A Novel MXene-Based Membrane with Exceptional Ion Transport and Long-Term Stability

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Abstract (Arial 10)

Achieving widespread adoption of ion-selective membranes for applications like energy harvesting is challenging due to the difficulty of simultaneously optimizing ion selectivity, overall performance, and cost [1–3]. To address this, we developed a novel hybrid ion-selective membrane, designated as SHMx, by incorporating 2D MXene nanosheets into a polymer matrix. The developed nanocomposite membrane was specifically engineered to overcome the performance limitations of conventional ion exchange membranes (IEMs) in reverse electrodialysis (RED) systems. The synthesized SHMx membranes demonstrated superior properties, including a high monovalent ion selectivity (t^+= 0.99 at a 50-fold concentration gradient) and low resistivity. These characteristics led to a significant improvement in energy conversion efficiency compared to commercial PSK membranes. Furthermore, the membranes exhibited robust mechanical strength and maintained operational stability in complex environments containing heavy metal ions and phenol. Our findings suggest that the integration of MXene provides a synergistic effect, creating interconnected nanochannels that facilitate efficient ion transport while maintaining high selectivity. This work presents a promising strategy for developing high-performance membranes for sustainable energy harvesting and various electrochemical applications by strategically leveraging the unique properties of 2D nanomaterials.

References

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Figures

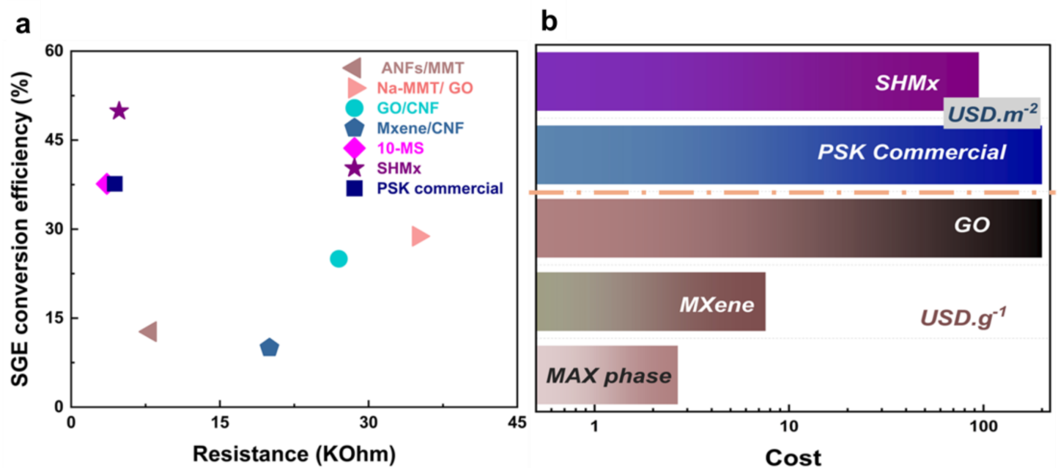

Figure 1: Figure S8. (a) Comparative plot of membrane resistivity and energy conversion efficiency of SHMx with those of commercial PSK CEM and other types of MMT and MXene-incorporated membranes (b) Unit cost of raw nanofiller materials per each mass (g) or unit cost of membranes per 1 m^2 area.