Electronic Supplementary Material (ESI) for Journal of Materials Chemistry B.

Supporting information

Flower-like Cu_9S_8 nanocatalysts with highly active sites for synergistic NIR-II photothermal therapy and chemodynamic therapy

Quan Zou,‡[a] Haiyan Pan,‡[c] Xuening Zhang*[a] and Cai Zhang*[b]

[a] *Department of Radiology, The Second Hospital of Tianjin Medical University, Tianjin 300211, China. E-mail: luckyxn@126.com*

[b] *Department of Radiology, Tianjin Medical University Cancer Institute and Hospital, National Clinical Research Centre of Cancer, Tianjin's Clinical Research Center for Cancer, Key Laboratory of Cancer Prevention and Therapy, Tianjin 300060, China. E-mail: caizhang@tmu.edu.cn*

[C] *Department of Radiology, Tianjin Medical University General Hospital, Tianjin 300052, China*

* Corresponding authors.

‡ These authors contributed equally to this work.

Supporting Materials and Methods

Materials

Thioacetamide, Copper(II) nitrate trihydrate $Cu(NO_3)_2 \cdot 3H_2O$, 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) and Fluorescein 5-isothiocyanate (FITC) were obtained from Shanghai Aladdin Biochemical Technology Co., Ltd (Shanghai, China). Protamine sulfate (PS), 2',7'-Dichlorofluorescin diacetate (DCFH-DA) and propidium iodide (PI) were purchased from Sigma-Aldrich (St. Louis, MO, USA). Ethanol and dimethyl sulfoxide (DMSO) were purchased from Tianjin Concord Technology Co., Ltd (Tianjin, China). All chemicals used in this work were at least analytical pure and without any further purification.

Synthesis of FITC-labeled PS@Cu_9S_8 nanocatalysts

10 mg PS@Cu_9S_8 in 10 mL Na_2CO_3/$NaHCO_3$ buffer solution (10 mM, pH 9.0) was added to a single neck flask and stirred at 4 ℃. Then, 0.5 mg FITC in DMSO was added to PS@Cu_9S_8 solution and stirred in dark at 4 ℃ for 12 h. The products were purified by centrifugation (10000 rpm, 10 min) with ultrapure water for three times.

Synthesis of BSA@CuS nanoparticles

The BSA@CuS nanoparticles were synthesized according to our previously reported method[1]. $Cu(NO_3)_2 \cdot 3H_2O$ (1 mL, 0.2 M) was added to bovine serum albumin (BSA) solution (250 mg, 7.5 mL) in a single neck flask and stirred at room temperature for 10 min. Then, NaOH solution (0.5 mL, 1 M) was quickly added under stirring, and Na_2S solution (2 mL, 0.2 M) was further added. After that, the flask was transferred to a 90 ℃ water bath and reacted for 30 min under stirring. After naturally cooling to ambient temperature, the products were purified via dialysis (Mw 8-14 kDa) for 24 h.

Characterization

Transmission electron microscopy (TEM) imaging was performed via a TEM (Hitachi HT7700, Japan). The scanning electron microscope (SEM) imaging and energy-dispersive X-ray spectroscopy (EDS) element mapping were applied on scanning electron microscope (JSM 7800F, JEOL, Japan). Fourier transform-infrared (FT-IR) spectra were measured on a Nicolet IS10 spectrometer (Thermo Scientific, Madison, USA). The X-ray diffraction (XRD) analysis was measured on an Ultima IV X-ray diffractometer (Rigaku, Japan). The X-ray photoelectron spectroscopy (XPS) spectra were measured by an Axis Ultra DLD instrument (Manchester, UK). The hydrodynamic size of PS@Cu_9S_8 nanocatalysts was determined via a Malvern Zetasizer (Nano series ZS, UK). UV-vis-NIR spectra were acquired by a UV-3600 plus spectrophotometer (Hitachi, Japan).

Supporting Figures

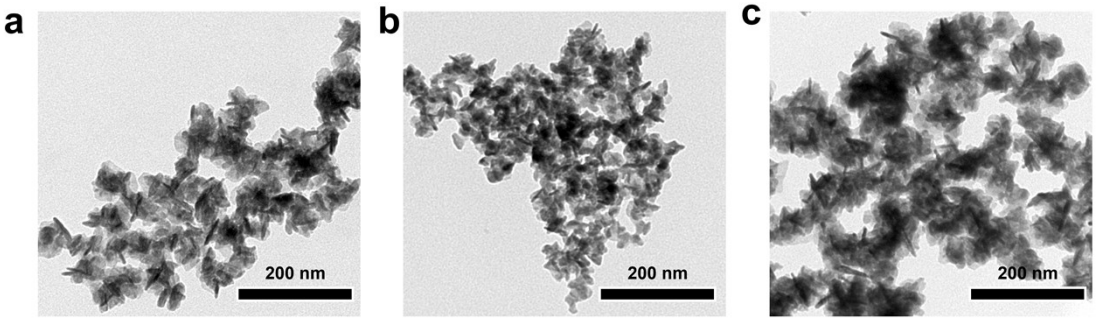

Fig. S1 TEM images of PS@Cu_9S_8 nanocatalysts synthesized with different Cu^{2+} concentration of 100 mM (a) and 200 mM (b) at Cu:S ratio of 1:1. (c) TEM images of PS@Cu_9S_8 nanocatalysts synthesized with Cu^{2+} concentration of 50 mM at Cu:S mol ratio of 1:2.

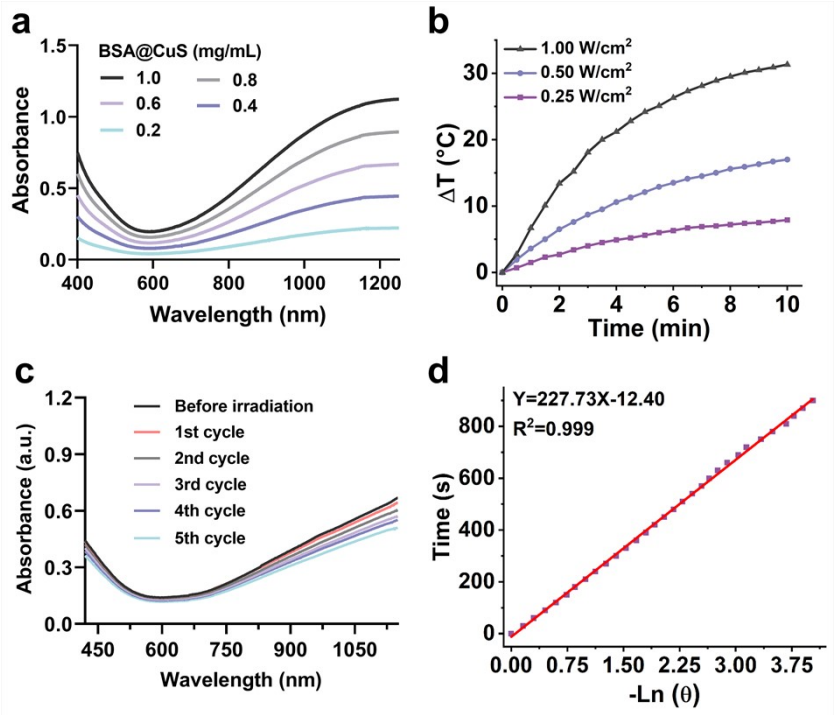

Fig. S2 (a) UV-vis-NIR spectra of various concentrations of BSA@CuS solution. (b) photothermal heating curves of PS@Cu_9S_8 nanocatalysts at different power density and same concentration of 75 mg/L for 10 min. (c) UV-vis-NIR spectra of PS@Cu_9S_8 solution before and after each cycle irradiation. (d) The linear fitting of the time versus negative natural logarithm of the driving force temperature obtained from a cooling stage.

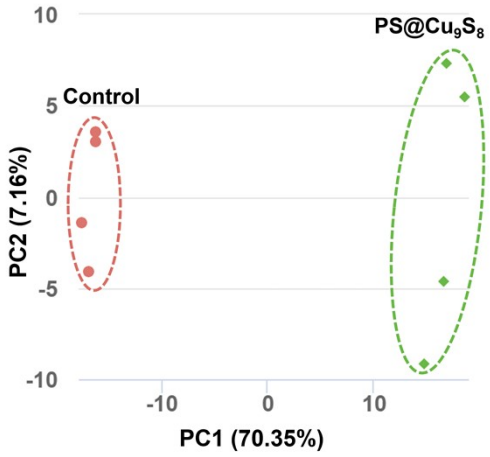

Fig. S3 Principal component analysis (PCA) plot of all samples used in RNA-sequencing study.

Supporting Reference

1. Zhang, C., Fu, Y. Y., Zhang, X., Yu, C., Zhao, Y., Sun, S. K., BSA-directed synthesis of CuS nanoparticles as a biocompatible photothermal agent for tumor ablation in vivo. *Dalton Trans.* **2015,** *44*, 13112-13118.