

Supplementary material

Improved the Methanol Electro-Oxidation and Carbon Monoxide Tolerance for Direct Methanol Fuel Cells Using Strontium Molybdate

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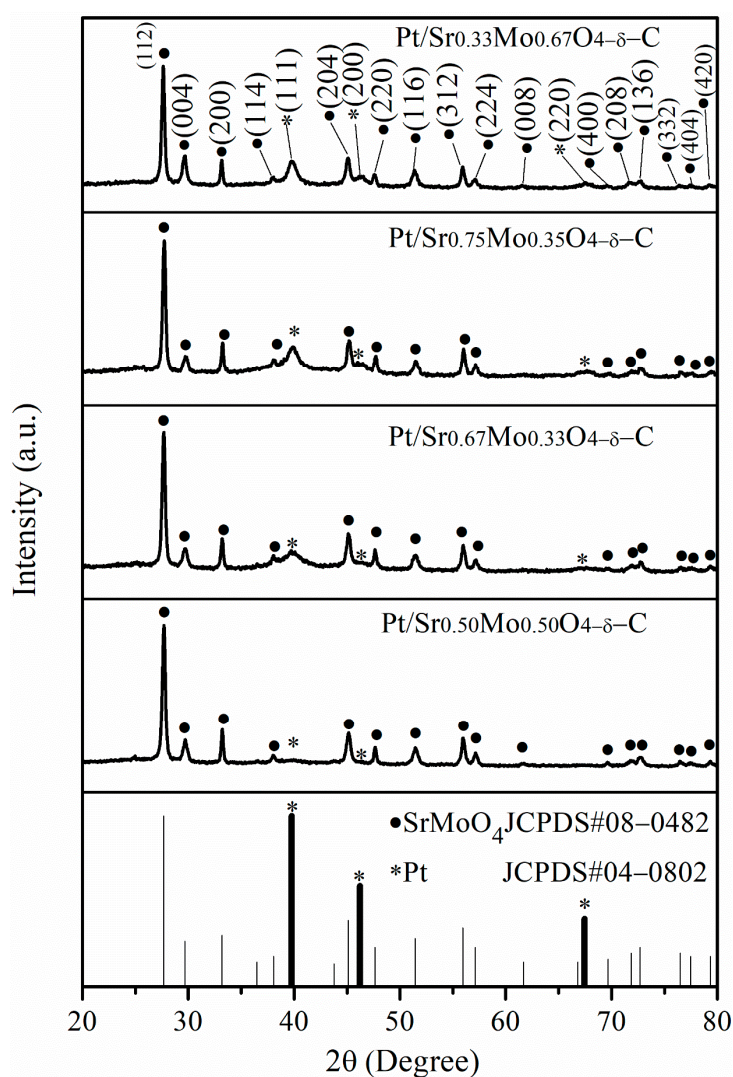
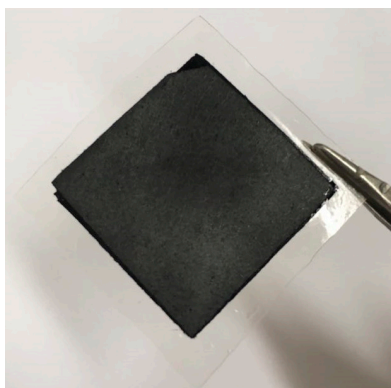
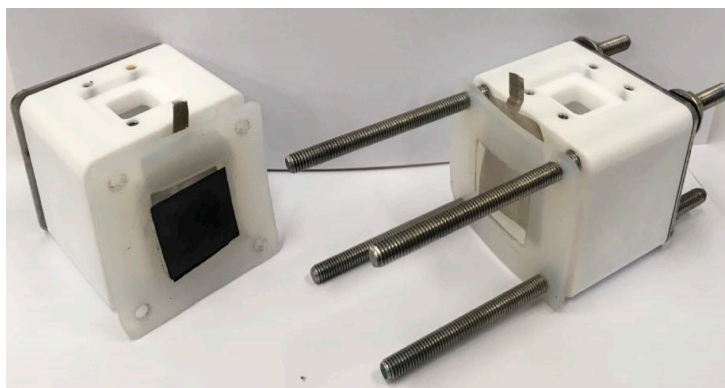


Figure S1. XRD of various electrocatalysts, the * symbol means Pt structure, and • symbol means SrMoO₄ form.



(a)



(b)

Figure S2. (a) MEA and (b) simple single DMFC assembly.

Table S1. The peak fitting for various electrocatalysts in the Mo 3d region

Electrocatalysts	Peak	Position (eV)	FWHM (eV)	Doublet separation (eV)
20%-Pt/uncalcined $\text{Sr}_{0.5}\text{Mo}_{0.5}\text{O}_{4-\delta}\text{-C}$	$\text{Mo}^{5+}(3d_{5/2})$	232.76	1.2	3.13
	$\text{Mo}^{5+}(3d_{3/2})$	235.89	1.2	
	$\text{Mo}^{6+}(3d_{5/2})$	234.19	1.9	3.13
	$\text{Mo}^{6+}(3d_{3/2})$	237.32	1.9	
20%-Pt/ 200°C $\text{Sr}_{0.5}\text{Mo}_{0.5}\text{O}_{4-\delta}\text{-C}$	$\text{Mo}^{5+}(3d_{5/2})$	232.90	1.6	3.13
	$\text{Mo}^{5+}(3d_{3/2})$	236.10	1.6	
	$\text{Mo}^{6+}(3d_{5/2})$	234.10	1.4	3.13
	$\text{Mo}^{6+}(3d_{3/2})$	237.15	1.4	
20%-Pt/ 400°C $\text{Sr}_{0.5}\text{Mo}_{0.5}\text{O}_{4-\delta}\text{-C}$	$\text{Mo}^{5+}(3d_{5/2})$	233.75	2.3	3.13
	$\text{Mo}^{5+}(3d_{3/2})$	236.88	2.3	
	$\text{Mo}^{6+}(3d_{5/2})$	234.77	2.4	3.13
	$\text{Mo}^{6+}(3d_{3/2})$	238.00	2.4	
20%-Pt/ $\text{Sr}_{0.33}\text{Mo}_{0.67}\text{O}_{4-\delta}\text{-C}$	$\text{Mo}^{5+}(3d_{5/2})$	232.80	1.3	3.13
	$\text{Mo}^{5+}(3d_{3/2})$	235.93	1.3	
	$\text{Mo}^{6+}(3d_{5/2})$	24.10	1.4	3.13
	$\text{Mo}^{6+}(3d_{3/2})$	237.2	1.4	
20%-Pt/ $\text{Sr}_{0.67}\text{Mo}_{0.33}\text{O}_{4-\delta}\text{-C}$	$\text{Mo}^{5+}(3d_{5/2})$	232.86	1.4	3.13
	$\text{Mo}^{5+}(3d_{3/2})$	236.04	1.0	
	$\text{Mo}^{6+}(3d_{5/2})$	234.00	1.2	3.13
	$\text{Mo}^{6+}(3d_{3/2})$	237.13	1.2	
20%- $\text{Sr}_{0.75}\text{Mo}_{0.25}\text{O}_{4-\delta}\text{-C}$	$\text{Mo}^{5+}(3d_{5/2})$	233.20	1.3	3.13
	$\text{Mo}^{5+}(3d_{3/2})$	236.33	1.3	

	Mo ⁶⁺ (3d _{5/2})	234.30	2.4	3.13
	Mo ⁶⁺ (3d _{3/2})	237.23	2.4	

Table S2. The peak fitting for various electrocatalysts in the Sr 3d region

Electrocatalysts	Peak	Position (eV)	FWHM (eV)	Doublet separation (eV)
20%-Pt/uncalcined Sr _{0.5} Mo _{0.5} O _{4-δ} -C	SrO(3d _{5/2})	132.90	1.9	1.79
	SrO (3d _{3/2})	134.69	1.9	
20%-Pt/ 200°C Sr _{0.5} Mo _{0.5} O _{4-δ} -C	SrO(3d _{5/2})	132.95	1.8	1.79
	SrO (3d _{3/2})	134.74	1.8	
20%-Pt/ 400°C Sr _{0.5} Mo _{0.5} O _{4-δ} -C	SrO(3d _{5/2})	132.90	1.6	1.79
	SrO (3d _{3/2})	134.69	1.6	
	SrCO ₃ (3d _{5/2})	133.90	1.1	1.79
	SrCO ₃ (3d _{3/2})	135.69	1.1	
20%-Pt/Sr _{0.33} Mo _{0.67} O _{4-δ} -C	SrO(3d _{5/2})	132.80	1.0	1.79
	SrO (3d _{3/2})	134.59	1.3	
20%-Pt/Sr _{0.67} Mo _{0.33} O _{4-δ} -C	SrO(3d _{5/2})	132.85	1.3	1.79
	SrO (3d _{3/2})	135.44	1.3	
	SrCO ₃ (3d _{5/2})	133.80	1.7	1.79
	SrCO ₃ (3d _{3/2})	135.59	1.7	
20%-Sr _{0.75} Mo _{0.25} O _{4-δ} -C	SrO(3d _{5/2})	133.00	1.6	1.79
	SrO (3d _{3/2})	134.79	1.7	

Table S3. The peak fitting for various electrocatalysts in the Pt 4f region

Electrocatalysts	Peak	Position (eV)	FWHM (eV)	Doublet separation (eV)
Pt/C	Pt ⁰ (4f _{7/2})	71.25	1.3	3.33
	Pt ⁰ (4f _{5/2})	74.58	1.3	
	Pt ²⁺ (4f _{7/2})	72.34	2.0	3.33
	Pt ²⁺ (4f _{5/2})	75.67	2.0	
	Pt ⁴⁺ (4f _{7/2})	74.24	1.3	3.33
	Pt ⁴⁺ (4f _{5/2})	77.57	1.3	
20%-Pt/uncalcined Sr _{0.5} Mo _{0.5} O _{4-δ} -C	Pt ⁰ (4f _{7/2})	71.17	1.1	3.33
	Pt ⁰ (4f _{5/2})	74.50	1.1	
	Pt ²⁺ (4f _{7/2})	72.22	1.5	3.33
	Pt ²⁺ (4f _{5/2})	75.55	1.5	
	Pt ⁴⁺ (4f _{7/2})	73.87	1.3	3.33
	Pt ⁴⁺ (4f _{5/2})	77.20	1.3	
20%-Pt/ 200°C	Pt ⁰ (4f _{7/2})	71.47	1.0	3.33

$\text{Sr}_{0.5}\text{Mo}_{0.5}\text{O}_{4-\delta}\text{-C}$	$\text{Pt}^0(4f_{5/2})$	74.76	1.0	
	$\text{Pt}^{2+}(4f_{7/2})$	72.25	2.3	3.33
	$\text{Pt}^{2+}(4f_{5/2})$	75.58	2.3	
	$\text{Pt}^{4+}(4f_{7/2})$	74.01	2.2	3.33
	$\text{Pt}^{4+}(4f_{5/2})$	77.34	2.2	
20%-Pt/ 400°C $\text{Sr}_{0.5}\text{Mo}_{0.5}\text{O}_{4-\delta}\text{-C}$	$\text{Pt}^0(4f_{7/2})$	71.40	1.1	3.33
	$\text{Pt}^0(4f_{5/2})$	74.73	1.1	
	$\text{Pt}^{2+}(4f_{7/2})$	72.31	1.9	3.33
	$\text{Pt}^{2+}(4f_{5/2})$	75.64	1.9	
	$\text{Pt}^{4+}(4f_{7/2})$	74.28	2.7	3.33
	$\text{Pt}^{4+}(4f_{5/2})$	77.61	2.7	
20%-Pt/ $\text{Sr}_{0.33}\text{Mo}_{0.67}\text{O}_{4-\delta}\text{-C}$	$\text{Pt}^0(4f_{7/2})$	71.30	1.0	3.33
	$\text{Pt}^0(4f_{5/2})$	74.53	1.0	
	$\text{Pt}^{2+}(4f_{7/2})$	72.00	1.7	3.33
	$\text{Pt}^{2+}(4f_{5/2})$	75.33	1.7	
	$\text{Pt}^{4+}(4f_{7/2})$	73.97	2.4	3.33
	$\text{Pt}^{4+}(4f_{5/2})$	77.30	2.4	
20%-Pt/ $\text{Sr}_{0.67}\text{Mo}_{0.33}\text{O}_{4-\delta}\text{-C}$	$\text{Pt}^0(4f_{7/2})$	71.20	1.0	3.33
	$\text{Pt}^0(4f_{5/2})$	74.13	1.0	
	$\text{Pt}^{2+}(4f_{7/2})$	72.10	1.7	3.33
	$\text{Pt}^{2+}(4f_{5/2})$	75.43	1.7	
	$\text{Pt}^{4+}(4f_{7/2})$	73.94	2.0	3.33
	$\text{Pt}^{4+}(4f_{5/2})$	77.27	2.0	
20%- $\text{Sr}_{0.75}\text{Mo}_{0.25}\text{O}_{4-\delta}\text{-C}$	$\text{Pt}^0(4f_{7/2})$	71.19	1.1	3.33
	$\text{Pt}^0(4f_{5/2})$	74.52	1.1	
	$\text{Pt}^{2+}(4f_{7/2})$	72.10	1.7	3.33
	$\text{Pt}^{2+}(4f_{5/2})$	75.43	1.7	
	$\text{Pt}^{4+}(4f_{7/2})$	73.97	1.4	3.33
	$\text{Pt}^{4+}(4f_{5/2})$	77.30	1.4	