**Nanofiber Based Dual Functional Enzymatic and Thermo-Responsive Membranes for Protein Self-Cleaning**

*Anbharasi VanangamudiA,B\*, Ludovic F. DumeeB, Mikel C. DukeA and Xing YangA*

AInstitute of Sustainable Industries & Liveable Cities (ISILC), College of Engineering and Science, Victoria University, Melbourne, Australia; BDeakin University, Waurn Ponds, Institute of Frontier Materials (IFM), Victoria, Australia.

**Introduction**

One of the most versatile methods to reduce fouling and self-clean the membranes is to incorporate self-cleaning materials such as proteolytic enzymes that can lyse and detach the protein foulants from the membrane surface (Shi *et al*. 2011, Cordeiro *et al*. 2011) and thermo-responsive polymers that offer facile temperature based cleaning for membranes (Tripathi *et al*. 2014). However, the combined self-cleaning effect of PNIPAAm and biocatalytic enzymes has not been explored so far.

**Method & Approach**

In this research, a new nanofiber based dual functional biocatalytic thermo-responsive poly(vinylidene fluoride)(PVDF)/nylon-6,6/poly(N-isopropylacrylamide)(PNIPAAm) ultrafiltration membrane was fabricated by integrating a hydrophobic PVDF cast layer and hydrophilic nylon-6,6/PNIPAAm nanofiber layer where trypsin enzymes were covalently immobilized. The structural and functional properties of the as-prepared membranes were investigated and correlated to the membrane performance. Also, the impact of thermo-switchable volume-phase transition on the stability of immobilized enzymes was studied. Figure 1 shows the schematic of enzymatic and thermo-responsive self-cleaning of membranes. D:\VU\PAPERS\Paper 4\Membranes\Graphical Abstract.tif

**Fig. 1.** Schematic of enzymatic and thermo-responsive self-cleaning of membranes

**Results & Discussion**

The immobilization density of enzymes on the membrane surface decreased with increasing PNIPAAm concentration, due to the decreased number of amine functional sites. Through an UF study using a model solution containing BSA/NaCl/CaCl2, the membrane without PNIPAAm revealed superior fouling resistance and self-cleaning with an RPD of 22%, compared to membranes with 2 and 4 wt% PNIPAAm with 26% and 33% RPD, respectively, after an intermediate temperature cleaning at 50°C, indicating that higher enzyme density offers more efficient self-cleaning than the combined effect of enzyme and PNIPAAm at low concentration.

**Conclusion**

Overall, the thermo-switchable conformational volume phase transition of the as-prepared membranes did not affect the stability of surface immobilized enzymes. Hence, the approach of enzyme immobilization onto nanofibrous surface has greater potential including fouling mitigation and surface self-cleaning beyond membrane separation.

**References**

1. Cordeiro, A.L. & Werner, C. (2011). Enzymes for antifouling strategies. J. Adhes. Sci and Technol. 25, 2317-2344.
2. Shi, Q.; Su, Y.; Ning, X.; Chen, W.; Peng, J. & Jiang, Z. (2011). Trypsin-enabled construction of anti-fouling and self-cleaning polyethersulfone membrane. Biores. Technol., 102, 647-651.
3. Tripathi, B.P.; Dubey, N.; Simon, F. & Stamm, M. (2014). Thermo responsive ultrafiltration membranes of grafted poly(n-isopropyl acrylamide) via polydopamine. RSC Adv., 4, 34073-34083.

\*Corresponding author email: anbharasi.vanangamudi@live.vu.edu.au