Electronic Supplementary Information

Reduction of lead dioxide with oxalic acid to prepare lead oxide as the positive electrode material for lead acid batteries

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Tables

Table S1

The composition of the reductive products calculated from the content of C element.

r[a]	w_1[b] (wt.%)	Composition (wt.%)[c]	
		PbC_2O_4	PbO_2
1	3.39	41.7	58.3
2	5.67	69.7	30.3
3	7.46	91.8	8.2
4	7.37	90.7	9.3

[a] $r = n(H_2C_2O_4) / n(PbO_2)$;

[b] w_1 is the mass percentage of C element in the reductive products;

[c] The mass percentage of PbC_2O_4 (w_2) was calculated through the formula:

$$w_2 = \frac{w_1}{2 \times M_{r(C)}} \times M_{r(PbC_2O_4)}$$

Table S2

The composition and theoretical capacity of the samples A400, A450, A500 and A550.

Sample	Composition (wt.%)*			Theoretical capacity
	Pb_3O_4	α-PbO	β-PbO	(mAh g^{-1})
A400	42.7	57.3	–	237.8
A450	51.1	48.9	–	237.3
A500	6.5	90.4	3.1	239.5
A550	–	14.9	85.1	240.1

* The compositions were determined according to the XRD patterns shown in Fig. 4 with the Jade® software.

The theoretical discharge capacity C in mAh g^{-1} of the mixture containing x% Pb_3O_4 and (1−x)% PbO can be calculated from the formula:

$$C = 53600 \times \left(\frac{3x}{M_{r(Pb_3O_4)}} + \frac{1-x}{M_{r(PbO)}}\right)$$

Consequently, the theoretical capacity of A400, A450, A500 and A550 are 237.8, 237.3, 239.5 and 240.1 mAh g^{-1}, respectively.

Figures

Materials and chemicals

3,3,5,5-tetramethylbenzidine (TMB), dimethyl sulfoxide (DMSO) and horseradish peroxidase (HRP) were purchased from Sinopharm Chemical Reagent Co., Ltd. (China).

Method

H_2O_2 detection was carried out as follows: after 1 h reduction reaction, 4 mL of reaction solution was firstly taken out and the solid particles were filtered from the solution. Secondly, 500 μL of the filtered solution, 200 μL of TMB solution (16 mM, DMSO) and 20 μL of HRP (1 mg mL^{-1}) were mixed in 5 mL of phosphate buffer solution (PBS, 10 mM, pH 7.4). Subsequently, the mixture was incubated for 30 min at 35 °C in a water bath. The blank experiment was carried by using 500 μL of deionized water to replace the filtered solution.

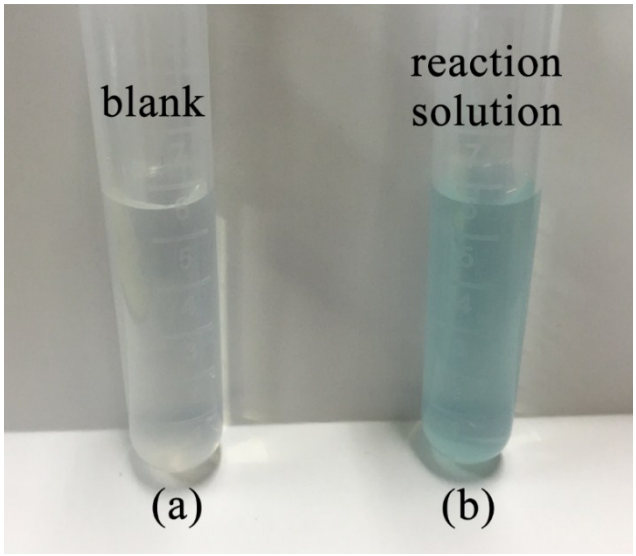

Fig. S1 Photographs of chromogenic reactions in different systems: (a) TMB + HRP + H_2O (blank) and (b) TMB + HRP + reaction solution.

As shown in Fig. S1, TMB was oxidized producing a blue color in the reaction solution, indicating the existence of H_2O_2.

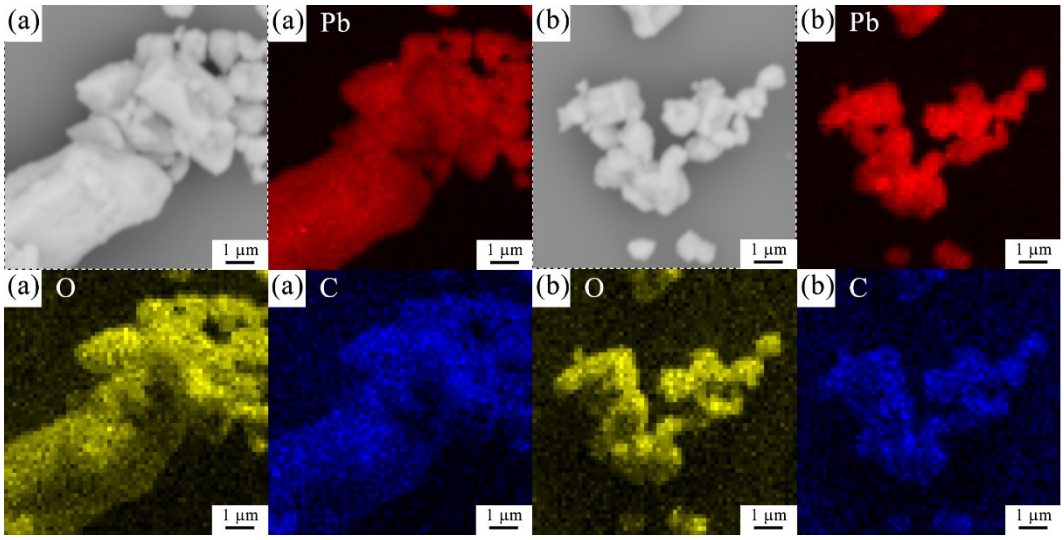

Fig. S2 (a and b) EDS mapping analysis of the reduction products prepared in 0.2 mol L^{-1} of $H_2C_2O_4$ solution.

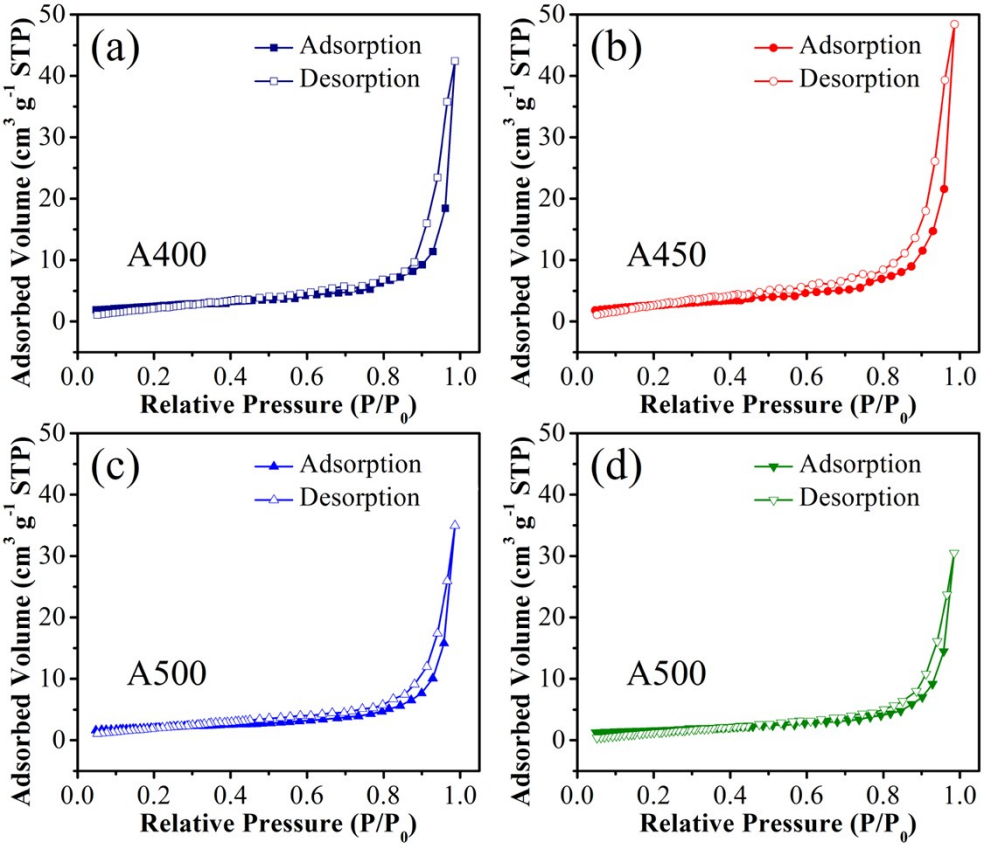

Fig. S3 N_2 adsorption–desorption isotherms of (a) A400, (b) A450, (c) A500 and (d) A550 samples after formation.

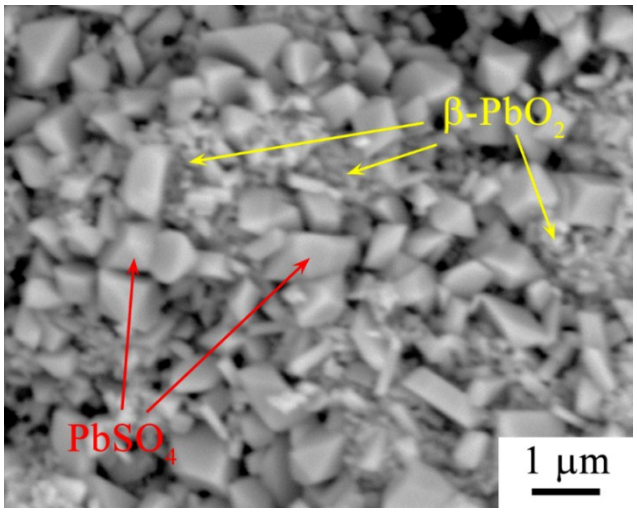

Fig. S4 SEM micrograph of A450 electrode after soaking in H_2SO_4 solution for 2 hour.