Pervaporation Desalination Membrane with Defective MOFs

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Composite membranes containing metal-organic frameworks (MOFs) are regarded promising candidates for advanced separation. Recent research has migrated towards exploring the physical, chemical and structural properties of the MOFs materials that are already known, rather than the application of new MOF materials. This work synthesized the fumarate-based MIL-53(Al) and applied a modulator (urea) to controllable generate defects on the MOFs. The gradual hydrolysis of urea can lead to the ligand replacement process, leading to MIL-53(Al) with hierarchical porosity and higher Brønsted acidity, while the crystalline structure and pH stability of the MOF can be well maintained (Figure 1). The generation of defects can be controlled by the modulated reaction time, i.e. longer reaction time leads to MOFs with more defects.

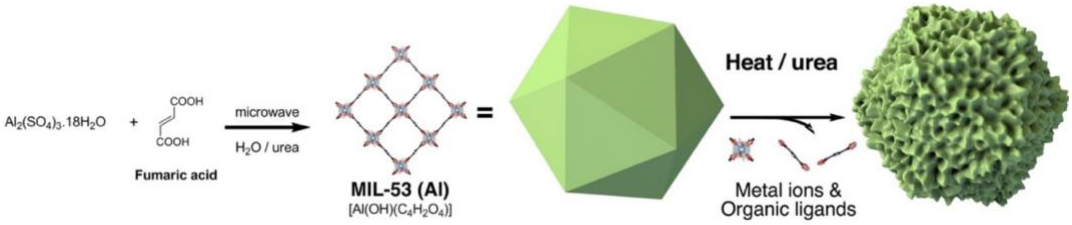


Figure 1. Schematic diagram of the defective fumarate-based MIL-53(Al) synthesis process.

We subsequently incorporated the defective MOFs into polyvinyl alcohol pervaporation membranes for brine desalination (Figure 2a). When compared with pristine MOFs, the addition of defective MOFs leads to more open voids at the MOF-polymer interfacial area (Figure 2b-c). The resultant nanocomposite membrane has nearly 80 % higher water productivity in concentrated brine treatment, with salt reaction of >99.999%. The nanocomposite membrane also have good long-term operational stability with satisfactory antifouling behaviour with the presence of humic acid and calcium ions.

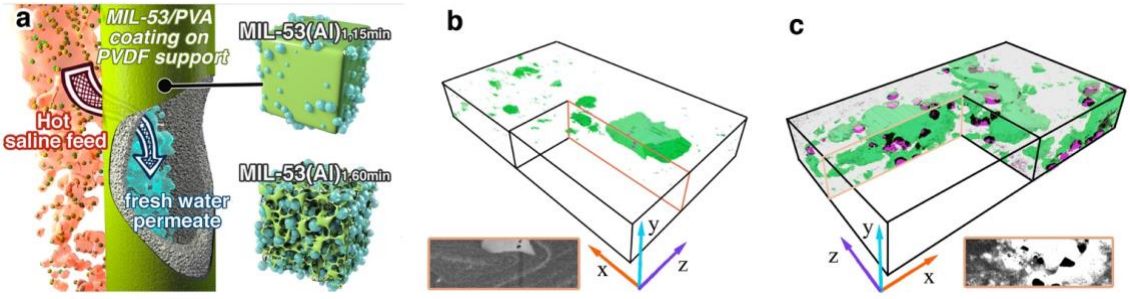


Figure 2. (a) Schematic diagram of the nanocomposite pervaporation membrane for brine treatment; (b, c) Surface-rendered views of the segmented FIB-SEM tomograms for mixed matrix membranes containing (b) MIL-53(Al)$_{1,15min}$ and (c) defective type MIL-53(Al)$_{1,60min}$ in PVA matrix. MOF particles are shown in green, while voids are shown in purple. The dimensions of the boxes shown in b and c along the x:y:z directions are 9.25, 1.5 and 5.0 µm, respectively. The insert are reference SEM images for the highlighted cross-sectional area.