3D printed ultrafiltration and nanofiltration thin film composite membranes

Davide Mattia, contact: [d.mattia@bath.ac.uk](mailto:d.mattia@bath.ac.uk)

Department of Chemical Engineering, and Centre for Advanced Separations Engineering, University of Bath, UK

**Abstract**: Fouling presents the largest challenge towards more widespread use of membranes in liquid separations. Patterning of membrane surfaces is a promising chemical-free approach to promote fluid shear stress and create localised turbulence near the membrane surface, leading to reduced or slower fouling build-up. Current patterning methods suffer from insufficient fidelity and flexibility, while at the same time negatively affecting the performance and durability of the membranes. 3D printing can overcome these challenges by enabling the fabrication of complex/irregular patterns.1

This study presents an innovative and systematic approach to the design and fabrication of fouling-resistant composite membranes, using a combination of computational modelling and 3D printing. Flat and double sinusoidal (wavy) structured supports were printed using an industrial Multi-jet 3D printer. Ultrafiltration (UF) polyethersulfone (PES) and nanofiltration (NF) polydopamine‐coated polyvinylidene fluoride (PVDF/PDA) selective layers were subsequently deposited onto the 3D printed supports by vacuum filtration. COMSOL MultiphysicsTM was used to elucidate the fluid mechanics of the filtration process of flat and wavy composite membranes.

Bovine serum albumin (BSA) filtration tests on UF PES composite membranes revealed that in comparison to the flat composite membrane, the wavy composite membrane showed superior performance in terms of pure water permeance (PWP) (10% higher) and permeance recovery ratio (87% versus 53%) after the first filtration cycle at Re = 1000. Prolonged testing showed that the wavy membrane could retain approximately 87% of its initial PWP after 10 complete filtration cycles.2 This impressive fouling-resistant behaviour is attributed to the localised fluid turbulence induced by the 3D printed wavy structure since the maximum surface shear stress for the wavy pattern was significantly higher than the one for the flat one. Divalent salt rejection tests on NF PVDF/PDA membranes showed that the wavy structure significantly reduced concertation polarisation at the membrane surface compared to the flat membranes, reducing the increase in energy consumption for prolonged testing. These results show that a suitable chemical-free approach to mitigate fouling for extended membrane operations can be achieved by using carefully designed 3D printed composite membranes.3

[**1**] Low, Z.-X., et al., *Journal of Membrane Science* **2017,** *523*, 596-613.

[**2**] Mazinani, S., et al., *ACS Appl Mater Interf* **2019**.

[**3**] Al-Shimmery, A., et al., *Journal of Membrane Science* **2019,** *574*, 76-85.

**Short Bio**: Davide Mattia, FIChemE, CEng, is Professor of Chemical Engineering at the University of Bath. He earned a MEng in Materials Engineering in 2002 from the University ‘Federico II, Napoli, Italy and a PhD in Materials Engineering from Drexel University, Philadelphia, USA, in 2007. He joined Bath in 2008 as a Lecturer and was promoted to a full professor in 2016. His current research focuses on using membranes to address environmental challenges, including the sustainable manufacturing of materials and the removal of organic micropollutants from water. He is a past Royal Academy of Engineering Research Fellow and currently holds an EPSRC Established Career Fellowship in Water Engineering. He serves as Associate Dean for Research in the Faculty of Engineering at the University of Bath and as Secretary of the European Membrane Society council.