Electronic Supplementary Material (ESI) for New Journal of Chemistry.
This journal is © The Royal Society of Chemistry and the Centre National de la Recherche Scientifique 2018

Electronic Supplementary Information

S, N-Co-doped Carbon Nanoparticles with High Quantum Yield for metal ions detection, IMP logic gates and bioimaging Applications

Jinping Song, Qi Ma *, Sufang Zhang, Huijun Liu, Yong Guo, Feng Feng *

College of Chemistry and Environmental Engineering, and Institute of Applied Chemistry, Shanxi Datong University, Datong, Shanxi, 037009, China

*Corresponding authors：maqihx@163.com (Q. Ma), feng-feng64@263.com (F. Feng)

Table S1. Quantum yield of S,N-CNPs prepared under different synthetic conditions.

	Reaction temperature/ ℃	Reaction time/ h	QYs (%) in water	QYs (%) in ethanol
1	200	1.0	33.59 %	5.02 %
2	200	1.5	53.35 %	42.72 %
3	200	2.0	57.35 %	43.99 %
4	200	2.5	67.02%	44.32 %
5	200	3.0	62.27 %	41.01 %
6	180	2.5	41.54 %	40.67 %
7	**220**	**2.5**	**69.04 %**	**43.84 %**
8	240	2.5	65.32 %	41.56 %

Table S2. Stern–Volmer quenching constants at different temperatures

	pH	T (K)	K_{sv} (L mol^{-1})	R
Hg^{2+}	6	298	6.765×10^4	0.9951
	6	310	5.408×10^4	0.9978
	6	318	4.024×10^4	0.9784
Ag^{+}	11	298	8.859×10^4	0.9903
	11	310	8.548×10^4	0.9924
	11	318	7.752×10^4	0.9931
Ni^{2+}	11	298	1.367×10^4	0.9971
	11	310	0.846×10^4	0.9977
	11	318	0.631×10^4	0.9923

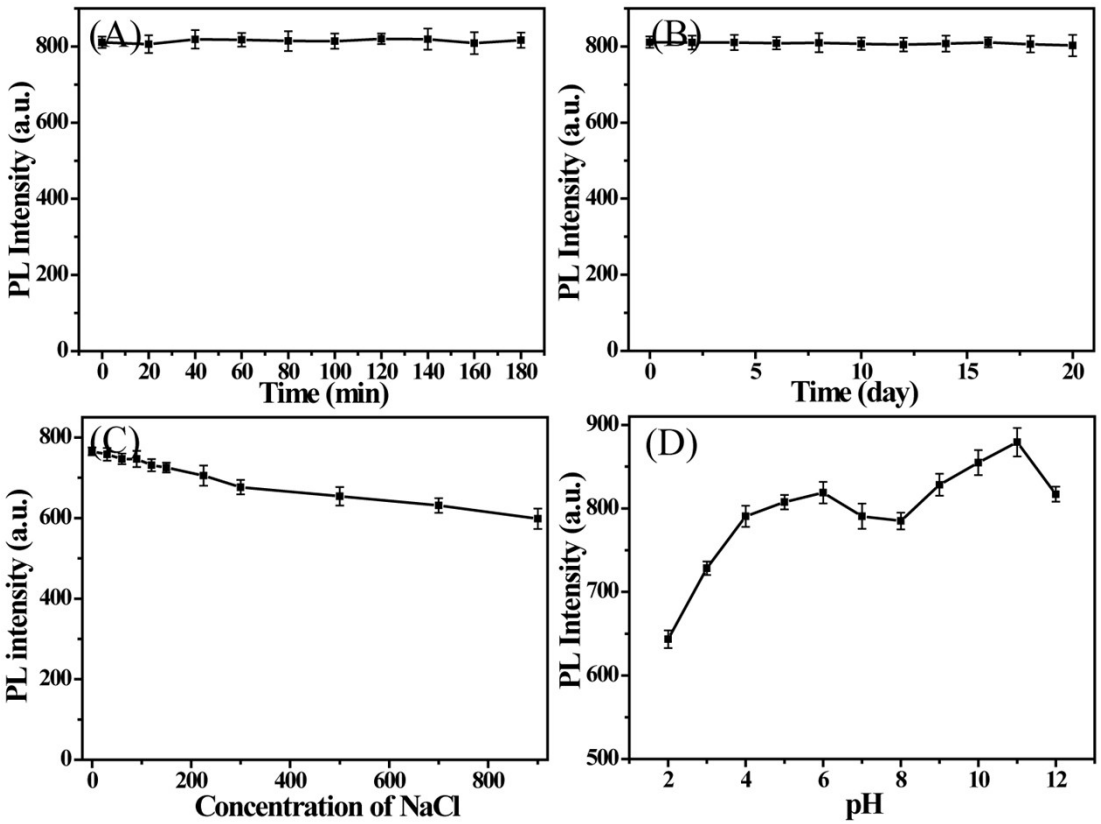

Figure S1 Stability performance of S, N-CNPs. Effect of UV lamp irradiation (A), storage time (B), ionic strength (C) and pH (D**)** on the fluorescence intensity of S, N-CNPs.

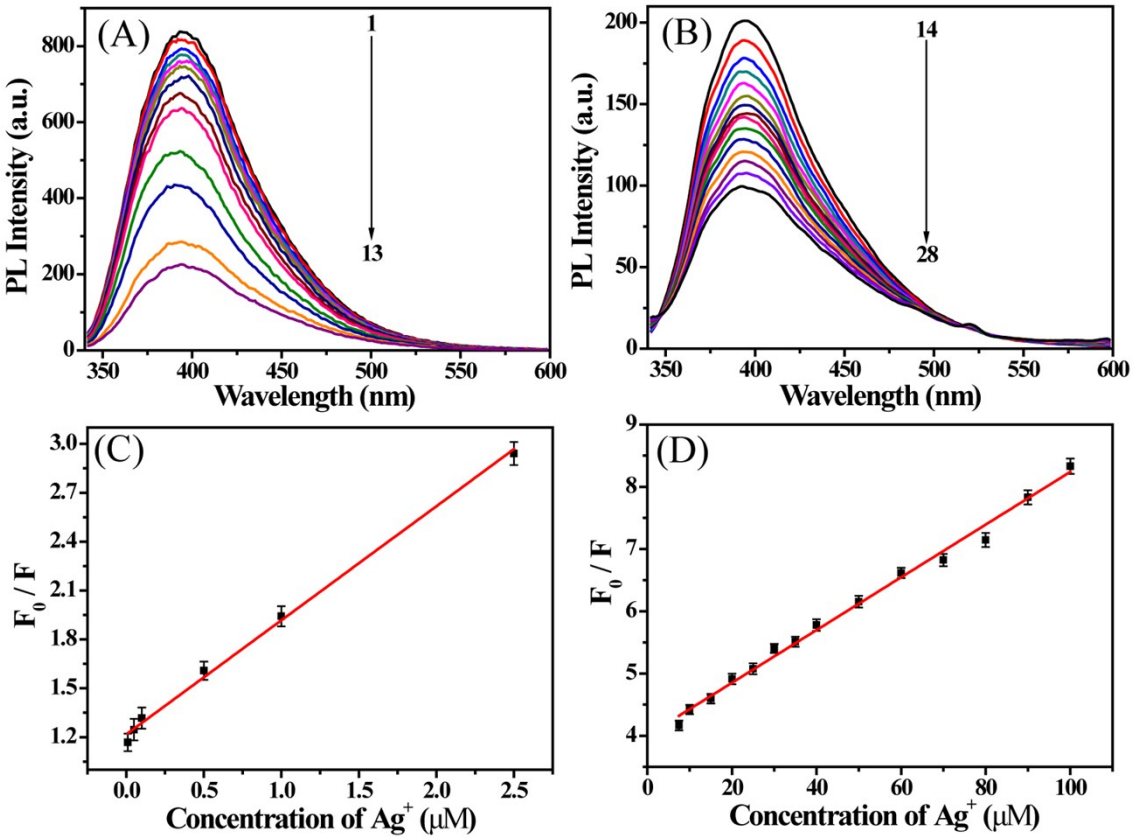

Figure S2 (A and B) Fluorescence spectra of S, N-CNPs in the presence of different concentration of Ag^+ (1: 0 M; 2 ~ 13: 1.0×10^{-11} M ~ 5.0×10^{-6} M; 14 ~ 28: 7.5×10^{-6} M ~ 1.0×10^{-4} M) in pH 11 BR buffer solution. (C) The linear plot between F_0/F and the concentration of Ag^+ in the range of 1.0×10^{-8} ~ 2.5×10^{-6} M. (D) The linear plot between F_0/F and the concentration of Ag^+ in the range of 7.5×10^{-6} ~ 1.0×10^{-4} M.

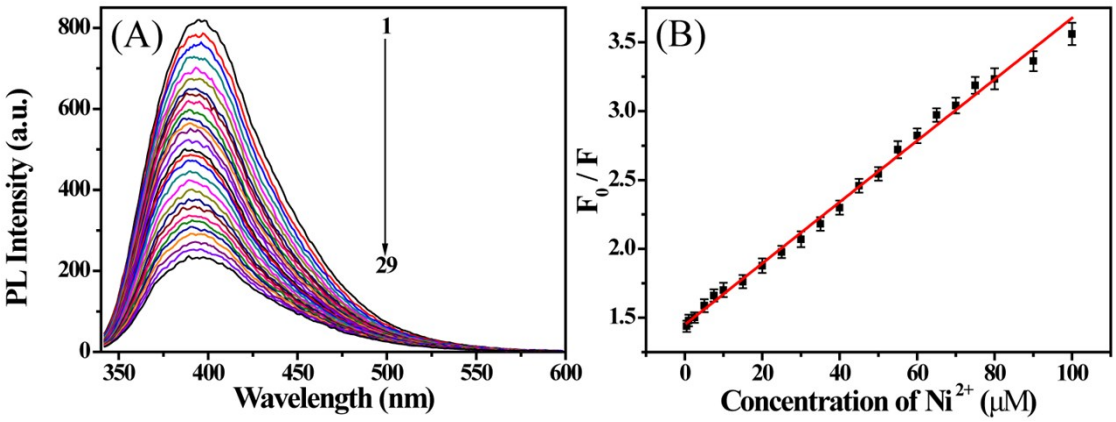

Figure S3 (A) Fluorescence spectra of S,N-CNPs in the presence of different concentration of Ni^{2+} (1: 0 M; 2 ~ 29: 1.0×10^{-12} M ~ 1.0×10^{-4} M) in pH 11 BR buffer solution. (B) The linear plot between F_0/F and the concentration of Ni^{2+}.

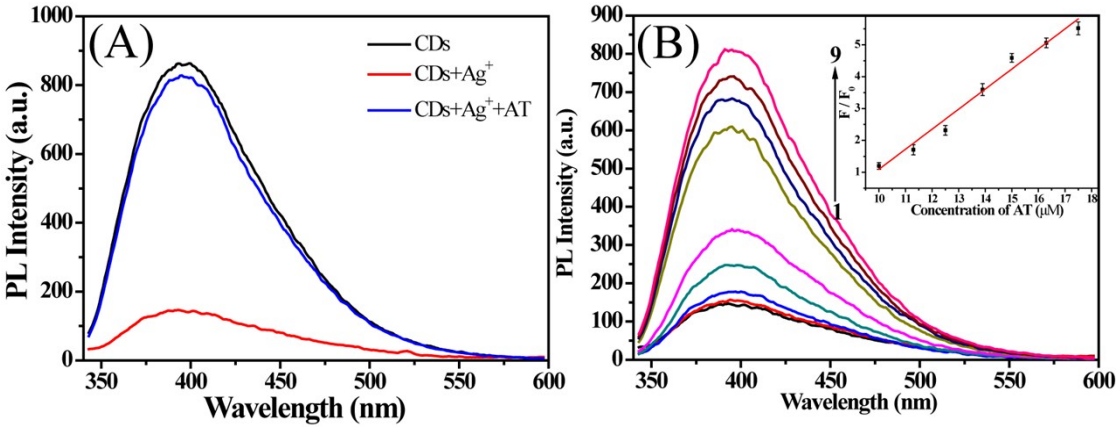

Figure S4 (A) Fluorescence spectra of S,N-CNPs (black curve), S,N-CNPs+0.1 mM Ag^+ (red curve) and S,N-CNPs+ 0.1 mM Ag^++ 20 μM AT (blue curve), respectively. (B) Fluorescence spectra of S,N-CNPs containing 0.1 mM Ag^+ in the absence and presence of different concentration of AT ($5.0 \times 10^{-6} \sim 2.0 \times 10^{-5}$ M). (Inset) Linear plot between F/F_0 and the concentration of AT. All above experiments were carried out in pH 11 BR buffer solution.

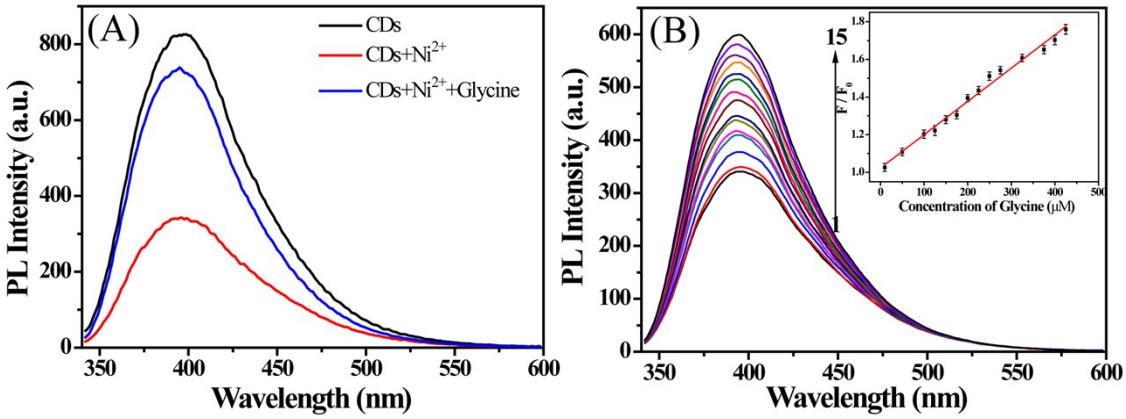

Figure S5 (A) Fluorescence spectra of S,N-CNPs (black curve), S,N-CNPs+0.1 mM Ni^{2+} (red curve) and S,N-CNPs+ 50 μM Ni^{2+}+ 1 mM glycine (blue curve), respectively. (B) Fluorescence spectra of S,N-CNPs containing 50 μM Ni^{2+} in the absence and presence of different concentration of Ni^{2+} (1: 0 M; 2 ~ 15: 1.0×10^{-5} ~ 4.25×10^{-4} M). (B) Linear plot between F_0/F and the concentration of Ni^{2+} in the range of 1.0×10^{-5} ~ 4.25×10^{-4} M. All above experiments were carried out in pH 11 BR buffer solution.

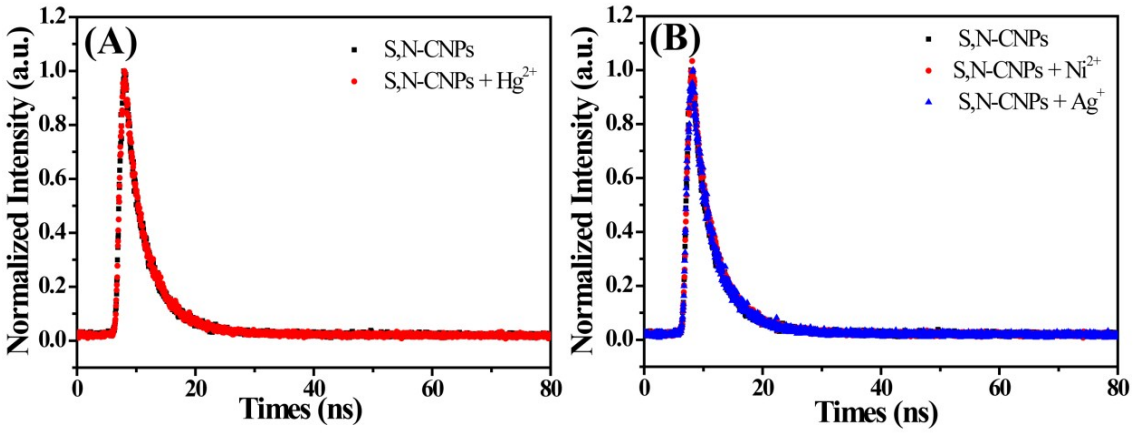

Figure S6 (A) Lifetime decay of S,N-CNPs, and S,N-CNPs+Hg^{2+} in pH 6 BR buffer solution. (B) Lifetime decay of S,N-CNPs, S,N-CNPs+Ni^{2+} and S,N-CNPs+Ag^{+} in pH 11 BR buffer solution.

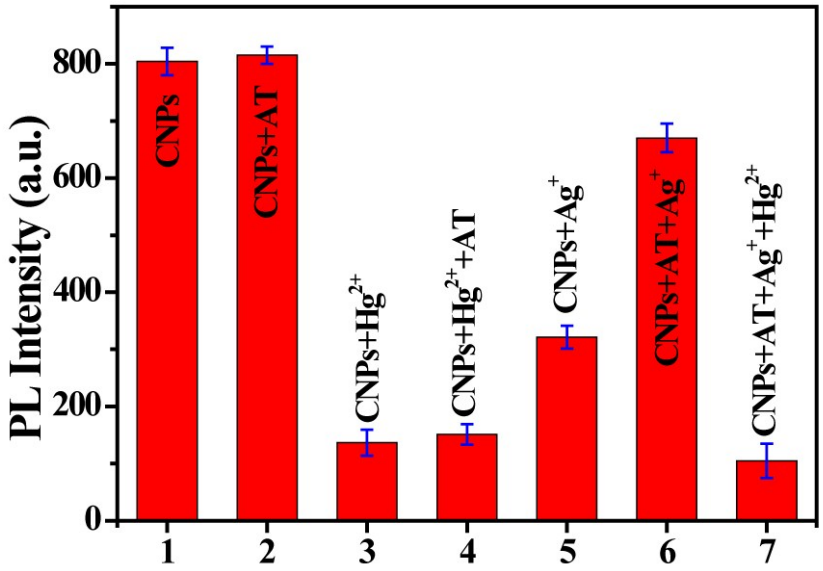

Figure S7 Fluorescence histogram of (1) S,N-CNPs, (2) S,N-CNPs + 0.1 mM AT, (3) S,N-CNPs + 0.1 mM Hg^{2+}, (4) S,N-CNPs + 0.1 mM Hg^{2+} + 0.1 mM AT, (5) S,N-CNPs + 50 μM Ag^{+}, (6) S,N-CNPs + 50 μM Ag^{+} + 0.1 mM AT and (7) S,N-CNPs + 50 μM Ag^{+} + 0.1 mM AT + 0.1 mM Hg^{2+} in pH 6 buffer solution, respectively.

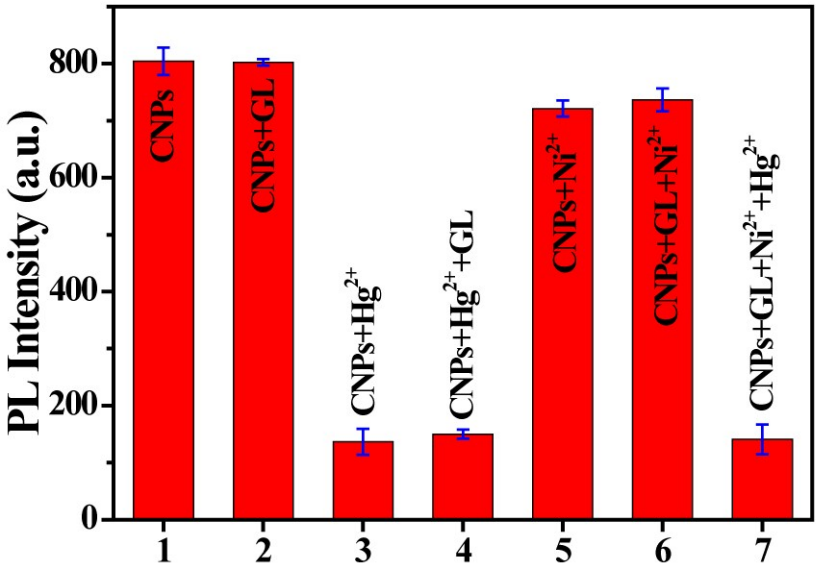

Figure S8 Fluorescence histogram of (1) S,N-CNPs, (2) S,N-CNPs + 0.1 mM GL, (3) S,N-CNPs + 0.1 mM Hg^{2+}, (4) S,N-CNPs + 0.1 mM Hg^{2+} + 0.1 mM GL, (5) S,N-CNPs + 0.1 mM Ni^{2+}, (6) S,N-CNPs + 0.1 mM Ni^{2+} + 0.1 mM GL and (7) S,N-CNPs + 0.1 mM Ni^{2+} + 0.1 mM GL + 0.1 mM Hg^{2+} in pH 6 buffer solution, respectively.

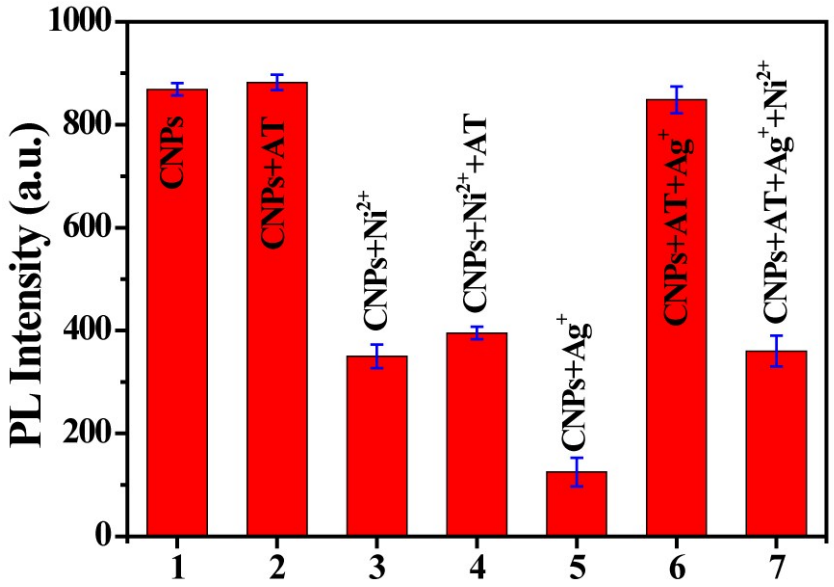

Figure S9 Fluorescence histogram of (1) S,N-CNPs, (2) S,N-CNPs + 20 μM AT, (3) S,N-CNPs + 50 μM Ni^{2+}, (4) S,N-CNPs + 50 μM Ni^{2+} + 20 μM AT, (5) S,N-CNPs + 0.1 mM Ag^{+}, (6) S,N-CNPs + 0.1 mM Ag^{+} + 20 μM AT and (7) S,N-CNPs + 0.1 mM Ag^{+} + 20 μM AT + 50 μM Ni^{2+} in pH 11 buffer solution, respectively.

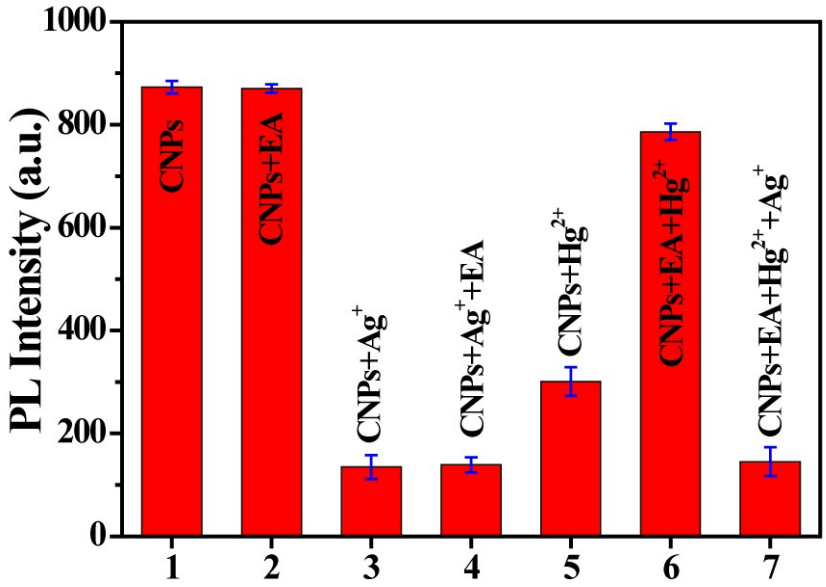

Figure S10 Fluorescence histogram of (1) S,N-CNPs, (2) S,N-CNPs + 10 mM EA, (3) S,N-CNPs + 0.1 mM Ag^{+}, (4) S,N-CNPs + 0.1 mM Ag^{+} +10 mM EA, (5) S,N-CNPs + 0.1 mM Hg^{2+}, (6) S,N-CNPs + 0.1 mM Hg^{2+} + 10 mM EA and (7) S,N-CNPs + 0.1 mM Hg^{2+} +10 mM EA + 0.1 mM Ag^{+} in pH 11 buffer solution, respectively.

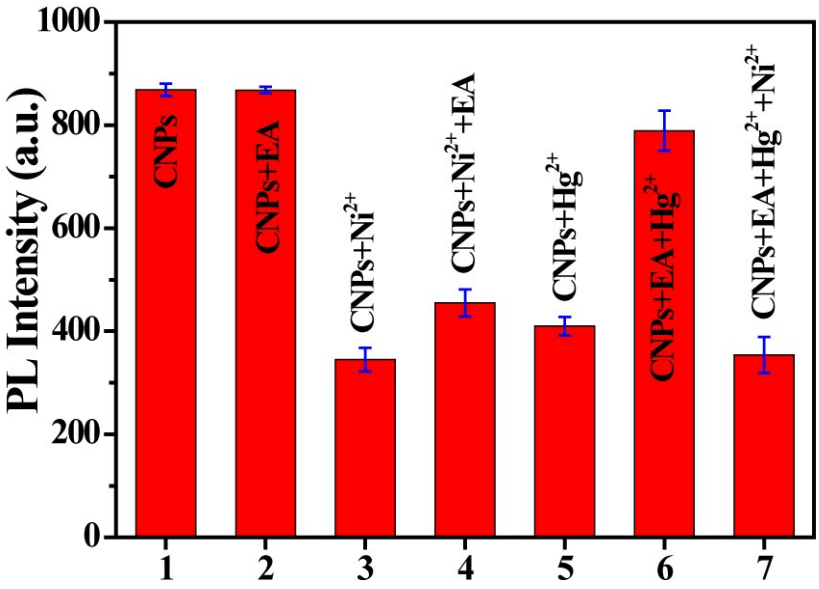

Figure S11 Fluorescence histogram of (1) S,N-CNPs, (2) S,N-CNPs + 0.2 mM EA, (3) S,N-CNPs + 50 μM Ni^{2+}, (4) S,N-CNPs + 50 μM Ni^{2+} + 0.2 mM EA, (5) S,N-CNPs + 50 μM Hg^{2+}, (6) S,N-CNPs + 50 μM Hg^{2+} + 0.2 mM EA and (7) S,N-CNPs + 50 μM Hg^{2+} + 0.2 mM EA + 50 μM Ni^{2+} in pH 11 buffer solution, respectively.

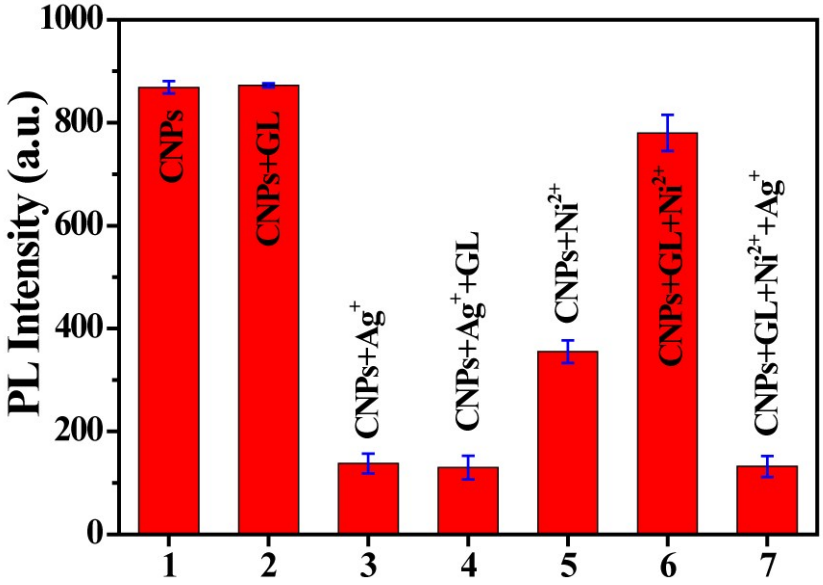

Figure S12 Fluorescence histogram of (1) S,N-CNPs, (2) S,N-CNPs + 0.5 mM GL, (3) S,N-CNPs + 0.1 mM Ag^{+}, (4) S,N-CNPs + 0.1 mM Ag^{+} + 0.5 mM GL, (5) S,N-CNPs + 50 μM Ni^{2+}, (6) S,N-CNPs + 50 μM Ni^{2+} + 0.5 mM GL and (7) S,N-CNPs + 50 μM Ni^{2+} + 0.5 mM GL + 0.1 mM Ag^{+} in pH 11 buffer solution, respectively.

Input 1	Input 2			Output
Ag^+	AT	EA	GL	F
1	0	0	0	0
1	1	0	0	1
1	0	1	0	0
1	0	0	1	0

Figure S13 Truth table for IMP logic gate operation (it always keeps Ag^+ as input 1 and changes input 2).

Input 1			Input 2	Output
Ag^{+}	Hg^{2+}	Ni^{2+}	AT	F
1	0	0	1	1
0	1	0	1	0
0	0	1	1	0

Figure S14 Truth table for IMP logic gate operation (it always keeps AT as input 2 and changes input 1).

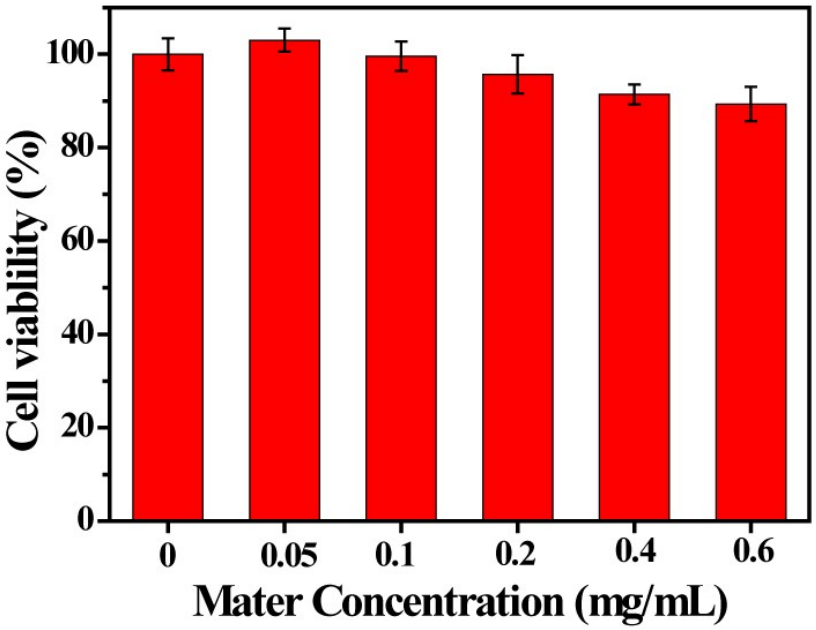

Figure S15 Cell cytotoxic effect of S,N-CNPs on Hela cells.