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Supporting Information

Layer-by-Layer assemble of Au and CdS nanoparticles on the surface of bacterial cell for photo-assisted bioanode in microbial fuel cells

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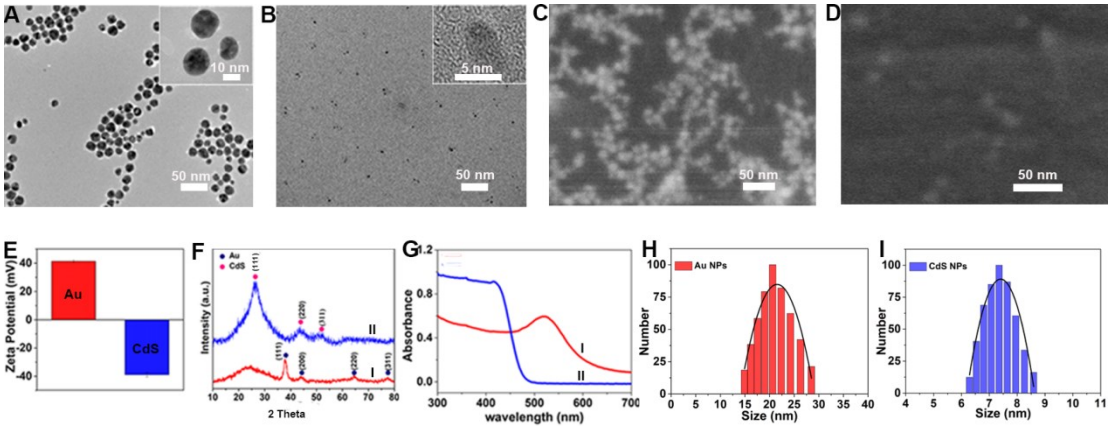

Fig. S1 Transmission electron microscopy images of Au NPs (A) and CdS NPs (B). The inset is the enlarged view of the images. Scanning electron microscopy images of Au NPs (C) and CdS NPs (D). ζ-potential (E), X-ray diffraction analysis (F) and UV-Visible spectroscopy analysis (G) of Au NPs (I) and CdS NPs (II). The hydrodynamic diameter of Au NPs (H) and CdS NPs (I). The size of Au NPs were about 10-15 nm while the size of CdS NPs were about 3-5 nm. Regular and uniform spherical shapes are observed for the Au NPs. The ζ-potential of Au NPs and CdS NPs were 41.3 ± 0.9 mV and -38.9 ± 1.6 mV respectively. In the XRD pattern, the peaks at 2θ = 38.2°,44.4°, 64.6° and 77.6° (curve I) correspond to (111), (200), (220) and (311) planes of Au NPs, while the peaks at 2θ = 26.4°, 43.9°, 51.9°, can be assigned to (111), (220) and (311) planes of CdS NPs.[1, 2] As shown in Fig. S1G, there were obvious absorption peak at 525 nm (I) and 420 nm (II) in curve, corresponding to the absorption peaks of Au and CdS respectively.[1,2] Dynamic Light Scattering (DLS) revealed the hydrodynamic diameter of Au NPs were 18.36 ± 0.18 nm while the hydrodynamic diameter of CdS NPs were 7.29 ± 0.14 nm. As mentioned above, the positively-charged Au NPs and negatively-charged CdS NPs were successfully prepared.

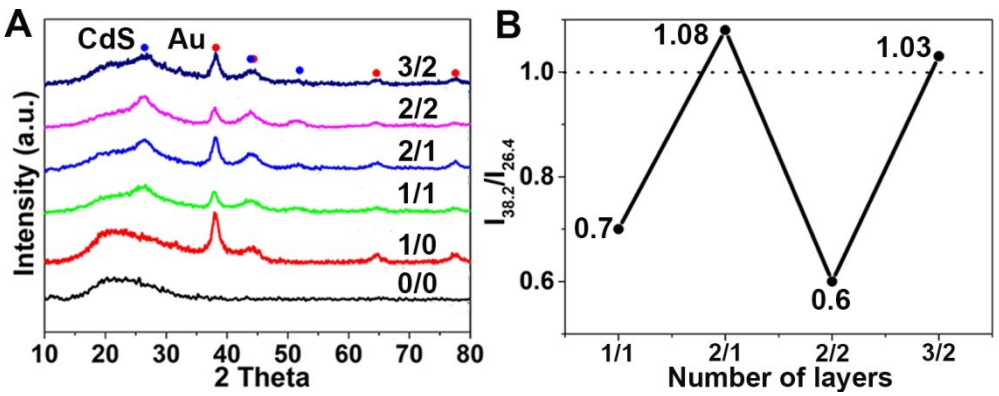

Fig. S2 X-ray diffraction analysis of *E. coli* after each modification (A) and intensity ratio of peak at 38.2°to peak at 26.4° (B).

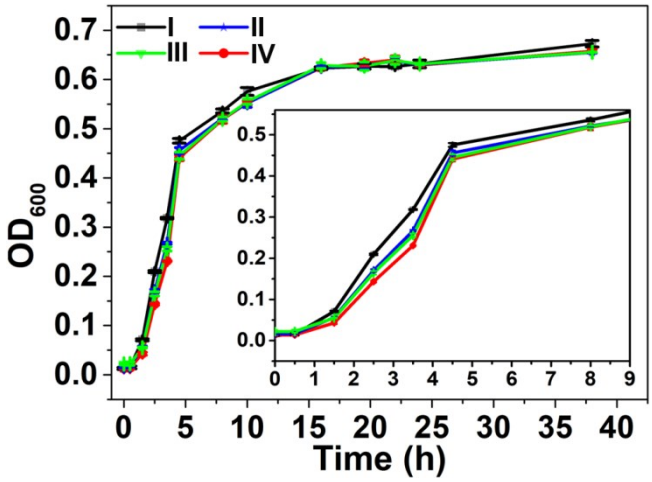

Fig. S3 Cell-growth curves of native *E. coli* (I) and LbL self-assembled *E. coli* (II *E. coli*@Au_1@CdS_0, III *E. coli*@Au_1@CdS_1, and IV *E. coli*@Au_3@CdS_2). The inset is the enlarged view of the curves. Error bars represent standard error (s.e.) determined by three independent experiments.

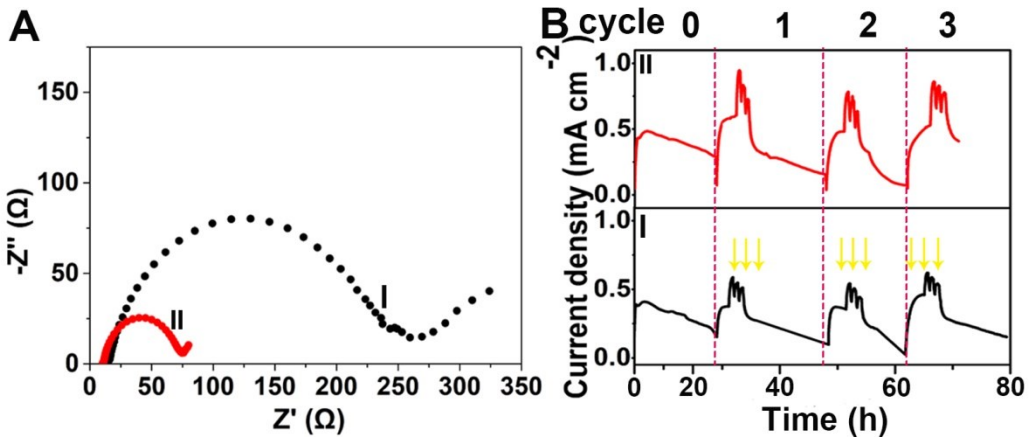

Fig. S4 The Nyquist curves (A) and current-time curves (B) of photo-bioanode with LbL self-assembled *E. coli* (I *E. coli*@Au_2@CdS_2 and II *E. coli*@Au_3@CdS_2). The frequency ranged from 10^5 to 10^{-3} Hz, and the inset is the enlarged view of the curves.

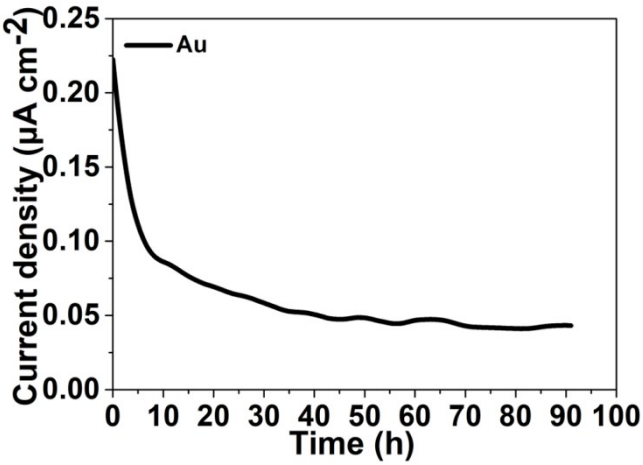

Fig. S5 Current-time curve of electrode modified with Au NPs separately in the electrochemical cells (ECs) with the addition of 2-hydroxy-1, 4-naphthoquinone (HNQ) as mediator and the glucose as substrate.

Table S1 The statistical table of current density produced by photo-bioanodes in dark condition and light illumination.

Layer No.	plateau current density in each cycle without light illumination (mA cm^{-2})					average of three plateau currents densities in each cycle with light illumination (mA cm^{-2})				averaged current density increment (mA cm^{-2})	averaged current density increment / averaged plateau current density without light illumination
	0	1	2	3	average	1	2	3	average		
0/0	0.23	0.21	0.16	0.15	0.19±0.04	0.27	0.24	0.20	0.24±0.04	0.05	26.32%
0/1	0.52	0.53	0.48	0.40	0.48±0.06	0.66	0.65	0.53	0.61±0.07	0.12	25.00%
1/1	0.40	0.40	0.36	0.37	0.38±0.02	0.52	0.53	0.47	0.51±0.03	0.13	34.21%
2/1	0.51	0.52	0.57	0.51	0.53±0.03	0.80	0.80	0.76	0.79±0.02	0.26	49.06%
2/2	0.41	0.37	0.37	0.46	0.4±0.04	0.54	0.49	0.57	0.53±0.04	0.13	32.50%
3/2	0.48	0.60	0.48	0.53	0.52±0.03	0.84	0.73	0.83	0.80±0.06	0.28	53.85%

Table S2 Comparison of the performance of previous photo-assisted MFCs employing biofilm-attached photoanodes and previous MFCs using functionalized bacterial cells.

Electrode Substrates	Photoanode Materials	Exoelectrogen Type	Maximum Power Density (mW m^{-2})	Ref.
FTO	Fe_2O_3	*Shewanella oneidensis*	185 (light)	3
Crabon Felt	TiO_2/TNT	sludge	1284 (light)	4
/	Nb_2O_5	*Escherichia coli*	1196 (light)	5
FTO	Ag-TiO_2	sludge	1850 (light)	6
Graphite Felt	TiO_2/Fe_2O_3	sludge	638.3 (light)	7
Carbon Felt	/	carbon dots-coated *Shewanella oneidensis*	1697.9 (light)	8
Carbon Cloth	/	carbon dots−fed *Shewanella oneidensis*	491 (dark)	9
Carbon Felt	/	PDA modified *S.xiamenensi*	452.8 (dark)	10
Carbon Cloth	/	Polypyrrole-coated *Shewanella oneidensis*	1479 (dark)	11
Carbon Felt	**/**	**LbL self-assembled *Escherichia coli***	**1704.3 (dark) 2300.4 (light)**	**This work**

References

1. R.-B. Song, S. Zhou, D. Guo, P. Li, L.-P. Jiang, J.-R. Zhang, X. Wu and J.-J. Zhu, *ACS Sustainable Chem. Eng.*, 2019, **8**, 1311-1318.
2. A. Aboulaich, D. Billaud, M. Abyan, L. Balan, J. J. Gaumet, G. Medjadhi, J. Ghanbaja and R. Schneider, *ACS Appl. Mater. Interfaces*, 2012, **4**, 2561-2569.
3. G. Zhu, Y. Yang, J. Liu, F. Liu, A. Lu and W. He, *Biosens. Bioelectron.*, 2017, **94**, 227-234.
4. H.-W. Kim, K.-S. Lee, A. Razzaq, S. H. Lee, C. A. Grimes and S.-I. In, *Energy Technol.*, 2018, **6**, 257-262.
5. M. Li, X. He, Y. Zeng, M. Chen, Z. Zhang, H. Yang, P. Fang, X. Lu and Y. Tong, *Chem. Sci.*, 2015, **6**, 6799-6805.
6. G. Lui, G. Jiang, M. Fowler, A. Yu and Z. Chen, *J. Power Sources*, 2019, **425**, 69-75.
7. G. Ren, Y. Sun, A. Lu, Y. Li and H. Ding, *J. Power Sources*, 2018, **408**, 46-50.
8. D. Guo, H.-F. Wei, R.-B. Song, J. Fu, X. Lu, R. Jelinek, Q. Min, J.-R. Zhang, Q. Zhang and J.-J. Zhu, *Nano Energy*, 2019, **63**. 103875.
9. C. Yang, H. Aslan, P. Zhang, S. Zhu, Y. Xiao, L. Chen, N. Khan, T. Boesen, Y. Wang, Y. Liu, L. Wang, Y. Sun, Y. Feng, F. Besenbacher, F. Zhao and M. Yu, *Nat. Commun.*, 2020, **11**, 1379.
10. S.-R. Liu, L.-F. Cai, L.-Y. Wang, X.-F. Yi, Y.-J. Peng, N. He, X. Wu and Y.-P. Wang, *Chem. Commun.*, 2019, **55**, 10535-10538.
11. R.-B. Song, Y. Wu, Z.-Q. Lin, J. Xie, C. H. Tan, J. S. C. Loo, B. Cao, J.-R. Zhang, J.-J. Zhu and Q. Zhang, *Angew. Chem. Int. Ed.*, 2017, **56**, 10516-10520.