Supplementary Material

Proton Conducting Organic-Inorganic Composite Membranes for All-Vanadium Redox Flow Battery

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Supplementary Figures and Table

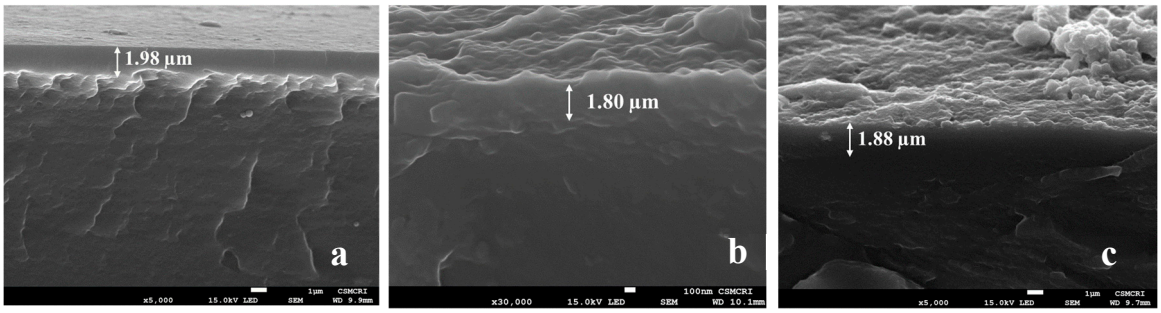

Figure S1. a-c, Cross-sectional SEM images of the membranes. PVA-SiO_2-Si, b. PVA-SiO_2-Zr and c. PVA-SiO_2-Sn.

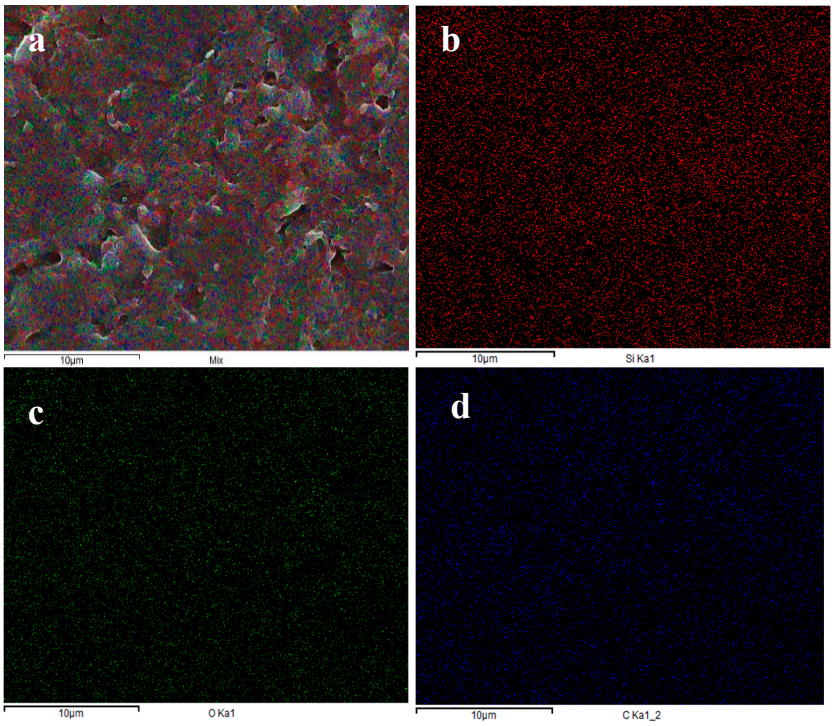

Figure S2: a. SEM image of PVA-SiO_2-Si and b–d. corresponding elemental mapping of Silica, oxygen, and carbon of PVA-SiO_2-Si.

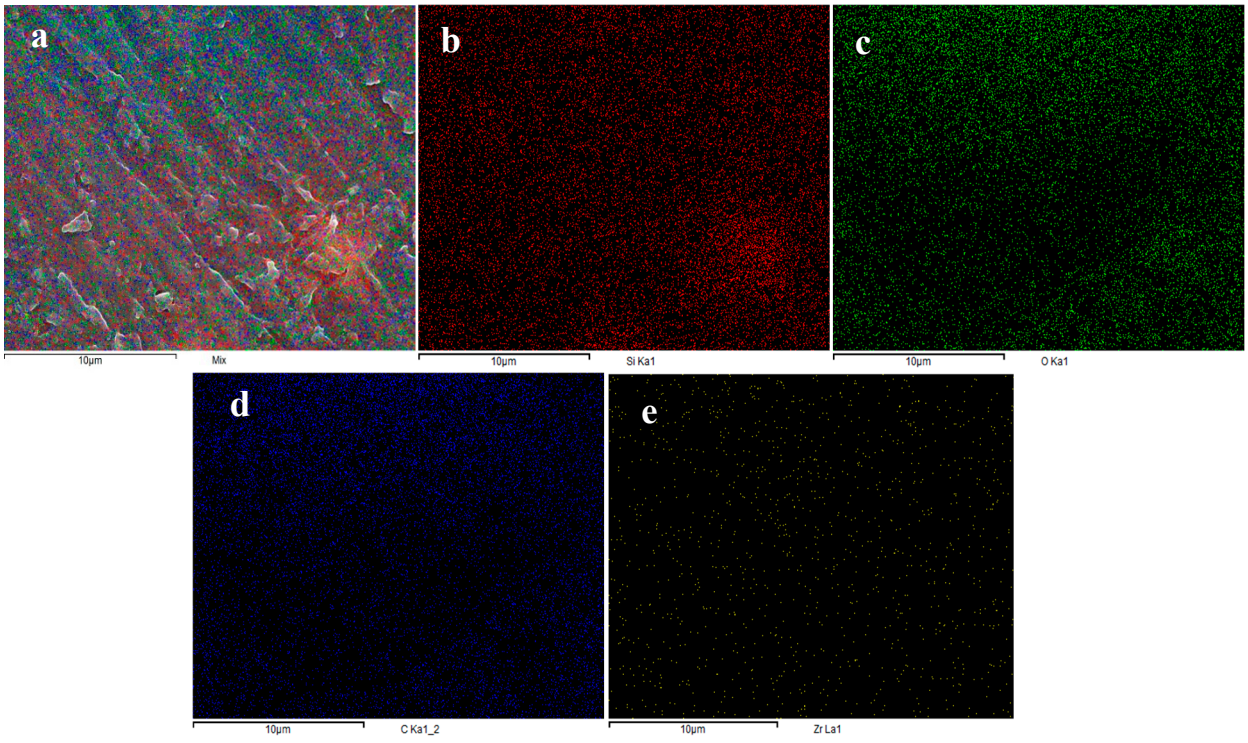

Figure S3: a. SEM image of PVA-SiO_2-Zr and b–e. corresponding elemental mapping of Silica, oxygen, carbon, and zirconium of PVA-SiO_2-Zr.

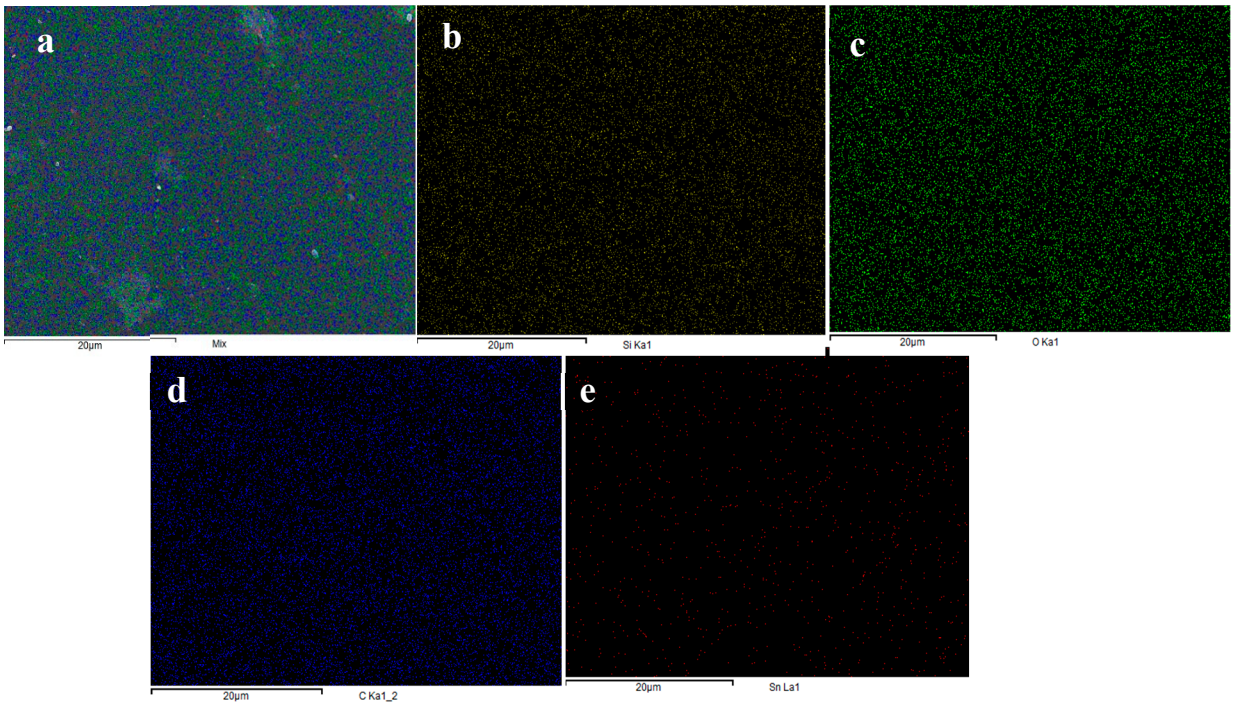

Figure S4: a. SEM image of PVA-SiO_2-Sn and b–e. corresponding elemental mapping of Silica, oxygen, carbon, and tin of PVA-SiO_2-Sn.

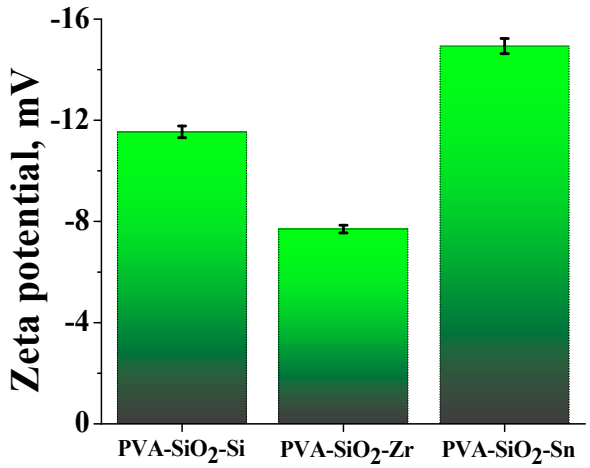

Figure S5. Zeta potential values of metal oxide coated PVA-SiO_2 membranes

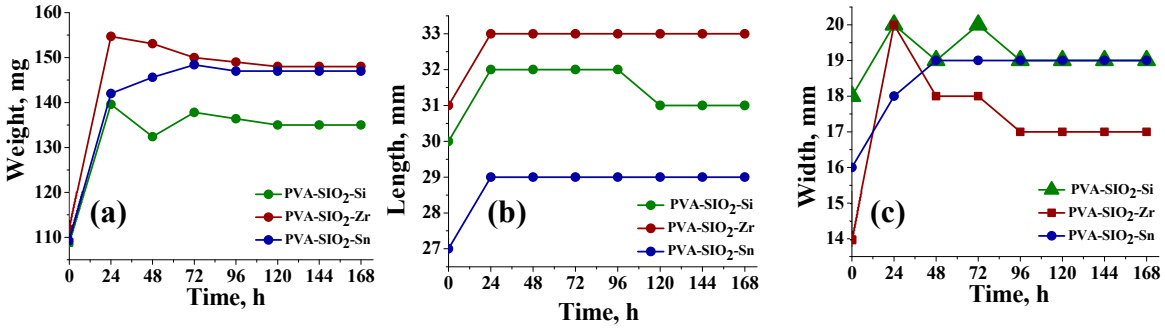

Figure S6: a. Weight; b. length and c. width of PVA-SiO_2-Si, PVA-SiO_2-Zr and PVA-SiO_2-Sn membranes as function of immersing time in 1.5 M VO_2^+ dissolved in 2 M H_2SO_4 solutions.

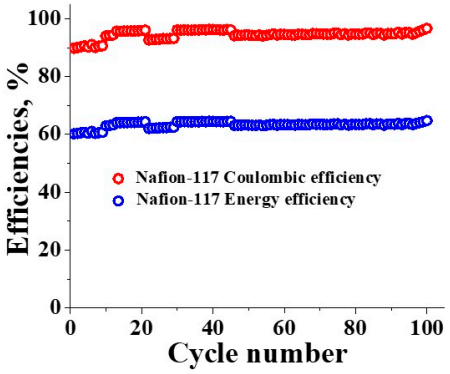

Figure S7. Cycling test of Nafion-117 at 100 mA cm^{-2}

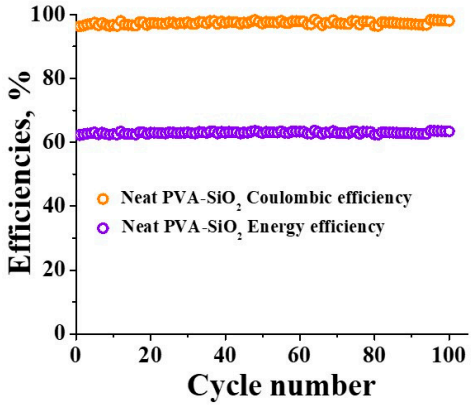

Figure S8. Cycling test of neat PVA-SiO_2 membrane at 100 mA cm^{-2}

Table S1: Comparison of through-plane conductivity and sulfuric acid (2 M) uptake values of the metal oxide coated membranes before and after VRFB study.

Membranes code	Conductivity (mS cm^{-1})		Conductivity retention after VRFB (%)	2 M sulfuric acid uptake (%)		Water uptake retention after VRFB (%)
	Before VRFB	After VRFB		Before VRFB	After VRFB	
PVA-SiO_2-Si	15.00	12.90	86.00	95.0	87.0	91.57
PVA-SiO_2-Zr	12.28	9.95	81.02	86.0	80.0	93.02
PVA-SiO_2-Sn	20.27	18.94	93.43	89.0	87.0	97.75