Enhanced removal of short-chain PFAS from water using modified Graphene Oxide membrane

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Abstract

Per- and polyfluoroalkyl substances (PFAS) are highly persistent in the environment and can accumulate in human bodies, leading to significant health risks [1]. Traditional methods struggle to effectively remove short-chain PFAS (those with fewer than eight carbon atoms) from water [2]. In this study, we developed a beta-cyclodextrin modified graphene oxide (GO-βCD) membrane featuring asymmetrically sized nanochannels that interact favourably with these persistent pollutants. We enhanced water flux by incorporating an intercalant that enlarges the nanochannels and modifies the chemistry to improve PFAS transport through complexation and coordination sites. Our innovative GO-βCD membrane successfully eliminates over 90% of PFBA, PFPeA, PFHxA, and PFOA from water mixtures, achieving a high permeance of 21.7 ± 2 $Lm^{-2}h^{-1}bar^{-1}$, which surpasses that of standard NF270 membranes, while concentrating these contaminants in the retentate. By combining permeation experiments with molecular dynamics simulations and transition state theory [3], we showed that the energy barrier for PFAS transport is higher in the GO-βCD structure compared to both GO-αCD and pristine GO. This modified membrane features strategically placed sites that effectively impede PFAS transport under realistic conditions, ensuring long-term performance (up to 24 hours) at concentrations typical of drinking and recreational waters.

Keywords: beta-cyclodextrin, short chain PFAS, graphene oxide membrane, nanofiltration, energy barriers.

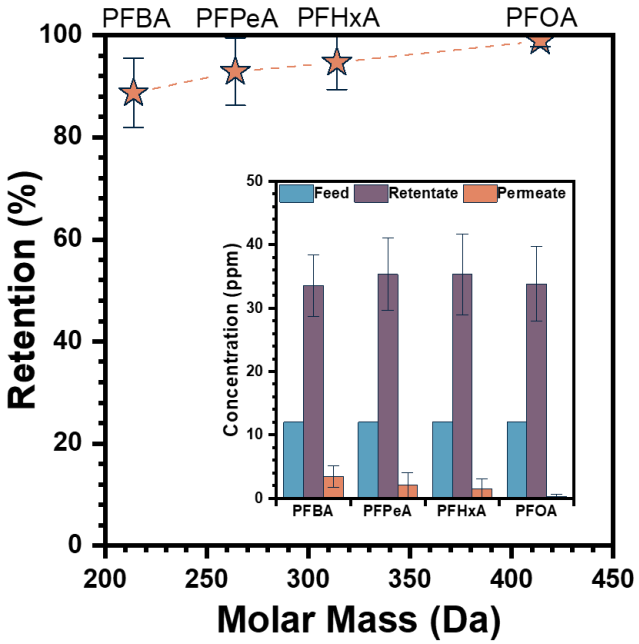

Figure 1: Retention of mixtures of PFAS with an inset displaying mass balance detail

References

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