United States Environmental Protection Agency

Novel Membrane Fabrication for Improved Flux, Reduced Fouling, and Efficient Treatment of PFOA

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US EPA P3 PEOPLE PROSPERITY PLANET

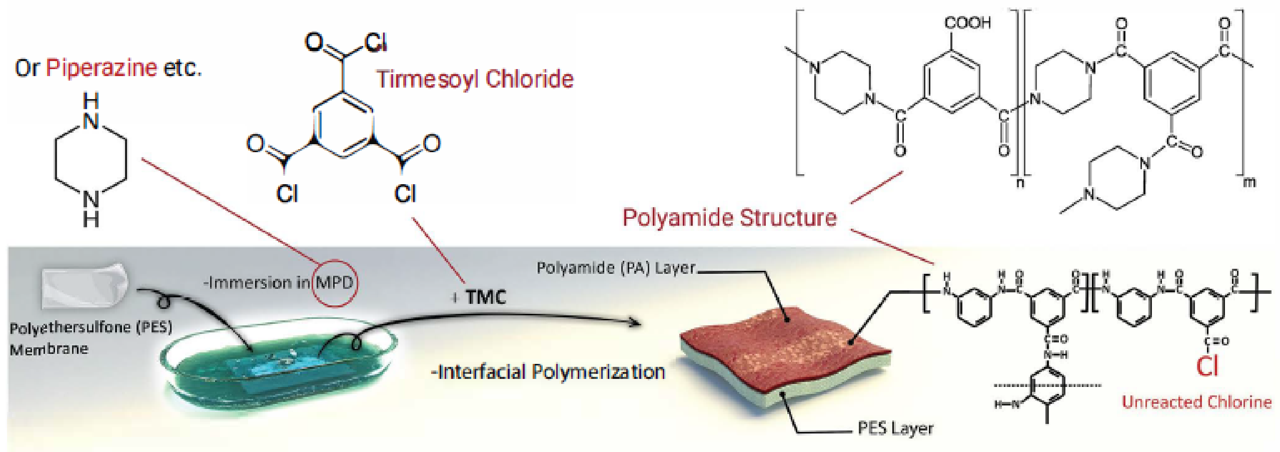
Introduction

Recent studies reported the application of nanofiltration (NF) polyamide membranes for perfluorooctanoic acid (PFOA) and salt removal. However, membranes with higher water flux and lower fouling propensity can address this challenge adequately for real-world applications. Although conventionally dip-coated polyamide NF membranes can remove PFOA and salts sufficiently, there is no control over the thickness of the thin-film layer in these methods. A thicker layer results in lower water flux and increases the fouling rates. Besides, alterations in membrane surface charge by nano-additives can increase the repulsion between the membrane and contaminant resulting in lower fouling rates.

In our study plan, we showed that spin coating could solve both challenges by enforcing the monomers and nano-additives through parallel diffusion on the membrane surface, in contrast to the conventional dip-coating process with normal diffusion directions. Furthermore, dip-coating, a traditional fabrication method, is a static process in which nano-additives do not face any external force for dispersion. At the same time, in spin coating, solutions are dispersed by centrifugal force.

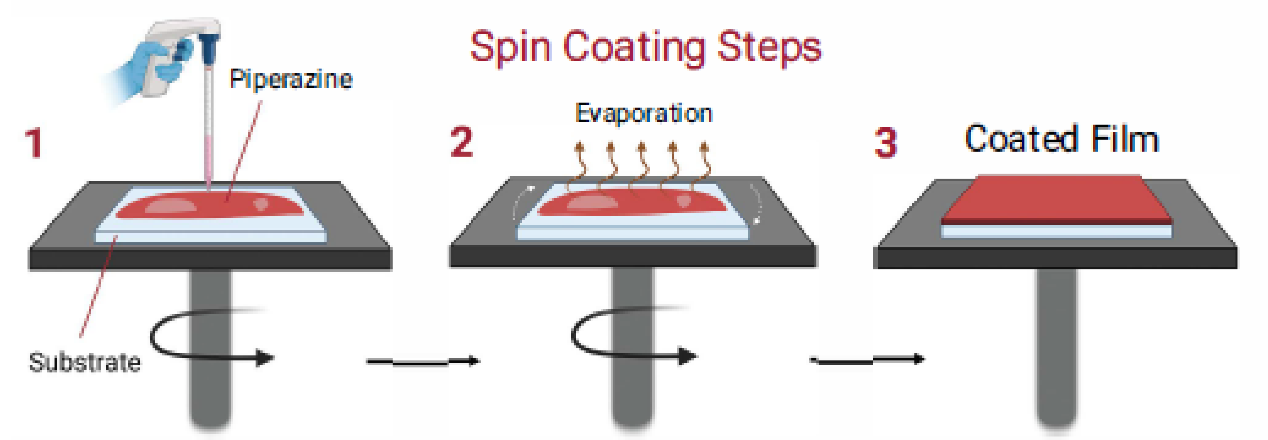
The dynamic distribution of nano-additives and dispensation of monomers via spin coating makes it easier to control the thickness and morphology of the polyamide layer. The thinner the polyamide layer, the higher the water flux rate will be while it will not negatively affect the rejection. Additionally, spin coating does not require an excessive amount of monomer for the formation of polyamide, which decreases the chemical consumption of the whole procedure.

Uniform dispersion of Silver metal-organic framework (AgMOF) would increase the negative surface charge of the membrane as these materials are proven to be porous, reactive, and negatively charged. The negative surface charge can help better mitigate the fouling for the long-term performance of the membrane.

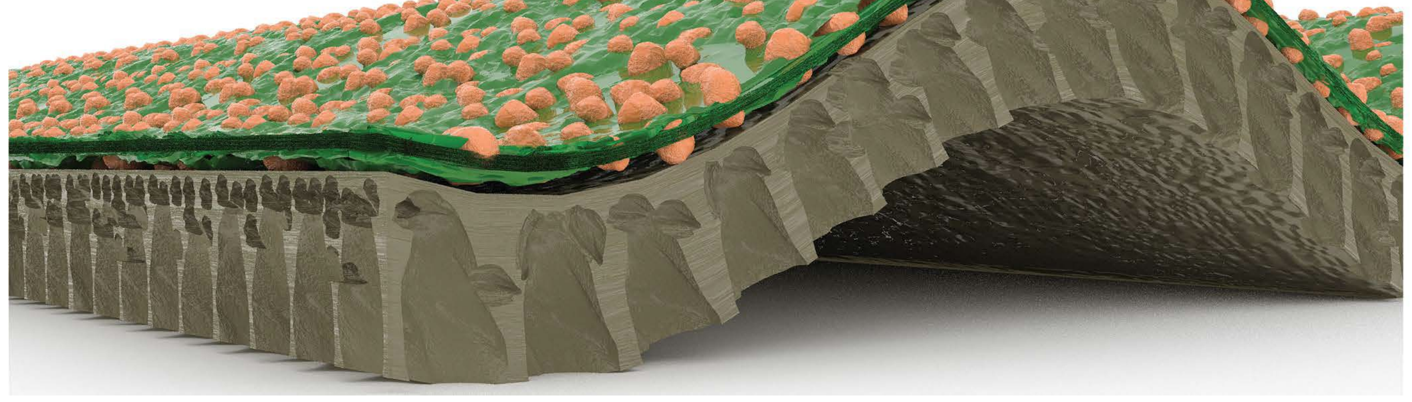


Caption. Schematic representation of interfacial polymerization. The most common monomers for polyamide polyemerization are Piperazine and m-phenylenediamine cross-linked with trimesoyl chloride.

Technique

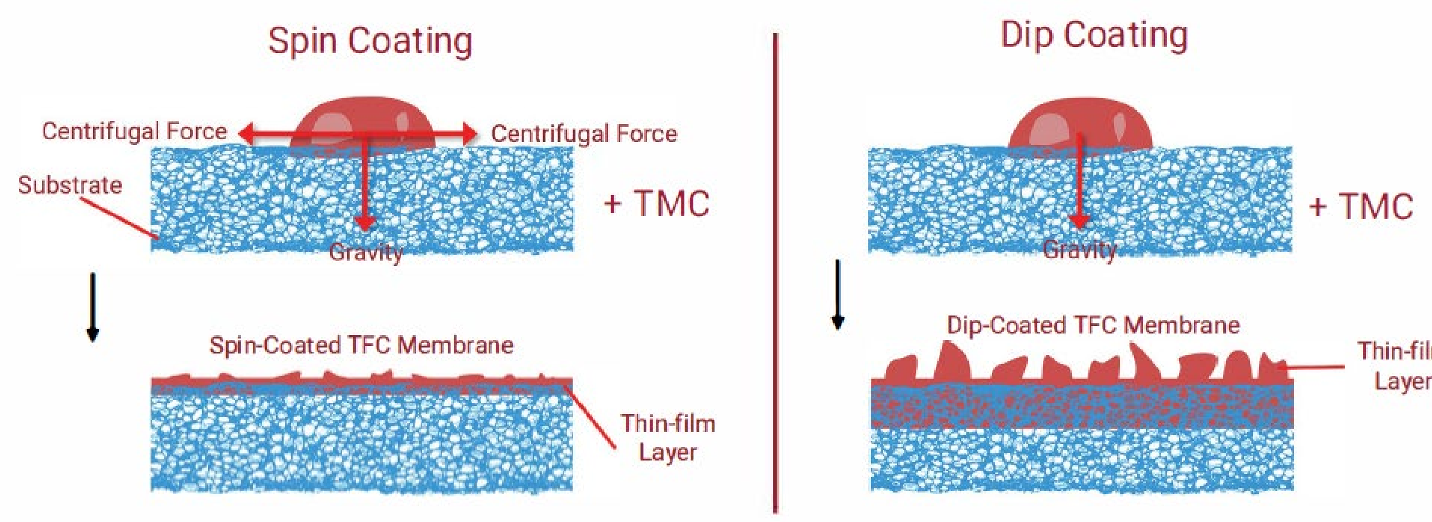


Caption. Schematic illustration of spin-coating process for polyamide formation. In this project, we used spin-coating technique instead of conventional dip-coating process to form the polyamide layer on the polyethersulfone (PES) substrate. Later, we investigated the effect of silver metal-organic framework addition to the structure for fouling performance mitigation.

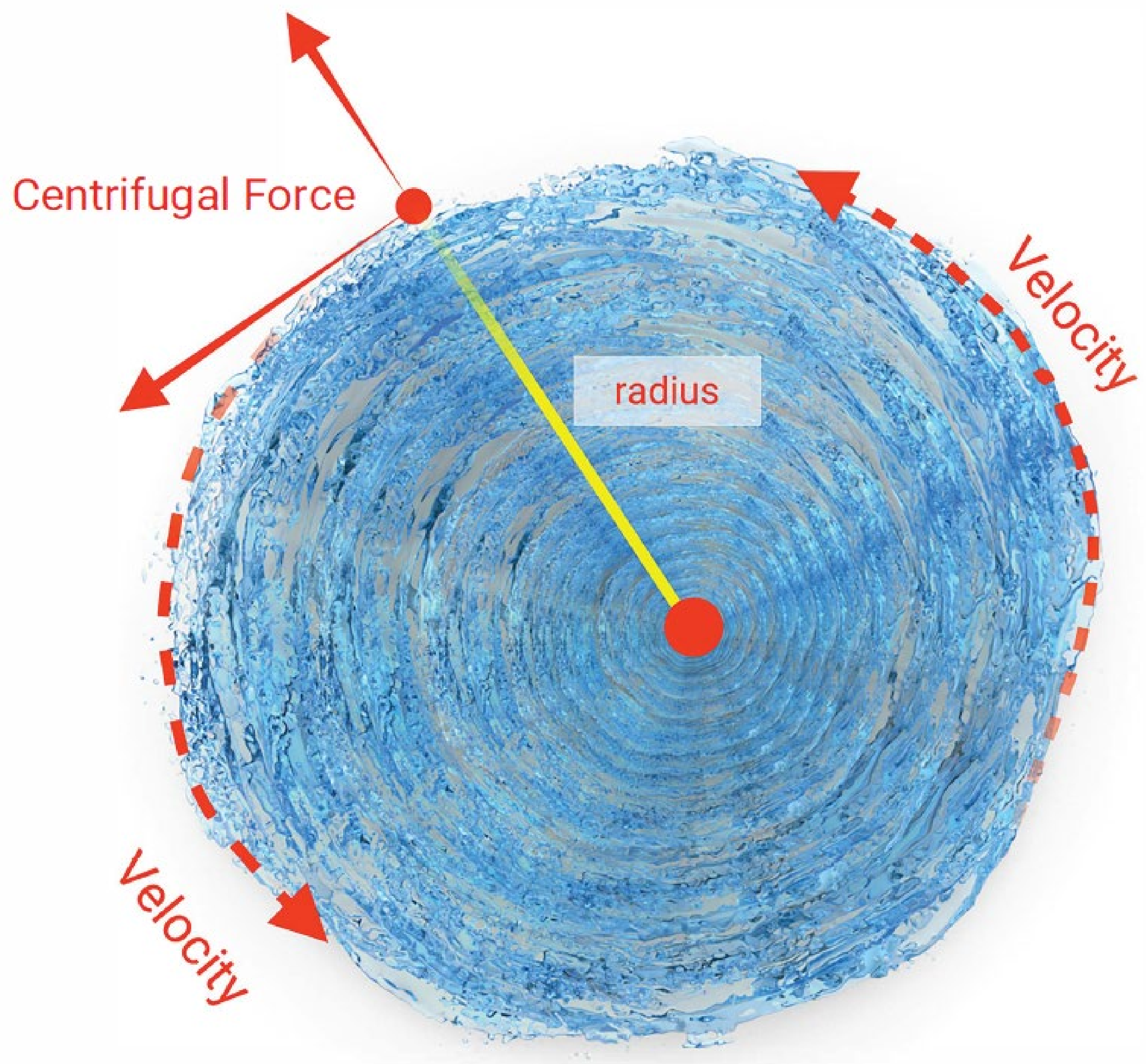


Caption. Schematic illustration of MOF Incorporated thin-film composite polyamide membrane.

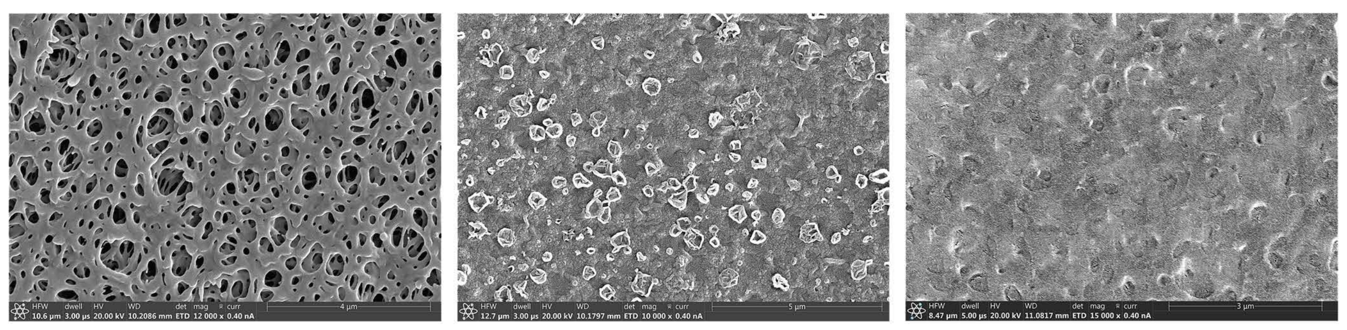
Theory Behind the Project



Caption. Schematic illustration of polyamide formation mechanism in spin-coating and conventional dip-coating process.

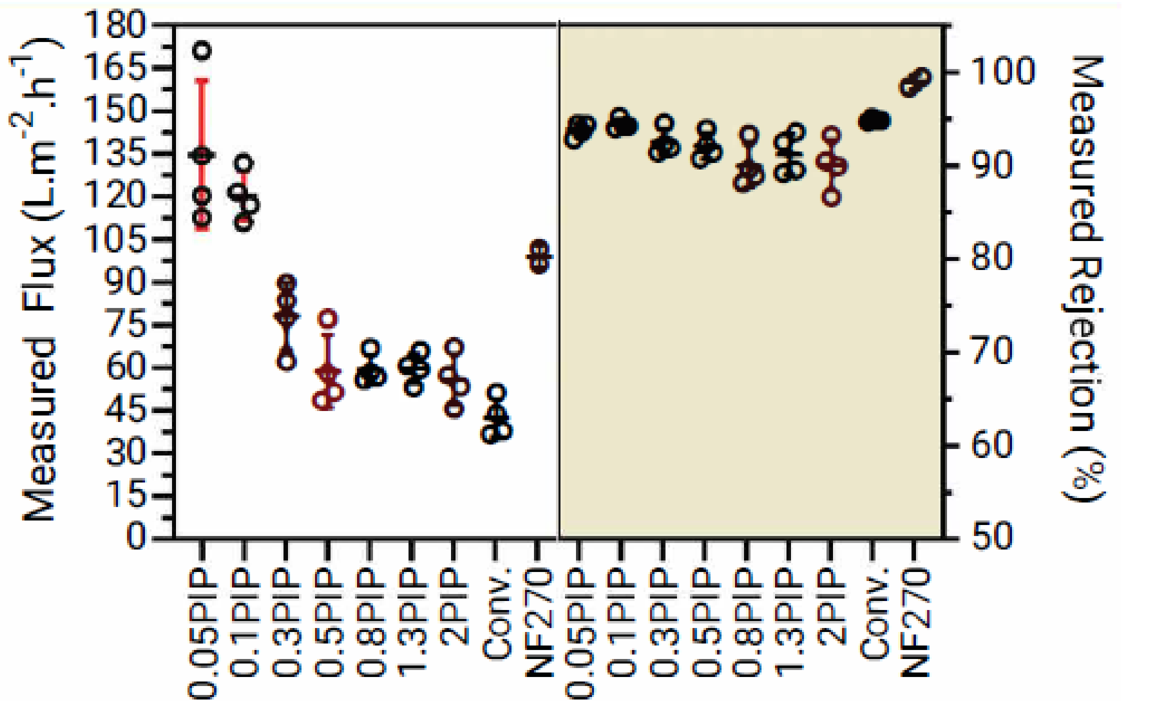


Characterizations

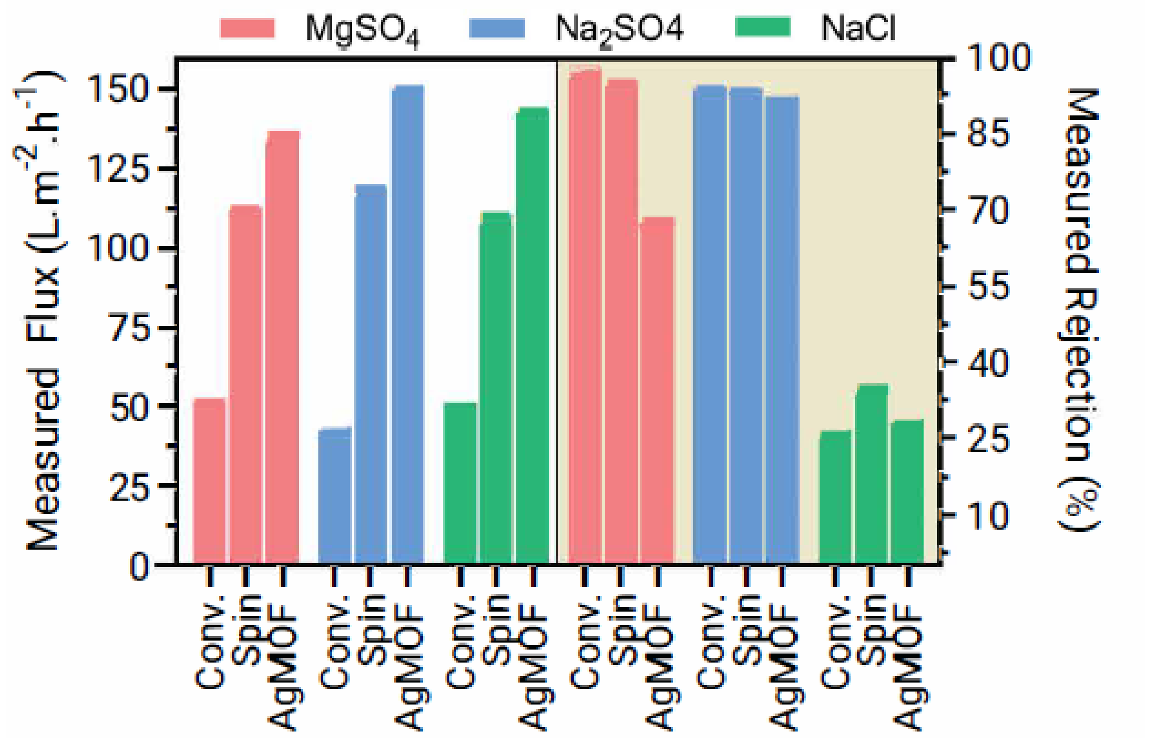


Caption. The top surface SEM images of the (a) PES ultrafiltration membrane, (b) conventional TFC membrane, (c) spin-coated UTFC membrane.

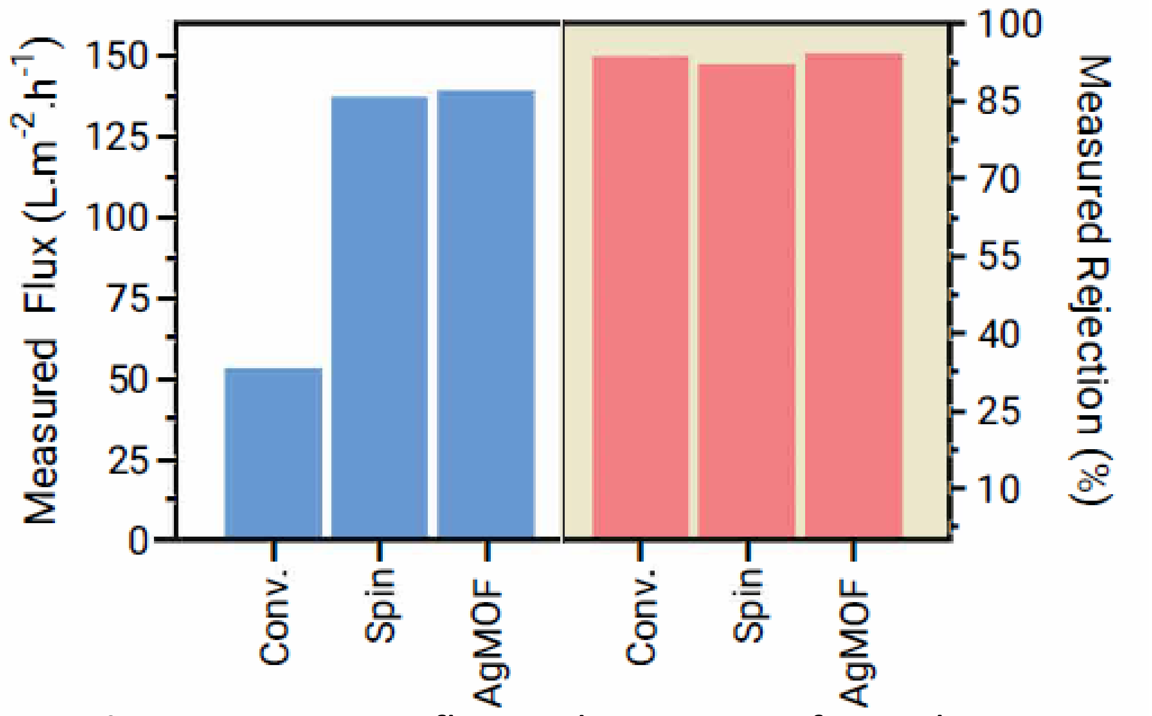
Results



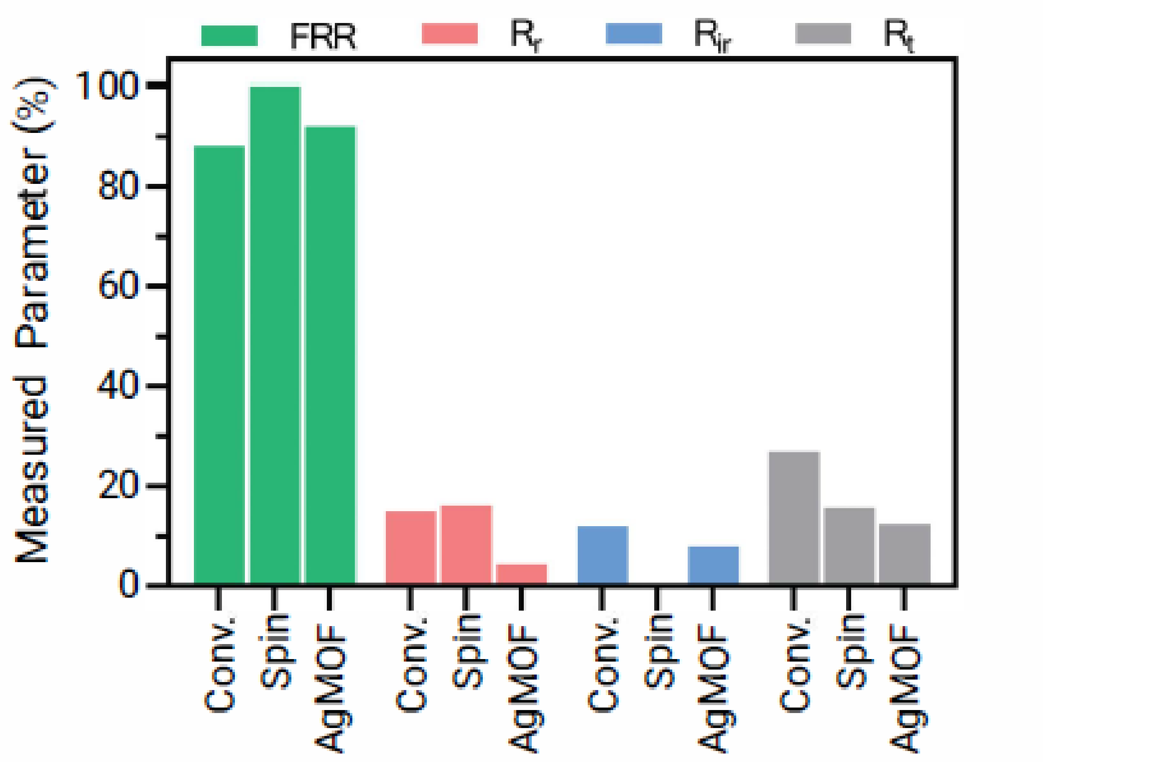
Caption. Salt water flux and rejection of membranes in NF.



Caption. Salt water flux and rejection of membranes in NF.



Caption. PFOA water flux and rejection of membranes in NF.



Caption. PFOA fouling parameters of membranes in NF.