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Supplementary Information

A novel strategy for low-temperature synthesis of Ruddlesden-Popper type layered perovskite $La_3Mn_2O_{7+\delta}$ for methane combustion

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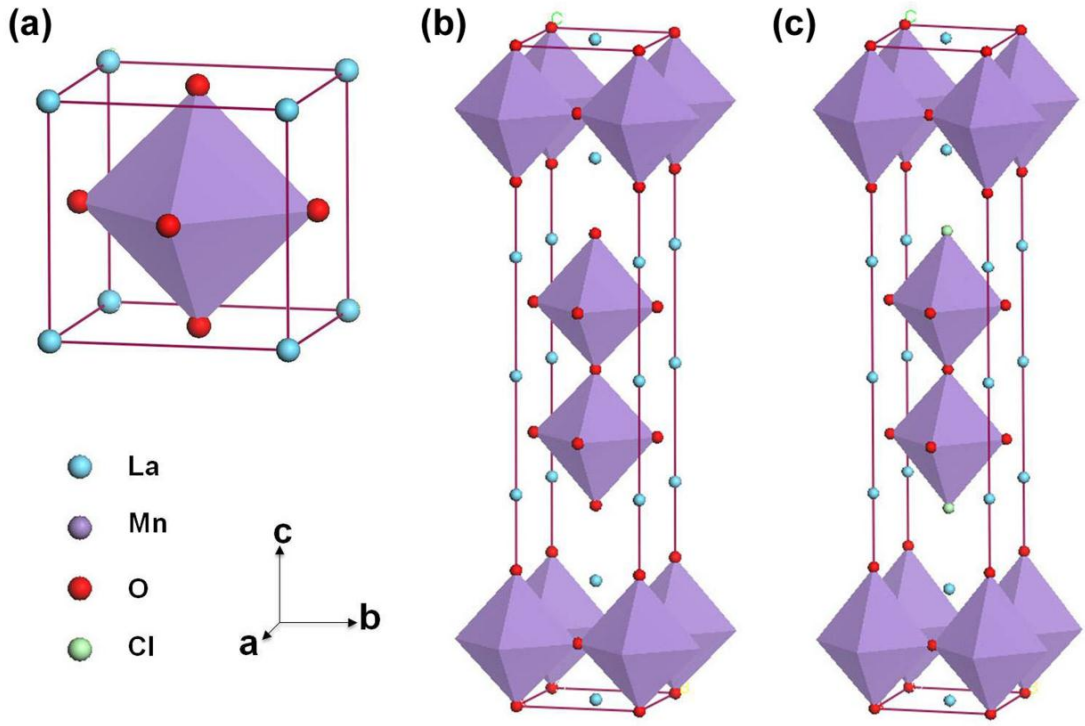

Figure S1. The spin-polarized density functional theory (DFT) calculation simulation pictures: (a) the 5-atom $LaMnO_3$ unit cell (space group: *Pm*3*m*), (b) the modeled 24-atom $La_3Mn_2O_7$ unit cell (space group: *I4/mmm*), and (c) the modeled Cl doped $La_3Mn_2O_6Cl$.

Table S1. The Miller indices corresponding to the X-ray diffraction peaks of LLM-700

2θ (degree)	d_{exp}[a] (Å)	Miller Indices (hkl)[b]	d_{cal}[c] (Å)
15.733	5.6278	(0 0 4)	5.6279
22.992	3.8648	(1 0 0)	3.8710
25.822	3.4473	(1 0 3)	3.4402
28.039	3.1795	(1 0 4)	3.1894
30.307	2.9466	(1 0 5)	2.9353
32.683	2.7376	(1 1 0)	2.7372
40.206	2.2410	(1 0 8)	2.2761
40.751	2.2123	(1 1 6)	2.2113
46.890	1.9359	(2 0 0)	1.9355
48.624	1.8709	(2 0 3)	1.8742
52.674	1.7362	(2 1 0)	1.7312
55.105	1.6652	(2 1 4)	1.6547
58.016	1.5884	(2 1 5)	1.6158
58.665	1.5723	(2 1 6)	1.5719
68.187	1.3741	(2 2 0)	1.3686
68.756	1.3641	(2 2 1)	1.3661
73.232	1.2914	(3 0 0)	1.2903
78.177	1.2216	(3 1 1)	1.2223
82.527	1.1679	(2 2 10)	1.1694
86.729	1.1218	(2 2 11)	1.1377

[a] The experimental *d* values.

[b] The calculated Miller indices based on the d_{exp} values and the lattice spacing formula. The space group was initially set to be *I*4/*mmm*, and the lattice spacing formula was $\frac{1}{d^2} = \frac{h^2 + k^2}{a^2} + \frac{l^2}{c^2}$. The peaks at 2θ = 15.733°, 32.683° were initially assigned to the (004) and (110) planes, respectively, and the preliminary lattice parameters $a = b$ = 3.871 Å, and c = 22.5116 Å were consequently calculated.

[c] The quasi *d* values calculated in turn based on the obtained lattice parameters and Miller indices.

The d_{cal} values were consistent with the d_{exp} values substantially, demonstrating that the space group and lattice parameter were set appropriately. The slight differences between d_{cal} and d_{exp} values may have resulted from the lattice distortion in LLM-700.

Table S2. The ICP-MS results of the LLM-700 sample.

	La [b]	Mn [b]	O [c]
Wt.%	63.74	17.05	19.21
n [a]	3	2.03	7.85

[a] The atomic ratio of elements La, Mn and O.

[b] Experimental values of elements La and Mn measured by inductively coupled plasma-mass spectrometry (ICP-MS).

[c] The calculated value determined from the experimental values of elements La and Mn.

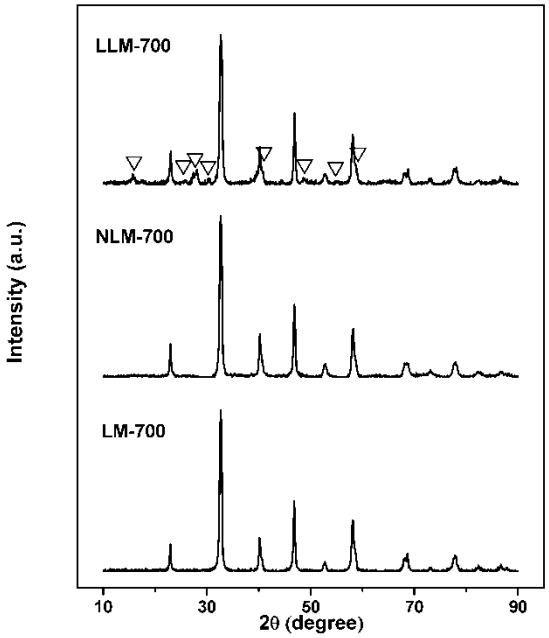

Figure S2. X-ray diffraction (XRD) patterns of the conventional $LaMnO_3$ calcined at 700 °C (LM-700), the sample with a nominal composition of $La_3Mn_2O_{7+\delta}$ calcined at 700 °C (NLM-700), and the R-P type layered perovskite samples calcined at 700 °C (LLM-700); (▽) the typical peaks of the LLM-700 sample.

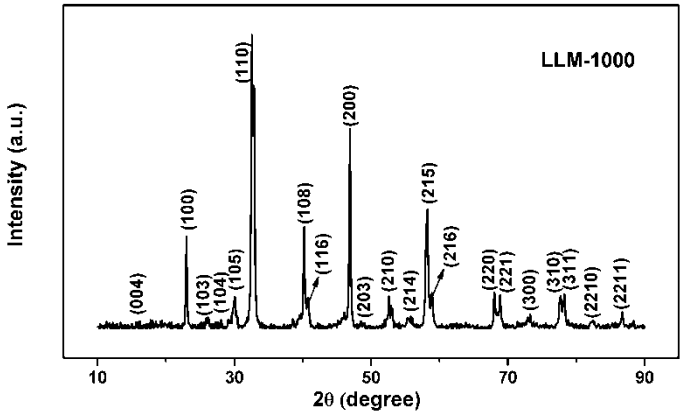

Figure S3. X-ray diffraction (XRD) pattern of the R-P type layered perovskite samples calcinated at 1000 °C (LLM-1000).

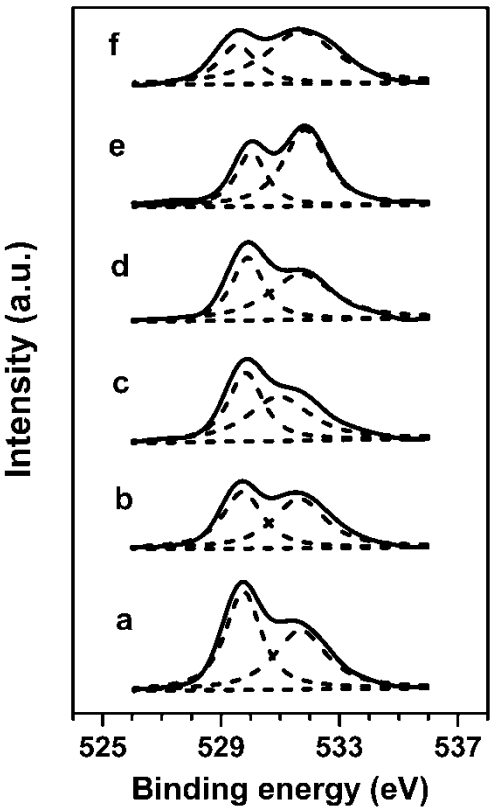

Figure S4. O1s XPS profiles of different catalysts: (a) LLM-700, (b) LLM-1000, (c) LM-700, (d) LM-1000, (e) NLM-700, and (f) LLMCl-700. The binding energy of 529 to 530 eV is characteristic of the lattice oxygen (O^{2-} , denoted as O_α), and the binding energy of 531 to 532 eV might be assigned to absorbed surface oxygen ions with low coordination (denoted as O_β).