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Heterogeneous Assembly of Pt-Clusters on Hierarchical Structured CoO_x@$SnPd_2$@SnO_2 Quaternary Nanocatalyst Manifesting Oxygen Reduction Reaction Performance

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1. HRTEM analysis of CSP NC (i.e. without Pt decoration).

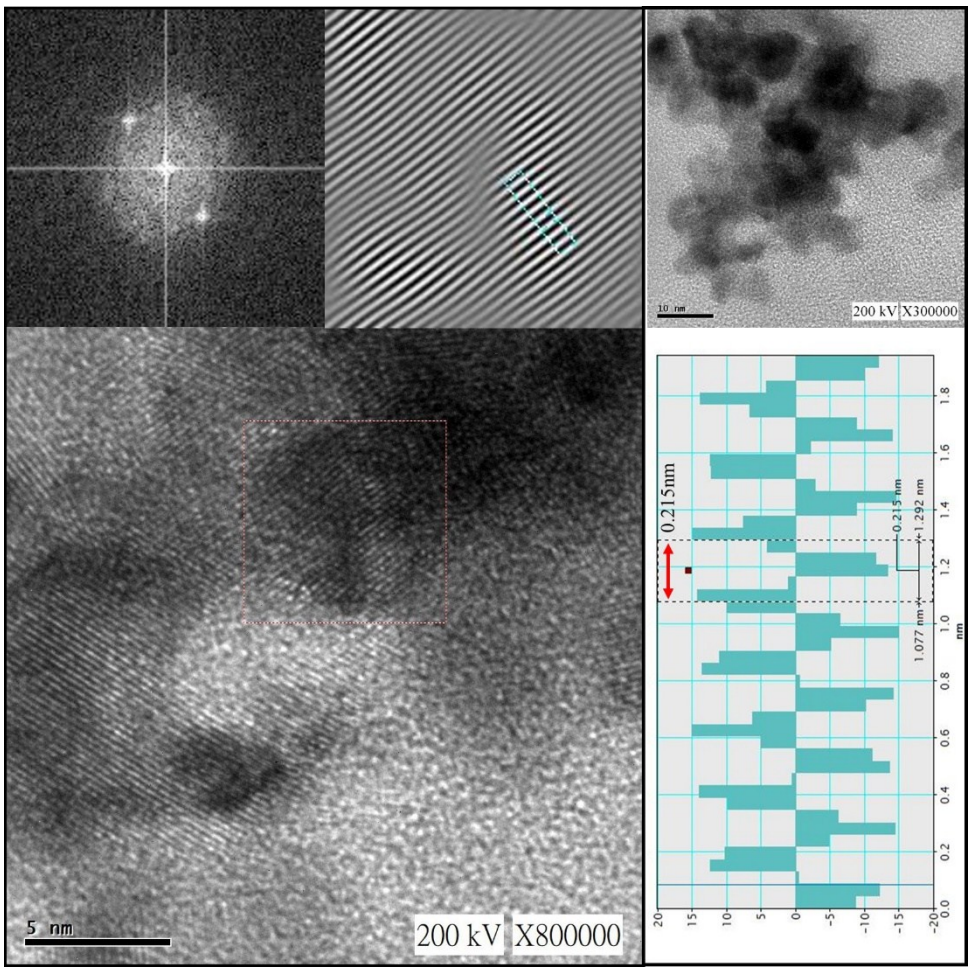

Figure S1. HRTEM images of CSP nanocatalyst.

2. XRD patterns of control samples

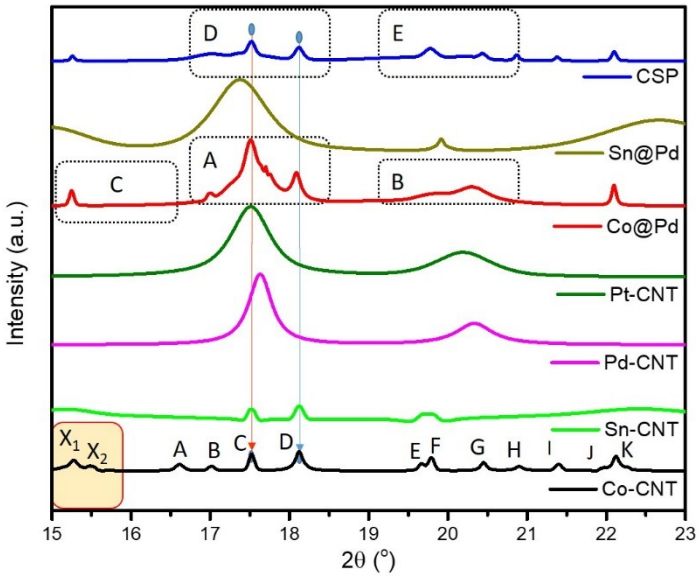

Figure S2. XRD patterns of control samples. The characteristics diffraction peaks A, B, C, D, E, F, G H, I, J and K for Co-CNT are corresponding to tetragonal (211), hexagonal (211), (330), (301), (510), (20 -2 4), (321), tetragonal (510), hexagonal (510), tetragonal (411) and hexagonal (411) planes, respectively. Meanwhile two peaks X_1 and X_2 (denoted in yellow region) are characteristics reflections from tetragonally packed CoO_2 planes

3. Pd K-edge X-ray absorption spectra of control samples (a) XANES and (b) Fourier transformed EXAFS regions.

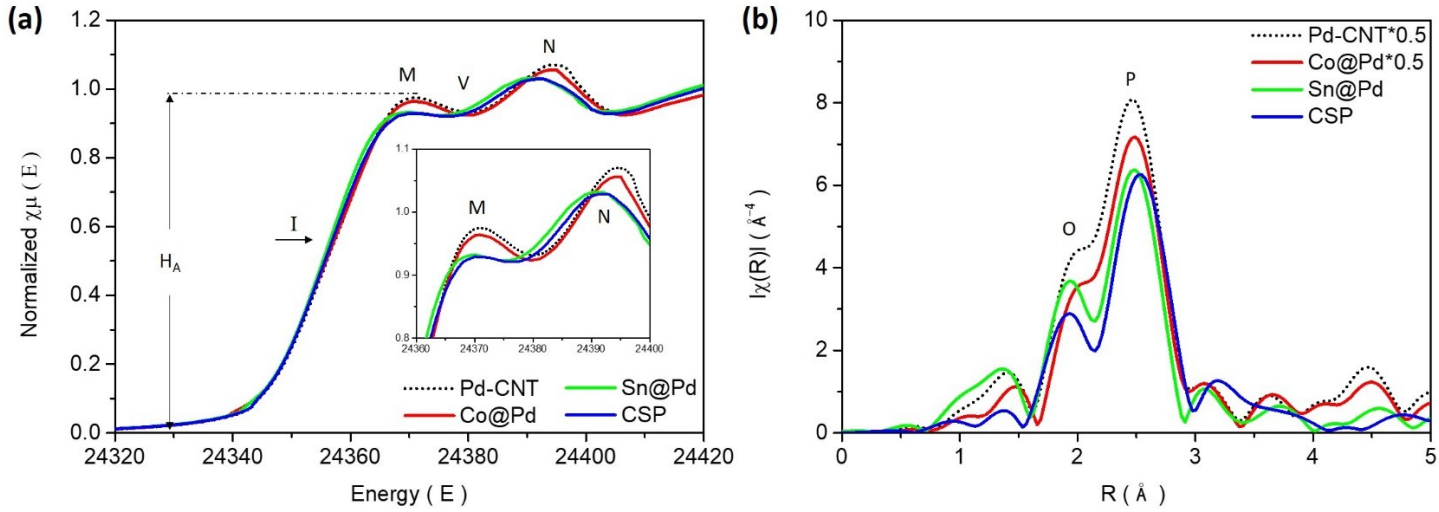

Figure S3. Pd K-edge X-ray absorption spectra of control samples (a) XANES and (b) Fourier transformed EXAFS regions.

4. X-ray absorption spectroscopy analysis at Co k-edge and Sn k-edge of experimental CSPP NCs series and control samples.

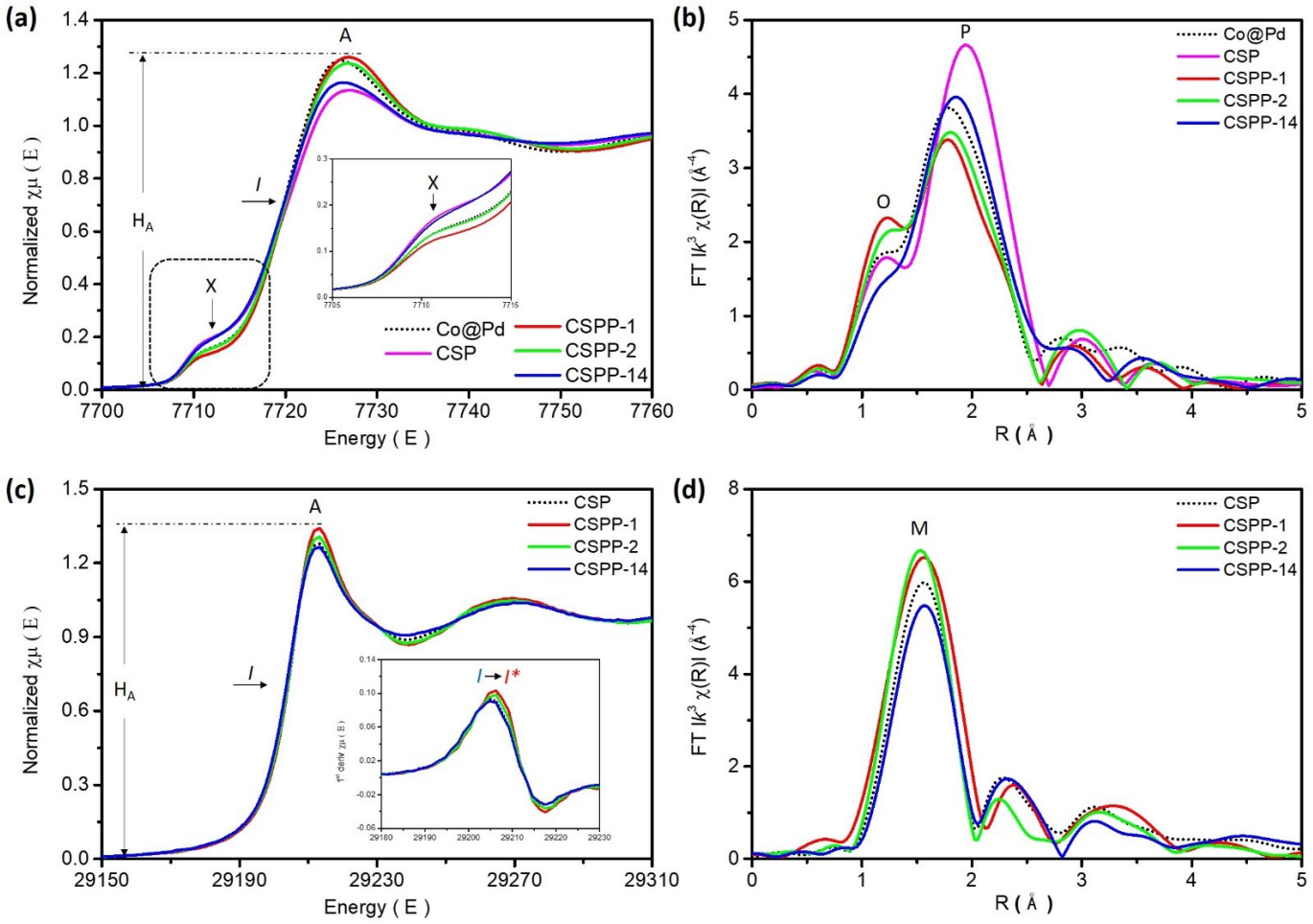

Figure S4. X-ray absorption spectroscopy of CSPP NCs and control samples. (a) XANES and (b) FT-EXAFS spectra of CSPP NCs at Co K-edge, compared with control sample. (c) XANES and (d) FT-EXAFS spectra of CSPP NCs at Sn K-edge.

5. Sn K-edge X-ray absorption spectra of control samples (a) XANES and (b) Fourier transformed EXAFS regions.

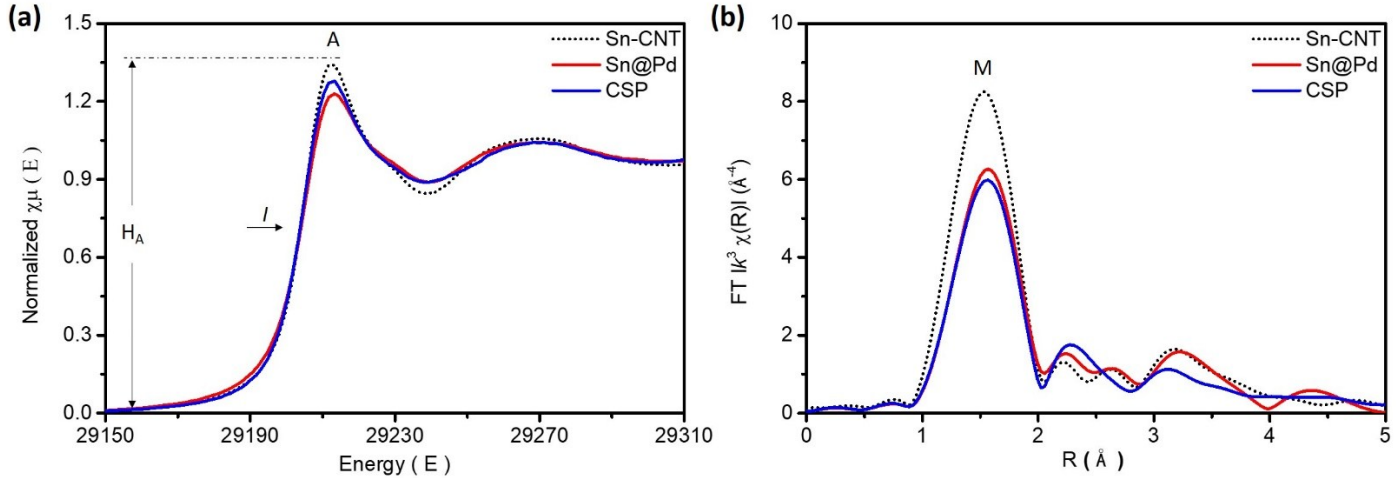

Figure S5. Sn K-edge X-ray absorption spectra of control samples (a) XANES and (b) Fourier transformed EXAFS regions.

6. XPS determined composition ratios of experimental CSPP nanocatalysts

Table S1. Comparative XPS determined composition ratios of experimental CSPP nanocatalysts.

Samples	Surface composition (%)			
	Co	Sn	Pd	Pt
CSPP-1	23.31	57.87	18.23	0.59
CSPP-2	25.73	55.57	17.81	1.48
CSPP-14	32.32	51.55	10.94	5.2

7. Comparative Nyquist plots of CSPP NCs under different applied potentials.

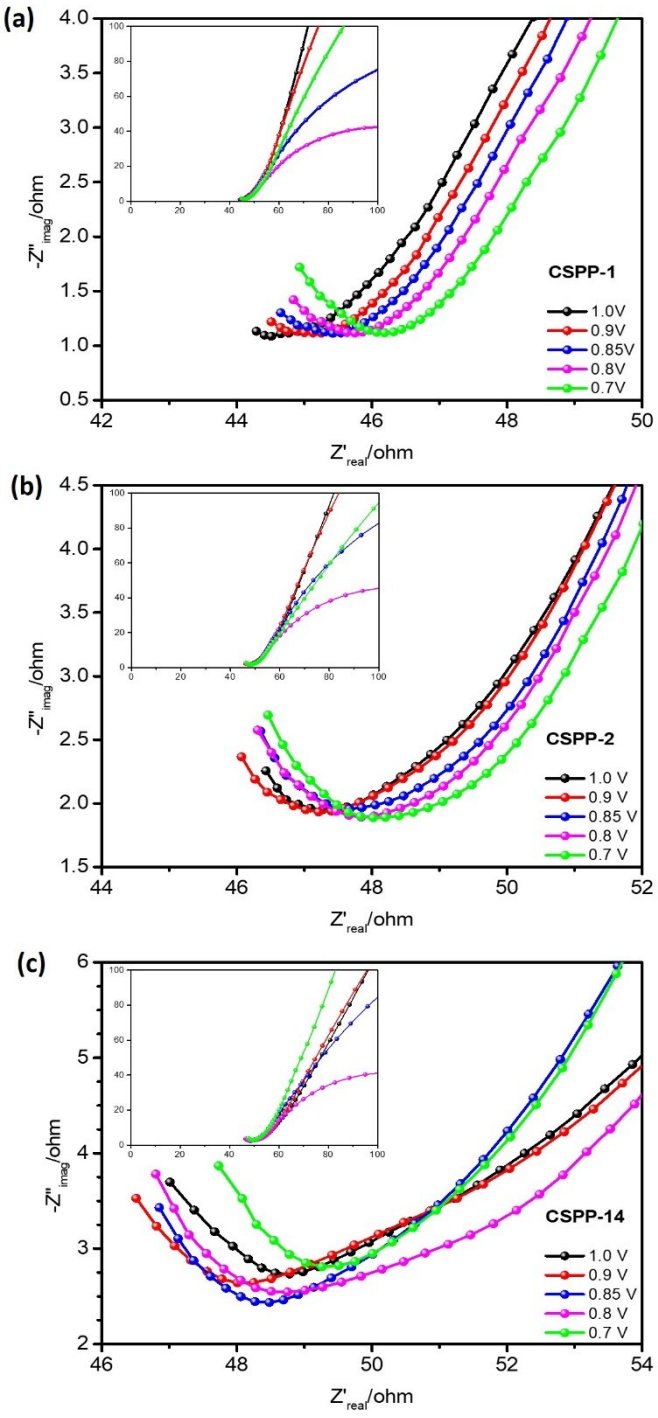

Figure S6. (a) Comparative Nyquist plots of (a) CSPP-1, (b) CSPP-2 and (c) CSPP-14 NCs under different applied potentials.

Table S2. Electrochemical performances of CSPP NCs compared with CSP and commercial catalysts (JM-Pt/C)

Sample	N (0.5V)	V_{oc} V vs RHE	$E_{1/2}$ V vs RHE	SA ($mAcm^{-2}$)	$J_{k\ 0.85V}$ $mAcm^{-2}$	M.A. $_{0.85V}$ ($mAmg_{Pt}^{-1}$)	M.A. $_{0.85V}$ ($mAmg_{Pd+Pt}^{-1}$)
J.M.-Pt/C	4.0	0.910	0.844	0.261	4.37	67.0	67.0
Pd-standard	4.0	0.895	0.831	N/A	2.33	N/A	41.6
CSP	3.2	0.896	0.834	NA	1.95	NA	36.3
CSPP-1	4.4	0.926	0.867	0.534	5.23	2146.2	94.0
CSPP-2	3.9	0.925	0.865	0.603	6.15	1555.7	67.7
CSPP-14	3.9	0.917	0.860	0.711	4.91	223.6	47.9

8. Comparative LSV curves of Pd-standard and CSPP nanocatalysts.

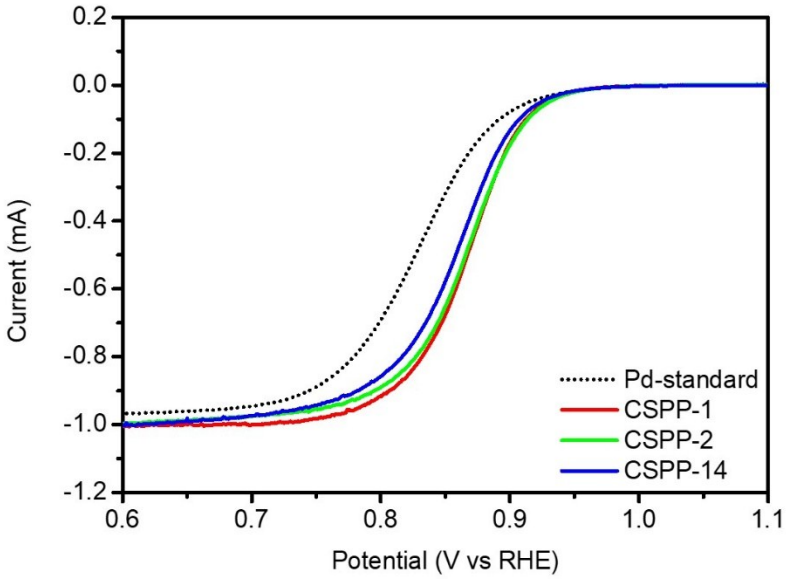

Figure S7. Comparative LSV curves of Pd-standard and CSPP nanocatalysts.

9. Fitted EIS curves of CSPP NCs.

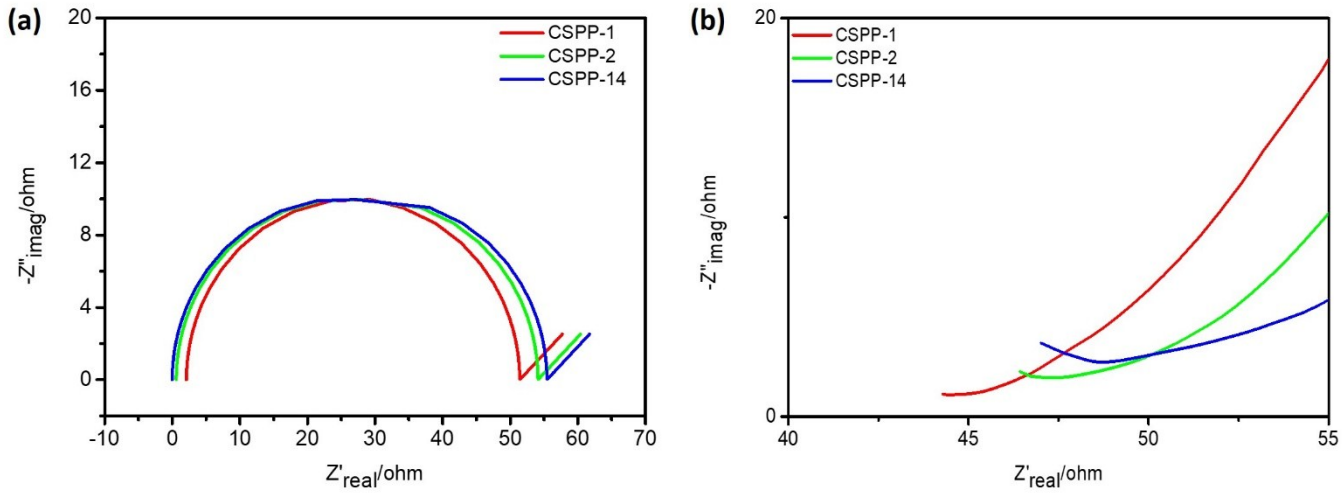

Figure S8. (a) Fitting and (b) as-obtained EIS curves of CSPP NCs.