Optimization of SnPd Shell Configuration to Boost ORR Performance of Pt-Clusters Decorated CoO_x@SnPd Core-Shell Nanocatalyst

1. The HRTEM image of CSP nanocatalyst.

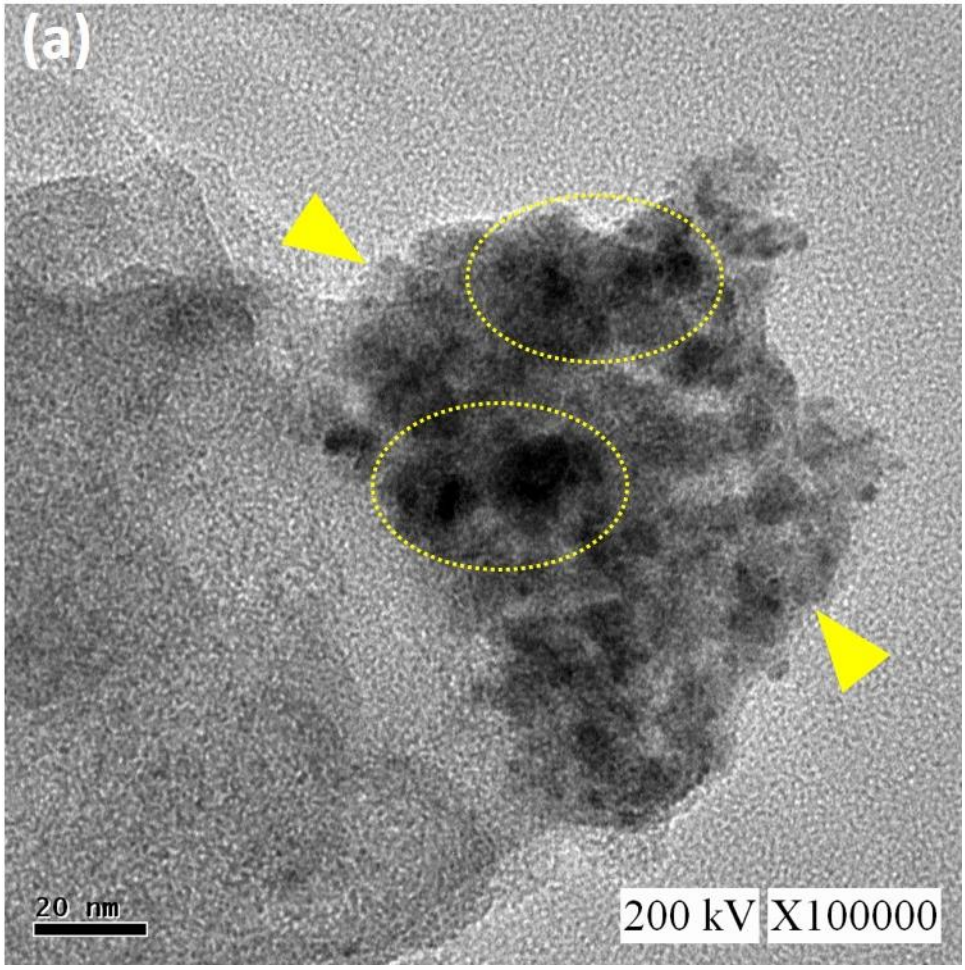

Figure S1. The HRTEM image of CSP nanocatalyst.

2. XRD results of control samples

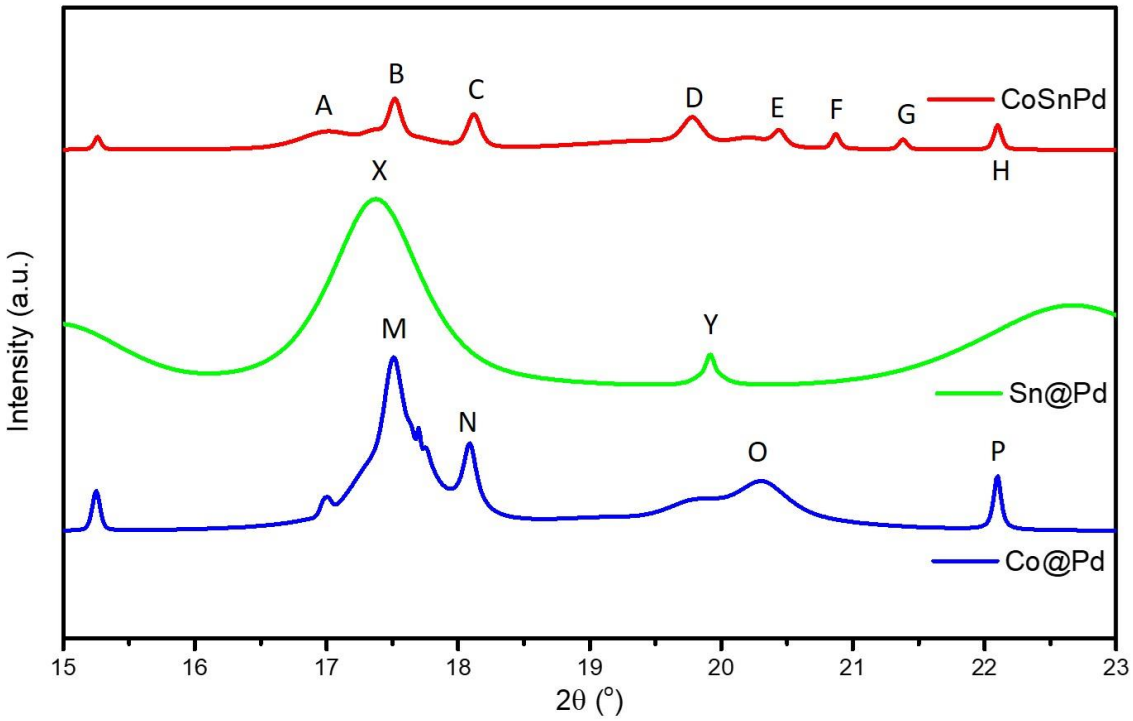

Figure S2. X-ray diffraction patterns of control samples. All the spectra were measured under the incident X-rays of 18 keV.

3. The ORR performance of reference sample (CSP) with CSPP NCs.

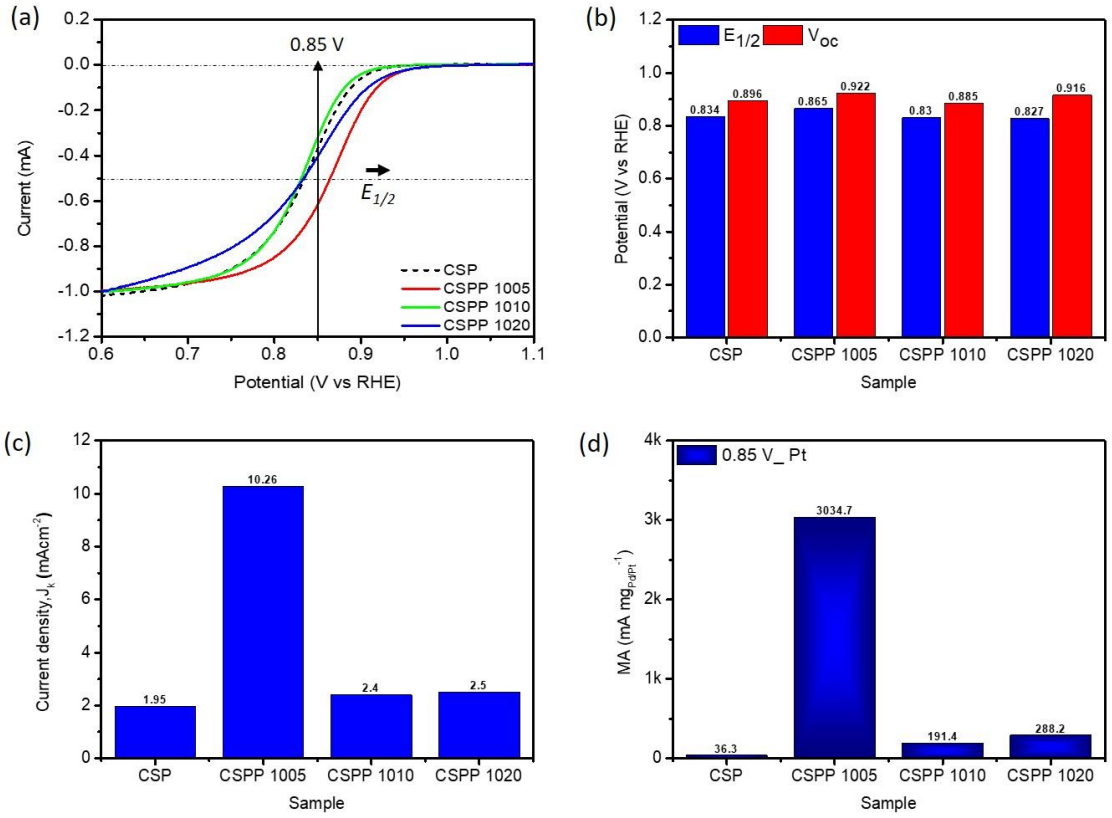

Figure S3. Electrochemical results of CSPP NCs. (a) LSV, (b) Onset potential (Voc) / half wave potential ($E_{1/2}$), (c) kinetic current density and (d) ORR mass activity of CSPP NCs compared with reference sample (CSP).

Table S1. The ICP-AES determined atomic composition of CSPP NCs.

Samples	Composition (%)				
	Co	Sn	Pd	Pt	C
CSPP 1005	10.07	12.65	5.47	0.829	70.981
CSPP 1010	13.11	11.58	10.65	0.925	63.735
CSPP 1020	14.53	8.69	15.23	0.878	60.672

Table S2. Benchmark of catalysts in ORR application

Catalyst	MA ($mAmg^{-1}$)	Electrolyte	Reference
CSPP 1005	3034.7 @ 0.85 V	0.1 M KOH	This work
Ni@Pd-Ir (NPI-0025)	2066 @ 0.85V		[1]
CoPdPt	2056.3 @ 0.85 V		[2]
Dealloyed-CoAuPd-1	59.195 @ 0.8 V		[3]
Dealloyed-CoAuPd-3	81.559 @ 0.8 V		
Pd_6Ni icosahedra	220 @ 0.9 V		[4]
Cu@Pd/Pt	414 @ 0.85V		[5]
$Ni@Pd_3$	95 @ 0.85 V		[6]
$O\text{-}Pd_6Sn_3Co/C$	134.8 @ 0.85 V		[7]
Ordered Pd_3Pb/C	168.9 @ 0.9 V		[8]
PdMn/C-Pol	70 @ 0.85 V		[9]
PdMn/C-BAE	93 @ 0.85 V		
PdFe/C-Pol	27 @ 0.85 V		
PdFe/C-BAE	81 @ 0.85 V		
Pd/C-BAE	49 @ 0.85 V		
AuPdCo/C intermetallic (800 ºC)	130 @ 0.9 V		[10]
$Pd/W_{18}O_{49}$ hybrids	216 @ 0.9 V		[11]

References

1. Bhalothia, D.; Tsai, D.-L.; Wang, S.-P.; Yan, C.; Chan, T.-S.; Wang, K.-W.; Chen, T.-Y.; Chen, P.-C. Ir-oxide mediated surface restructure and corresponding impacts on durability of bimetallic NiO_x@Pd nanocatalysts in oxygen reduction reaction. *J. Alloys Compd.* **2020**, *844*, 156160. https://doi.org/10.1016/j.jallcom.2020.156160.

2. Dai, S., Chou, J.-P., Wang, K.-W.; Hsu, Y.-Y.; Hu, A.; Pan, X.; Chen, T.-Y. Platinum-trimer decorated cobalt-palladium core-shell nanocatalyst with promising performance for oxygen reduction reaction. *Nat Commun* **2019**, *10*, 440. https://doi.org/10.1038/s41467-019-08323-w.
3. Luo, L.-M.; Zhan, W.; Zhang, R.-H.; Chen, D.; Hu, Q.-Y.; Guo, Y.F.; Zhou, X.-W. Ternary CoAuPd and binary AuPd electrocatalysts for methanol oxidation and oxygen reduction reaction: Enhanced catalytic performance by surface reconstruction. Journal of Power Sources **2019**, *412*, 142–152. https://doi.org/10.1016/j.jpowsour.2018.11.044.
4. Feng, Y.; Shao, Q.; Ji, Y.; Cui, X.; Li, Y.; Zhu, X.; Huang, X. Surface-modulated palladium-nickel icosahedra as high-performance non-platinum oxygen reduction electrocatalysts. *Sci. Adv.* **2018**, *4*, 7, https://doi.org/10.1126/sciadv.aap8817.
5. Chen, H.-Y.T.; Chou, J.-P.; Lin, C.-Y.; Hu, C.-W.; Yang, Y.-T.; Chen, T.-Y. Heterogeneous Cu-Pd binary interface boosts stability and mass activity of atomic Pt clusters in the oxygen reduction reaction. Nanoscale, **2017**, *9*, 7207–7216. https://doi.org/10.1039/C7NR01224A.
6. Jiang, J.; Gao, H.; Lu, S.; Zhang, X.; Wang, C.-Y.; Wang, W.-K.; Yu, H.-Q. Ni-Pd core-shell nanoparticles with Pt-like oxygen reduction electrocatalytic performance in both acidic and alkaline electrolytes. *J. Mater. Chem. A*, **2017**, *5*, 9233-9240. https://doi.org/10.1039/C7TA01754E.
7. Wu, Y.; Wang, C.; Zou, L.; Huang, Q.; Yang, H. Incorporation of cobalt into Pd_2Sn intermetallic nanoparticles as durable oxygen reduction electrocatalyst. *J. Electroanal. Chem.* **2017**, *789*, 167–173.
8. Cui, Z.; Chen, H.; Zhao, M.; DiSalvo, F.J. High-Performance Pd_3Pb Intermetallic Catalyst for Electrochemical Oxygen Reduction. *Nano Lett.* **2016**, *16*, 4, 2560–2566. https://doi.org/10.1021/acs.nanolett.6b00121.
9. Holade, Y.; da Silva, R.G.; Servat, K.; Napporn, T.W.; Canaff, C.; de Andrade, A.R.; Kokoh, K.B. Facile synthesis of highly active and durable PdM/C (M = Fe, Mn) nanocatalysts for the oxygen reduction reaction in an alkaline medium. *J. Mater. Chem. A*, 2016, 4, 8337-8349. https://doi.org/10.1039/C6TA02096H.
10. Kuttiyiel, K.A.; Sasaki, K.; Su, D.; Wu, L.; Zhu, Y.; Adzic, R.R. Gold-promoted structurally ordered intermetallic palladium cobalt nanoparticles for the oxygen reduction reaction. *Nat. Commun* **2014**, *5*, 5185. https://doi.org/10.1038/ncomms6185.
11. Lu, Y.; Jiang, Y.; Gao, X.; Wang, X.; Chen, W. Strongly Coupled Pd Nanotetrahedron/Tungsten Oxide Nanosheet Hybrids with Enhanced Catalytic Activity and Stability as Oxygen Reduction Electrocatalysts. *J. Am. Chem. Soc.* **2014**, *136*, 11687–11697. https://doi.org/10.1021/ja5041094.