Supporting Information

Near - infrared light - responsive photothermal α-Fe_2O_3@Au/PDA core/shell nanostructure with on-off controllable anti-bacterial effect

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1. Synthesis of α-Fe_2O_3@Au/PDA core-shell nanocube.

Firstly, 10 mg α-Fe_2O_3 nanocubes was dispersed in 40 mL EtOH by ultrasonication, then $HAuCl_4$ (0.15M), trisodium citrate (10 mg) and 30 mL DA-HCl (17.5 mM) in Tris (pH = 8.5) were added to the mixed solution respectively. After sonication for 3 h, the product was obtained from the mixed solution using centrifugal separation and washed 3 times with deionized water and ethanol. At last, the final α-Fe_2O_3@Au/PDA was vacuum dried at 45 ℃ for 12 h.

2. Preparation of the α-Fe_2O_3@PDA core/shell nanospindle.

10 mg α-Fe_2O_3 was dispersed in 40 mL EtOH by ultrasonication, then 30 mL DA-HCl (17.5 mM) in Tris (pH = 8.5) were added to the mixed solution. After sonication for 6 h, the product was obtained from the mixed solution using centrifugal separation at 8000 rpm and washed 3 times with deionized water and ethanol. Finally, the α-Fe_2O_3@PDA was vacuum dried at 45 ℃ for 12 h.

3. Fabrication of α-Fe_2O_3@Au/PDA@Au/PDA core-shell nanospindle.

$HAuCl_4$ (0.15M), trisodium citrate (10 mg) and 30 mL DA-HCl (17.5 mM) in Tris (pH = 8.5) were added to the EtOH (40 mL) dispersed with 10 mg α-Fe_2O_3@Au/PDA nanospindles, after sonication for 3 h, the solid particle was separated from the mixed solution by centrifugal separation at 8000 rpm and washed 3 times with deionized water and ethanol. Finally, the α-Fe_2O_3@Au/PDA@Au/PDA was vacuum dried at 45 ℃ for 12 h.

4. The photothermal conversion efficiency of the α-Fe_2O_3@Au/PDA core/shell nanostructure

The the scatter in black in Figure. 8d mean time data from the cooling period versus negative natural logarithm of driving force temperature which was obtained from the cooling process. The curve in red was used for calculating the time constants for heat transfer of the α-Fe_2O_3@Au/PDA which were determined to be τ_s = 311.69. The

photothermal conversion efficiency of the α-Fe_2O_3@Au/PDA core/shell nanostructure was calculated according to the reported method.[1] The η value was calculated by the following formula:

$$\eta = \frac{-hS(T_{max} - T_{Surr}) - Q_S}{I(1 - 10^{-A_{808}})} \times 100\%$$

h and S were the heat transfer coefficient and the surface area of the sample container respectively; T_{max} and T_{Surr} were the equilibrium temperature and the ambient temperature of the surroundings; Q_S was expressed as the heat associated with the light absorbance, I was the laser power and A_{808} was the absorbance of the sample at 808 nm.

References

1. W.-N. Wang, C.-Y. Zhang, M.-F. Zhang, P. Pei, W. Zhou, Z.-B. Zha, M. Shao and H.-S. Qian, *Chem. Eng. J.*, 2020, **381**, 125488.

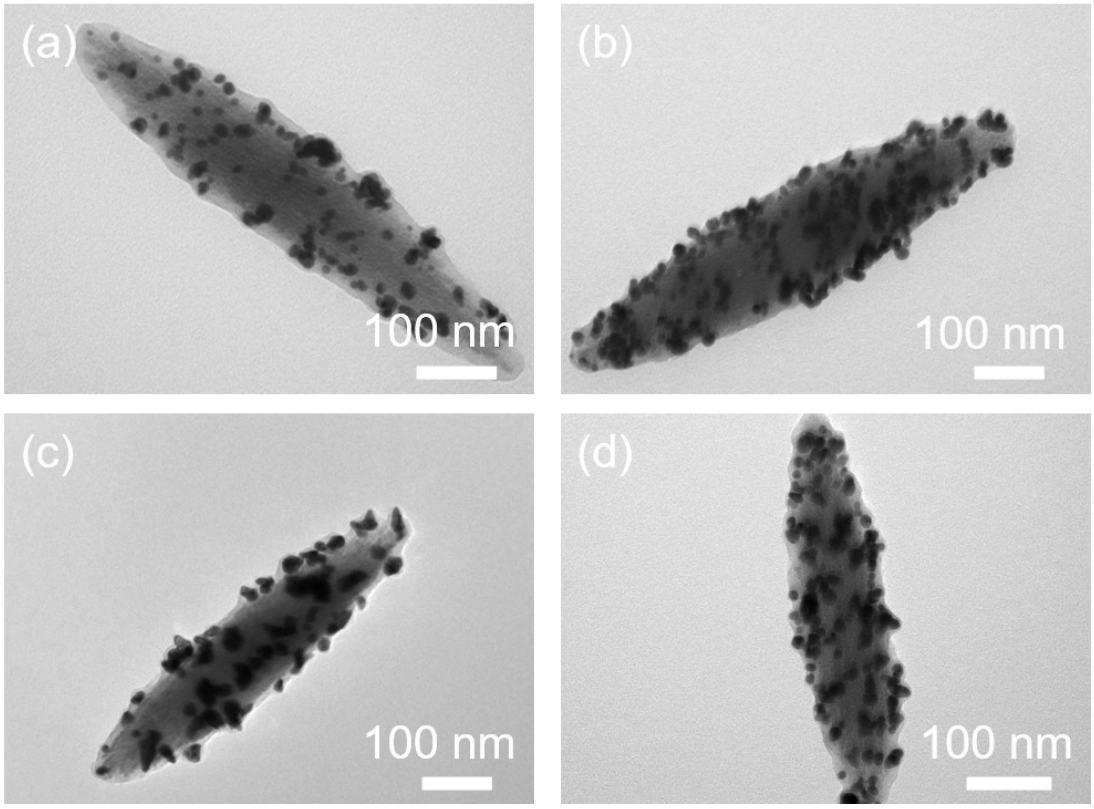

Figure S1. TEM images of α-Fe_2O_3@Au/PDA nanospindle prepared under the same

conditions of DA (30 mg), with different concentrations of $HAuCl_4$: 4.8×10^{-5} M (a), 7.2×10^{-5} M (b), 9.6×10^{-5} M (c), and 1.2×10^{-4} M (d).

Concentrations of $HAuCl_4$(M)	Au wt%
4.8×10^{-5}	7.8
7.2×10^{-5}	12.0
9.6×10^{-5}	14.3
1.2×10^{-4}	17.6

Table S1. The percent of Au in α-Fe_2O_3@Au@PDA with different concentrations of $HAuCl_4$.

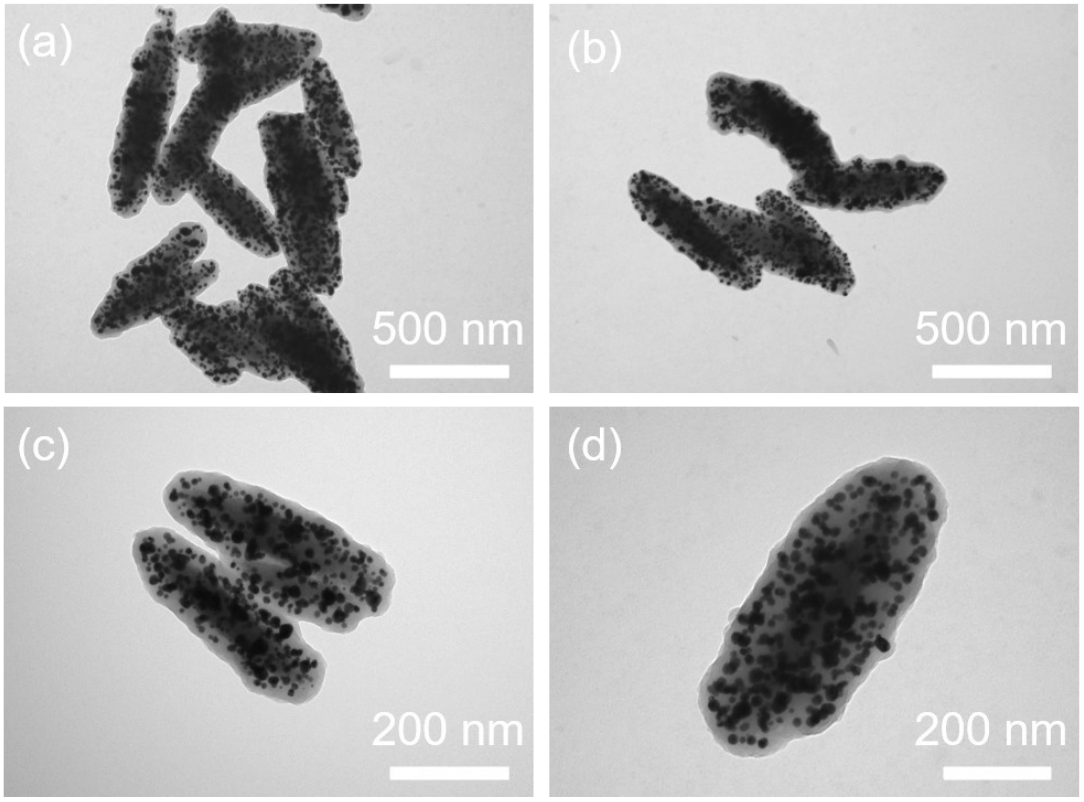

Figure S2. TEM images of spindle α-Fe_2O_3 @Au/PDA@Au/PDA prepared with 2.4×10^{-4} M $HAuCl_4$ and 120 mg PDA.

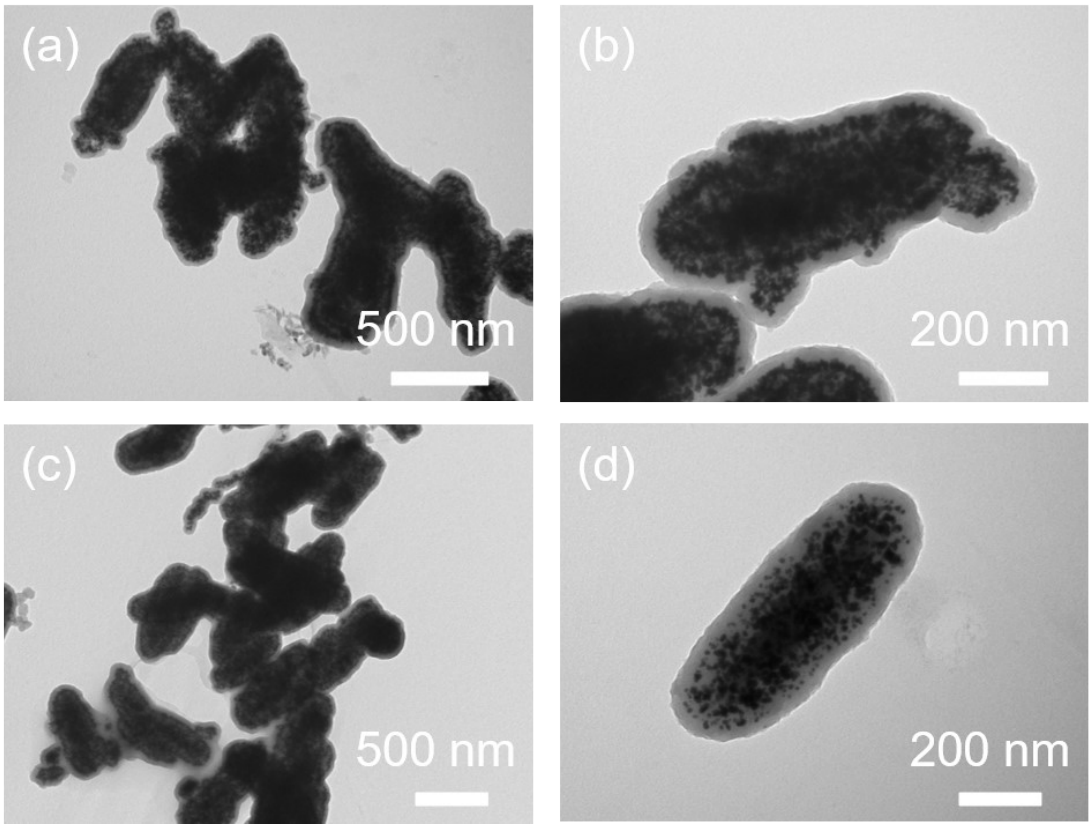

Figure S3. TEM images of spindle α-Fe_2O_3@Au/PDA@Au/PDA@Au/PDA prepared with 3.6 × 10^{-5} M $HAuCl_4$ and 180 mg PDA.

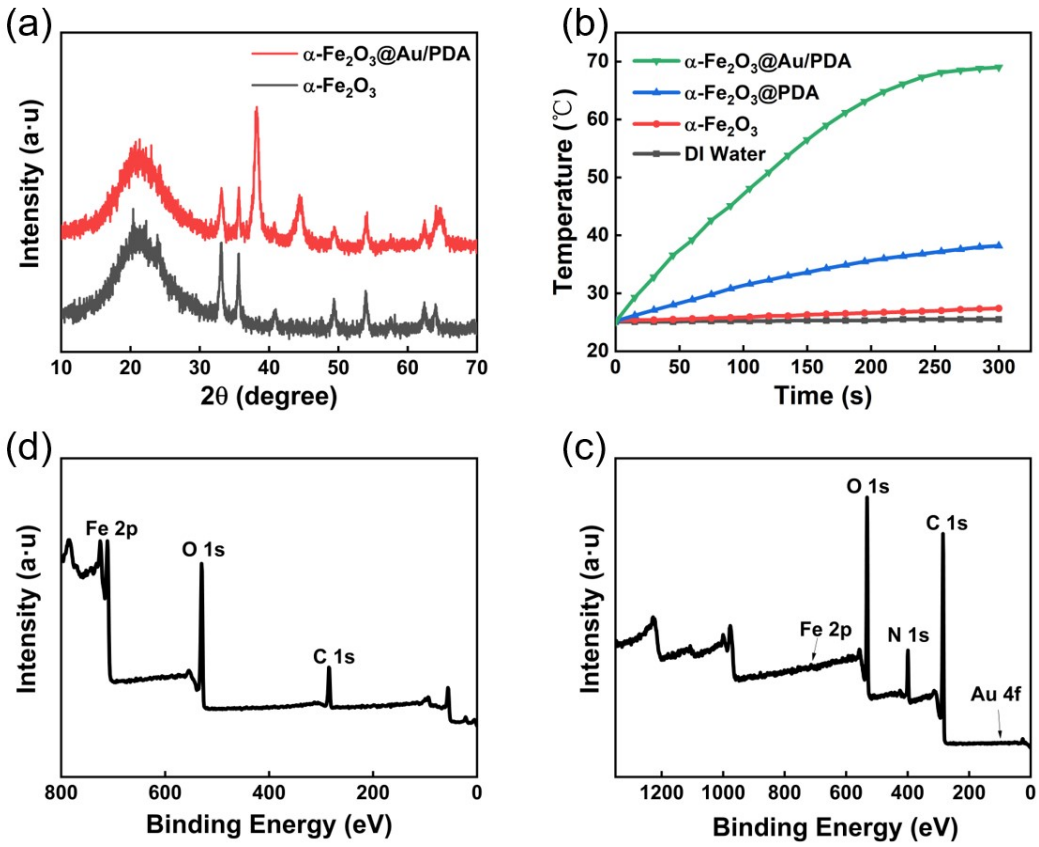

Figure S4. XRD diffraction patterns (a), temperature elevation curves of DI water, cubic α-Fe_2O_3 (50 μg/mL), cubic α-Fe_2O_3@PDA (50 μg/mL), cubic α-Fe_2O_3@Au/PDA (50 μg/mL), under NIR laser irradiation (808 nm, 2.0 W cm^{-2}) (b), and X-ray photoelectron spectroscopy (XPS) spectra of α-Fe_2O_3 (c) and α-Fe_2O_3@Au/PDA (d) nanocubes.

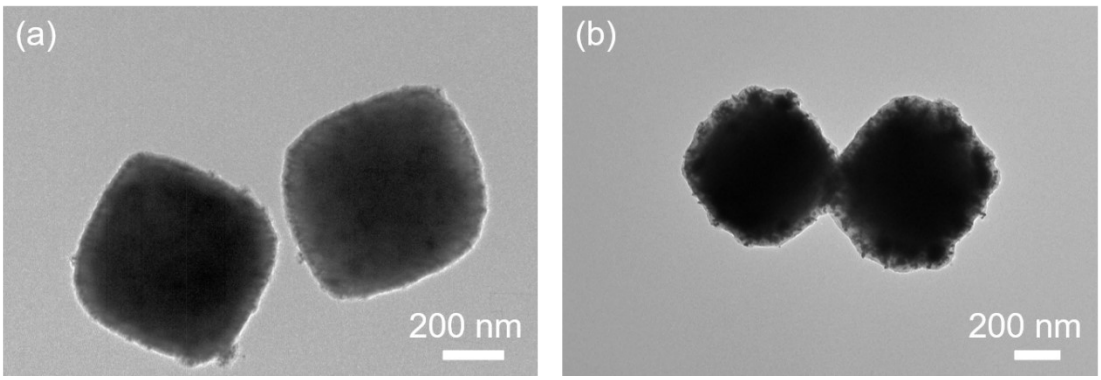

Figure S5. TEM images of cube α-Fe_2O_3@Au/PDA prepared with 7.2 × 10^{-5} M $HAuCl_4$ and 60 mg PDA (a), 1.2 × 10^{-4} M $HAuCl_4$ and 100 mg PDA (b).

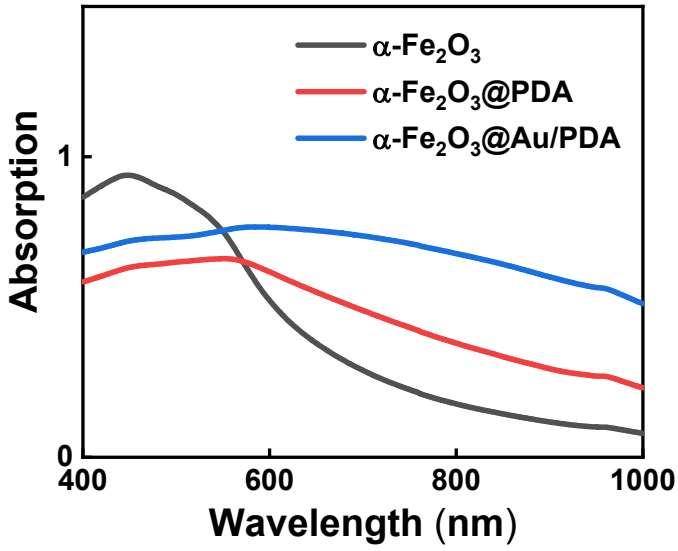

Figure S6. The UV-vis spectra of spindle-like α-Fe_2O_3, α-Fe_2O_3@PDA and α-Fe_2O_3@Au@PDA.

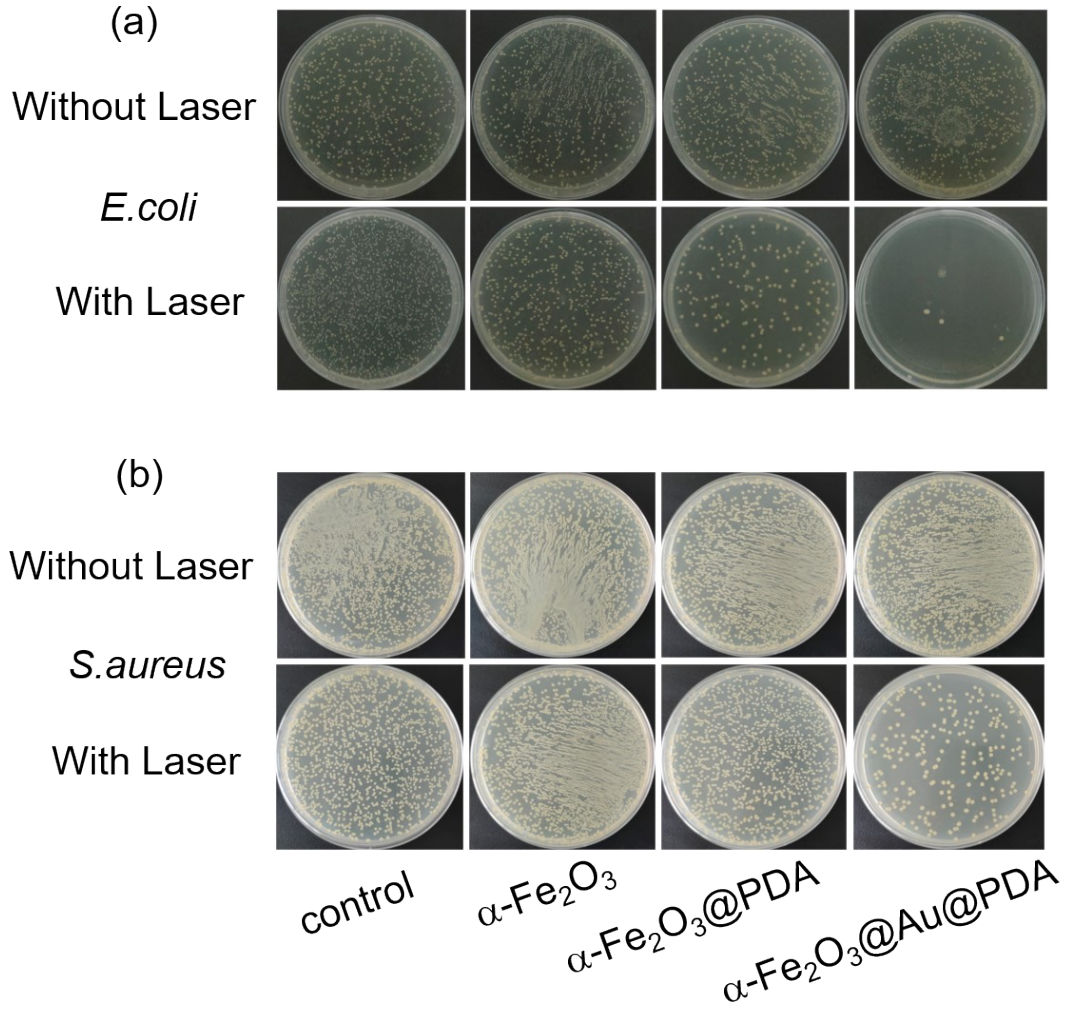

Figure S7. Photographs of colonies of *E. coli* and *S. aureus* incubated with DI water, α-Fe_2O_3 nanocube, α-Fe_2O_3@PDA nanocube, and α-Fe_2O_3@Au/PDA nanocube (50 μg/mL) with/without 808 nm laser irradiation for 5 min.

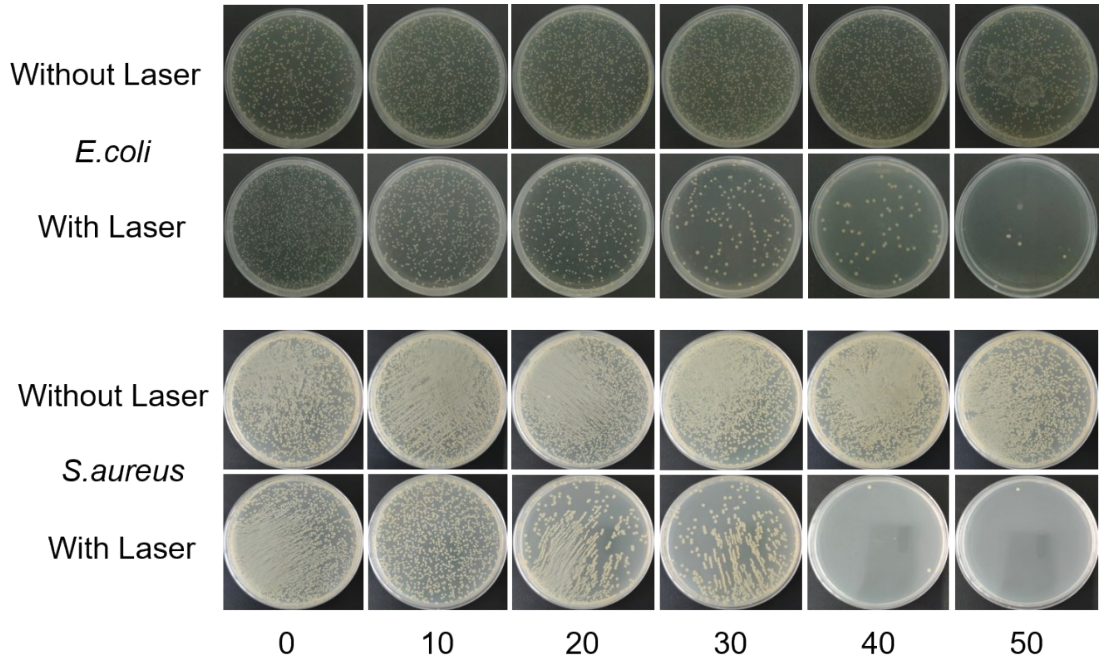

Figure S8. Photographs of colonies of *E. coli* and *S. aureus* incubated with various concentrations (0, 10, 20, 30, 40 and 50 μg/mL) of α-Fe_2O_3@Au/PDA nanocubes with/without 808 nm laser irradiation for 5 min.