Electronic Supplementary Information

Sensitive fluorescence detection of heparin based on self-assembly of mesoporous silica nanoparticle-gold nanoclusters with emission enhancement characteristic

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Experimental section

Optimization of method

To obtain the best performance of the method, the following parameters were optimized:

(1) MSNs concentrations

To investigate the effect of MSNs concentrations on the fluorescence emission enhancement of MSN-AuNCs nanocomposites, the assay was carried out by varying the concentration of MSNs in the range of 0 to 0.6 mg/mL and fixing the volume of AuNCs solution at 15 μL in Tris-HCl buffer with the total volume of 300 μL. The mixture was gently shaken on a thermostatic oscillator at 25 °C for 30 min, and then the fluorescence spectra were recorded with the excitation of 365 nm.

(2) pH values

To investigate the effect of pH values on the performance of Hep detection, the assay was carried out in Tris-HCl buffer with different pH (6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0). Typically, 60 μL of MSNs solution (2 mg/mL), 165 μL Tris–HCl buffer were mixed with 60 μL of Hep solution (1 μM) and incubated at 37 °C for 15 min. Then, 15 μL of AuNCs solution was added in the as-mentioned solution and gently shaken on a thermostatic oscillator at 25 °C for 30 min. Finally, the fluorescence spectra were recorded with the excitation of 365 nm.

(3) Self-assembly time of MSN-AuNCs nanocomposites

To investigate the effect of self-assemble time of MSN-AuNCs nanocomposites on the performance of Hep detection, the assay was carried out by varying the self-assemble time of AuNCs with MSNs under a fixed concentration of MSNs at 0.4 mg/mL and a fixed volume of AuNCs solution at 15 μL in Tris-HCl buffer with the total volume of 300 μL. The mixture was gently shaken on a thermostatic oscillator at 25 °C for 30 min, and then the fluorescence spectra were recorded with the excitation of 365 nm.

(4) Hep incubation time

To investigate the effect of Hep incubation time on the performance of Hep

detection, the assay was carried out in Tris-HCl buffer with different Hep incubation time. The other experimental conditions and procedure were the same as the experimental section (2).

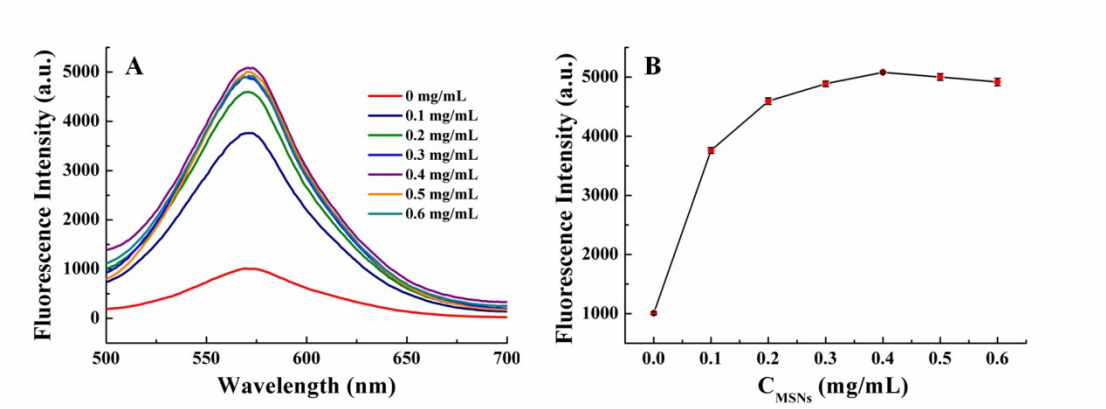

Fig. S1. Effect of the MSNs concentration on the emission enhancement of MSN-AuNCs nanocomposites. (A) Fluorescence emission responses of MSN-AuNCs nanocomposites obtained by varying the concentration of MSNs under a fixed volume of 15 μL AuNCs solution in Tris-HCl buffer. (B) Fluorescence intensities at 570 nm to different concentration of MSNs. The error bars were estimated from three replicate measurements.

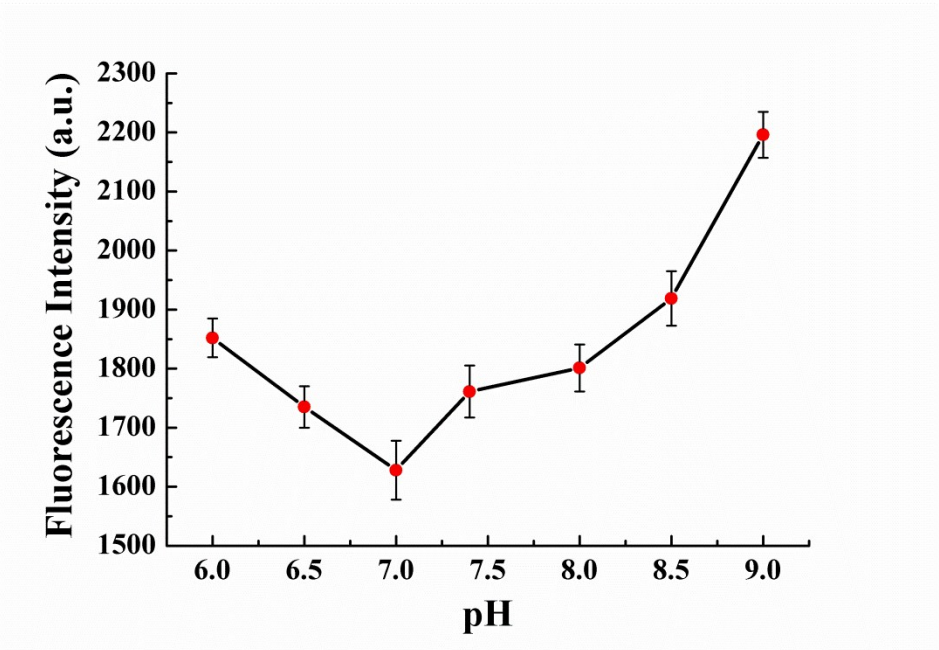

Fig. S2. Effect of the pH on the performance of the method for Hep detection, V_{AuNCs} =15 μL, [Hep] = 200 nM, [MSNs] = 0.4 mg/mL. The error bars were estimated from three replicate measurements.

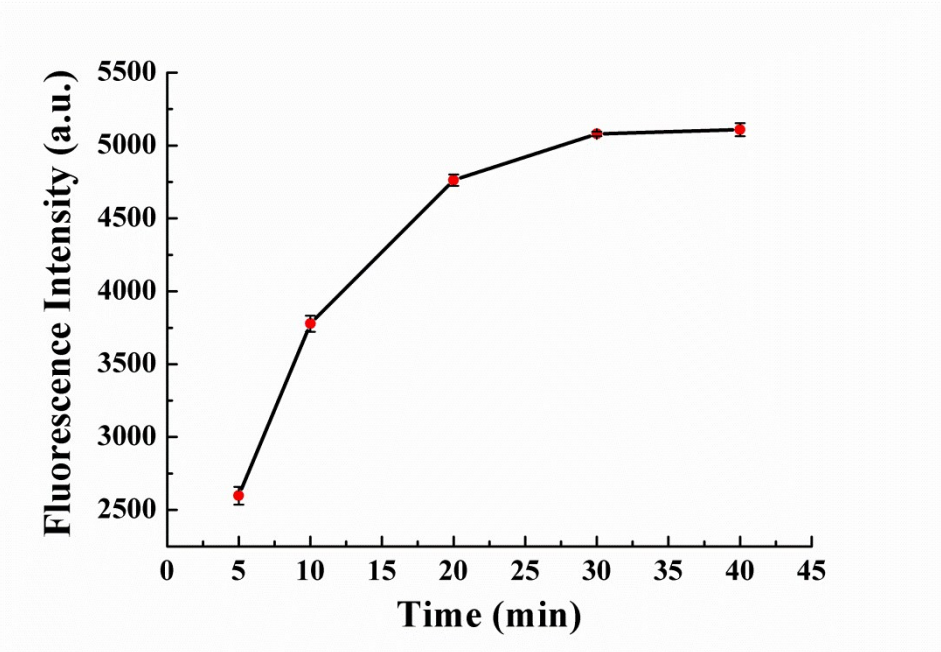

Fig. S3. Effect of the self-assembly time on the emission enhancement of MSN-AuNCs nanocomposites, V_{AuNCs} =15 μL, [MSNs] = 0.4 mg/mL. The error bars were estimated from three replicate measurements.

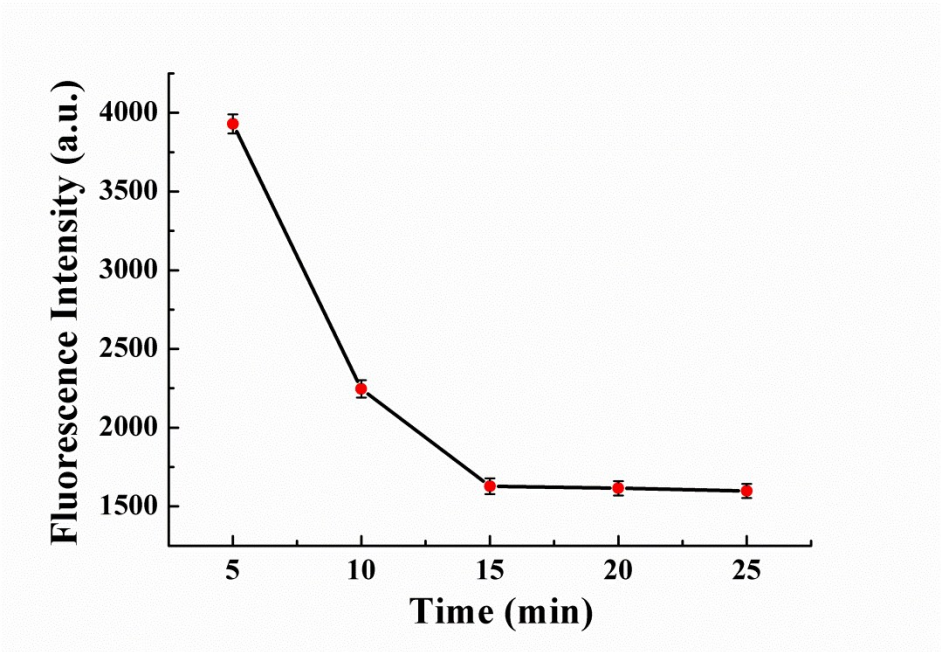

Fig. S4. Effect of incubation time of Hep with MSNs on the performance of the method for detection of Hep, V_{AuNCs} =15 μL, [Hep] = 200 nM, [MSNs] = 0.4 mg/mL. The error bars were estimated from three replicate measurements.

Table S1. Comparison of various fluorescence methods for the detection of Hep.

Probe	Linear range	Detection limit	Ref.
Phloxine B/tetraphenylethene (TPE) derivative and protamine	0−1.5 U/mL	0.02 U/mL	1
AIE-based fluorescent probe (TIBI)	0–10 μM	8 nM	2
AIE-based fluorescent probe (HPQ-TBP-I)	1.7–10 μM	22 nM	3
AIE-based fluorescent probe (TPE-1)	0.064–0.32 μg/mL	3.8 ng/mL	4
AIE-based fluorescent probe/ GO	0–13.2 μM	10 nM	5
Adenosine-based molecular beacons	10-100 nM	3 nM	6
Polyelectrolyte-induced pyrene excimers	0.1−2.3 μM	0.14 μM	7
BSA-AuNCs /NH_2-graphene oxide (GO)	0.1-30 μg/mL	40 ng/mL	8
Polyethyleneimine capped Ag_2S quantum dots (QDs)	0.069–2.275 μM	6 nM	9
Trypsin stabilized AuNCs	0.1–4.0 μg/mL	0.05 μg/mL	10
Poly (amidoanime) dendrimers/graphene quantum dots	0.04–1.6 μg/mL	0.02 μg/mL	11
$CuInS_2$ QDs	0.05–15 μM	12.46 nM	12
MSN-AuNCs	5-150 nM	2 nM	this work

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