

Assessment of Dye-absorbed Eggshell Membrane Composites as Solid Polymer Electrolyte of Fuel Cells

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Figure S1. Preparation of the ESM. (a) the boiled egg immersed in 2 M HCl. (b) The belt-like ESM. (c) The square-shaped ESM.

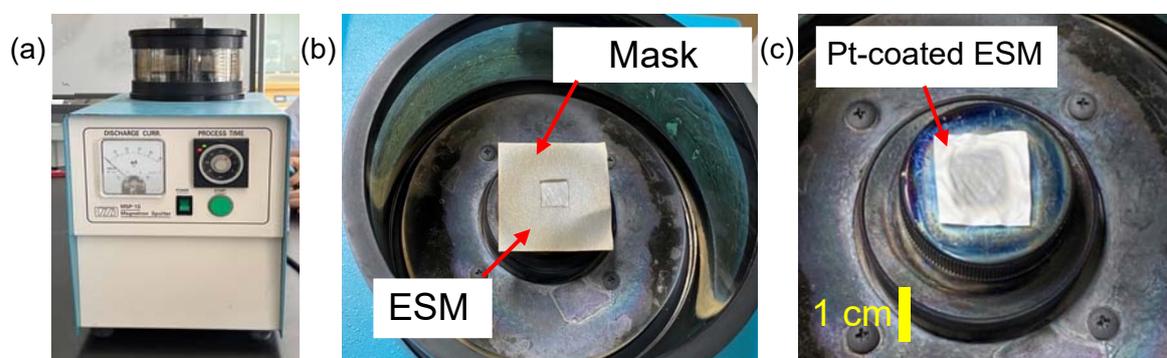


Figure S2. The Pt-sputter coating method. (a) The photograph of the magnetron sputtering equipment, MSP-1S. (b) The ESM covered with the mask to sputter Pt. (c) The Pt-coated ESM.

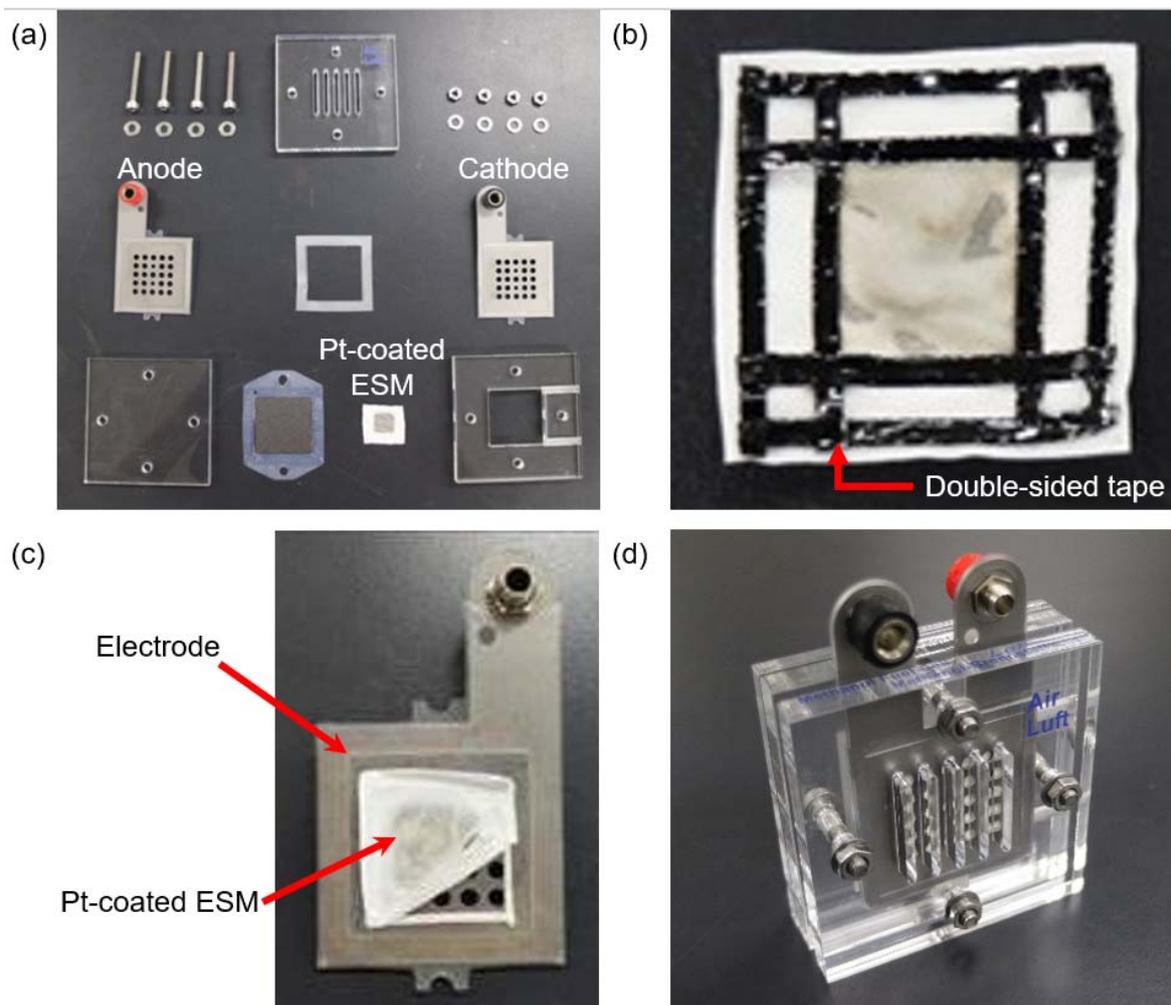


Figure S3. (a) The assembly of the PEFCs using ESM. (a) The components of the PEFC. (b) The Pt-coated ESM attached with the double-sided tapes. (c) Pt-coated ESM attached to the electrode. (d) The assembled PEFC.

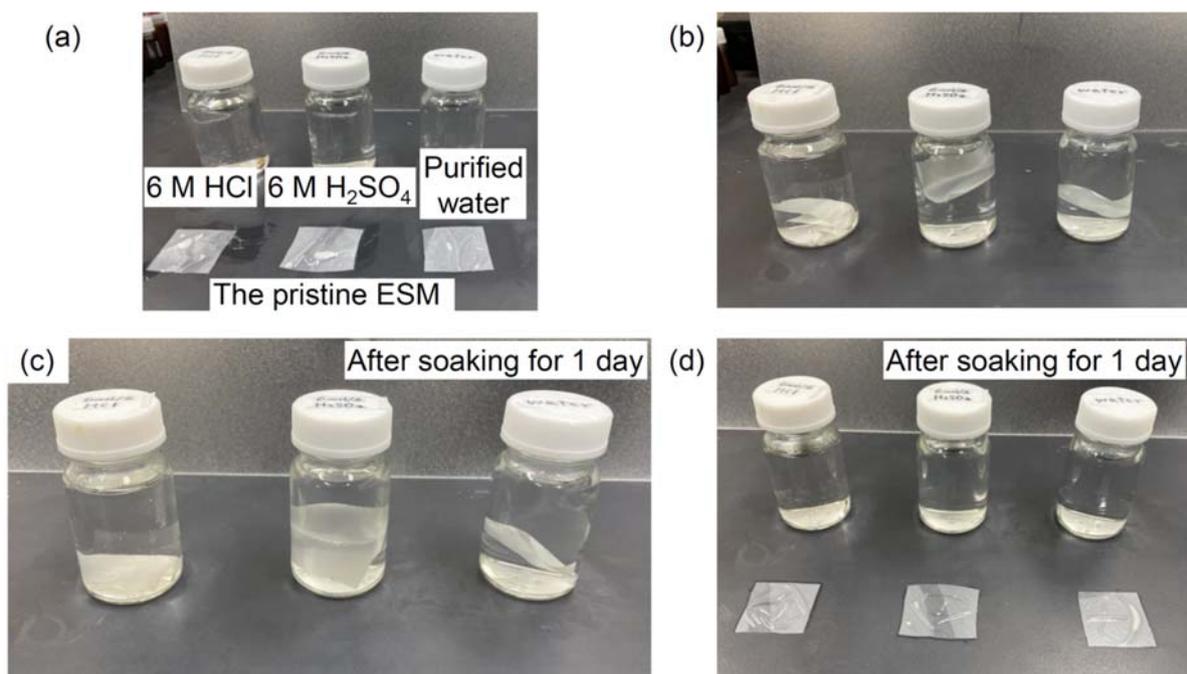


Figure S4. The chemical stability of the pristine ESM to strong acids (HCl and H₂SO₄). (a) Before soaking the pristine ESM in 6 M HCl, 6 M H₂SO₄, and purified water. (b) The pristine ESM soaked in 6 M HCl, 6 M H₂SO₄, and purified water. (a) The pristine ESM soaked in 6 M HCl, 6 M H₂SO₄, and purified water for one day. (d) After soaking the pristine ESM in 6 M HCl, 6 M H₂SO₄, and purified water.

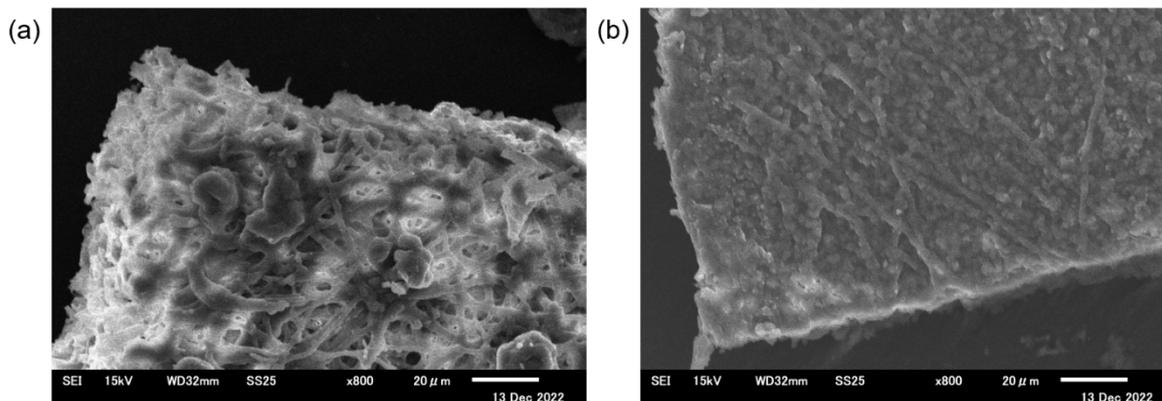


Figure S5. SEM images of the front (a) and back (b) of the pristine ESM. The ESM has the interwoven fiber structure with too tiny pores to observe by using SEM.

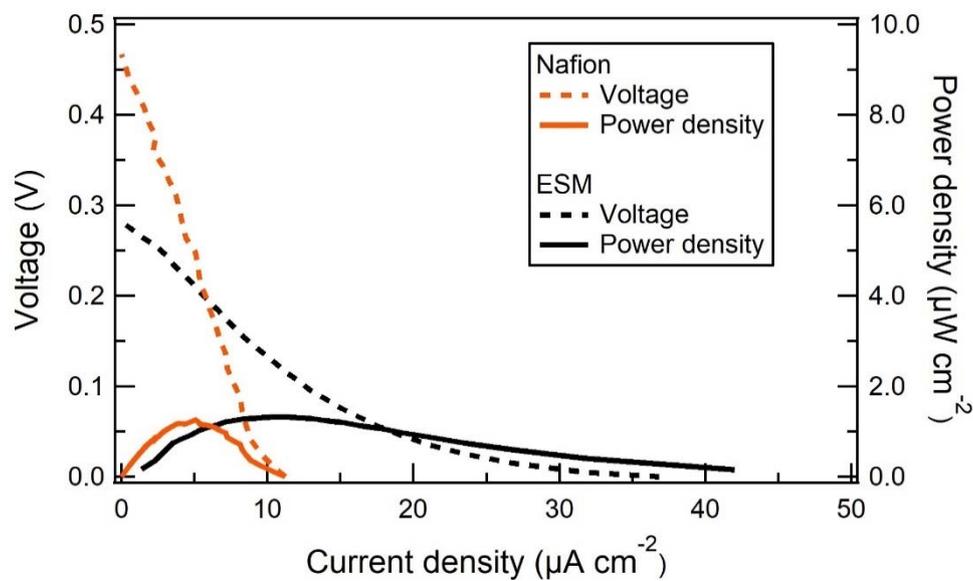


Figure S6. The *I-V* curve of the FC using Nafion.

Table S1. Comparison of performances among the ionomer-free PEMFCs.

Materials	Pt loading [$\mu\text{g cm}^{-2}$]	Maximum power density [W cm^{-2}]	Ref
MPL2A	8.5	1.0-1.2	28
MPL2B	3.4	0.5-0.7	
Sputtered-Pt/C	20	1.24	29
CeO _y /CN _x	1.7	0.54-0.65	30
ESM	30	1.32×10^{-6}	This work
Erythrosine-ESM	30	4.88×10^{-6}	This work
Acid Red 52-ESM	30	7.23×10^{-6}	This work
Brilliant Blue FCF-ESM	30	3.25×10^{-6}	This work
Fast Green FCF-ESM	30	2.61×10^{-6}	This work
Tartrazine-ESM	30	3.25×10^{-6}	This work
Sunset Yellow FCF- ESM	30	3.99×10^{-6}	This work

MPL: carbon microporous layer