Supplementary Materials:

Redox performances and optimizations of chemical composition of lanthanum-strontium-manganese-based perovskite oxide for two-step thermochemical CO_2 splitting

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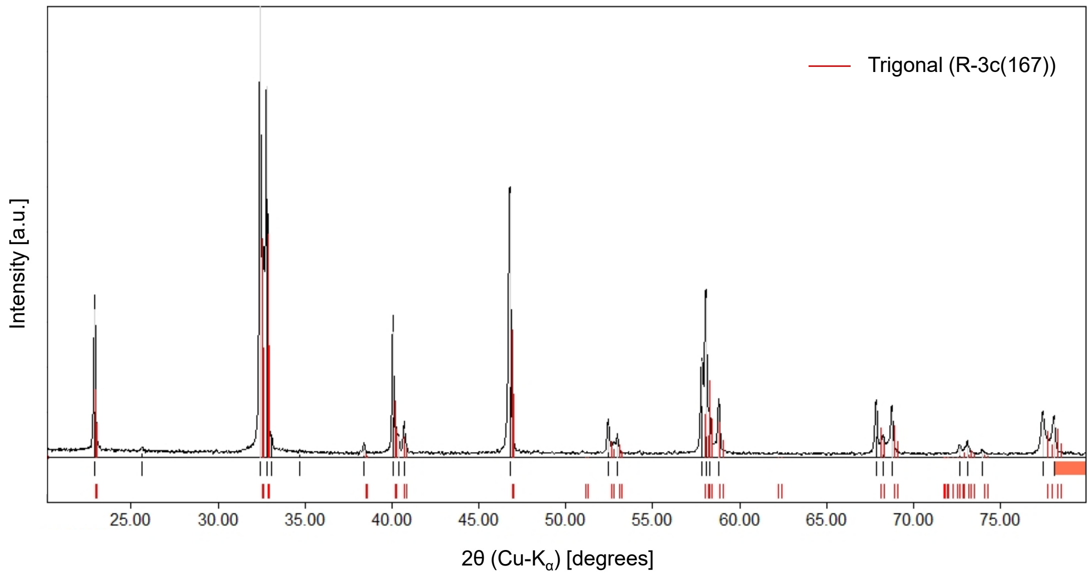

Figure S1. Powder XRD pattern of the as-prepared sample (x = 0, $La_{1-x}Sr_xMn_{0.8}Ni_{0.2}O_3$).

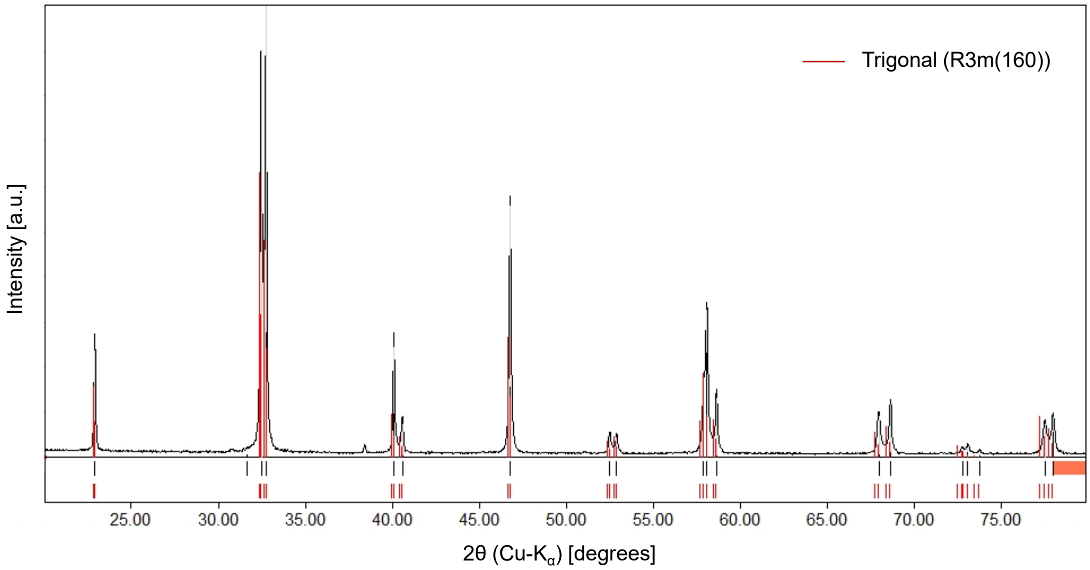

Figure S2. Powder XRD pattern of the as-prepared sample (x = 0.2, $La_{1-x}Sr_xMn_{0.8}Ni_{0.2}O_3$).

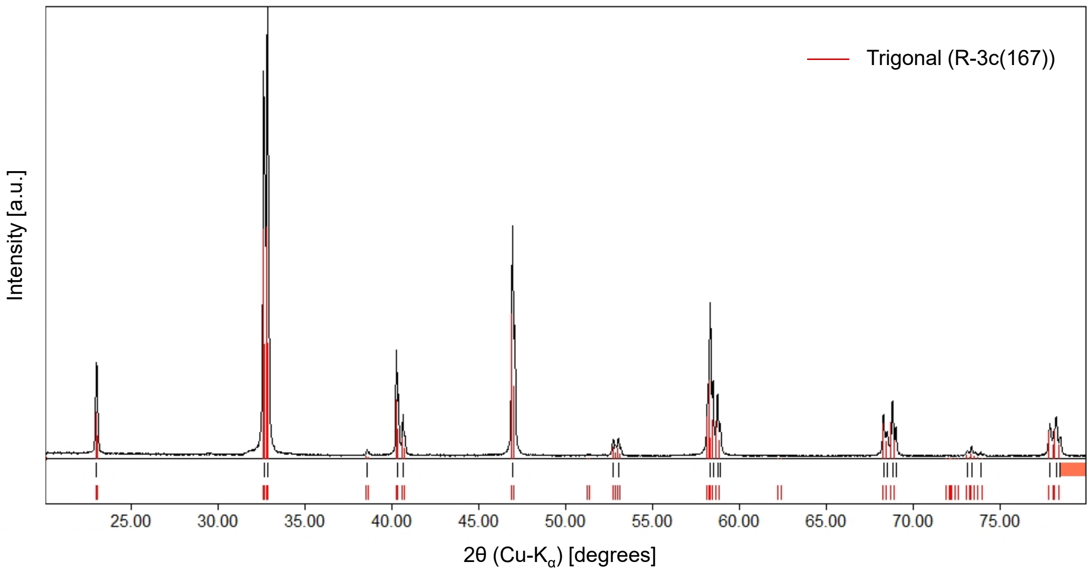

Figure S3. Powder XRD pattern of the as-prepared sample (x = 0.3, $La_{1-x}Sr_xMn_{0.8}Ni_{0.2}O_3$).

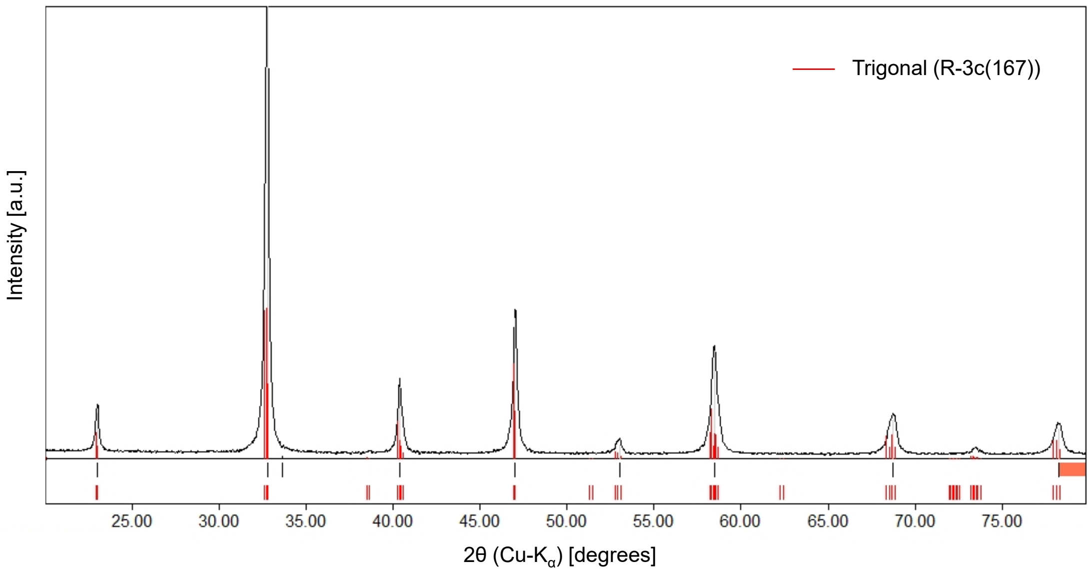

Figure S4. Powder XRD pattern of the as-prepared sample (x = 0.4, $La_{1-x}Sr_xMn_{0.8}Ni_{0.2}O_3$).

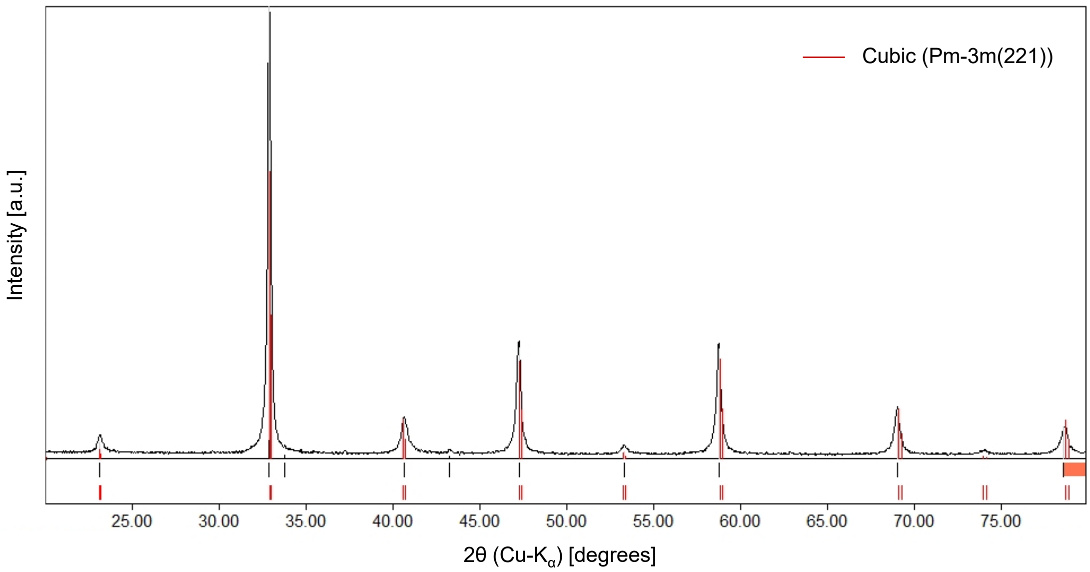

Figure S5. Powder XRD pattern of the as-prepared sample (x = 0.6, $La_{1-x}Sr_xMn_{0.8}Ni_{0.2}O_3$).

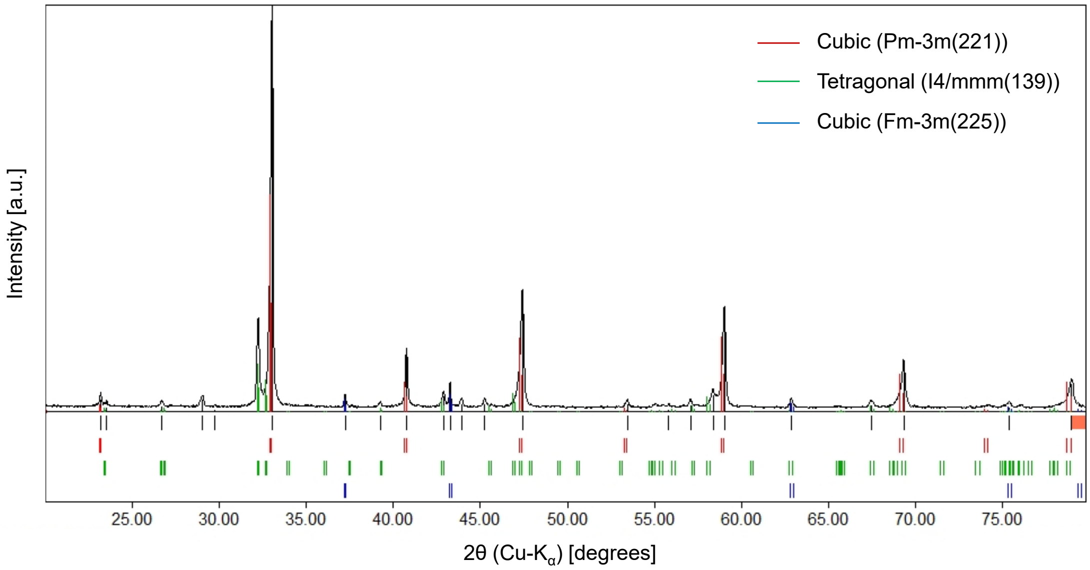

Figure S6. Powder XRD pattern of the as-prepared sample (x = 0.8, $La_{1-x}Sr_xMn_{0.8}Ni_{0.2}O_3$).

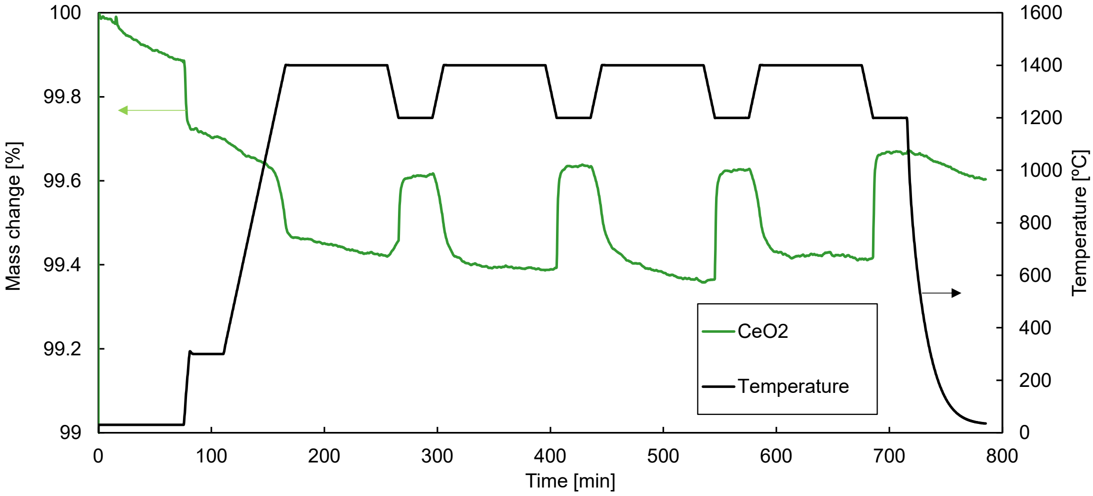

Figure S7. Thermochemical cycling test of the ceria sample (CeO_2).

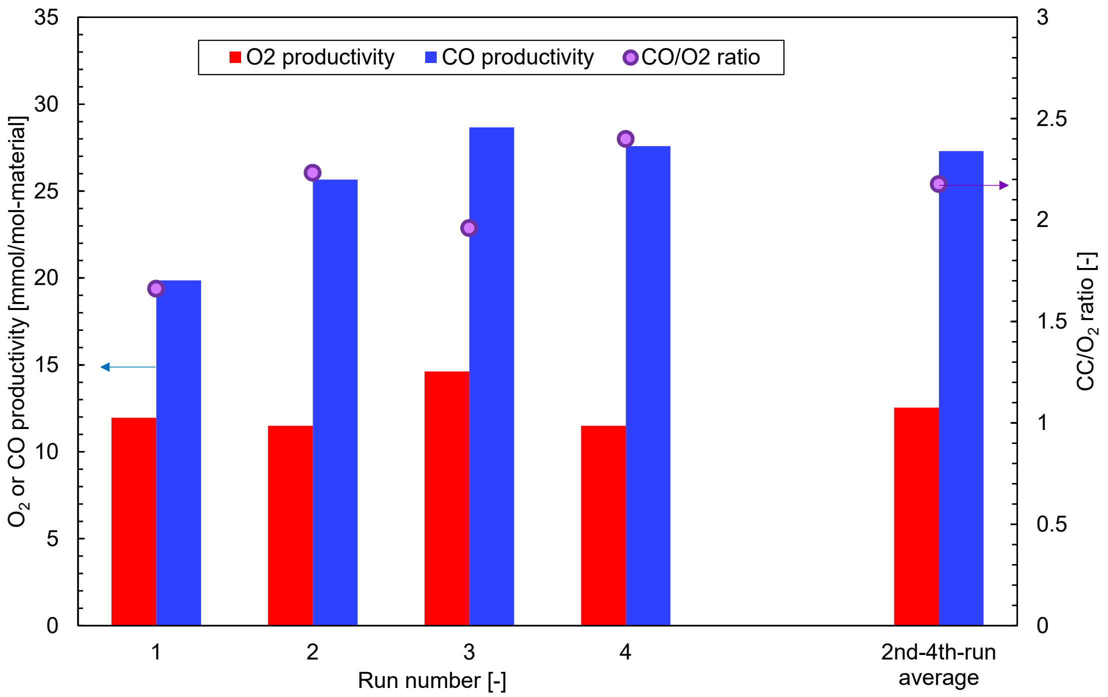

Figure S8. O_2 and CO productivities, and CO/O_2 ratio for thermochemical cycling using the ceria sample (CeO_2).

Table S1. Comparison of O_2 productivity, average CO productivity, cycle-averaged CO production rate, and reaction conditions of LSMCo0.35, LSMNi0.20, LSMMg0.125, CeO_2, and LSM perovskites reported in the literature.

Materials	Reaction equipment	Run number [-]	TR temp. [°C]	average O_2 productivity [μmol/g]	CS temp. [°C]	average CO productivity [μmol/g]	CS duration [min]	CO_2 conc. [-]	total flow rate at CS step [mL/min]	total feeding amount of CO_2 [μmol]	Cycle-averaged CO production rate [μmol/(min·g)]	Reference
$La_{0.7}Sr_{0.3}Mn_{0.65}Co_{0.35}O_3$ (LSMCo0.35)	TGA	2	1400	90	1200	533	30	0.500	100	6.05×10^4	17.8	Present study
$La_{0.7}Sr_{0.3}Mn_{0.8}Ni_{0.3}O_3$ (LSMNi0.20)	TGA	2	1400	90	1200	456	30	0.500	100	6.05×10^4	15.2	Present study
$La_{0.7}Sr_{0.3}Mn_{0.875}Mg_{0.125}O_3$ (LSMMg 0.125)	TGA	2	1400	90	1200	387	30	0.500	100	6.05×10^4	12.9	Present study
CeO_2	TGA	2	1400	90	1200	158	30	0.500	100	6.05×10^4	5.27	Present study
$La_{0.7}Sr_{0.3}Mn_{0.9}Mg_{0.1}O_3$	TGA	3	1400	90	1200	354	30	0.500	100	6.05×10^4	11.8	[53]
$La_{0.7}Sr_{0.3}Mn_{0.9}Ni_{0.1}O_3$	TGA	3	1400	90	1200	351	30	0.500	100	6.05×10^4	11.7	[53]
$La_{0.7}Sr_{0.3}Mn_{0.9}Co_{0.1}O_3$	TGA	3	1400	90	1200	347	30	0.500	100	6.05×10^4	11.6	[53]
$La_{0.7}Sr_{0.3}MnO_3$	TGA	3	1400	90	1200	248	30	0.500	100	6.05×10^4	8.27	[53]
$La_{0.5}Sr_{0.5}Mn_{0.95}Sc_{0.05}O_3$	TGA	3	1400	45	1100	506	45	0.400	40	6.05×10^4	11.2	[39]
$La_{0.5}Sr_{0.5}$	TGA	3	1400	45	1100	460	45	0.400	40	2.90 ×	10.2	[39]

$Mn_{0.75}Ga_{0.25}O_3$										10^4		
$La_{0.65}Sr_{0.35}MnO_3$	TGA	2	1400	45	1050	194	60	0.500	20	2.42×10^4	3.23	[29]
$La_{0.5}Sr_{0.5}MnO_3$	TGA	2	1400	45	1050	242	60	0.500	20	2.42×10^4	4.03	[29]
$La_{0.6}Sr_{0.4}Mn_{0.5}Co_{0.5}O_3$	TGA	2	1300	45	1050	139	45	0.500	20	1.81×10^4	3.09	[29]
$LaMn_{0.5}Ni_{0.5}O_3$	TGA	2	1400	45	1050	105	45	0.500	20	1.81×10^4	2.33	[29]
$La_{0.7}Sr_{0.3}Mn_{0.9}Cr_{0.1}O_3$	fixed bed	3	1350	30	1200	215	50	0.840	75	1.27×10^5	4.30	[47]
$LaCo_{0.7}Zr_{0.3}O_3$	TGA	3	1300	20	800	224	60	0.500	80	9.68×10^4	3.73	[41]
$La_{0.7}Sr_{0.3}MnO_3$	TGA	9	1400	60	1000	209	30	0.500	100	6.05×10^4	6.97	[33]
$La_{0.6}Sr_{0.4}MnO_3$	TGA	9	1400	60	1000	295	30	0.500	100	6.05×10^4	9.83	[33]
$La_{0.3}Sr_{0.7}MnO_3$	TGA	9	1400	60	1000	342	30	0.500	100	6.05×10^4	11.4	[33]
$La_{0.6}Sr_{0.4}FeO_3$	TGA	1	1350	20	1000	251	50	1.000	100	2.02×10^4	5.02	[45]
$La_{0.6}Sr_{0.4}MnO_3$	TGA	1	1350	20	1000	469	50	1.000	100	2.02×10^4	9.38	[45]
$La_{0.6}Sr_{0.4}Mn_{0.8}Fe_{0.2}O_3$	TGA	1	1350	20	1000	330	50	1.000	100	2.02×10^4	6.60	[45]
$La_{0.5}Sr_{0.5}Mn_{0.83}Mg_{0.17}O_3$	TGA	2	1400	45	1050	208	60	0.500	20	2.42×10^4	3.47	[31]
$La_{0.5}Sr_{0.5}Mn_{0.75}Al_{0.25}O_3$	TGA	2	1400	45	1050	221	60	0.500	20	2.42×10^4	3.68	[31]
$La_{0.5}Sr_{0.5}Mn_{0.9}Mg_{0.1}O_3$	TGA	2	1400	45	1050	215	60	0.500	20	2.42×10^4	3.58	[32]
$La_{0.6}Sr_{0.4}Mn_{0.6}Al_{0.4}O_3$	stagnation flow reactor	1	1350	-	1000	294	-	-	-	-	-	[36]

$(La_{0.8}Sr_{0.2})(Mn_{0.2}Fe_{0.2}Co_{0.4}Al_{0.2})O_3$	TGA	2	1400	45	1050	85	60	0.500	20	2.42×10^4	1.42	[67]
$(La_{0.5}Sr_{0.5})Mn_{0.9}Mg_{0.1}O_3$	TGA	2	1400	45	1050	248	60	0.500	20	2.42×10^4	4.13	[67]