Supplementary Information

Surfactant-Assisted Perovskite Nanofillers Incorporated in Quaternized Poly(vinyl Alcohol) Composite Membrane as an Effective Hydroxide-Conducting Electrolyte

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Table S1. Typical open-circuit voltage and experimental error values[a] of direct alkaline methanol fuel cell[b] using pristine QPVA, QPVA/CTAB-coated $LaFeO_3$, and QPVA/annealed $LaFeO_3$ nanocomposite membrane.

Temperature	QPVA membrane			QPVA/CTAB-coated $LaFeO_3$			QPVA/annealed $LaFeO_3$		
	Methanol molar concentrations in 6 M KOH								
	1 M	**2 M**	**4 M**	**1 M**	**2 M**	**4 M**	**1 M**	**2 M**	**4 M**
30°C	0.61 ±0.01	0.63 ±0.005	0.51 ±0.004	0.62 ±0.004	0.65 ±0.014	0.65 ±0.014	0.61 ±0.021	0.62 ±0.013	0.64 ±0.008
60°C	0.55 ±0.002	0.73 ±0.028	0.72 ±0.004	0.67 ±0.016	0.81 ±0.013	0.80 ±0.002	0.67 ±0.016	0.73 ±0.024	0.80 ±0.003
70°C	0.51 ±0.009	0.73 ±0.014	0.73 ±0.002	0.67 ±0.007	0.79 ±0.007	0.80 ±0.026	0.67 ±0.025	0.72 ±0.004	0.75 ±0.043

[a] Mean ± standard deviation in open-circuit voltage (V), N=3.
[b] Operating conditions: catalysts of 2 mg cm^{-2} PtRu/C for anode and 1 mg cm^{-2} Pt/C for cathode on MPL-free carbon cloth. Anode fuel: 1, 2, and 4 M methanol in 6 M KOH with a flow rate of 5 mL min^{-1}. Cathode: Humidified oxygen with a flow rate of 100 mL min^{-1}.

Table S2. Typical maximum power densities and experimental error values[a] of direct alkaline methanol fuel cell[b] using pristine QPVA, QPVA/CTAB-coated $LaFeO_3$ and QPVA/annealed $LaFeO_3$ nanocomposite membranes.

Temperature	QPVA membrane			QPVA/CTAB-coated $LaFeO_3$			QPVA/annealed $LaFeO_3$		
	Methanol molar concentration in 6 M KOH								
	1 M	**2 M**	**4 M**	**1 M**	**2 M**	**4 M**	**1 M**	**2 M**	**4 M**
30°C	30	54.6	75	30	75.7	108.3	27.5	55	95.6
	±7.0	±8.7	±3.6	±7.2	±8.0	±5.0	±6.3	±8.1	±5.1
60°C	90	169.5	154.5	183	256	269.6	179.5	193	249.3
	±4.5	±2.0	±0.7	±5.6	±5.8	±2.0	±4.9	±1.2	±5.0
70°C	71.5	139	169.5	184	247.5	238.6	166	157.5	184.5
	±4.9	±2.1	±1.6	±5.5	±0.7	±2.7	±0.1	±6.3	±7.6

[a] Mean ± standard deviation in power densities (mW cm^{-2}), N=3.

[b] Operating conditions: catalysts of 2 mg cm^{-2} PtRu/C for anode and 1 mg cm^{-2} Pt/C for cathode on MPL-free carbon cloth. Anode fuel: 1, 2, and 4 M methanol in 6 M KOH with a flow rate of 5 mL min^{-1}. Cathode: Humidified oxygen with a flow rate of 100 mL min^{-1}.

Table S3. Ionic conductivity values (in mS cm^{-1}) of different composite membranes at 30-60°C.

Membrane	30°C	40°C	50°C	60°C
Pristine PVA	1.80	1.83	1.86	1.89
PVA/0.05% CTAB	2.99 (66%)[a]	3.62 (98%)	3.75 (100%)	3.77 (100%)
PVA/0.05% $LaFeO_3$	3.95 (120%)	4.06 (120%)	4.33 (130%)	4.71 (150%)
PVA/0.1% pristine $LaFeO_3$ with CTAB	8.65 (380%)	10.50 (470%)	11.50 (520%)	11.6 (510%)
PVA/0.1% pristine $LaFeO_3$ without CTAB	4.18 (130%)	6.01 (230%)	7.02 (280%)	7.29 (290%)
PVA/0.1% annealed $LaFeO_3$	7.20 (300%)	7.25 (300%)	7.36 (300%)	7.56 (300%)

[a] Values in parentheses are the increases percentage compared to pristine PVA conductivity at corresponding temperature.

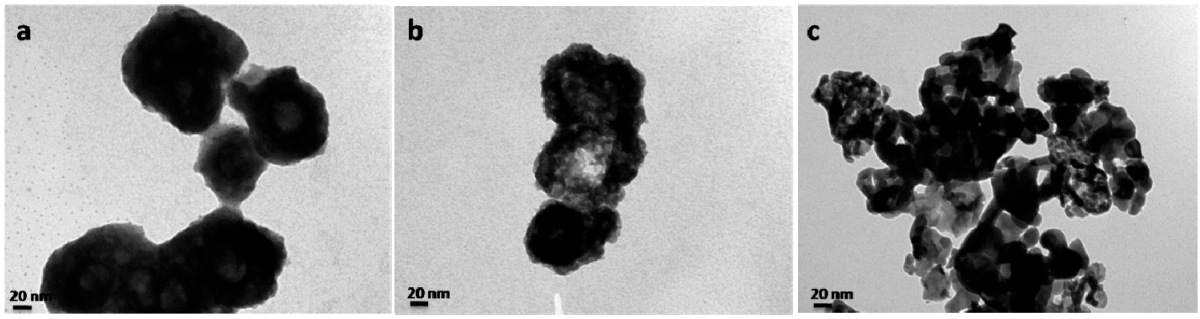

Figure S1. TEM microscopic images of (a) 200°C, (b) 400°C, and (c) 600°C annealed $LaFeO_3$ nanoparticles.

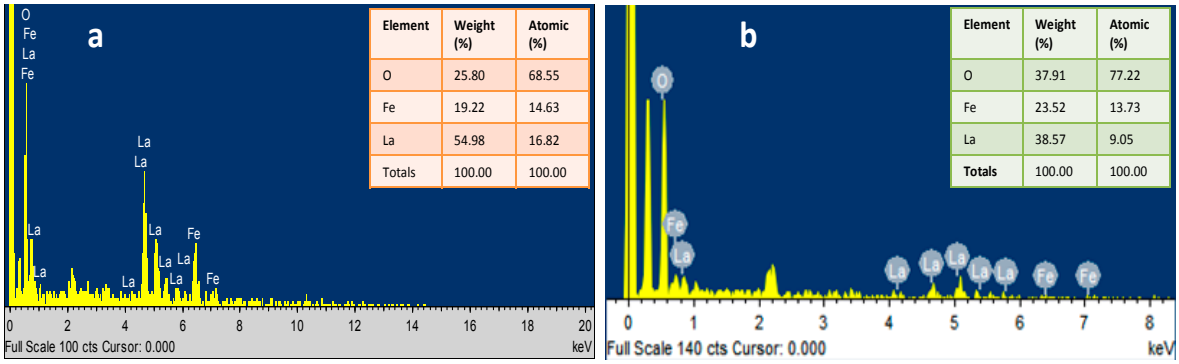

Figure S2. EDX spectrum of (a) CTAB-coated $LaFeO_3$ and (b) 800°C annealed $LaFeO_3$ nanoparticles.

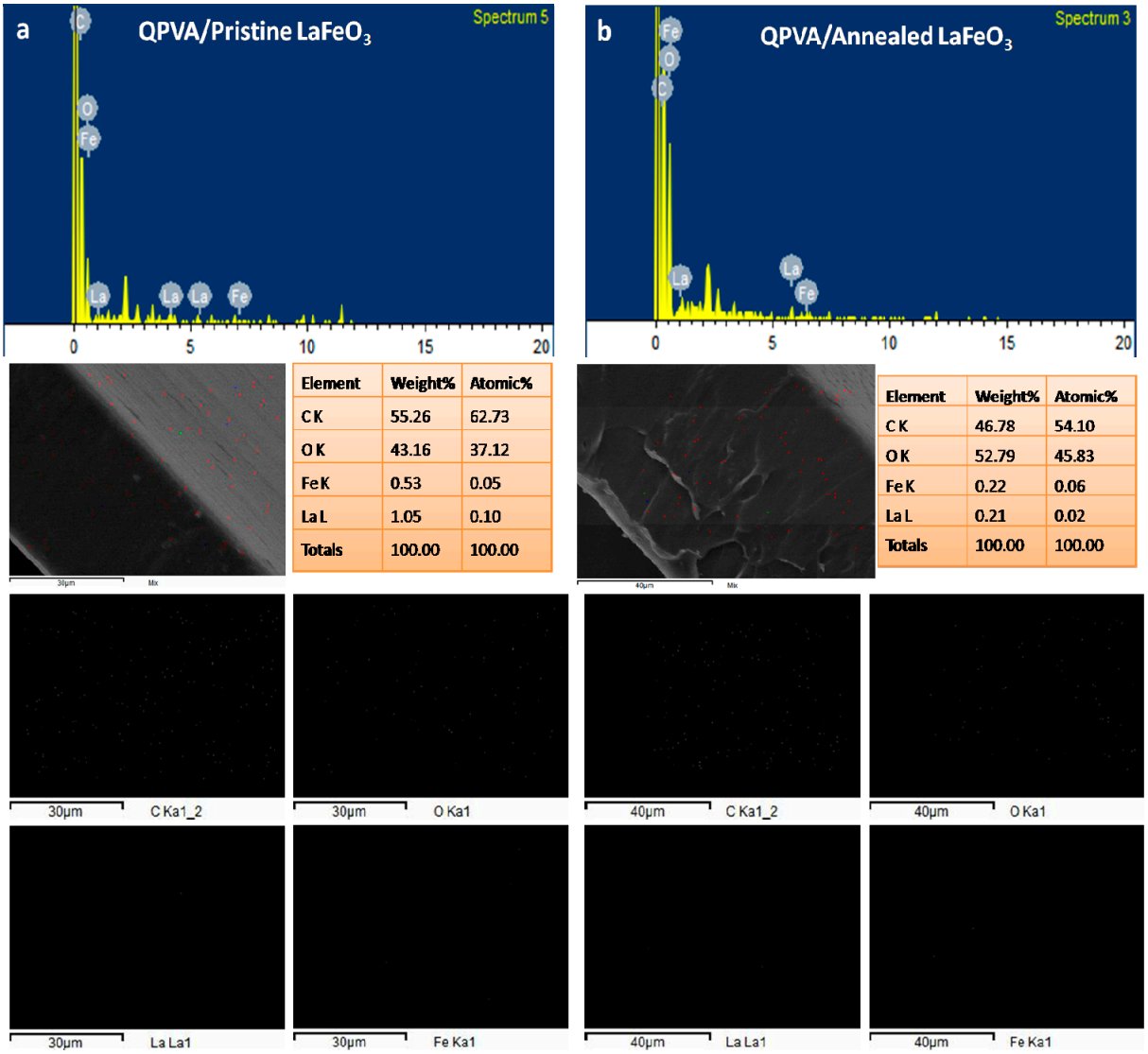

Figure S3. EDX graphs and EDX mapping of (a) QPVA/CTAB-coated $LaFeO_3$ and (b) QPVA/annealed $LaFeO_3$ nanocomposite membranes.

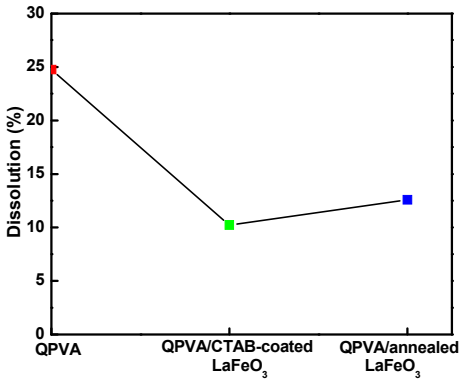

Figure S4. Dissolution of KOH-doped QPVA, QPVA/CTAB-coated $LaFeO_3$, and QPVA/annealed $LaFeO_3$ nanocomposite membranes in 25°C water for 72 h.

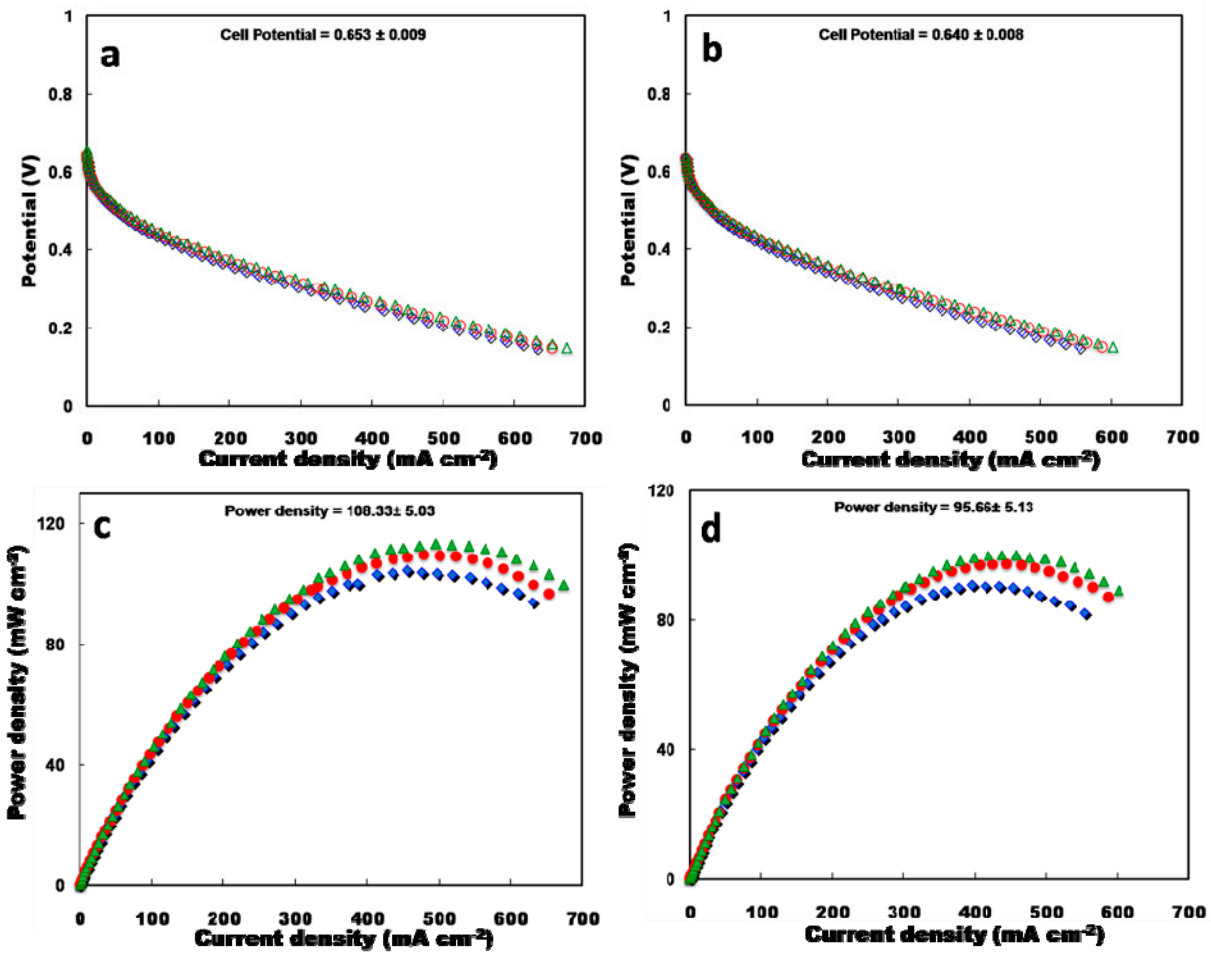

Figure S5. Replicate DAMFC runs using QPVA/CTAB-coated $LaFeO_3$ and QPVA/annealed $LaFeO_3$ nanocomposite membrane: (a,b) cell potential *vs.* current density and (c,d) power density *vs.* current density curves (N = 3, temperature = 30°C).

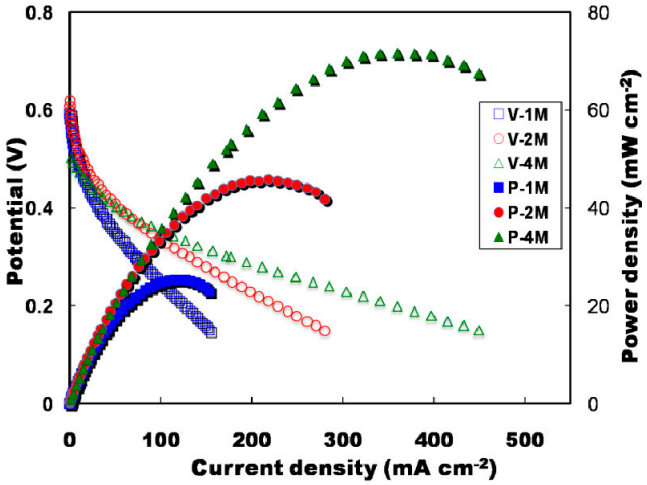

Figure S6. Direct alkaline methanol fuel cell voltage (left axis) and power density (right axis) as a function of current density at 30°C using a QPVA electrolyte.

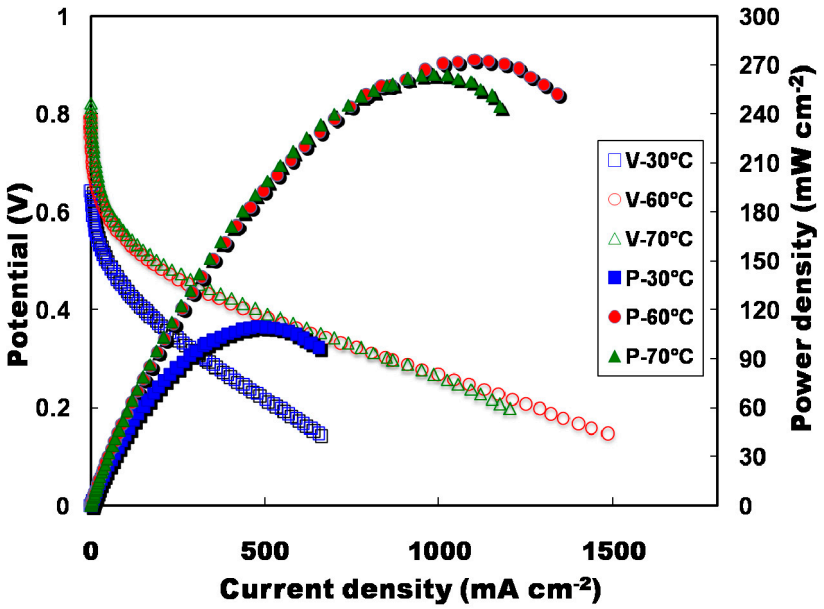

Figure S7. Direct alkaline methanol fuel cell voltage (left axis) and power density (right axis) as a function of current density at different temperatures using QPVA/CTAB-coated $LaFeO_3$ electrolyte.