SUPPORTING INFORMATION

A yellow-emission carbon quantum dots-based fluorescent logic gate for continuous detection of biological and environmental species

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1. Materials and instrumentation

Cys was purchased from Sinopharm chemical reagent Co., Ltd. DL-Homocysteine (Hcy) was commercially obtained by Tokyo chemical industry Co., Ltd. O-phenylenedimine was bought from Aladdin chemistry Co., Ltd. All the chemicals not mentioned here were analytical reagent grade and obtained from commercial sources. Tap water was obtained from a chemical laboratory (Yantai, China).

Fluorescence spectra were performed on a LS-55 spectrophotometer (PerkinElmer, America), with an excitation wavelength of 410 nm. The scanning rate was set as 500 nm/min, and the slits width of excitation was the same as that of emission (both set as 10 nm). The UV-vis absorption spectrum was analyzed by a UV-2550 Spectrometer (Shimadzu, Japan). The morphologies and the sizes of the prepared Y-CQDs before and after addition of Au^{3+} were collected on a Talos F200X G2 high resolution transmission electron microscopy (HR-TEM, Thermo Fisher Scientific, America). X-ray photoelectron spectroscopy (XPS) information were measured by an ESCALAB Xi+ photoelectron spectrometer (Thermo Fisher Scientific, America). Fourier transform infrared (FTIR) spectra were observed from a Nicolet is50 spectrometer (Thermo Fisher Scientific, America). The zeta potential was acquired on a Nano-ZS90 instruments (Malvern Zetasizer, Britain).

2. Synthesis of Y-CQDs

A simple hydrothermal method was employed to synthesize Y-CQDs. In brief, 0.2 g o-phenylenedimine and 5 mL ethylene glycol were evenly dispersed in 20 mL distilled water, and then the mixture reacted at 180 °C for 10 h in a 50 mL autoclave. After that,

the sealed reactor was cooled down to ambient temperature naturally, followed by filter through a 0.22 μm membrane to remove impurities, and then purified by dialysis in ultrapure water for 8 h. Finally, the orange-yellow solution was collected and stored at 4 °C before use.

3. Determination of Au^{3+} using Y-CQDs

For the detection of Au^{3+}, Au^{3+} with a final concentration of 0-28 μM were mixed with 3 mL tap water containing 0.5 mg/mL Y-CQDs in a quartz cuvette. After incubation at room temperature for 1 min, their fluorescence spectra were recorded, and the emission intensity (552 nm) was selected for quantitative analysis. In addition, the fluorescence signals of other metal ions were also collected to determine the selectivity of this nano-sensor. To be specific, Au^{3+} was replaced by other metal ions (16 μM) without changing other experimental conditions. All experiments were carried out at ambient temperature and repeated three times.

4. Determination of biothiols using Y-CQDs/Au^{3+}

Sensitivity of biothiols was measured by adding biothiols with final concentration of 0-60 μM to tap water, in which the concentration of Y-CQDs and Au^{3+} was 0.5 mg/mL and 28 μM, respectively. After 5 min, the strong emission spectra of the mixtures were obtained. Furthermore, the selectivity for biothiols was confirmed by adding other amino acids (20 μM) instead of biothiols under the same conditions.

5. Fluorescence analysis of Au^{3+} and biothiols in envrionmental, medical and food fields

The standard addition method was employed for analysis of Au^{3+} in lake water and mineral water. The lake water was obtained from Ludong university (Yantai, China) and filtrated by a 0.22 μm membrane. The mineral water was purchased from local supermarket (Huzhou, China) and used directly. Au^{3+} with a final concentration of 8 μM or 16 μM, were added to water samples containing 0.5 mg/mL Y-CQDs, and the fluorescence spectra were recorded after 1 min.

In addition, urine was obtained from healthy adults and centrifuged 10 min (12000 rpm) to collect the supernatant. Lemon flavored beverage was purchased from local supermarket (Huzhou, China) without additional treatment. For determination of biothiols in medical and food field, final concentration of 10 μM biothiols were added to the diluted urine and lemon flavored beverage (0.5%), while other experimental conditions remained unchanged. And then the fluorescence emission spectra were measured to calculate the recovery of biothiols.

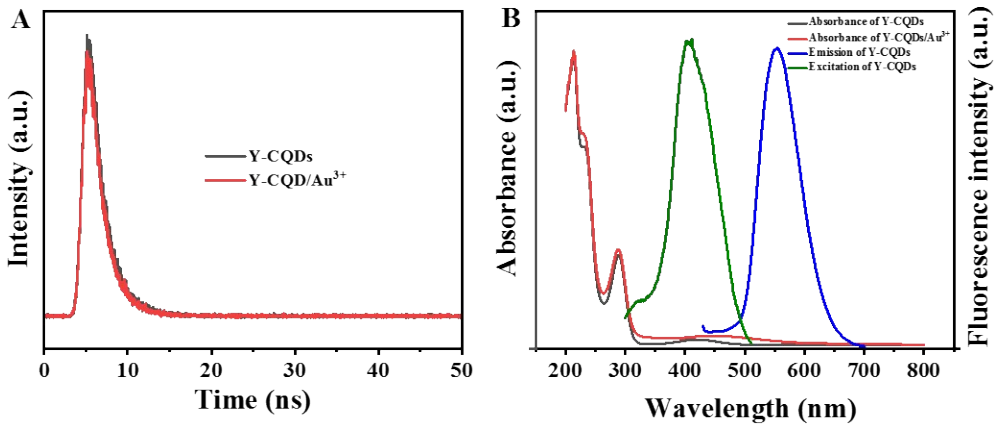

Fig. S1 The fluorescence lifetime of Y-CQDs and Y-CQDs/Au^{3+} system (A), the UV-vis absorption spectra of Y-CQDs and Y-CQDs/Au^{3+}, excitation and emission spectra of Y-CQDs (B).

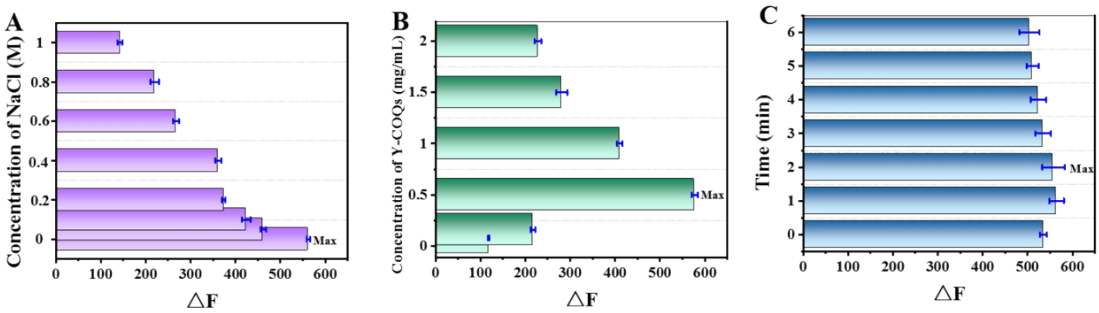

Fig. S2 Effect of NaCl concentration (A), the concentration of Y-CQDs (B) and reaction time (C) on the △F. The concentration Au^{3+} was 16 μM.

Table S1 Detection of Au^{3+} in mineral water and lake water samples with fluorescence signals

Samples	Added (μM)	Found (μM)	Recovery (%)	RSD (%) / n=3
Mineral water	8	8.08	101.0	1.64
	16	15.91	99.4	2.24
Lake water	8	8.40	105.0	1.36
	16	15.97	99.8	2.89

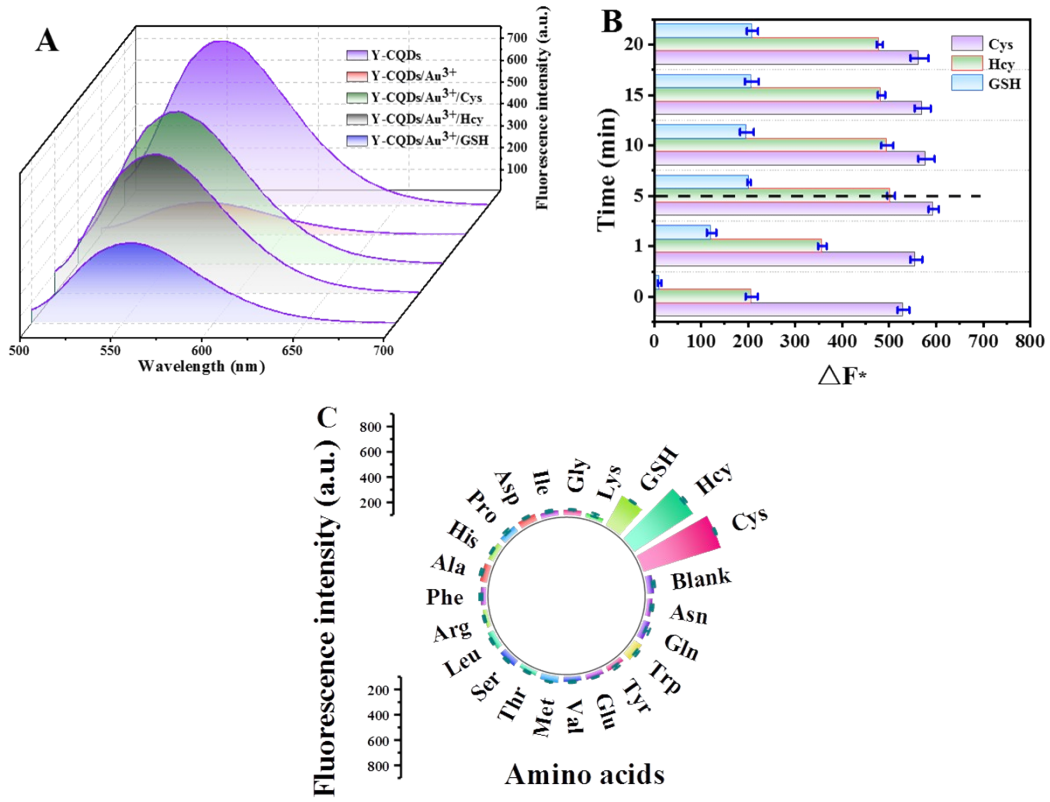

Fig. S3 (A) Fluorescence spectra of Y-CQDs, Y-CQDs/Au^{3+}, Y-CQDs/Au^{3+}/Cys, Y-CQDs/Au^{3+}/Hcy, Y-CQDs/Au^{3+}/GSH, the concentration of Au^{3+}, Cys, Hcy and GSH were , 28 μM, 20 μM, 20 μM and 20 μM, respectively. (B) Effect of the reaction time on △F*, △F* represented the difference in fluorescence before and after biothiols addition, the concentrations of Au^{3+}, Cys, Hcy and GSH were 28 μM, 20 μM, 20 μM and 16 μM, respectively. (C) Fluorescence intensity at 552 nm after adding various amino acids. The concentrations of Au^{3+}, amino acids and biothiols were 28μM, 20μM and 20μM, respectively. Amino acids: L-cysteine (Cys), L-glutathione (GSH), DL-homocysteine (Hcy), L-glycine (Gly), L-aspartic acid (Asp), L-proline (Pro), L-tyrosine (Tyr), L-histidine (His), L-leucine (Leu), L-glutamic (Glu), L-threonine (Thr), L-valine (Val), L-

arginine (Arg), L-methionine (Met), L-isoleucine(Ile), L-phenylalanine (Phe), L-serine (Ser), L-tryptophan (Trp), L-lysine (Lys), L-alanine (Ala), L-Glutamine (Gln), L-Asparagine (Asp).

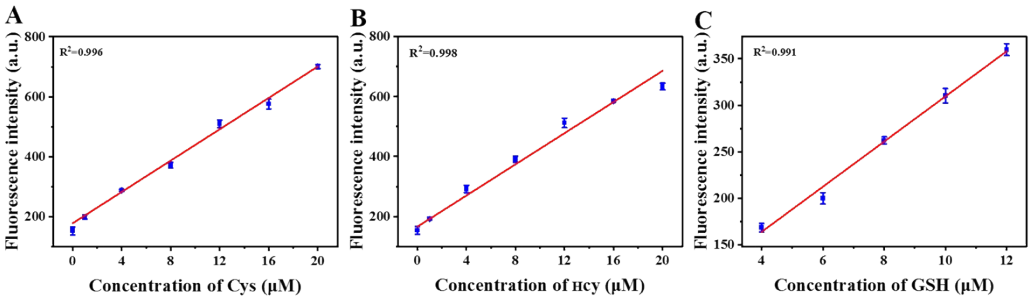

Fig. S4 The linear detection ranges for Cys, Hcy and GSH, respectively.

Table S2 Detection of biothiols in duilted urine and lemon flavored beverage samples with fluorescence signals

Samples	Biothiols	Add (μM)	Found (μM)	Recovery (%)	RSD (%) / n=3
Urine	Cys	10	10.14	101.4	1.52
	Hcy	10	10.24	102.4	1.42
	GSH	10	10.25	102.5	2.07
Beverage	Cys	10	9.87	98.7	0.77
	Hcy	10	9.84	98.4	2.08
	GSH	10	10.03	100.3	2.22

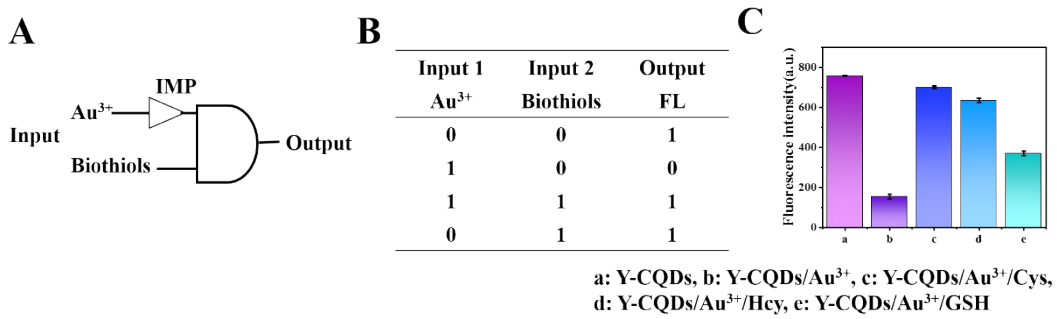

Fig. S5 (A) IMPLICATION logic scheme. (B) Truth table. (C) Fluorescence spectra under four different input conditions. Input 1 and Input 2 represented input Au^{3+} (28 μM) and input biothiols (20 μM), respectively; Output was the fluorescence emission at 552 nm.

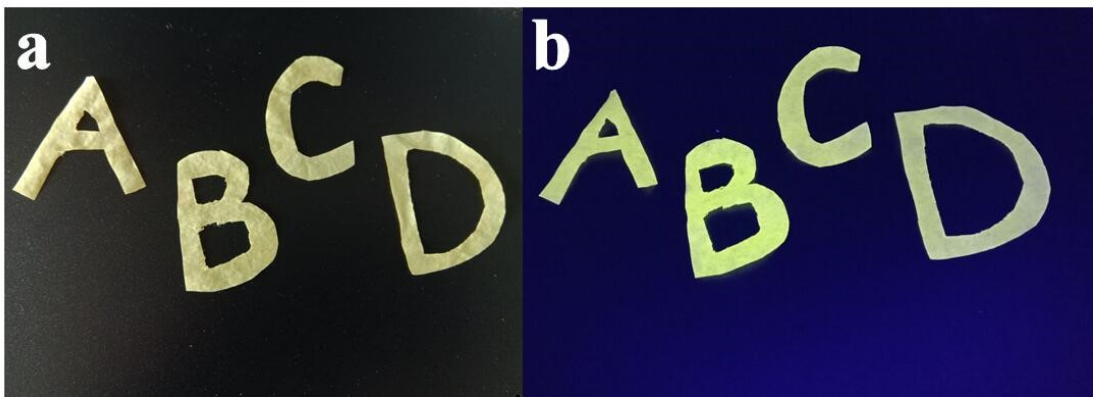

Fig. S6 The image of letters under sunlight (a) and a UV-light (b) using Y-CQDs solution.