كلية الهندسة
College of Engineering
QATAR UNIVERSITY جامعة قطر

Graduate students, Sciences and Engineering

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Bio-Inspired Fabrication of Ultrafiltration Membranes incorporating Polydopamine Functionalized Graphene Oxide Nanoparticles

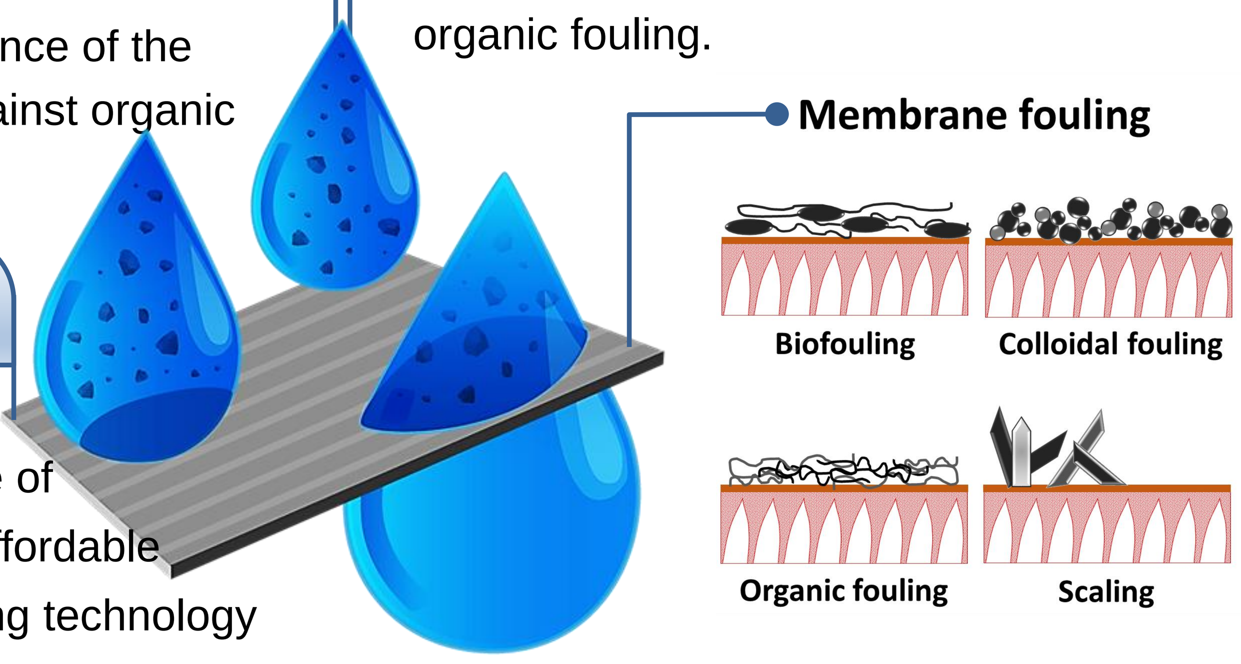
Abedalkader Alkhouzaam, Hazim Qiblawey, Majeda Khraisheh

Objectives

- NOx free and high-oxidation synthesis of graphene oxide (GO) nanosheets *via* an improved Hummers' method.
- Amine-functionalization of GO nanosheets with polydopamine (PDA)
- Fabrication of polysulfone (PSF. ultrafiltration membranes incorporating GO and rGO-PDA nanosheets.
- Testing the separation properties of the prepared membranes.
- Testing the fouling resistance of the prepared membranes against organic and protein fouling.

Highlights

- GO nanosheets were prepared and then functionalized and reduced with PDA..
- PSF/rGO-PDA membranes were fabricated via the phase inversion method.
- The addition of rGO-PDA enhanced the flux by ~ 80% without reducing the rejection.
- PSF/rGO-PDA MMMs exhibited high fouling resistance against protein and organic fouling.



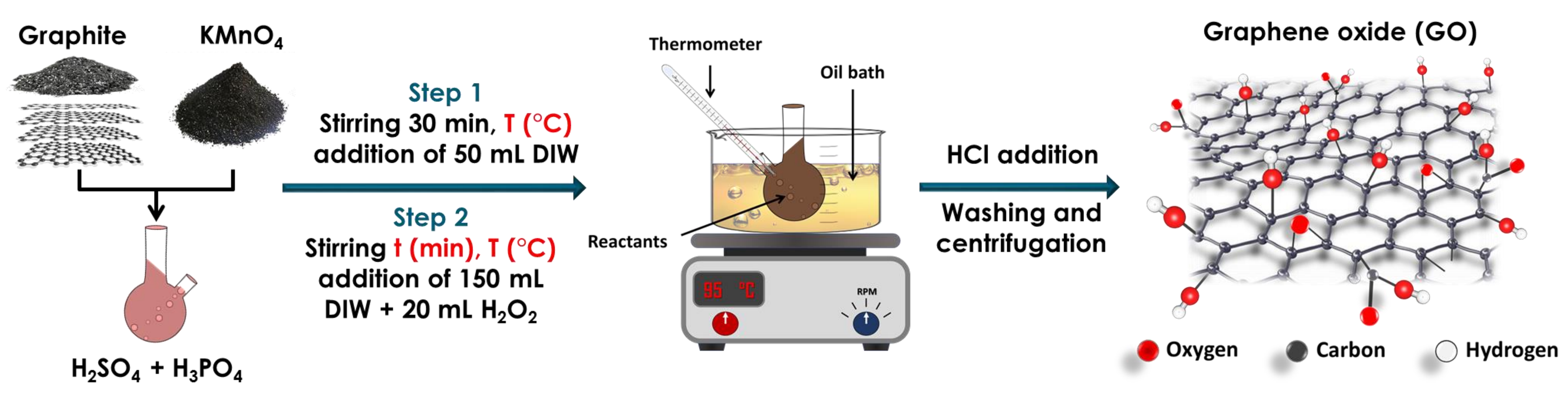
Overview

Membrane treatment for wastewater treatment is one of the promising solutions to affordable clean water. It is a developing technology throughout the world and considered as the most effective and economical method available. However, the limitations of membranes' mechanical and chemical properties restrict their industrial applications. Fouling is a process where contaminants in feed water deposit onto membrane surface or within the membrane pores, consequently causing flux decline and lowering the permeate quality. Therefore, developing antifouling membranes and finding new antifouling agents have become an important research objective.

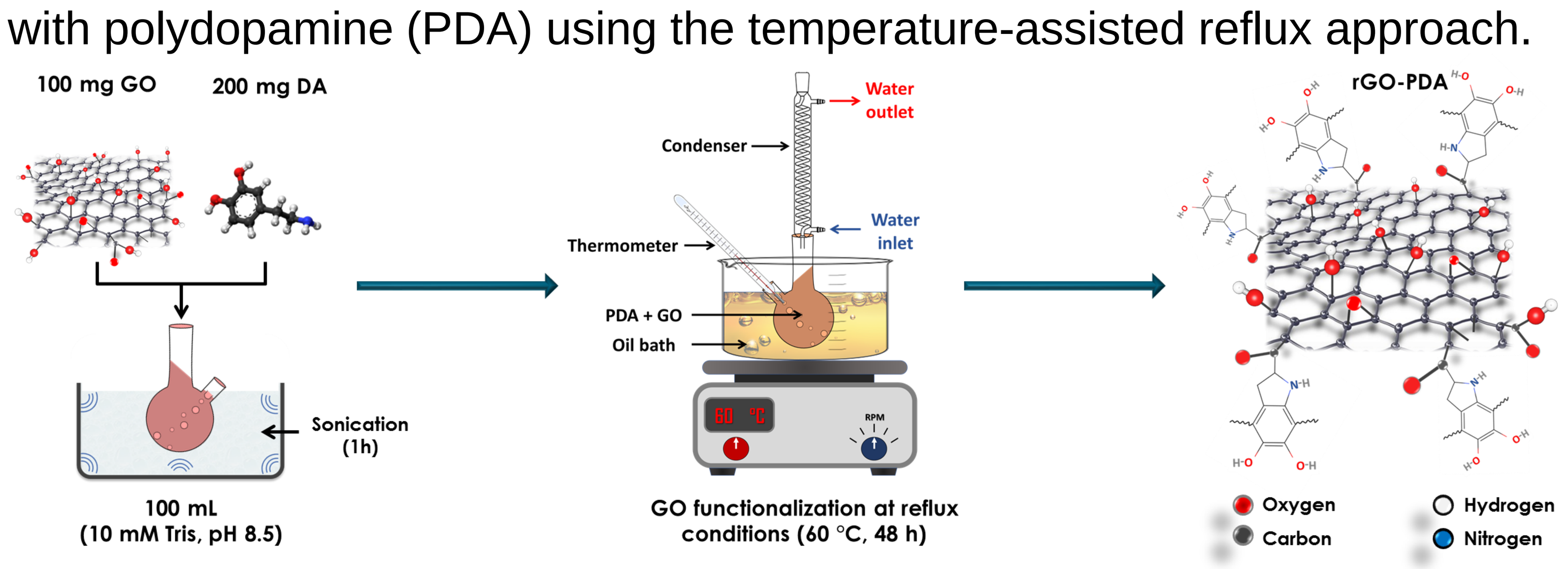
One of the recently investigated nanomaterials in membrane science for water treatment and desalination is graphene oxides (GO) and GO-based materials (f-GO). Because of their high mechanical strength easy accessibility, and chemical stabilities, GO and f-GO nanomaterials are considered promising nanofillers that can reduce the membranes fouling while enhancing their performance with respect to water flux and salt rejection.

Methodology

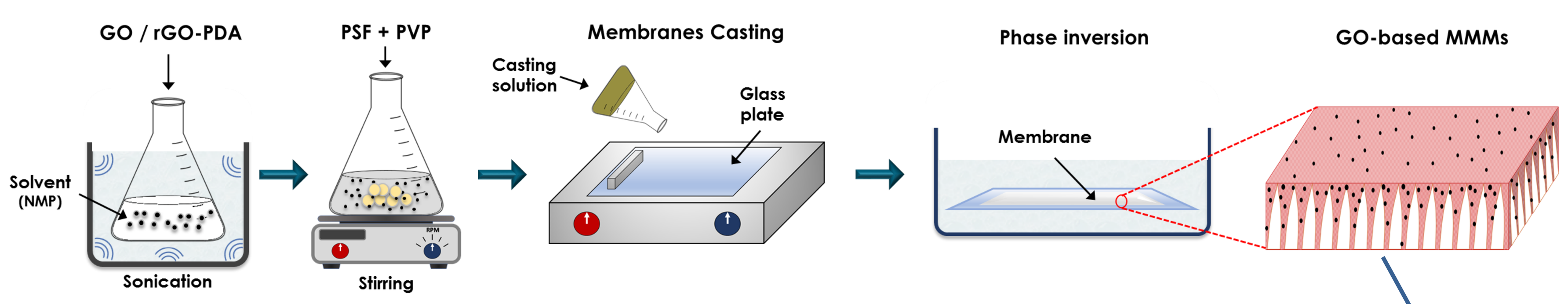
Synthesis of graphene oxide (GO): High-oxidation and NO_x free synthesis of GO was conducted using a modified *Hummers' method.*



Functionalization of GO: Amine-functionalization of GO was performed with polydopamine (PDA) using the temperature-assisted reflux approach.

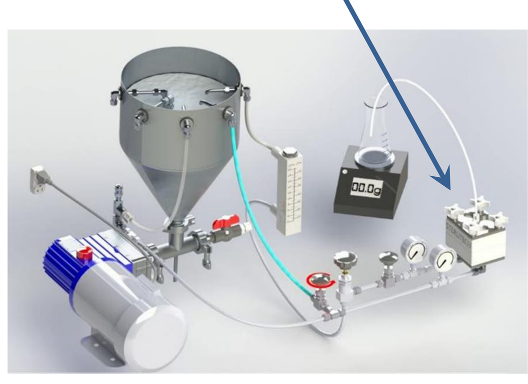


Membranes preparation: Pristine polysulfone (PSF) and GO-PSF composite membranes were prepared via phase inversion technique.



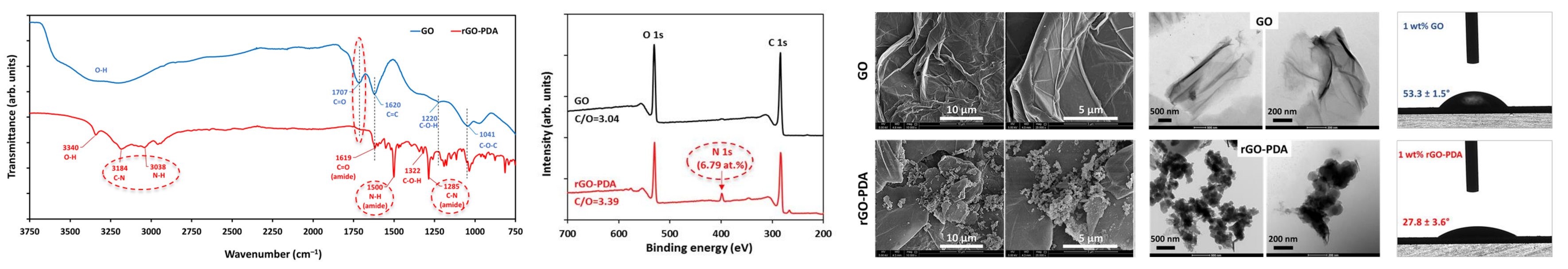
Separation, flux, and antifouling measurements:

- Experiments were conducted using cross-flow membrane unit.
- Two model foulants were used, BSA and HA, representing protein and organic fouling.



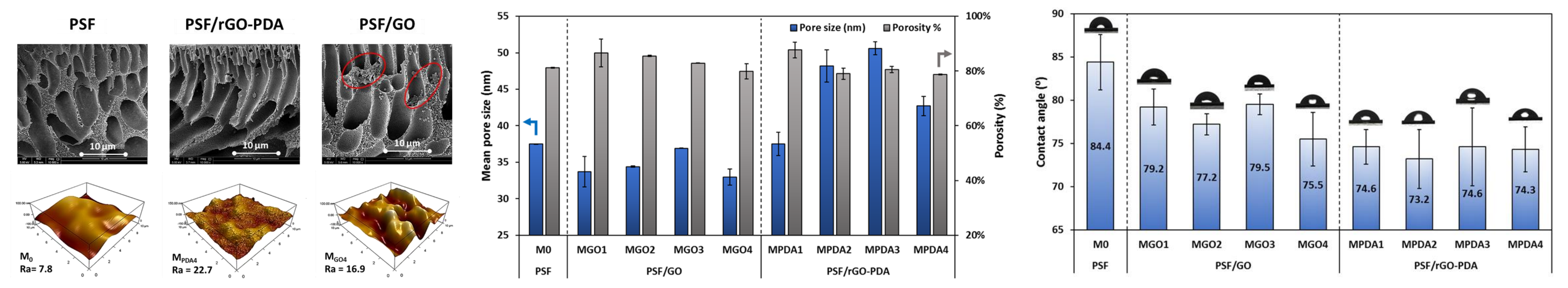
Results

GO characterization: FTIR, Raman spectroscopy, SEM, and TEM confirmed the oxidation of graphite and the success of functionalization.



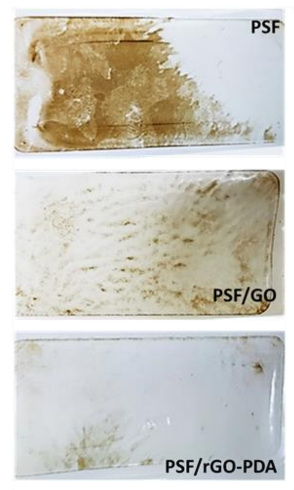
Membranes characterization:

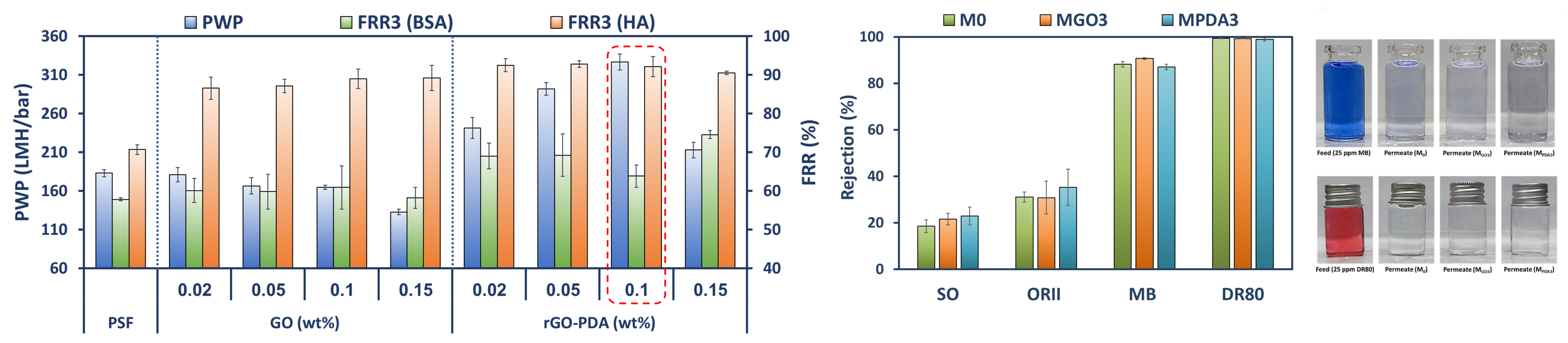
- SEM images showed well distribution of rGO-PDA in the PSF matrix while the pristine GO nanosheets were agglomerated.
- The increase in surface roughness was higher with the addition of rGO-PDA even at low concentrations.
- Pore size decreased with GO addition due to the agglomeration of GO in the pores, while it increased with the rGO-PDA embedding.
- Hydrophilicity was enhanced with rGO-PDA addition.



Separation & antifouling properties:

- The flux was enhanced by ~80% with rGO-PDA embedding, while it decreased with GO addition.
- All membranes showed complete rejection of BSA and HA; and excellent rejection of MB and DR80 dyes.
- Fouling resistance was significantly improved with the embedding of rGO-PDA against protein and organic fouling.

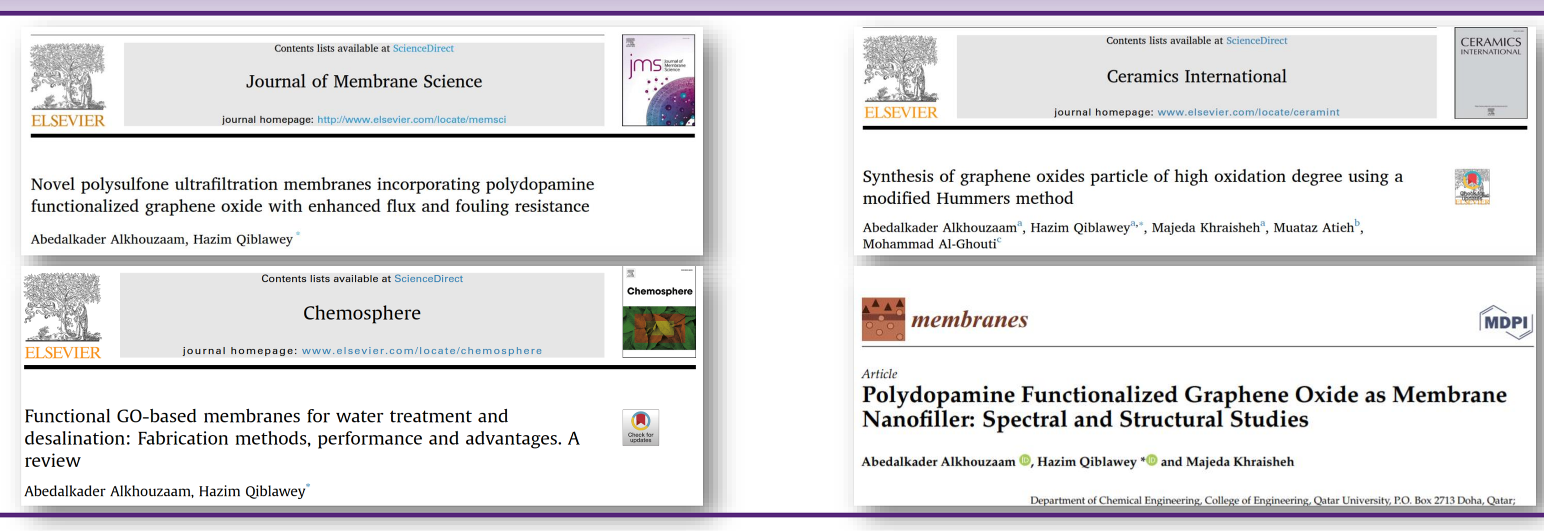




Conclusion

- GO nanosheets were synthesized via an improved Hummers' method and then were functionalized using polydopamine (PDA).
- PSF MMMs embedding different loadings of GO and rGO-PDA nanosheets were prepared via the phase inversion technique.
- The embedding of pristine GO resulted in flux decline due to the agglomeration of GO nanosheets as confirmed by the SEM images.
- PSF/rGO-PDA MMMs showed higher FRR after 3 fouling cycles.
- All membranes showed complete rejection of BSA and HA with excellent rejection of DR80 and MB.

Outcomes



Acknowledgment

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