Development of highly flexible nanoporous membranes – Potential of 3D printing technology

Laura F. P. Carvalho, Hari K. Balakrishnan, Hassan A. Arafat, Ludovic F. Dumée
Khalifa University, Department of Chemical Engineering, Abu Dhabi, United Arab Emirates
Research and Innovation Center on Graphene and Nanomaterials (RIC2D)

lauracarvalhoeq@gmail.com

Nanoporous membranes are a pivotal technology in supporting the future growth of water purification, desalination, and wastewater treatment industries owing to their ability to selectively remove contaminants at the molecular level. However, they struggle with limited mechanical and chemical resistance under compression, fouling and achieving high permeance [1]. Meanwhile, standard fabrication methods struggle with scalability, waste production, and narrowing the pore size distribution at low costs which is essential to water applications [2]. In contrast, Digital Light Projection (DLP) printing is promising as it allows precise control over membrane structure with high customization and minimal waste [3]. This poster will present the ongoing work of exploring the tools provided by DLP 3D printing to manufacture compression-resistant nanoporous membranes for wastewater treatment applications. We have implemented polymerization-induced phase separation (PIPS) techniques associating different monomers in additive manufacturing to impart flexibility, compressive strength, and overall stability to the material. By benefiting from DLP printing's versatility in fine-tuning membrane properties through specialized chemistries, our research investigates 2D nanomaterials. By incorporating graphene into the polymeric matrix, we not only may improve mechanical strength but also introduce additional functionalities such as anti-fouling systems that enhance performance and broaden the application scope of such composite materials. Therefore, as a proof of concept, this poster will present how DLP technology enables the production of 2D material membranes. Following, we will showcase a new compression test methodology in development to translate the characteristics bestowed on the membranes through 3D printing into measurable KPIs that represent their behavior under operation to further benchmark our membranes against commercial ones. Despite the wide variety of characterization techniques in the literature, a lack of standardization leads to the employment of procedures, like tensile testing, that provide parameters of limited relevance to real operational conditions. Finally, we expect to show that this newly developed methodology greatly contributes to the understanding of the compressibility of membranes and compaction over time effects that cause loss in flux performance, allowing the better engineering of materials that are mechanically sturdy without becoming brittle.

References

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[3] Balakrishnan, H.K., Dumée, L.F., Merenda, A., Aubry, C., Yuan, D., Doeven, E.H. and Guijt, R.M, Small Structures, Vol. 4, Issue 5 (2023).

Figures

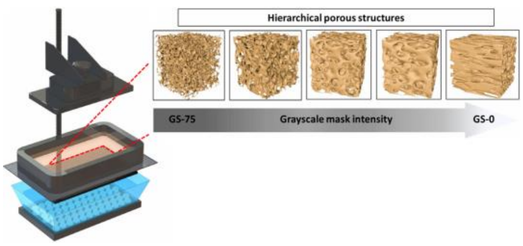

Figure 1: Scheme of DLP printing of porous structures (Adapted from [3])

Figure 2: DLP 3D printed membrane (RIC2D group proprietary picture)