

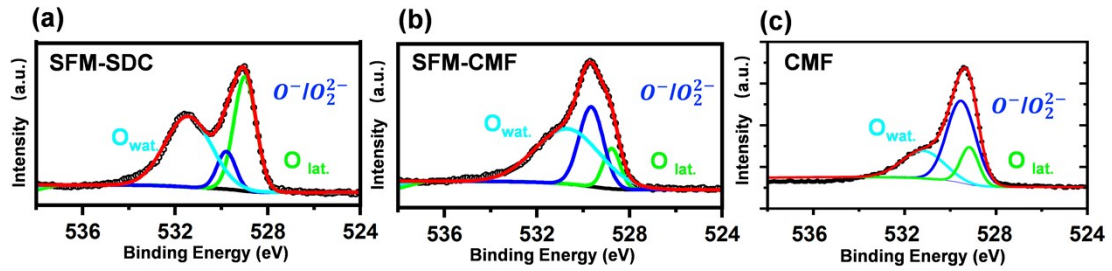
## **Supplementary Materials**

### **Composite of Perovskite and Fluorite Fuel Electrodes for Efficient Carbon Dioxide electrolysis in Solid Oxide Electrolyzer Cells**

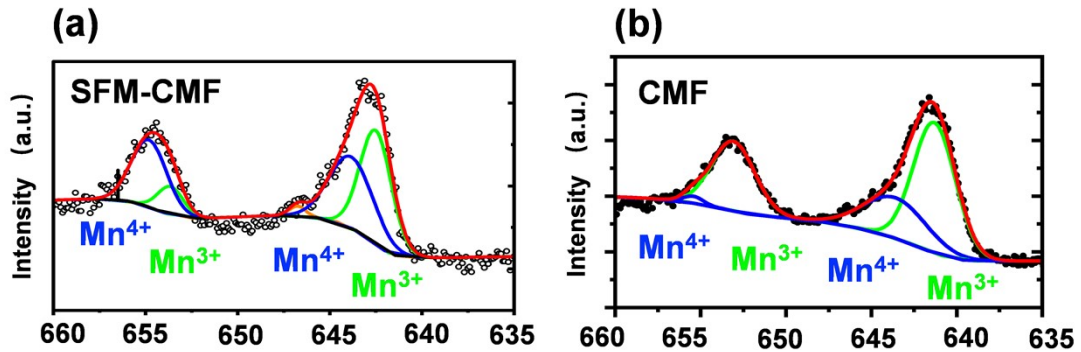
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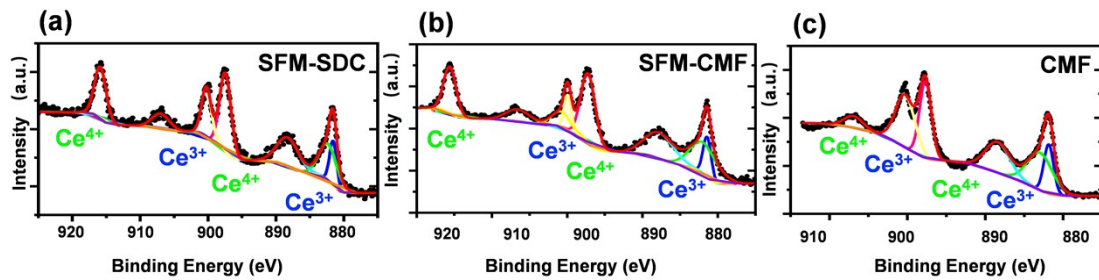
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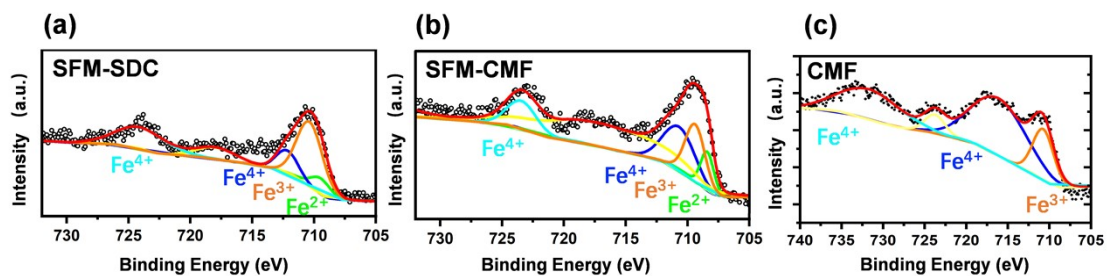
**Fig. S1** - XPS spectra of O 1s on (a) SFM-SDC, (b) SFM-CMF, (c) CMF electrodes.



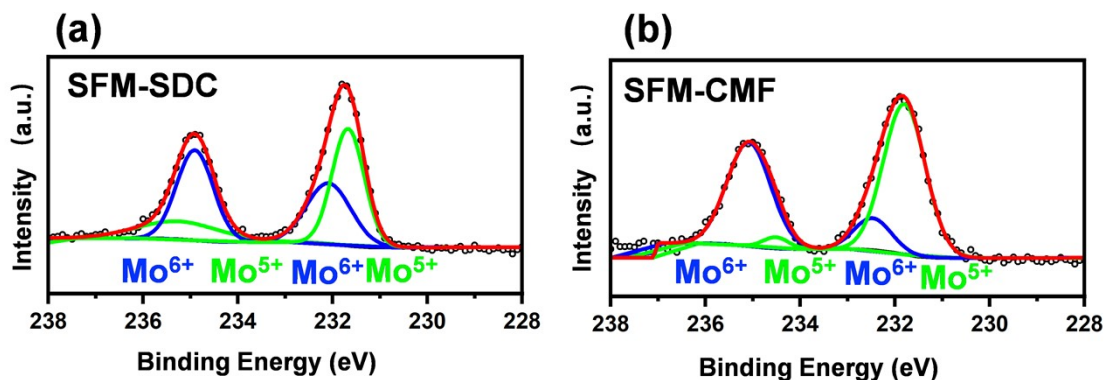
**Fig. S2** - XPS spectra of Mn 2p on (a) SFM-CMF, (b) CMF electrodes.



**Fig. S3** - XPS spectra of Ce 3d on (a) SFM-SDC, (b) SFM-CMF, (c) CMF electrodes.



**Fig. S4** - XPS spectra of Fe 2p<sub>3/2</sub> on (a) SFM-SDC, (b) SFM-CMF, (c) CMF electrodes.



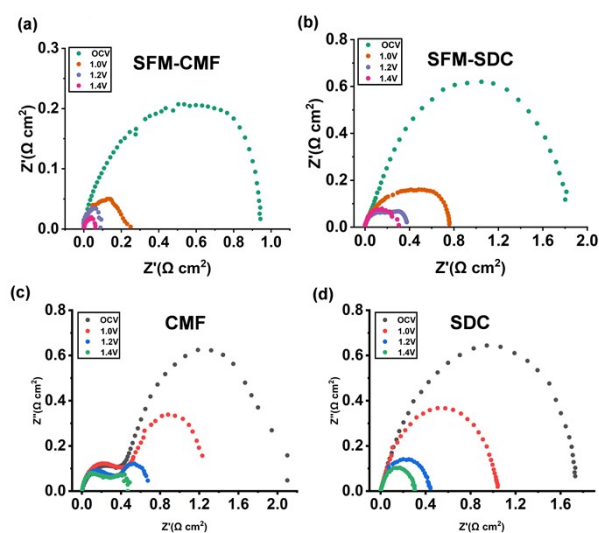
**Fig. S5** - XPS spectra of Mo 3d<sub>5/2</sub> on (a) SFM-SDC, (b) SFM-CMF electrodes.

**Table S1** - Atomic ratio of Fe ions at different valence-states in SFM-CMF (weigh ratio = 6:4) electrodes.

	Fe <sup>4+</sup>	Fe <sup>3+</sup>	Fe <sup>2+</sup>	Average valence
<b>Theoretical</b>	44 at. %	34 at. %	22 at. %	3.2
<b>Practical</b>	56 at. %	29 at. %	15 at. %	3.4

Theoretical: Mathematical calculation, data from XPS results of SFM<sup>1</sup> and CMF (Fig. - S5)

Practical: XPS characterization result. (Fig. 3d)



**Fig. S6** - EIS of cells from OCV to 1.4 V at 1073 K with (a) SFM-CMF, (b) SFM-SDC, (c) CMF, (d) SDC as cathode

**Table S2.** Comparison of the properties with state-of-the-art electrolyzers for pure CO<sub>2</sub> electrolysis at 1073K. Polarization resistances ( $R_p$ ) was collected at 1.2 V, and current density at 1.6 V.

<b>Cells configuration</b>	<b><math>R_p</math> (<math>\Omega</math> cm<sup>-2</sup>)</b>	<b>Current Density (A cm<sup>-2</sup>)</b>	<b>Durability</b>	<b>References</b>
Ni-YSZ YSZ RuO <sub>2</sub> @LSM-YSZ	~0.4	0.927	Unstable.	2
FeNi <sub>3</sub> @SFMN-GDC LDC/LSGM  LSCF-GDC	0.42	0.93	18% degradation under 0.934 A cm <sup>-2</sup> for 20min	3
SFM-SDC LDC/LSGM LSCF-SDC	0.19@1.5V	1.09	Relatively stable under ~1 A cm <sup>-2</sup> for 20min	1
CoFe@SFMC-GDC LDC/LSGM  BSCF-GDC	0.12	1.20	Stable under ~1 A cm <sup>-2</sup> for 20min	4
SFNM+1.2Fe-GDC GDC/LSGM  LSCF-GDC (850°C)	0.2453 (CO/CO <sub>2</sub> )	1.13	~30% degradation under ~1 A cm <sup>-2</sup> for 40 hour	5
RuFe@SFRuM-GDC LSGM  BSCF- GDC	0.11	2.25	~30% degradation under ~0.6 A cm <sup>-2</sup> for 100 hour	6
Ni-Fe-LSFM LSGM BLC	~2	2.32	Conduct 100h electrolysis at 0.5A	7
CoFe@LSCFM-GDC LDC/LSGM  BSCF-GDC	0.15	2.40	~30% degradation under ~0.6 A cm <sup>-2</sup> for 100 hour	8
<b>SFM-CMF LSGM  SSC-SDC</b>	<b>0.089</b> <b>(CO/CO<sub>2</sub>)</b>	<b>3.02</b>	<b>13.4% degradation under ~1.0 A cm<sup>-2</sup> for 40 hour</b>	<b>This work</b>

## References

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