environmental compartments, including clean water systems. PFAS possess chemically stable carbon-fluorine bonds, consequently making them resistant to biodegradation and permitting their long-term ecological presence.[3] Current EPA regulations have phased out and set water health advisories of 70 parts per trillion for legacy, long-chain PFAS such as perfluorooctanoic acid (PFOA) and perfluoro-1-ocanesulfoic acid (PFOS).[2] However, these regulatory efforts have influenced manufacturers to create alternative, emerging, short-chain PFAS such as GenX to replace legacy compounds. These shorter chain compounds are harder to remove from water, creating a need for technology that better addresses the changing profile of PFAS.[3]



Perfluorooctanoic Acid (PFOA)

Perfluorohexanoic Acid (PFHxA)



GenX (PFOH-DA)

IONIC FLUOROGEL SORPTION & MINI-RSSCT TREATMENT

SYNERGISTIC MECHANISM FOR SORPTION

Fluorous–Fluorous Interaction + Ion Exchange

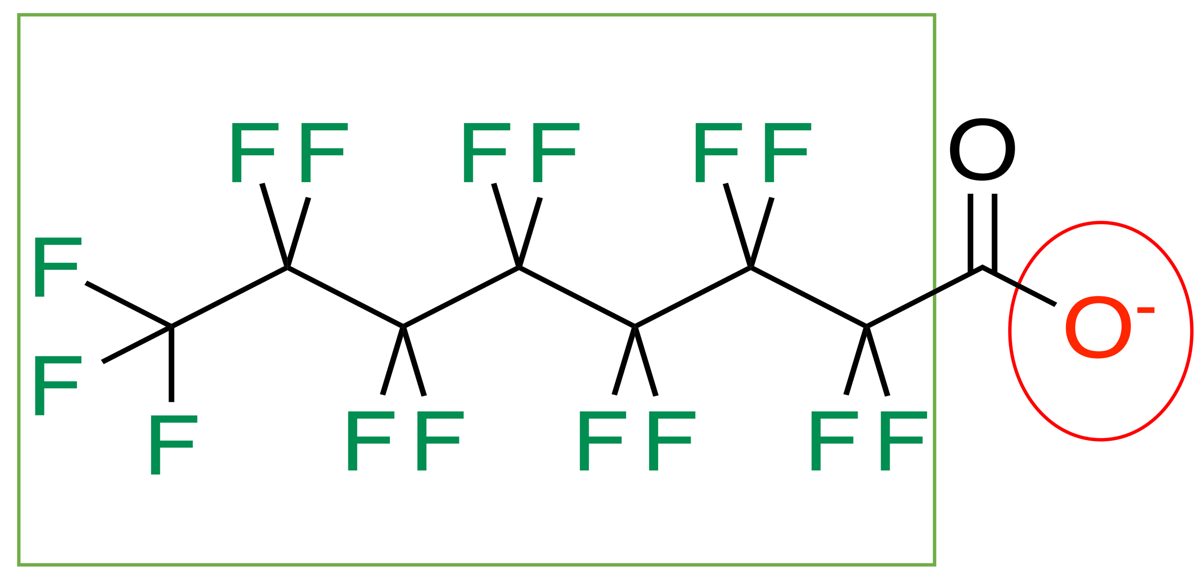


Figure 1. PFOA is a known legacy PFAS which exists as a negatively charged, anion in waters at environmentally relevant pH values. The negative charge that most PFAS carry in water, typically with a pH from 6-8, is because these compounds have a very low pKa.

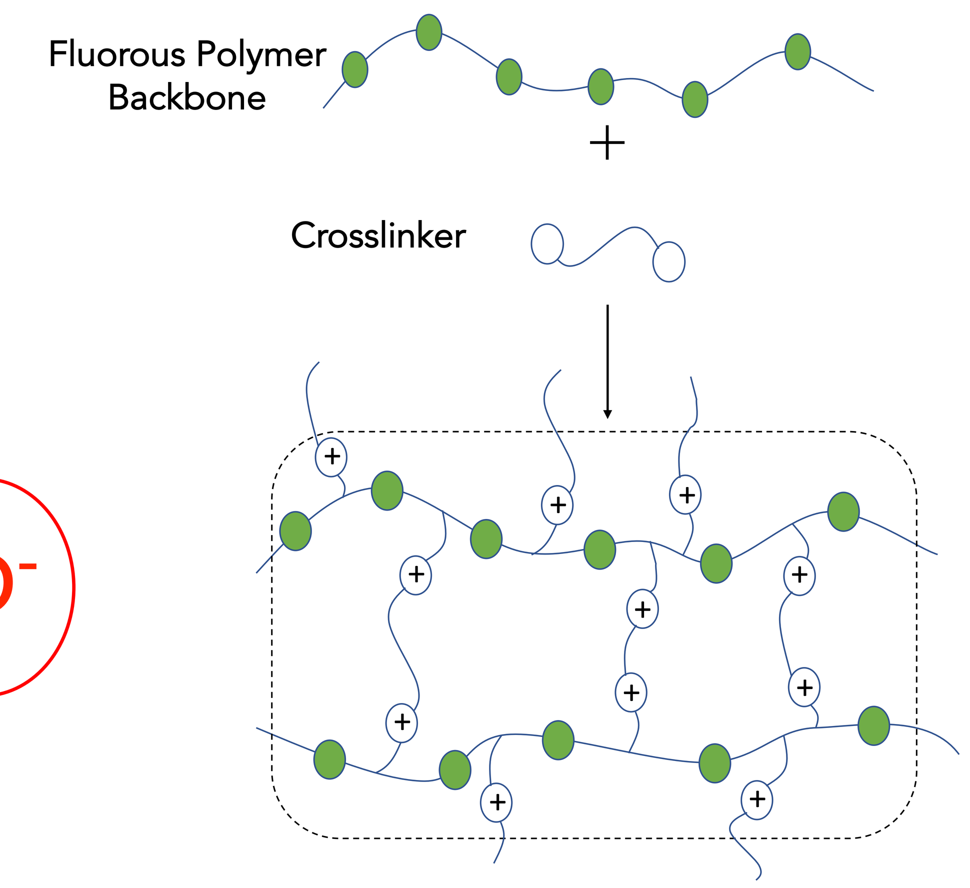
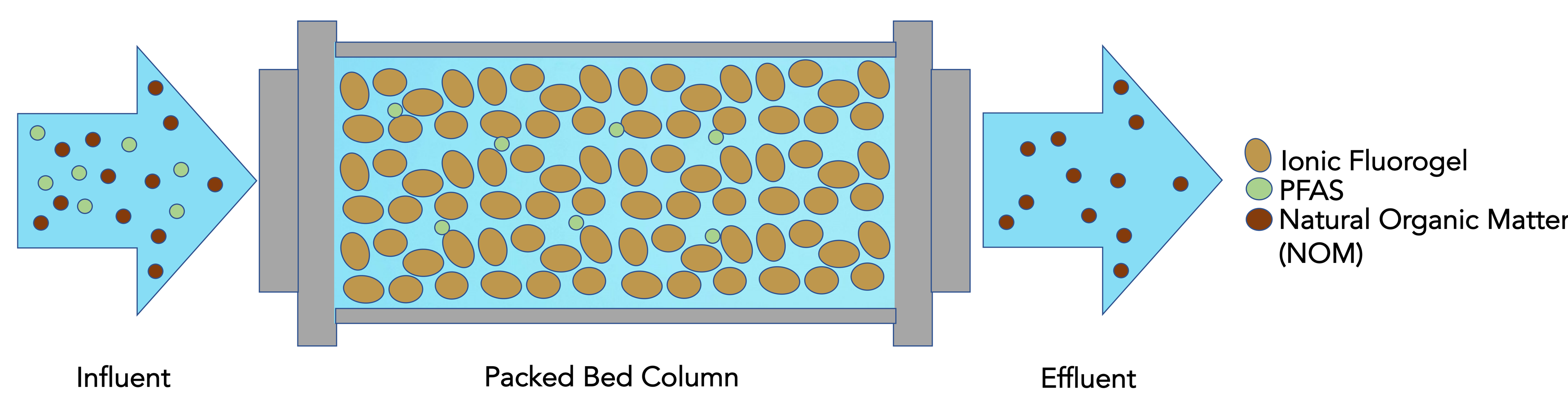


Figure 2. The polymerization and quaternization of ionic fluorogels utilizes a fluorous polymer backbone which is then cross-linked to create a positively charged resin, permitting targeted ion exchange for PFAS sorption.

SELECTIVE REMOVAL THROUGH MINI-RSSCTS



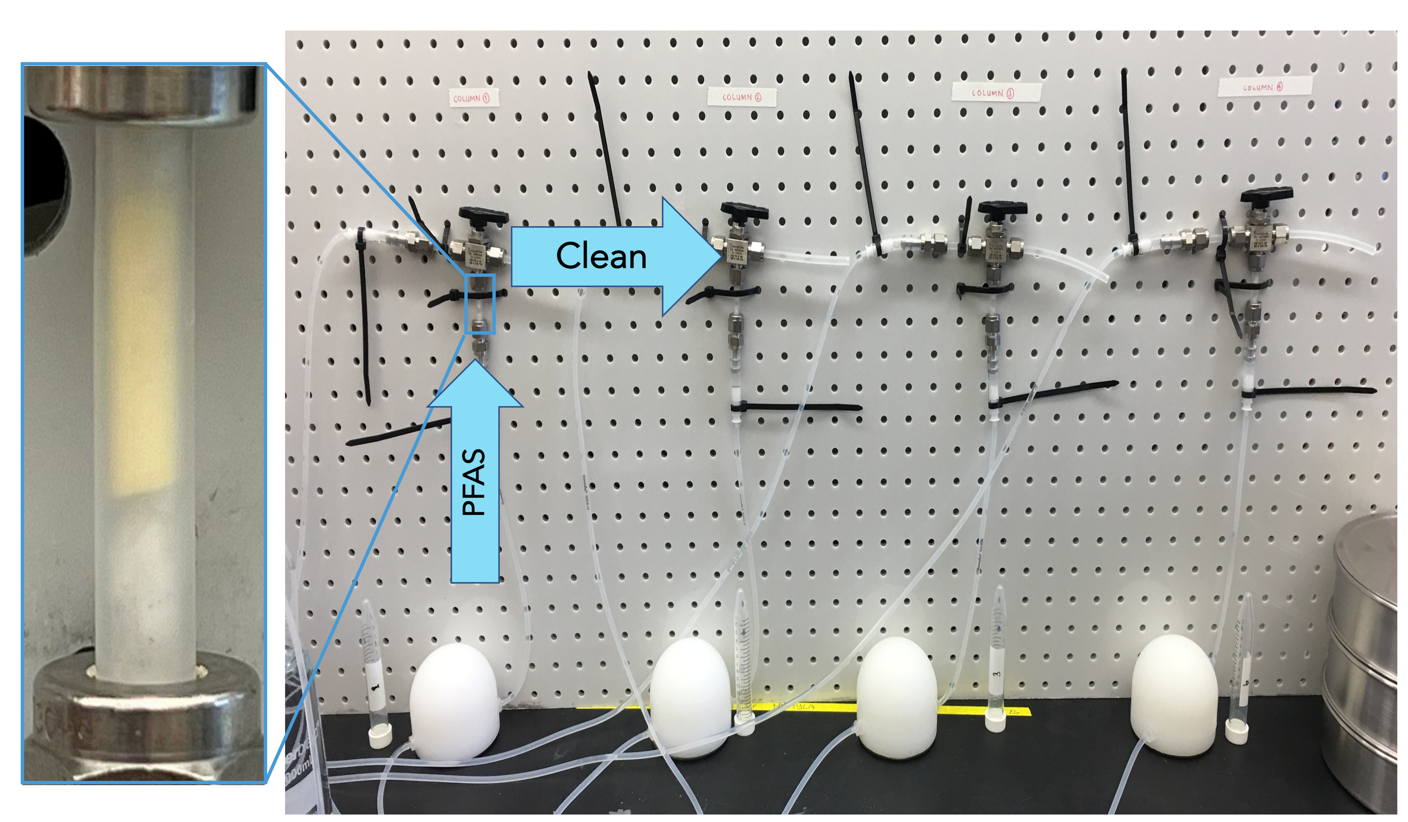


Figure 3. Mini-RSSCTs are loaded with IF resin in packed bed columns. Influent flows through the mini-RSSCTs and IF resin selectively adsorbs PFAS from water samples. Despite concentrations of PFAS being lower than NOM, this selective removal process targets PFAS over negatively charged NOM, resulting in filtered effluent that is free from PFAS toxicity.

RESULTS

Local water treatment plants have provided settled conventional water samples for sorption testing. Settled water is collected from the point in the treatment process before filtration and after sedimentation. Utilizing settled water in mini-RSSCTs models water matrixes in treatment plants, where PFAS remediation technologies, like ionic fluorogels, would be implemented.[4]

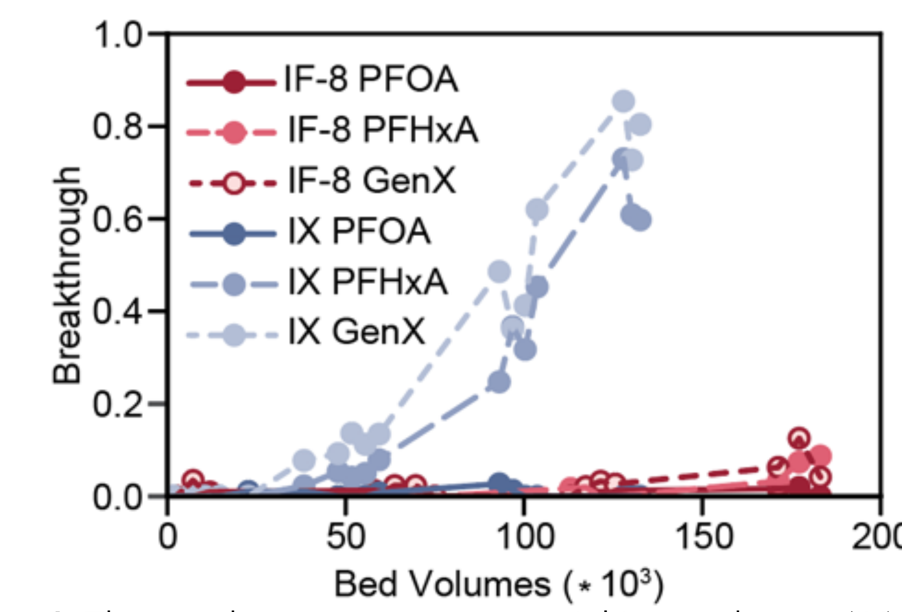


Figure 4. The graph compares commercial ion exchange (IX) resin to ionic fluorogel resin, measuring the amount of PFAS breakthrough against bed column volumes. IX resin displayed high PFAS breakthrough; whereas, IF resin was more effective at targeting and adsorbing short-chain PFAS compounds, significantly reducing breakthrough.

CONCLUSIONS & FUTURE WORK

- The synergistic mechanisms of fluorous-fluorous interactions and ion exchange within ionic fluorogels result in the rapid, efficient, high-capacity, selective removal of a variety of PFAS under laboratory tests mimicking environmentally relevant conditions.[2]
- IF resins removed short-chain PFAS more effectively than commercial IX resin.
- Ionic fluorogels are being further developed and evaluated at bench-scale towards identifying an improved material formulation for pilot-testing in several NC sites.

References

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3. Forrester, E. *Calgon Carbon Corporation*. 2018.
4. Crittenden, J.; Berrigan, J.; Hand, D. *Water Pollution Control*. 1986. 58, 4, 312-319.

Acknowledgements

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