## **Supporting Information**

# High peroxidase-mimicking gold@platinum bimetallic nanoparticles-

## supported molybdenum disulfide nanohybrids for selectively

### colorimetric analysis of cysteine

Ling Wan, Liquan Wu, Shao Su\*, Dan Zhu, Jie Chao\*, Lianhui Wang\*

Key Laboratory for Organic Electronics and Information Displays (KLOEID) & Jiangsu Key Laboratory for Biosensors, Institute of Advanced Materials (IAM), National Synergetic Innovation Center for Advanced Materials (SICAM), Nanjing University of Posts and Telecommunications, 9 Wenyuan Road, Nanjing 210023, China.

Email: iamssu@njupt.edu.cn, iamjchao@njupt.edu.cn, iamlhwang@njupt.edu.cn

#### **EXPERIMENTAL SECTION**

Chloroplatinic acid Reagents and Materials. hydrate  $(H_2PtCl_6 \cdot xH_2O)$ and cetyltrimethylammonium bromide (CTAB) were purchased from Sigma-Aldrich (USA). Ascorbic acid (AA), methionine (Met) and cystine (Cyst) were purchased from Sinopharm Chemical Reagent Co., Ltd (Shanghai, China). Cys and other 18 amino acids were purchased from Shanghai Maclean Biochemical Technology Co., Ltd (China). TMB chromogenic solution A (3,3',5,5'tetramethylbenzidine, TMB), TMB chromogenic solution B (hydrogen peroxide, H<sub>2</sub>O<sub>2</sub>), sodium carboxymethylcellulose (CMC) and sodium borohydrate (NaBH<sub>4</sub>) were purchased from Aladdin Reagent Company (China). All solutions were prepared with Milli-Q water from the Milli-pore system.

**Apparatus.** Transmission electron microscope (TEM, Hitachi H-7500, 120 kV) was used to characterize the morphologies of the MoS<sub>2</sub> nanosheets, Au@Pt nanoparticles (NPs) MoS<sub>2</sub>-AuNPs nanocomposites, MoS<sub>2</sub>-PtNPs nanocomposites and MoS<sub>2</sub>-Au@Pt nanocomposites. The absorption peaks and electrochemical tests were recorded by using an ultraviolet spectrophotometer (UV-3600, Shimadzu) and Autolab PGSTAT302 (Switzerland Vantone China Co. LTD), respectively.

**Preparation of MoS<sub>2</sub> Nanosheets and MoS<sub>2</sub>-based Nanocomposites.**  $MoS_2$  nanosheets,  $MoS_2$ -AuNPs,  $MoS_2$ -PtNPs and  $MoS_2$ -Au@Pt nanocomposites were synthesized according to our previous works.<sup>1</sup> For comparison, Au@Pt NPs were synthesized after minor modification. Briefly, 0.3 mL gold nanoseeds were dispersed into 2 mL Milli-Q water, then 0.5 mL 10 mM CTAB, 1 mL 100 mM AA, and 0.1 mL 5 mM H<sub>2</sub>PtCl<sub>6</sub> were added into the solution and stirred for 1 minute. After stirring, the mixed solution was heated at 100 °C for 10 minutes with microwave-assisted. Finally, the product of Au@Pt NPs were purified and stored in refrigerator.

**Detection of Cys.** For Cys detection, different concentrations of Cys were added into the mixture solution of 0.015 mL MoS<sub>2</sub>-Au@Pt nanocomposites (12.0 mg·mL<sup>-1</sup>) and 50  $\mu$ L TMB solution A and 40  $\mu$ L solution B in 0.1 mL acetate solution at pH 4.0. After incubation at 35 °C for 10 minutes, the reaction was stopped by 2.0 M H<sub>2</sub>SO<sub>4</sub> and the absorption peaks was recorded at 450 nm using a UV-vis spectrophotometer.



**Figure S1.** TEM images of (A) MoS<sub>2</sub>-AuNPs nanocomposites, (B) MoS<sub>2</sub>-PtNPs nanocomposites (C) MoS<sub>2</sub>-Au@Pt nanocomposites and (D) Au@Pt NPs. Scale bars correspond to 100 nm.



**Figure S2.** Photographs and UV-vis spectra of (a) TMB+MoS<sub>2</sub>-Au@Pt, (b) H<sub>2</sub>O<sub>2</sub>+MoS<sub>2</sub>-Au@Pt, (c) TMB+H<sub>2</sub>O<sub>2</sub>+MoS<sub>2</sub>-Au@Pt and (d) TMB+H<sub>2</sub>O<sub>2</sub>.



Figure S3. UV-vis spectra of different materials ( $\Delta A = A_{no Cys} - A_{Cys}$ ) without and with Cys.



**Figure S4.** Photos of different (A)  $MoS_2$ -Au@Pt concentrations (0.1-40 mg·mL<sup>-1</sup>), (B) incubation temperature (20-50 °C) and (C) detection time (3-40 min).



**Figure S5.** UV-vis spectra of different (A)  $MoS_2$ -Au@Pt concentrations (0.1-40 mg·mL<sup>-1</sup>), (B) incubation temperature (20-50 °C) and (C) detection time (3-40 min).



**Figure S6.** Effect of (A) MoS<sub>2</sub>-Au@Pt nanocomposites concentration, (B) incubation temperature and (C) reaction time on the Cys analysis performance



Figure S7. Photographs of this colorimetric sensor for different Cys concentration detection ranging from  $0.8-400 \mu M$ .



Figure S8. The selectivity of this sensor for amino acids detection.



**Figure S9.** Photos of the designed colorimetric sensors for cysteine, homocysteine and glutathione detection (A) in the absence and (B) in the presence of  $H_2SO_4$ . (C) The peak intensity of this sensor for cysteine, homocysteine and glutathione detection.



**Figure S10.** Photos of TMB+ $H_2O_2$  mixture solution added in buffer, 1%, 5% and 10% serum (A) in the absence and (B) in the presence of  $H_2SO_4$ . (C) The corresponding absorption peak intensities.



**Figure S11.** (A) Absorption spectra of this colorimetric sensor for Cys detection ranging from 0.8-400  $\mu$ M. Inset: solution color for different Cys concentration detection. (B) The corresponding relationship between peak intensity and Cys concentration. Inset: linear calibration plots for Cys detection.



**Figure S12.** Photos of this developed colorimetric sensor for Cys, Hcy, GSH and other 19 amino acids detection (A) in the absence and (B) in the presence of  $H_2SO_4$ . (C) The corresponding peak intensities of this sensor for Cys, Hcy, GSH and other 19 amino acids detection.

#### References

1 S. Su, C. Zhang, L. Yuwen, X. Liu, L. Wang, C. Fan and L. Wang, *Nanoscale*, 2016, **8**, 602-608.