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Octahedral Pd Nanocages with Porous Shells Converted by $Co(OH)_2$ Nanocages with Nanosheet surface as Robust Electrocatalysts for Ethanol Oxidation

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Table S1 the Pd mass loading on GCE for resulting samples determined by ICP.

Samples	Pd nanocages	Pd/C	Pd-D
mass loading for Pd ($\mu g\ cm^{-2}$)	26.5	23.0	24.5

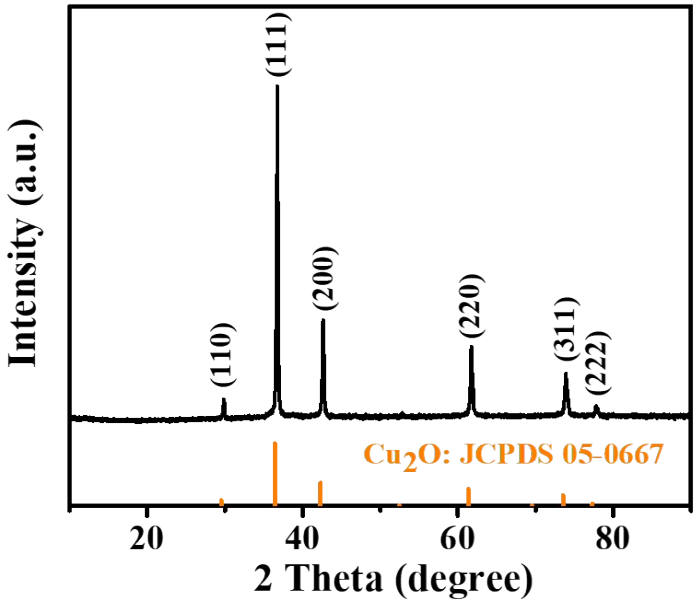

Figure S1 XRD pattern of Cu_2O precursor.

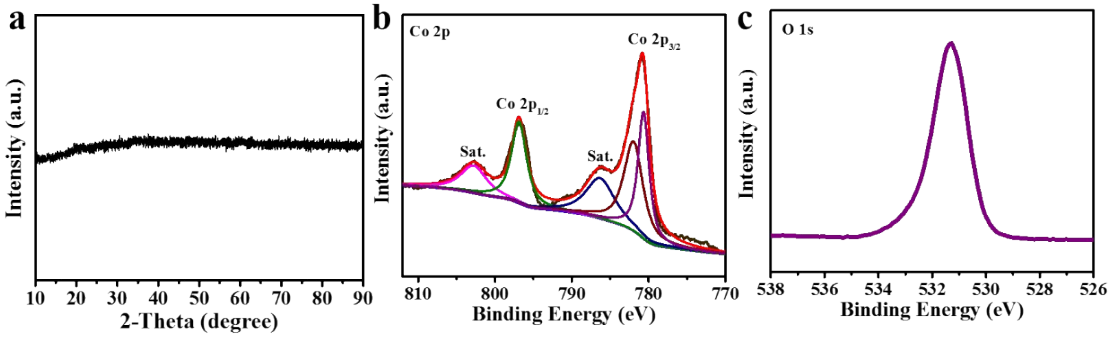

Figure S2 a) XRD pattern, b) Co 2p spectra and c) O 1s spectra of $Co(OH)_2$ nanocages.

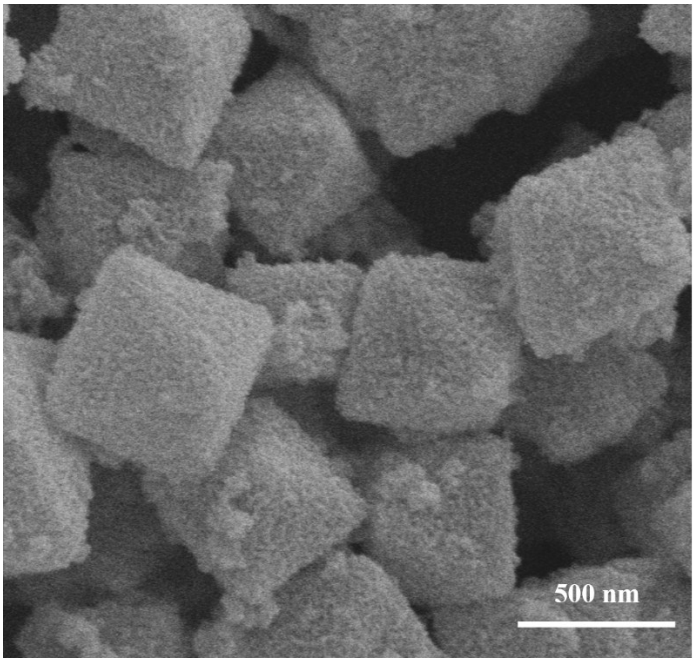

Figure S3 the large-scale FESEM of Pd nanocages after sonicating 30 min.

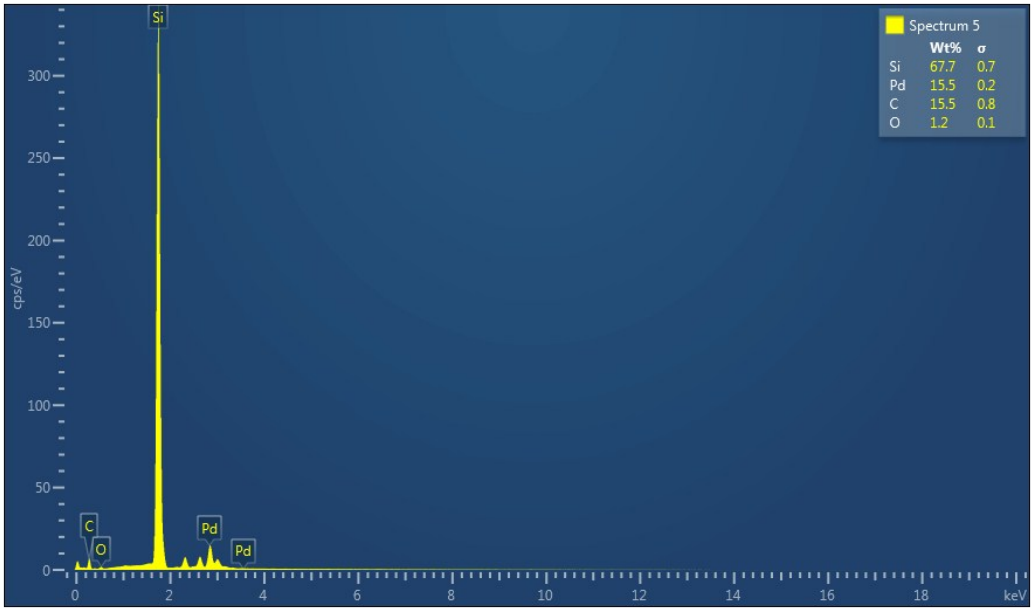

Figure S4. The large area EDS pattern of Pd nanocages.

In Figure S4, element Si should come from the substrate and thus not contain in the analysis of the elements proportion of Pd nanocages. Element C should mainly come from the adsorbed CO_2

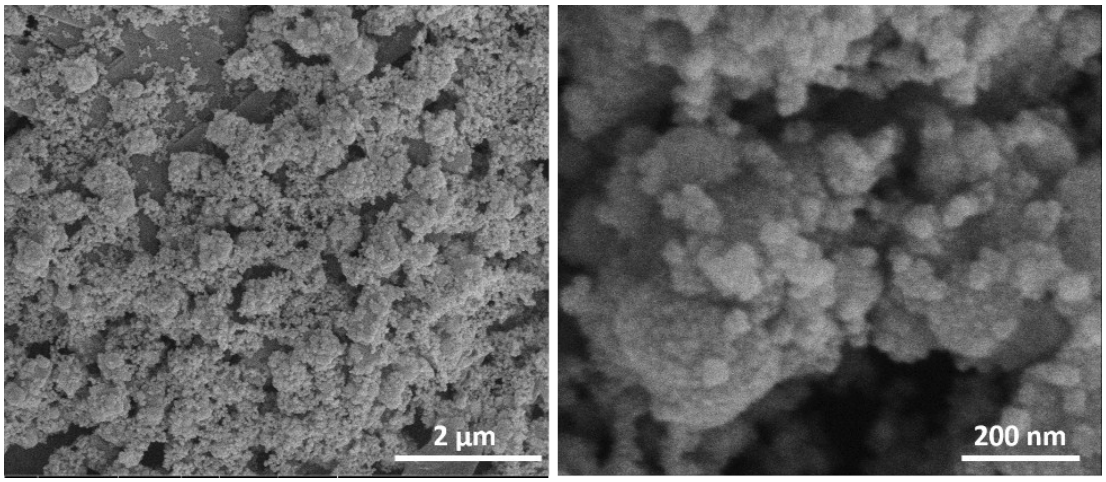

Figure S5. FESEM images of Pd-D.

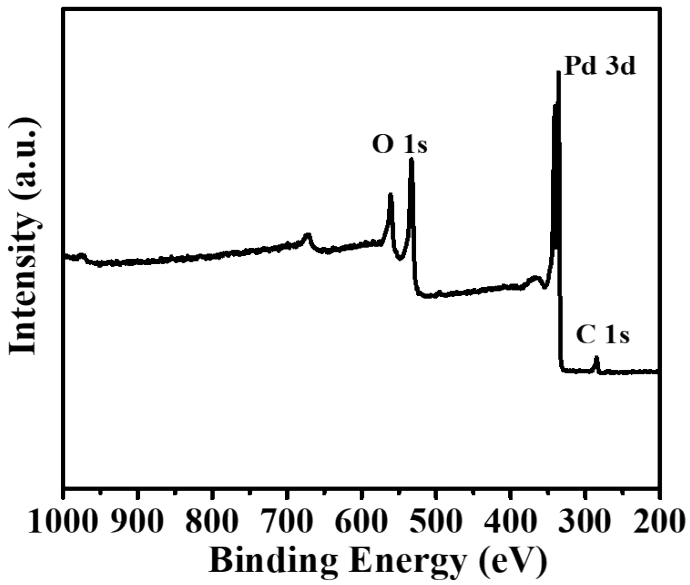

Figure S6. The survey XPS spectrum of Pd nanocages.

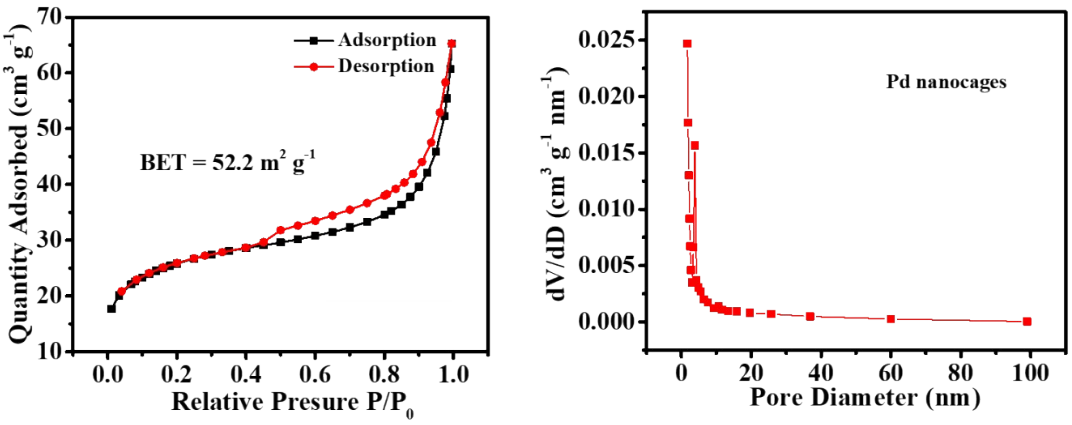

Figure S7 a) N_2 physisorption isotherms and b) pore size distribution and cumulative pore volumes determined from the isotherms using the Barrett-Joyner-Halenda (BJH) method for Pd nanocages.

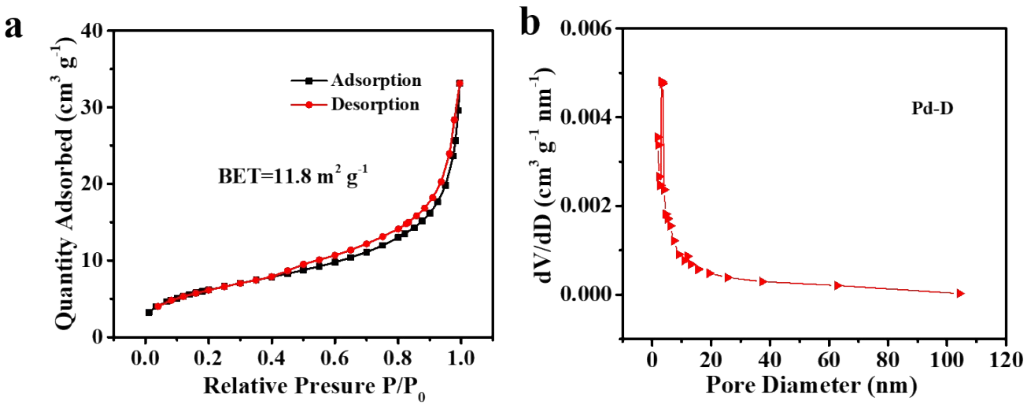

Figure S8 a) N_2 physisorption isotherms and b) pore size distribution and cumulative pore volumes determined from the isotherms using the Barrett-Joyner-Halenda (BJH) method for Pd nanocages.

Table S2. Comparison of the results of Pd nanocages with recently reported materials

Catalysts	Test protocol	Mass activity mA mg^{-1} $_{Noble\ metal}$	Specific activity mA cm^{-2}	ECSA m^2 g^{-1}	Ref.
Pd nanocages	**1.0 M KOH + 1.0 M ethanol**	**3765**	**4.13**	**91.3**	**This work**
Au@Pd NRs	1.0 M KOH + 1.0 M ethanol	2920	--	--	[1]
Pd/$Ni(OH)_2$/rGO	1.0 M KOH + 1.0 M ethanol	1546	--	40.3	[2]
$Pd_{83}Ni_{17}$ HNS aerogel	1.0 M NaOH + 1.0 M ethanol	3630	6.54	55.5	[3]
IM-Pd3Pb NNs	1 M NaOH + 1 M ethanol	3200	--	44.8	[4]
porous PtPdRu PNDs	1.0 M NaOH + 1.0 M ethanol	16320	23.75	68.8	[5]
Pd/Carbon nanocage	1.0 M KOH + 1.0 M ethanol	2412	--	63.6	[6]
Pd_2Ge Intermetallic Nanoparticles	1.0 M KOH + 1.0 M ethanol	--	4.1	14.1	[7]
Pd-Cu(F)/RGO	0.5 M NaOH + 0.5 M ethanol	2416	--	151.9	[8]
Pd-on-Cu/RGO	0.5 M NaOH + 0.5 M ethanol	181.30	--	64.98	[9]
H-$PdSnNi_{2.5}$	1.0 M NaOH + 1.0 M ethanol	1902	--	93.3	[10]
Pd nanoparticles supported on carbon nanotubes	1.0 M KOH + 1.0 M ethanol	2939	--	89	[11]
Pd nanoparticles supported on carbon nanotubes	1.0 M KOH + 1.0 M ethanol	3540	--	--	[12]

1. Y. Chen, Z. Fan, Z. Luo, X. Liu, Z. Lai, B. Li, Y. Zong, L. Gu and H. Zhang, *Advanced Materials*,
2. 2017, **29**.
2. W. Huang, X. Y. Ma, H. Wang, R. Feng, J. Zhou, P. N. Duchesne, P. Zhang, F. Chen, N. Han and F. Zhao, *Advanced Materials*, 2017, **29**.
3. B. Cai, D. Wen, W. Liu, A. K. Herrmann, A. Benad and A. Eychmüller, *Angewandte Chemie International Edition*, 2015, **54**, 13101-13105.

4. Q. Shi, C. Zhu, C. Bi, H. Xia, M. H. Engelhard, D. Du and Y. Lin, *Journal of Materials Chemistry A*, 2017, **5**, 23952-23959.
5. K. Eid, Y. H. Ahmad, H. Yu, Y. Li, X. Li, S. Y. AlQaradawi, H. Wang and L. Wang, *Nanoscale*, 2017, **9**, 18881-18889.
6. Q. Zhang, L. Jiang, H. Wang, J. Liu, J. Zhang, Y. Zheng, F. Li, C. Yao and S. Hou, *ACS Sustainable Chemistry & Engineering*, 2018.
7. S. Sarkar, R. Jana, U. V. Waghmare, B. Kuppan, S. Sampath and S. C. Peter, *Chem Mater*, 2015, **27**, 7459-7467.
8. J. Zhang, A. Feng, J. Bai, Z. Tan, W. Shao, Y. Yang, W. Hong and Z. Xiao, *Nanoscale research letters*, 2017, **12**, 521.
9. Q.-L. Zhang, J.-N. Zheng, T.-Q. Xu, A.-J. Wang, J. Wei, J.-R. Chen and J.-J. Feng, *Electrochim Acta*, 2014, **132**, 551-560.
10. L. Ning, A. Zhu, M. Deng, Q. Zhang and Q. Liu, *Electrochim Acta*, 2017.
11. M. S. Ahmed and S. Jeon, *J Power Sources*, 2015, **282**, 479-488.
12. N. Mackiewicz, G. Surendran, H. Remita, B. Keita, G. Zhang, L. Nadjo, A. Hagege, E. Doris and C. Mioskowski, *Journal of the American Chemical Society*, 2008, **130**, 8110-8111.

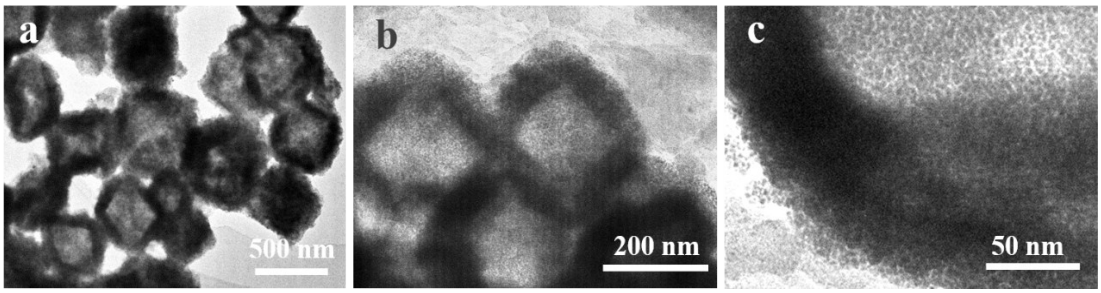

Figure S9 TEM images of Pd nanocages after chronoamperometry test.

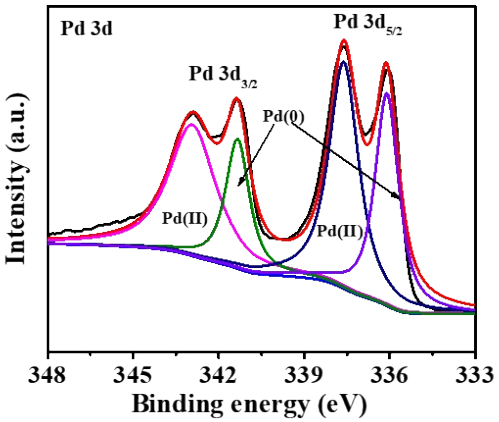

Figure S10 Pd 3d spectrum of Pd nanocages after chronoamperometry test.