Supporting Information

Integration detection of mercury(II) and GSH with fluorescent "on-off-on" switch sensor based on nitrogen, sulfur co-doped carbon dots

Haiyan Qi[a *], Xiaona Sun[a], Jinlong Li[b], Jun Li[c], Xiuwen Wang[a]

[a]*College of Chemistry and Chemical Engineering, Qiqihar University, No. 42, Wenhua Street, Qiqihar, 161006, P. R. China.*

[b]*Key Laboratory of Fine Chemicals of College of Heilongjiang Province, Qiqihar University, No. 42, Wenhua Street, Qiqihar, 161006, P. R. China.*

[c]*Heilongjiang Industrial Hemp Processing Technology Innovation Center, Qiqihar University, No. 42, Wenhua Street, Qiqihar, 161006, P. R. China.*

** Corresponding authors: Hayan Qi*

Tel.: +86-452-2738214

E. mail: qhy120@sina.com

Materials

Citric acid, taurine and L-glutathione reduced GSH were acquired from Aladdin Chemical Reagent Co., Ltd (Shanghai, China).KCl, $MgCl_2$, $CuSO_4$, $CaCl_2$,NaCl, $MnSO_4$, $SrCl_2$, $CdSO_4$, $HgCl_2$, $PbSO_4$, $ZnCl_2$,$NiSO_4$, $AlCl_3$, $Fe_2(SO_4)_3$and $FeSO_4$wereacquired from Tianjin Kaitong Chemical Reagent Co., Ltd (Tianjin, China).Sodium hydroxide was purchased from Macklin Biochemical Co., Ltd(Shanghai, China). Hydrochloric acid was purchased from Liaoning Quanrui Reagent Co., Ltd Beijing chemical plant (Beijing, China).Dialysis bags (retainedmolecular weight 500 Da) were enrolled from Yi Bo Biological.(Beijing, China). Ultrapure water was used throughout whole experiments.

Apparatus and characterizations of NS-CDs

Transmission electron microscopy (HRTEM) imageswere captured throughJEM-2100F electron microscope (JEOL, Japan). X-ray diffraction (XRD) was performed on D8 focus type (BRUKER-AXS, Germany). Fourier transform infrared(FTIR) spectrum was characterized by NICOLET 380 (Thermo, USA).Fluorescence spectra were recordedon RF-5301PCfluorescence spectrophotometer (Shimadzu, Japan). UV–vis absorption spectra were acquired on TU-1901 UV-visible spectrophotometer (Purkinje, China). Fluorescence lifetimes were recorded on FLUOROMAX-4 high sensitivity fluorescence spectrometer (HORIBA, USA). X-ray photoelectron spectroscopy (XPS) was characterized by ESCALAB250xi X-ray photoelectron spectrometer (Thermo, USA).

The fluorescent QY of NS-CDs was calculated by the following formula:

$$\Phi_x = \Phi_s \frac{I_x}{I_s} \bullet \frac{A_s}{A_x} \bullet \left(\frac{\eta_x}{\eta_s}\right)^2$$

where Φ_s was the QY of quinine sulfate (54%); I_x and I_s were the fluorescence intensity of NS-CDs and quinine sulfate, respectively; A_x and A_s were the UV-Vis absorption of NS-CDs and quinine sulfate; η was the refractive index.

Synthesis of NS-CDs

Firstly, the mixture of 2 g citric acid and 1g taurine was heated in oven at 200 ℃ for 15 min to a molten state. After being cooled down to room temperature, the obtained sample was mixed with sodium hydroxide solution (250 mL, 10 mM). Then, the pH of the mixed solution was adjusted to 7.0 by hydrochloric acid solution. Next,

the solution was filtrated by 0.22 μm filtermembrane and then dialyzed through a dialysis bag (molecular weight cut-off is 500 Da) against ultrapure water for 60 h for the final solution in the dialysis bag. Finally, the solid NS-CDs were obtained after vacuum freeze drying the final solution for 24 h.

Detection of $Hg^{2+}$and GSH

All the fluorescence measurements were implemented at room temperature. In the Hg^{2+} detection experiment, the concentrations of Hg^{2+} ions ranged from 0 to 100 μM after the Hg^{2+} solution was added into the aqueous NS-CDs solutions (2 mL). Then, the fluorescence spectra of the mixed solutions were recorded (excited at 345 nm) after these solutions stood for 5 min. In regard to the sensitivity of GSH to the NS-CDs-Hg^{2+}, the concentrations of GSH ranged from 0 to 85 μM in the mixed solutions, and the fluorescence spectra of the mixed solutions were recorded under the same condition as above. The concentration of GSH in fetal bovine serum samples is calculated using the calibration curve obtained. The fetal bovine serum was obtained from Qiqihar Medical University, which have been treated as previously reported[1] without further dilution.

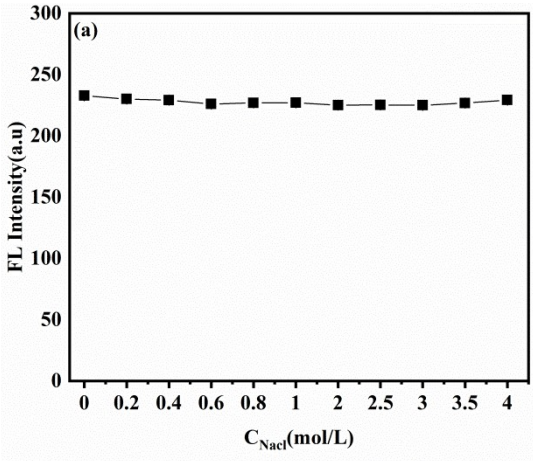

Fig.S1. Fluorescence intensities of NS-CDs in different concentration of NaCl.

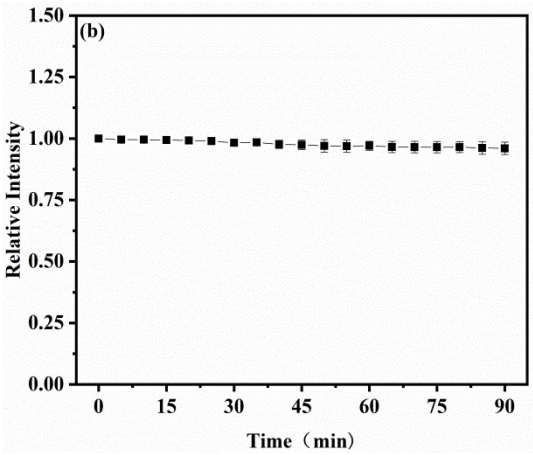

Fig.S2. Fluorescence intensities of NS-CDs during continuous UV light irradiation.

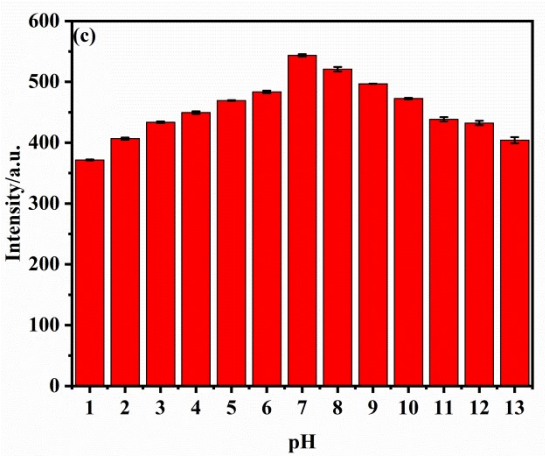

Fig.S3. Fluorescence intensities of NS-CDs at different pH.

Table S1Detection of Hg^{2+} in tap water

Sample	Initial/μM	Added/μM	Founded /μM	Recovery (%)	RSD (%)
Tap water	0	2	1.88	94.0	3.4
		4	3.96	97.8	2.0
		8	8.42	105.2	2.8

Table S2Detection of GSH in fetal bovine serum

Sample	Initial/μM	Added/μM	Founded /μM	Recovery (%)	RSD (%)
Fetal bovine serum	0.35	2	2.40	102.5	2.4
		4	4.36	100.3	1.6
		8	8.22	98.4	1.2

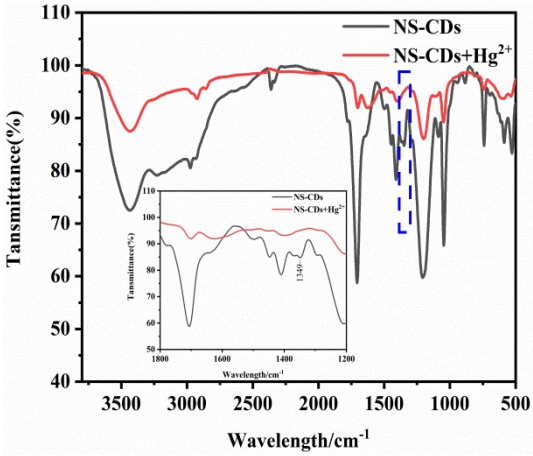

Fig.S4. FTIR spectra of NS-CDs and NS-CDs+Hg^{2+}

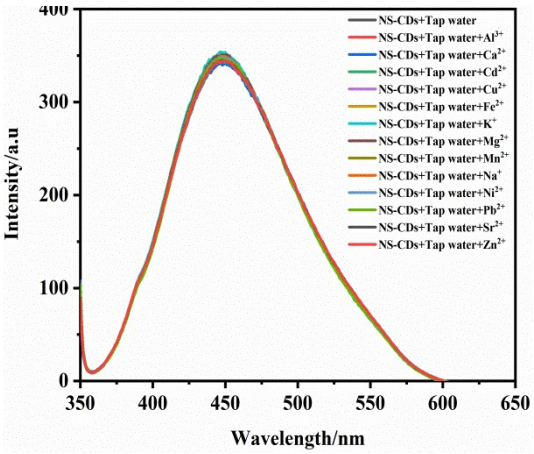

Fig.S5 Interferences experiment of common ions in tap water

[1] H.D. Zhang, S.F Wu, Z.H. Xing, H.B. Wang, Analyst,, 2021, **146**, 7250-7256.