Electronic Supplementary Information

Efficient cascade conversion of starch to gluconic acid by a chemoenzymatic system with co-immobilized Au nanoparticles and enzymes

Jie Gao[a,1], Zhenfu Wang[a,1], Ranran Guo[a,1], Yang Hu[b], Xiaoyan Dong[a], Qinghong Shi[a], Yan Sun[a,*]

[a] Department of Biochemical Engineering, School of Chemical Engineering and Technology and Key Laboratory of Systems Bioengineering and Frontiers Science Center for Synthetic Biology (Ministry of Education), Tianjin University, Tianjin 300350, China

[b] College of Food Science and Engineering, Ocean University of China, Qingdao, 266003, China

[1] These authors contributed equally to this work.

[*] Corresponding author.

E-mail address:

18130282595@163.com (J.Gao)

wangzhf@tju.edu.cn (Z.Wang)

grr@tju.edu.cn (R. Guo)

huyang@ouc.edu.cn (Y.Hu)

d_xy@tju.edu.cn (X.Dong)

qhshi@tju.edu.cn (Q.Shi)

ysun@tju.edu.cn (Y. Sun)

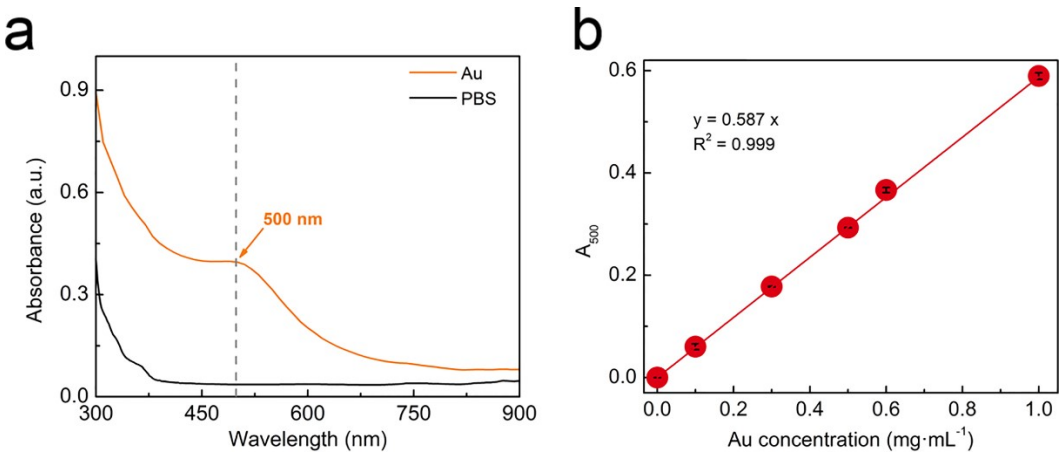

Fig. S1. (a) UV-Vis spectrum and (b) calibration curve of Au. Error bars represent standard deviations from triplicate experiments.

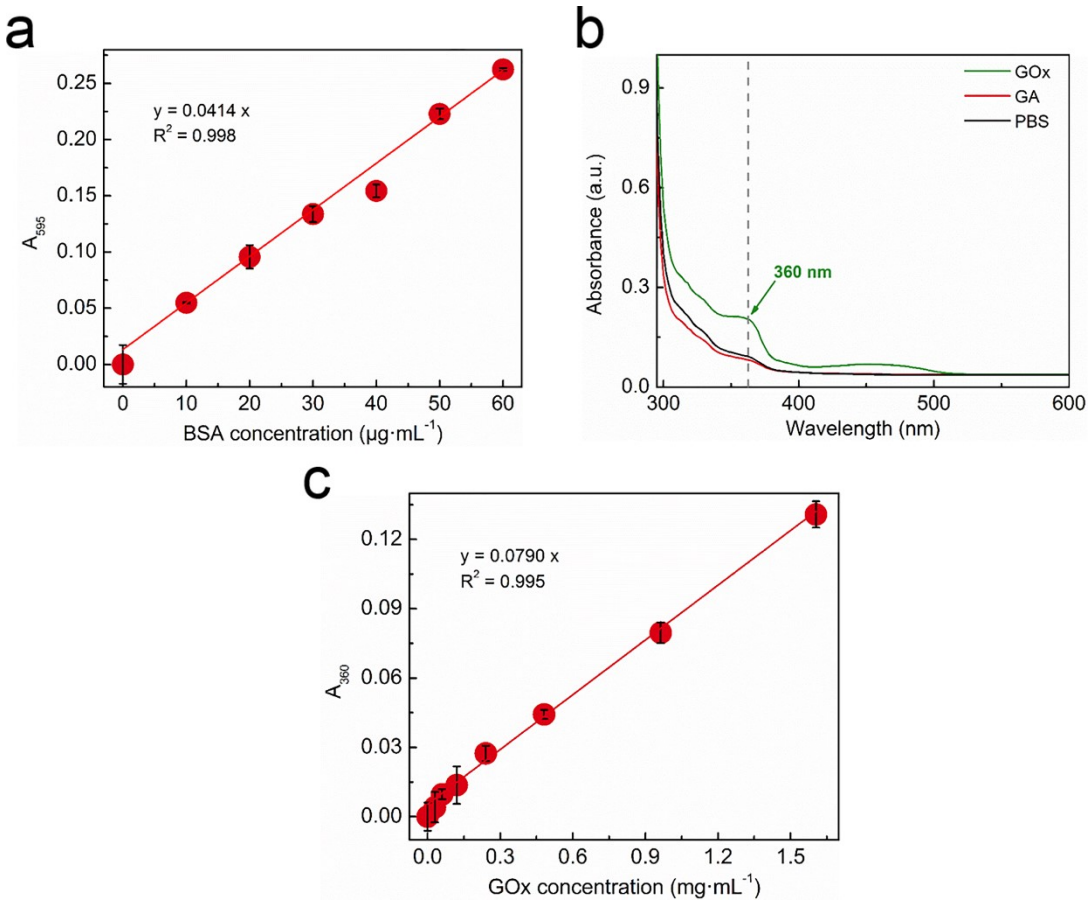

Fig. S2. (a) Calibration curve of BSA measured by Bradford method; (b) UV-Vis spectrum and (c) calibration curve of GOx. Error bars represent standard deviations from triplicate experiments.

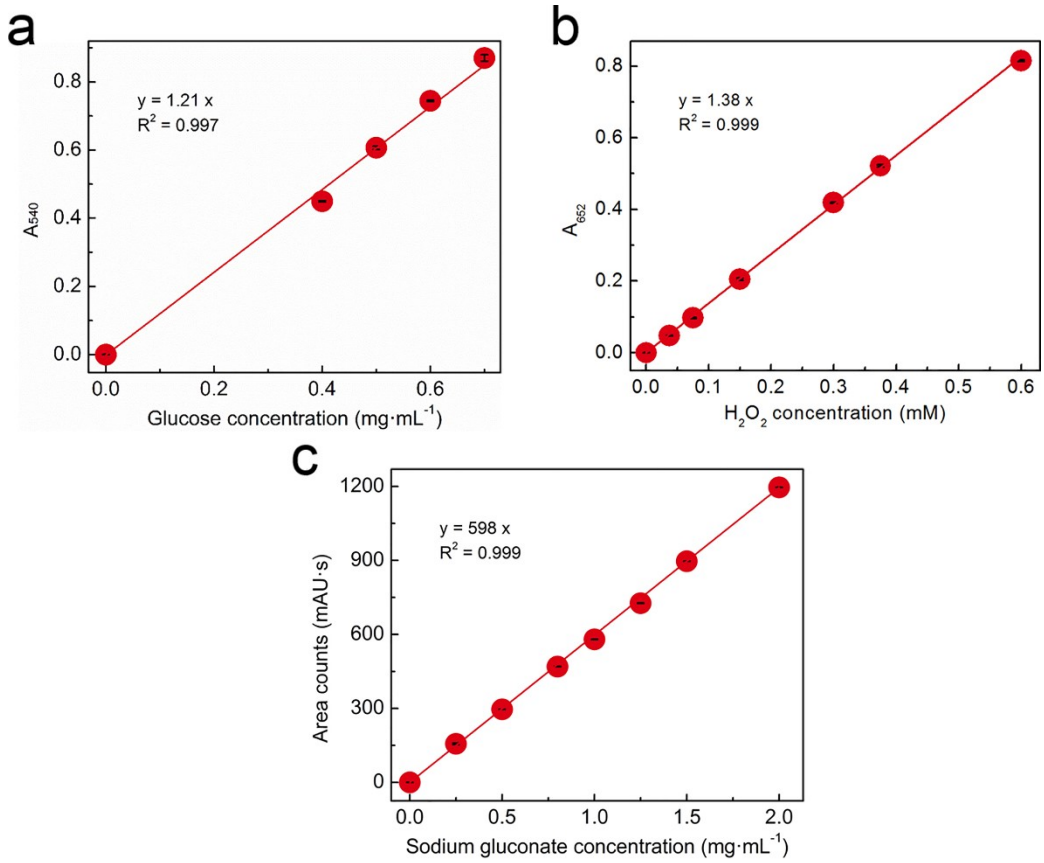

Fig. S3. Calibration curves of (a) glucose, (b) H_2O_2, and (c) sodium gluconate. Error bars represent standard deviations from triplicate experiments.

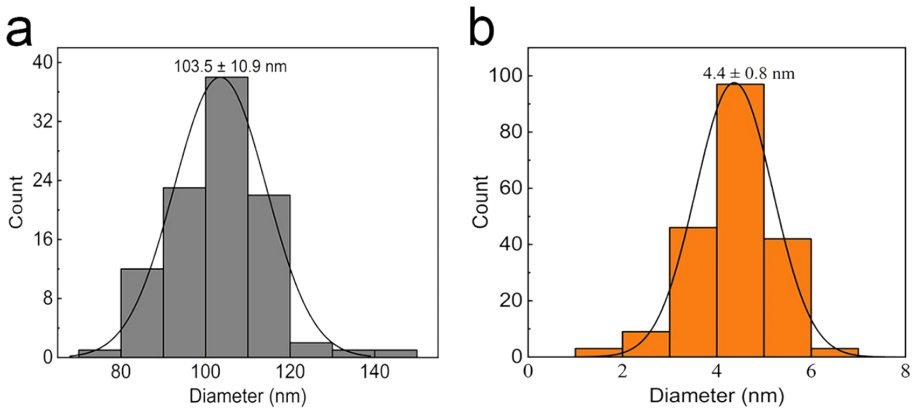

Fig. S4. Size distributions of (a) SiO_2 and (b) Au NPs.

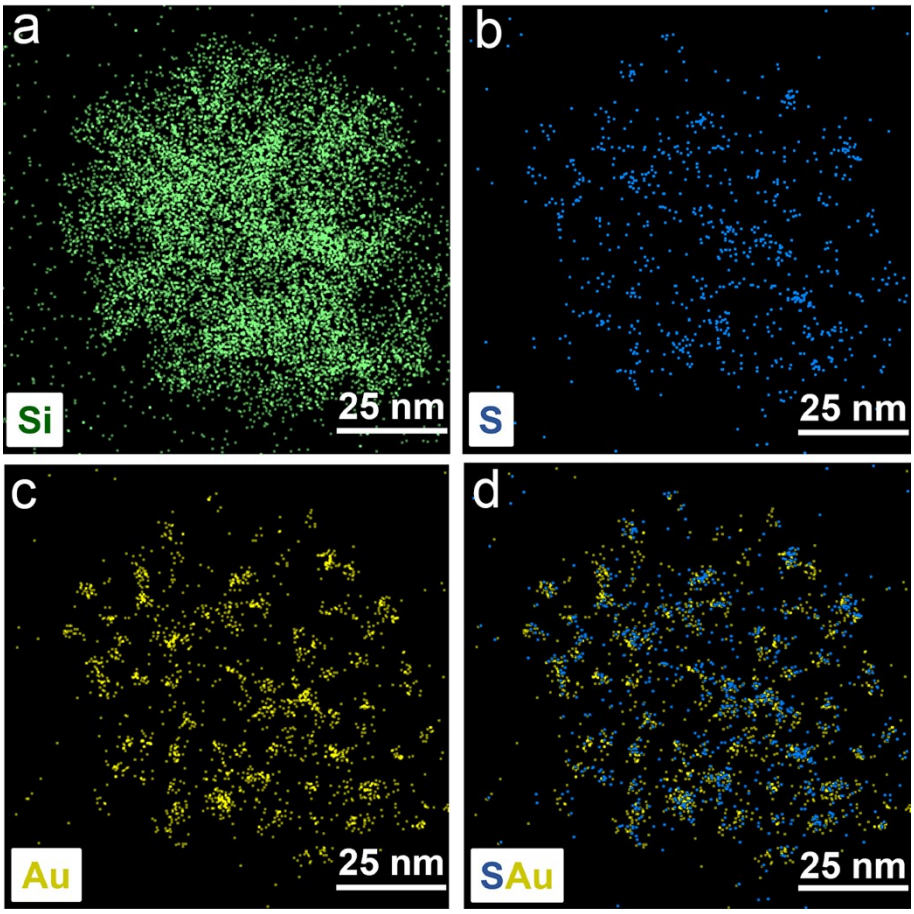

Fig. S5. EDX mapping images of Au-SiO_2, (a) Si, (b) S, (c)Au, and (d) S&Au.

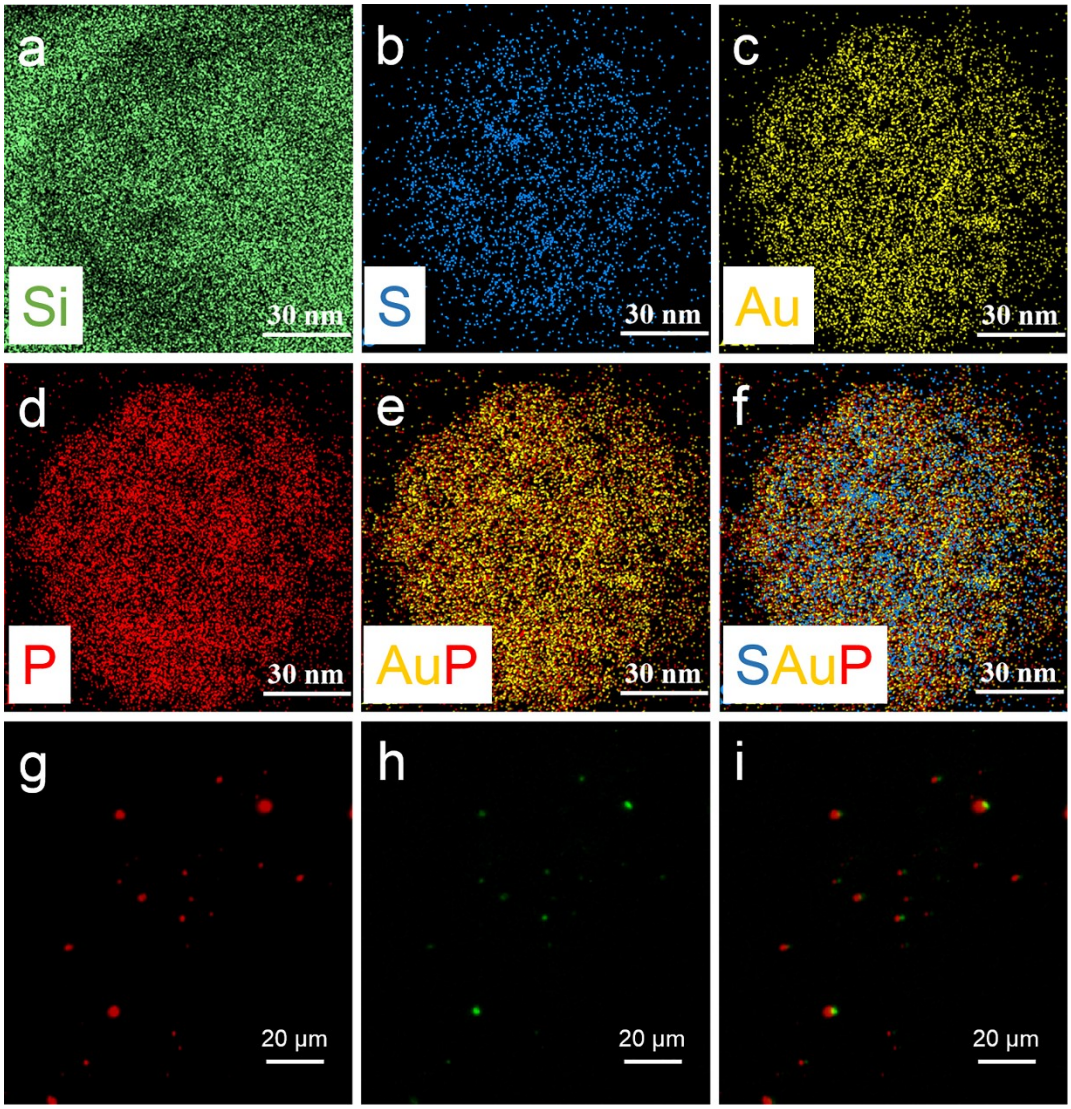

Fig. S6. EDX mapping images of GA&GOx@Au-SiO_2, (a) Si, (b) S, (c) Au, (d) P, (e) Au&P, and (f) S&Au&P. Confocal microscopy images of GA&GOx@Au-SiO_2 (g-i), GA was labeled with RhB (red) (g) and GOx was labeled with FITC (green) (h).

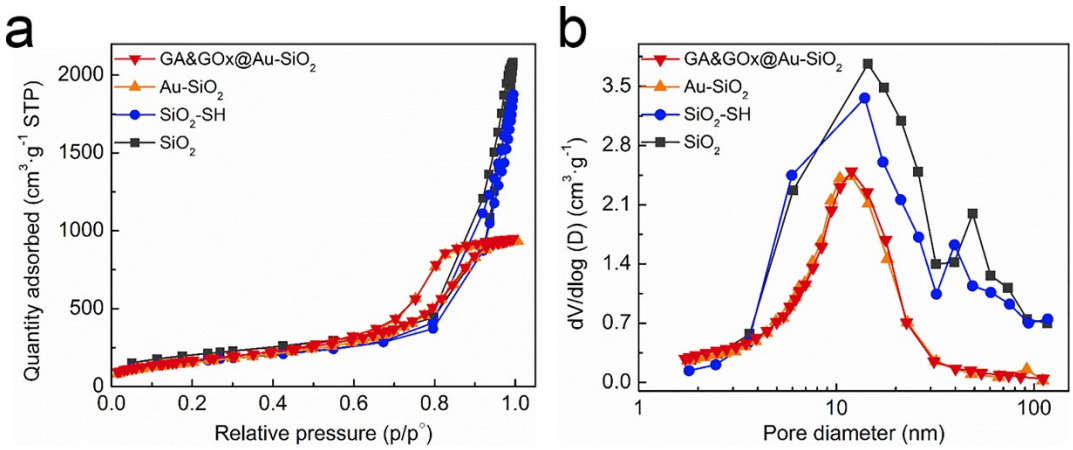

Fig. S7. (a) N_2 adsorption-desorption isotherms and (b) pore size distributions of SiO_2, SiO_2-SH, Au-SiO_2, and GA&GOx@Au-SiO_2.

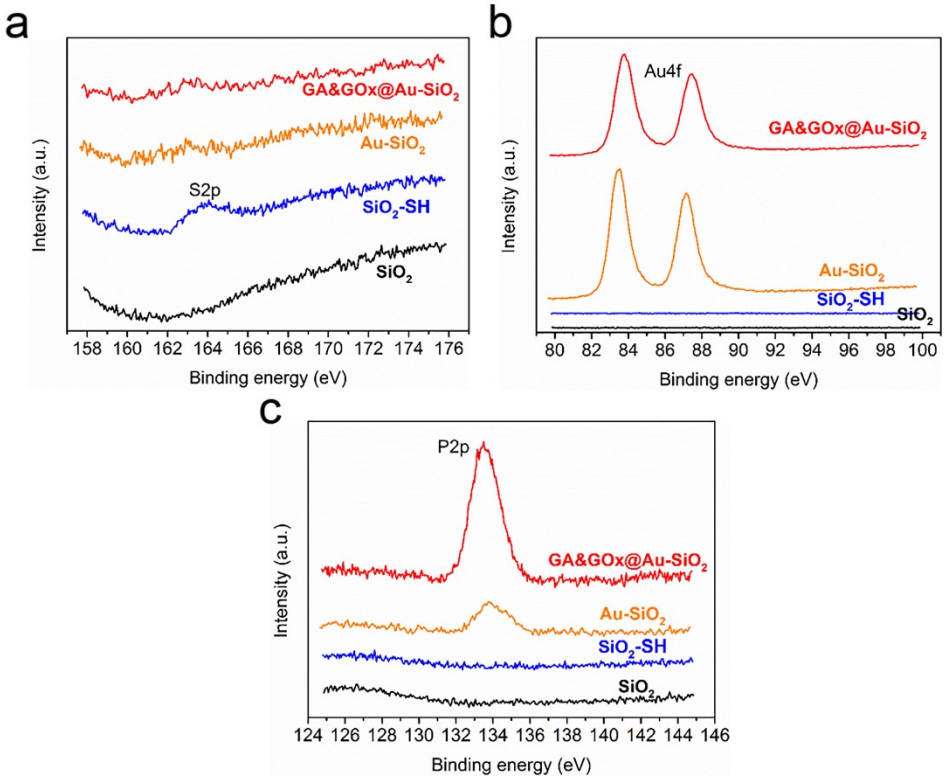

Fig. S8. XPS spectra of (a) S 2p, (b) Au 4f, and (c) P 2p of SiO_2, SiO_2-SH, Au-SiO_2, and GA&GOx@Au-SiO_2.

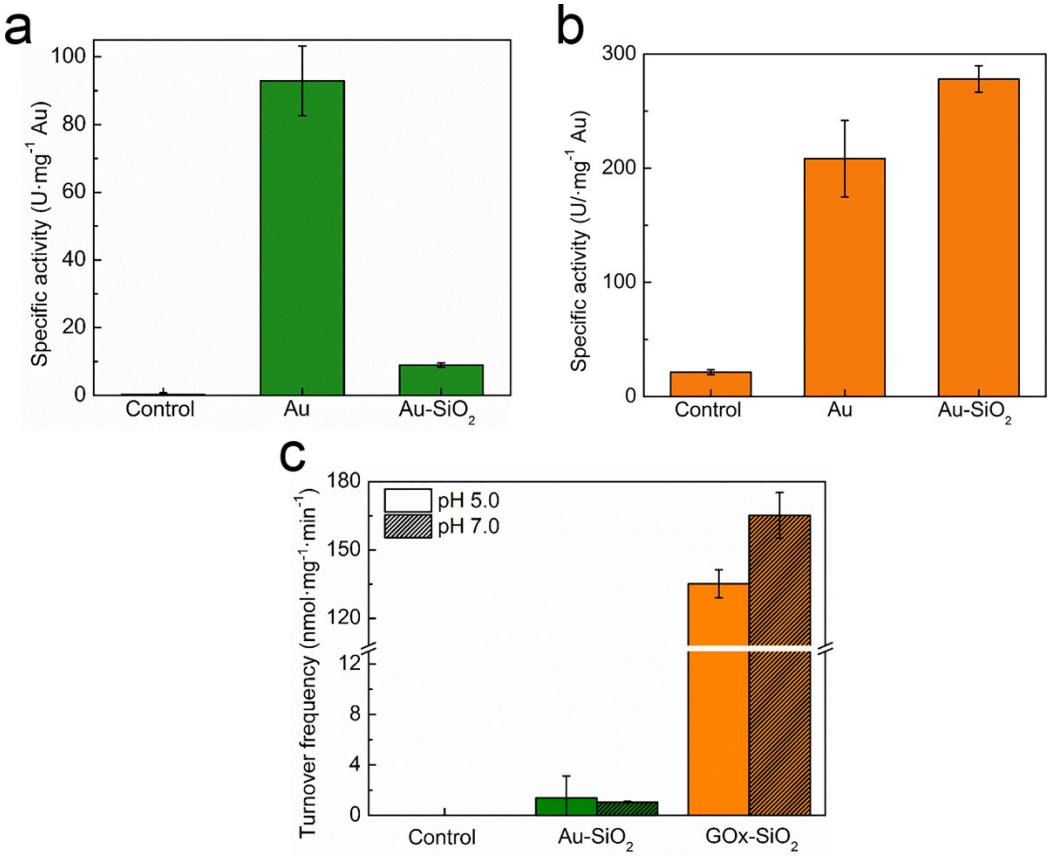

Fig. S9. Specific activities of Au and Au-SiO_2 for (a) glucose oxidation and (b) H_2O_2 decomposition. Reaction condition: 1 mg·mL^{-1} glucose or 10 mM H_2O_2, 100 mM PBS (pH 5.0, containing 10 mM NaCl), 40 °C. Error bars represent standard deviations from triplicate experiments. (c) Turnover frequencies of Au-SiO_2 and GOx-SiO_2 for glucose oxidation. Reaction condition: 1 mg·mL^{-1} glucose, 100 mM PBS (pH 5.0 or 7.0, containing 10 mM NaCl), 40 °C. Error bars represent standard deviations from triplicate experiments.

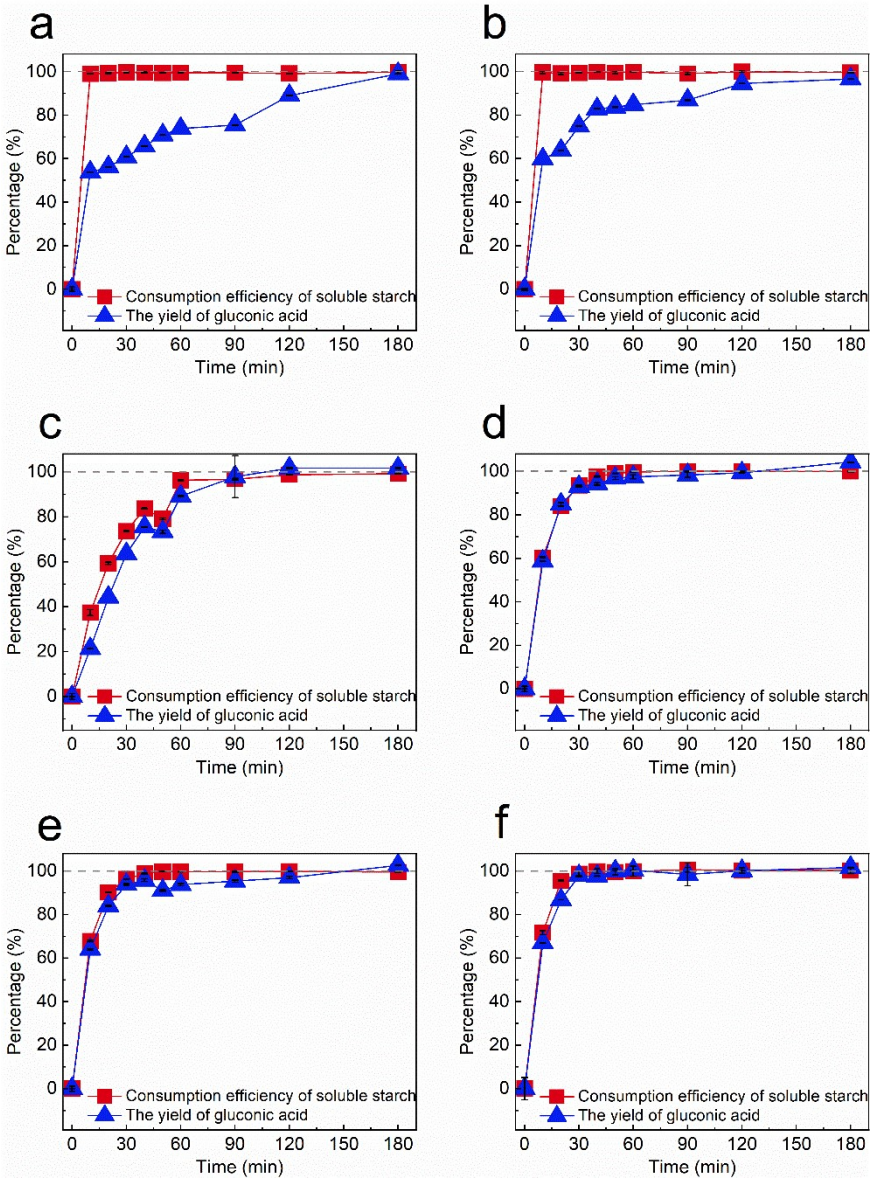

Fig. S10. Time course of the consumption efficiency of soluble starch and the yield of gluconic acid in the reactions catalyzed by (a) free enzymatic cascade system (GA and GOx), (b) free chemoenzymatic cascade system (GA, GOx, and Au-SiO_2), (c) partly integrated system (GA&GOx@SiO_2 and Au-SiO_2), and highly integrated system (GA&GOx@Au-SiO_2) with the GA/GOx ratios of (d) 1/1.48, (e) 1.06/1, and (f) 1.44/1 with different loadings of GA and GOx. Reaction condition: 100 mM PBS (pH 5.0, containing 10 mM NaCl), 40 °C, 0.5 mg·mL^{-1} soluble starch. Error bars represent standard deviations from triplicate experiments.

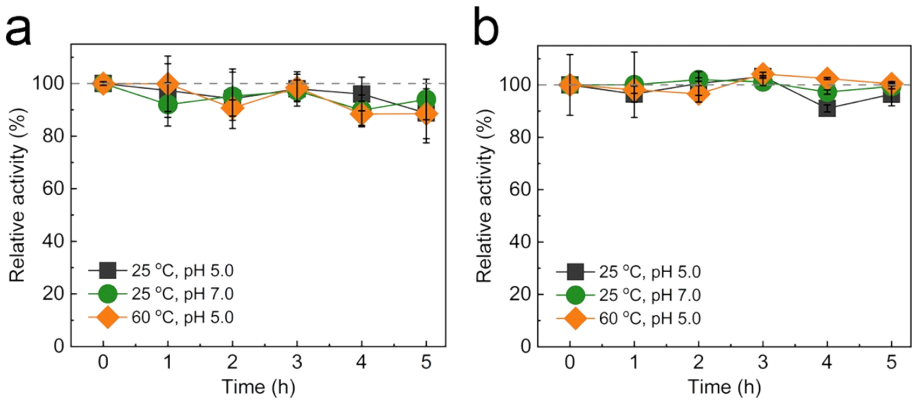

Fig. S11. The stability of Au-SiO_2 with (a) glucose and (b) H_2O_2 as substrates at different conditions. Reaction condition: 100 mM PBS (pH 5.0, containing 10 mM NaCl), 40 °C, 1 mg·mL^{-1} glucose or 10 mM H_2O_2, 0.2 mg·mL^{-1} Au-SiO_2. Error bars represent standard deviations from triplicate experiments.

Table S1.

Pore structure characteristics of SiO_2, SiO_2-SH, Au-SiO_2 and GA&GOx@Au-SiO_2.

Samples	Specific surface area ($m^2 \cdot g^{-1}$)	Pore volume ($cm^3 \cdot g^{-1}$)	Average pore size (nm)
SiO_2	706.4	3.18	8.29
SiO_2-SH	567.3	2.92	8.43
Au-SiO_2	606.7	0.14	7.22
GA&GOx@Au-SiO_2	560.8	0.13	7.13

Table S2.

The isoelectric points of SiO_2, SiO_2-SH, Au NPs, and Au-SiO_2.

Samples	Isoelectric point
SiO_2	4.48
SiO_2-SH	3.90
Au	1.52
Au-SiO_2	3.69