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Gradient atomic layer deposition for controlled hydrophilization of ultrafiltration polymer membranes

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MSc Seminar

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Membrane surface modifications can significantly enhance membrane performance in terms of membrane hydrophilicity, permeability, selectivity, and anti-fouling properties. Most of the commonly used surface modifications methods are based on polymer incorporation within the membrane or adsorption onto the membrane surface, polymer surface grafting, or surface coating with small organic molecules. In the last decade, atomic layer deposition (ALD) has emerged as a powerful technique for membrane surface modifications due to its ability to grow thin inorganic coatings on the membranes' tortuous porous network with sub-nm control over the coating thickness. ALD is based on sequential exposure of two gas phase precursors, creating thin films- one atomic layer at a time, allowing precise control over the growth process in a wide array of inorganic materials.

In this research we investigated Al_2O_3 ALD on two phase inverted polymeric membranes- poly(acrylonitrile) (PAN) and poly(etherimide) (PEI) and probed the ALD growth process and how it can be utilized to enhance membrane performance. The directional growth of Al_2O_3 ALD due to exposure to gas precursors from the top of the membrane, enabled us to tune the growth gradient through the membranes' depth, as characterized by high resolution cross-sectional transmission electron microscopy (TEM) and scanning (STEM) energy dispersive spectroscopy (EDS) characterization. Interestingly, by controlling the process exposure time we tuned the gradient growth of Al_2O_3 from the top surface into the membrane pores and controlled the precursor penetration depth. In addition, Al_2O_3 ALD was utilized to control both the membranes' pore size and the membranes' hydrophilization, resulting in tunable membranes permeability.