Supporting Information

Seeded Growth of Gold-based Nanoscale Homojunctions *via* Controlled Etching-Regrowth and Their Applications for Methanol Oxidation Reaction

Quansen Wu,[a] Gongguo Zhang,[b] Yingying Wang,[c*] Yaqi Jiao,[b] Yanyun Ma,[d] and Yiqun Zheng[b*]

[a] School of Engineering, Jining University, Qufu, Shandong 273155, China

[b] School of Chemistry, Chemical Engineering, and Materials, Jining University, Qufu, Shandong 273155, China

[c] Health Management Department, Shandong Vocational College of Light Industry, Zibo, 255300, P. R. China

[d] Institute of Functional Nano & Soft Materials (FUNSOM), Jiangsu Key Laboratory of Advanced Negative Carbon Technologies, Soochow University, Suzhou, 215123, Jiangsu, China

[*] Corresponding authors: Prof. Dr. Y. Zheng, E-mail: whzyq@163.com; Prof. Dr. Y. Wang, *E-mail*: hxwyy2005@mail.sdu.edu.cn

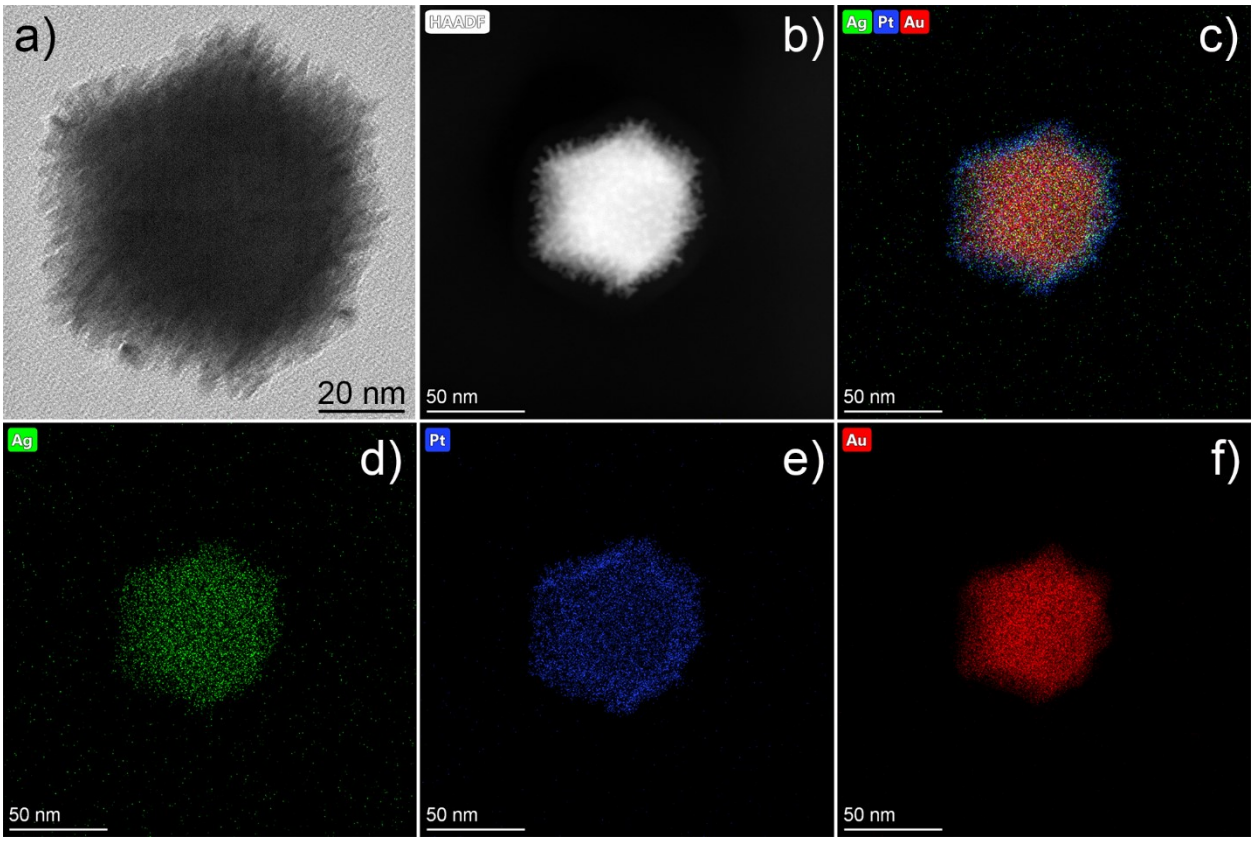

Figure S1. Morphology and structural characterizations of Pt/Ag doped TOH Au seeds: a) TEM; b) HAADF-STEM; c-f) EDX-STEM: c) Au+Pt+Ag, d) Ag, e) Pt, f) Au.

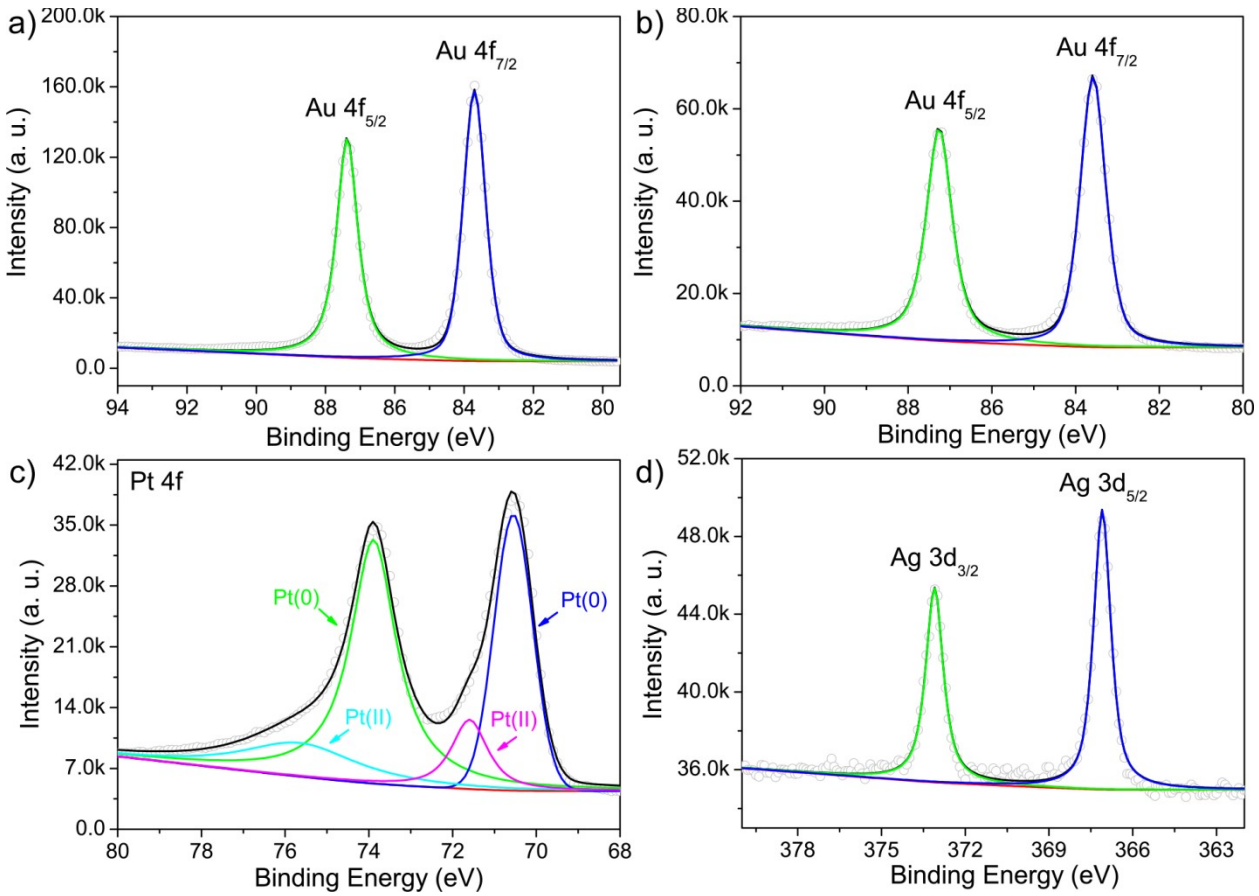

Figure S2. High-resolution XPS spectra of a) TOH Au seeds and b-d) Pt/Ag doped TOH Au seeds: a, b) Au 4f; c) Pt 4f; d) Ag 3d.

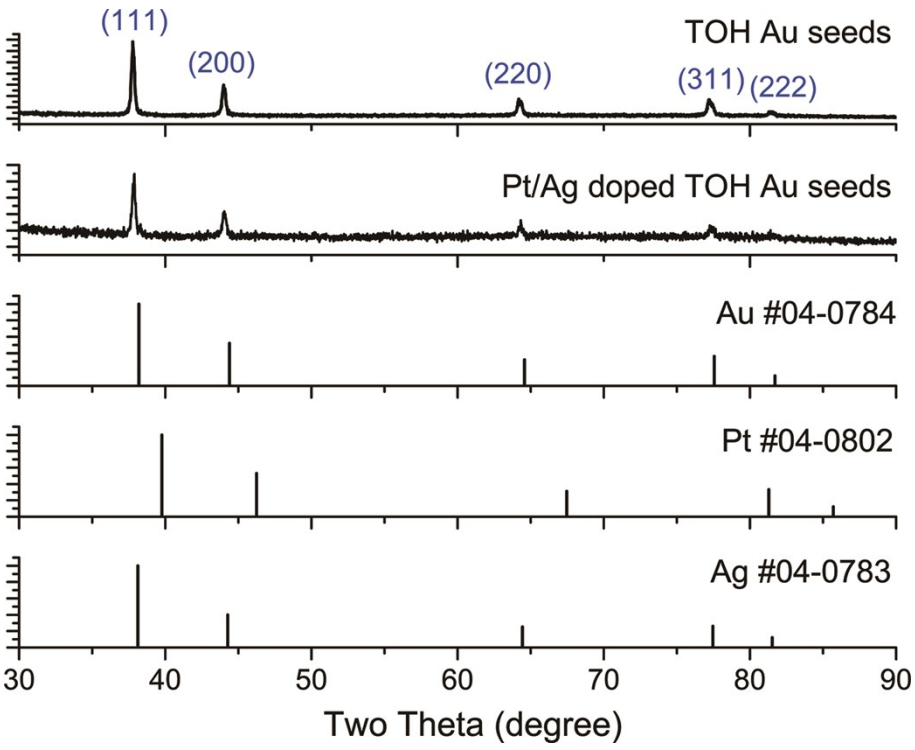

Figure S3. XRD patterns of TOH Au seeds and Pt/Ag doped TOH Au seeds.

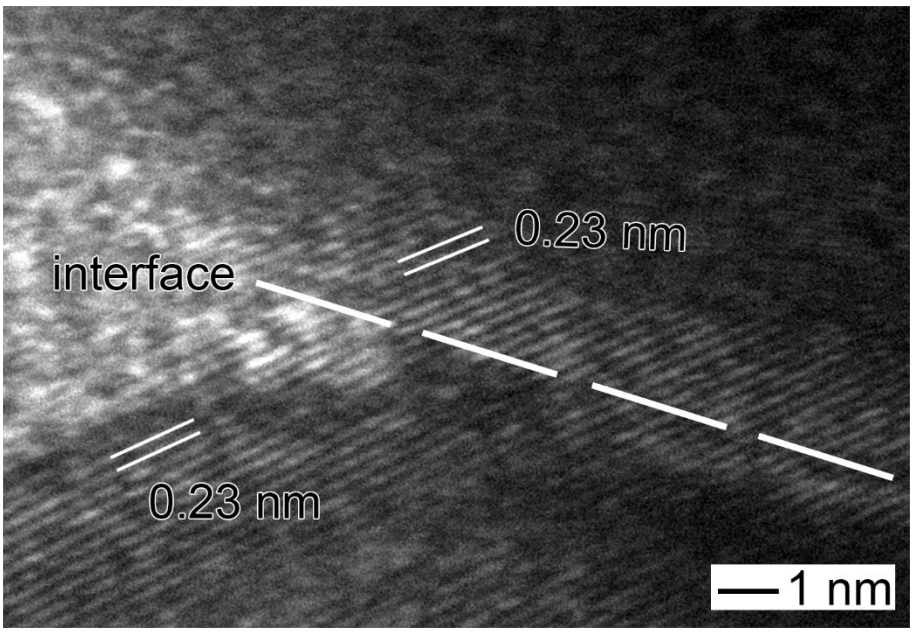

Figure S4. HRTEM image of the interface region of an individual Au-based NHJ.

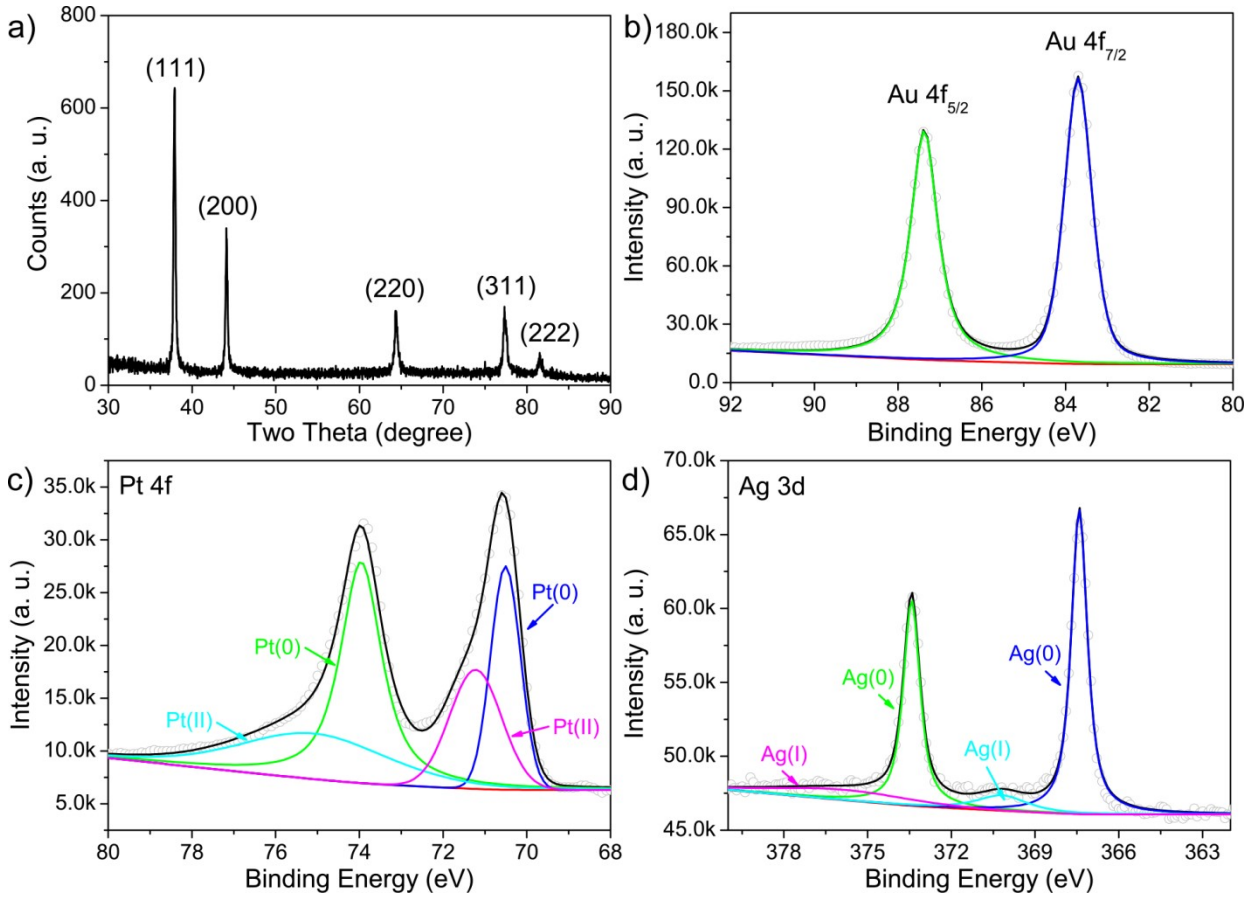

Figure S5. a) XRD patterns and b-d) high resolution XPS spectra of Au-based NHJs: b) Au 4f, c) Pt 4f, and d) Ag 3d.

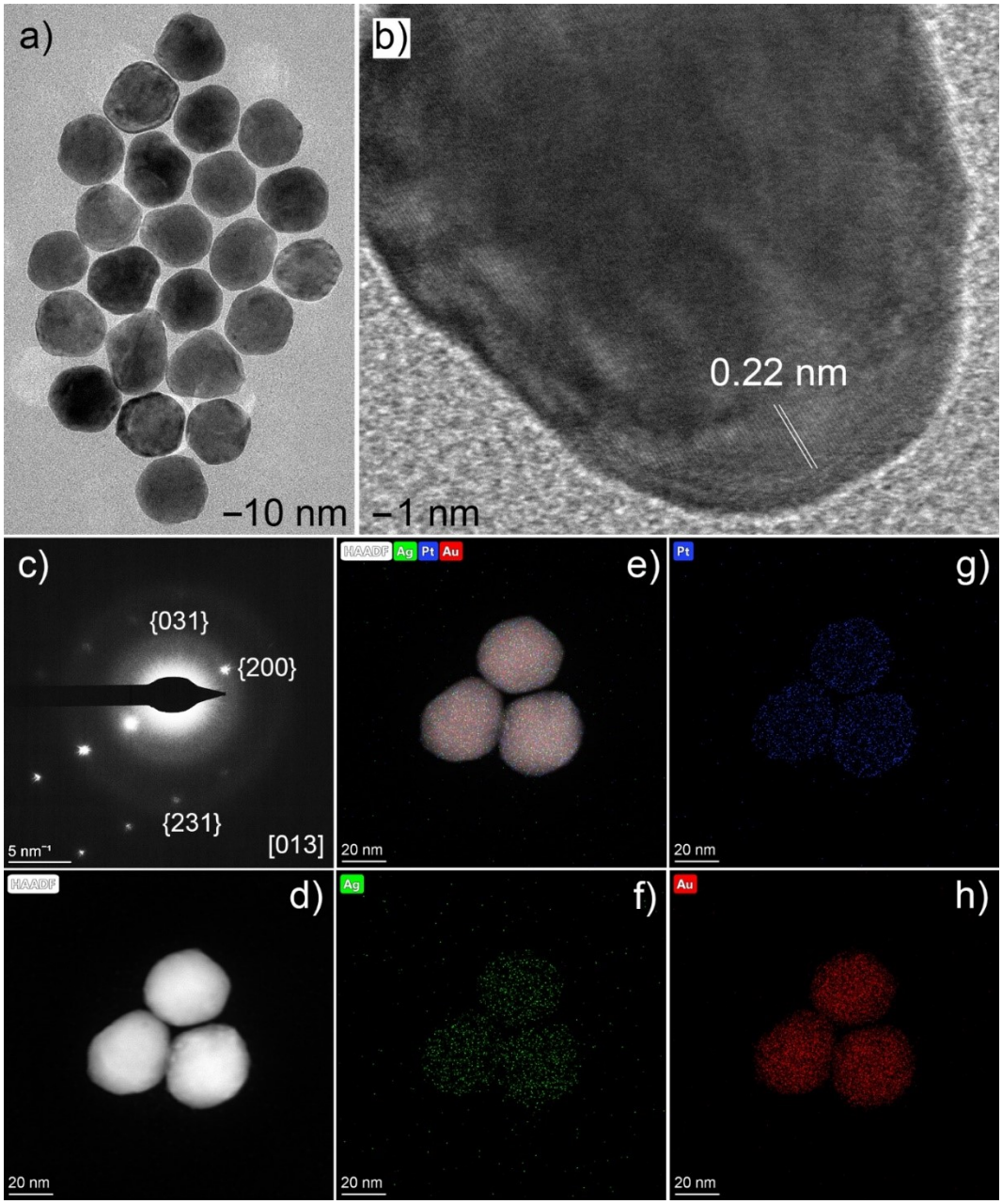

Figure S6. Morphology and structural characterizations of products shown in Figure 4d: a) TEM; b) HRTEM; c) SAED; d) HAADF-STEM; e-h) EDX-STEM: e) Au+Pt+Ag, f) Au, g) Pt, h) Au.

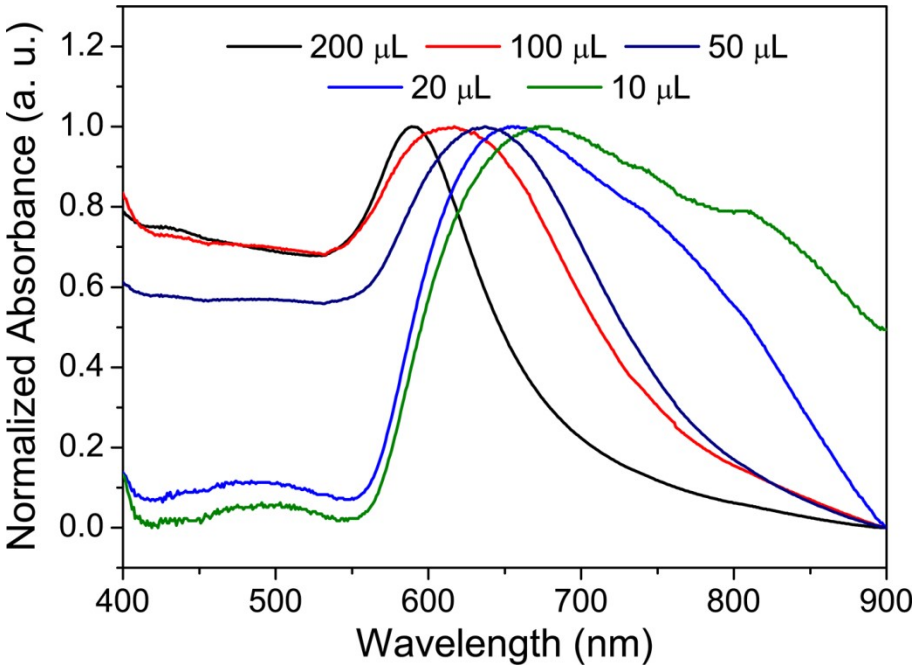

Figure S7. UV-vis extinction spectra of Au-based products obtained via the standard procedure, except for the use of 10-nm Au seeds stock solution at different volumes.

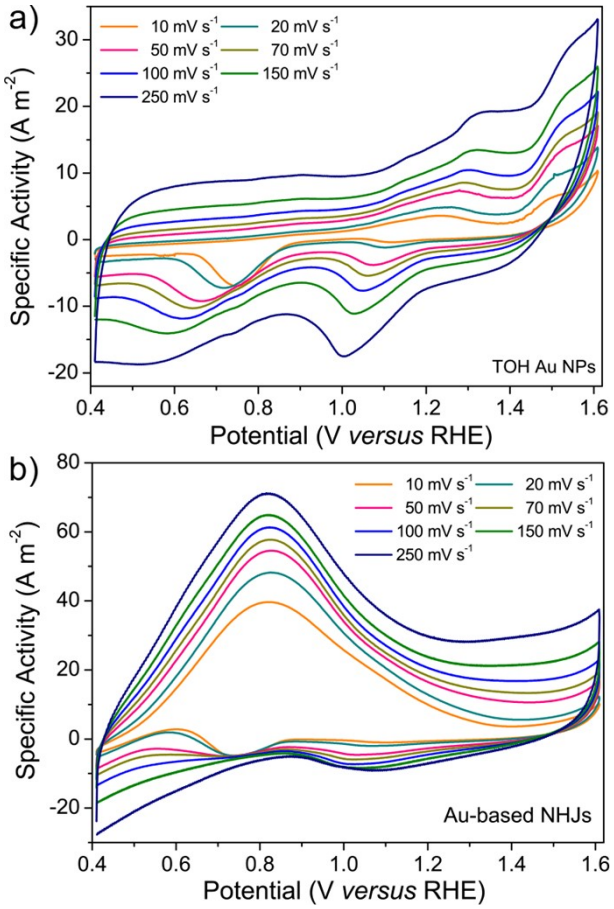

Figure S8. CV traces of a) TOH Au NPs/C and b) Au-based NHJs/C recorded in 0.5 M KOH+1 M methanol under different scan rates.

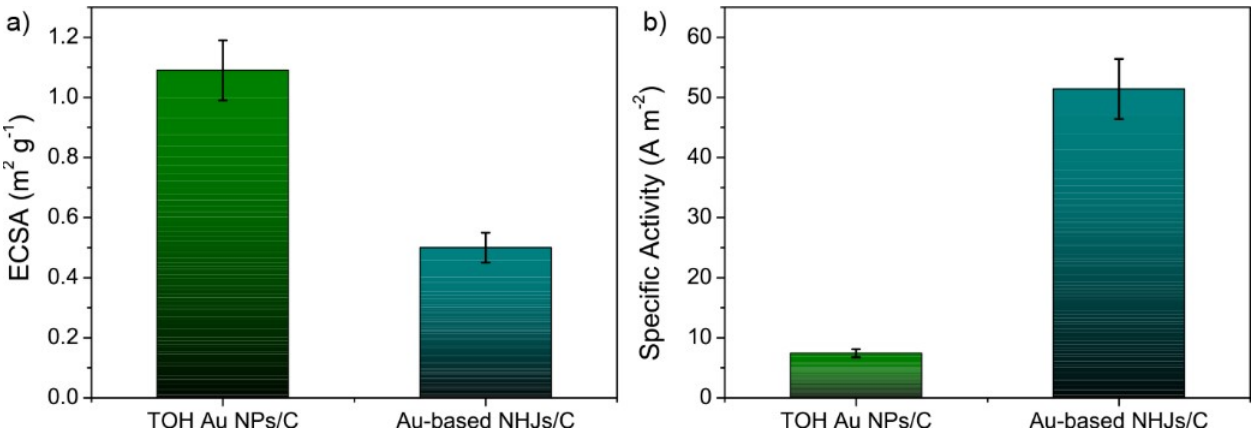

Figure S9. Histograms showing the MOR data of a) ECSA and b) specific activity, which were collected *via* multiple parallel tests under the same measurement conditions as described in the experimental section.

Table S1. XRD peak positions of TOH Au seeds, Pt/Ag doped TOH Au seeds, Au-based NHJs.

Sample	Diffraction Peak Position				
	(111)	**(200)**	**(220)**	**(311)**	**(222)**
TOH Au seeds	38.2	44.4	64.6	77.6	81.5
Pt/Ag doped TOH Au seeds	38.3	44.4	64.7	77.8	/
Au-based NHJs	38.3	44.5	64.8	77.7	81.9
Au (JCPDS No. 04-0784)	38.2	44.4	64.6	77.5	81.7
Pt (JCPDS No. 04-0802)	39.8	46.2	67.5	81.3	85.7
Ag (JCPDS No. 04-0783)	38.1	44.3	64.4	77.5	81.5

Table S2. Statistical size information of Au-based NHJs obtained using different amounts of 10-nm Au seeds.

Sample	volume of Au seeds (μL)	Part I		Part II	
		d (nm)	σ (nm)	d (nm)	σ (nm)
Figure 4a	10	90.8	20.6	65.4	13.4
Figure 2	20	79.7	28.4	58.7	21.4
Figure 4b	50	67.8	27.2	44.9	15.3
Figure 4c	100	58.2	8.2	30.8	7.5

Table S3. LSPR peak positions of Au-based NHJs with different sizes.

Sample	LSPR Peak Position	
Au-based NHJs (10 μL)	676 nm	497 nm
Au-based NHJs (20 μL)	654 nm	486 nm
Au-based NHJs (50 μL)	637 nm	
Au-based NHJs (100 μL)	614 nm	

Table S4. Summary of MOR electrocatalytic performance for Au-based electrocatalysts in the present study.

Electrocatalyst	E_s* (mV)	E_p* (mV)	ECSA ($m^2\ g^{-1}$)	Specific Activity ($A\ m^{-2}$)	j(t=3000s) ($A\ m^{-2}$)
TOH Au NPs	479	1280	1.09	7.42	0.10
Au-based NHJs	435	825	0.500	51.4	21.7

*E_s=onset potential vs. RHE; E_p=peak potential vs. RHE.

Table S5. Comparison of MOR electrocatalytic performance of Au-based electrocatalysts among recent studies.

Electrocatalyst	Electrolyte	Scan Rate	Electrochemical Activity	Ref.
Trisoctahedron Au nanocrystals	0.5 M KOH+1 M CH_3OH	20 mV s^{-1}	0.139 mA cm^{-2}	[1]
Au micromeshes/PDMS	0.5 M KOH+1 M CH_3OH	20 mV s^{-1}	0.264 mA cm^{-2}	[2]
Dendritic Au	0.1 M KOH+1 M CH_3OH	10 mV s^{-1}	0.095 mA cm^{-2}	[3]
Nanoporous Au	0.5 M KOH+1 M CH_3OH	20 mV s^{-1}	0.088 mA cm^{-2}	[4]
Dendritic Au	0.1 M KOH+2 M CH_3OH	10 mV s^{-1}	0.056 mA cm^{-2}	[5]
Dealloyed nanosponge Au particles	0.5 M KOH+1 M CH_3OH	5 mV s^{-1}	0.182 mA cm^{-2}	[6]
Au-based NHJs	0.5 M KOH+1 M CH_3OH	20 mV s^{-1}	5.14 mA cm^{-2}	current work

References

1. Y. Song, T. Miao, P. Zhang, C. Bi, H. Xia, D. Wang and X. Tao, *Nanoscale*, 2015, **7**, 8405-8415.
2. J. Sun, F. Wang, Y. Liu, Y. Ni, H. Zhou, C. F. Guo and S. Chen, *RSC Adv.*, 2017, **7**, 22479-22484.
3. X. Han, D. Wang, J. Huang, D. Liu and T. You, *J. Colloid Interf. Sci.*, 2011, **354**, 577-584.
4. J. Zhang, P. Liu, H. Ma and Y. Ding, *J. Phys. Chem. C*, 2007, **111**, 10382-10388.
5. T. Huang, F. Meng and L. Qi, *Langmuir*, 2010, **26**, 7582-7589.
6. G. G. Li, Y. Lin and H. Wang, *Nano Lett.*, 2016, **16**, 7248-7253.