

## Supporting Information

### A Depropargylation-Triggered Spontaneous Cyclization Based Fluorescent “Turn-On” Chemodosimeter for the Detection of Palladium Ions and Its Application in Live-Cell Imaging

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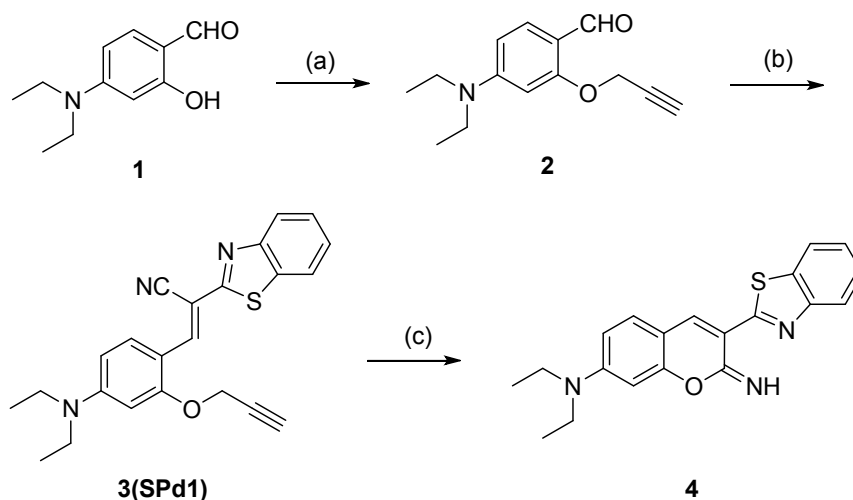
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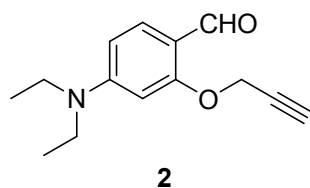
## Materials and methods

All the solvents were of analytic grade. NMR experiments were carried out on a Bruker AV-400 NMR spectrometer with chemical shifts reported in ppm (in  $\text{CDCl}_3$  or TMS as an internal standard). Mass spectra were measured on an Agilent 1290 LC-MS spectrometer. All pH measurements were made with a Sartorius basic pH-Meter PB-10. Fluorescence spectra were determined on a PerkinElmer LS55 Fluorescence spectrophotometer. Absorption spectra were collected on a Shimadzu UV 2501(PC)S UV-Visible spectrophotometer. All the cation solutions were prepared from  $\text{AlCl}_3$ ,  $\text{CdCl}_2$ ,  $\text{CrCl}_3$ ,  $\text{CuCl}_2$ ,  $\text{FeCl}_2$ ,  $\text{FeCl}_3$ ,  $\text{CsCl}$ ,  $\text{HgCl}_2$ ,  $\text{MgCl}_2$ ,  $\text{ZnCl}_2$ ,  $\text{Pb}(\text{OAc})_2$ , and  $\text{PdCl}_2$  in distilled water, with a concentration of 1 mM, respectively. The excitation and emission widths for **SPd1** were all 3/5.

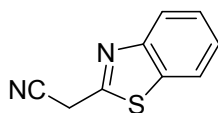
## Synthesis and characterization



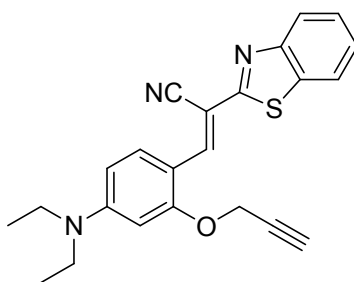
**Scheme S1** Synthesis of **SPd1**: (a) 3-bromoprop-1-yne/ $K_2CO_3$ , acetone, reflux, 12 h, 93%; (b)  $Et_3N$ , EtOH, rt, 12 h, 65%; (c)  $PdCl_2$ , THF- $H_2O$  (1:1), rt, 3 h, 72%.



**4-(diethylamino)-2-(prop-2-yn-1-yloxy)benzaldehyde (2)**: 4-(diethylamino)-2-hydroxybenzaldehyde (0.50 g, 2.6 mmol) and potassium carbonate (1.07 g, 7.8 mmol) were dissolved in acetone (8 mL) under nitrogen atmosphere, then 3-bromoprop-1-yne (0.22 mL, 2.6 mmol) was added and the solution was refluxed for 12 h until all starting material got consumed which was monitored by TLC analysis. Water (50 mL) was then added to the solution, and the reaction mixture was extracted with DCM ( $3 \times 20$  mL). The extract was washed with brine (60 mL), dried over sodium sulfate and then concentrated under vacuum. The product was purified by flash chromatography using petroleum ether/ethyl acetate (5:1, v/v) as eluant to give **2** (0.56 g, 93%) as a pale yellow gum.  $^1H$  NMR (400 MHz, Chloroform-*d*)  $\delta$  10.10 (s, 1H), 7.69 (d,  $J = 9.0$  Hz, 1H), 6.30 (dd,  $J = 9.0, 2.2$  Hz, 1H), 6.19 (d,  $J = 2.2$  Hz, 1H), 4.77 (d,  $J = 2.4$  Hz, 2H), 3.40 (q,  $J = 7.1$  Hz, 4H), 1.20 (t,  $J = 7.2$  Hz, 6H).



**2-(benzo[d]thiazol-2-yl)acetonitrile** was synthesized according to the literature.<sup>1</sup> <sup>1</sup>H NMR (400 MHz, Chloroform-*d*)  $\delta$  8.02 (d,  $J$  = 8.2 Hz, 1H), 7.86 (dd,  $J$  = 8.2, 1.3 Hz, 1H), 7.56-7.46 (m, 1H), 7.47-7.37 (m, 1H), 4.22 (s, 2H).



**3(SPd1)**

**2-(benzo[d]thiazol-2-yl)-3-(4-(diethylamino)-2-(prop-2-yn-1-yloxy)phenyl)acrylonitrile (3, SPd1):** 2-(benzo[d]thiazol-2-yl)acetonitrile (174 mg, 1.0 mmol) and **2** (231 mg, 1.0 mmol) were dissolved in ethanol (5 mL) under nitrogen atmosphere, then triethylamine (0.14 mL, 1.0 mmol) was added and the solution was stirred at room temperature for 12 h until all starting material got consumed which was monitored by TLC analysis. The precipitate was filtered and washed with cold ethanol to give **3** (250 mg, 65%) as a red solid.

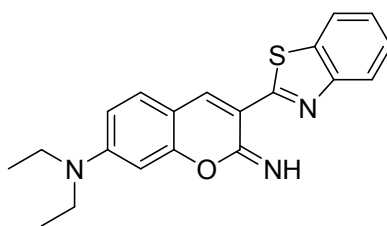
$R_f$  = 0.45 (DCM);

M.p. = 151-152 °C;

<sup>1</sup>H NMR (400 MHz, Chloroform-*d*)  $\delta$  8.52 (s, 1H), 8.44 (d,  $J$  = 9.1 Hz, 1H), 8.02 (d,  $J$  = 8.2 Hz, 1H), 7.84 (d,  $J$  = 8.0 Hz, 1H), 7.50-7.43 (m, 1H), 7.34 (t,  $J$  = 7.6 Hz, 1H), 6.41 (dd,  $J$  = 9.2, 2.3 Hz, 1H), 6.30 (d,  $J$  = 2.3 Hz, 1H), 4.84 (d,  $J$  = 2.3 Hz, 2H), 3.45 (q,  $J$  = 7.2 Hz, 4H), 1.25 (t,  $J$  = 7.1 Hz, 6H).

<sup>13</sup>C NMR (100 MHz, Chloroform-*d*)  $\delta$  165.64, 159.20, 153.86, 152.35, 140.78, 134.42, 130.50, 126.30, 124.82, 122.78, 121.25, 118.60, 109.96, 105.63, 94.63, 78.14, 56.13, 44.97, 12.70.

HR-MS (TOF-ESI): *Calcd.* for ([M])<sup>+</sup>, 388.1484; *Found*, 388.1480.



**4**

**3-(benzo[d]thiazol-2-yl)-N,N-diethyl-2-imino-2H-chromen-7-amine (4):** 3 (20 mg, 0.05 mmol) and PdCl<sub>2</sub> (40 mg, 0.23 mmol) were dissolved in THF (25 mL, containing 50% H<sub>2</sub>O) and the solution was stirred at room temperature for 3 h. The solvent was pumped off and then water (10 mL) was added. The mixture was then extracted with DCM (3 × 5 mL). The extract was washed with brine (15 mL), dried over sodium sulfate and then concentrated under vacuum. The product was purified by flash chromatography using DCM/ethyl acetate (5:1, v/v) as eluant to give **4** (13 mg, 72%) as a red solid.<sup>2</sup> <sup>1</sup>H NMR (400 MHz, Chloroform-*d*) δ 8.40 (brs, 1H), 8.01 (dd, *J* = 8.3, 3.3 Hz, 1H), 7.88 (d, *J* = 7.8 Hz, 1H), 7.45 (td, *J* = 7.8, 3.0 Hz, 1H), 7.34 (td, *J* = 7.6, 3.0 Hz, 1H), 7.24 (m, 1H), 6.42 (dd, *J* = 7.3, 4.3 Hz, 1H), 6.35 (s, 1H), 3.36 (q, *J* = 6.9 Hz, 4H), 1.18 (t, *J* = 6.9 Hz, 6H).

## Photophysical properties of SPd1

**Table S1** Photophysical properties of the probe.

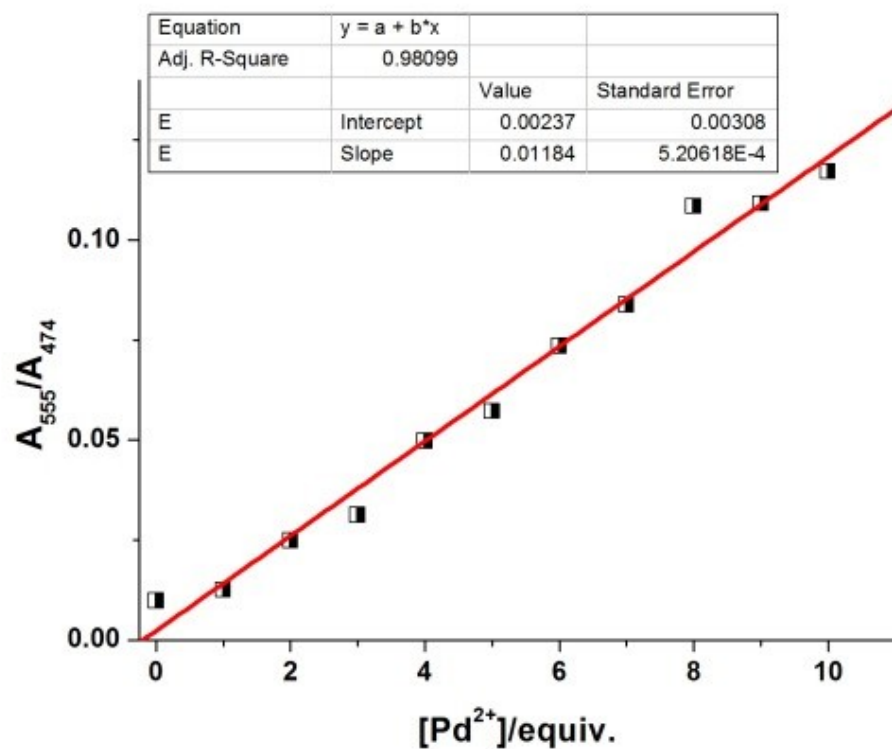
entry	$\lambda_{\text{ab}}$ (nm)	$\lambda_{\text{em}}$ (nm)	$\Phi^{\text{a}}$	$\epsilon / \text{M}^{-1} \text{cm}^{-1}$
<b>SPd1</b>	474	542	0.004	53918
<b>SPd1+Pd<sup>2+</sup></b>	474	542	0.023 <sup>b</sup>	40571

(a) The quantum yield ( $\Phi$ ) of **SPd1** and **SPd1-Pd<sup>2+</sup>** system were determined according to the literature.<sup>3</sup> (b)  $\Phi$  was determined in the present of 10.0 equiv. of Pd<sup>2+</sup>.

$$\Phi_{\text{Sample}} = \frac{\Phi_{\text{QS}} \cdot A_{\text{QS}} \cdot F_{\text{Sample}} \cdot \lambda_{\text{exQS}} \cdot \eta_{\text{Sample}}^2}{A_{\text{Sample}} \cdot F_{\text{QS}} \cdot \lambda_{\text{exSample}} \cdot \eta_{\text{QS}}^2}$$

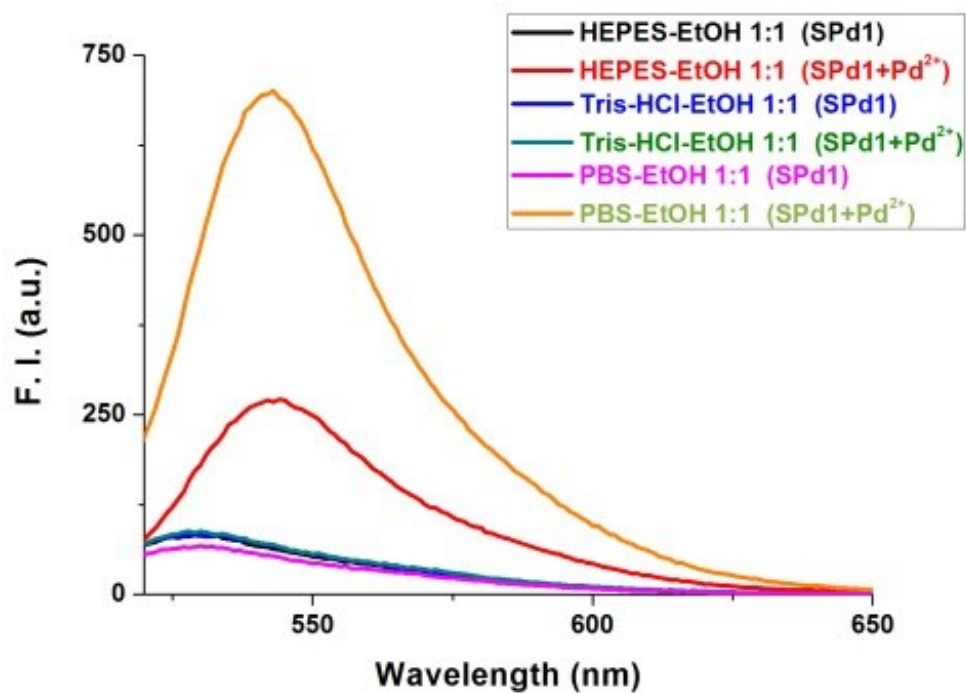
Where  $\Phi$  is quantum yield; A is absorbance at the excitation wavelength; F is integrated area under the corrected emission spectra;  $\lambda_{\text{ex}}$  is the excitation wavelength;  $\eta$  is the refractive index of the solution; the Sample and QS refer to the sample and the standard, respectively. We chose Rhodamine 6G in EtOH as standard, which has the quantum yield of 0.95.<sup>4</sup>

## Additional spectroscopic data

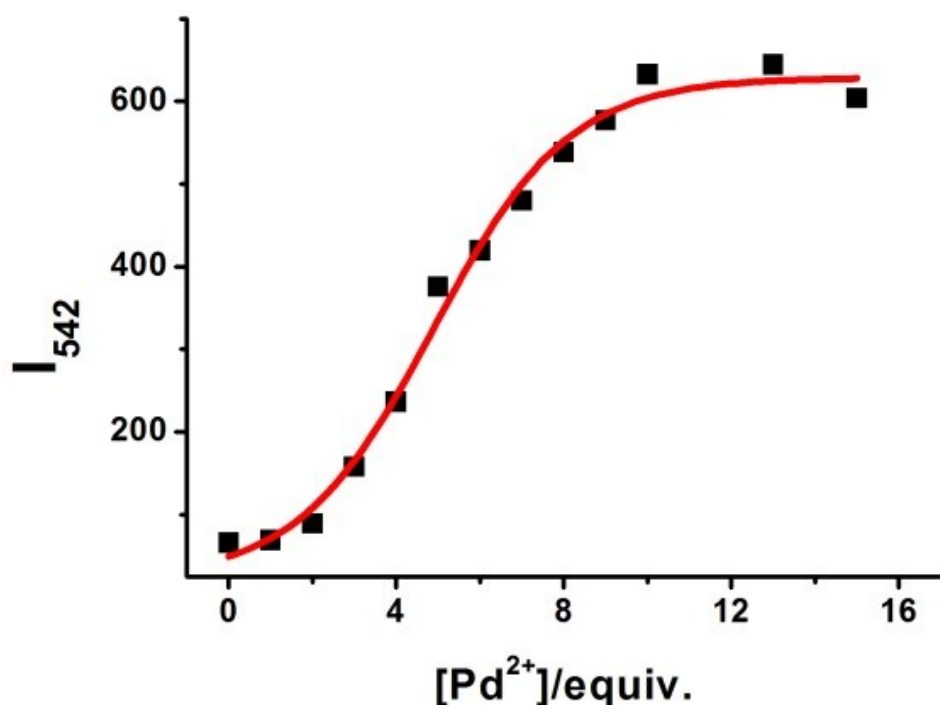


**Fig. S1** The ratio of UV-vis absorption of **SPd1** (20.0  $\mu\text{M}$ ) at 555 and 474 nm as a function of  $Pd^{2+}$  concentration (0-200.0  $\mu\text{M}$ ) in PBS buffer solution (10 mM, pH 7.4, containing 50% EtOH).

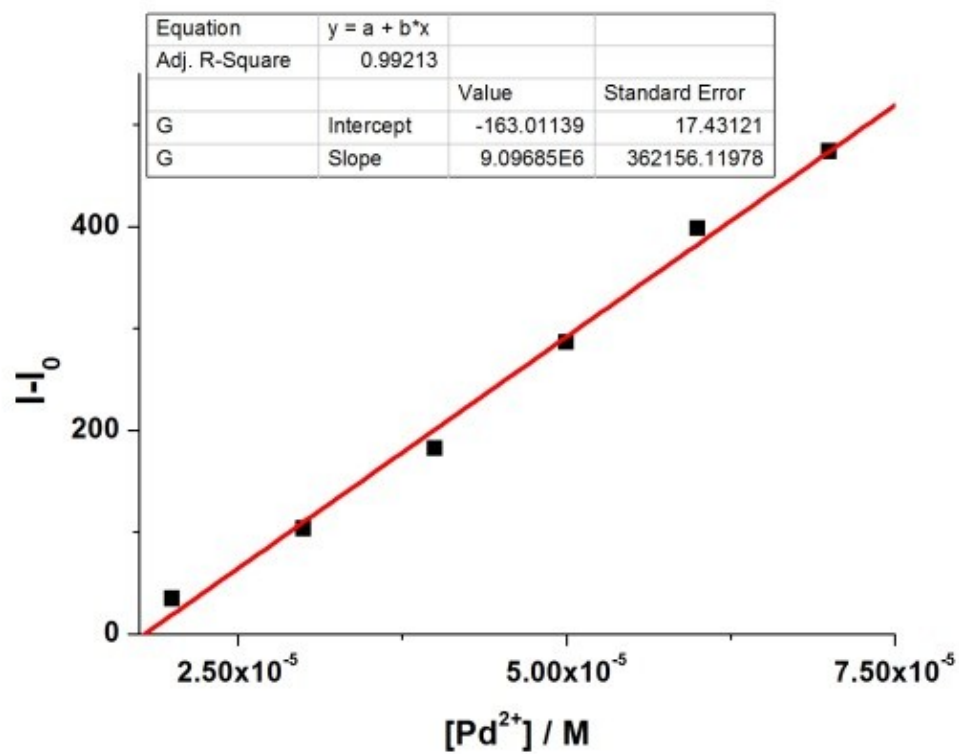




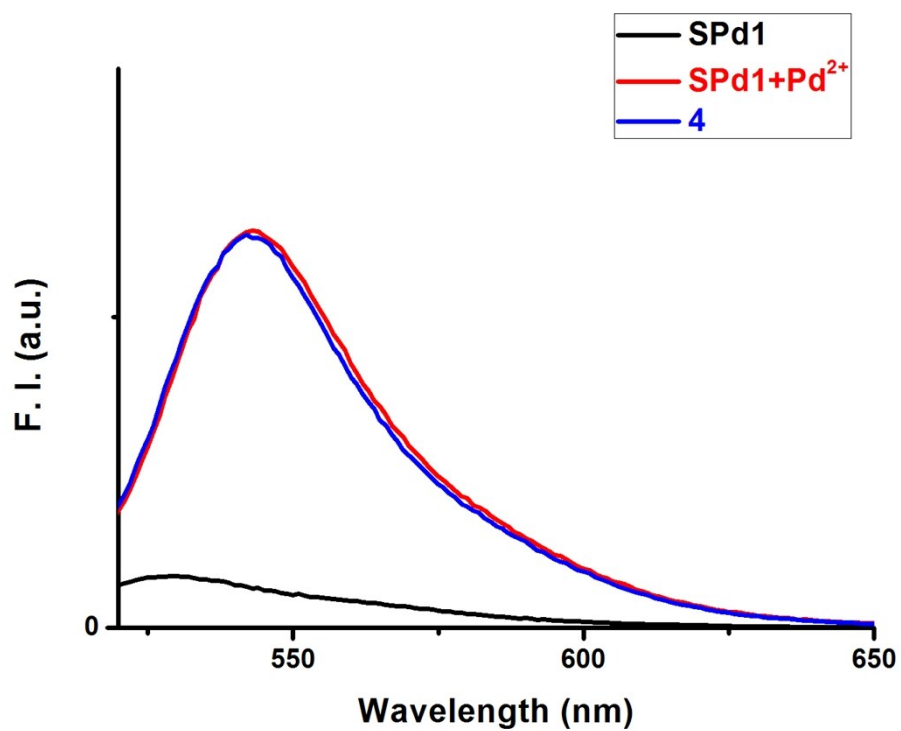
**Fig. S2** Fluorescence response of different solvents on the **SPd1** (10.0  $\mu\text{M}$ ) alone and the reaction of **SPd1** (10.0  $\mu\text{M}$ ) with  $\text{Pd}^{2+}$  (100.0  $\mu\text{M}$ ) ( $\lambda_{\text{ex}} = 510 \text{ nm}$ ).



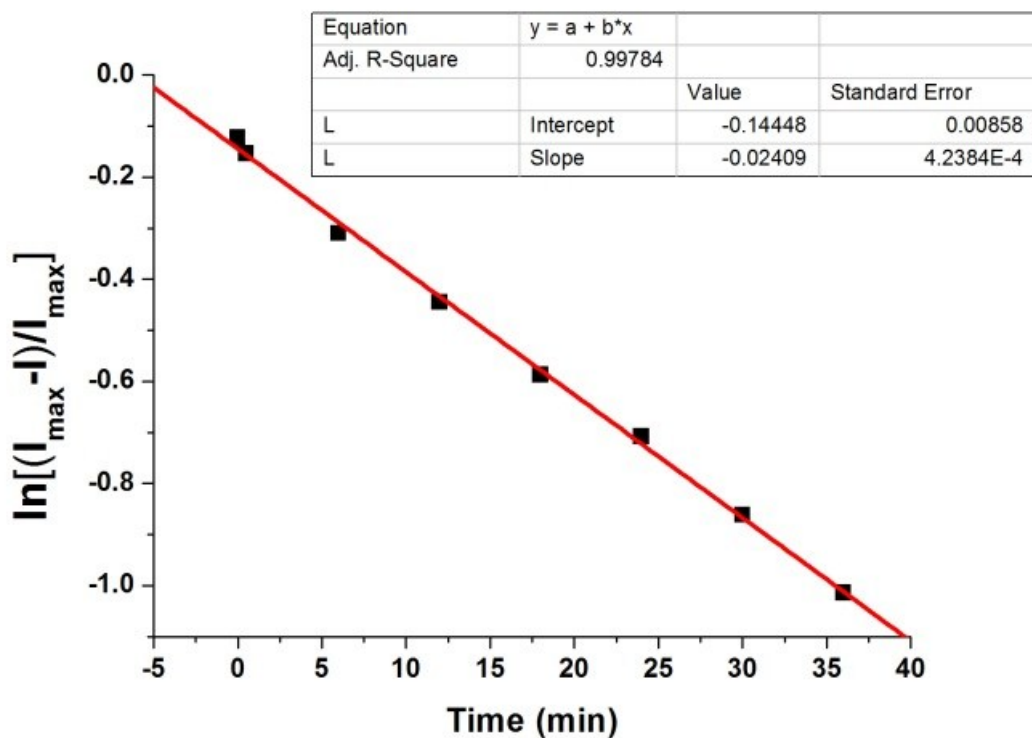
**Fig. S3** Fluorescent intensity of **SPd1** (10.0  $\mu\text{M}$ ) at 542 nm as a function of  $\text{Pd}^{2+}$  concentration (0-150.0  $\mu\text{M}$ ) in PBS buffer solution (10 mM, pH 7.4, containing 50% EtOH) ( $\lambda_{\text{ex}} = 510 \text{ nm}$ ).



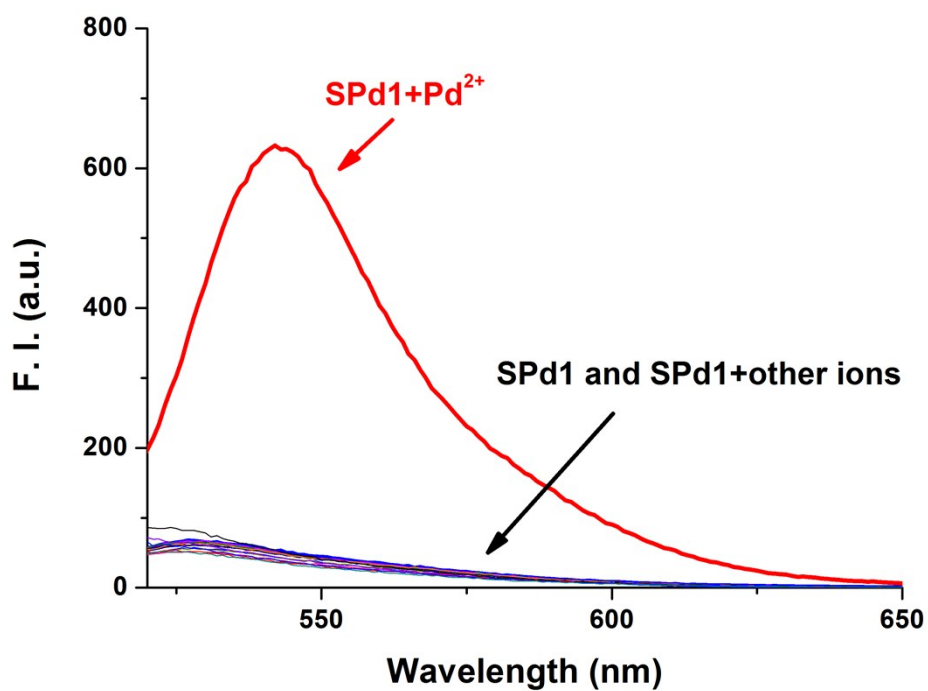
**Fig. S4** The changes of fluorescent intensity of **SPd1** ( $10.0 \mu\text{M}$ ) at  $542 \text{ nm}$  as a function of  $\text{Pd}^{2+}$  concentration ( $0\text{-}70.0 \mu\text{M}$ ) under the same condition as the  $\text{Pd}^{2+}$  titration.



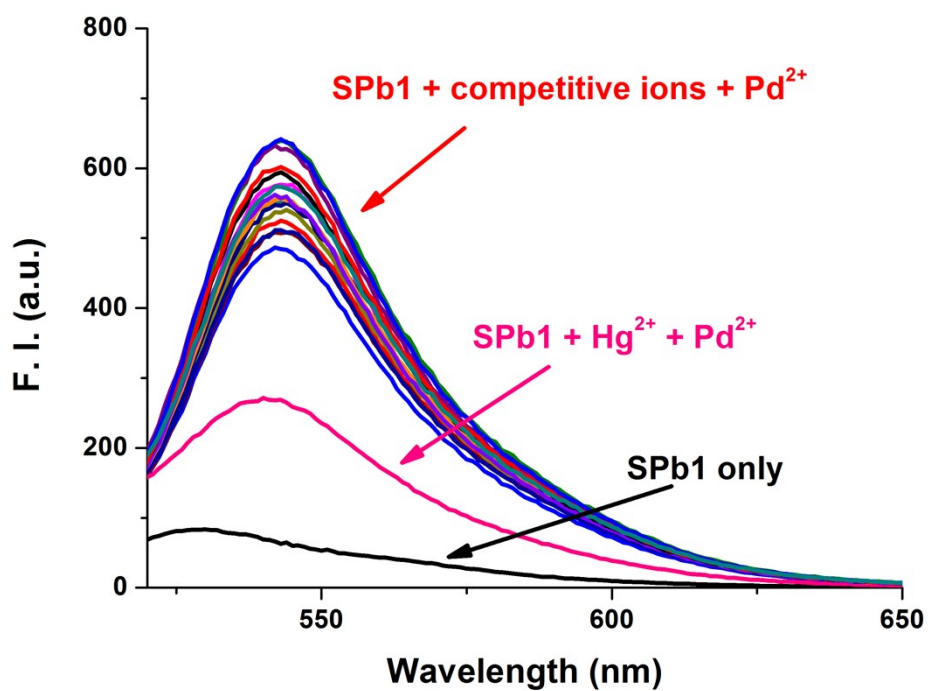
**Fig. S5** The comparison of fluorescent spectra of probe **SPd1**, **SPd1**+Pd<sup>2+</sup> system, and compound **4** in 10 mM PBS buffer solution, pH 7.4, containing 50% EtOH,  $\lambda_{\text{ex}} = 510$  nm.



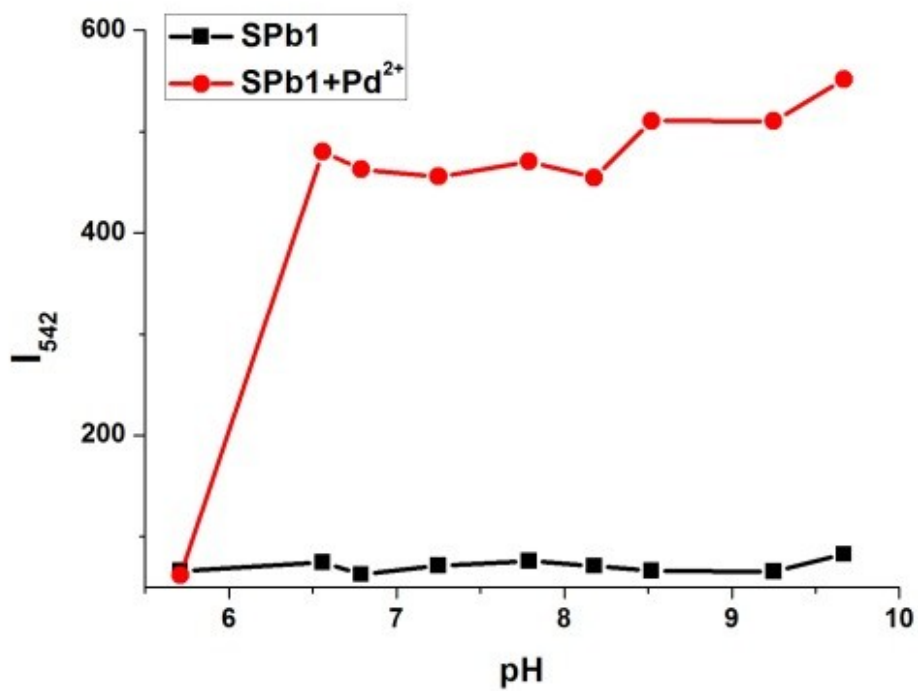
**Fig. S6** Kinetic plot of fluorescent emission intensity at 542 nm of the pseudo-first order reaction of **SPd1** (10.0  $\mu\text{M}$ ) to  $\text{Pd}^{2+}$  (100.0  $\mu\text{M}$ ), using excitation wavelength at 510 nm. The slope of the plot corresponds to observed reaction rate of  $2.4 \times 10^{-2} \text{ min}^{-1}$ .



**Fig. S7** Fluorescence responses of **SPd1** (10.0  $\mu\text{M}$ ) with 10.0 equiv. of metal ions in PBS buffer solution (10 mM, pH 7.4, containing 50% EtOH). Metal ions include  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ag}^+$ ,  $\text{Co}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Cs}^+$ ,  $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Hg}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Pb}^{2+}$ , and  $\text{Pd}^{2+}$ , ( $\lambda_{\text{ex}} = 510 \text{ nm}$ ).

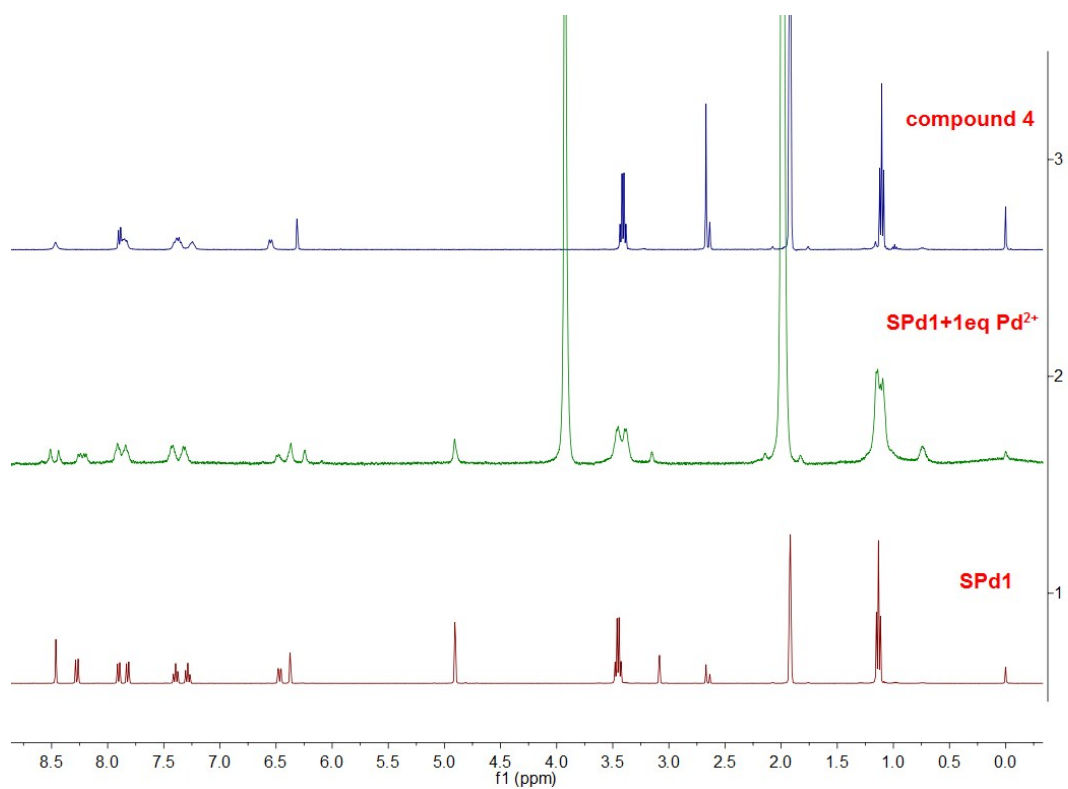


**Fig. S8** Fluorescence responses of **SPd1** ( $10.0 \mu\text{M}$ ) in the presence of 10.0 equiv. of metal ions ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ag}^+$ ,  $\text{Co}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Cs}^+$ ,  $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Hg}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Pb}^{2+}$ , and  $\text{Pd}^{2+}$ ) in PBS buffer solution (10 mM, pH 7.4, containing 50% EtOH), followed by 10.0 equiv. of  $\text{Pd}^{2+}$  ( $\lambda_{\text{ex}} = 510 \text{ nm}$ ).

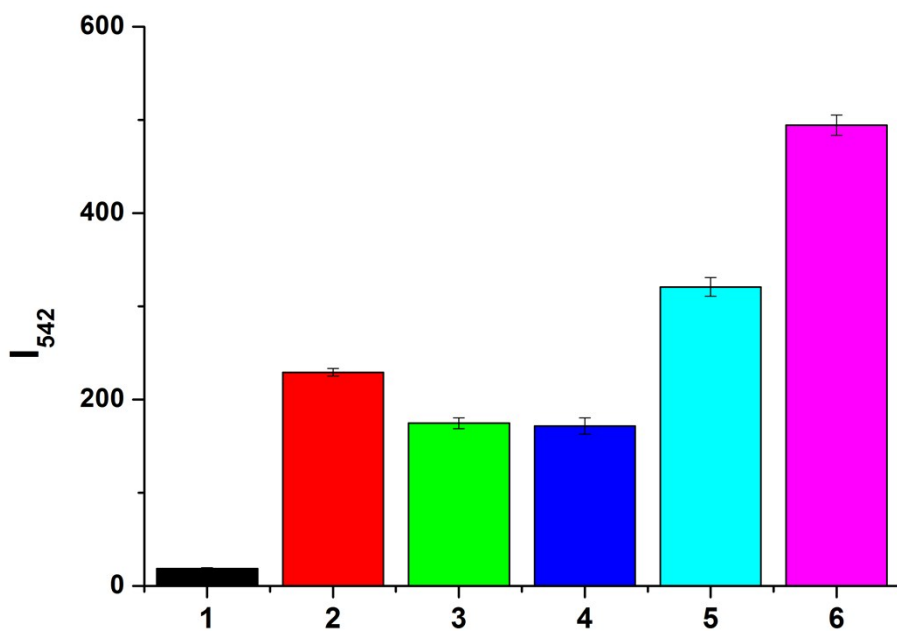


**Fig. S9** Effect of the pH on the fluorescence emission of **SPd1** (10.0  $\mu\text{M}$ ) alone and **SPd1** (10.0  $\mu\text{M}$ ) reacted with  $\text{Pd}^{2+}$  (100.0  $\mu\text{M}$ ) ( $\lambda_{\text{ex}} = 510 \text{ nm}$ ).





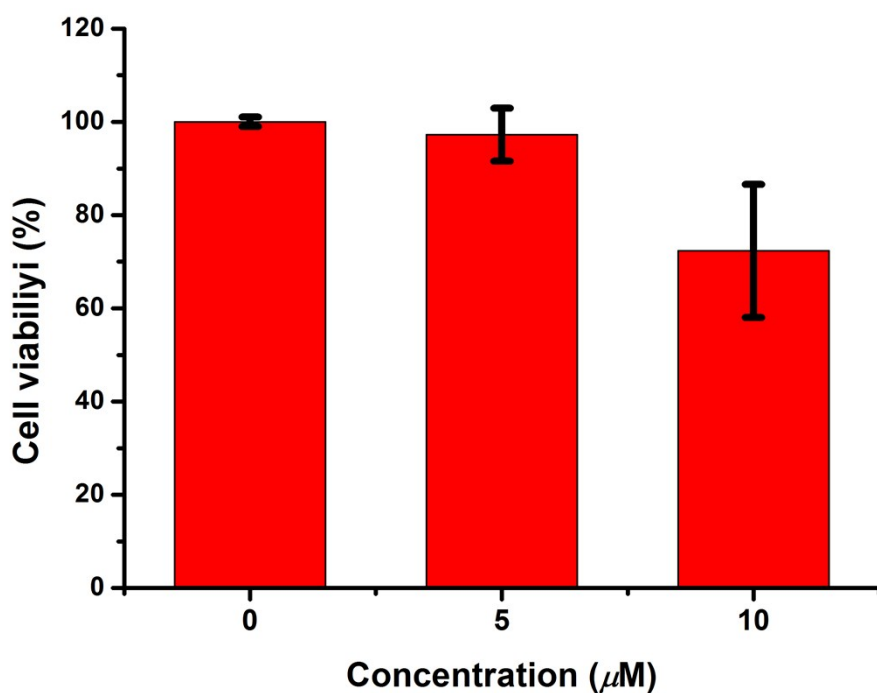
**Fig. S10** The <sup>1</sup>H NMR spectra of **SPd1**, **SPd1-Pd<sup>2+</sup>** (with 1 equiv of Pd<sup>2+</sup>, after 30 min incubation) solution, and **compound 4** (in CD<sub>3</sub>COCD<sub>3</sub>).



**Fig. S11** Fluorescence responses of **SPd1** to various Pd (including 1: probe; 2: PdCl<sub>2</sub>, 3: Pd(CF<sub>3</sub>COO)<sub>2</sub>, 4: Pd(OAc)<sub>2</sub>, 5: K<sub>2</sub>PdCl<sub>6</sub>, and 6: Pd(PPh<sub>3</sub>)<sub>4</sub>). (The addition of 3.0 equiv. of the appropriate Pd to a 10.0 μM solution of **SPd1**, in PBS buffer solution, 10 mM, pH 7.4, containing 50% EtOH,  $\lambda_{\text{ex}} = 510$  nm, slit 3/3).

### Cell lines and imaging experiments

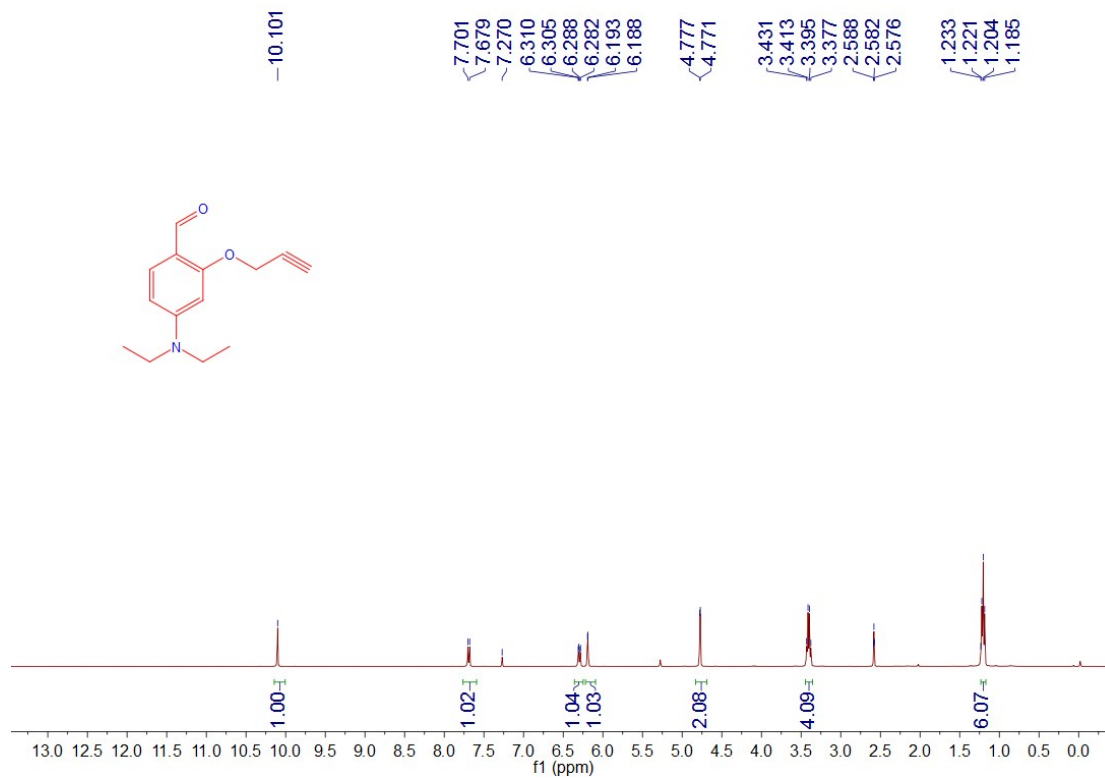
HeLa cells were cultured in DMEM (Invitrogen, Carlsbad, CA), supplemented with 10% fetal bovine serum in a humidified atmosphere of 5% CO<sub>2</sub> at 37 °C. For imaging experiments, exponentially growing cells (at a density of 20000-40000 cells per well, respectively) were seeded in 24-well plate. Cells were cultured at 37 °C in a 5% CO<sub>2</sub> atmosphere for 24 h before they were exposed to reagents. After the staining steps as described in figure captions, the images were collected upon excitation using the corresponding filters for DAPI (purple).



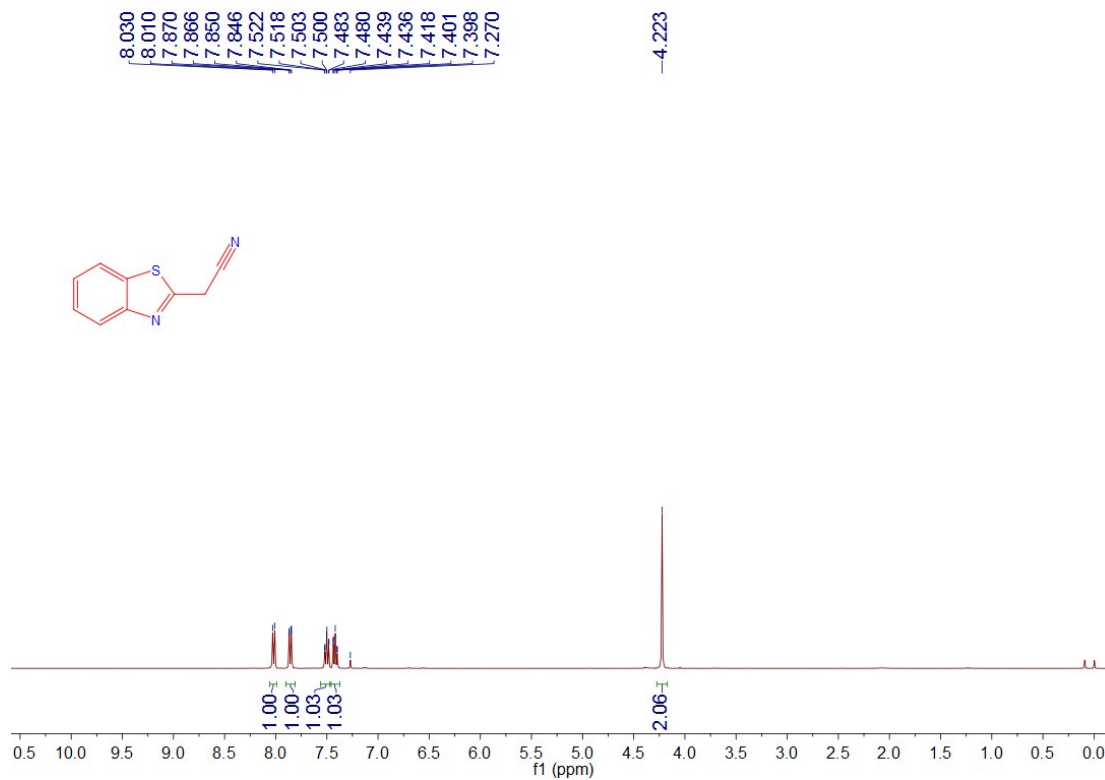
**Fig. S12** Cell viability of HeLa cells treated with different concentration of **SPd1** for different time periods. No cytotoxic effect was observed for the cells incubated with **SPd1** at 10  $\mu\text{M}$  even for 24 h.

## The characterization data of SPd1

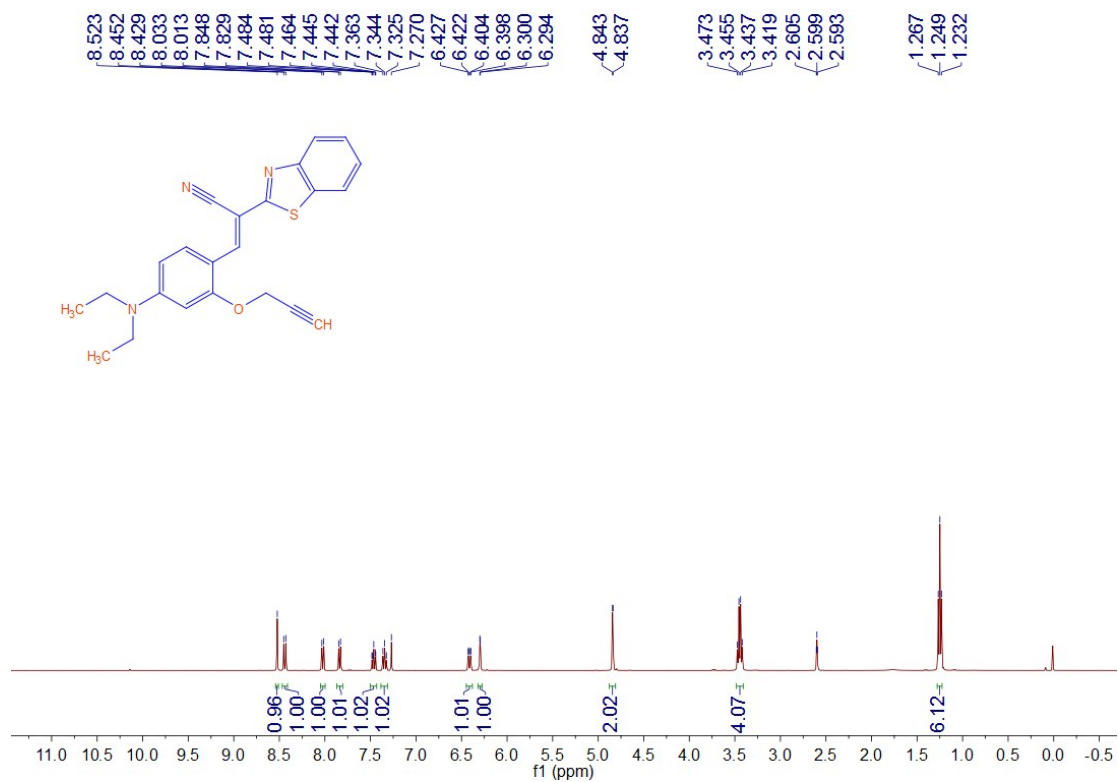
<sup>1</sup>H NMR of **2**



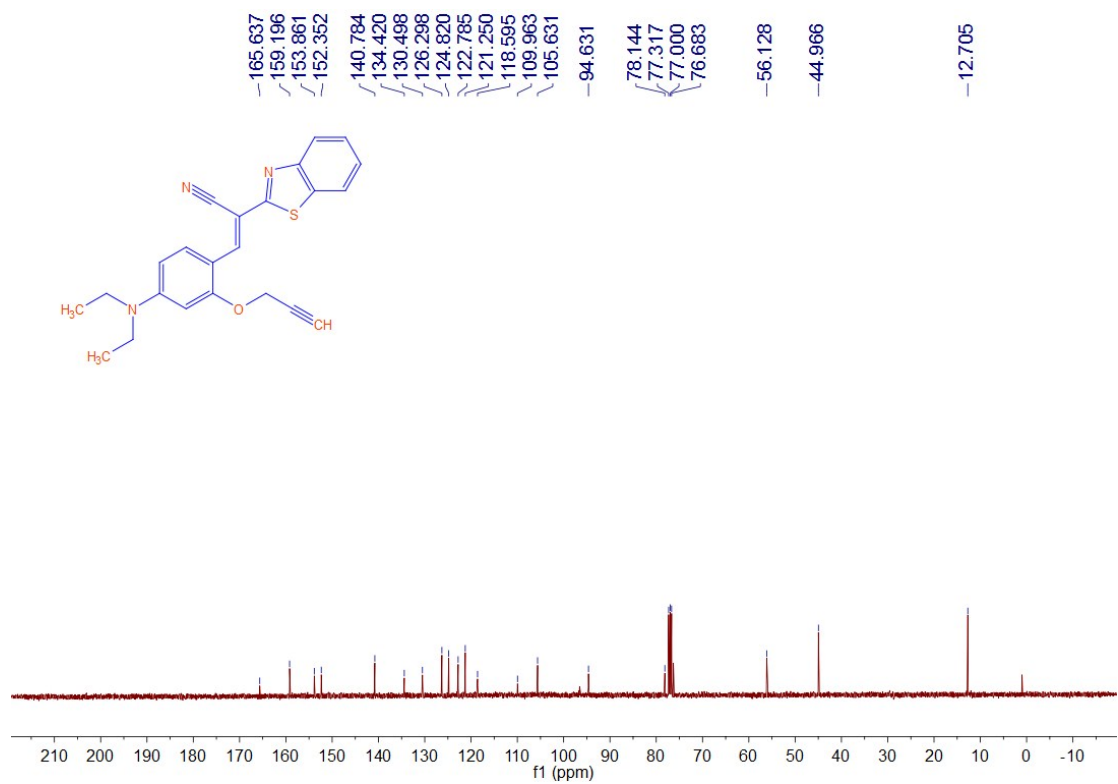
<sup>1</sup>H NMR of **2-(benzo[d]thiazol-2-yl)acetonitrile**



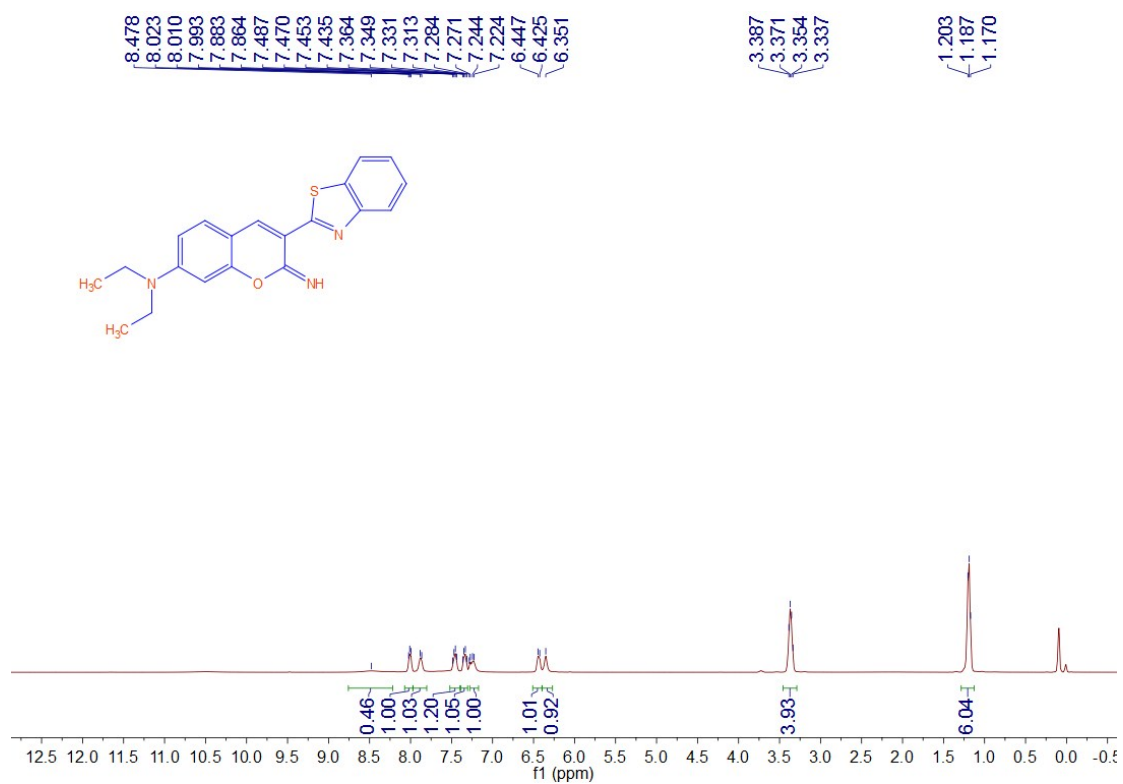
### <sup>1</sup>H NMR of 3 (SPd1)



### <sup>13</sup>C NMR of 3 (SPd1)



<sup>1</sup>H NMR of 4



## References

- 1 C. Li, S. Wang, Y. Huang, Q. Wen, L. Wang, Y. Kan, *Dalton Trans.*, 2014, **43**, 5595-5602.
- 2 K. Komatsu, Y. Urano, H. Kojima, T. Nagano, *J. Am. Chem. Soc.*, 2007, **129**, 13447-13454.
- 3 R. A. Velapoldi, and H. H. Tønnesen, *J. Fluoresc.*, 2004, **14**, 465-472.
- 4 (a) D. F. Eaton, *Pure Appl. Chem.*, 1988, **60**, 1107-1114; (b) D. Magde, R. Wong, and P. G. Seybold, *Photochem. Photobiol.*, 2002, **75**, 327-334.