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# A New Reactive 1,8-Naphthalimide Derivative for Highly Selective and Sensitive Detection of Hg<sup>2+</sup>

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Abstract A 1,8-naphthalimide derivative with a reactive aliphatic hydroxyl was designed and synthesized as a fluorescent probe. Its structure was characterized by IR, <sup>1</sup>H NMR, <sup>13</sup>C NMR, LC-MS and HPLC. The probe showed high selectivity and sensitivity to Hg<sup>2+</sup> over other metal ions such as Pb<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Cd<sup>2+</sup>, Cr<sup>3+</sup>, Zn<sup>2+</sup>, Cu<sup>2+</sup>, Ni<sup>2+</sup>, Ca<sup>2+</sup>, Fe<sup>3+</sup>, Fe<sup>2+</sup>, Co<sup>2+</sup>, Mn<sup>2+</sup> and Mg<sup>2+</sup> in MeCN/H<sub>2</sub>O (15/85, v/v). The increase in fluorescence intensity was linearly proportional to the concentration of Hg<sup>2+</sup> in the range of 18–40  $\mu$ M with a detection limit of 1.38 × 10<sup>-7</sup> mol/L. The probe could work in a pH span of 4.3–9.0 and respond to Hg<sup>2+</sup> quickly with strong anti-interference ability. Job's plot suggested a 1:2 complex of the probe and Hg<sup>2+</sup>.

**Keywords** Fluorescent probe  $\cdot$  Naphthalimide  $\cdot$  Phenyl isothiocyanate  $\cdot$  Hg<sup>2+</sup>

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# Introduction

 $Hg^{2+}$  is a kind of common heavy metal pollutant which can spread in the air, soil and water, accumulate in human body through food chain accumulation and cause a lot of health problems [1, 2]. Therefore, it is very important to detect the presence of  $Hg^{2+}$ . As being highly sensitive, simple, cheap as well as on-site and timely, fluorescent probe has been of great concern in the detection of heavy metal ions [3–5].

In the detection of  $Hg^{2+}$ , fluorescent probe has a sustained development. Fluorophores of  $Hg^{2+}$  fluorescent probe can be rhodamine [6–9], dansyl chloride [10–12], quinoline [13, 14], coumarin [15, 16], BODIPY [17, 18], fluorescein [19, 20] or 1,8-naphthalimide [21], and the recognition groups connected to the fluorophores are the myriads of changes but mainly hetero atom groups containing N, O, S atoms.

1,8-Naphthalimide derivatives have strong electronwithdrawing imide group and strong electron donating group at C-4 of the naphthalene ring. This kind of structure tends to form electron transfer and produces rich optical phenomena. Several 1,8-naphthalimide-based fluorescent sensors for  $Hg^{2+}$  have been reported. However, they mostly exist shortcomings, such as complex structure and difficult synthesis [22, 23], high solvent content of the test system [24, 25], poor anti-jamming [26, 27], and incomplete performance study [28, 29].

High selectivity is crucial to fluorescent probe, while water solubility can improve the probe's availability. In this paper, we use 4-bromine-1,8-naphthalic anhydride as fluorophore precusor, ethanol amine as water solubility and reactivity provider, hydrazine monohydrate as bridge and phenyl isothiocy-anate as receptor to construct a new fluorescent probe. As expected, the probe has satisfactory water solubility and high selectivity toward Hg<sup>2+</sup>. In addition, the hydroxyl in ethanol amine provides the probe reactivity which can be used for the

further modification of the probe itself and other materials. Exceptionally, this hydroxyl also can participate in the recognition of  $Hg^{2+}$ .

# Experimental

#### Materials

4-bromine-1,8-naphthalic anhydride (98%) was purchased from Anshan HIFI Chemical Co., Ltd., phenyl isothiocyanate (98%) was bought from Yake Chemical Reagent Co., Ltd., ethanol amine, NH<sub>2</sub>NH<sub>2</sub>·H<sub>2</sub>O (85%), the solvents and metal ions of chloride and nitrate, such as NaCl, KCl, MgCl<sub>2</sub>, CaCl<sub>2</sub>, CrCl<sub>3</sub>·6H<sub>2</sub>O, MnSO<sub>4</sub>·H<sub>2</sub>O, FeCl<sub>3</sub>·6H<sub>2</sub>O, FeCl<sub>2</sub>·7H<sub>2</sub>O, CoCl<sub>2</sub>· 6H<sub>2</sub>O, Ni(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O, CuCl<sub>2</sub>·2H<sub>2</sub>O, HgCl<sub>2</sub>, Pb(CH<sub>3</sub>COO)<sub>2</sub>, Zn(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O, CdCl<sub>2</sub>·2.5H<sub>2</sub>O, were provided by Sinopharm Chemical Reagent Co., Ltd. All of the reagents in this paper were the best commercial products and they were used without further purification. The solvents used in synthesis were analytical grade, others were spectroscopic grade. Deionized water (H<sub>2</sub>O) was used in the experiments unless specified otherwise.

# Apparatus

Infrared (IR) spectra were measured on a TENSOR27 spectrometer (Bruker Optics Co., Germany). LC-mass was performed on an Agilent 1200/6220 spectrometer (Agilent Co., USA) unless otherwise specified. <sup>1</sup>H NMR spectra were recorded on a 400 MHz Varian Unity Inova spectrometer (Varian Co., USA). <sup>13</sup>C NMR spectra were obtained on a 300 MHz Varian Unity Inova spectrometer (Varian Co., USA). High performance liquid chromatography (HPLC) was measured on an Waters 1525 HPLC (Waters Co., USA), using C18 column (150 mm  $\times$  4.6 mm  $\times$  5.0  $\mu$ m) and MeCN/H<sub>2</sub>O (50/50,v/v) as an eluent (the total flux was 1 mL/min), and the detection wavelength was 392 nm. Fluorescence spectra were recorded on a F-2500 spectrofluorometer (Hitachi Co., Japan). pH values were measured with precision pH test paper (Shanghai Sanaisi Reagent Co., Ltd., China). All the detections were carried out at 25 °C unless otherwise specified.

### **Probe Synthesis**

2-(2-(2-hydroxyethyl)-1,3-dioxo-2,3-dihydro-1*H*-benzo[*de*]isoquinolin-6-yl)-*N*-phenylhydrazine-1-carbothioamide (HTUN) was synthesized by three-step reactions between 4bromo-1,8-naphthalic anhydride, ethanol amine, hydrazine monohydrate and phenyl isothiocyanate, as shown in Scheme 1.

Intermediate N-hydroxyethyl-4-bromine-1,8naphthalimide (HBN) was obtained as a milky white solid with a yield of 85.6% according to reference [30]. Based on reference [31], HBN reacted with hydrazine hydrate to get intermediate N-hydroxyethyl-4-diazanyl-1,8-naphthalimide (HHN) with a yield of 89.0%. Phenyl isothiocyanate (0.108 mL, 0.91 mmol) and HHN (0.15 g, 0.55 mmol) were added in 20 mL absolute ethanol. Then the mixture was stirred and heated to reflux for 24 h. After cooled to room temperature, filtered and the filter cake was washed with absolute ethanol (2 mL  $\times$  3). The probe (HTUN) was achieved as a brown powder (0.156 g). Yield: 69.6%. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, 400 MHz, δ ppm): 10.11 (s, 2H), 9.86 (s, 1H), 8.69 (d, J = 8 Hz, 1H), 8.48 (d, J = 6.8 Hz, 1H), 8.42 (d, J = 8.8 Hz, 1H), 7.77 (t, J = 7.6 Hz, 1H), 7.43 (d, J = 6.4 Hz, 2H), 7.31 (t, J = 7.4 Hz, 2H, 7.15 (t, J = 7 Hz, 1H), 6.98 (d, J = 8.4 Hz, 1H), 4.81 (t, J = 5.6 Hz, 1H), 4.13 (t, J = 6.4 Hz, 2H), 3.60 (t, J = 6.2 Hz, 2H) (Fig. S1). <sup>13</sup>C NMR (DMSO-d<sub>6</sub>, 300 MHz, δ ppm): 42.007, 58.419, 105.921, 112.107, 119.887, 122.352, 125.344, 125.827, 126.599, 128.504, 129.411, 131.349, 134.152, 139.562, 150.321, 163.624, 164.303, 181.828 (Fig. S2). IR (KBr pellet,  $cm^{-1}$ ): 3524, 3234, 3152, 2968, 2893, 1689, 1650, 1587, 1537 (Fig. S3). LC-Mass: m/z: 407.1197 ([M + H]<sup>+</sup>), 429.1007 ([M + Na]<sup>+</sup>) (Fig. S4). Purity from HPLC: 99.7% (Fig. S5).

#### Methods

#### UV-Vis Absorption and Fluorescence Test

HTUN was dissolved in MeCN to form a  $1 \times 10^{-3}$  M stock solution. Metal salts were dissolved in H<sub>2</sub>O to get  $1 \times 10^{-2}$  M stock solutions. For the detection of Hg<sup>2+</sup>, stock solution of HTUN (100 µL) and one of the ion stock solution (40 or 100 µL) were added in a 10 mL volumetric flask and diluted to 10 mL with CH<sub>3</sub>CN and H<sub>2</sub>O to form MeCN/H<sub>2</sub>O (15/85, v/v) solutions. In fluorescence titration experiments, 100 µL





Fig. 1 UV–vis absorption spectra of HTUN with different ions. Solvent: MeCN/H<sub>2</sub>O (15/85, v/v), concentration: 10  $\mu$ M for HTUN, 100  $\mu$ M for various ions

stock solution of HTUN was mixed with a certain amount of the  $Hg^{2+}$  stock solution and diluted to 10 mL with  $CH_3CN$  and  $H_2O$ . The spectra were recorded at 30 min after the mixing. pH was adjusted by 0.1 M HCl and 0.1 M NaOH aqueous solutions. For fluorescence measurements, excitation wavelength was 400 nm. The excitation and emission slits were set at 5 nm respectively.

# Testing Hg<sup>2+</sup> in Spiked Environmental Water

1 mL pond water (after filtration) or tap water from Dushu Lake Campus of Soochow University was added in 10 mL volumetric flask, then 20 (or 30)  $\mu$ L stock solution of Hg<sup>2+</sup>, 100  $\mu$ L stock solution of HTUN and 1.4 mL acetonitrile were introduced. The mixture was diluted to volume with deionized water and the fluorescence spectra were recorded. The concentration of Hg<sup>2+</sup> was given by the linear relationship between the maximal fluorescence intensity of the solution and the concentration of Hg<sup>2+</sup>.

# Calculation of the Detection Limit and Association Constant

The detection limit was calculated by 3S/k [32], in which S is the standard deviation of five times blank measurement, k is the slope of the linear fit line in the titration experiment.



Fig. 2 Fluorescence spectra of HTUN with different ions. Solvent: MeCN/H<sub>2</sub>O (15/85, v/v), concentration: 10  $\mu$ M for HTUN, 40  $\mu$ M for various ions,  $\lambda_{ex}$ : 400 nm, slit width: 5 nm



Fig. 3 Fluorescence spectra of HTUN with different concentration of  $Hg^{2+}$ . Solvent: MeCN/H<sub>2</sub>O (15/85, v/v), concentration: 10  $\mu$ M for HTUN, from bottom to top, the equiv. of  $Hg^{2+}$ : 1.4, 0.2, 1.0, 0.4, 0.8, 1.2, 1.6, 0.6, 0, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8, 4.0, 4.2, 4.4, 4.6, 4.8,  $\lambda_{ex}$ : 400 nm, slit width: 5 nm. Inset: the relationship between the maximal fluorescence intensity F and the concentration of  $Hg^{2+}$ 



Fig. 4 Effects of coexisting ions on the fluorescence maxima of HTUN/Hg<sup>2+</sup>. Solvents: MeCN/H<sub>2</sub>O (15/85, v/v), concentration: 10  $\mu$ M for HTUN, 40  $\mu$ M for Hg<sup>2+</sup>,  $\lambda_{ex}$ : 400 nm, slit width: 5 nm, grey column: HTUN/Hg<sup>2+</sup>, slash column: HTUN/Hg<sup>2+</sup>/other ion



Fig. 5 Time response of HTUN and HTUN/Hg<sup>2+</sup>. Solvents: MeCN/H<sub>2</sub>O (15/85, v/v), concentration: 10  $\mu$ M for HTUN, 40  $\mu$ M for Hg<sup>2+</sup>



Fig. 6 Effects of pH on the fluorescence maxima of HTUN and HTUN/Hg<sup>2+</sup>. Solvents: MeCN/H<sub>2</sub>O (15/85, v/v), concentration: 10  $\mu$ M for HTUN, 40  $\mu$ M for Hg<sup>2+</sup>, pH: 2.7, 3.5, 4.3, 5.5, 6.0, 7.5, 8.5, 9.0, 10.5, 11.0 and 12.5,  $\lambda_{ex}$ : 400 nm, slit width: 5 nm

The association constant for HTUN and  $Hg^{2+}$  was obtained from nonlinear fitting of the fluorescence titration data with Benesi-Hildebrand Eq. (1) [33]. Where I<sub>0</sub> is the fluorescent intensity of HTUN at 527 nm, I and I<sub>max</sub> denote the values at a certain concentration of  $Hg^{2+}$  and at a complete-interaction concentration of  $Hg^{2+}$ . [ $Hg^{2+}$ ] is the concentration of  $Hg^{2+}$ , n is the binding stoichiometry for  $Hg^{2+}$  and HTUN, and Ks is the association constant.

$$\frac{1}{I-I_0} = \frac{1}{Ks(I_{max}-I_0)[Hg^{2+}]^n} + \frac{1}{I_{max}-I_0}$$
(1)

# **Results and Discussion**

# Response of HTUN to Hg<sup>2+</sup>

The UV-vis absorption response of HTUN (10  $\mu$ M) to various metal ions (100  $\mu$ M) was measured in MeCN/H<sub>2</sub>O (15/85, v/v) medium. The results were shown in Fig. 1, with the addition of different metal ions, the UV-vis absorption spectra of HTUN solutions exhibited some complicacy. Fe<sup>2+</sup>, Ni<sup>2+</sup>, Cu<sup>2+</sup> and Pb<sup>2+</sup> made the UV-vis absorption spectra change obviously, but these changes mostly located in the ultraviolet region. Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup> and Mg<sup>2+</sup> induced spectral changes in the visible region, however, the changes were similar and small. So

**Table 1** Recovery of  $Hg^{2+}$  in pond water and tap water (n = 3)

Sample	Hg <sup>2+</sup> added /µM	Hg <sup>2+</sup> found /µM	Recovery /%	RSD /%
Pond water 1	20	20.7	103.5	0.4
Pond water 2	30	30.9	103	0.8
Tap water 1	20	20.9	104.5	0.8
Tap water 2	30	29.9	99.7	0.8



**Fig. 7** Job's plot for Hg<sup>2+</sup> versus HTUN. Solvents: MeCN/H<sub>2</sub>O (15/ 85,v/v), total concentration ([HTUN] + [Hg<sup>2+</sup>]): 50  $\mu$ M, F and F<sub>0</sub>: the maximal fluorescence intensity with and without Hg<sup>2+</sup>, respectively,  $\lambda_{ex}$ : 400 nm, slit width: 5 nm

the UV-vis absorption spectra of HTUN were of little value to the detection of metal ions.

Then, the fluorescence response of HTUN (10  $\mu$ M) to various metal ions (40  $\mu$ M) was examined in the same medium. As could be seen in Fig. 2, the fluorescence intensity of the probe solution remained basically invariant when added Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Mn<sup>2+</sup>, Co<sup>2+</sup>, Cr<sup>3+</sup>, Fe<sup>3+</sup>, Fe<sup>2+</sup>, Ni<sup>2+</sup>, Cu<sup>2+</sup>, Cd<sup>2+</sup>, Zn<sup>2+</sup> and Pb<sup>2+</sup>. However, a significant fluorescence enhancement accompanied by a green color emerged soon after Hg<sup>2+</sup> was added into the system. The results implied the specific selectivity of the probe towards Hg<sup>2+</sup>.

# Fluorescence Titration with Hg<sup>2+</sup>

In order to investigate the possibility of HTUN used as a fluorescent probe for  $Hg^{2+}$ , titration experiment was done and the results shown in Fig. 3. It could be seen that the fluorescence intensity increased linearly with the concentration of  $Hg^{2+}$  in the range of 18–40  $\mu$ M with a correlation coefficient (R) of 0.99194 (Inset in Fig. 3), accompanied by



**Fig. 8** Fluorescence spectra of HTUN, HTUN/Hg<sup>2+</sup> and HTUN/Hg<sup>2+</sup>/ EDTA in MeCN/H<sub>2</sub>O (15/85, v/v), concentration: 10  $\mu$ M for HTUN, 40  $\mu$ M for Hg<sup>2+</sup>, 40, 80 or 120  $\mu$ M for EDTA.  $\lambda_{ex}$ : 400 nm, slit width: 5 nm





enhanced green fluorescence. The detection limit evaluated from this fluorescence titration was  $1.38 \times 10^{-7}$  mol/L. The results show that HTUN can quantitatively trace Hg<sup>2+</sup> in MeCN/H<sub>2</sub>O (15/85, v/v).

### **Anti-Jamming Performance**

In order to study the anti-interference ability of HTUN, Na<sup>+</sup>, Mg<sup>2+</sup>, Fe<sup>2+</sup>, Ca<sup>2+</sup>, Zn<sup>2+</sup>, K<sup>+</sup>, Mn<sup>2+</sup>, Cd<sup>2+</sup>, Pb<sup>2+</sup>, Co<sup>2+</sup> and Cr<sup>3+</sup> (40  $\mu$ M), Cu<sup>2+</sup>, Fe<sup>3+</sup> and Ni<sup>2+</sup> (20  $\mu$ M) were added to the MeCN/H<sub>2</sub>O (15/85, v/v) solution of HTUN (10  $\mu$ M)/Hg<sup>2+</sup> (40  $\mu$ M) individually and the fluorescence spectra were recorded. As shown in Fig. 4, no significant fluorescence variation was detected upon adding the above ions. These results indicated that HTUN exhibited high anti-jamming ability for the detection of Hg<sup>2+</sup> in MeCN/H<sub>2</sub>O (15/85, v/v).

#### **Time Dependence of the Detection**

The time response of HTUN to  $Hg^{2+}$  was investigated and the result was illustrated in Fig. 5. After the addition of  $Hg^{2+}$ , the fluorescence intensity of the solution increased rapidly, the maximal fluorescent intensity was got at about 20 min after adding  $Hg^{2+}$ , and then tended to be stable. While the fluorescence intensity of the HTUN solution without  $Hg^{2+}$  was almost unchanged during the testing time. These results showed that HTUN had a fast response to  $Hg^{2+}$ .

#### pH Dependence of the Detection

In order to study the practicability of HTUN in acid and alkali media, the effects of pH on the fluorescence intensity of HTUN and HTUN/Hg<sup>2+</sup> were investigated. As shown in Fig. 6, fluorescence intensity of the HTUN/Hg<sup>2+</sup> solution

was superior to that of the HTUN solution under the same conditions in the pH range of 4.3–9.0, so HTUN could signal  $Hg^{2+}$  over a wide pH range.

# Determination Hg<sup>2+</sup> in Spiked Environmental Water

We used HTUN to detect the concentration of  $Hg^{2+}$  in spiked tap water or pond water. The results were showed in Table 1, the found concentration of  $Hg^{2+}$  was close to that of the added  $Hg^{2+}$ , the recovery is between 99.7 and 104.5% and the relative standard deviation (RSD) of three measurements less than 0.8%. These results showed that HTUN could be used to analysis of  $Hg^{2+}$  in environmental water.

# Sensing Mechanism

To understand the sensing mechanism of HTUN for  $Hg^{2+}$ , Job's plot experiment was conducted. The result was shown in Fig. 7, the maximum of fluorescence enhancement reached when the mole fraction of  $Hg^{2+}$  was 0.67, indicating a 1:2 stoichiometric ratio of HTUN to  $Hg^{2+}$ , the binding constant evaluated by Benesi-Hildebrand method was  $1.78 \times 10^8 M^{-2}$ .

To further research the sensing mechanism, we carried out reversibility experiment. As shown in Fig. 8, HTUN solution emitted weak fluorescence in MeCN/H<sub>2</sub>O (15/85, v/v) (line 1); after the addition of Hg<sup>2+</sup>, fluorescence intensity of the solution enhanced obviously (line 5); while 40 (line 2), 80 (line 3) and 120  $\mu$ M (line 4) of EDTA half quenched the fluorescence intensity of the HTUN/Hg<sup>2+</sup> solution. These results indicated that the process of HTUN recognizing Hg<sup>2+</sup> was partially reversible.

Yan et al. [34] reported that the carbonyl oxygen and hydroxyl group of 1,8- naphthalimide could be combined with



Scheme 3 Sensing mechanism reported by Zhenyu et al.



Scheme 4 Proposed sensing mechanism of HTUN for Hg<sup>2-</sup>



Au<sup>3+</sup> to form a five-membered ring (Scheme 2a). Mohammad et al. [35] disclosed that the carbonyl oxygen of 1,8-naphthalimide could be combined with  $Ag^+$  to form a sixmembered ring (Scheme 2b). Our team [36] found that thiourea structure could combine with  $Hg^{2+}$  and then lose HgS to form a three-membered ring (Scheme 3).

Taking into account of the partial reversibility and the 1:2 stoichiometric ratio of HTUN to  $Hg^{2+}$ , as well as those reported in the literature [34–36], we speculated that one of the two  $Hg^{2+}$  ions was expectedly combined with the S atom in thiourea followed by irreversible cleavage of HgS to form a threemembered ring, while the other  $Hg^{2+}$  ion was reversibly bound by the O atoms in hydroxyl and carbonyl beyond our design, as shown in Scheme 4.

In order to verify the binding mechanism of HTUN and  $Hg^{2+}$ , HTUN/ $Hg^{2+}$  solution was analyzed by mass spectrometry (MS). As shown in Fig. 9, peaks at m/z 854.9561 and 831.3978 belonged to [HTUN +  $2Hg^{2+}+2Na^+$ ] and [HTUN +  $2Hg^{2+}+Na^+$ ] respectively, which proved the 1:2 stoichiometry ratio of HTUN and  $Hg^{2+}$ . Peaks at m/z 675.6757, 516.7509 and 475.3473 corresponded to [HTUN' +  $Hg^{2+}+H_2O$  +  $2CH_3CN$ ], [HTUN' +  $K^++Na^++2CH_3CN$ ] and [HTUN' +  $Na^++K^++CH_3CN$ ] respectively. These results supported the proposed mechanism.



Fig. 9 Mass spectrum of HTUN/Hg<sup>2+</sup>

To further validate the hypothetical mechanism, <sup>1</sup>H NMR spectra of HTUN and HTUN/Hg<sup>2+</sup> were analyzed in DMSOd<sub>6</sub>, as shown in Fig. 10. Compared with HTUN, the peak at 10.11 ppm (j) corresponding to the NH in thiourea transferred to 10.17 ppm and greatly weakened, the peak at 9.86 ppm (i) assigned to the NH connected to the naphthalene ring almost disappeared, these changes were consistent with the hypothesis that S atom combined with Hg<sup>2+</sup> and then HgS removed. Especially the emergence of a new peak at 1.65 ppm classified as peak of H in NH indicated the formation of the threemembered ring. Hydroxyl proton peak at 4.81 ppm (a) disappeared, and the proton peak (b) intensity of the ethylidene connected to hydroxyl group was significantly decreased, which suggested the complexation of O atom in hydroxyl with Hg<sup>2+</sup>. Chemical shifts of H in benzene and naphthalene ring from 6.98-8.69 ppm moved to 6.95-8.88 ppm, accompanied by a



Fig. 10  $\,^{1}\mathrm{H}$  NMR spectra of HTUN and HTUN/Hg $^{2+}$  in DMSO-d\_6 (400 MHz)

increase of peak numbers and a decrease of the peak intensity, these changes might be caused by the events of the complexing of  $Hg^{2+}$  and HTUN as well as the following reactions.

The analytical results of MS and <sup>1</sup>H NMR spectra demonstrate the recognition mechanism of HTUN to Hg<sup>2+</sup>.

# Conclusions

In conclusion, a new fluorescent probe (HTUN) was successfully synthesized based on 1,8-naphthalimide, ethanol amine, hydrazine hydrate and phenyl isothiocyanate. HTUN shows high selectivity and high sensitivity to Hg<sup>2+</sup> over other metal ions in MeCN/H<sub>2</sub>O (15/85, v/v). In the Hg<sup>2+</sup> concentration range of 18-40 µM, the fluorescence intensity of the solution increases linearly with the Hg<sup>2+</sup> concentration. The detection limit of Hg<sup>2+</sup> is  $1.38 \times 10^{-7}$  mol/L. HTUN can be used in the range pH 4.3-9.0, and has a fast response and a strong antiinterference. HTUN can effectively detect Hg<sup>2+</sup> in pond water and tap water. HTUN combines with Hg<sup>2+</sup> at a 1:2 M ratio and the binding constant is  $1.78 \times 10^8$  M<sup>-2</sup>. One of the two Hg<sup>2+</sup> ions is expectedly bound by the sulfur atom in the thiourea unit of HTUN and followed by the irreversible reaction of removing HgS, and another Hg<sup>2+</sup> is unexpectedly combined with hydroxyl and carbonyl oxygen atoms in the imide side of HTUN reversibly. In addition, the aliphatic hydroxy at imide side affords HTUN's reactivity which can be used for selfmodification or modifying other materials.

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