

Supplementary Material (ESI) for xxx  
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### Electronic Supplementary Information

## Nitrogen and sulfur codoped graphene quantum dots as a new fluorescent probe for Au<sup>3+</sup> ion in aqueous media

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### Quantum yield (QY) measurement

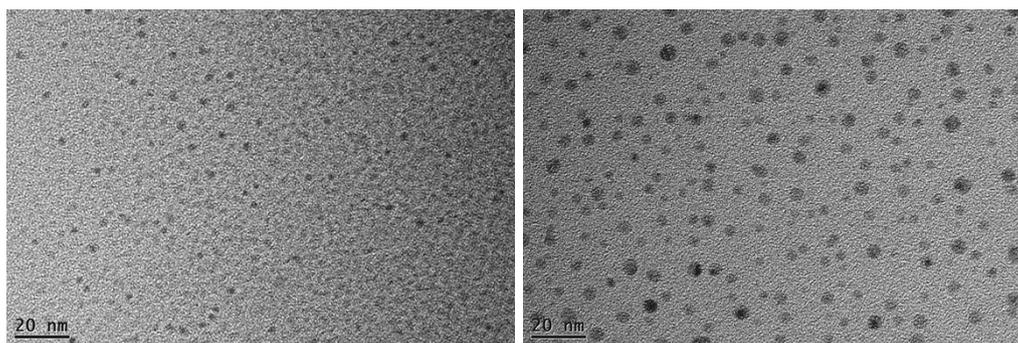
The QY of the N,S-GQDs was determined by using quinine sulfate as the standard sample and was calculated according to the following equation:

$$Q = Q_r \times \frac{I}{I_r} \times \frac{A_r}{A} \times \frac{n^2}{n_r^2} \quad (1)$$

where  $Q$  is the quantum yield,  $I$  is the measured integrated emission intensity,  $n$  is the refractive index of the solvent (1.33 for water), and  $A$  is the optical density. The subscript “ $r$ ” refers to the reference standard with known QY. The QY of the as-synthesized N,S-GQDs is shown in Table S1.

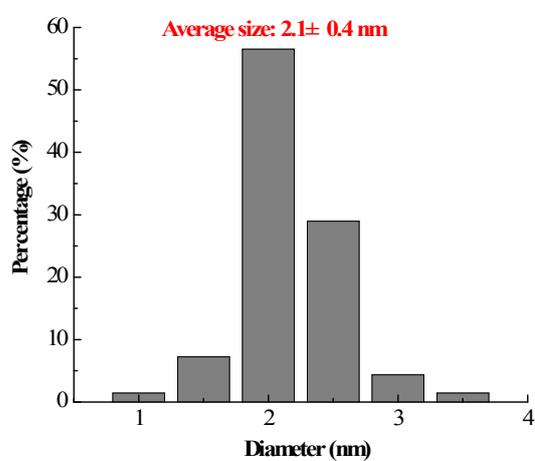
**Table S1.** QY of the as-synthesized N,S-GQDs

Sample	Integrated emission intensity ( $I$ )	Abs at 360 nm wavelength ( $A$ )	Refractive index of solvent ( $n$ )	Quantum Yield (%)
Quinine sulfate	3200	0.045	1.33	57.7
N,S-GQDs	1086	0.025	1.33	35.4
GQDs	110	0.035	1.33	2.6

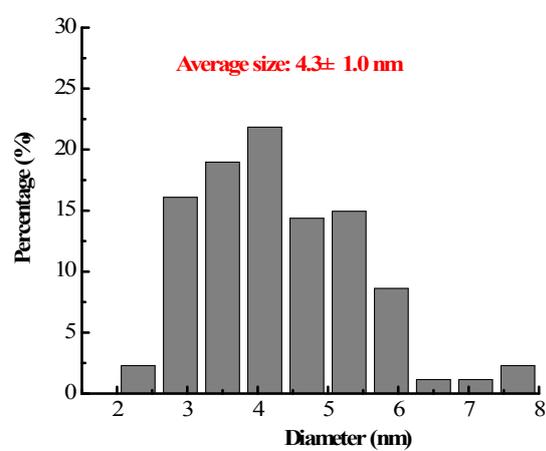


(A)

(B)

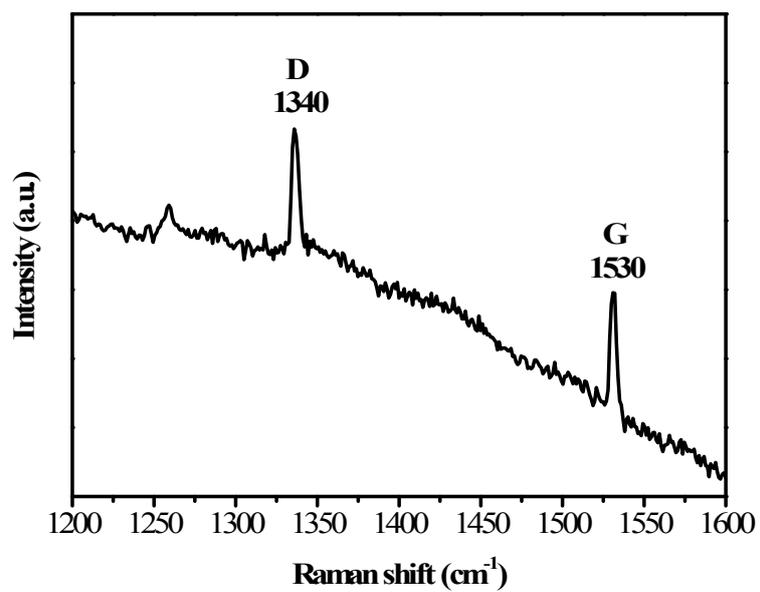


(C)

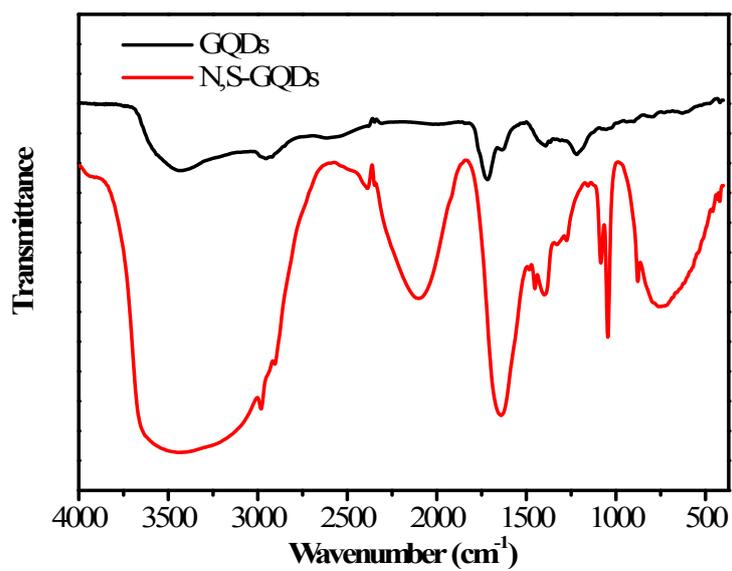


(D)

**Figure S1.** (A) TEM image of the N,S-GQDs; (B) TEM image of the N,S-GQDs after reaction with  $\text{Au}^{3+}$ ; (C) The size distribution histogram of the N,S-GQDs; (D) The size distribution histogram of the N,S-GQDs after reaction with  $\text{Au}^{3+}$ .



**Figure S2.** Raman spectra of the N,S-GQDs.



**Figure S3.** FT-IR spectra of the GQDs and N,S-GQDs.

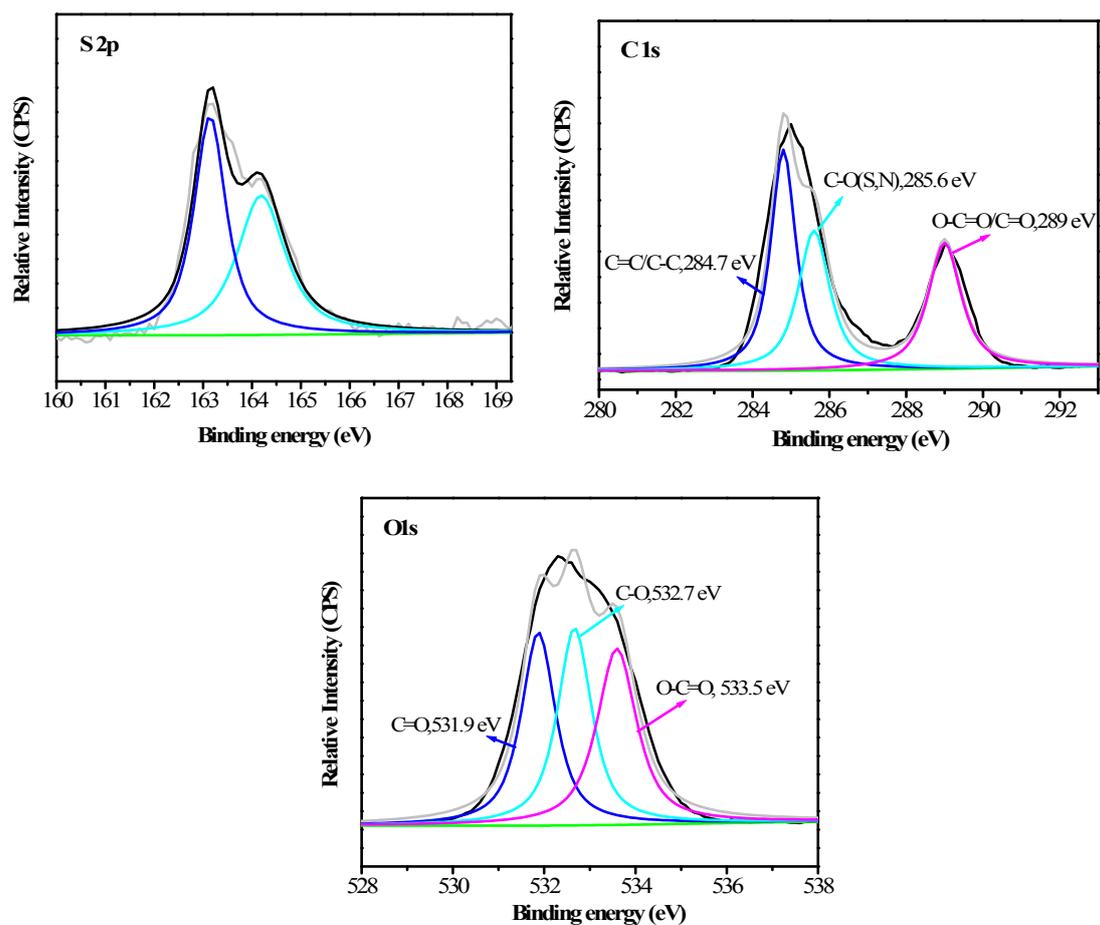
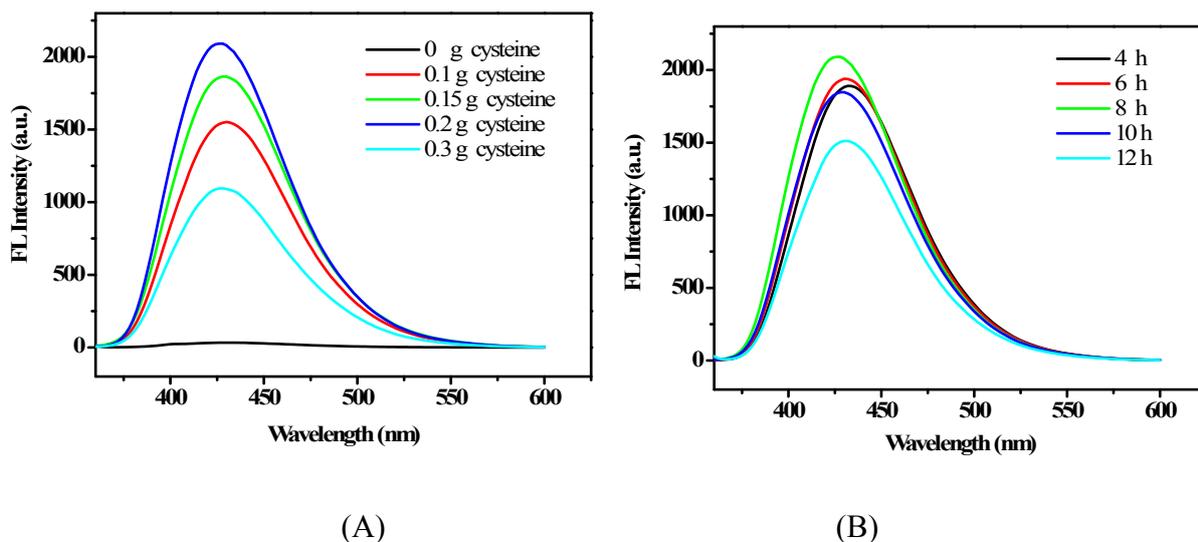
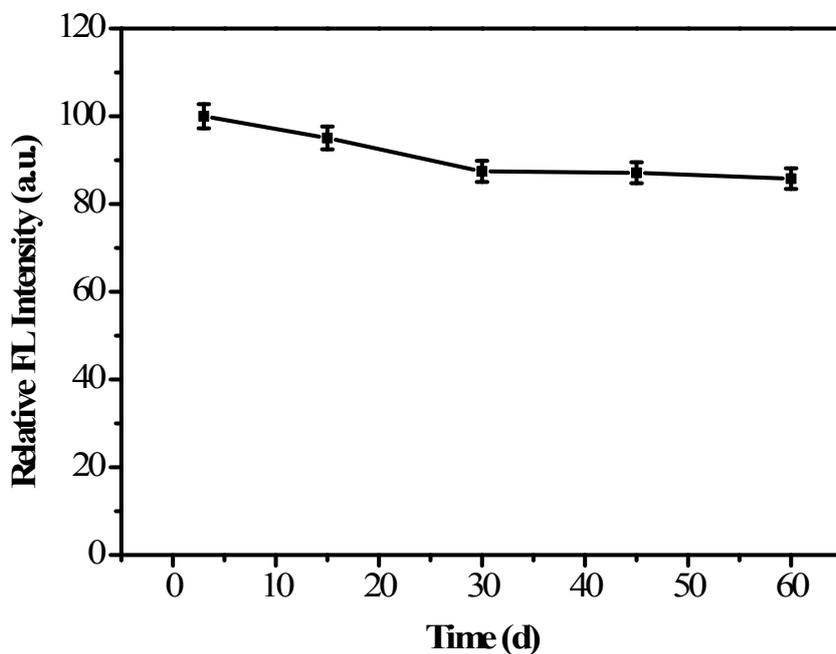


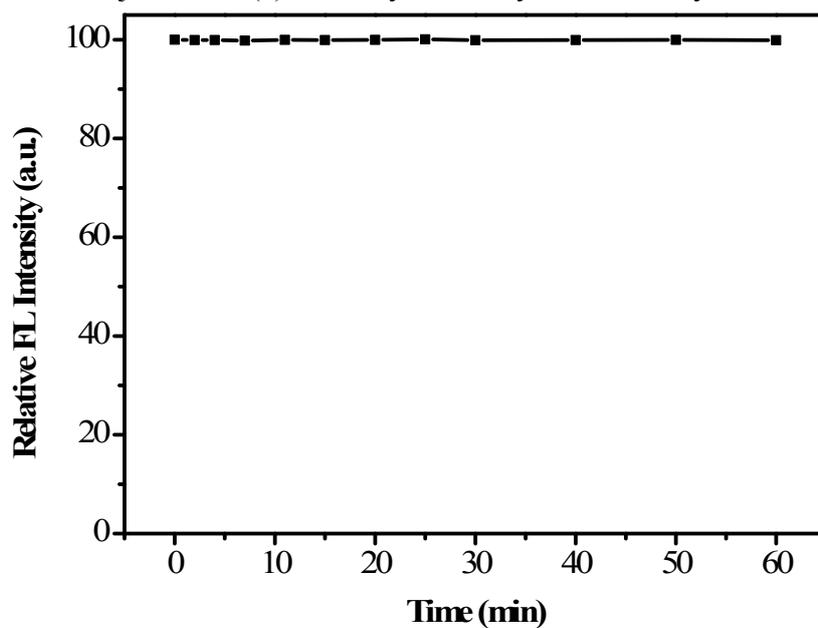
Figure S4. High resolution S2p, C1s and O1s XPS spectra for the N,S-GQDs.



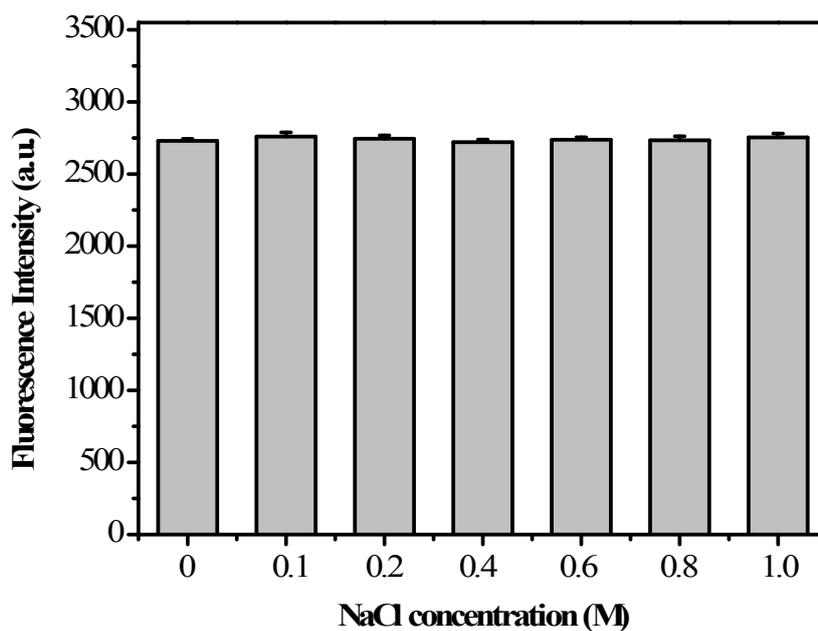
**Figure S5.** (A) The fluorescence emission spectra of the N,S-GQDs by hydrothermal reaction of different cysteine amount (0, 0.1, 0.15, 0.2, 0.3 g) while kept the amount of CA unchanged (2.0 g in the present work) at 200 °C for 8 h. (B) The fluorescence emission spectra of the N,S-GQDs by hydrothermal reaction of 0.2 g cysteine and 2.0 g CA at 200 °C for different reaction time (4 h, 6 h, 8 h, 10 h, 12 h, respectively).



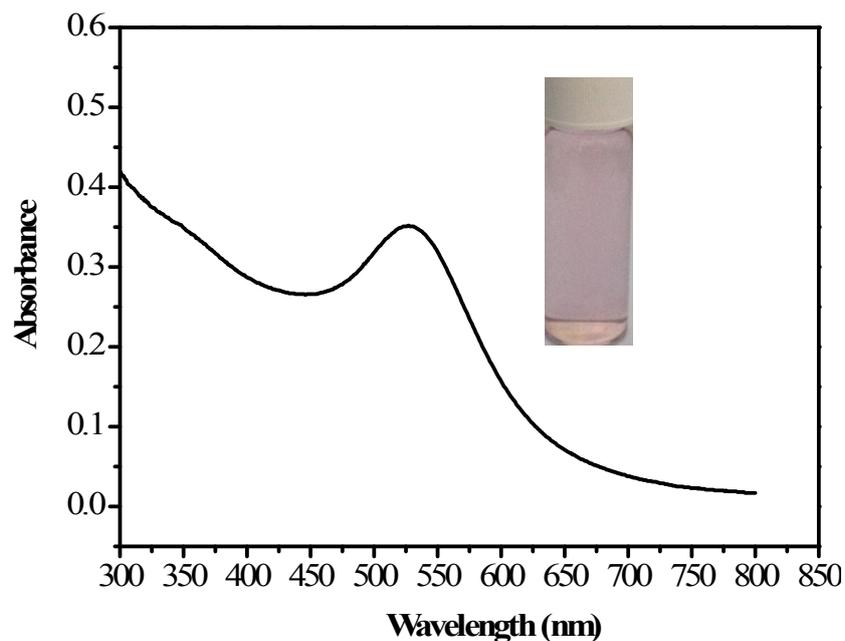
**Figure S6.** Variation of the fluorescence response of the N,S-GQDs suspension with time at room temperature.



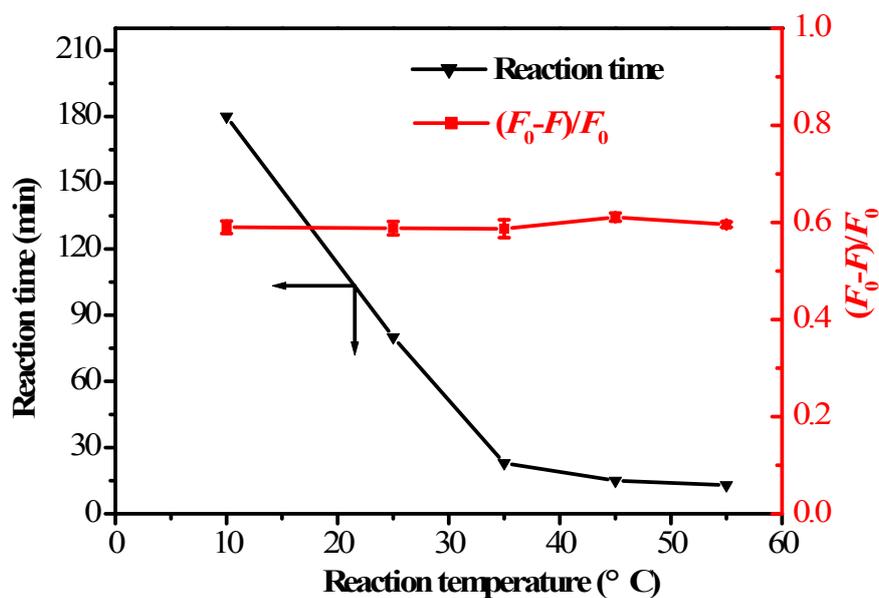
**Figure S7.** Photostability of 60 mg L<sup>-1</sup> N,S-GQDs. Irradiation source: 150 W Xe lamp.



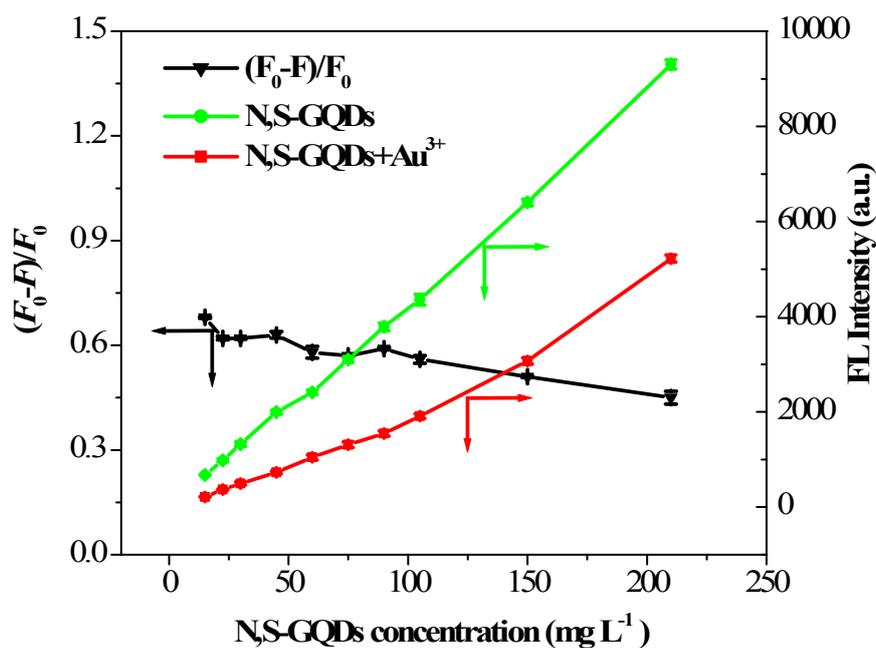
**Figure S8.** Effect of NaCl concentration on the fluorescence response of 60 mg L<sup>-1</sup> N,S-GQDs. Error bars represent one standard deviation for three measurements.



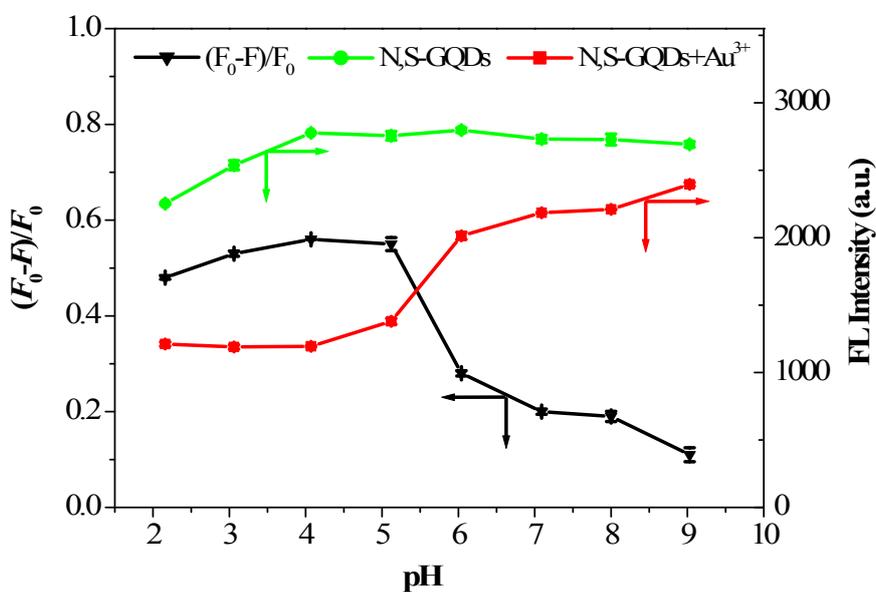
**Figure S9.** Absorption of  $150 \text{ mg L}^{-1}$  N,S-GQDs after reaction with  $50 \text{ } \mu\text{M Au}^{3+}$ . Insets: The photograph of the N,S-GQDs after reaction with  $\text{Au}^{3+}$ .



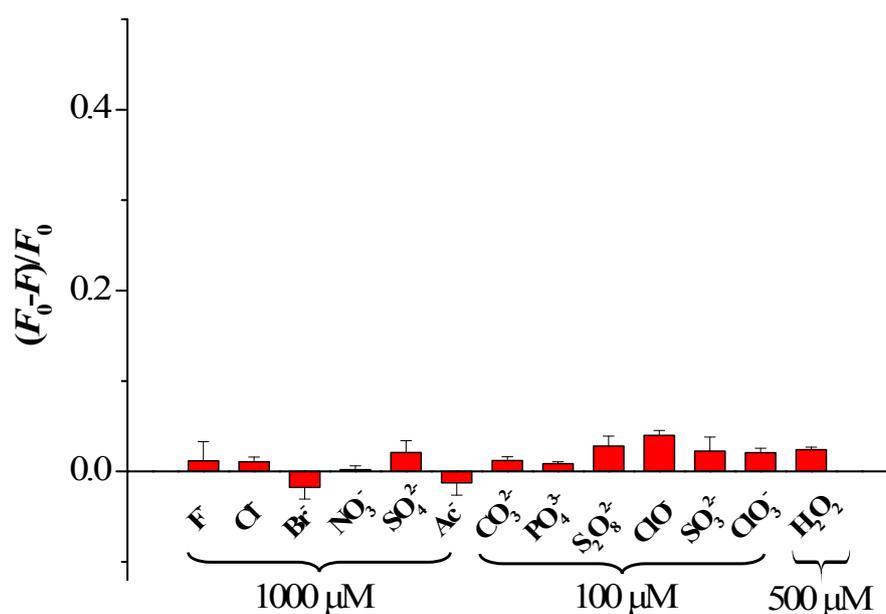
**Figure S10.** Effect of reaction temperature on the reaction time between  $60 \text{ mg L}^{-1}$  N,S-GQDs and  $50 \text{ } \mu\text{M Au}^{3+}$  (black line) and corresponding fluorescence intensity ratio  $(F_0 - F)/F_0$  of the resulting solution (red line).



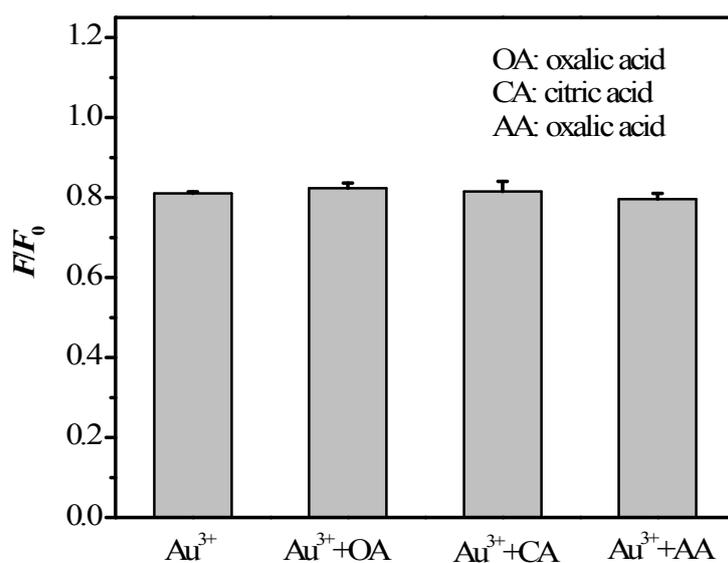
**Figure S11.** Effect of N,S-GQDs concentration on the fluorescence intensity in the absence and presence of 50  $\mu\text{M}$  Au<sup>3+</sup>. Error bars represent one standard deviation for three measurements.



**Figure S12.** FL responses of 60 mg/L N,S-GQDs at 425 nm in the absence (green line) and presence (black square) of 50  $\mu\text{M}$  Au<sup>3+</sup> ions at different pH values. Relative FL intensities  $[(F_0 - F)/F_0]$  of solutions of 60 mg L<sup>-1</sup> N,S-GQDs at 425 nm in the presence of 50  $\mu\text{M}$  Au<sup>3+</sup> ions at different pH values (black line).



(A)



(B)

**Figure S13.** (A) Relative FL intensities  $[(F_0 - F)/F_0]$  of the N,S-GQDs at 425 nm upon addition of various anions and H<sub>2</sub>O<sub>2</sub> (100, 500 or 1000  $\mu\text{M}$ ); (B) Fluorescence responses of the N,S-GQDs to Au<sup>3+</sup> in the absence and presence of 2 mM oxalic acid (OA), citric acid (CA) and ascorbic acid (AA). The error bars represent one standard deviation for three measurements.