

Semiconductor biohybrids for enhanced bifunctional wastewater sulfur and heavy metal removal

Yanju Zhang ^{a,b}, Furui Fang ^a, Xiaoxiao Qian ^a, Liangchen Li ^a, Zongli Huo^c, Jingjing Zhang ^c, Dandan Dong ^d, Chaofeng Huang^{*d}, JiaYuan Li^e, Yonghong Hu ^{a,b} *, Li Mi ^{a,b} *

a. College of Biotechnology and Pharmaceutical Engineering, Nanjing Tech University, No. 30, South Puzhu Road, Nanjing 211816, China.

b. State Key Laboratory of Materials-Oriented Chemical Engineering, Nanjing Tech University, No. 30, South Puzhu Road, Nanjing 211816, China.

c. Jiangsu Provincial Center for Disease Control and Prevention, No.172 Jiangsu Road, Nanjing, 210009, China

d. College of Chemical Engineering Shihezi University, Shihezi 832000, China

e. Nanjing Polytechnic Institute, No.188, Xinle Road, Jiangbei New Area, Nanjing, 210009, China



Figure S1 Photograph of the (A) *H. neapolitanus*, (B) *H. neapolitanus* with only Cd^{2+} , (C) *H. neapolitanus* with only cysteine, (D) only Cd^{2+} and cysteine, and (E) $\text{CdS-H. neapolitanus}$ biohybrid with Cd^{2+} and cysteine.

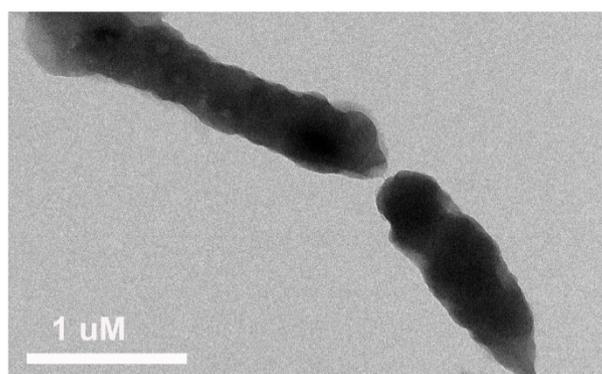


Figure S2 The SEM images of *H. neapolitanus*.

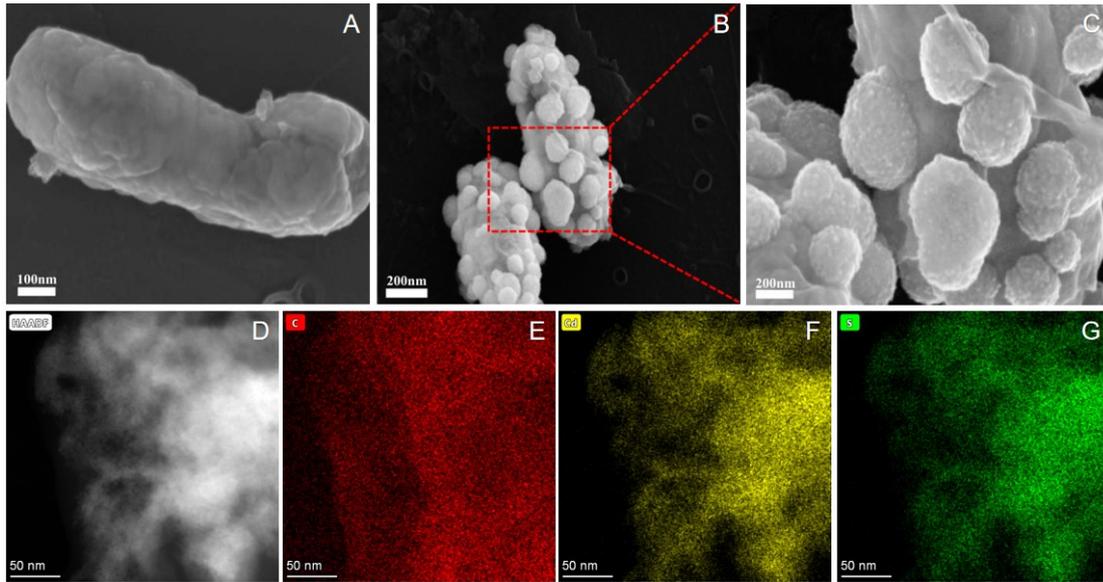


Figure S3 The SEM images of *H. neapolitanus* and CdS-*H. neapolitanus* biohybrid system; (A) *H. neapolitanus* (B) the overall view of the CdS-*H. neapolitanus* biohybrid system (C) the partial view of the CdS-*H. neapolitanus* biohybrid system.(D-G) SEM images of CdS-*H. neapolitanus* biohybrid system(D) and EDS mappings shows the distribution of (E) carbon (C), (F) cadmium (Cd) and (G) sulfur (S) in CdS-*H. neapolitanus* biohybrid system.

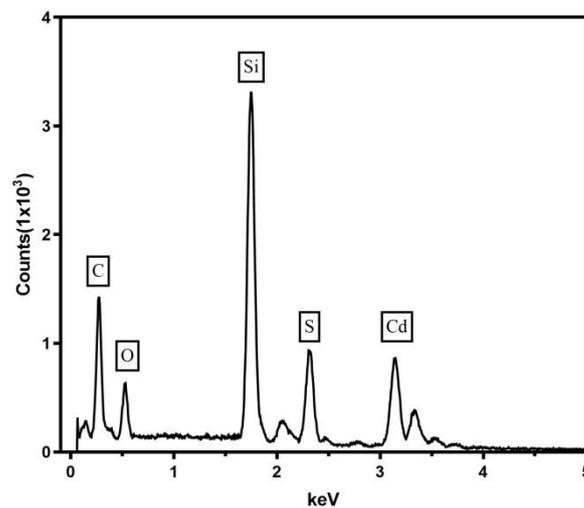


Figure S4 EDS spectrum analysis of CdS-*H. neapolitanus* biohybrid.

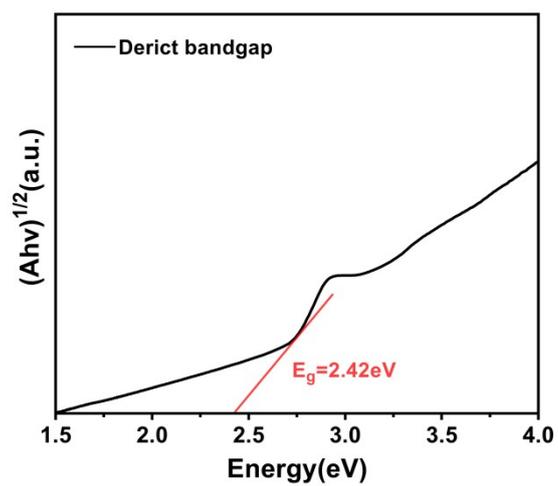


Figure S5 Calculation of direct bandgap of CdS NPs.

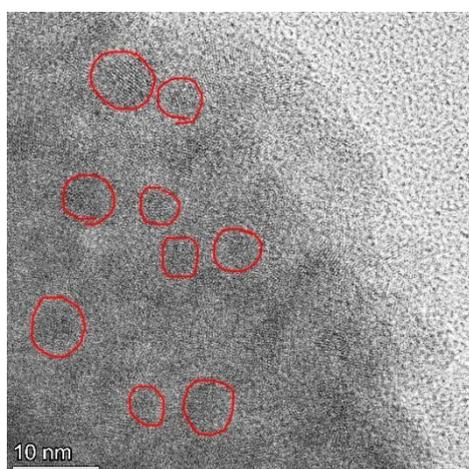


Figure S6 HRTEM images of CdS NPs.

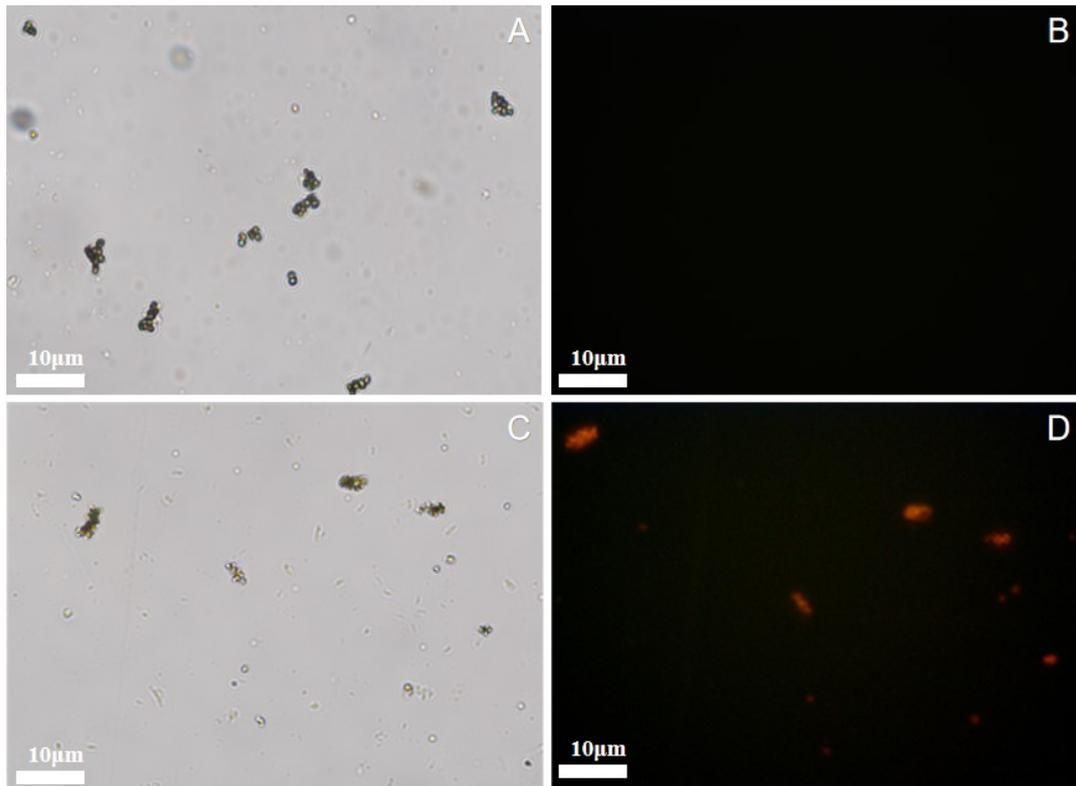


Figure S7 Optical fluorescence microscopy images of the *H. neapolitanus* (A-B) and the CdS-*H. neapolitanus* biohybrid system (C-D), where the scale bar represents 10 μm. Images (A) and (C) are in brightfields, while images (B) and (D) depicts the bright red channel, showing the fluorescence by the CdS-*H. neapolitanus* biohybrid system.

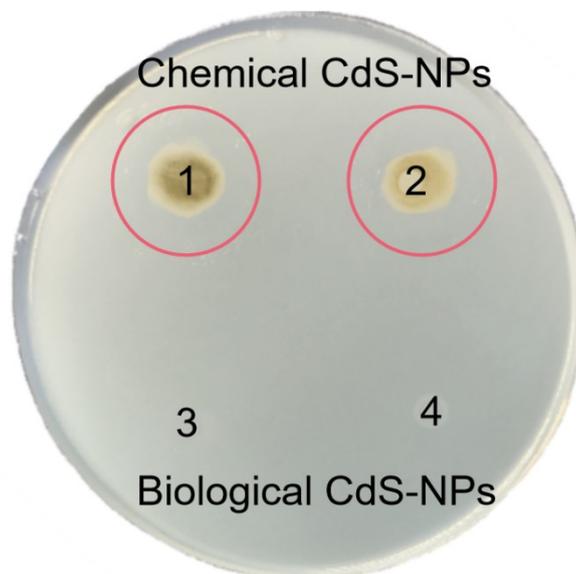


Figure S8 The ecotoxicity for Chemical and Biological Cds NPs.

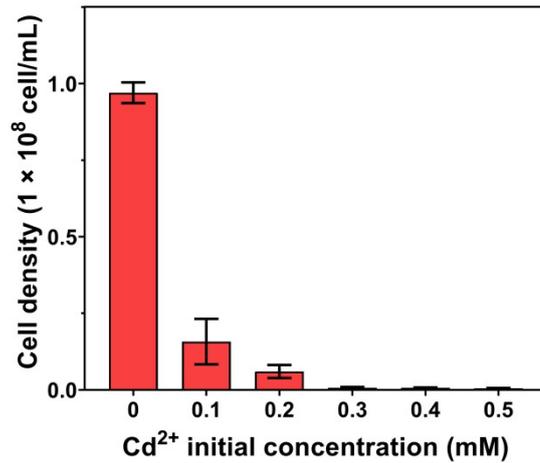


Figure S9 The cell density of *H. neapolitanus* with different initial Cd²⁺ concentrations after 120 h cultivation (without protection from the cysteine).

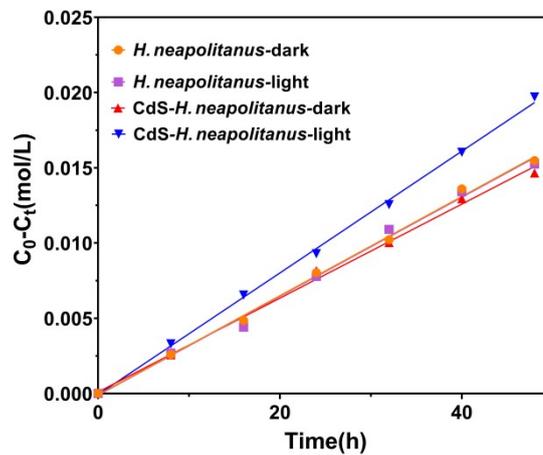


Figure S10 The sulphur removal efficiency of *H. neapolitanus* (light/dark) and CdS-*H. neapolitanus* biohybrid (light/dark).

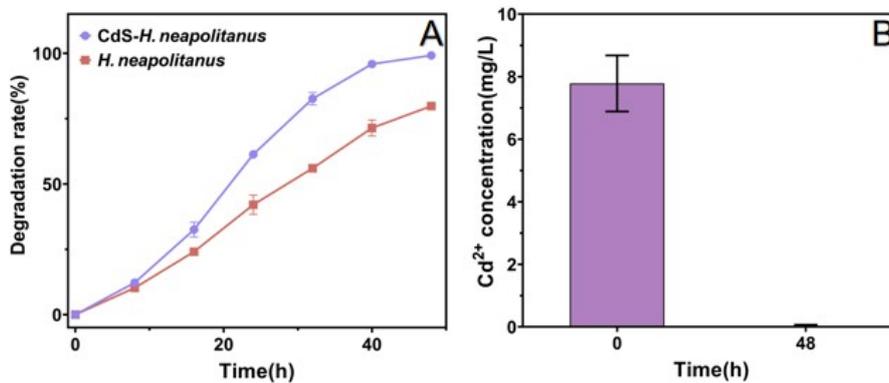


Figure S11 (A)The desulfurization efficiency in industrial wastewater of the *H. neapolitanus* (light/dark) and CdS-*H. neapolitanus* biohybrid (light/dark) (B)The Cd²⁺ density in industrial wastewater of the CdS-*H. neapolitanus* biohybrid (light/dark)

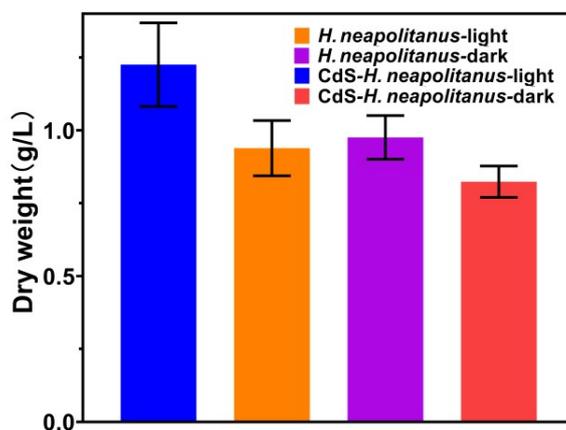


Figure S12 Dry weight of *H. neapolitanus* (light/dark) and CdS-*H. neapolitanus* biohybrid (light/dark) in the solar-driven desulfurization process.

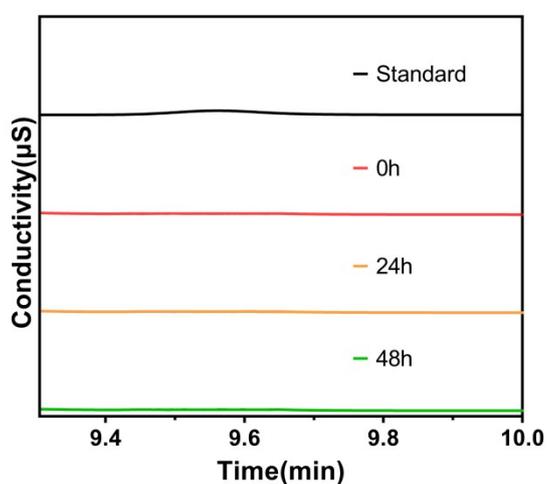


Figure S13 Ion chromatogram of CdS NPs to oxidize $\text{Na}_2\text{S}_2\text{O}_3$ to form SO_4^{2-} at different time.

Table S1 Mediums for cell culture

Medium I	1000mL
DDW	1000mL
$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$	5g
KNO_3	2g
KH_2PO_4	2g
NaHCO_3	1g
NHCl_4	0.5g

MgCl ₂	0.5g
FeSO ₄ ·7H ₂ O	0.02g
<hr/>	
Medium II	1000mL
<hr/>	
DDW	1000mL
KNO ₃	2g
KH ₂ PO ₄	2g
NaHCO ₃	1g
NHCl ₄	0.5g
MgCl ₂	0.5g
FeSO ₄ ·7H ₂ O	0.02g
<hr/>	