

Supplementary information

Design of Promising Green Cation Exchange Membranes Based Sulfonated PVA and Doped with Nano Sulfated Zirconia for Direct Borohydride Fuel Cells

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Supplementary information

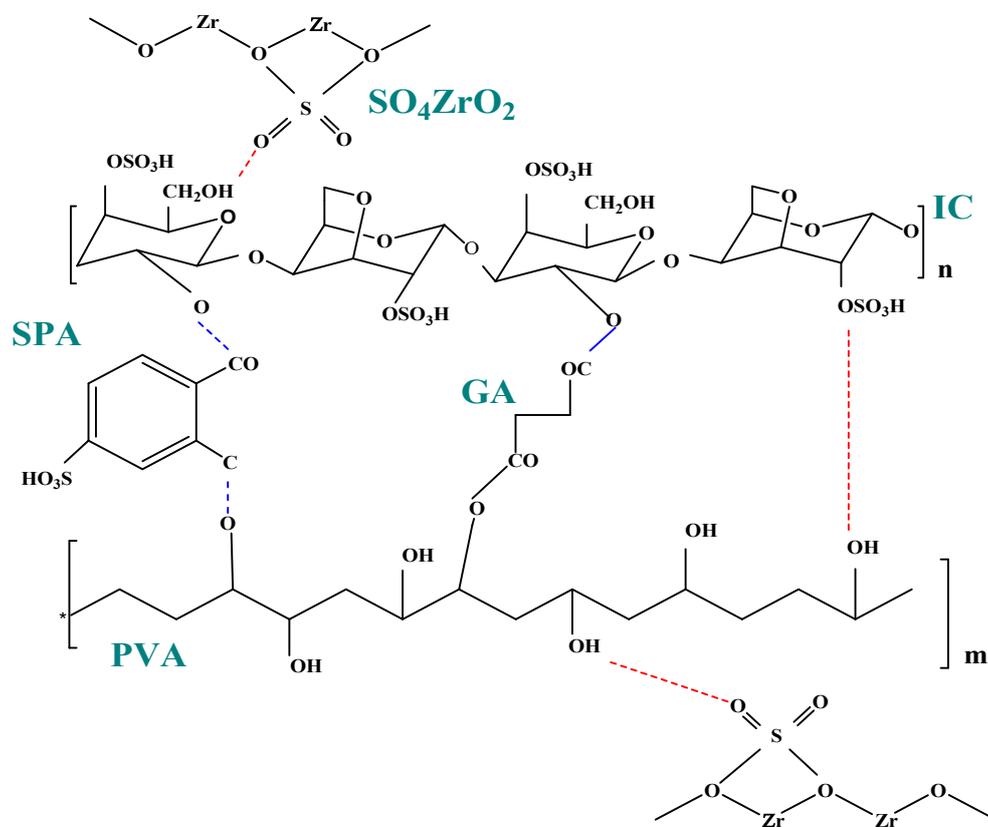


Figure S1: Possible structure of the S-PVA/ IC/ SO₄ZrO₂ membrane

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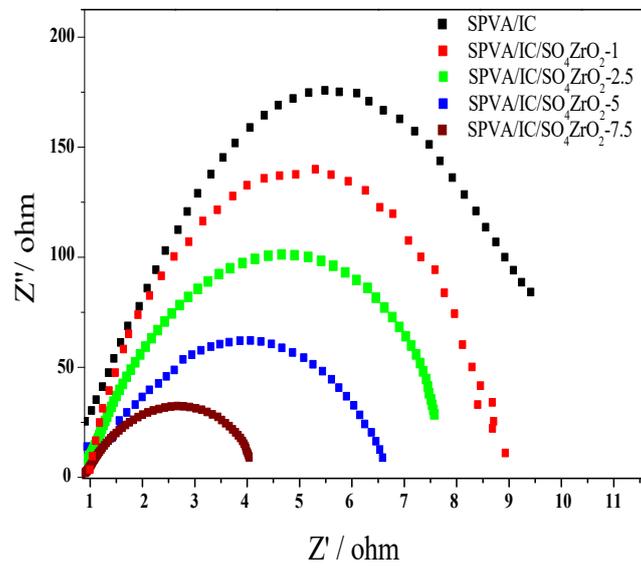


Figure S2: Nyquist plot of S-PVA/IC and S-PVA/IC/SO₄ZrO₂ nanocomposite membranes.

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Table S1: Physicochemical properties of the fabricated membranes and Nafion 117.

Membrane	Thickness (μm)	WU (%)**	SR (%)**	Contact angle (°)**	Tensile strength (MPa)**	Oxidative stability (RW, %)**
S-PVA/IC	110	> 100	90±0.3	45.36±0.1	12.2±0.4	81±0.63
S-PVA/IC/ SO ₄ ZrO ₂ -1	154	95±0.5	40±0.2	47.53±0.1	20.9±0.4	90±0.63
S-PVA/IC/ SO ₄ ZrO ₂ - 2.5	169	40±0.2	32±0.1	50.86±0.1	28.3±0.4	93±0.63
S-PVA/IC/ SO ₄ ZrO ₂ - 5	173	28±0.1	20±0.1	52.21±0.1	34.3±0.4	97±0.63
S-PVA/IC/ SO ₄ ZrO ₂ -7.5	179	22±0.08	16±0.1	60.60±0.1	38.5±0.4	99±0.63
Nafion 117	170	9.5	13	102	25	92

*The retained weight of membranes (RW) after immersion for a day in Fenton's reagent.

**The measurements were replicated three times for the same prepared membranes and the standard deviation was evaluated accordingly for all tests.

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Table S2: Ionic conductivity, Borohydride permeability, IEC and selectivity of the fabricated membranes and Nafion 117.

Membrane	IEC (meq g ⁻¹)*	Ionic conductivity (mS cm ⁻¹)*	Borohydride permeability (10 ⁻⁶ cm ² s ⁻¹)	Selectivity (10 ⁵ S cm ⁻³ s)
S-PVA/IC	0.12±0.28	8.1±0.13	3.8	0.021
S-PVA/IC/ SO ₄ ZrO ₂ -1	0.13±0.28	10.6±0.13	0.31	0.34
S-PVA/IC/ SO ₄ ZrO ₂ - 2.5	0.15±0.28	12.9±0.13	0.29	0.44
S-PVA/IC/ SO ₄ ZrO ₂ - 5	0.21±0.28	14.8±0.13	0.23	0.64
S-PVA/IC/ SO ₄ ZrO ₂ -7.5	0.24±0.28	21.6±0.13	0.10	2.16
Nafion 117	0.89	45.0	0.40	1.12

*The measurements were replicated three times for the same prepared membranes and the standard deviation was evaluated accordingly for all tests.