Electronic Supplementary Material (ESI) for Chemical Communications

Electronic Supplementary Information for:

6-Substituted quinoline-based ratiometric two-photon fluorescent probes for biological Zn^{2+} detection

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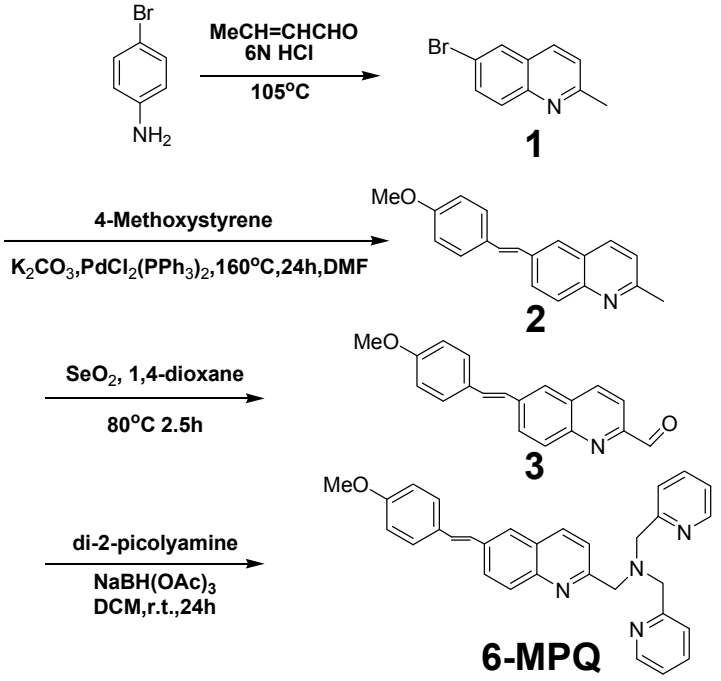
1. General Conditions

All the reagents were purchased from Alfa Aesar and used without further purification. Di-2-picolylamine was purchased from J&K Chemical Ltd. ^{1}H NMR spectra were recorded on Bruker-400 MHz spectrometers and ^{13}C NMR spectra recorded on 100 MHz spectrometers. The X-ray structure was recorded on Gemini S Ultra. UV–vis spectra were recorded on Techcomp UV 1000 spectrophotometer. Fluorescence responses were recorded on FL2500. UV–vis spectra and the fluorescence responses were carried out in MeOH : H_20=1:1, pH=7.4 buffer solution. Other experiments were carried out in the HEPES buffer (50 mM HEPES, 0.1 M $NaNO_3$, pH=7.4, I=0.1, 5% (v/v) DMSO) at the room temperature

2. Synthetic Procedures

2.1 The synthesis of 6-MPQ



6-bromo-2-methylquinoline (1)

A mixture of 4-bromobenzenamine (14.59g, 84.8mmol), HCl (6N, 60ml) was heated to 100°C, then crotonaldehyde (14.1ml) was added slowly, the result mixture was refluxed until TLC shows no raw material exist. After cooling to room temperature, 200ml H_2O was added, the mixture was extracted with acetic ether (100ml×2) to remove the un-reacted crotonaldehyde. The aqueous phase was neutralized with ammonia water and then extracted with acetic ether (50ml×2). The organic phase were dried over Na_2SO_4 and evaporated to give crude residue. The residue was recrystallized in acetic ether / petroleum ether to the 13.46g product. (60.64mmol 75.6%).

^{1}H-NMR (400MHz, $CDCl_3$, ppm): δ 2.73(3H, s), 7.29-7.31(1H, d, J=8.4Hz), 7.73-7.75(1H, d, J=9.0Hz), 7.87-7.96(3H, m). ^{13}C NMR (400MHz, $CDCl_3$, ppm): δ 25.18, 119.57, 122.91, 127.64, 129.54, 130.12, 133.03, 135.49, 146.05, 159.45

(E)-6-(4-methoxystyryl)-2-methylquinoline (2)

A mixture of 1 (6.03g, 27.15mmol), 1-methoxy-4-vinylbenzene (4.37g, 32.58mmol), $PdCl_2(PPh_3)_2$(77mg, 0.97mmol), K_2CO_3(11g, 79.7mmol), DMF (25ml) was heated at 160 ^oC for 24h. After cooling to room temperature, the mixture was filtered to remove salts, and then 100ml H_2O was added. The result mixture was extracted by DCM (50ml×3). The organic phase were combined and dried over Na_2SO_4 and evaporated to give crude product, which was recrystallized in acetic ether/petroleum ether to yield 6.77g title compound. (24.63mmol 90.72%).

^{1}H-NMR (400MHz, $CDCl_3$, ppm): δ 2.75(3H, s), 3.84(3H, s), 6.91-6.93(2H, d, J=8.6Hz), 7.08-7.21(2H, q, J=16.3Hz), 7.25-7.27(1H, d, J=8.3Hz), 7.48-7.50(2H, d, J=8.6Hz), 7.73(1H, s), 7.91-7.93(1H, d, J=8.9Hz), 8.01-8.03(2H, d, J=8.5Hz). ^{13}C-NMR (100MHz,$CDCl_3$, ppm): δ 25.11, 55.35, 114.23, 122.39, 125.19, 125.79, 126.81, 127.39, 127.87, 128.59, 129.36, 129.90, 135.26, 136.35, 147.07, 158.43, 159.54

(E)-6-(4-methoxystyryl)quinoline-2-carbaldehyde (3)

A solution of compound 2 (2.00g, 7.27mmol) in dioxane (20 mL) was heated to 60^{o}C. SeO_2 (8.00mmol, 0.889g) was added to this solution. Then the reaction temperature was increased to 80^{o}C. After 2.5h, the mixture was cooled to room temperature. Precipitates were filtered off and washed with dioxane (5mL×2). The organic phase were combined and concentrated to give a crude product. The crude material was purified by column chromatography (DCM as the flurent) to give 1.818g (6.61mmol 90.9%).

^{1}H NMR (400MHz, $CDCl_3$, ppm): δ 3.85(3H, s), 6.92-6.94(2H, d, J=8.6Hz), 7.11-7.30(2H, dd, J=16.1Hz), 7.50-7.52(2H, d, J=8.6Hz), 7.82(1H, s), 7.99-8.05(2H, dd, J=16.4Hz), 8.18-8.25(2H, dd, J=18.1Hz), 10.21(1H, s). ^{13}C NMR (100MHz, $CDCl_3$, ppm): δ 55.37, 114.33, 117.88, 125.11, 125.15, 128.19, 128.30, 129.41, 130.54, 130.64, 131.37, 136.97, 138.71, 147.44, 151.91, 159.97, 193.51

(E)-(6-(4-methoxystyryl)quinolin-2-yl)-N,N-bis(pyridin-2-ylmethyl)methanamine (6-MPQ)

To the solution of compound 3 (1.00g, 3.46 mmol) and di-2-picolylamine (0.69g, 3.46mmol) in dichloroethane (10 ml), the $NaBH(OAc)_3$ (1.10 g, 5.19 mmol) was added in portions. The result mixture was stirred at room temperature overnight. The solution was first acidified with 1 N HCl to pH 4–5, and then neutralized with 1 N NaOH to pH 7–8. The organic phase was separated, and the aqueous phase was extracted with dichloromethane (DCM, 3×15mL). The organic phases were combined and dried over Na_2SO_4. The solvent was removed by evaporation to give crude product, which was recrystallized in EtOAc/DCM to yield 1.06g target compound (2.25mmol, 65%).

^{1}H NMR (400MHz, $CDCl_3$, ppm): δ 3.82(3H, s), 3.94(4H, s), 4.04(2H, s), 6.90-6.92(2H, d, J=8.4Hz), 7.08-7.17(4H, m), 7.47-7.49(2H, d, J=8.4Hz), 7.58-7.60(2H, d, J=7.7Hz), 7.63-7.67(2H, t, J=7.5Hz), 7.71-7.74(2H, d, J=10.1Hz), 7.90-7.92(1H, d, J=8.8Hz), 8.00-8.02(1H, d, J=8.8Hz), 8.06-8.08(1H, d, J=8.4Hz), 8.53-8.54(2H, d, J=3.2Hz). ^{13}C NMR (100MHz,$CDCl_3$, ppm): δ 55.32, 60.32, 60.89, 114.23, 121.38, 122.01, 123.13, 125.14, 125.84, 127.14, 127.67, 127.85, 129.30, 129.44,129.90,135.58, 136.17, 136.37, 147.22, 149.11, 159.29, 159.56, 159.69

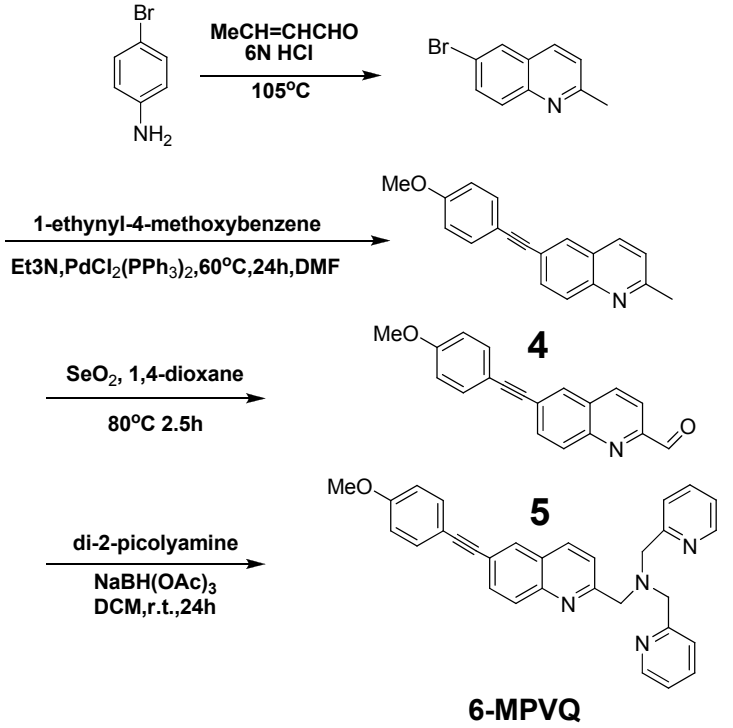
Zinc(II) complex of 6-MPQ

6-MPQ (100 mg 0.21mmol) and $Zn(ClO_4)_2/6H_2O$ (79mg 0.21mmol) were dissolved in 4 ml of methanol at room temperature. The mixtures were stirred for 5 min. Then 1.0 ml of the complex

solution was removed into a 5ml glass tube. The ethyl acetate was added into the tube slowly. After putted for several days, crystals appeared.

^{1}H NMR (400MHz, DMSO-d6, ppm): 3.81(3H, s), 4.48(4H, s), 4.78(2H, s), 7.01-7.03(2H, d, J=8.7Hz), 7.30-7.49(6H, m), 7.63-7.67(3H, t, J=7.9Hz), 7.91-7.95(2H, t, J=7.7Hz), 8.12(1H, s), 8.38-8.40(1H, d, J=9.0Hz), 8.54-8.56(1H, d, J=8.5Hz), 8.63-8.65(1H, d, J=9.0Hz), 8.73-8.74(2H, d, J=4.8Hz).

2.2 The synthesis of 6-MPVQ



6-MPVQ

6-((4-methoxyphenyl)ethynyl)-2-methylquinoline (4).

The mixture of compound 1 (4g, 18.1mmol), 1-ethynyl-4-methoxybenzene (2.87g, 21.72mmol), $PdCl_2(PPh_3)_2$ (71.8mg, 0.905mmol), Et_3N (3.66g, 36.2mmol), and DMF (20ml) was heated at 60^{o}C for 24h. After cooling to room temperature, the mixture was filtered to remove salts and followed with the addition of 100ml H_2O. The resulting mixture was extracted with EtOAc (50ml×3). The organic phase was combined and dried with Na_2SO_4, and evaporated to yield a crude product, than recrystallized in EtOAc/PE to give 7.5g of compound 2 (16.01mmol 89%). ^{1}H NMR (400MHz, $CDCl_3$, ppm): 2.75 (3H, s), 3.84 (3H,s), 6.89-6.91 (2H,d, *J*=8.36 Hz), 7.28-7.30 (1H, d, *J*=8.39 Hz), 7.50-7.52 (2H,d, *J*=8.37 Hz), 7.75-7.77 (1H, d, *J*=8.62 Hz), 7.94-7.99 (3H, m). ^{13}C NMR (100MHz, $CDCl_3$, ppm): δ 25.43, 55.28, 87.91, 90.38, 114.08, 115.14, 121.01, 122.62, 126.27, 128.68, 130.51, 132.19, 133.14, 135.80, 147.11, 159.57, 159.79

6-((4-methoxyphenyl)ethynyl)quinoline-2-carbaldehyde (5).

The solution of compound 2 (2.00g, 7.27mmol) in dioxane (20 ml) was heated to 60^{o}C. SeO_2 (8.00mmol, 0.889g) was added to this solution and the reaction temperature was increased to 80^{o}C. After 2.5h, the mixture was cooled to room temperature. Precipitates were filtered off and washed with dioxane (5mL×2). The organic phase was combined and concentrated to yield a crude product. The crude material was purified through column chromatography (DCM as the

eluent) to give 1.818g of compound 3 (6.61mmol 90.9%). ^{1}H NMR (400MHz, $CDCl_3$, ppm): 3.85 (3H, s), 6.90-6.92 (2H, d, *J*=8.65 Hz), 7.51-7.54 (2H, d, *J*=8.67 Hz), 7.87-7.89 (1H, d, *J*=8.77 Hz), 8.01-8.03 (2H, d, *J*=7.78 Hz), 8.18-8.26 (2H, dd, *J*=8.61 Hz, 22.20 Hz), 10.21 (1H, s). ^{13}C NMR (100MHz, $CDCl_3$, ppm): δ 55.36, 87.59, 92.72, 114.18, 114.61, 118.00, 124.86, 129.92, 130.35, 130.44, 133.22, 133.35, 136.93, 147.07, 152.58, 160.16, 193.42

1-(6-((4-methoxyphenyl)ethynyl)quinolin-2-yl)-N,N-bis(pyridin-2-ylmethyl)methanamine (6-MPVQ).

$NaBH(OAc)_3$ (1.10 g, 5.19 mmol) was added gradually to the solution of compound 3 (1.00g, 3.46 mmol) and di-2-picolylamine (0.69g, 3.46mmol) in DCM (10 ml). The resulting mixture was stirred at room temperature overnight. The solution was first acidified with 1 N HCl to pH 4–5, and then neutralized with 1 N NaOH to pH 7–8. The organic phase was separated, and the aqueous phase was extracted with DCM (3×15mL). The organic phases were combined and concentrated to yield a crude product, than recrystallized in EtOAc/DCM to yield 1.06g of **6-MPVQ** (2.25mmol, 65%). ^{1}H NMR (400MHz, $CDCl_3$, ppm): 3.83 (3H, s), 3.97 (4H, s), 4.07 (2H, s), 6.88-6.91 (2H, d, *J*=8.73 Hz), 7.13-7.16 (2H, m), 7.50-7.52 (2H, d, *J*=8.73 Hz), 7.58-7.60 (2H, d, *J*=7.77 Hz), 7.64-7.68 (2H, m), 7.95 (1H, s), 7.98-8.01 (1H, d, *J*=8.72 Hz), 8.06-8.08 (1H, d, *J*=8.50 Hz), 8.54-8.55 (2H, d, *J*=4.71 Hz). ^{13}C NMR (100MHz,$CDCl_3$, ppm): δ 55.32, 60.25, 60.74, 87.85, 90.59, 114.09, 115.08, 121.55, 121.62, 122.14, 126.23, 127.15, 129.08, 130.45, 132.19, 133.16, 136.07, 136.51, 146.80, 149.09, 158.87, 159.83, 160.40

Zinc(II) Complex of 6-MPVQ.

6-MPVQ (100 mg) and $Zn(ClO_4)_2$ (1 equiv) were dissolved in 4 mL of DMF at room temperature. The mixture was mixed for 10 min. Then 1.0 mL of the complex solution was transferred into another glass tube. The diethyl ether was slowly added into the tube and the mixture was allowed to stand. Crystals of zinc complexes were formed after several days. ^{1}H NMR (400MHz, $CDCl_3$, ppm): 3.83 (3H, s), 4.49 (4H, s), 4.80 (2H, s), 7.04-7.06 (2H, d, *J*=8.54 Hz), 7.44-7.45 (2H, d, *J*=7.84 Hz), 7.47-7.51 (2H, m), 7.56-7.58 (2H, d, *J*=8.53 Hz), 7.92-7.95 (2H, t, *J*=7.63 Hz), 8.15-8.17 (1H, d, *J*=8.76 Hz), 8.30 (1H, s), 8.59-8.61 (1H, d, *J*=8.51 Hz), 8.66-8.69 (1H, d, *J*=8.86 Hz), 8.71-8.72(2H, d, *J*=4.75 Hz).

3. UV–vis and fluorescence sepctra reponses of 6-MPQ/6-MPVQ to Zn^{2+}.

3.1 UV–vis spectra and fluorescence response of 6-MPQ to Zn(II)

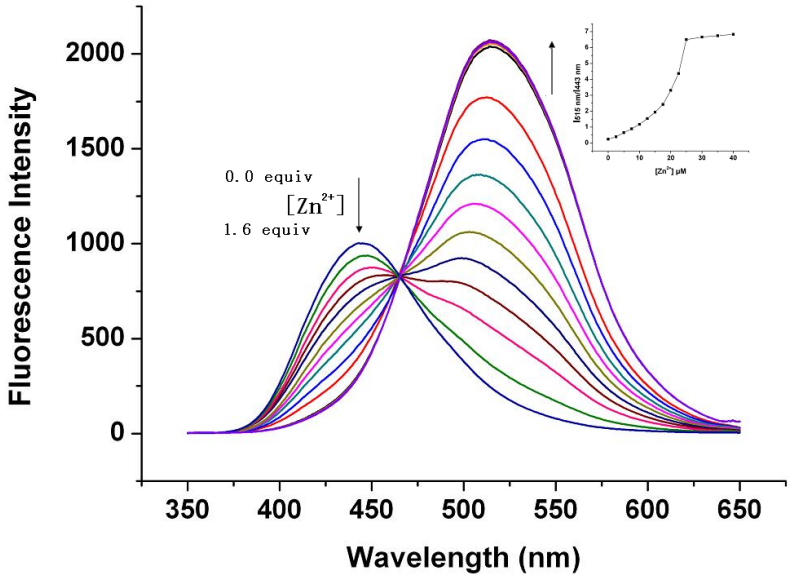


Figure S1. UV–vis spectra of 6-MPQ (25 μM) upon the titration of Zn^{2+} (0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.4 and 1.6 equiv) in the methanol-water solutions (1:1, v/v, 50mM HEPES buffer, pH=7.4).

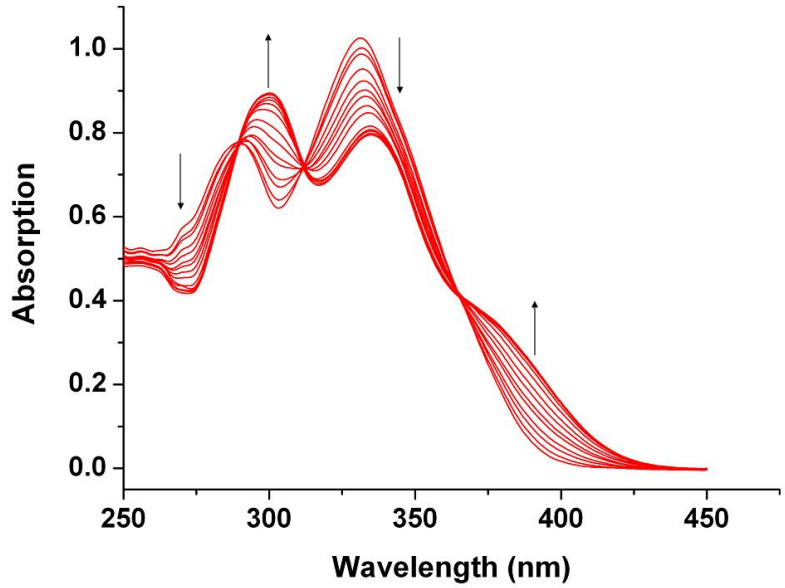


Figure S2. UV–vis spectra of 6-MPQ (25 μM) upon the titration of Zn^{2+} (0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.4 and 1.6 equiv) in the methanol-water solutions (1:1, v/v, 50mM HEPES buffer, pH=7.4).

3.2 UV–vis spectra and fluorescence response of 6-MPVQ to Zn(II)

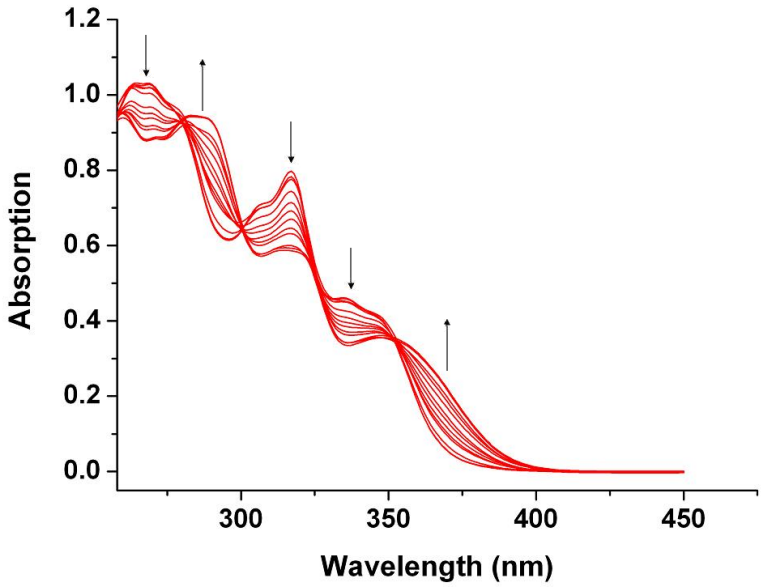


Figure S3. UV–vis spectra of 6-MPVQ (25 μM) upon the titration of Zn^{2+} (0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.4 and 1.6 equiv) in the methanol-water solutions (1:1, v/v, 50mM HEPES buffer, pH=7.4).

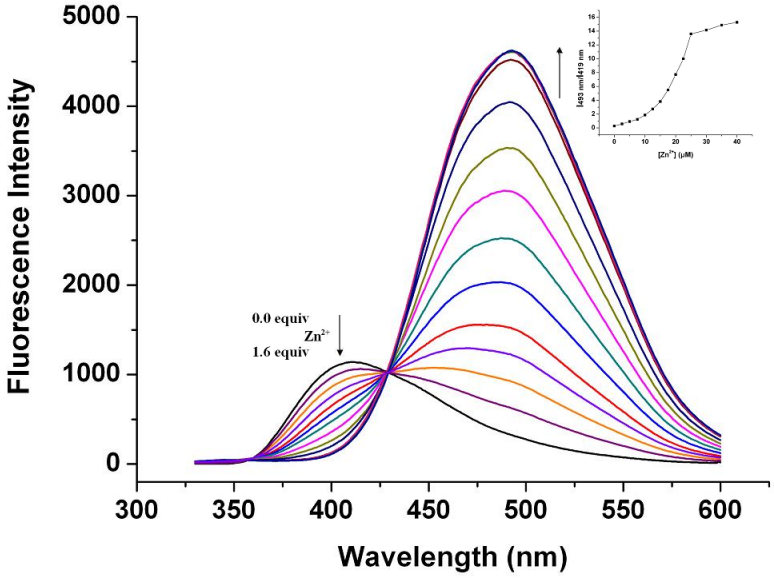


Figure S4. The fluorescence responses (λex = 320 nm) of 25 μM 6-MPVQ upon the titration of Zn^{2+} (0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.4 and 1.6 equiv) in the methanol-water solutions (1:1, v/v, 50mM HEPES buffer, pH=7.4).（Inset）Ratiometric calibration curve I_{493nm}/I_{419nm} as a function of Zn^{2+} concentration.

4. pH stability of fluorescence ratio

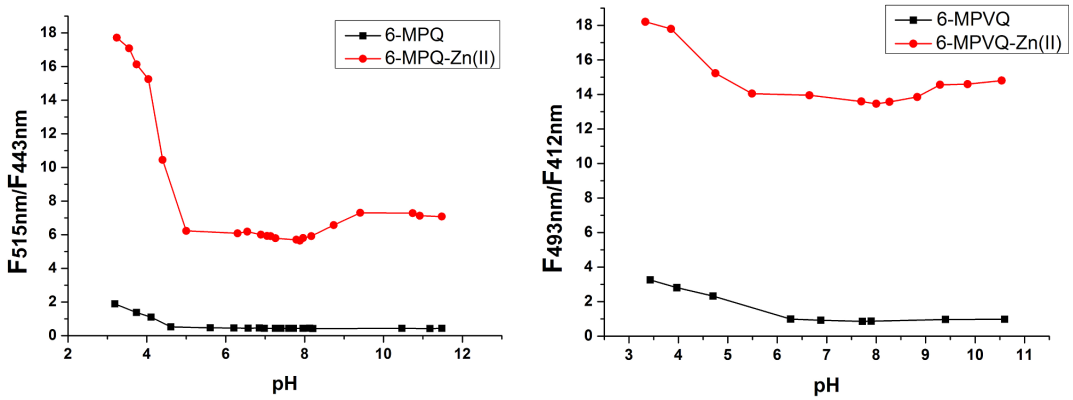


Figure S5. Fluorescence ratio 6-MPQ/6-MPVQ at various pH values in 10mM HEPES solution. F515nm/F443nm for 6-MPQ, F493nm/F412nm for 6-MPVQ.

5. Dissociation Constant Determination[S1]

Fluorescence intensities of 5μM 6-MPVQ and 6-MPQ as a function of the free Zn^{2+} concentration were measured in a HEPES buffer (50 mM HEPES, 0.1 M $NaNO_3$, pH=7.4, I=0.1, 5% (v/v) DMSO). Free Zn^{2+} concentrations were obtained by using a 10.15 mM nitrilotriacetic acid (NTA) and 0-9 mM $Zn(ClO_4)_2$. The solutions were allowed to equilibrate a 25°C for 5min after each addition. The fluorescence intensity data were fitted with 1 to calculate Kd in a 1:1 binding model.

The K_d is calculated by eq a.

$$K_d = \frac{[Zn^{2+}]_{free}(F_{max} - F)}{F - F_0} \qquad \textbf{a}$$

Where F=normalized fluorescence intensity, K_d=dissociation constant, F_{min}=fluorescence intensity of free ligand, F_{max}=fluorescence intensity of zinc-loaded sensor and $[Zn^{2+}]_{free}$ is the concentration of the free Zn^{2+}. $[Zn^{2+}]_{free}$ was calculated using the reported method.

$$\left[Zn^{2+}\right]_{free} = \frac{\left[Zn^{2+}\right]_{total}}{K(ZnL)\alpha_M \left[L\right]_{free}}$$

$$\alpha_M = 1 + 10^{pH-pKa1} + 10^{2pH-pKa1-pKa2} + 10^{3pH-pKa1-pKa2-pKa3}$$

$$\left[L\right]_{free} \approx \left[L\right]_{total} - \left[Zn^{2+}\right]_{total}$$

$[L]_{total}$ was set to 10.15mM, and $[Zn^{2+}]_{total}$ was varied from 0 to 9mM. Thus, a series of $[Zn^{2+}]_{free}$ was obtained:

$[Zn^{2+}]_{total}$ (mM)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
$[Zn^{2+}]_{free}$ (nM)	0.32	0.66	1.05	1.49	1.98	2.53	3.18	3.93	4.82
$[Zn^{2+}]_{total}$ (mM)	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
$[Zn^{2+}]_{free}$ (nM)	5.87	7.15	8.75	10.75	13.46	17.09	22.51	3.15	47.90

6. Job's plot of probes and Zn(II)[S2]

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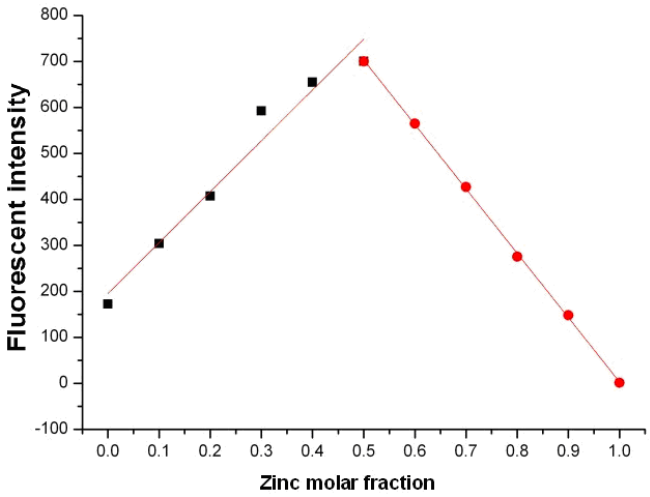


Figure S6 Job's plot of Sensor and Zn^{2+}(λex = 320 nm，λem=515nm). The total concentrations of 6-MPQ and Zn^{2+} are 10 μM. The experiments were measured at room temperature and the MeOH:H_2O=1:1, pH=7.4 solution.

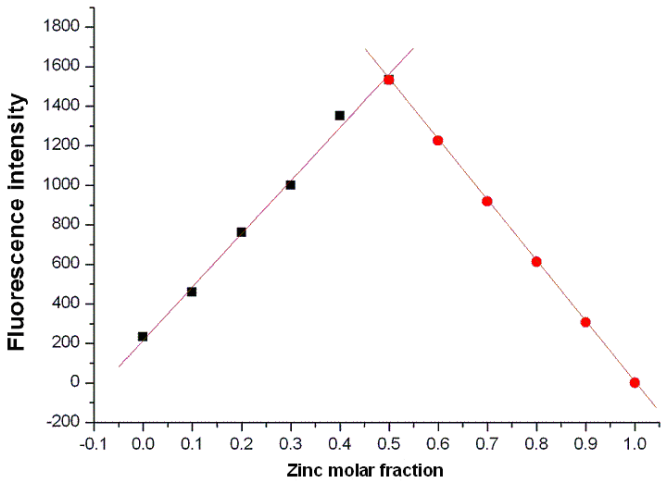


Figure S7. Job's plot of 6-MPVQ and Zn^{2+} (λ_{ex} = 320 nm，λ_{ex}=493nm). The total concentrations of 6-MPVQ and Zn^{2+} are 10 μM. The experiments were measured at room temperature and the methanol-water solutions (1:1, v/v, 50mM HEPES buffer, pH=7.4).

7. Determination of TPA cross-section (δ)

TPEF spectra were measured using femtosecond laser pulse and Ti: sapphire system(680–1080 nm, 80 MHz, 140 fs, Chameleon II) as the light source. All measurements were carried out in air at room temperature. TPA cross sections were measured using two-photon-induced fluorescence measurement technique. The TPA cross sections (δ) are determined by comparing their TPEF to that of fluorescein in different solvents, according to the following equation [S3]:

$$\delta = \delta_{ref} \frac{\Phi_{ref}}{\Phi} \frac{c_{ref}}{c} \frac{n_{ref}}{n} \frac{F}{F_{ref}}$$

Here, the subscripts *ref* stands for the reference molecule. δ is the TPA cross-section value, c is the concentration of solution, n is the refractive index of the solution, F is the TPEF integral intensities of the solution emitted at the exciting wavelength, and Φ is the fluorescence quantum yield. The δ_{ref} value of reference was taken from the literature [S4].

8. Two photon fluorescence microscopy imaging[S5]

Hela cells were cultured in Dulbecco's Modified Eagle Medium (DMEM) supplemented with 10% FCS, penicillin (100 μg/mL), and streptomycin (100 μg/mL) at 37°C in a humidified atmosphere with 5% CO_2 and 95% air. The cells were incubated with 30 μM 6-MPVQ or 6-MPQ at 37 °C under 5% CO_2 for 30 min, washed once and bathed in DMEM containing no FCS prior to imaging and/or zinc(II) addition. Zinc(II) was introduced to the cultured cells as the pyrithione salt using a zinc(II)/pyrithione ratio of 1:1. Stock solutions of zinc(II)/pyrithione in DMSO were combined and diluted with DMEM prior to addition. Cells were imaged on a confocal microscope (Zeiss LSM 510 Meta NLO). Two-photon fluorescence microscopy images of the MQ-labeled

cells were obtained by exciting the probes with a mode-locked titanium-sapphire laser source set at wavelength 800 nm.

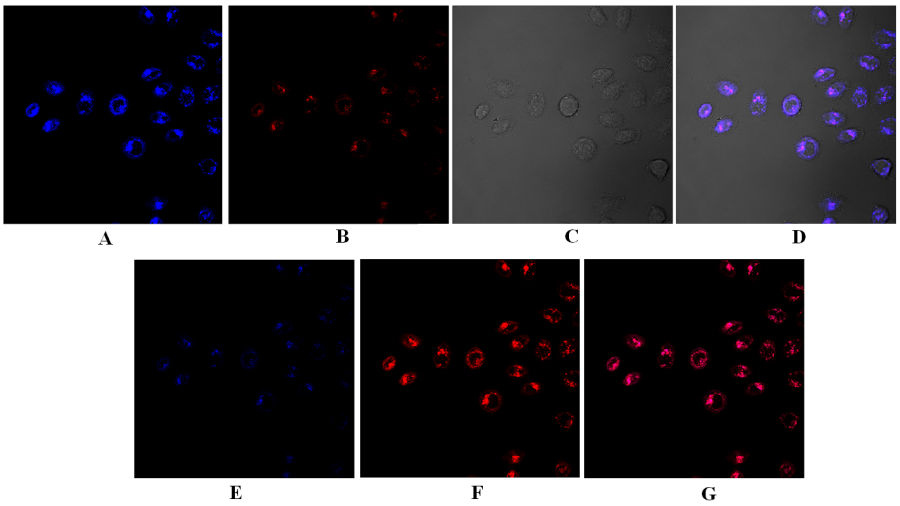


Figure S8. (A) TP image of Hela cells labled with 15μM 6-MPQ after 30min of incubation, washed three times with PBS buffer. λex = 800 nm emission wavelength form 390nm to 465 (B) Emission wavelength from 500 nm to 530 nm. (C) Bright-field image of Hela cells. (D) The overlay of figure (A) (B) and (C). (E) TP image following a 30min treatment with Zinc(II)/pyrithione(30μM, 1:1 ratio). Emission wavelength was used from 390nm to 465nm. (F) Emission wavelength from 500nm to 530nm. (G) The overlay of (E) and (F).

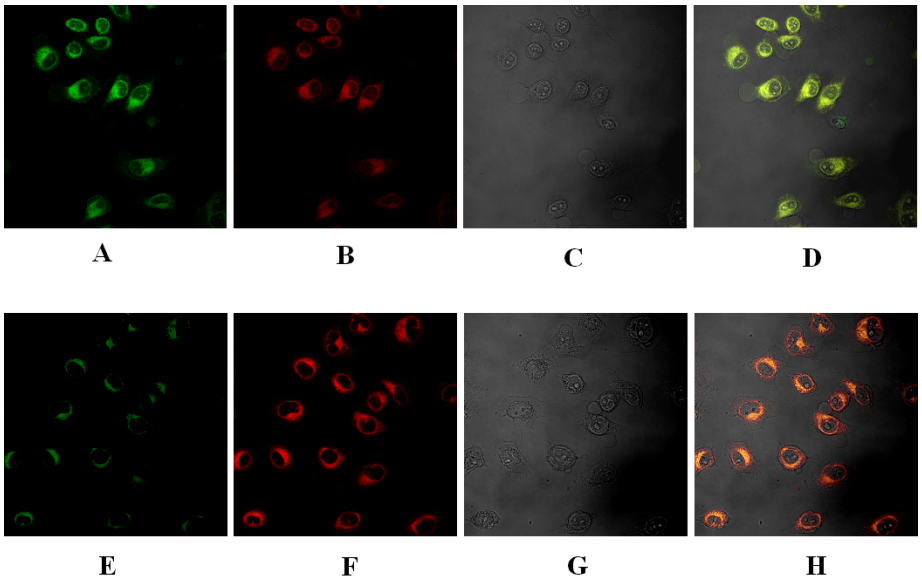


Figure S9. (A) TP image of Hela cells labled with 15μM 6-MPVQ after 30min of incubation, washed with PBS buffer. λex = 800 nm (emission wavelength from 390nm to 465nm) (B) Emission wavelength from 500nm to 550nm. (C) Bright-field image of Hela cells. (D) The overlay of (A) (B) and (C). (E) TP image following a 30min treatment with Zinc(II)/pyrithione (30μM, 1:1 ratio). Emission wavelength was used from 390nm to 465nm. (F) Emission wavelength from 500nm to 550nm. (G) Bright-field image of Hela cells. (H) The overlay of (E) (F) and (G).

9、Cytotoxicity Assays in Cells[S5]

To ascertain the cytotoxic effect of probe treatment over a 24h period, the MTT (5-dimethylthiazol-2-yl-2, 5-diphenyltetrazolium bromide) assay was performed as previously reported. HeLa cells were passed and plated to ～70% confluence in 96-well plates 24h before treatment. Prior to 6-MPQ/6-MPVQ treatment, the DMEM was removed and replaced with fresh DMEM, and aliquots of 6-MPQ/6-MPVQ stock solutions (5 mM DMSO) were added to obtain final concentrations of 10, 30, and 50 μM. The treated cells were incubated for 24 h at 37 ^{o}C and under 5% CO_2. Subsequently, the cells were treated with 5 mg/mL MTT (40 μL /well) and incubated for an additional 4 h (37^{o}C, 5% CO2). Then the cells were dissolved in DMSO (150 μL/well), and the absorbance at 570 nm was recorded. The cell viability (%) was calculated according to the following Equation: Cell viability%=OD570(sample)/OD570(control)×100, where OD570 (sample) represents the optical density of the wells treated with various concentration of 6-MPQ and OD570(control) represents that of the wells treated with DMEM+10% FCS. percent cell survival values are relative to untreated control cells.

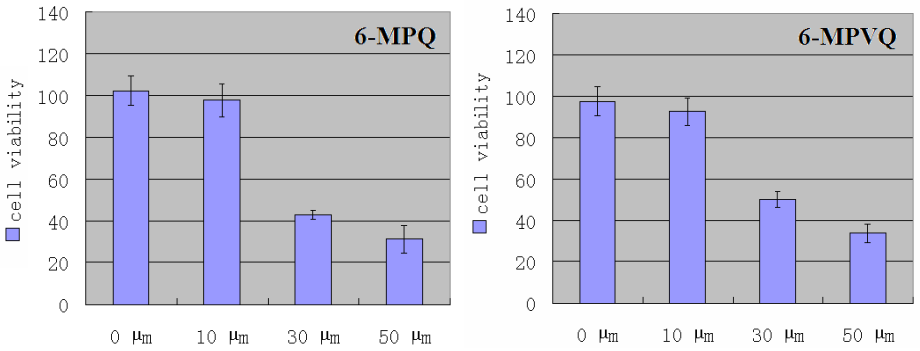


Figure S10. Cell viability was quantified by the MTT assay (mean ± SD).

S1 S. Maruyama, K. Kikuchi, T. Hirano, Y. Urano, and T. Nagano, *J. Am. Chem. Soc*., 2002, **124**, 10650

S2 L, Xue, C. Liu and H, Jiang, *Chem. Commun.*, 2009, 1061.

S3 M. A. Albota, C. Xu and W. W. Webb, *Applied Optics.,* 1998, **37**, 7352.

S4 O. Varnavski, T. Goodson, L. Sukhomlinova and R. Twieg, *J. Phys. Chem. B.*, 2004, **108**, 10484.

S5 X. Y. Chen, J. Shi, Y. M. Li, F. L. Wang, X. Wu, Q. X. Guo and L. Liu, *Org. Lett.*, 2009, **11**, 4426.

10. X-ray Crystallography

10.1 X-ray Crystallography of 6-MPVQ-Zn(II)

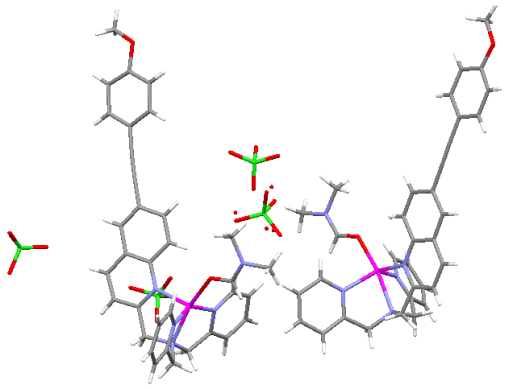


Figure S11. Crystal structures of zinc complex with 6-MPQ

Table S1 Crystallographic parameters for complex of zinc complex of 6-MPQ

Compound reference	pt101112
Chemical formula	$C_{34}H_{33}Cl_2N_5O_{10}Zn$
Formula Mass	807.92
Crystal system	Triclinic
a/Å	12.9920(5)
b/Å	14.2885(5)
c/Å	20.9414(7)
α/°	100.626(3)
β/°	106.166(3)
γ/°	91.344(3)
Unit cell volume/Å^3	3658.2(2)
Temperature/K	291(2)
Space group	$P\bar{1}$
No. of formula units per unit cell, *Z*	4
Radiation type	CuKα
Absorption coefficient, μ/mm^{-1}	2.816
No. of reflections measured	37638
No. of independent reflections	11646
R_{int}	0.0372
Final R_1 values ($I > 2\sigma(I)$)	0.0750
Final $wR(F^2)$ values ($I > 2\sigma(I)$)	0.1989
Final R_1 values (all data)	0.0901
Final $wR(F^2)$ values (all data)	0.2141
Goodness of fit on F^2	1.078

10.2 X-ray Crystallography of 6-MPQ-Zn(II)

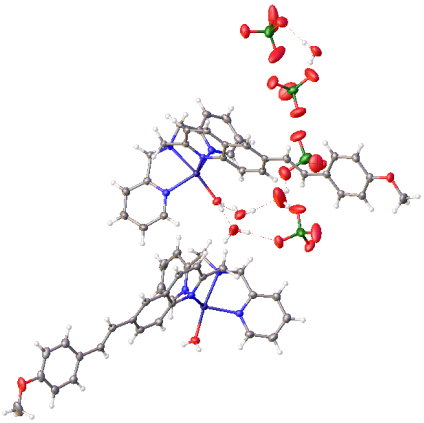
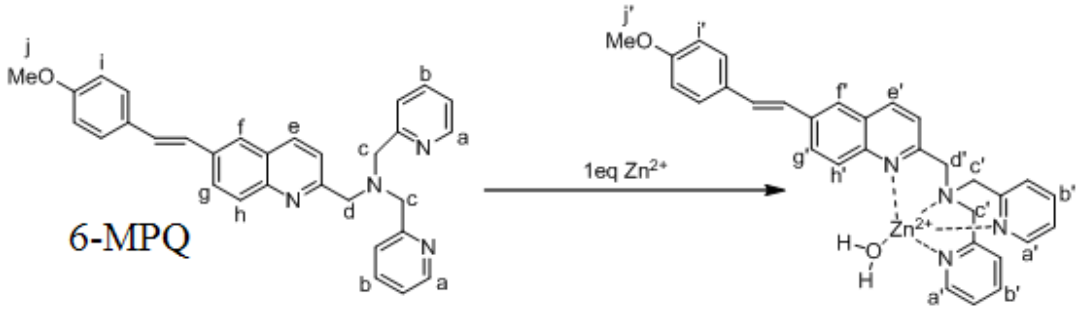


Figure S12. Crystal structures of zinc complex with 6-MPQ

Table S2. Crystallographic parameters for complex of zinc complex of 6-MPQ

Compound reference	pt100621-100k
Chemical formula	$C_{62}H_{68}N_8Zn_2Cl_4O_{24}$
Formula Mass	790.89
Crystal system	Monoclinic
a/Å	22.391(5)
b/Å	14.404(5)
c/Å	22.720(5)
α/°	90.000(5)
β/°	110.108(5)
γ/°	90.000(5)
Unit cell volume/Å^3	6881(3)
Temperature/K	100(2)
Space group	$P2_1/n$
Radiation type	CuKα
No. of reflections measured	27891
No. of independent reflections	10849[R(int) = 0.0228]
R_{int}	0.0372
Final R_1 values ($I > 2\sigma(I)$)	0.0468
Final $wR(F^2)$ values ($I > 2\sigma(I)$)	0.1409
Final R_1 values (all data)	0.0528
Final $wR(F^2)$ values (all data)	0.1456
Goodness of fit on F^2	1.066

11 NMR Spectra of 6-MPVQ/ 6-MPQ and intermediates



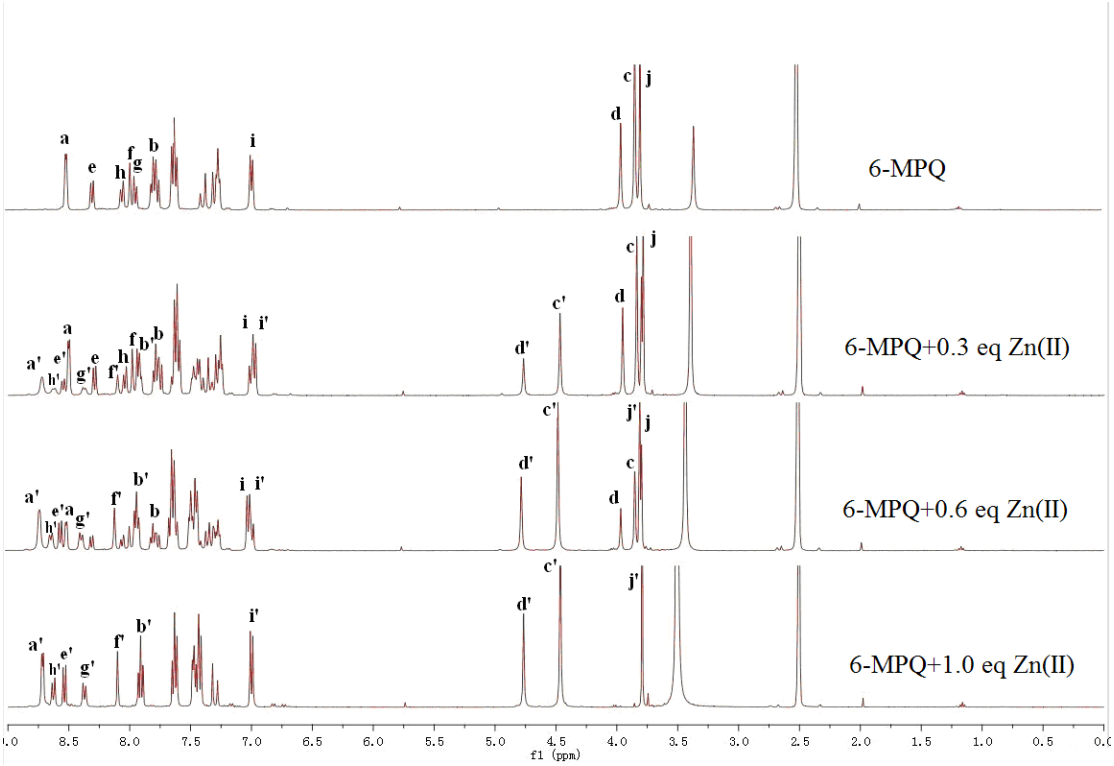
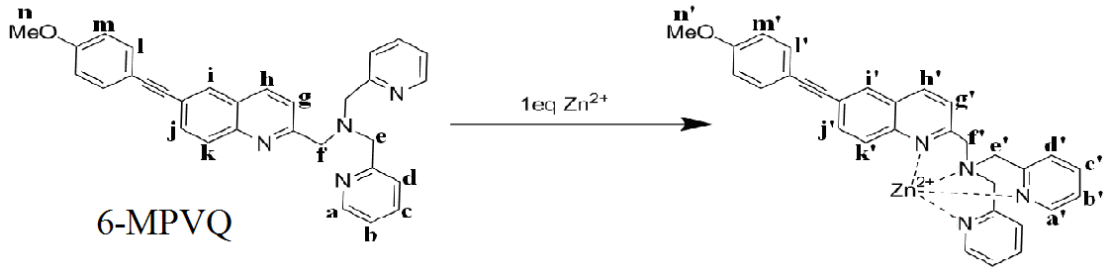


Figure S13. [1]H-NMR spectra of **6-MPQ** with 0, 0.3, 0.6, 1.0eq Zn in DMSO-d6.

Table S3. [1]H-NMR of the free 6-MPQ, and 6-MPQ-Zn(II)

protons	signals for free 6-MPQ (ppm)	protons	signals for 6-MPQ-Zn^{2+} (ppm)
Ha	8.51-8.52(2H,d,J=4.0Hz)	Ha'	8.73-8.74(2H,d,J=4.83Hz)
Hb	7.75-7.81(3H,dd,8.37Hz,17.49Hz)	Hb'	7.91-7.95(2H,t,J=7.69Hz)
Hc	3.84(4H,s)	Hc'	4.48(4H,s)
Hd	3.96(2H,s)	Hd'	4.78(2H,s)
He	8.28-8.31(1H,d,J=8.49Hz)	He'	8.54-8.56(1H,d,J=8.51Hz)
Hf	7.98(1H,s)	Hf'	8.12(1H,s)
Hg	7.93-7.95(1H,d,J=8.80Hz)	Hg'	8.38-8.40(1H,d,J=9.01Hz)
Hh	8.04-8.06(1H,d,J=8.82Hz)	Hh'	8.63-8.65(1H,d,J=8.96Hz)
Hi	6.98-6.70(2H,d,J=8.39Hz)	Hi'	7.01-7.03(2H,d,J=8.66Hz)
Hj	3.80(3H,s)	Hj'	3.81(3H,s)



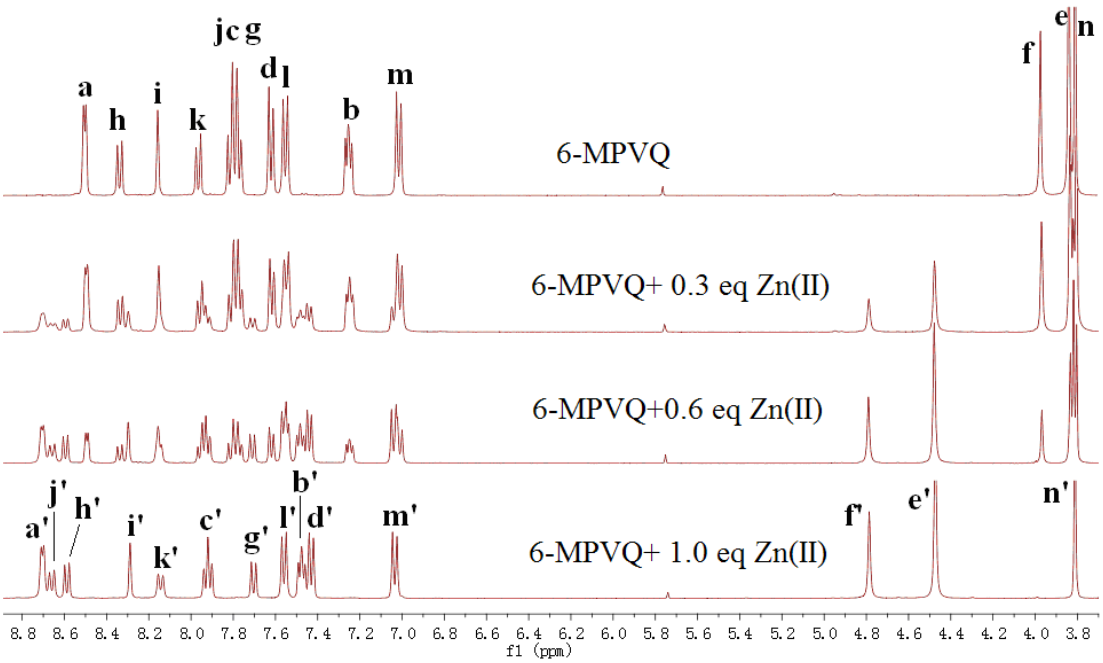
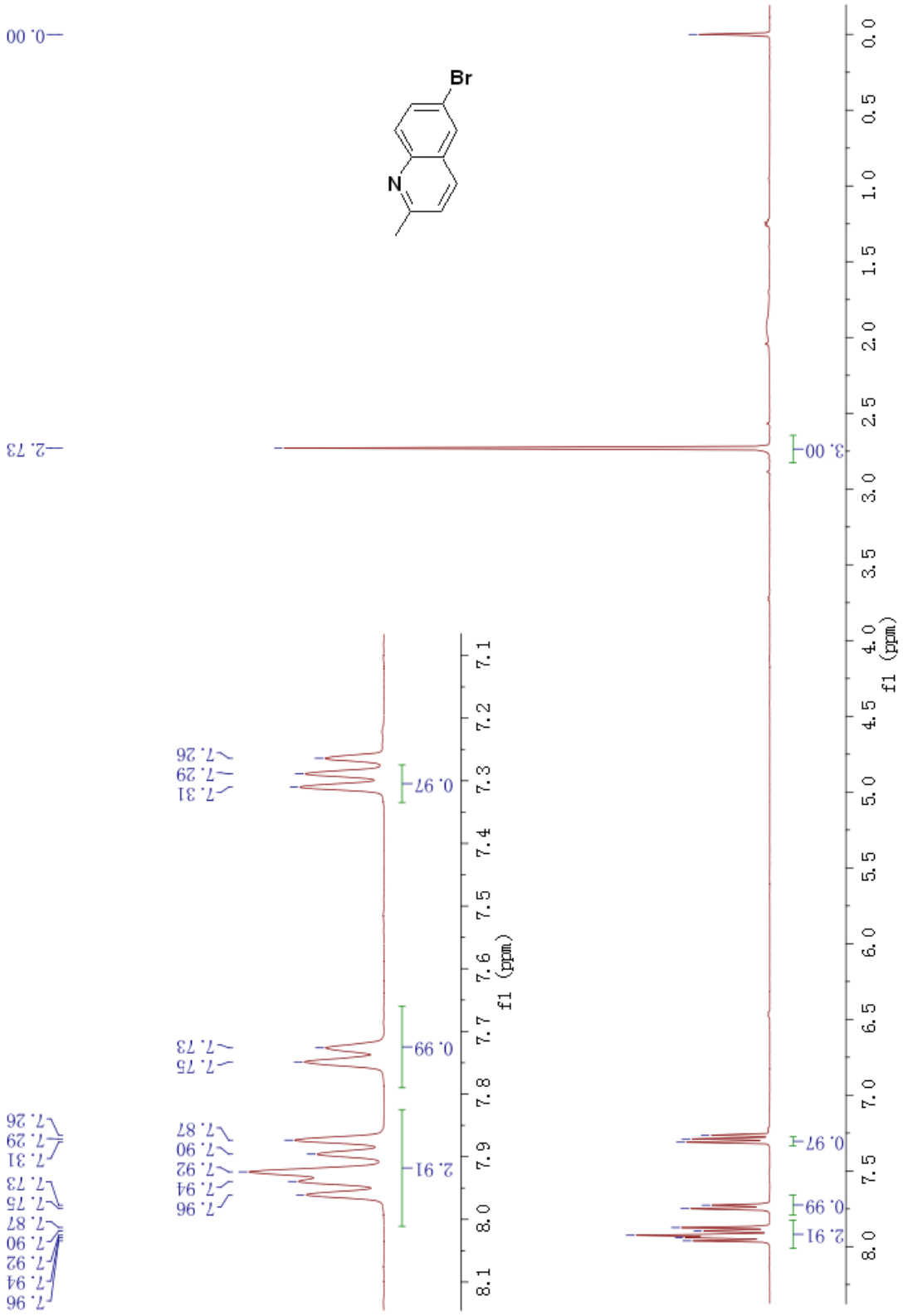
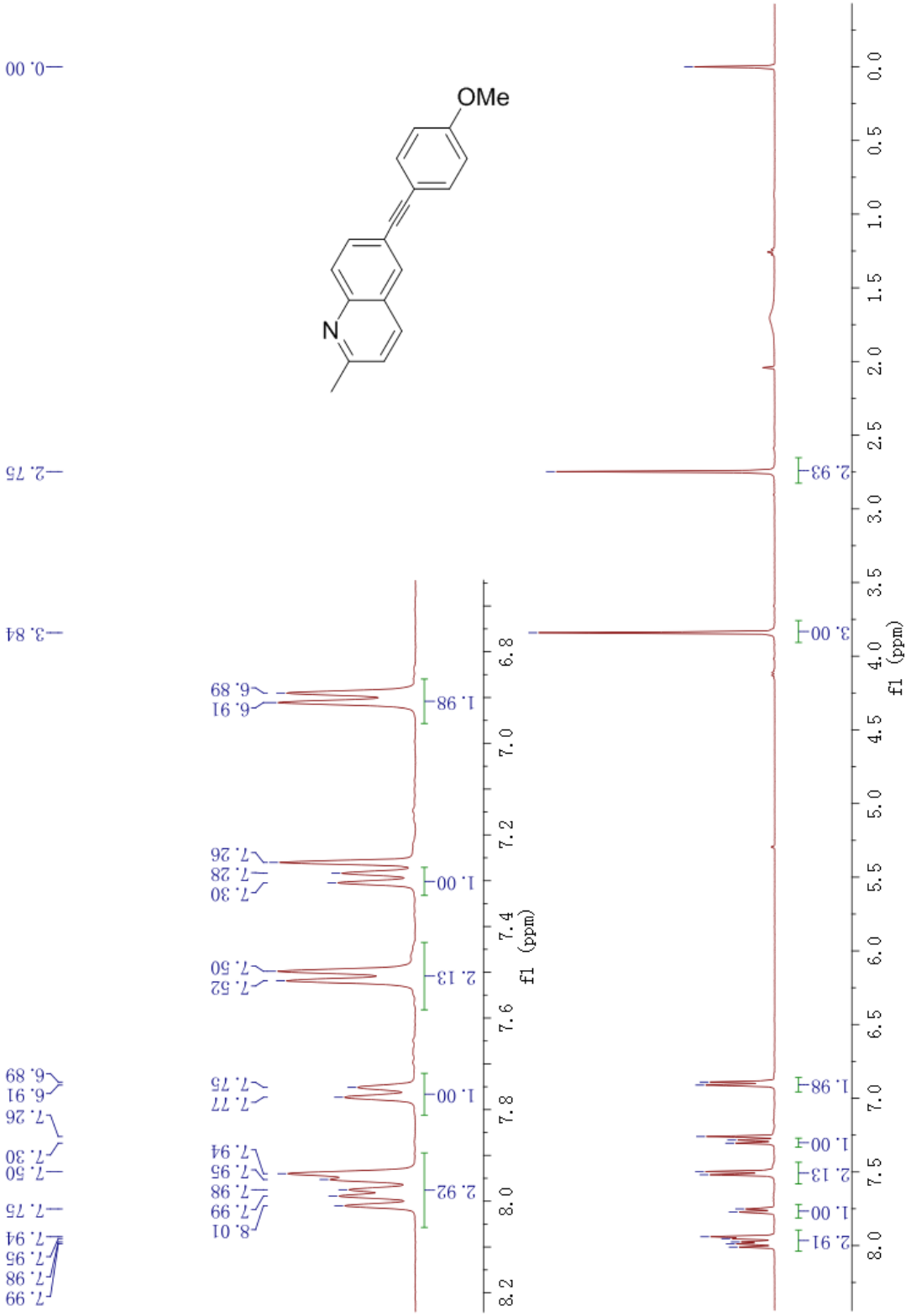


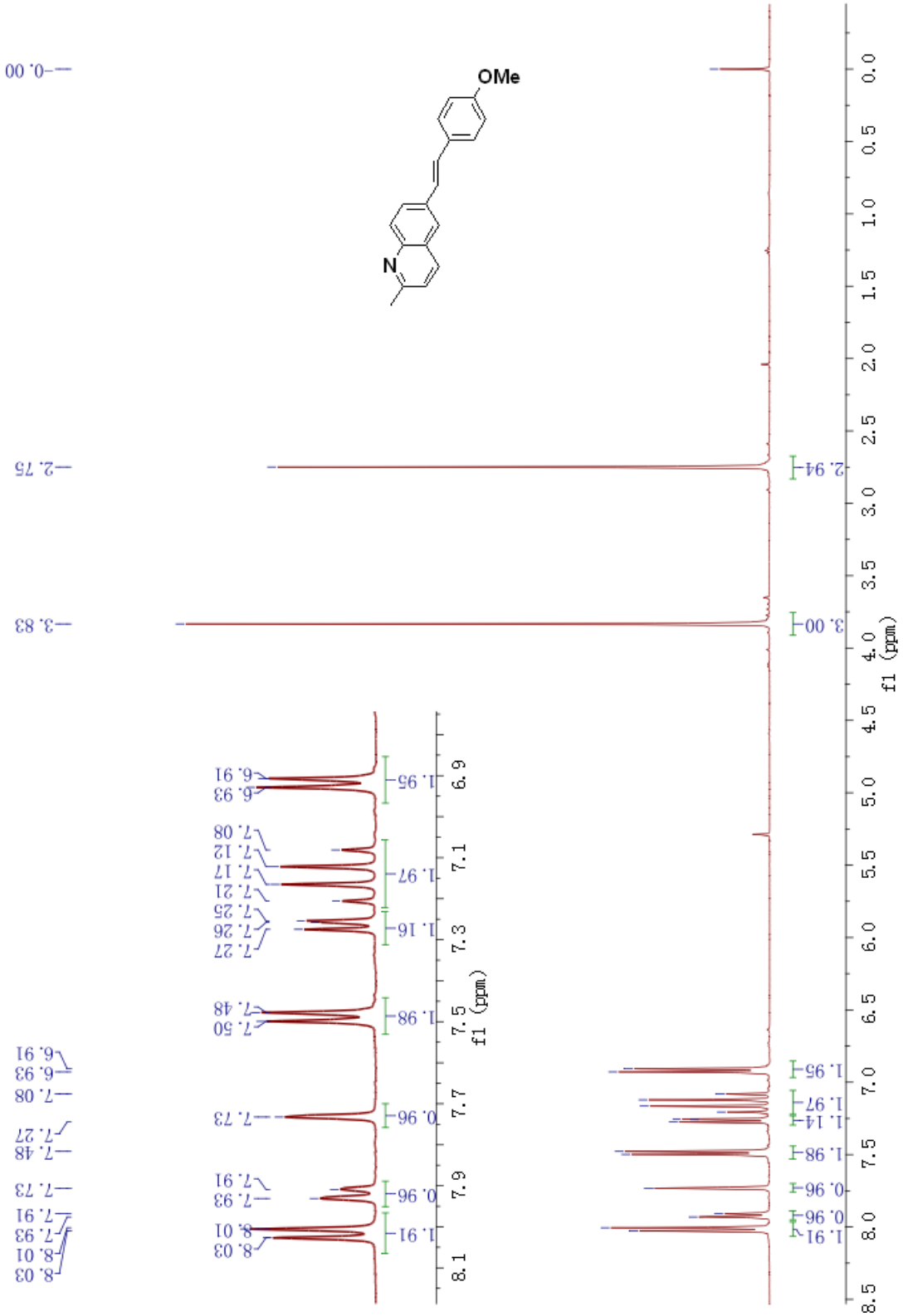
Figure S14. ^{1}H-NMR spectra of **6-MPVQ** with 0, 0.3, 0.6, 1.0eq Zn(II) in DMSO-d6.

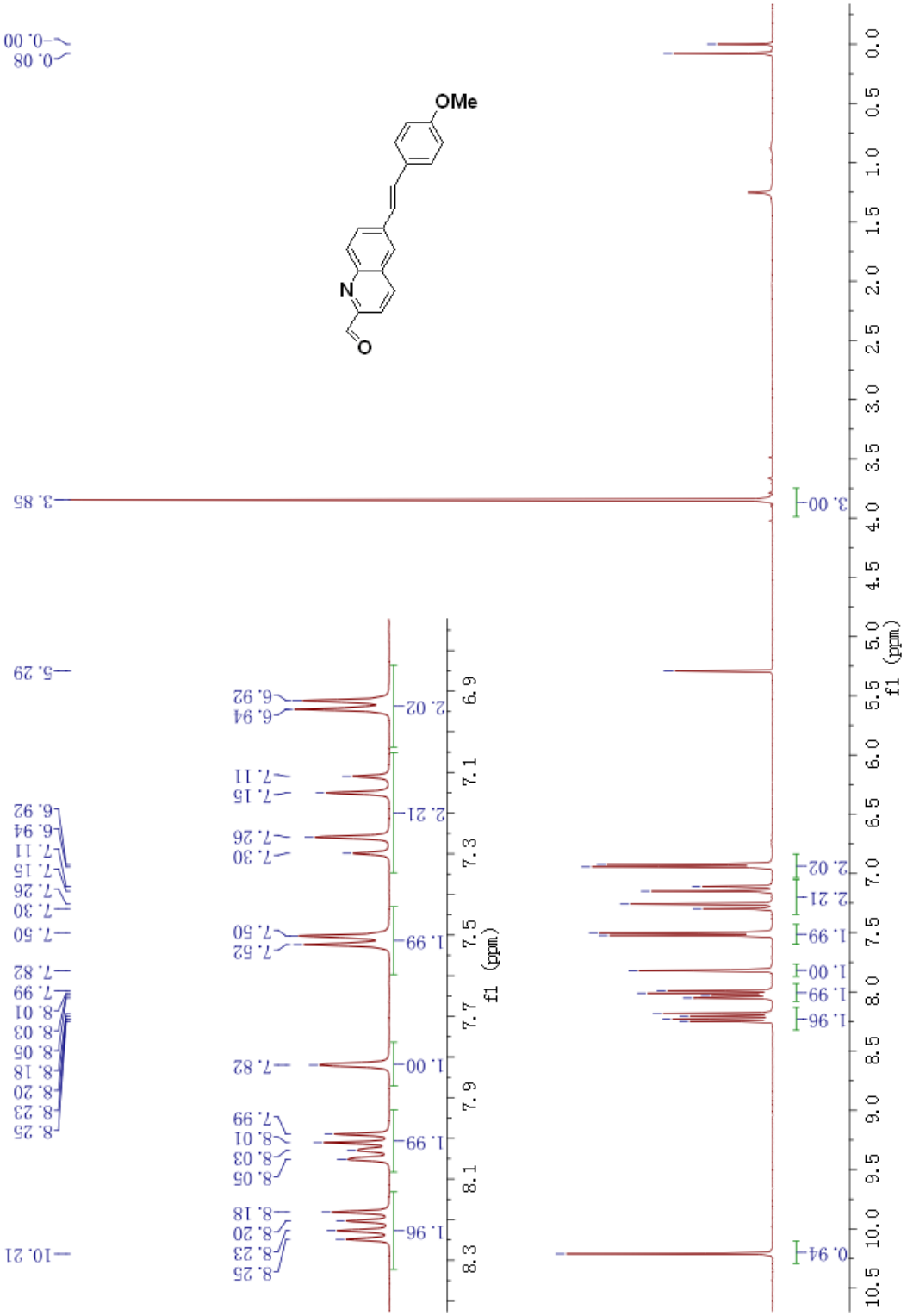
Table S4. The ^{1}H-NMR spectra of the 6-MPVQ with 0, 0.3, 0.6, 1.0 eq Zn(II) in DMSO-d_6.

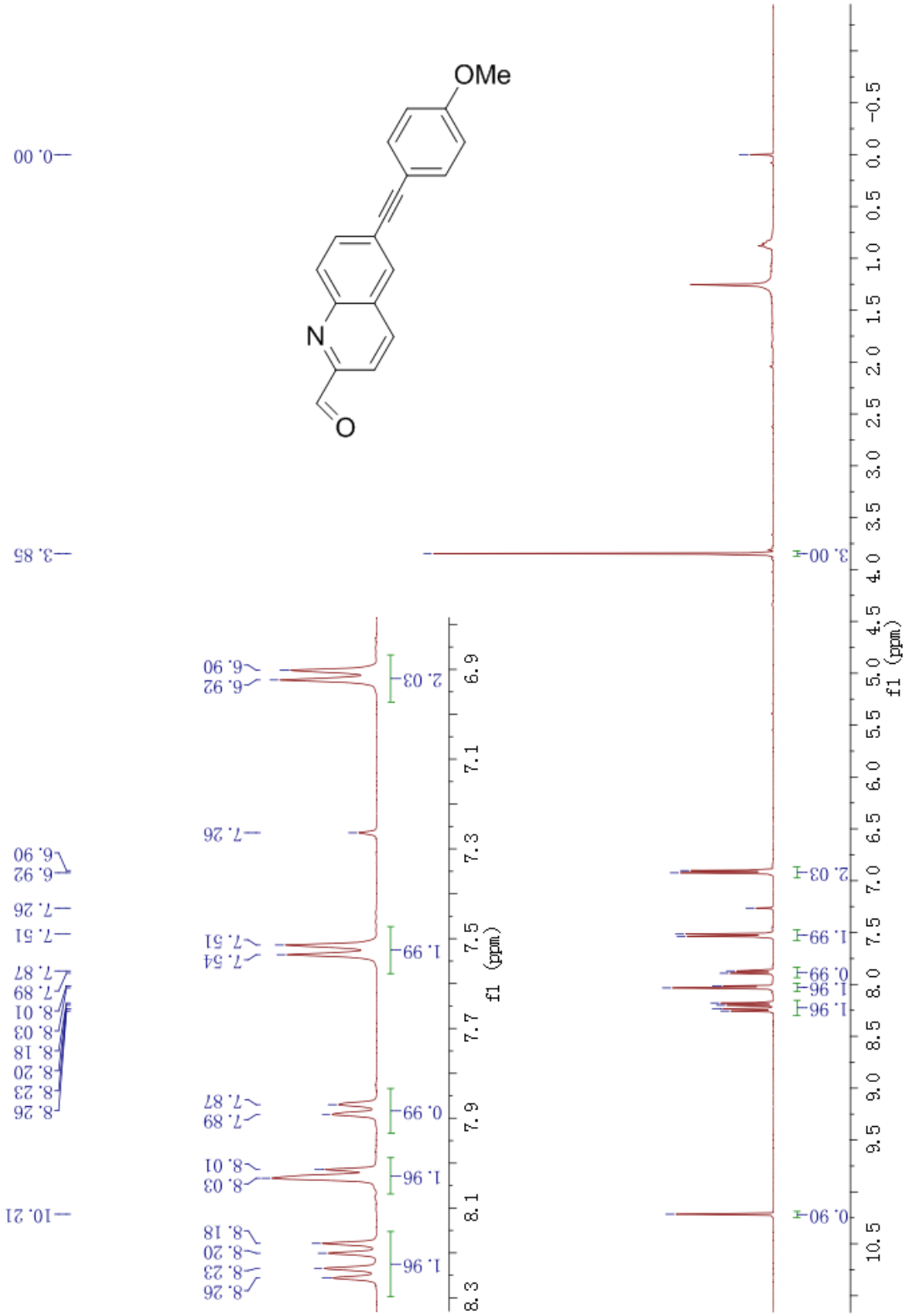
protons	signals for free 6-MPVQ (ppm)	protons	signals for 6-MPVQ-Zn^{2+} (ppm)
Ha	8.50-8.52 (2H, d, J=4.65Hz)	Ha'	8.71-8.72 (2H, d, J=4.75Hz)
Hb	7.24-7.28 (2H, m)	Hb'	7.47-7.51 (2H, m)
Hc	7.77-7.83 (4H, dd, J=8.19, 16.56)	Hc'	7.92-7.95 (2H, t, J=7.63, 7.63)
Hd	7.62-7.64 (2H, d, J=7.80Hz)	Hd'	7.44-7.45 (2H, d, J=7.84Hz)
He	3.85 (4H, s)	He'	4.49 (4H, s)
Hf	3.98 (2H, s)	Hf'	4.80 (2H, s)
Hg	7.77-7.83 (4H, dd, J=8.19, 16.56)	Hg'	7.71-7.73 (1H, d, J=8.53Hz)
Hh	8.33-8.36 (1H, d, J=8.55Hz)	Hh'	8.59-8.61 (1H, d, J=8.51Hz)
Hi	8.16 (1H, s)	Hi'	8.30 (1H, s)
Hj	7.77-7.83 (4H, dd, J=8.19, 16.56)	Hj'	8.66-8.69 (1H, d, J=8.86Hz)
Hk	7.96-7.98 (1H, d, J=8.72Hz)	Hk'	8.15-8.17 (1H, d, J=8.76Hz)
Hl	7.55-7.57 (2H, d, J=8.55Hz)	Hl'	7.56-7.58 (2H, d, J=8.46Hz)
Hm	7.01-7.03 (1H, d, J=8.58Hz)	Hm'	7.04-7.06 (2H, d, J=8.54Hz)
Hn	3.82 (3H, s)	Hn'	3.83 (3H, s)

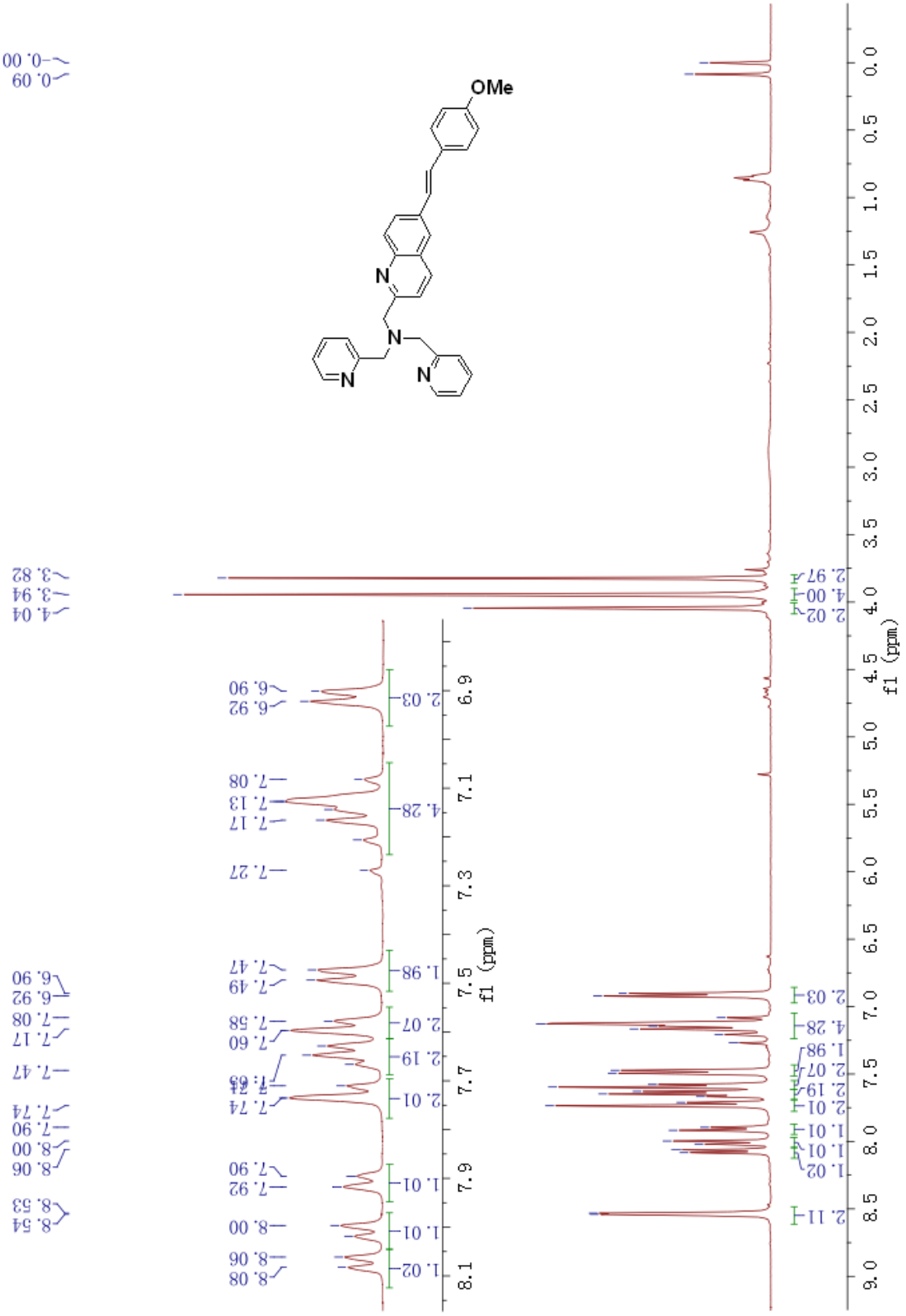


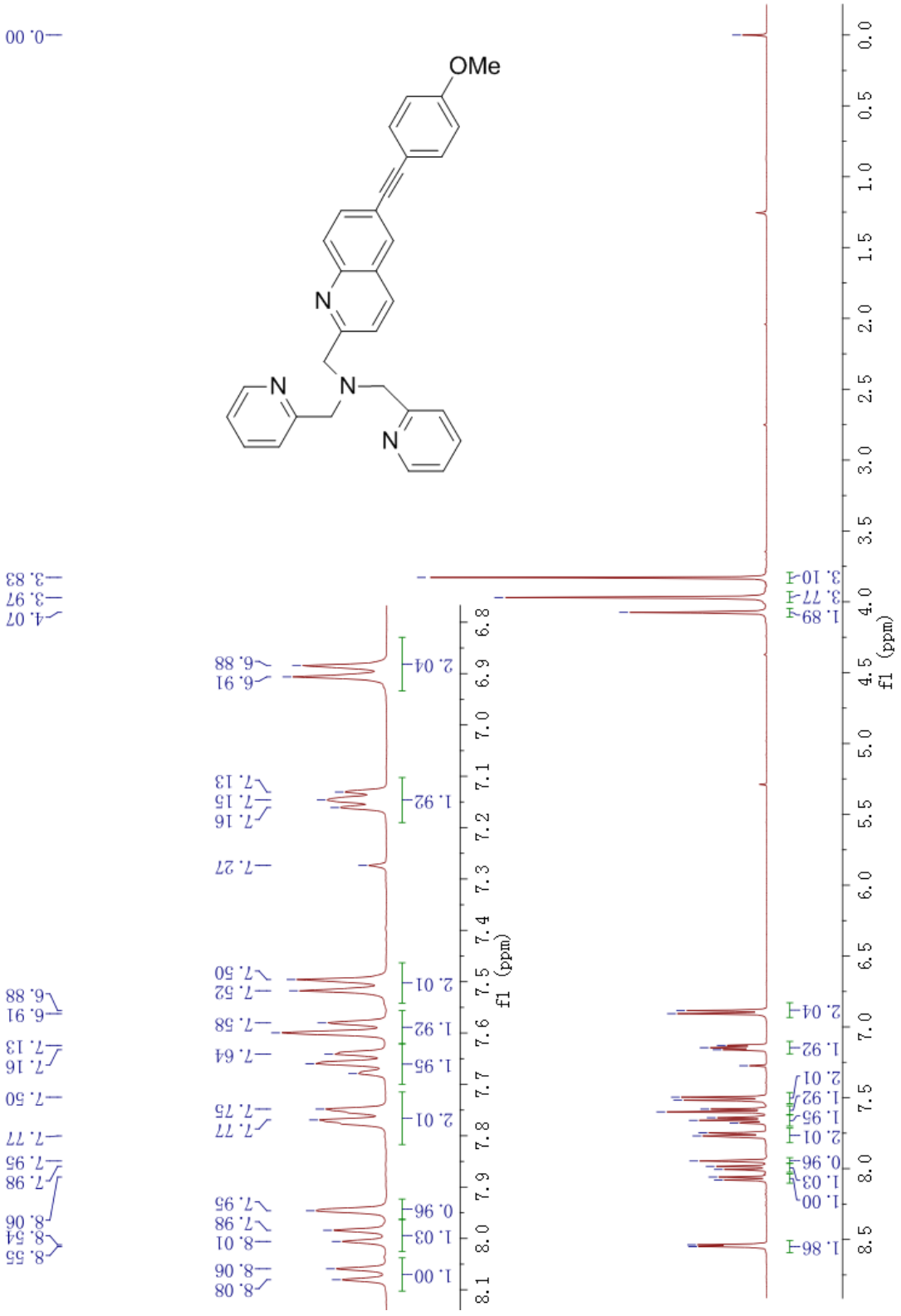


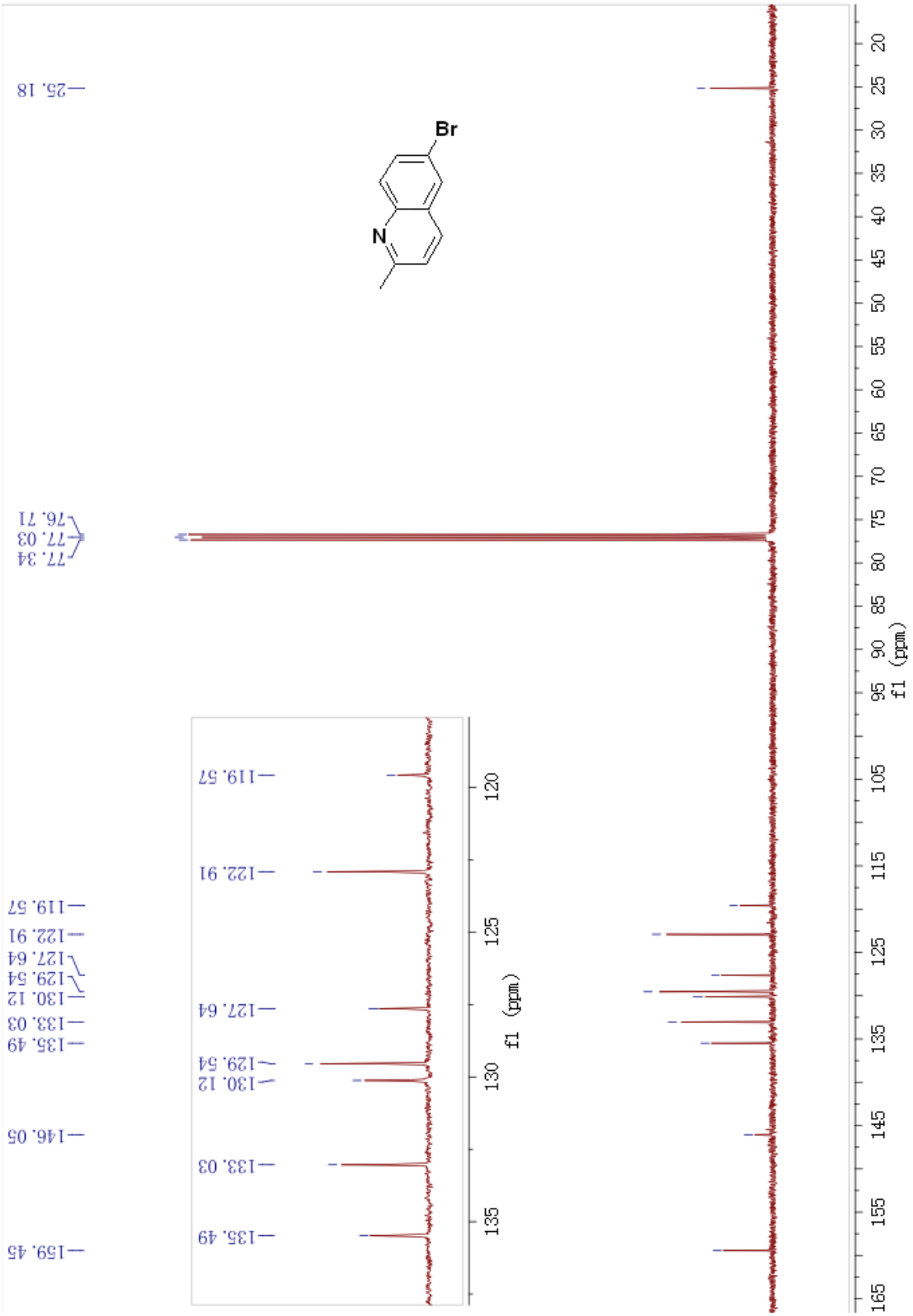


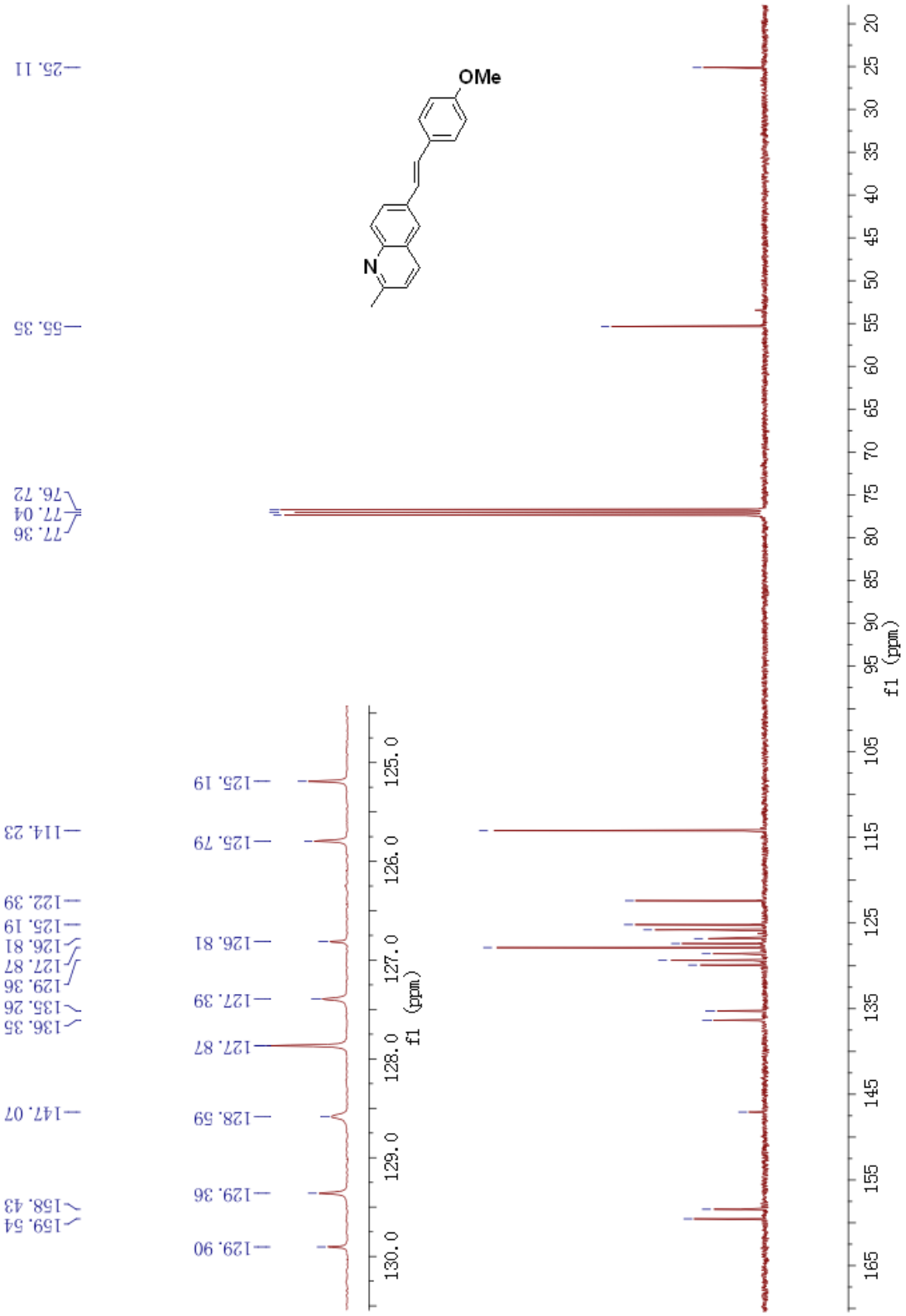


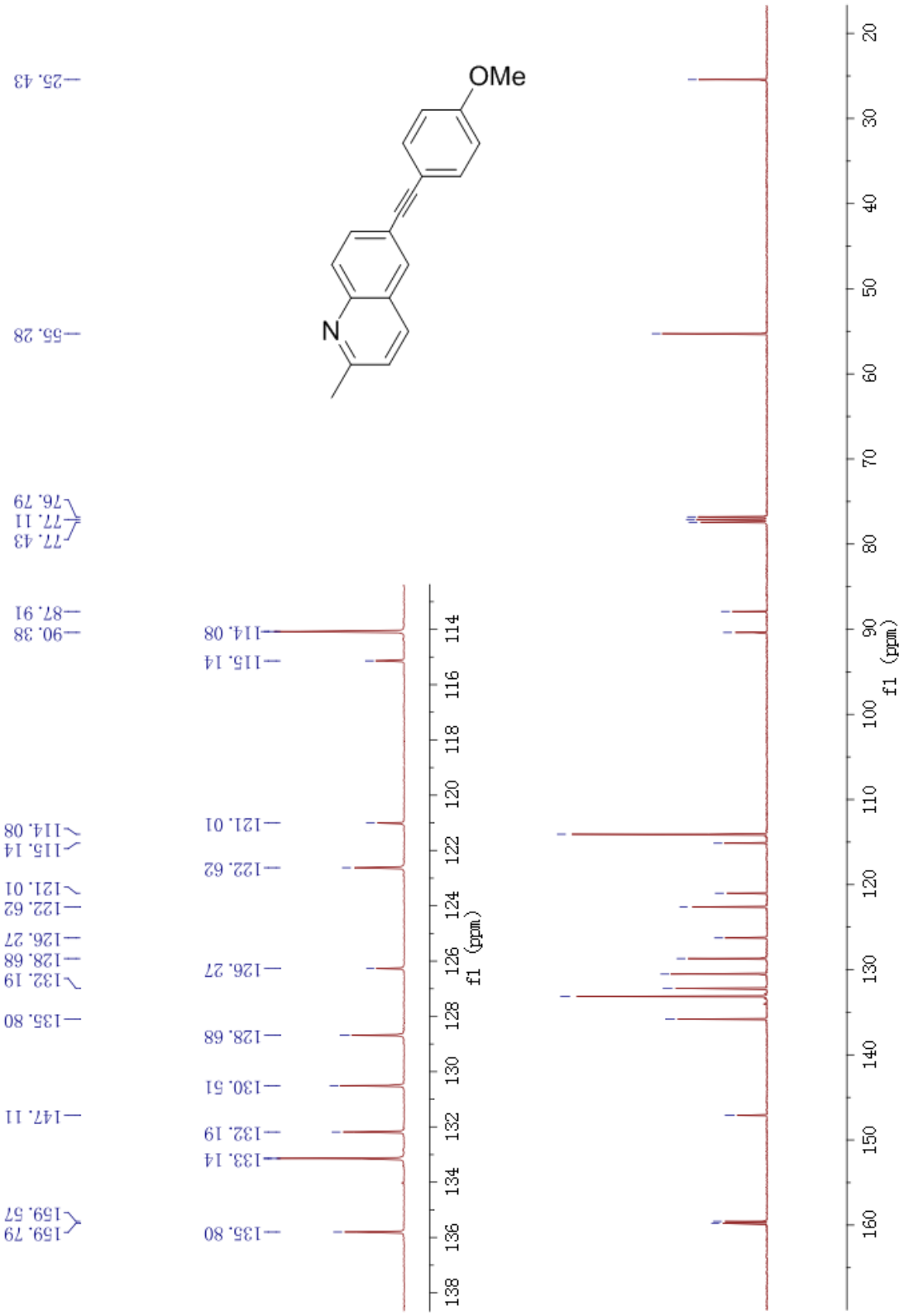


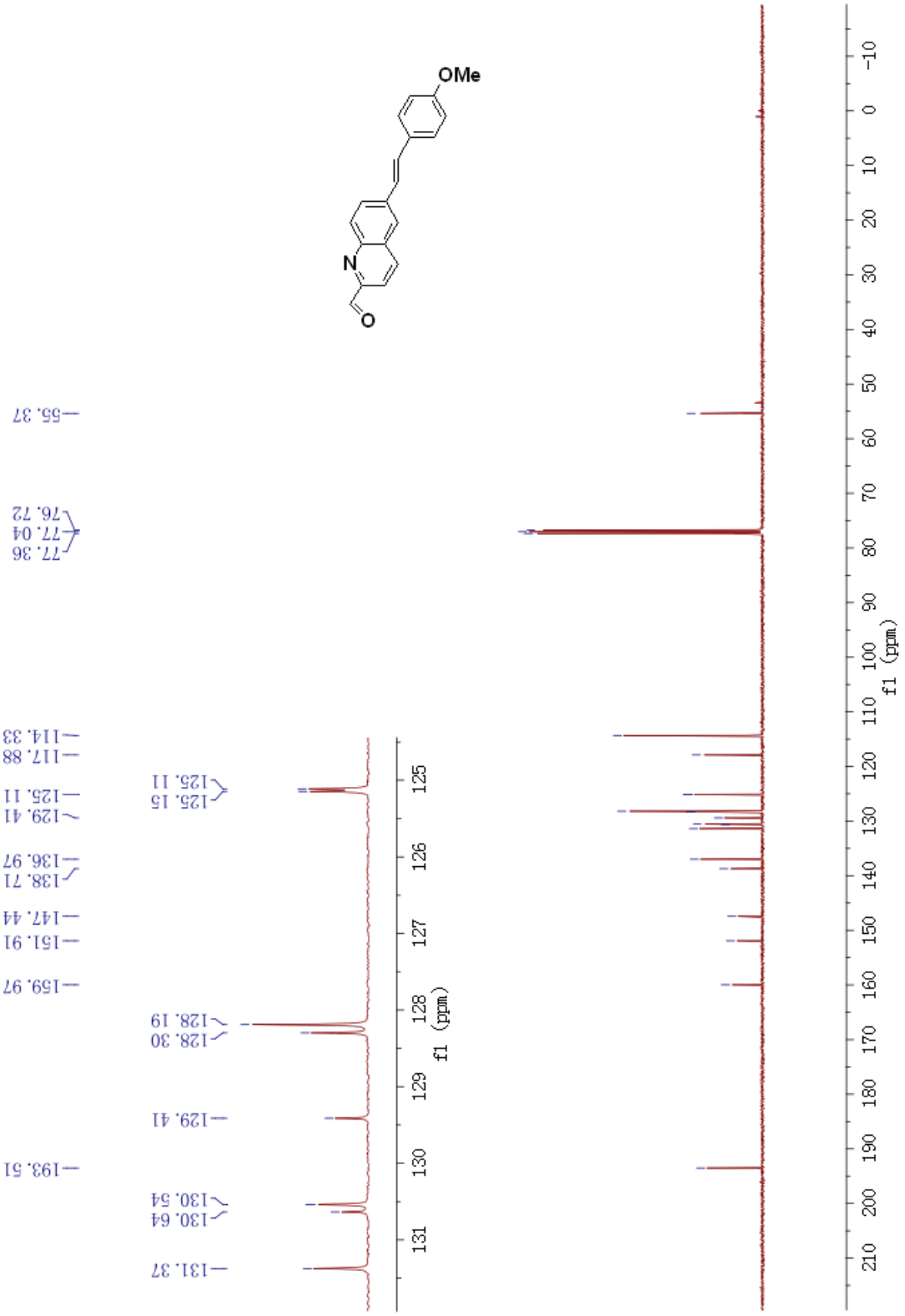


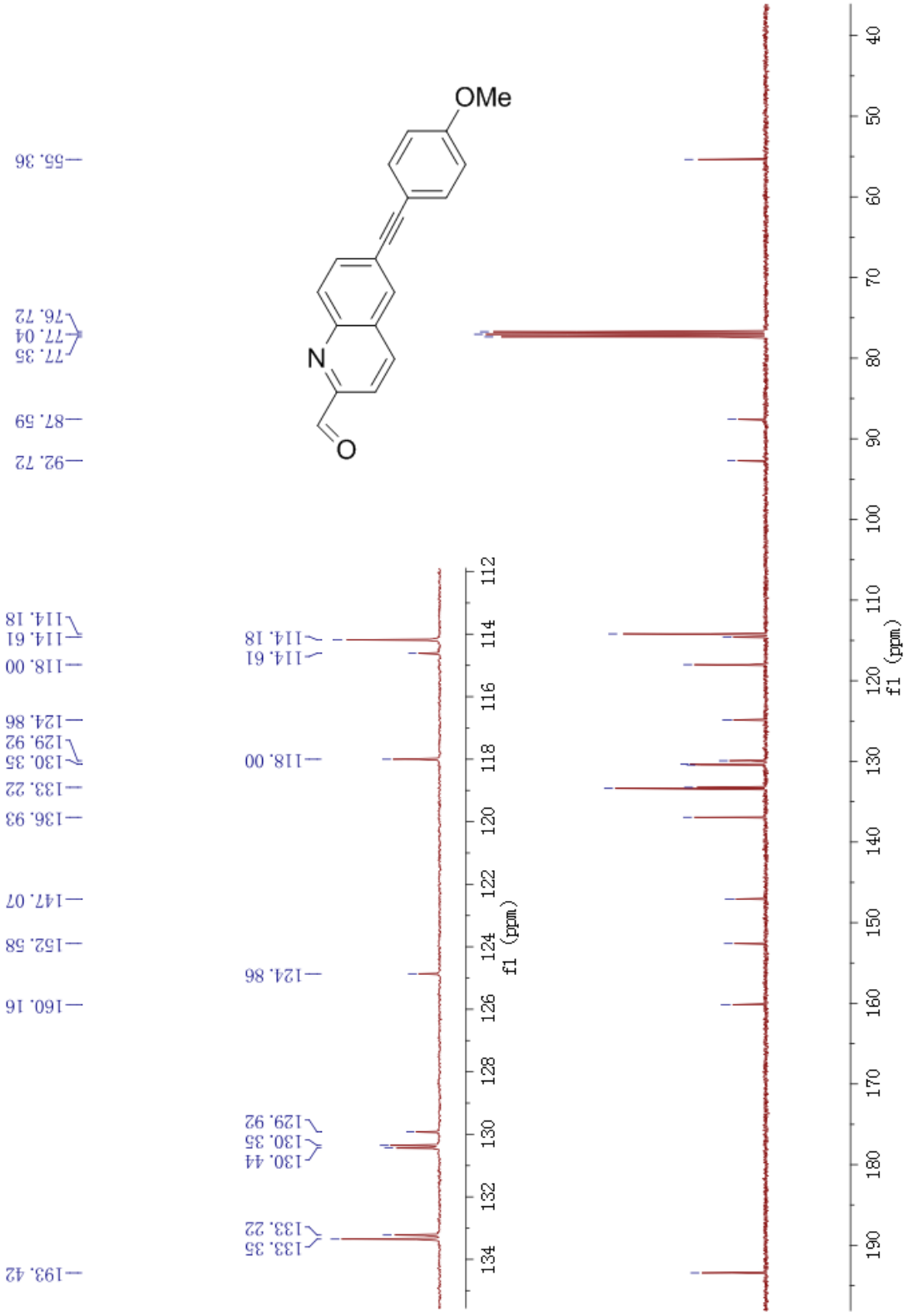


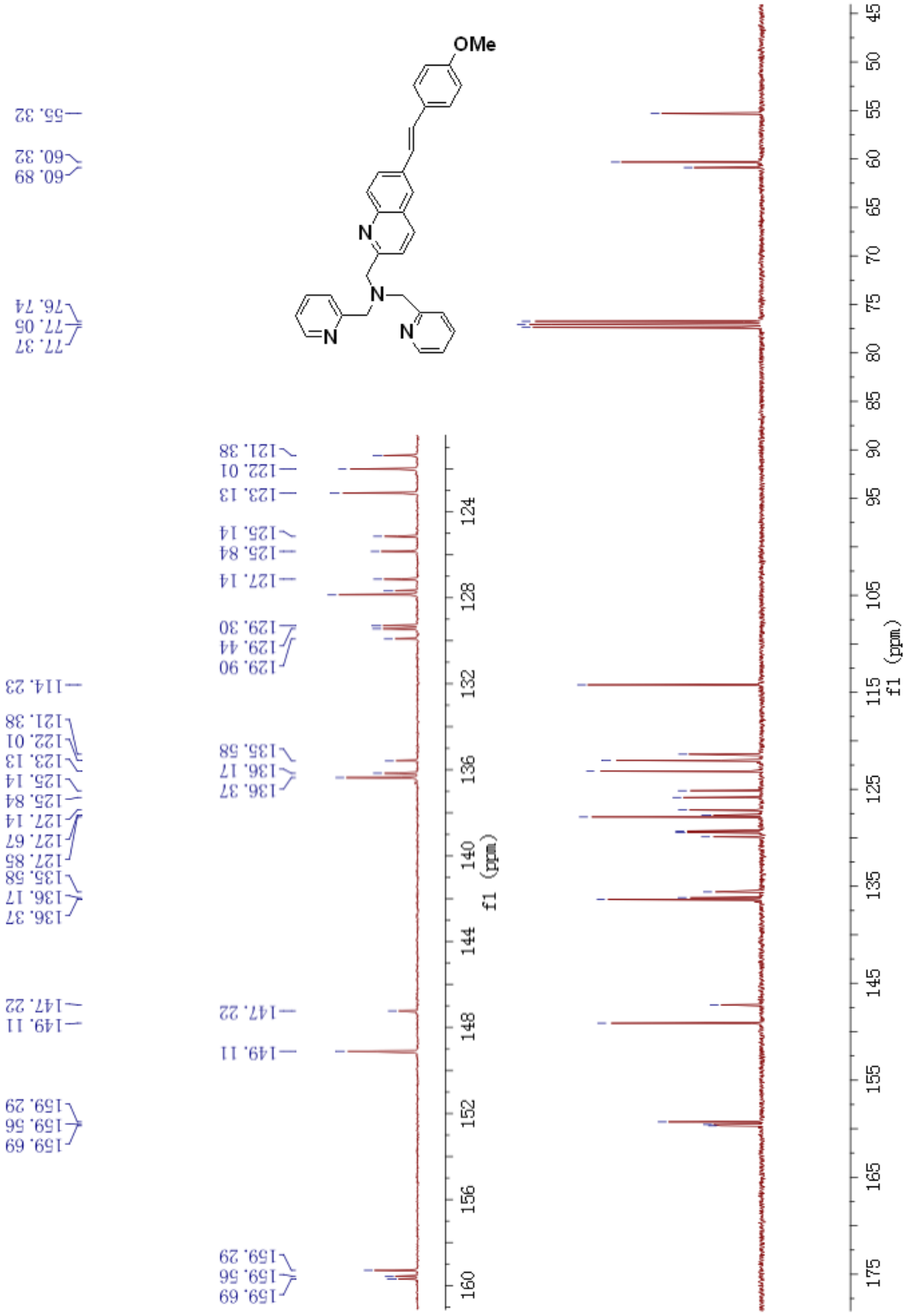


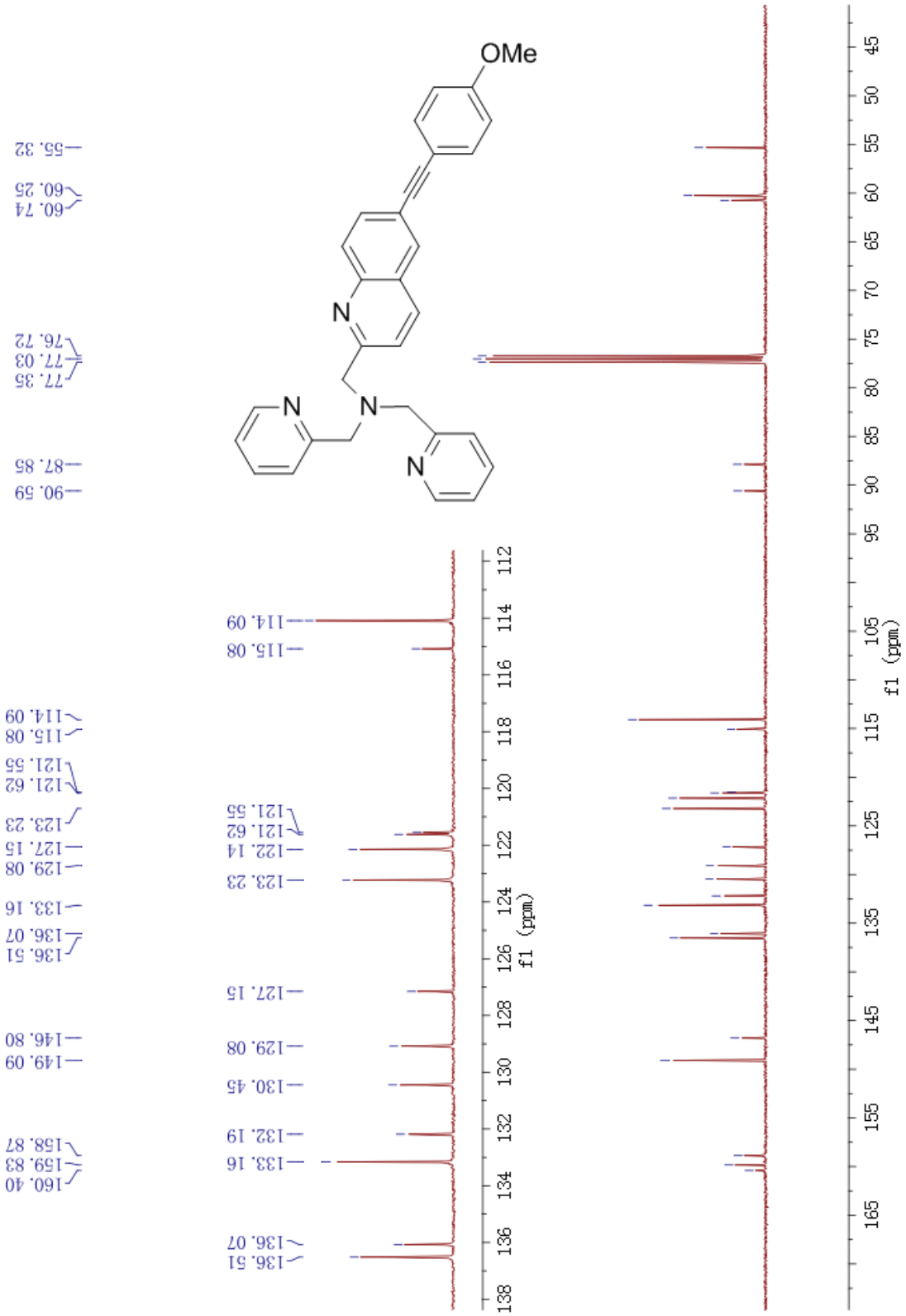


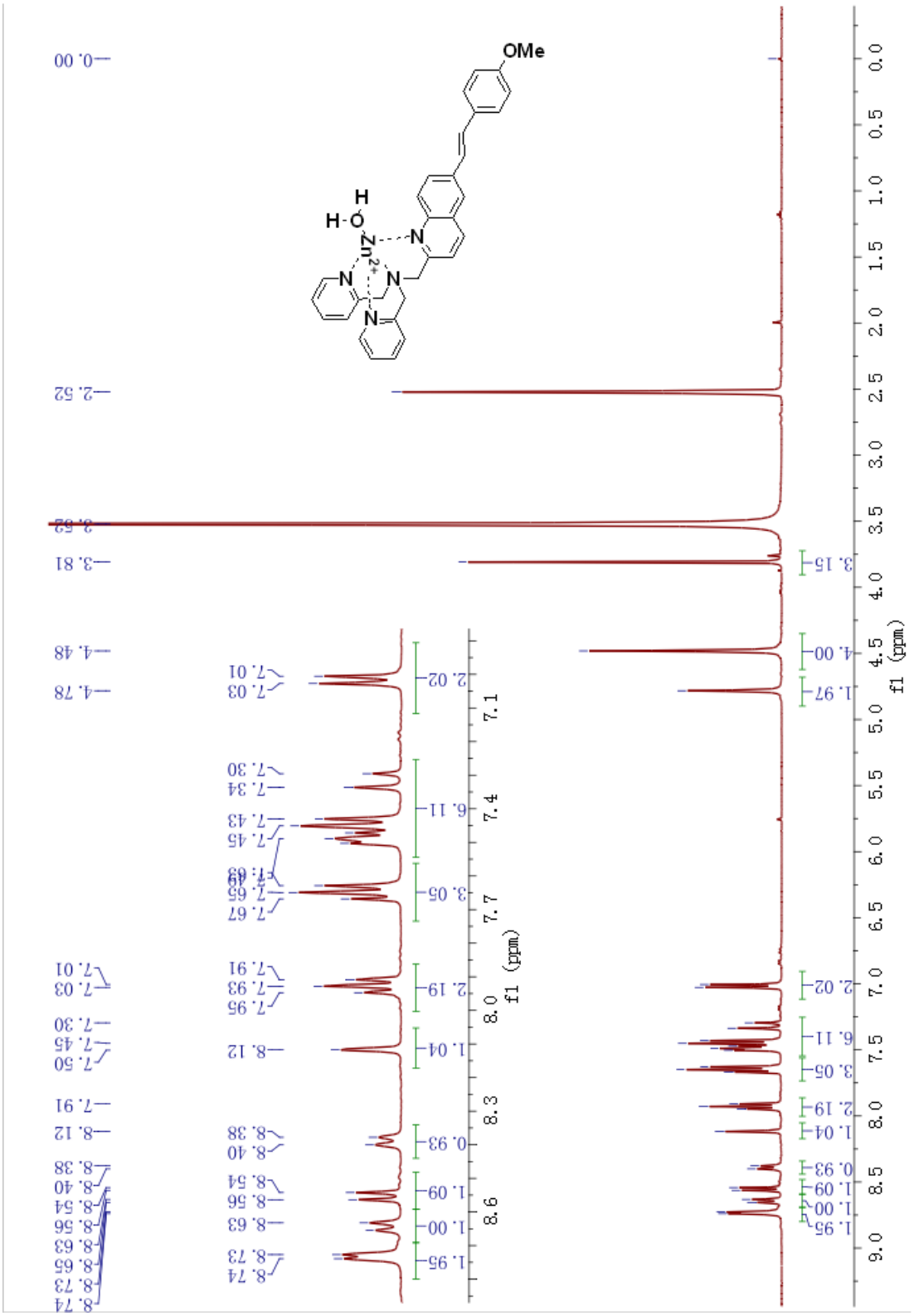


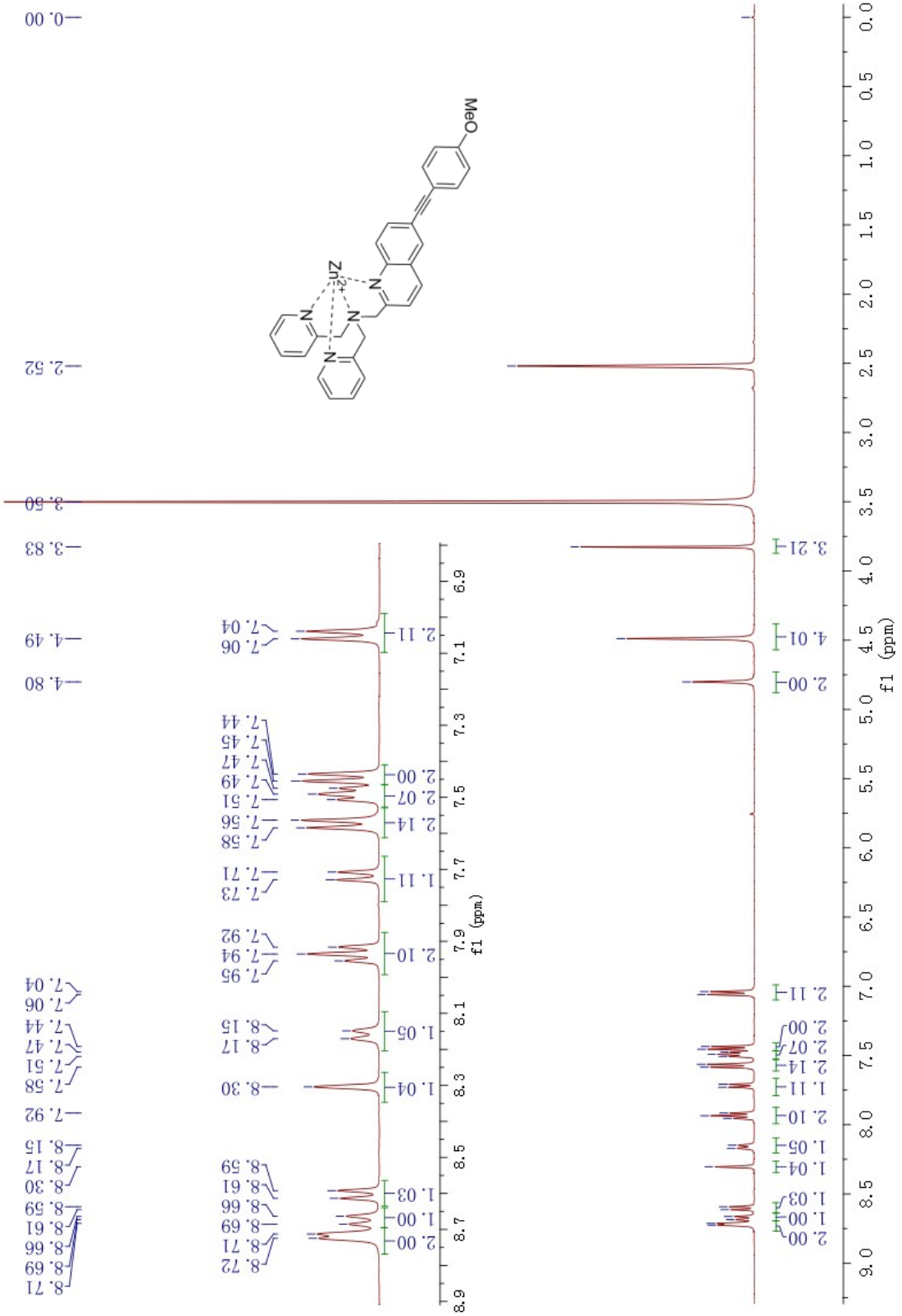











MeO
Zn
f1 (ppm)