Surface Modification Strategies for Nanofiltration Membranes

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Nanofiltration membranes play a vital role in water remediation strategies and with a quarter of the world's population without safely managed drinking water, the need for reliable, effective and robust technologies is ever increasing. Improving accessibility to clean water and sanitation is a key priority of the United Nations Sustainable Development Goals (UNSDG6).

Graphene oxide (GO) is a promising material for nanofiltration membranes, having an appropriate interlayer spacing and hydrophilicity to provide selectivity and anti-fouling properties that are required for nanofiltration applications. However, the resilience of these membranes is limited because exposure to water causes some exfoliation and therefore a change in filtration properties. Our recent results for the reinforcement of GO membranes highlight the influence of flexibility in the cross-linking agent and filtration performance, figure 1.[1] Through this detailed rheological assessment of membrane materials we find, surprisingly, that the flexibility of the crosslinker has little bearing on the flexibility of the GO composite, but the overall reinforcement is much improved with the use of flexible PEI crosslinkers. Our results also suggest a maximum level of reinforcement beyond which additional crosslinker appears to reduce performance, figure 2. We attribute this to the saturation of the GO surface preventing cross-linkers from forming effective bridges. Results for nanofiltration performance indicate that significant improvements to resilience can be achieved even at cross-linker concentrations as low as 0.2%(w/w) with respect to mass of GO.

Finally, we explore an entirely new approach to control surface modification of PES nanofiltration membranes, exploiting viscous reactive solutions to restrict the depth within a membrane to which modification occurs. Surface analysis with AFM (figure 3) shows that the rate of polydopamine deposition onto a surface is relatively independent of solution viscosity. Results for nanofiltration using a dead-end cell indicate that this strategy can provide an effective means to control selectivity for size whilst minimising the impact on flux because the surface modification from a viscous solution does not block the channels within the membrane as severely as when a more fluid solution is used.

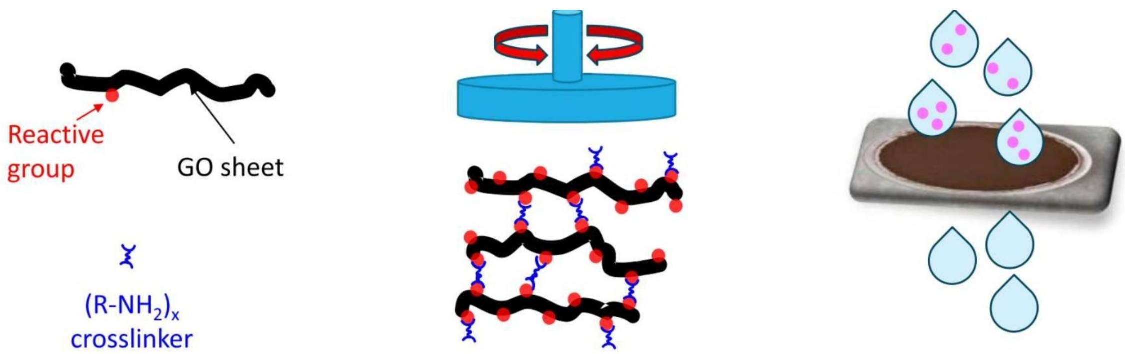

Figure 1. Sketch of cross-linking strategy for GO sheets, reinforcement analysis with oscillatory rheology and nanofiltration process.

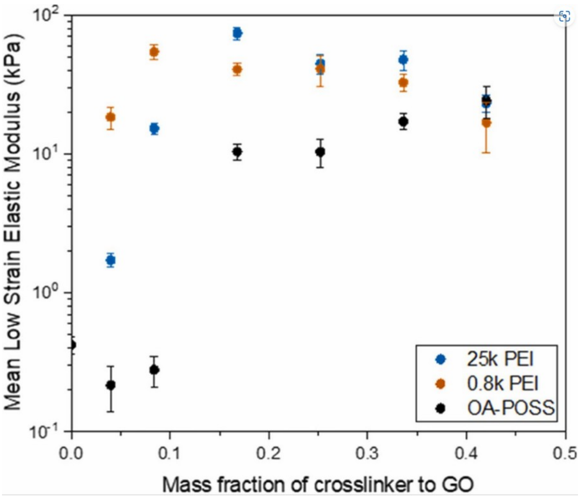

Figure 2. Dependence of GO composite reinforcement on cross-linker concentration

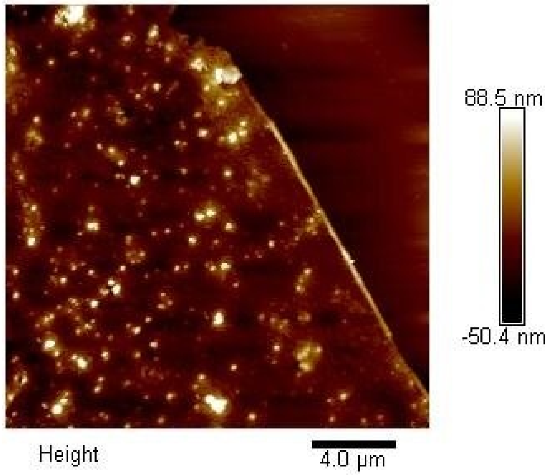

Figure 3. AFM image of polydopamine layer deposited onto flat silicon surface

Acknowledgements

We thank EU-RDF for financial support of this work through the ERDF – Intensive Industrial Innovation Programme – 25R17P01847.

References

(1) Kaur, P.; Bowen, L.; Hutchings, L. R.; Chaudhry, M. U.; Pugh, T.; Thompson, R. L. Reinforcement of GO composites using rigid and flexible crosslinkers. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* **2025**, *709*, 136156. DOI: https://doi.org/10.1016/j.colsurfa.2025.136156.