Supporting Information

Focused Fluorescent Probe Library for Metal Cations and Biological Anions

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1. Preparation of combinatorial building blocks.

Building blocks **A** and **B** were purchased and **C**, **D**, **E** blocks were prepared by following the reported procedure.[1] Building blocks **1**, **2**, **5**, **6**, and **7** blocks were prepared by following the published reports.[2]

(1) Rosania, G. R. ; Lee, J. W.; Ding, L.; Yoon, H. S.; Chang, Y. T. *J. Am. Chem. Soc. 2003,* **125**, 1130-1131.
(2) (a) Peng, X.; Du, J.; Fan, J.; Wang, J.; Wu, Y.; Zhao, J.; Sun, S.; Xu, T. *J. Am. Chem. Soc. 2007,* **129***,* 1500-1501. (b) Coskun, A.; Deniz, E.; Akkaya, E. U. *Tetrahedron Lett. 2007,* **48**, 5359-5361. (c) Zeng, L.; Miller, E. W.; Pralle, A.; Isacoff, E. Y.; Chang, C. J. *J. Am. Chem. Soc. 2006,* **128**, 10-11. (d) Rurack, K.; Kollmannsberger, M.; Resch-Genger, U.; Daub, J. *J. Am. Chem. Soc. 2000,* **122**, 968-969. (e) Yuan, M.; Li, Y.; Li, J.; Li, C.; Liu, X.; Lv, J.; Xu, J.; Liu, H.; Wang, S.; Zhu, D. *Org. Lett. 2007,* **9**, 2313-2316. (f) Lee, S. J.; Jung, J. H.; Seo, J.; Yoon, I.; Park, K.-M.; Lindoy, L. F.; Lee, S. S. *Org. Lett. 2006, 8*, 1641-1643. (g) Massin, J.; Dayoub, W.; Mulatier, J. C.; Aronica, C.; Bretonniere, Y.; Andraud, C. *Chem. Mater.* **2011**, *23*, 862–873.

Synthesis of building block 3

Scheme 1. Synthesis of building block 3

Synthesis of compound 3a To a solution of N-(2-hydroxyethyl)aniline (3.0 g, 21.8 mmol) in dichloromethane (CH_2Cl_2) (10 mL) was added dropwise phosphorous tribromide (22.0 mmol) at 0°C. The reaction mixture was stirred for 3 hr at room temperature. Checked by TLC, if N-(2-hydroxyethyl)aniline was totally consumed, the reaction mixture was added 20 mL of water and stirred 5 min more. Decanted the organic layer carefully and dried over sodium sulfate (Na_2SO_4). Removed organic solvent in low pressure and remained residue was directly used in the next step without further purification. The residue was solvated in dimethyl sulfoxide (DMSO) (2 mL) and which was stirred at room temperature. Sodium azide (5.2 g, 80 mmol) in DMSO (2 mL) was added to the solution, the reaction mixture was heated up to 80°C and stirred for 1 hr. The reaction mixture was poured into ethyl acetate (EA) (20 mL) and water (20 mL). Organic layer was washed with water three times. Decanted organic layer carefully and dried over Na_2SO_4. Filtrated organic solvent was condensed in low pressure. Remained crude compounds were purified by silica-gel column chromatography (hexane: EA = 10:1) to afford light brown solid, **3a** (3.21 g, 19.8 mmol, 91% yield^{1}H NMR (300 MHz, $CDCl_3$): δ 3.38 (2H, t, *J* = 5.4 Hz), 3.55 (2H, t, *J* = 5.4 Hz), 3.90 (1H, s), 6.68-6.71 (2H, m), 6.80 (1H, m), 7.25 (2H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 43.134, 50.596, 76.786, 77.209, 77.633, 113.144, 118.168, 129.464, 147.349.

Synthesis of compound 3b 2-bromomethylprydine hydrobromide (3.18 g, 12.6 mmol) was solvated in H_2O (0.5 mL), then **3a** (1.70 g, 10.5 mmol), 5 N NaOH (3 mL) and tetrabutylammonium bromide (15 mg) were added under N_2. Reaction mixture was stirred for 24 h at room temperature. Resulting solution was extracted with 10 mL of CH_2Cl_2, and the extract was washed with H_2O. Decanted organic solvent and dried over Na_2SO_4. Filtrated organic solvent was condensed in low pressure. Remained residue was purified by silica-gel column chromatography (CH_2Cl_2: EA = 4:1) yielded brown compound **3b** (1.57 g, 6.19 mmol, 59% yield). ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.50 (2H, t, *J* = 6.4 Hz), 3.66 (2H, t, *J* = 6.2 Hz), 4.73 (2H, s), 6.72-6.76 (3H, m), 7.11-7.23 (4H, m), 7.51-7.56 (1H, m), 8.59-8.60 (1H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 49.018, 50.864, 57.118, 112.608, 117.458, 120.837, 122.060, 129.476, 136.728, 147.490, 149.661, 158.861.

Synthesis of compound 3c The azide of **3b** (1.0 g, 3.9 mmol) was hydrogenated using MeOH as solvent and Pd/C (10%, 0.2 g) as catalyst with hydrogen gas bubbling. The mixture was stirred at room temperature for 24 h which was qualitatively monitored by TLC (n-hexane: EtOAc = 2: 1). When **3b** was consumed totally, Pd/C was removed by filtration and the solvent was evaporated *in vacuo*. The product (N^1-phenyl-N^1-(pyridin-2-ylmethyl) ethane-1,2-diamine) was directly used in the next step. N^1-phenyl-N^1-(pyridin-2-ylmethyl)ethane-1,2-diamine (0.89 g, 3.9 mmol) was added to a stirred solution of 2-pyridinecarboxaldehyde (0.88 g, 8.22 mmol) in 1,2-dicholroethane (60 mL). After 30 min, sodium triacetoxyborohydride (2.5 g, 12 mmol) was added to the mixture. The reaction mixture was stirred for overnight. After then, the solution was extracted with EA which was washed with water three times. Decanted organic layer carefully and dried over Na_2SO_4. Filtrated organic solvent was condensed in low pressure. Remained crude compounds were purified by silica-gel column chromatography (CH_2Cl_2 to 5% MeOH in CH_2Cl_2) to give sticky brown compound **3c** (0.80 g, 1.95 mmol, 50% yield). ^1H NMR (300 MHz, $CDCl_3$): δ 2.88 (2H, t, J = 7.2 Hz), 3.64 (2H, t, J = 7.6 Hz), 3.92 (4H, s), 4.59 (2H, s), 6.52 (2H, d, J = 8.0 Hz), 6.69 (1H, t, J =5.6 Hz), 7.06-7.16 (6H, m), 7.50-7.52 (3H, m), 7.62-7.64 (2H, m), 8.53-8.55 (3H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 49.664, 50.807, 56.845, 60.820, 111.856, 116.233, 120.561, 121.718, 121.988, 122.937, 129.073, 136.311, 136.513, 147.661, 148.904, 149.312, 159.100, 159.168.

*Synthesis of compound **3*** $POCl_3$ (1 mL, 17 mmol) was added dropwise to a stirring solution of DMF (2 mL, 26mmol) at 0 °C. Stirred for 30 min, then **3c** (0.50 g, 1.22 mmol) in dimethyl formamide (DMF) (1 mL) was slowly added dropwise. The reaction mixture was warmed to room temperature and stirred overnight. The reaction mixture was poured into ice cool water (15 mL), and the pH was adjusted to pH 7-8 with saturated $K_2CO_{3(aq)}$ solution. The mixture was extracted with CH_2Cl_2 for three times. Combined organic extracts were dried over Na_2SO_4. Filtrated organic solvent was condensed in low pressure. Remained crude reaction mixture was purified by silica-gel column chromatography (CH_2Cl_2 to 7% MeOH in CH_2Cl_2) to give the product **3**(sticky brown compound) (0.28 g, 0.64 mmol, 52 % yield). ^1H NMR (300 MHz, $CDCl_3$): δ 2.88 (2H, t, J = 7.0 Hz), 3.69 (2H, t, J = 7.6 Hz), 3.93 (4H, s), 4.67 (2H, s), 6.56 (2H, d, J = 8.9 Hz), 7.05 (1H, d, J =5.6 Hz), 7.17-7.19 (3H, m), 7.46 (2H, d, J =7.8 Hz), 7.58-7.65 (5H, m), 8.55-8.56 (3H, m), 9.70 (1H, s). ^{13}C NMR (75 MHz, $CDCl_3$): δ 49.779, 50.285, 56.723, 60.918, 111.302, 120.360, 122.212, 123.137, 125.562, 131.912, 136.449, 136.818, 149.098, 149.738, 152.634, 157.504, 158.777, 189.996 HRMS (FAB): m/e calcd. for $C_{27}H_{28}N_5O$ $[M+H]^+$ 438.2294, found 438.2290.

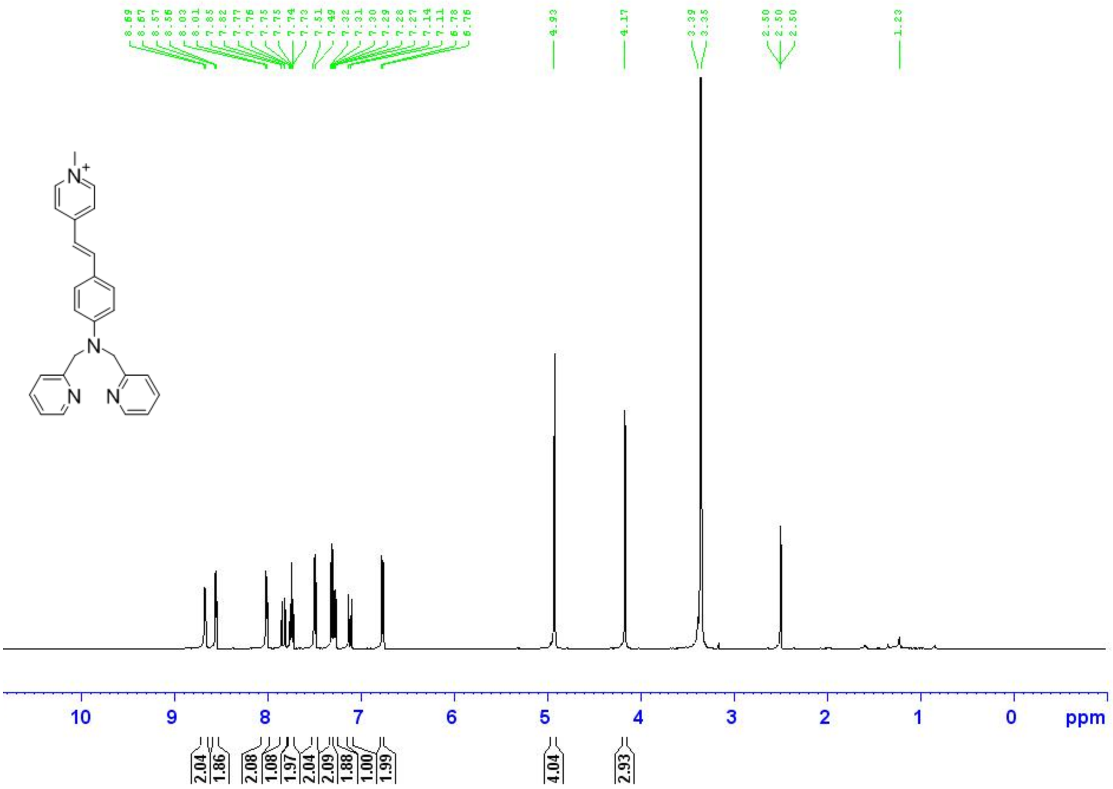
Synthesis of building block 4

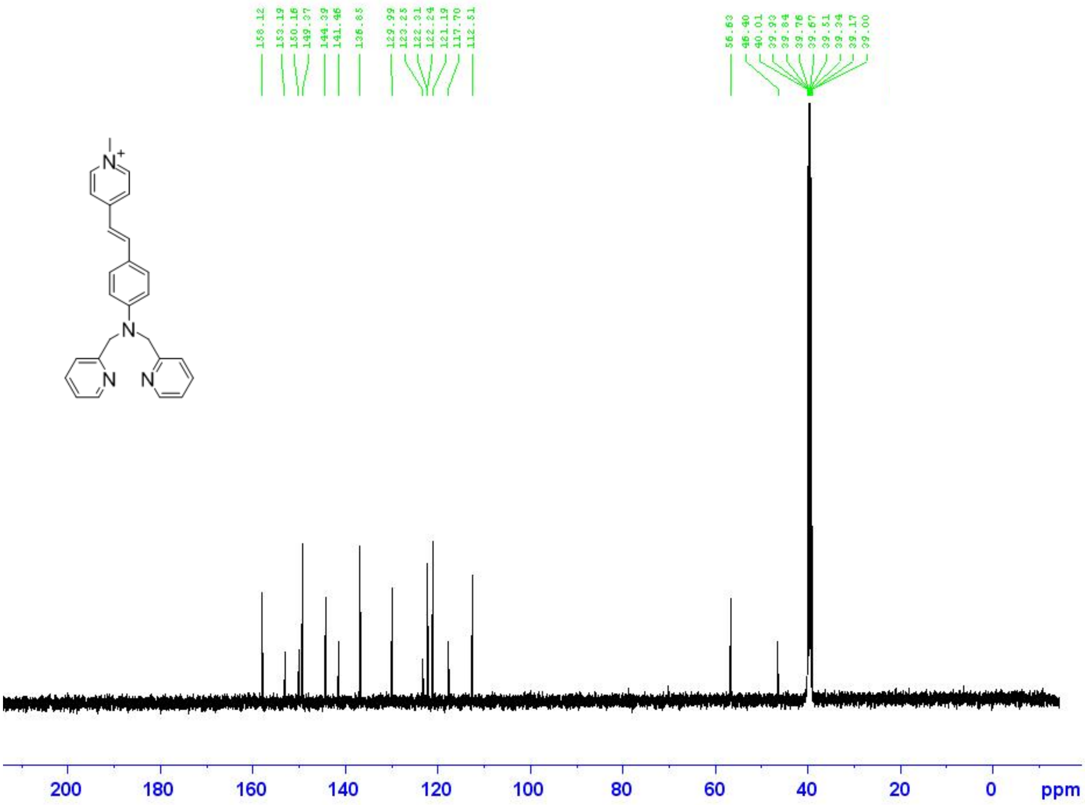
Scheme 2. Synthesis of building block 4

*Synthesis of compound **4b*** With compound **4a**,[2(f),(g)] the synthesis procedure is similar to that of **3C**. The crude product was purified by column chromatography (silica gel, CH2Cl2 to 5% MeOH in CH2Cl2) to obtain sticky brown compound. (48% yield) ^1H NMR (300 MHz, $CDCl_3$): δ 2.65 (4H, t, J = 7.1 Hz), 3.35 (4H, t, J = 7.7 Hz), 3.85 (8H, s), 6.36 (2H, d, J = 8.1 Hz), 6.52 (1H, t, J = 7.3 Hz), 6.99 (2H, t, J = 7.4 Hz), 7.11-7.16 (4H, m), 7.45-7.47 (4H, m), 7.58-7.64 (4H, m), 8.52 (4H, q, J_1 = 4.1 Hz). ^{13}C NMR (75 MHz, $CDCl_3$): δ 49.110, 50.832, 60.865, 111.268, 115.310, 121.970, 122.843, 129.008, 136.302, 147.377, 148.941, 159.301.

*Synthesis of compound **4*** The synthesis procedure is similar to that of **3**. The crude product was purified by column chromatography (silica gel, CH_2Cl_2 to 7% MeOH in CH_2Cl_2) to obtain sticky brown compound. (45% yield) ^1H NMR (300 MHz, $CDCl_3$):). ^1H NMR (300 MHz, $CDCl_3$): δ 2.65 (4H, t, J = 7.2 Hz), 3.41 (4H, t, J = 7.6 Hz), 3.85 (8H, s), 6.33 (2H, d, J = 8.9 Hz), 7.11-7.15 (4H, m), 7.40-7.47 (6H, m), 7.56-7.62 (4H, m), 8.50 (4H, d, J = 4.7 Hz), 9.62 (1H, s). ^{13}C NMR (75 MHz, $CDCl_3$): δ 49.837, 50.181, 60.700, 110.528, 122.199, 123.012, 124.533, 131.847, 136.513, 148.876, 152.223, 158.773, 189.871. HRMS (FAB): m/e calcd. for $C_{35}H_{38}N_7O$ $[M+H]^+$ 572.3138, found 572.3141.

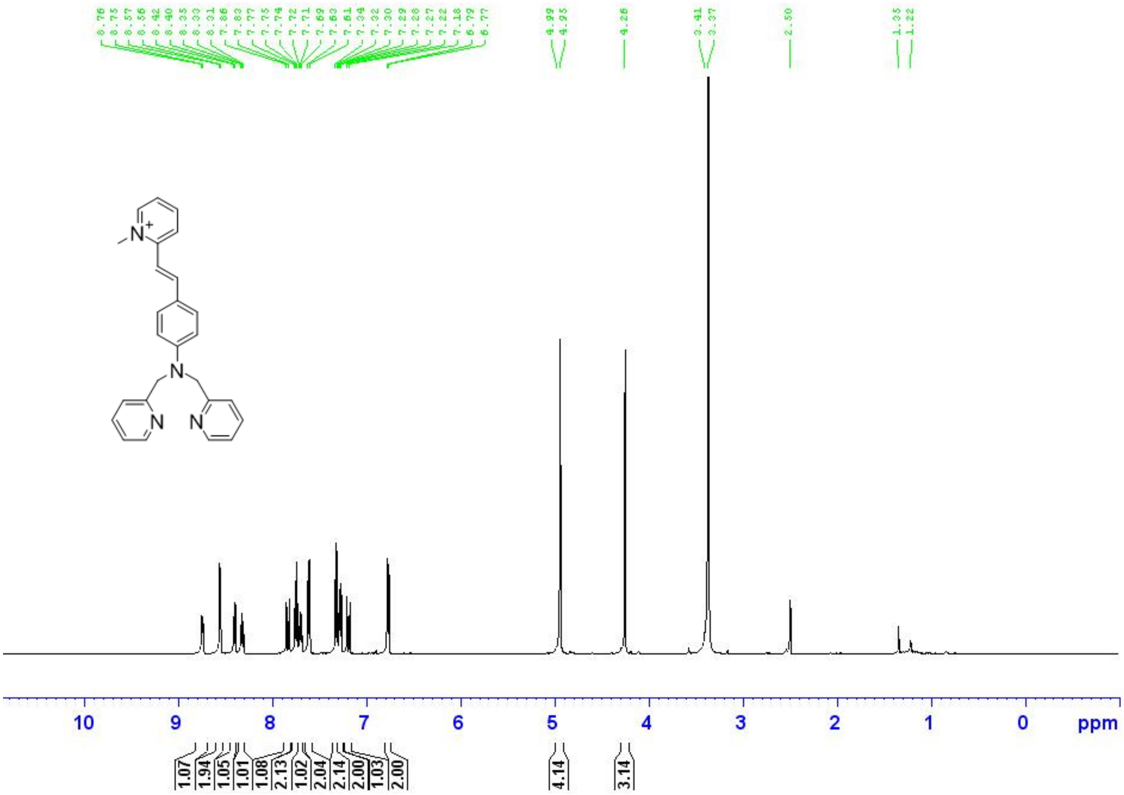
1. Characterization of fluorescent probes

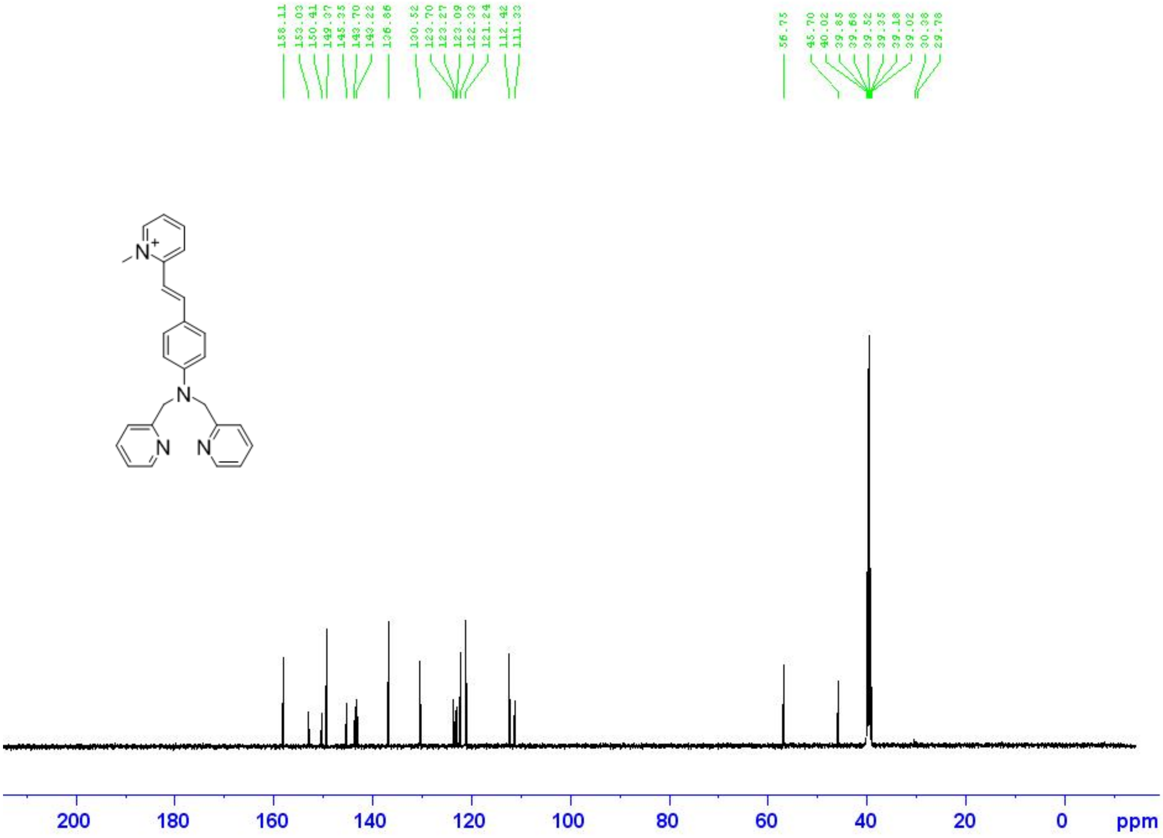




Characteristics of **1A**

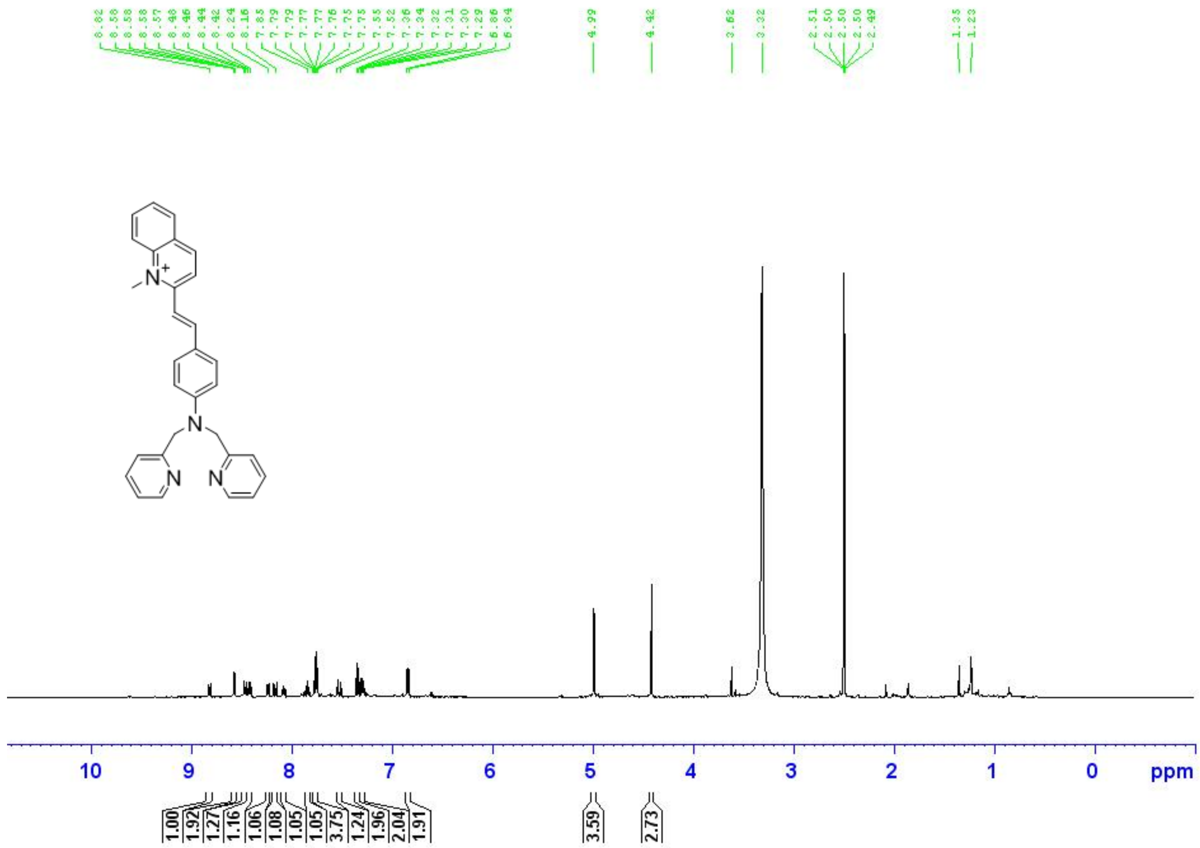
^{1}H NMR (500 MHz, DMSO-d_6) δ 4.17 (3H, s), 4.93 (4H, s), 6.76 (2H, d, *J* = 9 Hz), 7.11 (1H, d, *J* = 16 Hz), 7.27-7.32 (4H, m), 7.49 (2H, d, *J* = 15.2 Hz), 7.74-7.75 (2H, m), 7.82 (1H, d, *J* = 15.8 Hz), 8.01 (2H, d, *J* = 6.5 Hz), 8.55 (2H, d, *J* = 4.5 Hz), 8.67 (2H, d, *J* = 6.3 Hz). ^{13}C NMR (125 MHz, DMSO-d_6) δ 46.396, 56.635, 112.508, 117.700, 121.191, 122.244, 122.315, 123.245, 129.985, 136.851, 141.461, 144.387, 149.371, 150.162, 153.186, 158.119. HRMS (FAB): m/e calcd. For $C_{26}H_{25}N_4$ [M^+] 393.2079, found 393.2086.

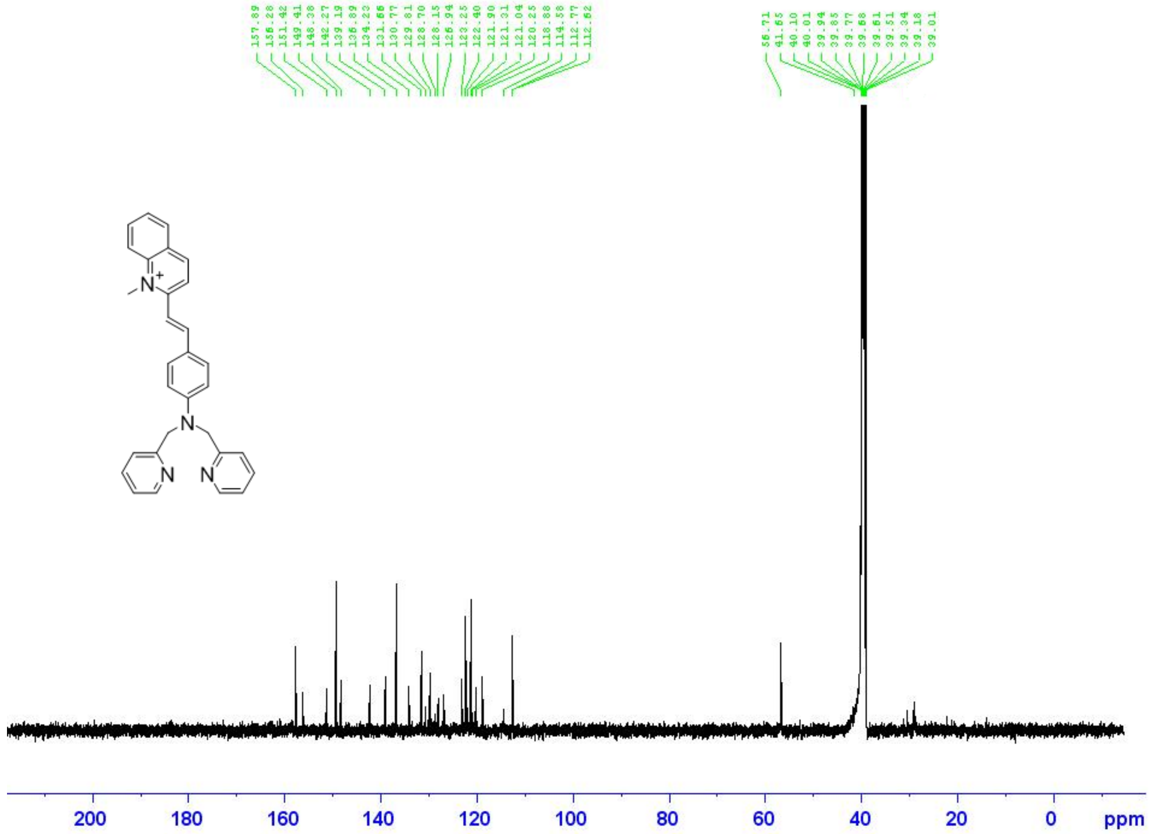




Characteristics of **1B**

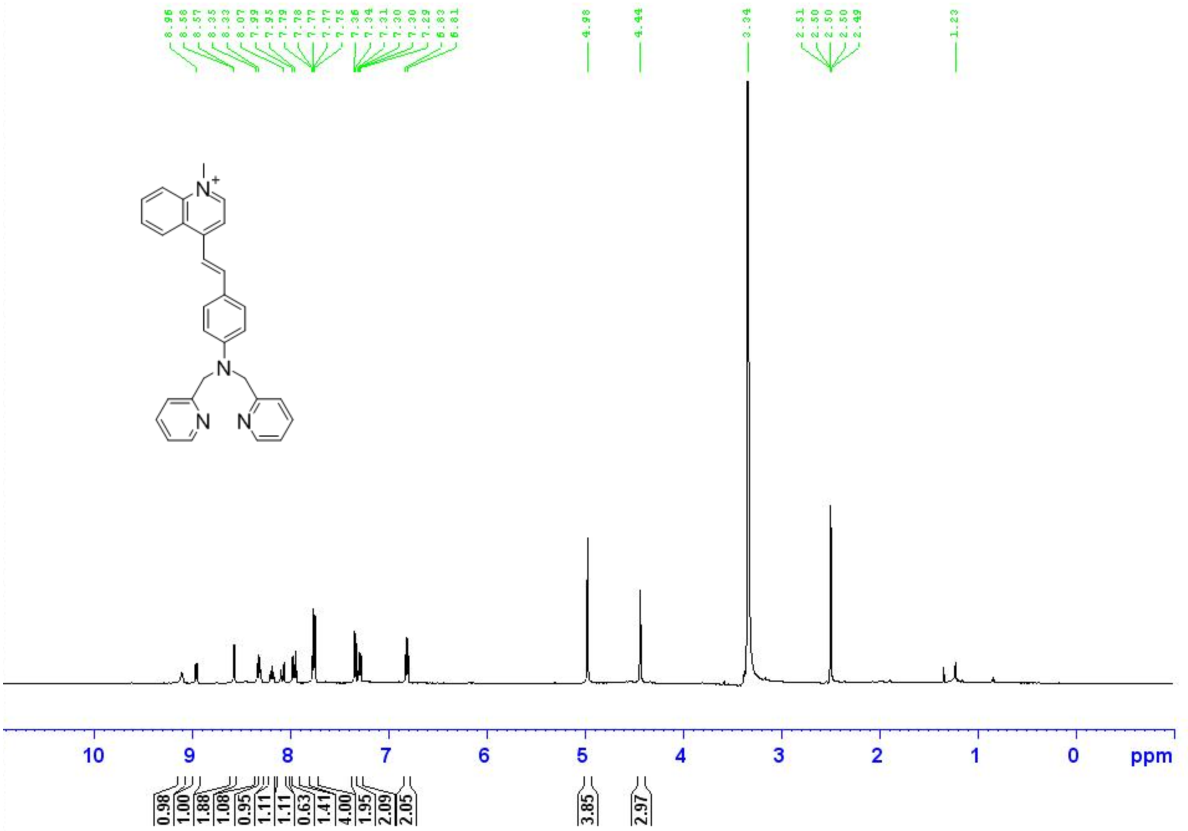
^{1}H NMR (500 MHz, DMSO-d_6) δ 4.26(3H, s), 4.95(4H, s), 6.77(2H, d, *J* = 8.7 Hz), 7.18 (1H, d, *J* = 15.6 Hz), 7.28(2H, m), 7.32(2H, d, *J* = 7.7 Hz), 7.61 (2H, d, *J* = 8.7 Hz), 7.71(1H, t, *J* = 7.5 Hz), 7.74(2H, t, *J* = 7.7 Hz), 7.83(1H, d, *J* = 15.6 Hz), 8.33(1H, t, *J* = 7.7 Hz), 8.40(1H, d, *J* = 7.7 Hz), 8.56(2H, d, *J* = 4.8 Hz), 8.76(1H, d, *J* = 4.7 Hz). ^{13}C NMR (125 MHz, DMSO-d_6) δ 45.704, 56.753, 111.327, 112.421, 121.244, 122.335, 123.090, 123.269, 123.701, 130.525, 136.864, 143.225, 143.702, 145.352, 149.371, 150.405, 153.033, 158.107. HRMS (FAB): m/e calcd. For $C_{26}H_{25}N_4$ [M^+] 393.2079, found 393.2073.

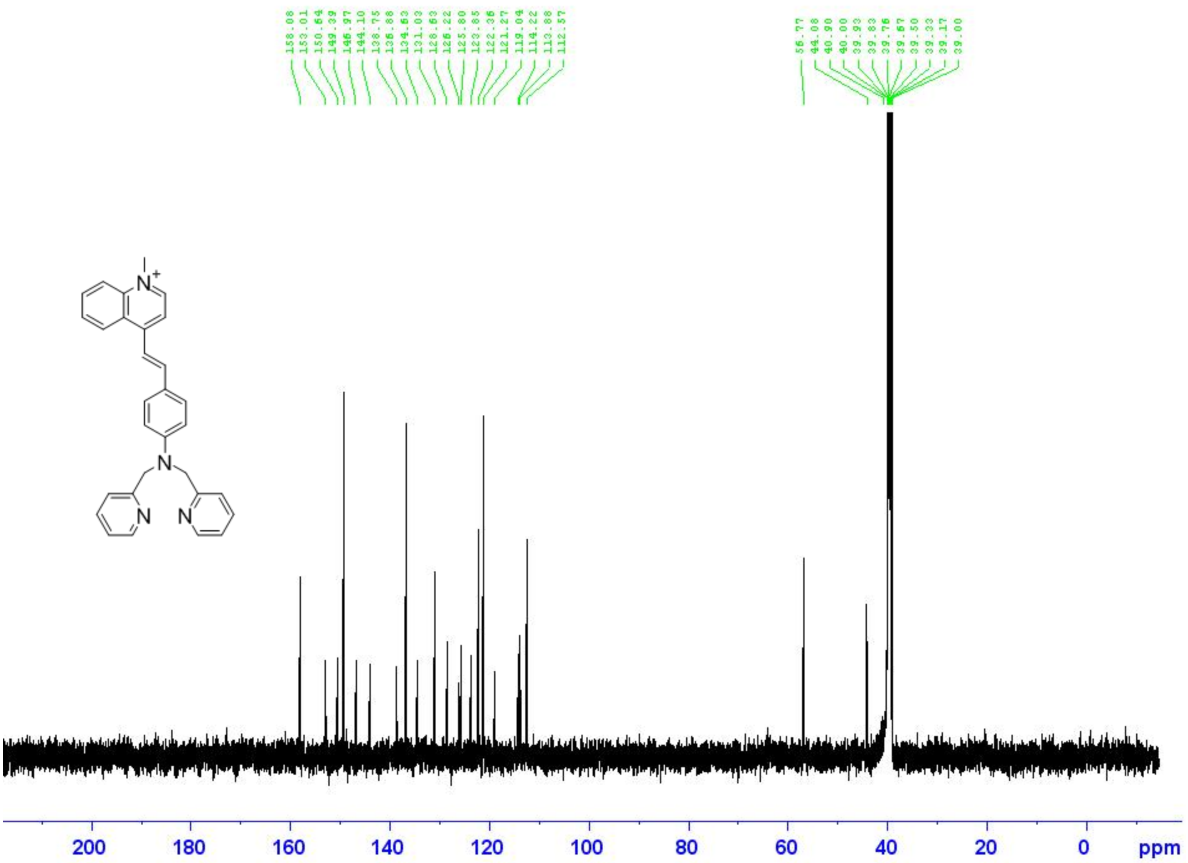




Characteristics of **1C**

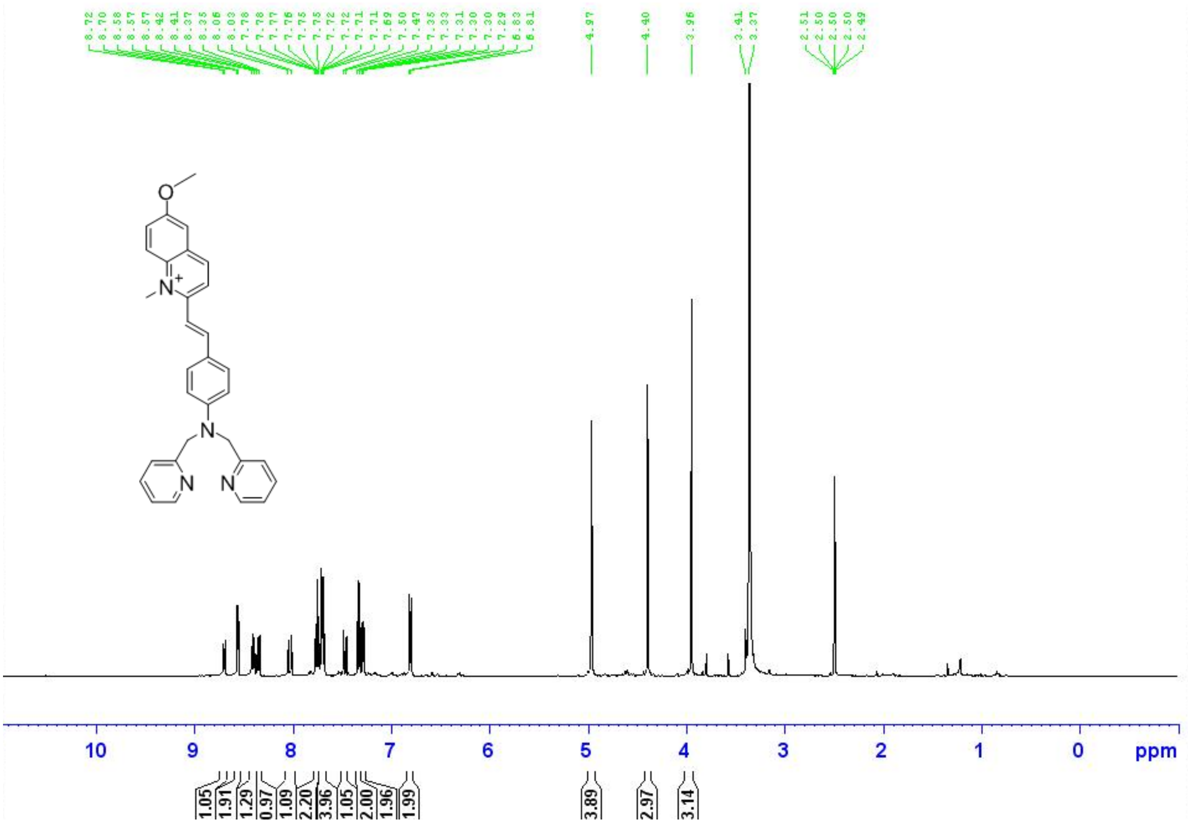
^{1}H NMR (500 MHz, DMSO-d_6): δ 4.42(3H, s), 4.99(4H, s), 6.83(2H, d, *J* = 8.96 Hz), 7.29-7.31(2H, m), 7.34(2H, d, *J* = 7.9 Hz), 7.51(1H, d, *J* = 15.5 Hz), 7.75-7.78(4H, m), 7.85(1H, t, *J* = 7.7 Hz), 8.08(1H, t, *J* = 7.7 Hz), 8.19(1H, d, *J* = 15.6 Hz), 8.26(1H, d, *J* = 7.8 Hz), 8.48-8.52(2H, m), 8.57-8.58(2H, m), 8.81(1H, d, *J* = 8.0 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 41.646, 56.715, 112.624, 118.878, 120.251, 121.309, 121.902, 122.399, 123.249, 126.935, 128.153, 128.699, 129.808, 130.771, 134.234, 136.892, 139.195, 148.376, 149.411, 151.422, 156.284, 157.885. HRMS (FAB): m/e calcd. For $C_{30}H_{27}N_4$ [M^+] 443.2236, found 443.2236.

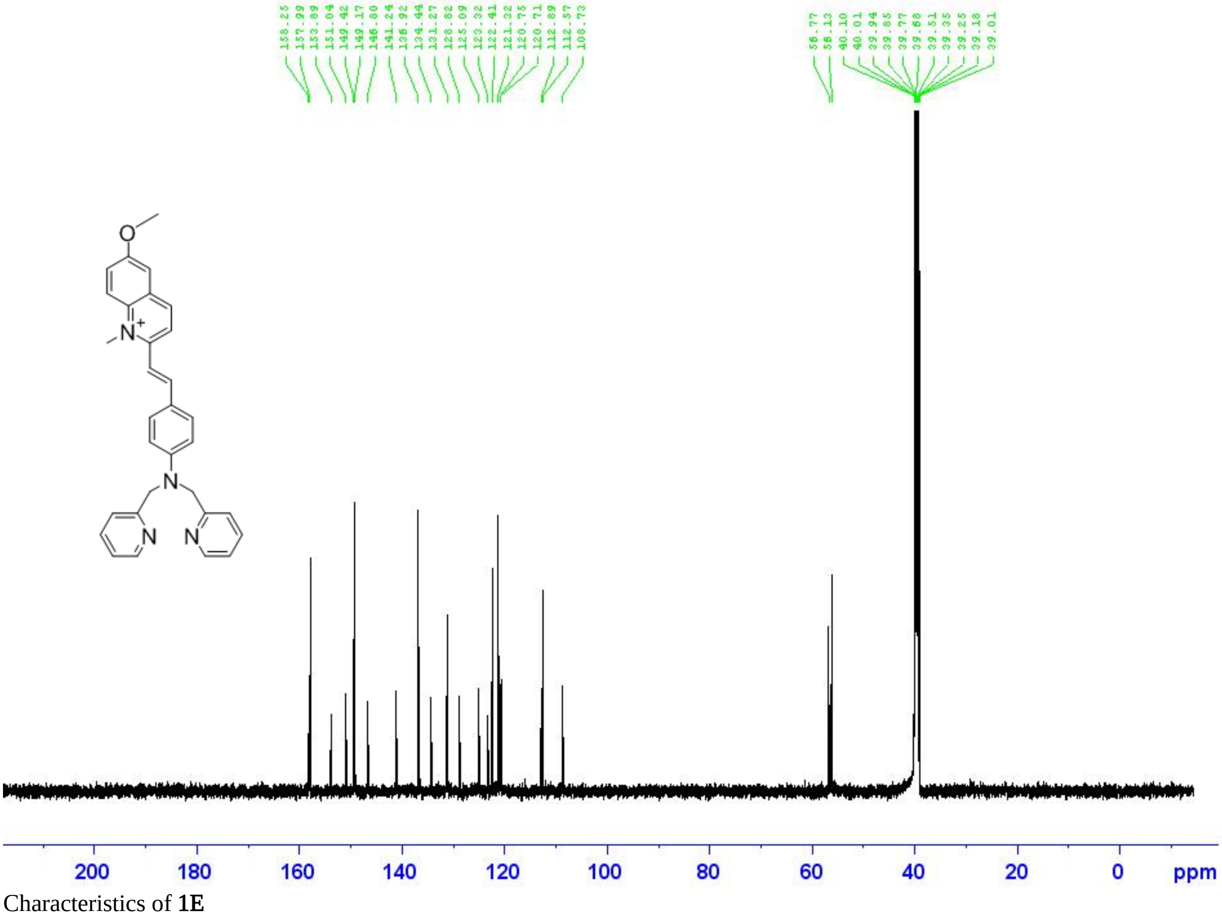




Characteristics of **1D**

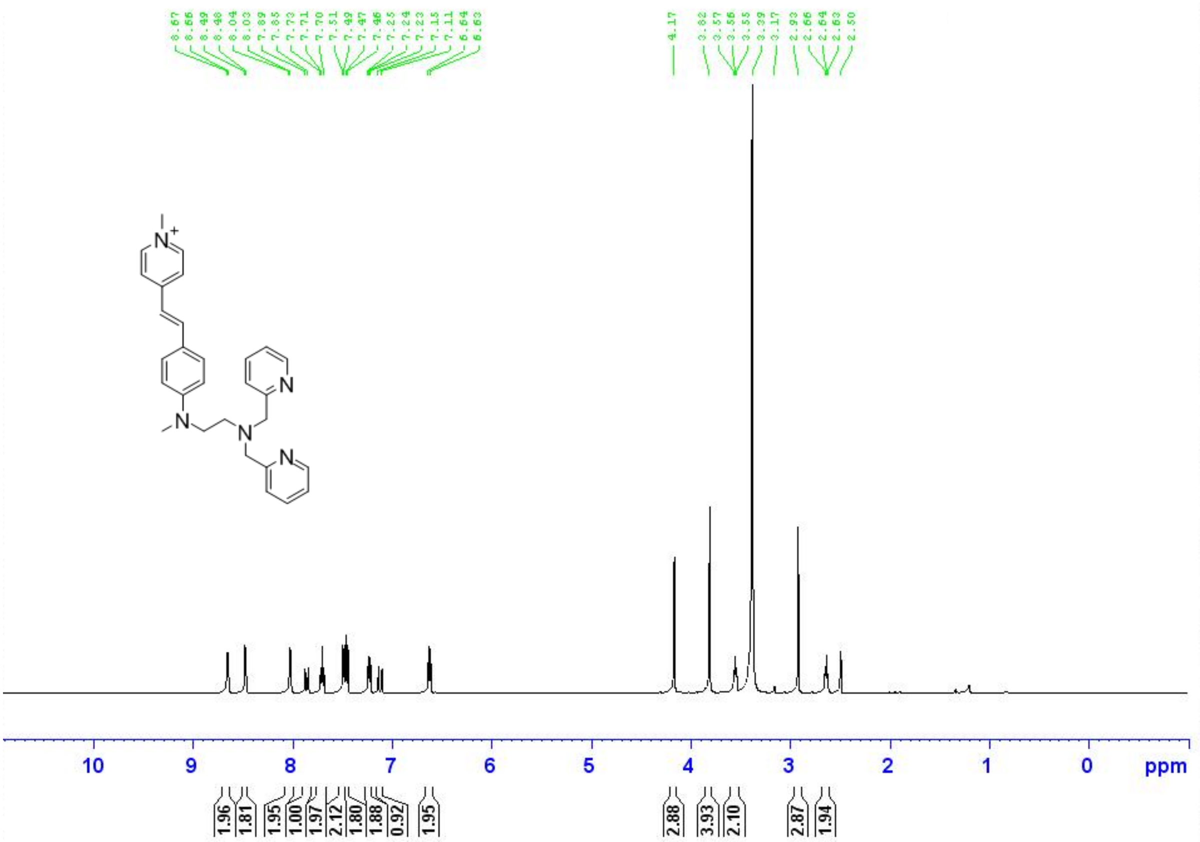
^{1}H NMR (500 MHz, DMSO-d_6): δ 4.44(3H, s), 4.98(4H, s), 6.81(2H, d, J = 8.89 Hz), 7.28-7.31(2H, m), 7.34(2H, d, J = 7.75 Hz), 7.75-7.78(4H, m), 7.95-7.98(2H, m), 8.07(1H, d, J = 15.5 Hz), 8.19(1H, t, J = 7.7 Hz), 8.32-8.34(2H, m), 8.57(2H, d, J = 3.87 Hz), 8.97(1H, d, J = 8.45 Hz), 9.12-9.13(1H, m). ^{13}C NMR (125 MHz, DMSO-d_6): δ 44.080, 56.767, 112.574, 113.877, 114.222, 119.044, 121.269, 122.357, 123.848, 125.800, 126.223, 128.635, 131.031, 134.633, 136.878, 138.750, 144.101, 146.966, 149.390, 150.644, 153.012, 158.080. HRMS (FAB): m/e calcd. For $C_{30}H_{27}N_4$ [M^+] 443.2236, found 443.2233.

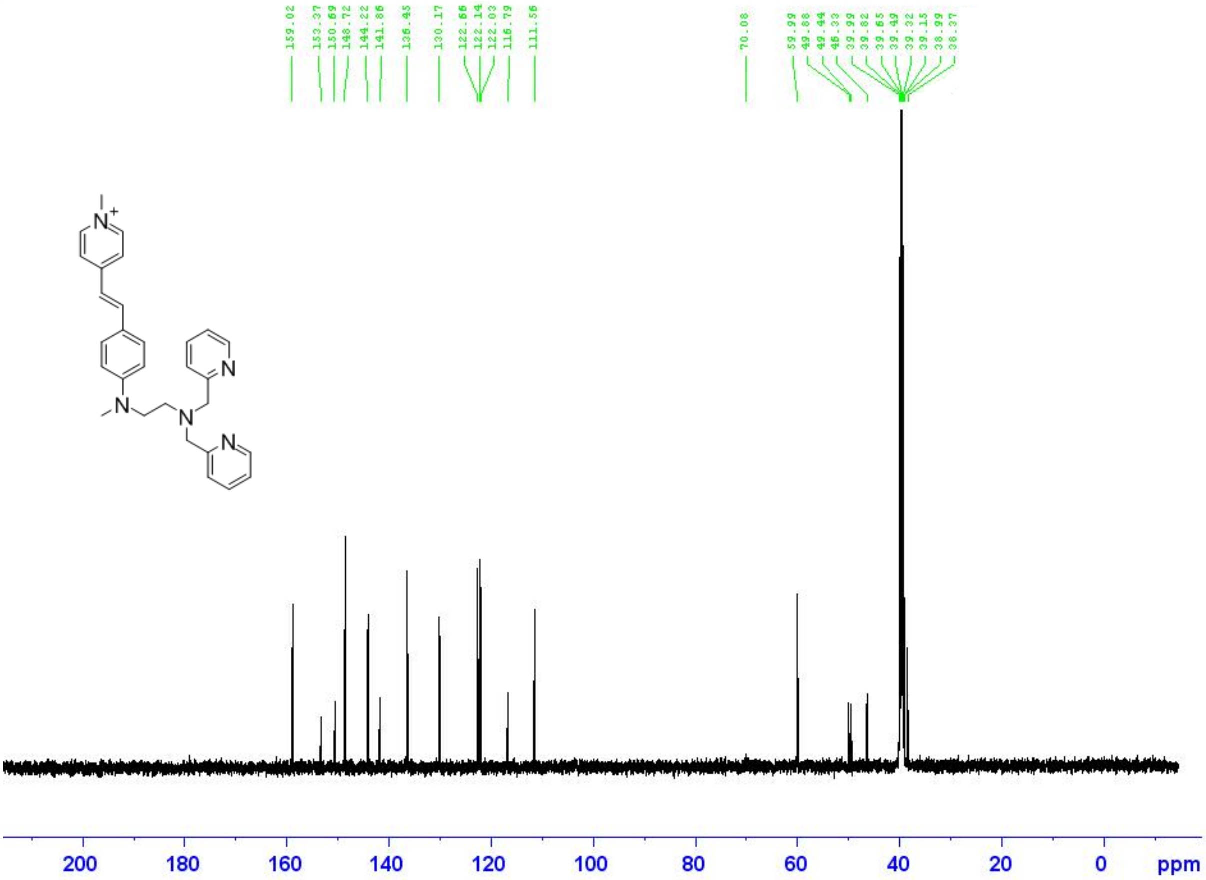




Characteristics of **1E**

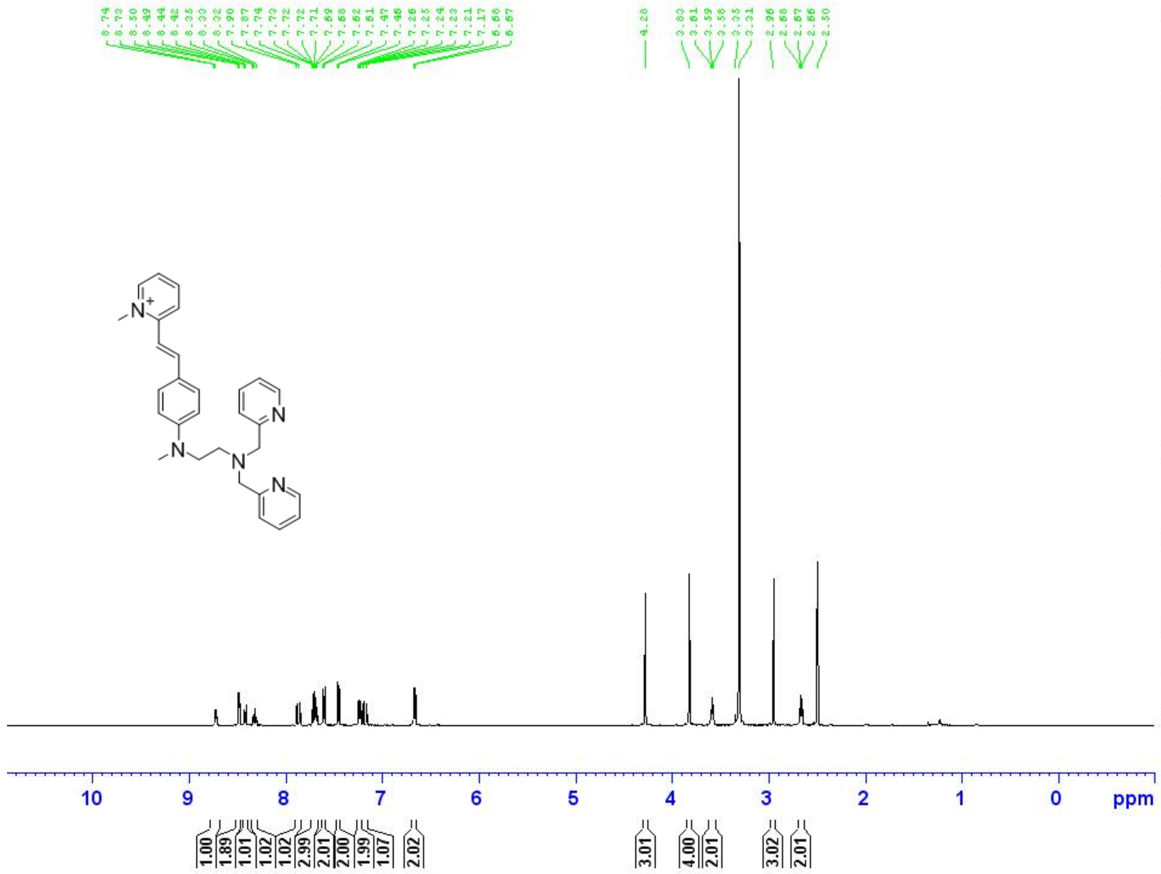
[1]H NMR (500 MHz, DMSO-d_6): δ 3.95(3H, s), 4.40(3H, s), 4.97(4H, s), 6.80(2H, d, J = 8.96 Hz), 7.28-7.31(2H, q, J_1 = 4.85 Hz, J_2 = 1.9 Hz), 7.33(2H, d, J = 7.76 Hz), 7.49(1H, d, J = 15 Hz), 7.71-7.72(4H, m), 7.75-7.78(2H, m), 8.03(1H, d, J = 15 Hz), 8.35-8.42(2H, m), 8.56-8.57(2H, m), 8.70(1H, d, J = 8.4 Hz). [13]C NMR (125 MHz, DMSO-d_6): δ 40.102, 56.134, 56.766, 108.729, 112.574, 112.890, 120.707, 120.751, 121.316, 122.415, 123.319, 125.094, 128.825, 131.267, 134.437, 136.923, 141.238, 146.799, 149.168, 149.422, 151.037, 153.888, 158.252. HRMS (FAB): m/e calcd. For $C_{31}H_{29}N_4O$ [M^+] 473.2341, found 473.2349.

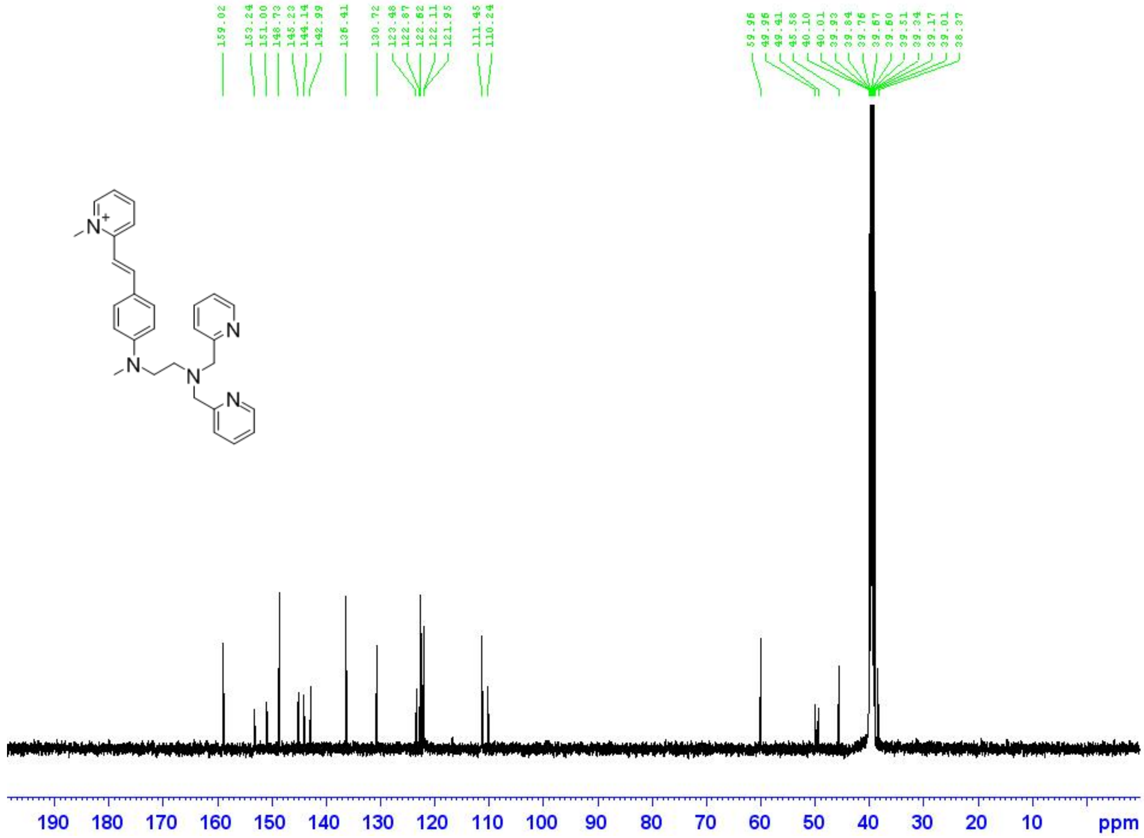




Characterization of 2A

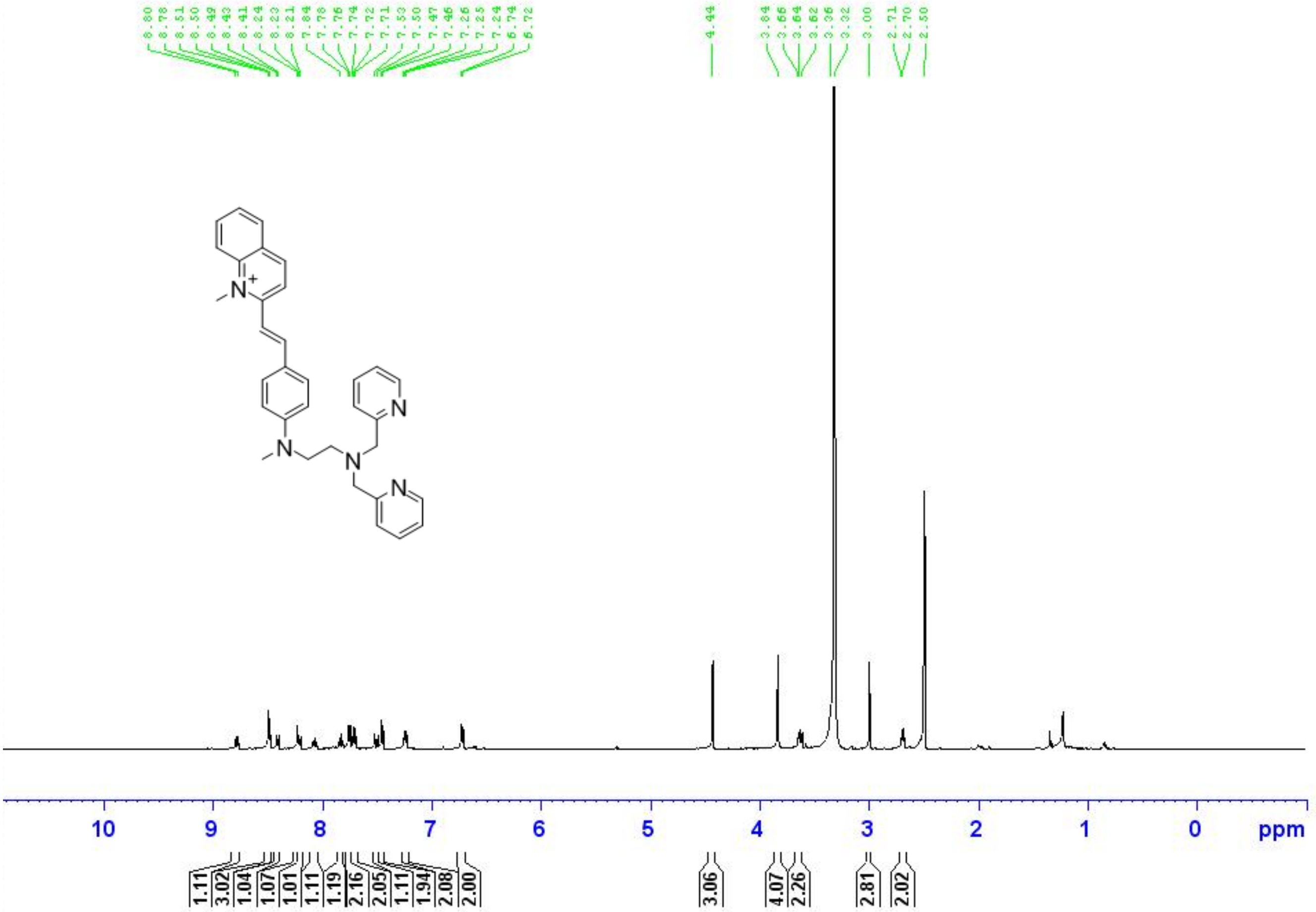
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.62 (2H, t, J = 6.7 Hz), 2.92 (3H, s), 3.55 (2H, t, J = 6.7 Hz), 3.81 (4H, s), 4.17 (3H, s), 6.62 (2H, d, J = 8.6 Hz), 7.11 (1H, d, J = 16.0 Hz), 7.22-7.25 (2H, m), 7.45-7.50 (4H, m), 7.69 (2H, t, J = 7.6 Hz), 7.85 (1H, d, J = 16.1 Hz), 8.02 (2H, d, J = 6.4 Hz), 8.48 (2H, d, J = 4.7 Hz), 8.65 (2H, d, J = 6.4 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 38.368, 46.333, 49.436, 49.882, 59.987, 111.560, 116.789, 122.032, 122.142, 122.655, 130.165, 136.452, 141.864, 144.217, 148.719, 150.686, 153.366, 159.024. HRMS (FAB): m/e calcd. For $C_{29}H_{32}N_5$ [M^+] 450.2658, found 450.2661.

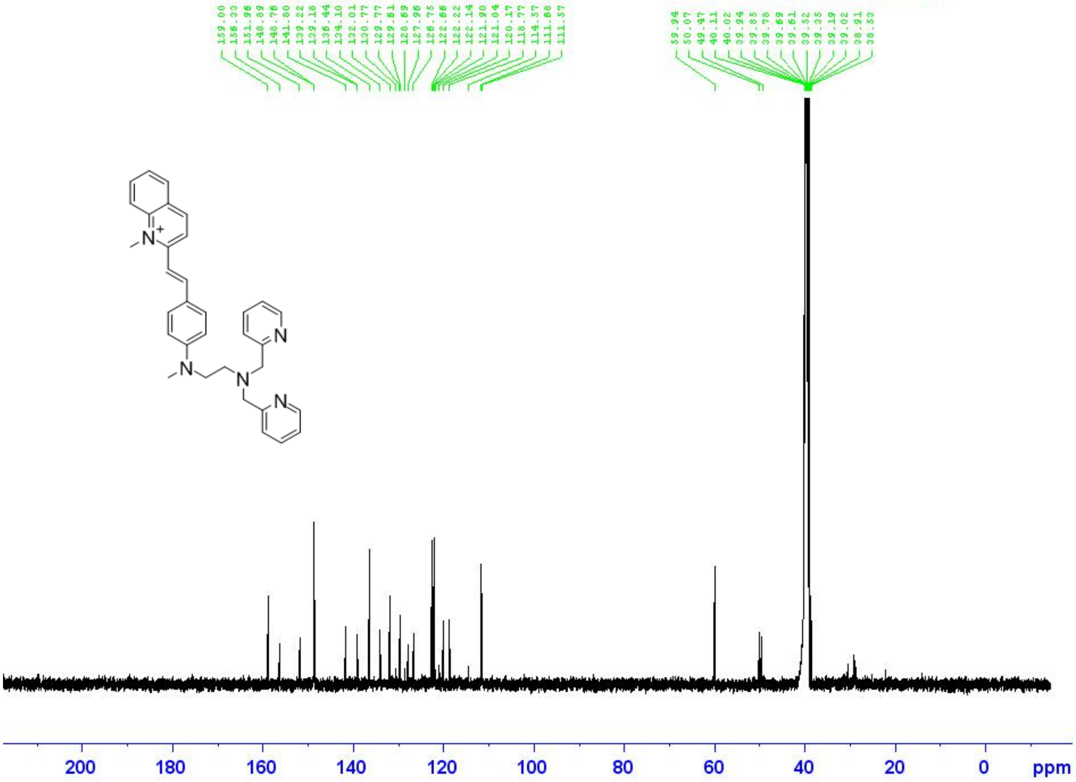




Characterization of 2B

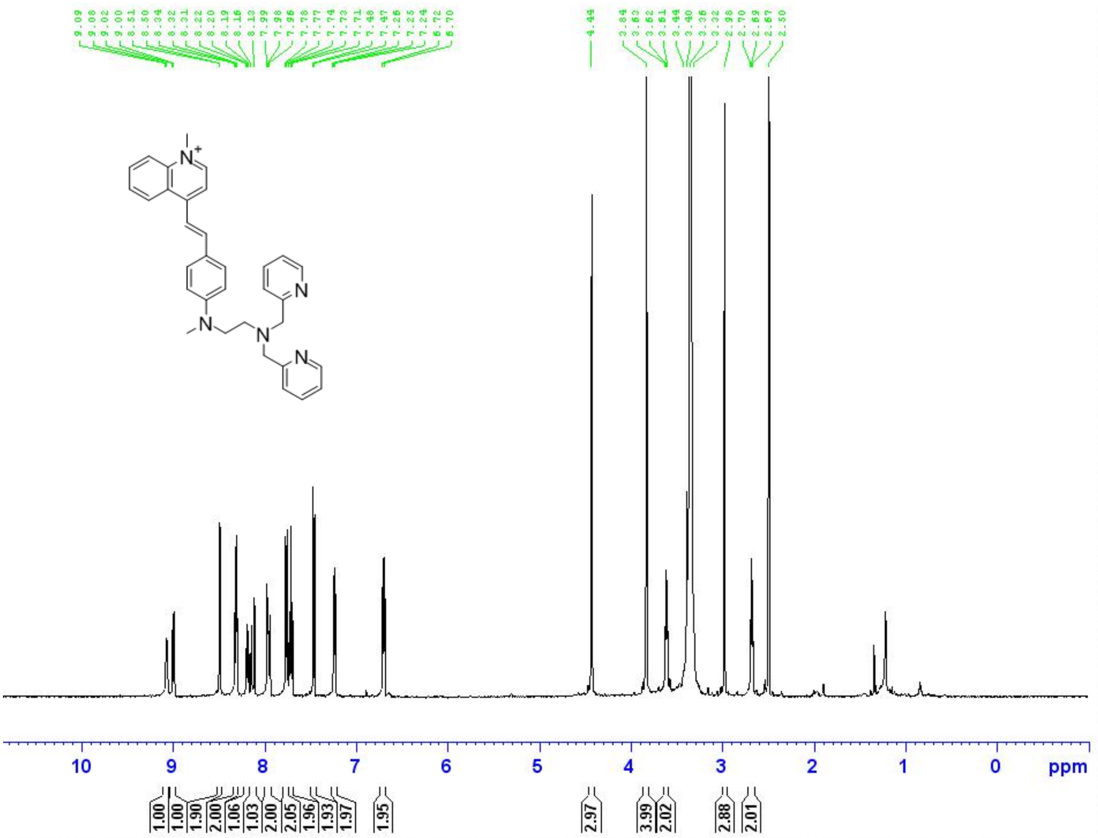
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.65 (2H, t, *J* = 6.7 Hz), 2.95 (3H, s), 3.57 (2H, t, *J* = 6.8 Hz), 3.83 (4H, s), 4.28 (3H, s), 6.67 (2H, d, *J* = 8.8 Hz), 7.17 (1H, d, *J* = 15.7 Hz), 7.23-7.25 (2H, m), 7.45 (2H, d, *J* = 7.6 Hz), 7.60 (2H, d, *J* = 8.7 Hz), 7.69-7.71 (3H, m), 7.86 (1H, d, *J* = 15.7 Hz), 8.33 (1H, m), 8.42 (1H, d, *J* = 7.6 Hz), 8.49 (2H, d, *J* = 4.1 Hz), 8.73 (1H, d, *J* = 6.4 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 38.369, 45.581, 49.407, 49.965, 59.955, 110.242, 111.446, 121.954, 122.112, 122.616, 122.872, 123.476, 130.719, 136.411, 142.986, 144.138, 145.229, 148.727, 151.000, 153.239, 159.025. HRMS (FAB): m/e calcd. For $C_{29}H_{32}N_5$ [M^+] 450.2658, found 450.2663.

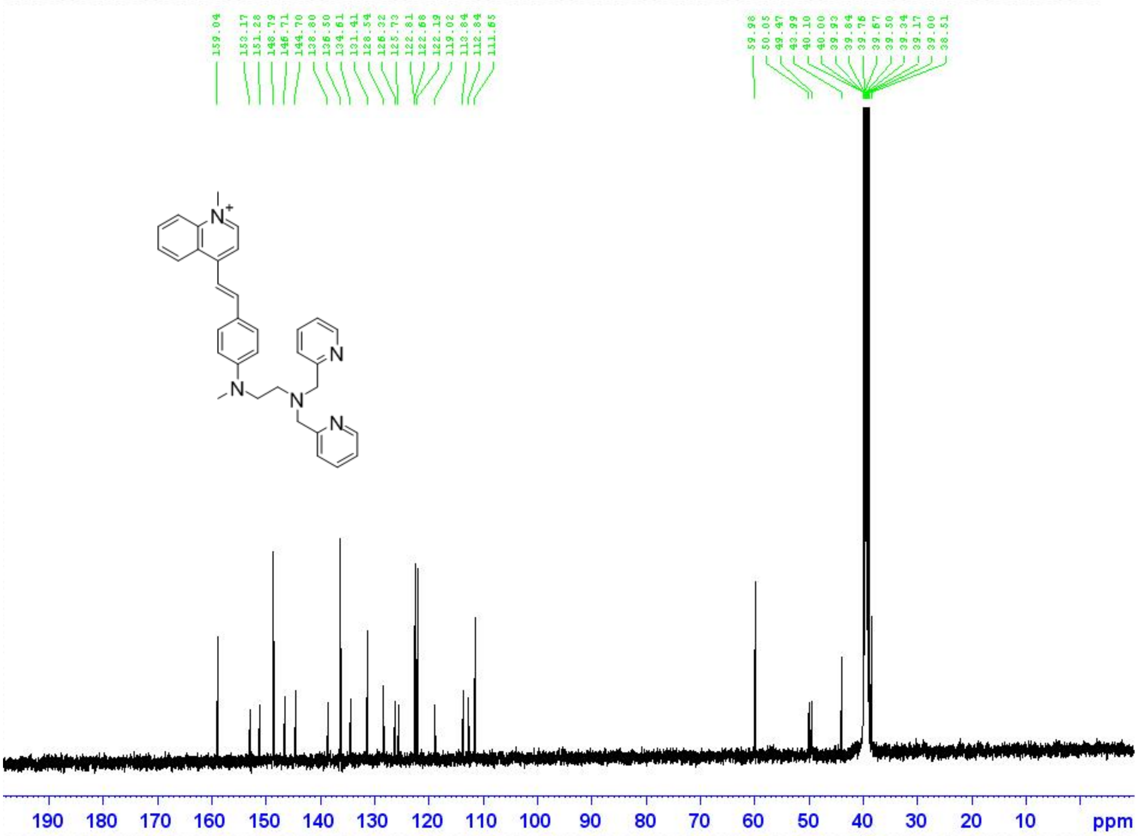




Characterization of 2C

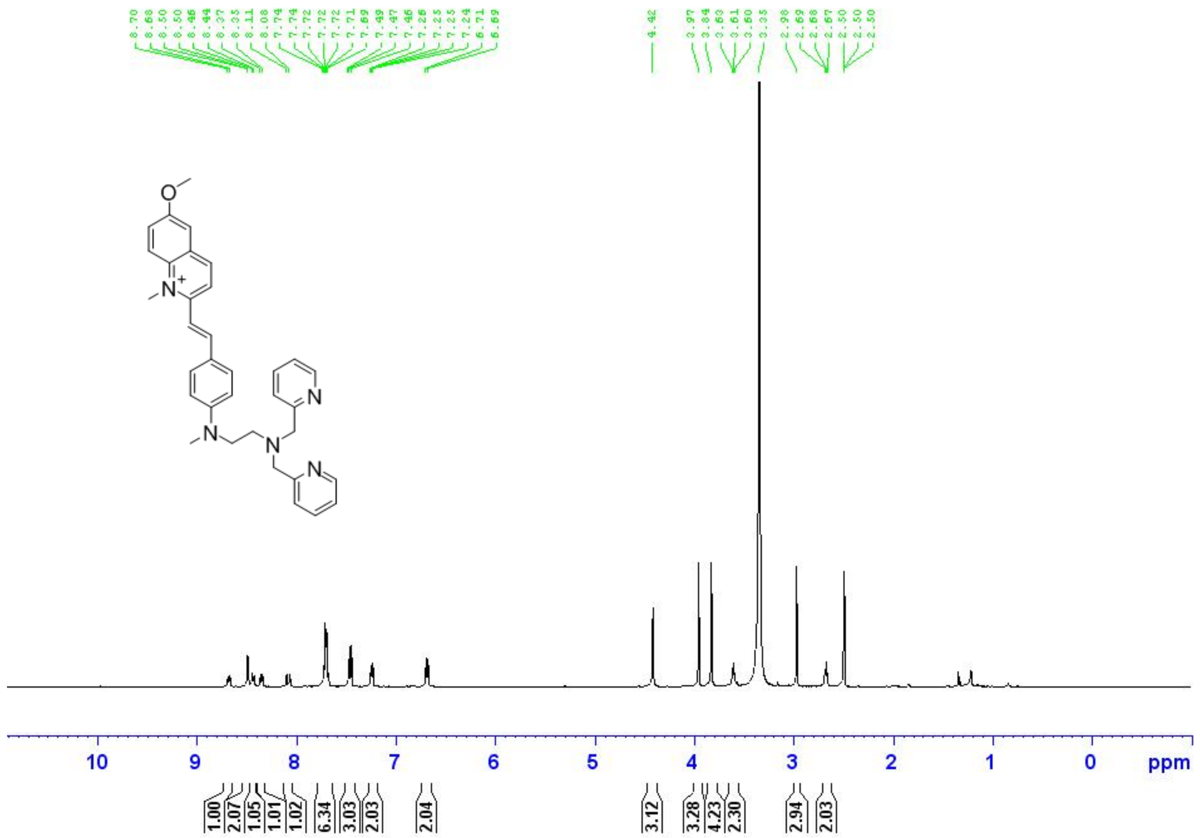
[1]H NMR (500 MHz, DMSO-d_6): δ 2.68 (2H, t, *J* = 6.6 Hz), 3.00 (3H, s), 3.61-3.65 (2H, m), 3.84 (4H, s), 4.43 (3H, s), 6.72 (2H, d, *J* = 8.7 Hz), 7.23-7.26 (2H, m), 7.45 (2H, d, *J* = 7.7 Hz), 7.50 (1H, d, *J* = 15.5 Hz), 7.70-7.77 (4H, m), 7.84 (1H, m), 8.21 (1H, t, *J* = 8.5 Hz), 8.41 (1H, d, *J* = 8.9 Hz), 8.48-8.50 (3H, m), 8.78 (1H, d, *J* = 6.7 Hz). [13]C NMR (125 MHz, DMSO-d_6): δ 38.535, 49.473, 50.068, 59.941, 111.574, 111.679, 118.769, 120.167, 122.143, 122.223, 122.658, 126.749, 127.958, 129.765, 132.014, 134.098, 136.436, 139.225, 141.796, 148.756, 148.887, 151.957, 156.332, 158.998 HRMS (FAB): m/e calcd. For $C_{33}H_{34}N_5$ [M^+] 500.2814, found 500.2818.

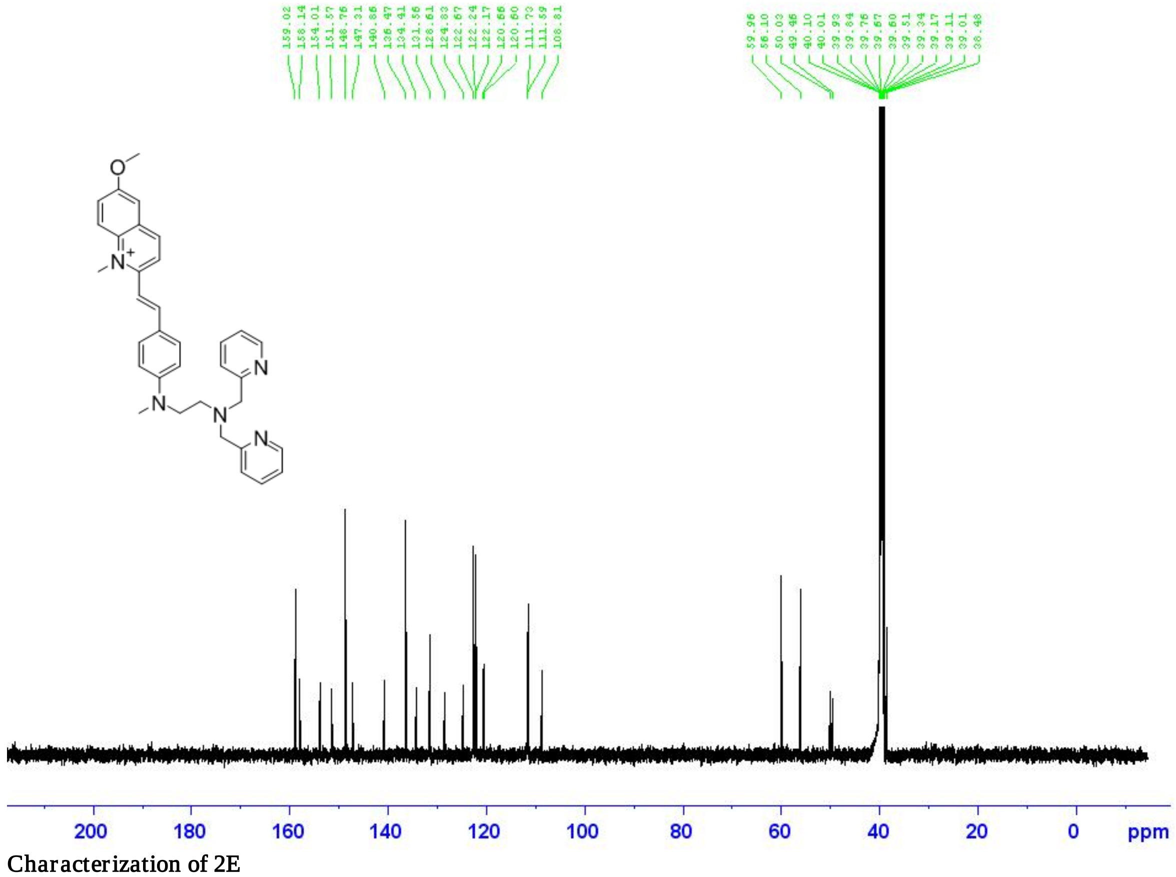




Characterization of 2D

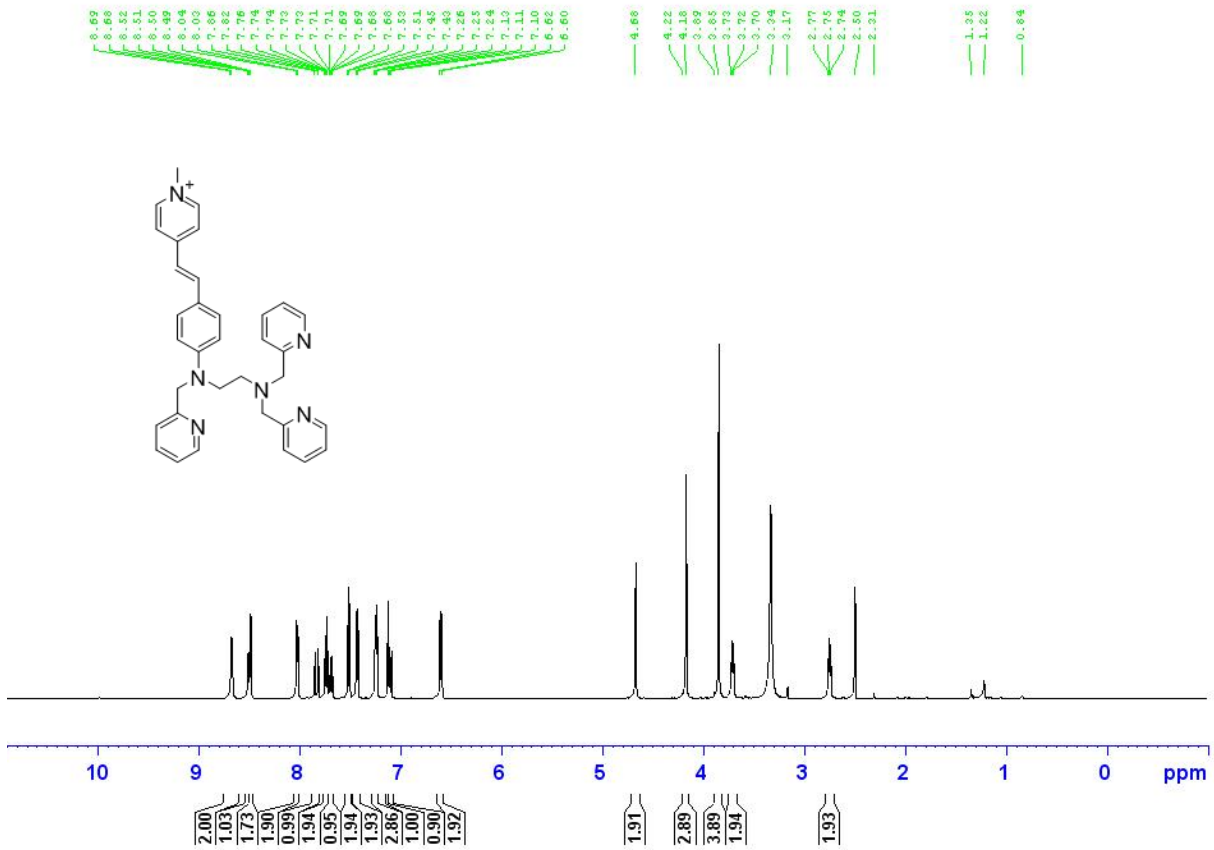
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.67 (2H, t, J = 6.7 Hz), 2.98 (3H, s), 3.60 (2H, t, J = 6.7 Hz), 3.84 (4H, s), 4.43 (3H, s), 6.70 (2H, d, J = 8.7 Hz), 7.23 (2H, d, J = 6.3 Hz), 7.46 (2H, d, J = 7.7 Hz), 7.71-7.74 (4H,m), 7.76 (2H, d, J = 8.6 Hz), 7.95-7.98 (2H, m), 8.12-8.20 (2H, m), 8.31-8.34 (2H, m), 8.49 (2H, d, J = 4.5 Hz), 9.00 (1H, d, J = 8.6 Hz) 9.11 (1H, d, J = 6.4 Hz). ^{13}C NMR (125 MHz, DMSO-d_6) δ 38.505, 43.985, 49.471, 50.053, 59.980, 111.650, 112.840, 113.836, 119.016, 122.194, 122.684, 122.813, 125.734, 126.319, 128.539, 131.412, 134.606, 136.498, 138.802, 144.704, 146.713, 148.787, 151.278, 153.172, 159.041. HRMS (FAB): m/e calcd. For $C_{33}H_{34}N_5$ [M^+] 500.2814, found 500.2817.

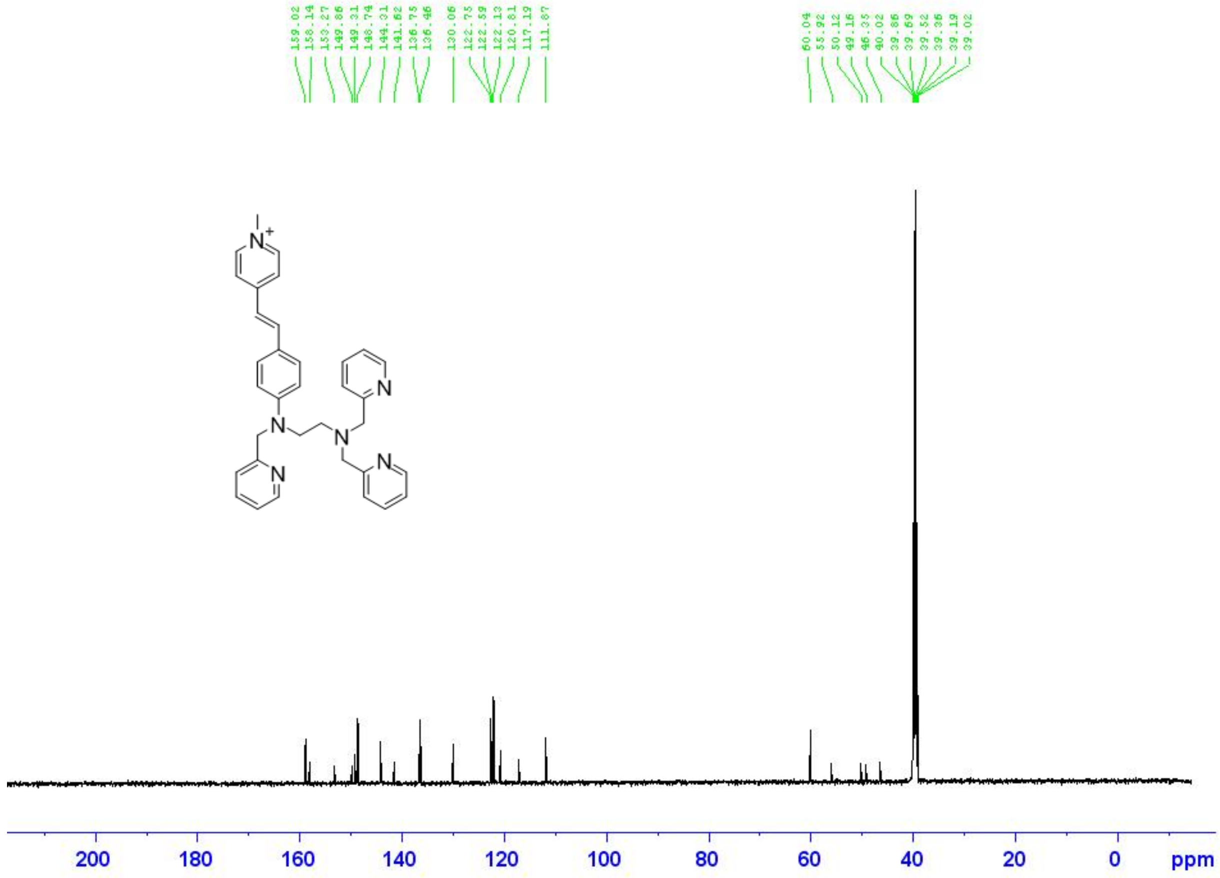




Characterization of 2E

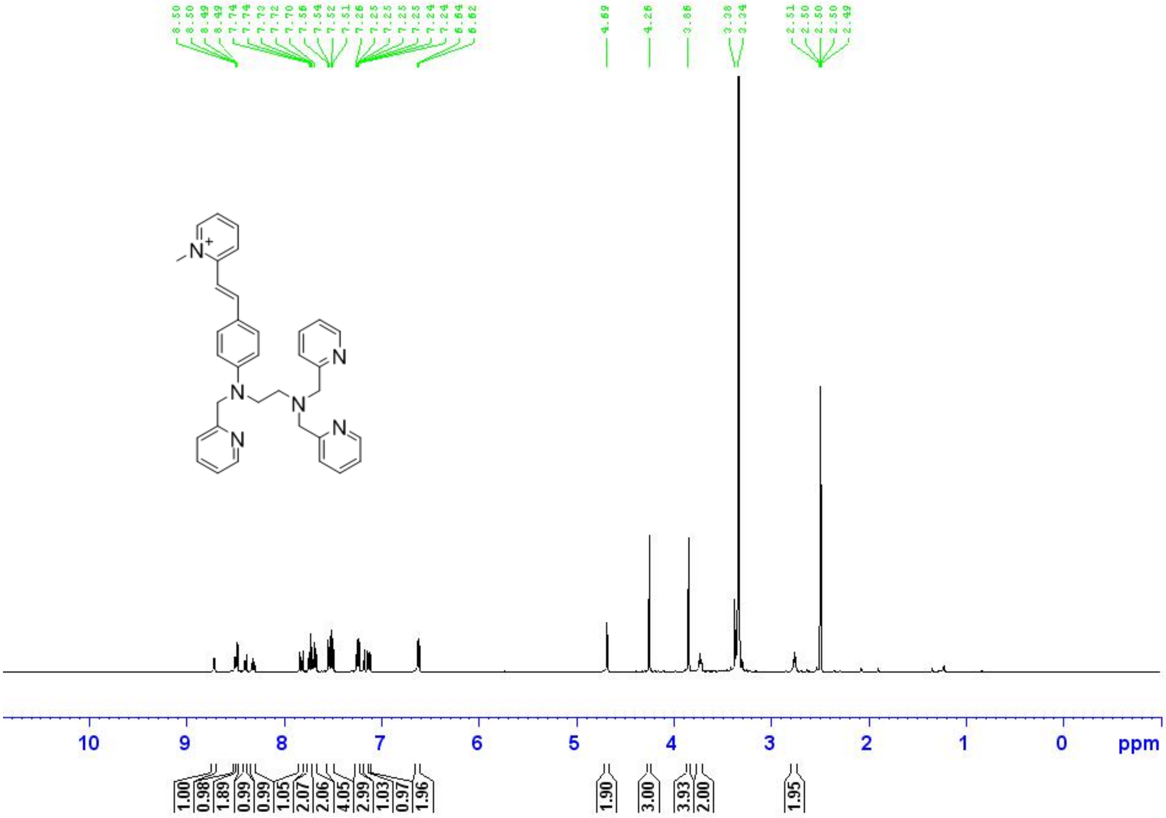
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.66 (2H, t, J = 6.7 Hz), 2.97 (3H, s), 3.59 (2H, t, J = 6.7 Hz), 3.83 (4H, s), 3.96 (3H, s), 4.42 (3H, s), 6.68 (2H, d, J = 8.7 Hz), 7.23 (2H, q, J_1 = 5.21 Hz), 7.45 (3H, m), 7.69-7.74 (6H, m), 8.07 (1H, d, J = 15 Hz), 8.35 (1H, d, J = 9.3 Hz), 8.45 (1H, d, J = 7.5 Hz), 8.49 (2H, d, J = 4.4 Hz), 8.68 (1H, d, J = 9.3 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 38.484, 49.458, 50.034, 56.098, 59.962, 108.808, 111.589, 111.726, 120.598, 120.656, 122.166, 122.236, 122.672, 124.827, 128.612, 131.562, 134.408, 136.469, 140.858, 147.305, 148.764, 151.574, 154.010, 158.143, 159.016. HRMS (FAB): m/e calcd. for $C_{34}H_{36}N_5O$ [M^+] 530.2920, found 530.2911.

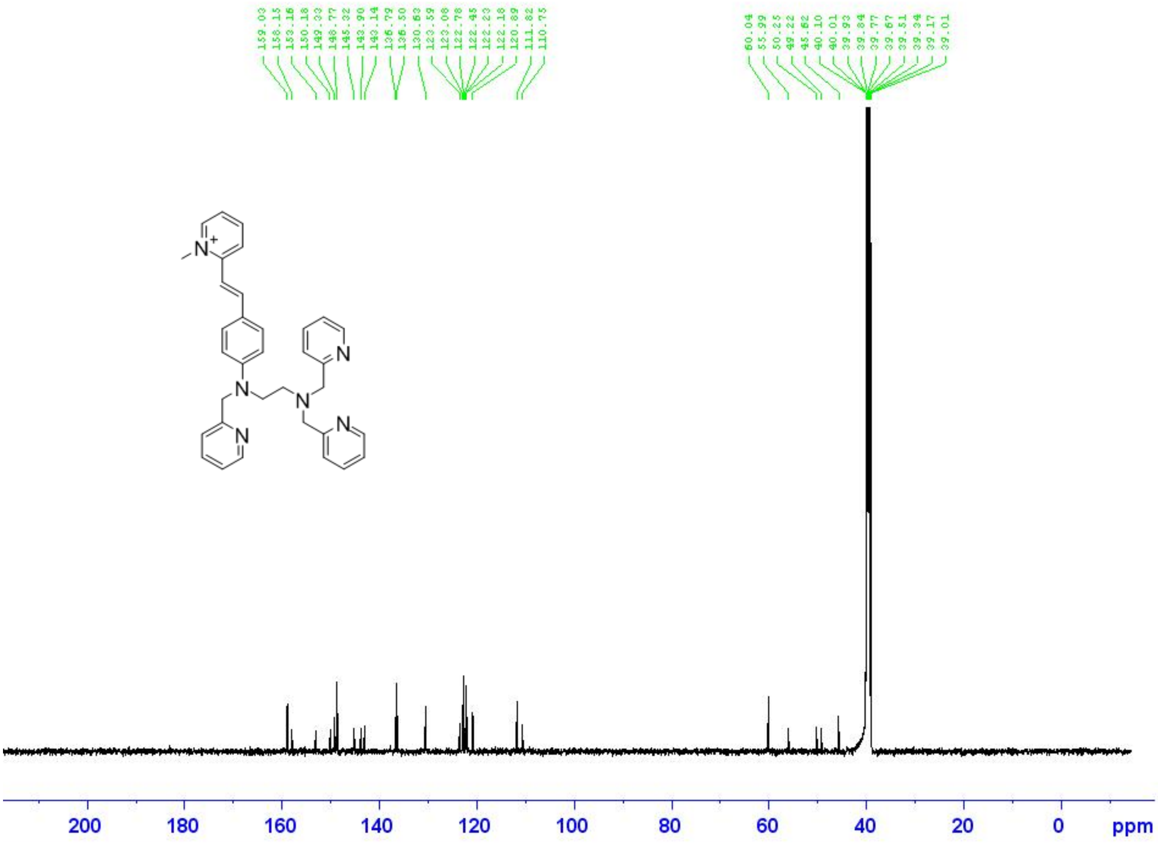




Characterization of 3A

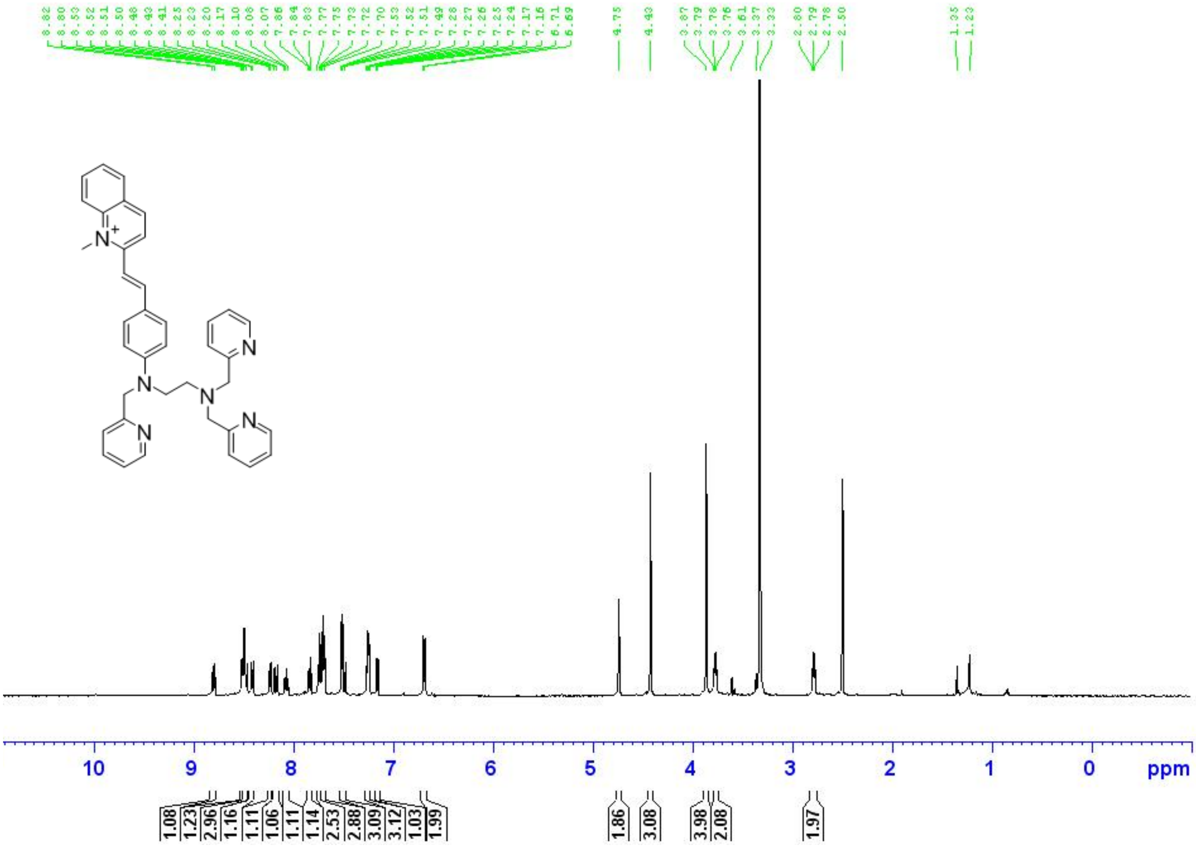
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.73 (2H, t, J = 7.0 Hz), 3.70 (2H, t, J = 7.1 Hz), 3.85 (4H, s), 4.17 (3H, s), 4.67 (2H, s), 6.61 (2H, d, J = 8.8 Hz), 7.09-7.12 (2H, m), 7.23-7.26 (3H, m), 7.42 (2H, d, J = 8.7 Hz), 7.51 (2H, d, J = 7.6 Hz), 7.72-7.74 (3H, m), 7.82 (1H, d, J =15 Hz), 8.02 (2H, d, J = 6.4 Hz), 8.49-8.52 (3H, m), 8.68 (2H, d, J = 6.3 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 46.350, 49.158, 50.122, 55.917, 60.043, 111.865, 117.194, 120.811, 122.134, 122.589, 122.754, 130.058, 136.457, 136.747, 141.619, 144.308, 148.740, 149.306, 149.858, 153.275, 158.144, 159.025. HRMS (FAB): m/e calcd. for $C_{34}H_{35}N_6$ [M^+] 527.2923, found 527.2916.

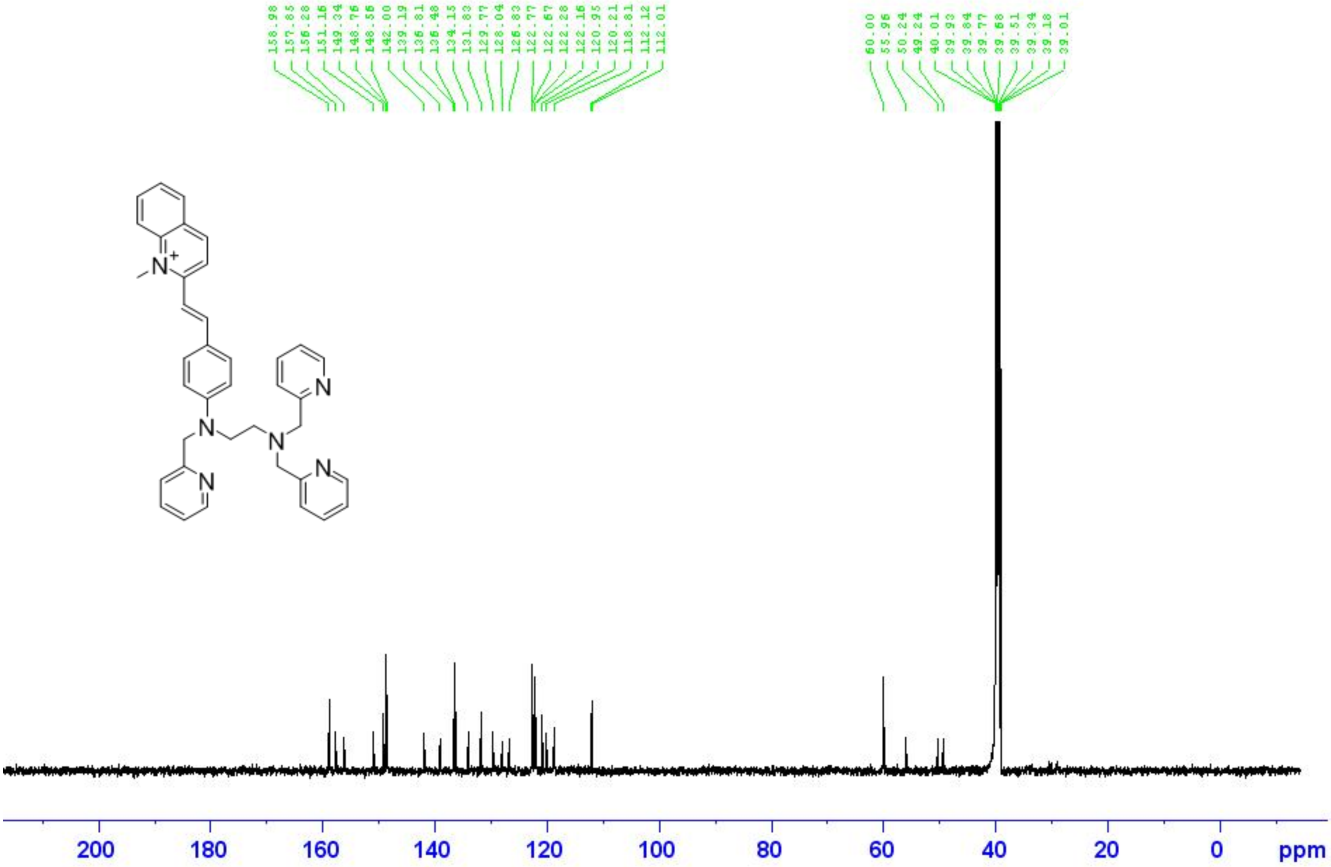




Characterization of 3B

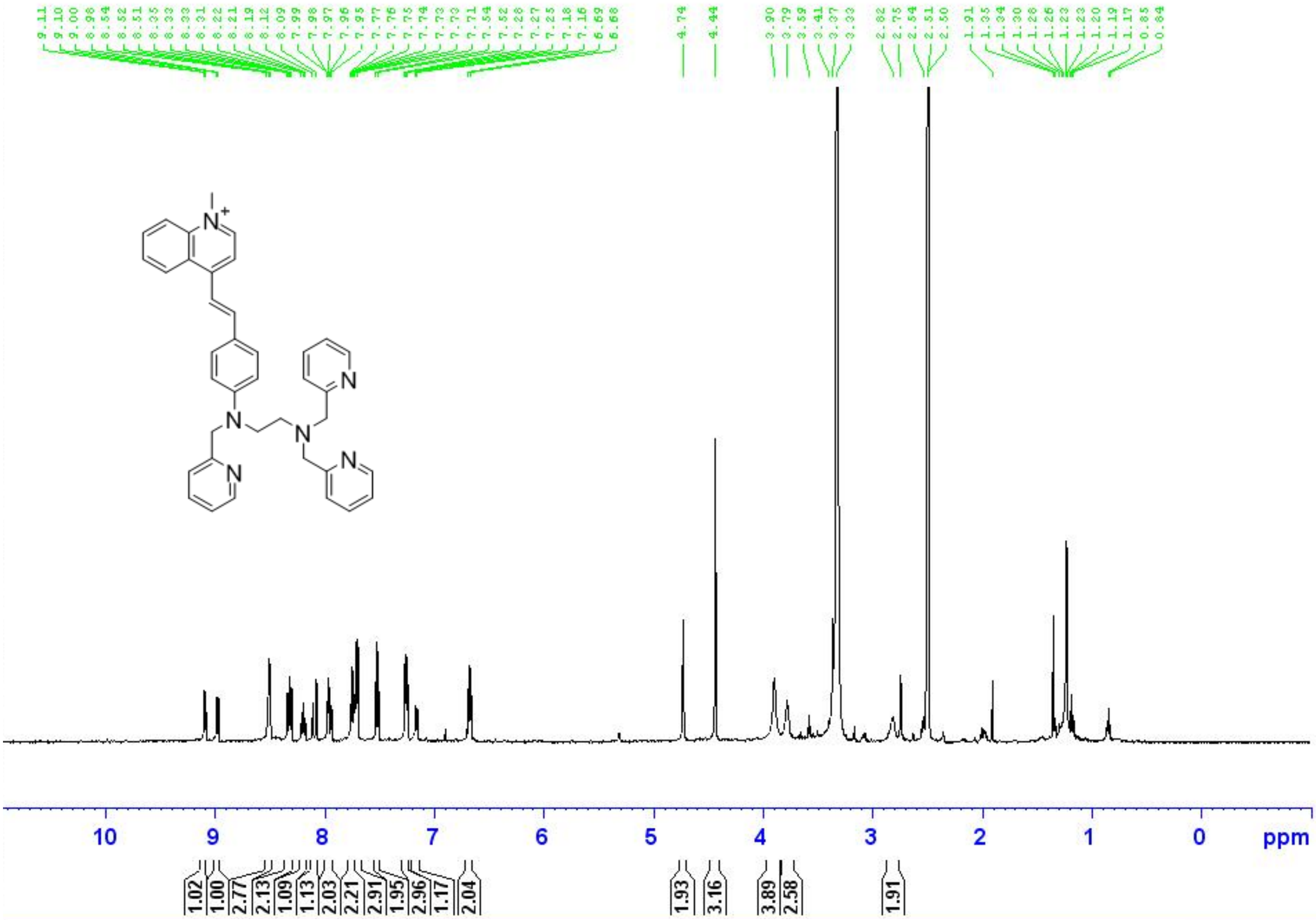
[1]H NMR (500 MHz, DMSO-d_6): δ 2.75 (2H, t, J = 6.99 Hz), 3.72 (2H, t, J = 7.1 Hz), 3.85 (4H, s), 4.25 (3H, s), 4.69 (2H, s), 6.62 (2H, d, J = 9.0 Hz), 7.12-7.18 (2H, m), 7.23-7.26 (3H, m), 7.50-7.55 (4H, m), 7.68-7.75 (4H, m), 7.81 (1H, d, J = 15.7 Hz), 8.32 (1H, t, J = 7.2 Hz), 8.39 (1H, d, J = 9.3 Hz), 8.48-8.52 (3H, m), 8.72 (1H, d, J = 6.2 Hz). [13]C NMR (125 MHz, DMSO-d_6): δ 45.619, 49.225, 50.255, 55.991, 60.043, 110.754, 111.816, 120.888, 122.179, 122.229, 122.451, 122.777, 123.084, 123.587, 130.627, 136.502, 136.789, 143.135, 143.900, 145.317, 148.772, 149.334, 150.177, 153.160, 158.147, 159.034. HRMS (FAB): m/e calcd. for $C_{34}H_{35}N_6$ [M^+] 527.2923, found 527.2924.

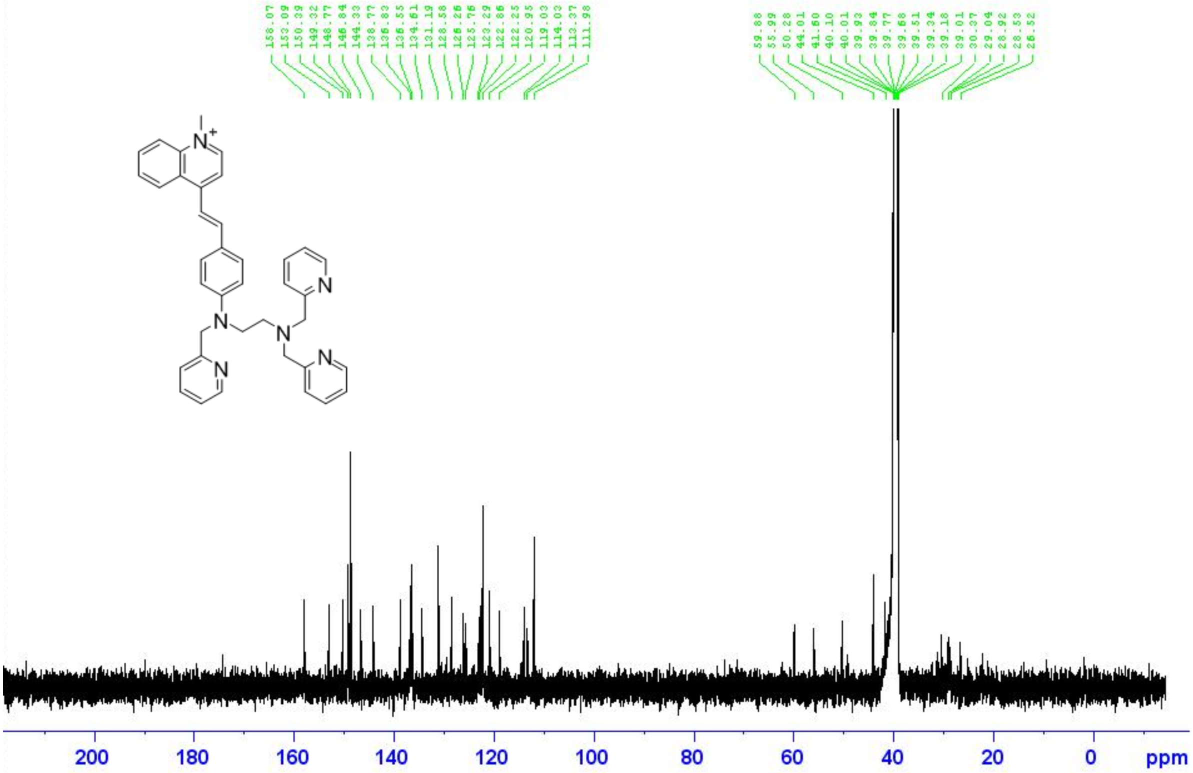




Characterization of 3C

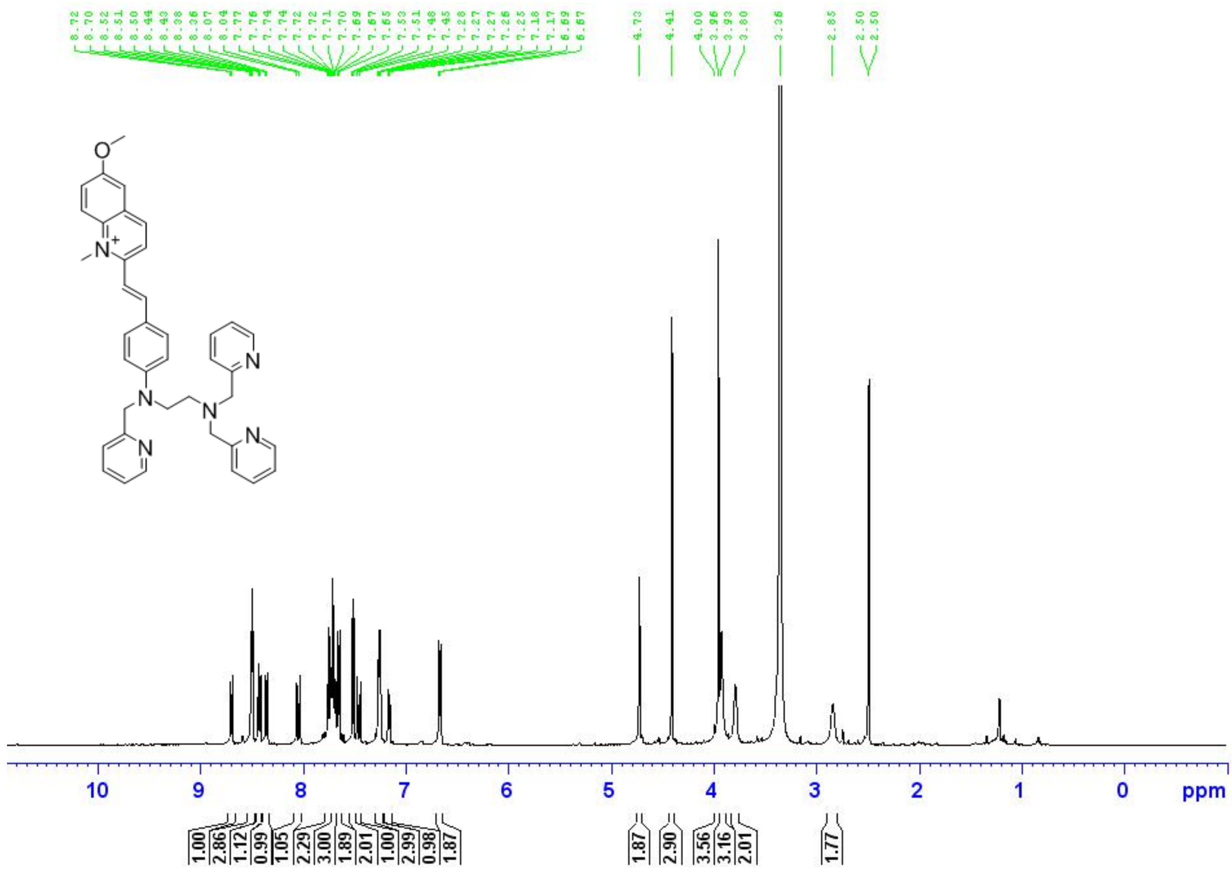
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.77 (2H, t, J = 6.9 Hz), 3.76 (2H, t, J = 6.9 Hz), 3.86 (4H, s), 4.42 (3H, s), 4.74 (2H, s), 6.68 (2H, d, J = 8.8 Hz), 7.15 (1H, d, J = 7.9 Hz), 7.24-7.26 (3H, m), 7.51-7.52 (3H, m), 7.69-7.74 (4H, m), 7.84 (1H, m), 8.10 (1H, t, J = 7.5 Hz), 8.18 (1H, d, J = 15 Hz), 8.23 (1H, d, J = 7.3 Hz), 8.41 (1H, d, J = 7.2 Hz), 8.50-8.53 (4H, m), 8.80 (1H, d, J = 6.3 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 49.240, 50.237, 55.965, 59.996, 112.010, 112.123, 118.814, 120.208, 120.954, 122.161, 122.279, 122.666, 122.766, 126.827, 128.037, 129.773, 131.826, 134.152, 136.478, 136.810, 139.193, 141.999, 148.565, 148.763, 149.345, 151.161, 156.278, 157.851, 158.976. HRMS (FAB): m/e calcd. for $C_{38}H_{37}N_6$ [M^+] 577.3080, found 577.3074.

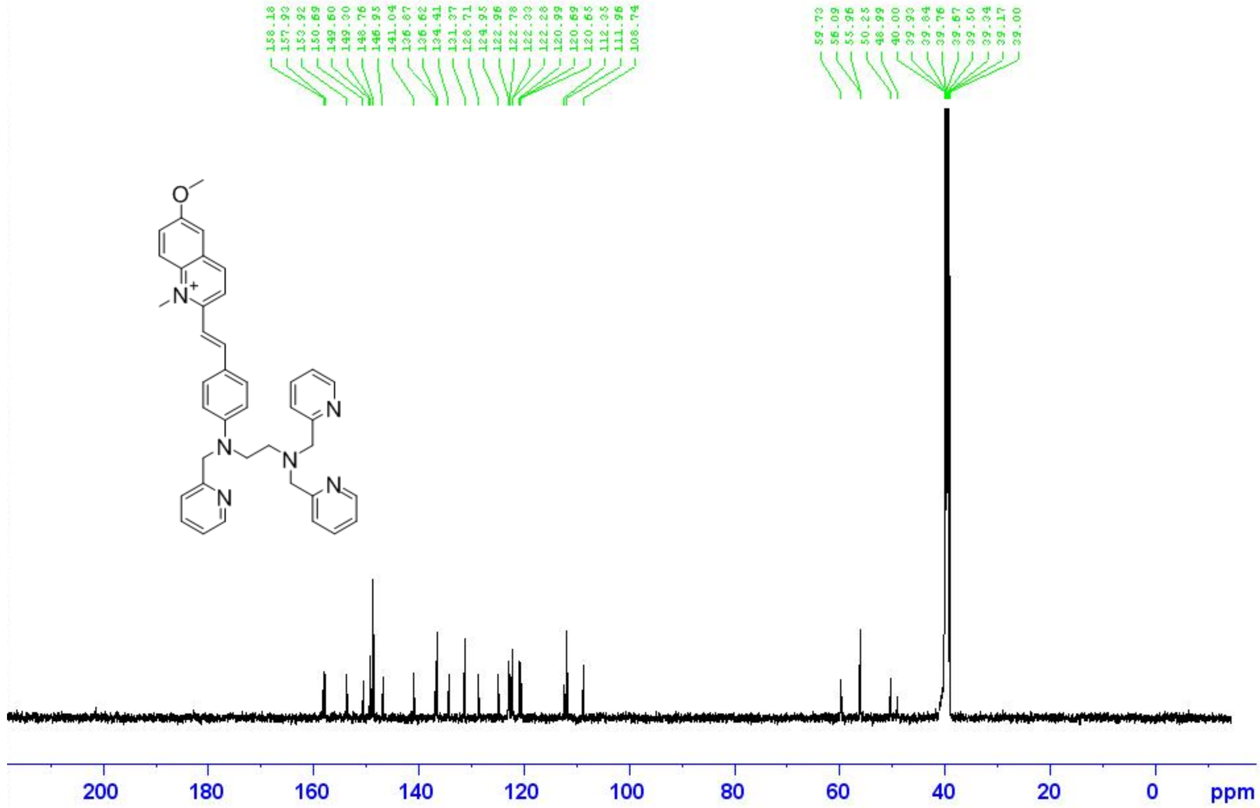




Characterization of 3D

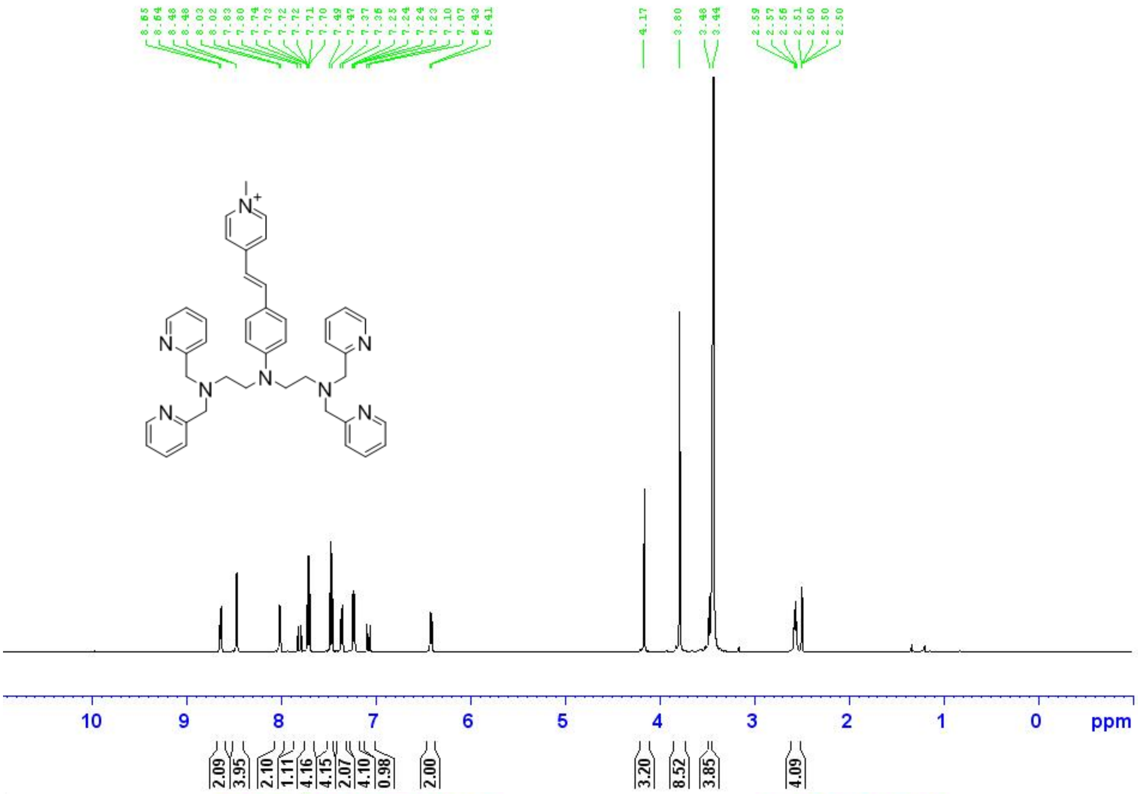
[1]H NMR (500 MHz, DMSO-d_6): δ 2.82 (2H, t, J = 6.9 Hz), 3.78 (2H, t, J = 6.9 Hz), 3.90 (4H, s), 4.44 (3H, s), 4.74 (2H, s), 6.68 (2H, d, J = 8.8 Hz), 7.19 (1H, d, J = 6.8 Hz), 7.25-7.27 (3H, m), 7.52 (2H, d, J = 7.8 Hz), 7.70-7.76 (5H, m), 7.97-7.98 (2H, m), 8.08 (1H, d, J = 15 Hz), 8.13 (1H, t, J = 7.2 Hz), 8.31-8.35 (2H, m), 8.50-8.53 (3H, m), 8.99 (1H, d, J = 7.8 Hz), 9.10 (1H, d, J = 6.7 Hz). [13]C NMR (125 MHz, DMSO-d_6): δ 41.597, 44.005, 50.276, 55.993, 59.879, 111.978, 113.366, 114.025, 119.028, 120.947, 122.250, 122.864, 123.292, 125.763, 126.256, 128.577, 131.188, 134.606, 136.554, 136.827, 138.773, 144.334, 146.841, 148.774, 149.317, 150.388, 153.086, 158.067. HRMS (FAB): m/e calcd. for $C_{38}H_{37}N_6$ [M^+] 577.3080, found 577.3087.

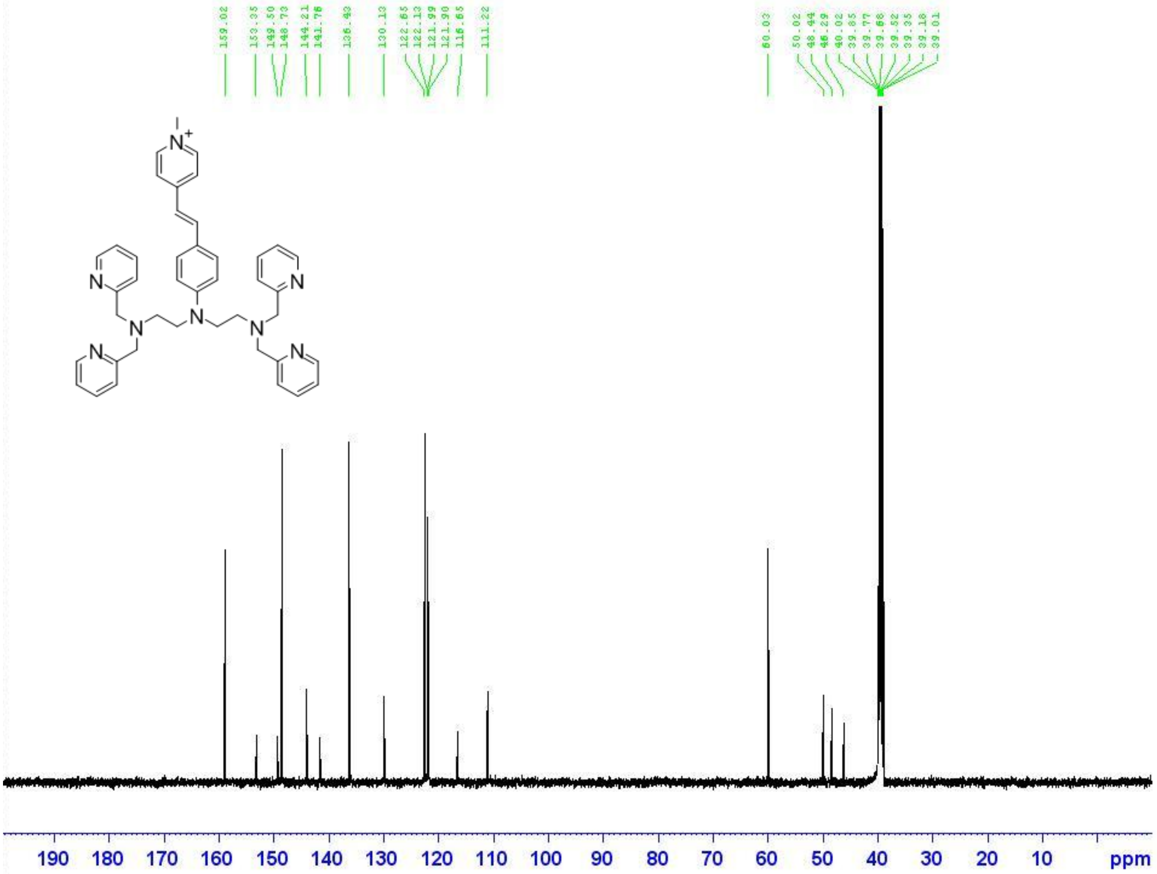




Characterization of 3E

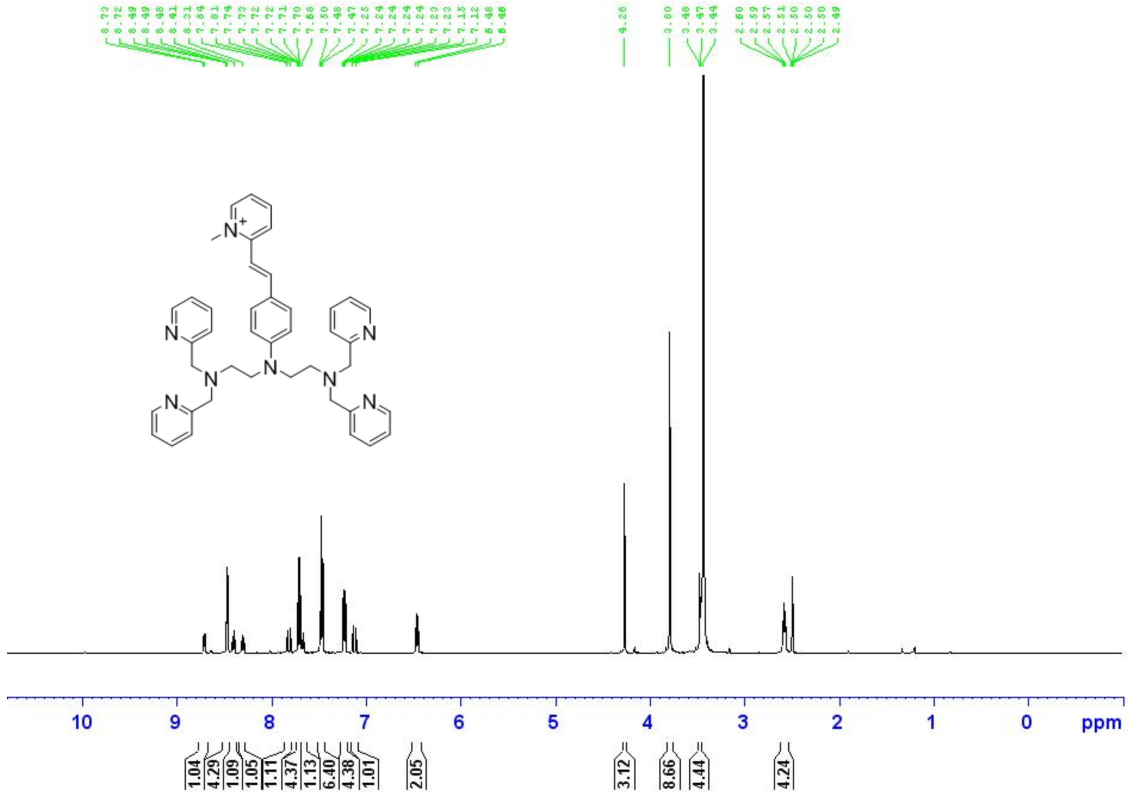
^{1}H NMR (500 MHz, DMSO-d$_6$): δ 2.85 (2H, t, J = 6.9 Hz), 3.80 (2H, t, J = 6.7 Hz), 3.93-4.00 (7H, m), 4.41 (3H, s), 4.73 (2H, s), 6.67 (2H, d, J = 8.7 Hz), 7.18 (1H, d, J = 8.3 Hz), 7.25-7.28 (3H, m), 7.41 (1H, d, J = 15 Hz), 7.51-7.52 (2H, m), 7.65-7.75 (8H, m), 8.04 (1H, d, J = 15 Hz), 8.35 (1H, d, J = 9.0 Hz), 8.42 (1H, d, J = 9.1 Hz), 8.49-8.52 (3H, m), 8.70 (1H, d, J = 6.8 Hz). ^{13}C NMR (125 MHz, DMSO-d$_6$): δ 48.995, 50.248, 55.959, 56.093, 59.733, 108.742, 111.960, 112.352, 120.651, 120.690, 120.994, 122.284, 122.331, 122.777, 122.965, 124.950, 128.710, 131.366, 134.409, 136.622, 136.870, 141.041, 146.949, 148.759, 149.300, 149.603, 150.693, 153.918, 157.932, 158.183. HRMS (FAB): m/e calcd. for $C_{39}H_{39}N_6O[M^+]$ 607.3185, found 607.3179.

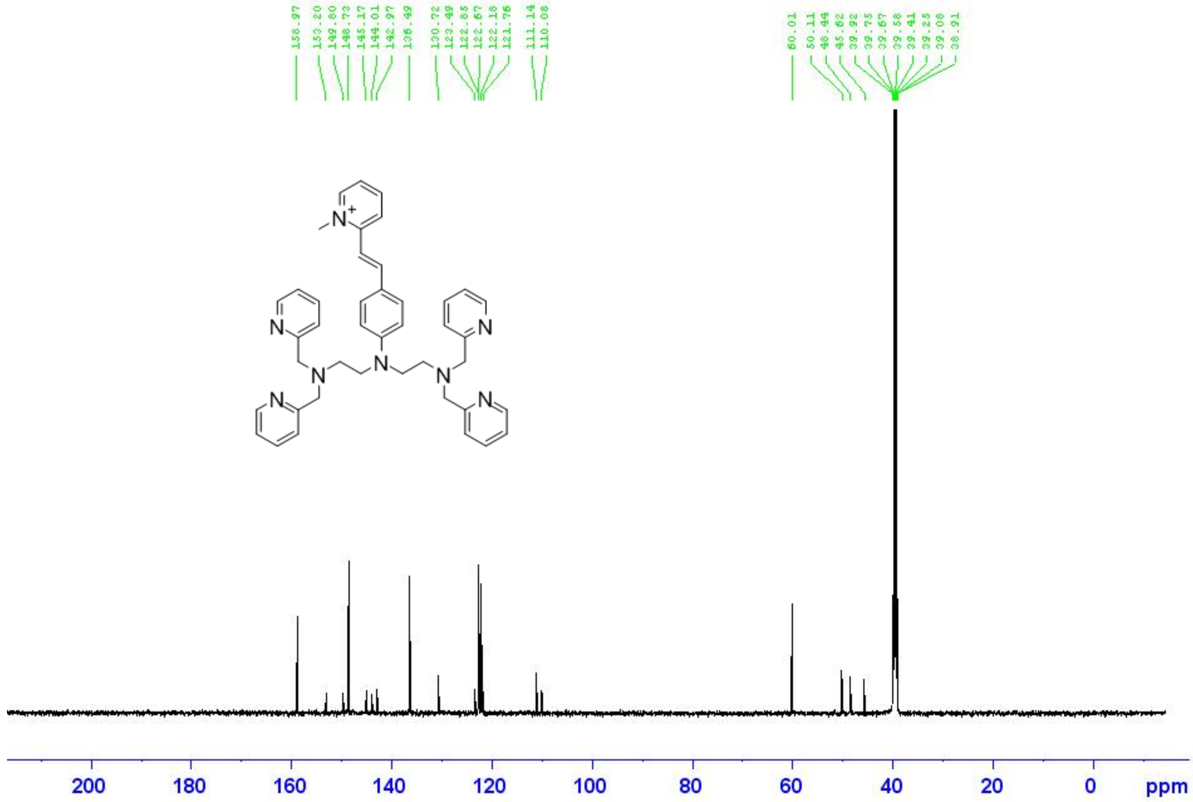




Characterization of 4A

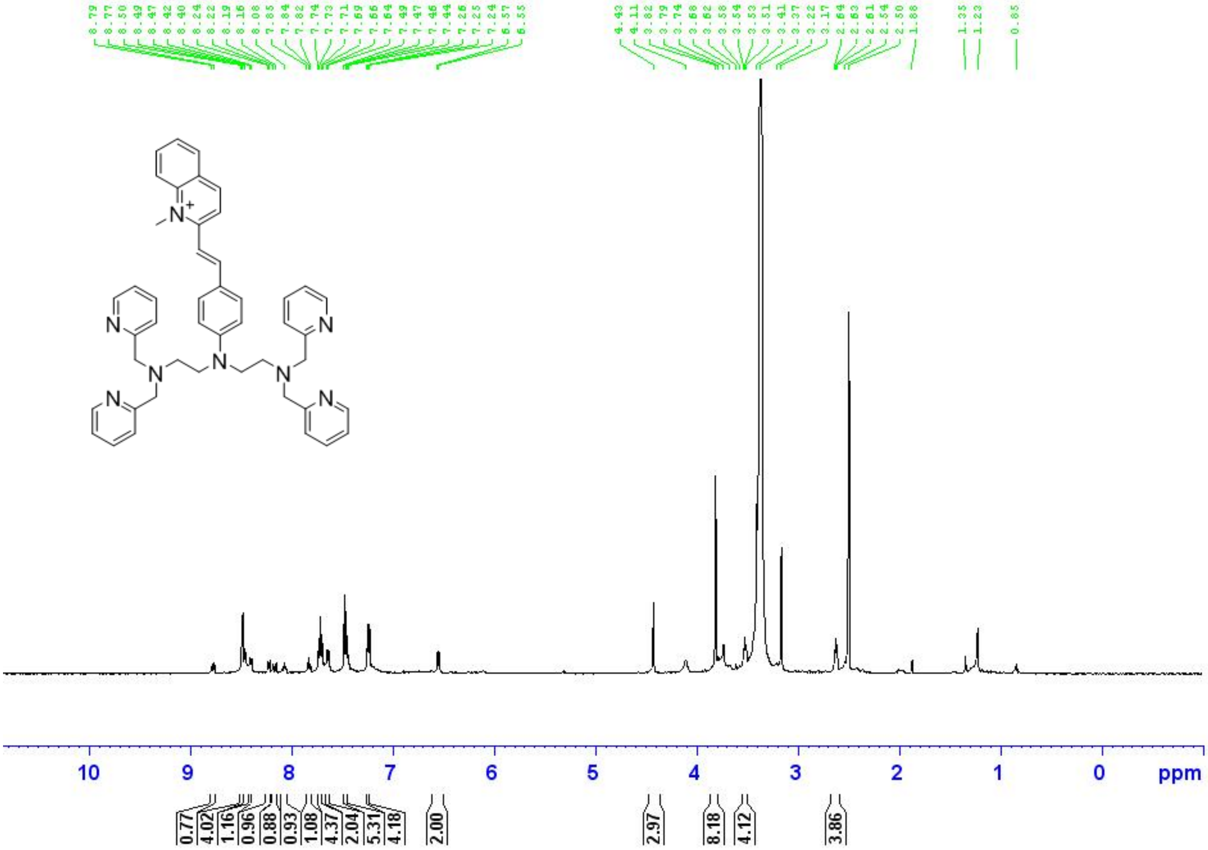
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.55 (4H, t, J = 7.1 Hz), 3.46 (4H, covered with DMSO peak), 3.79 (8H, s), 4.17 (3H, s), 6.41 (2H, d, J = 8.9 Hz), 7.10 (1H, d, J = 15 Hz), 7.22-7.25 (4H, m), 7.35 (2H, d, J = 8.8 Hz), 7.47-7.48 (4H, m), 7.70-7.73 (4H, m), 7.80 (1H, d, J = 15 Hz), 8.01 (2H, d, J = 6.8 Hz), 8.47 (4H, d, J = 4.2 Hz), 8.64 (2H, d, J = 6.7 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 46.304, 48.439, 50.017, 60.024, 111.211, 116.643, 121.888, 122.000, 122.175, 122.683, 130.147, 136.482, 141.742, 144.167, 148.715, 149.476, 153.346, 158.978. HRMS (FAB): m/e calcd. for $C_{42}H_{45}N_8[M^+]$ 661.3767, found 661.3772.

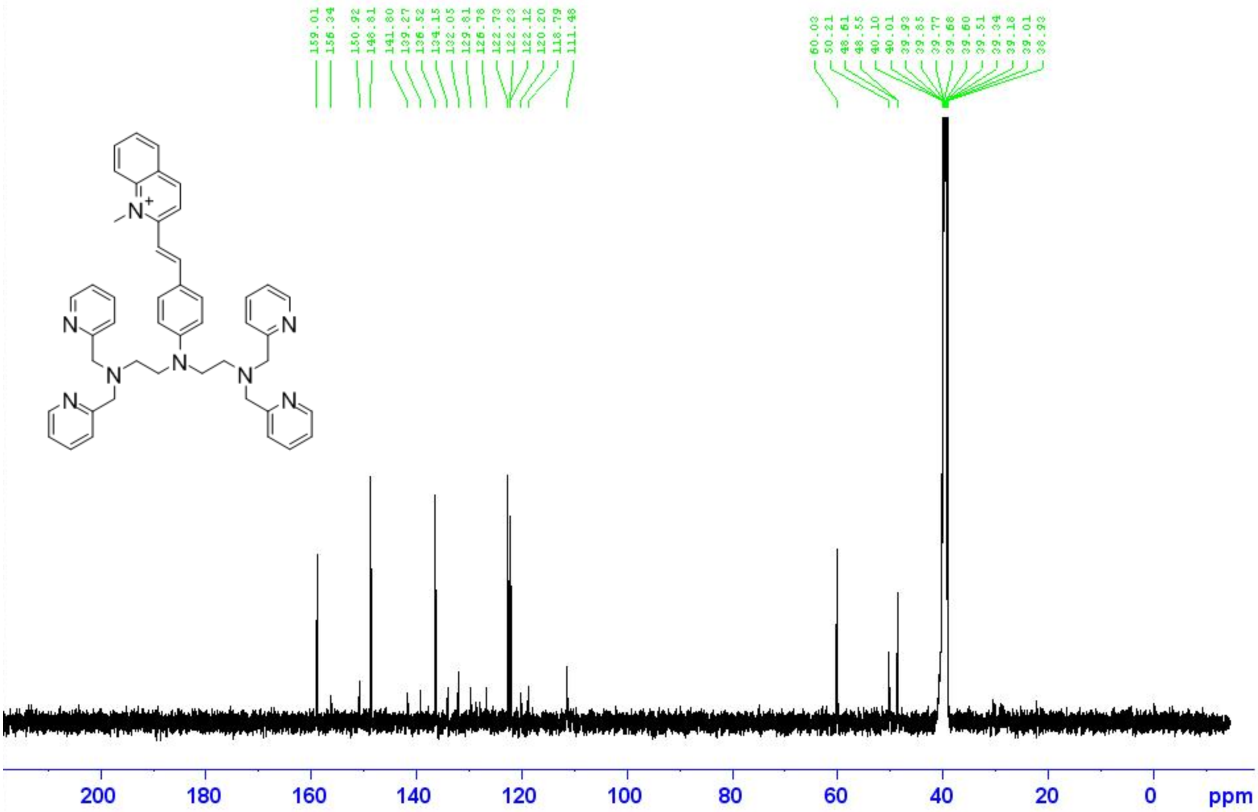




Characterization of 4B

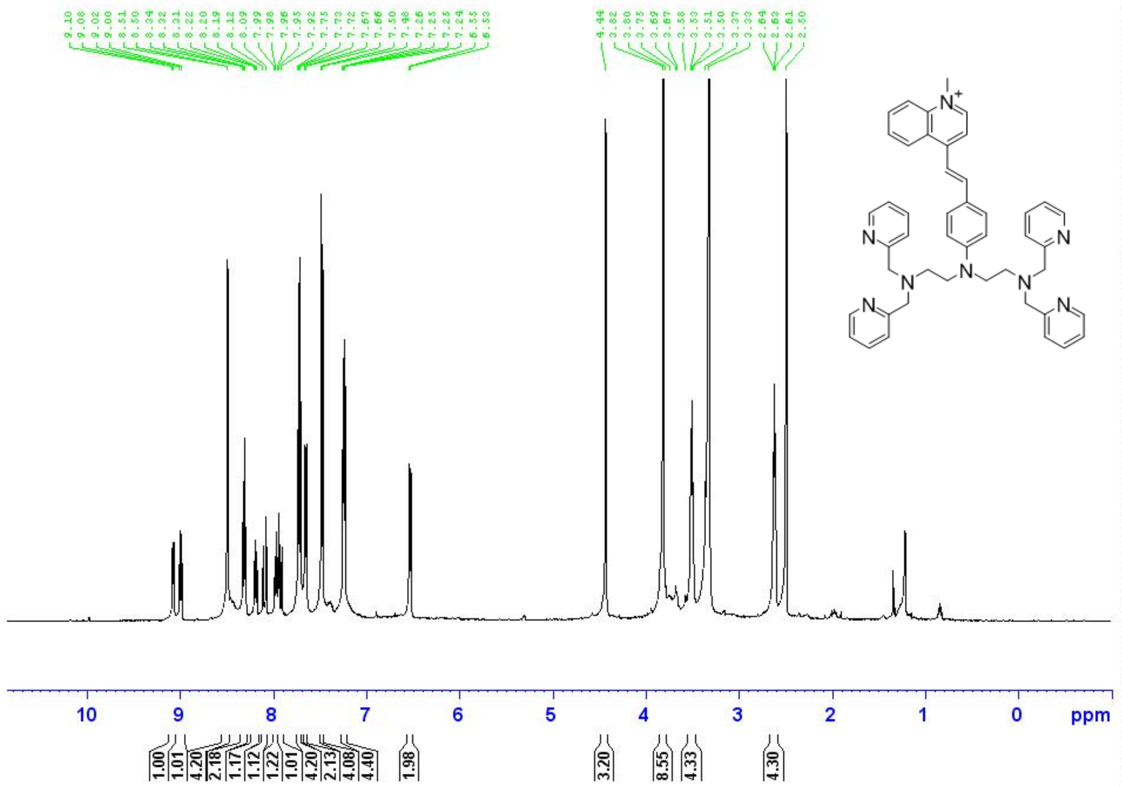
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.57 (4H, t, J = 7.0 Hz), 3.46 (4H, covered with DMSO peak), 3.79 (8H, s), 4.28 (3H, s), 6.46 (2H, d, J = 8.9 Hz), 7.15 (1H, d, J = 15 Hz), 7.22-7.25 (4H, m), 7.46-7.49 (6H, m), 7.70-7.73 (4H, m), 7.80 (1H, d, J = 15 Hz), 8.30 (1H, t, J = 7.9 Hz), 8.41 (1H, d, J = 8.4 Hz), 8.47-8.48 (4H, m), 8.71 (1H, d, J = 6.2 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 45.615, 48.440, 50.107, 60.015, 110.081, 111.140, 121.759, 122.181, 122.674, 122.849, 123.489, 130.725, 136.489, 142.974, 144.008, 145.171, 148.727, 149.797, 153.202, 158.970. HRMS (FAB): m/e calcd. for $C_{42}H_{45}N_8[M^+]$ 661.3767, found 661.3773.

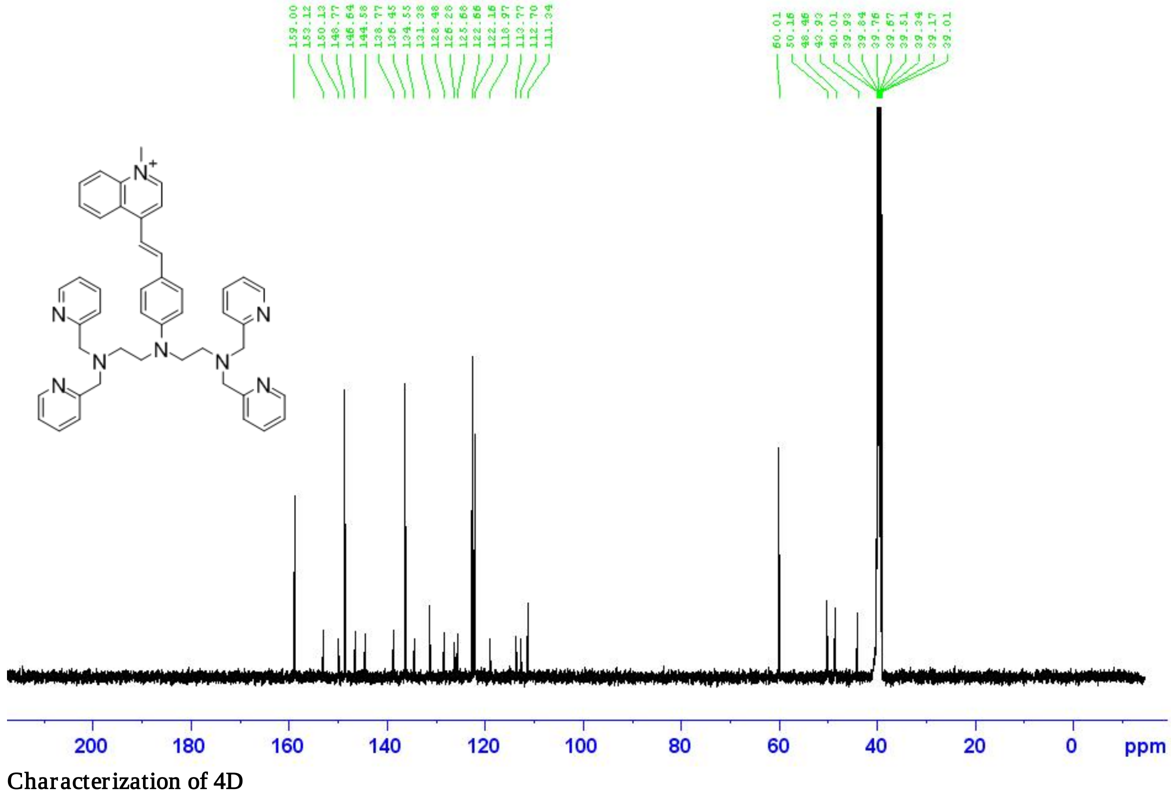




Characterization of 4C

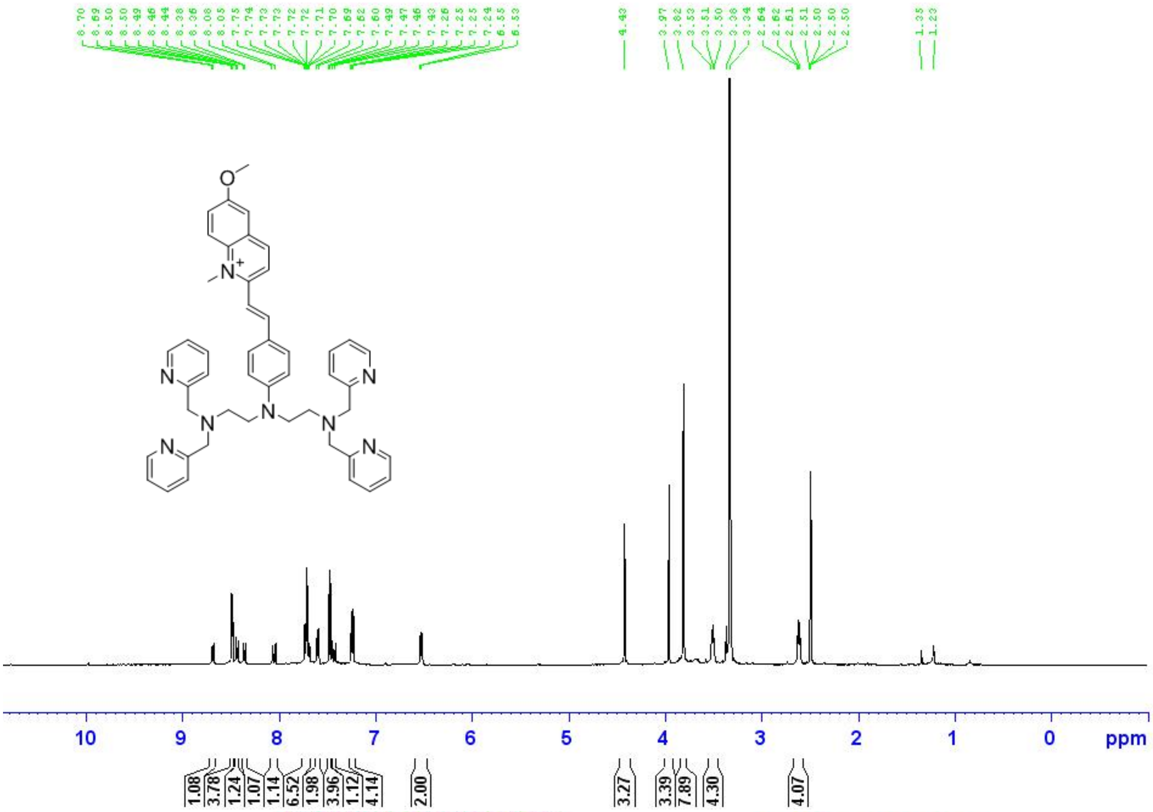
[1]H NMR (500 MHz, DMSO-d_6): δ 2.64 (4H, t, J = 7.1 Hz), 3.52 (4H, t, J = 7.0 Hz), 3.81 (8H, s), 4.43 (3H, s), 6.54 (2H, d, J = 8.7 Hz), 7.23-7.26 (4H, m), 7.45-7.48 (5H, m), 7.63-7.65 (2H, m), 7.71-7.74 (4H, m), 7.83 (1H, t, J = 7.5 Hz), 8.08 (1H, t, J = 7.8 Hz), 8.15 (1H, d, J = 15 Hz), 8.22 (1H, d, J = 7.9 Hz), 8.40 (1H, d, J = 8.8 Hz), 8.47-8.50 (6H, m), 8.77 (1H, d, J = 6.8 Hz). [13]C NMR (125 MHz, DMSO-d_6): δ 48.555, 48.612, 50.206, 60.035, 111.479, 118.786, 120.202, 122.122, 122.232, 122.731, 126.777, 129.810, 132.047, 134.153, 136.525, 139.268, 141.804, 148.813, 150.920, 156.338, 159.014. HRMS (FAB): m/e calcd. For $C_{46}H_{47}N_8[M^+]$ 711.3924, found 711.3925.

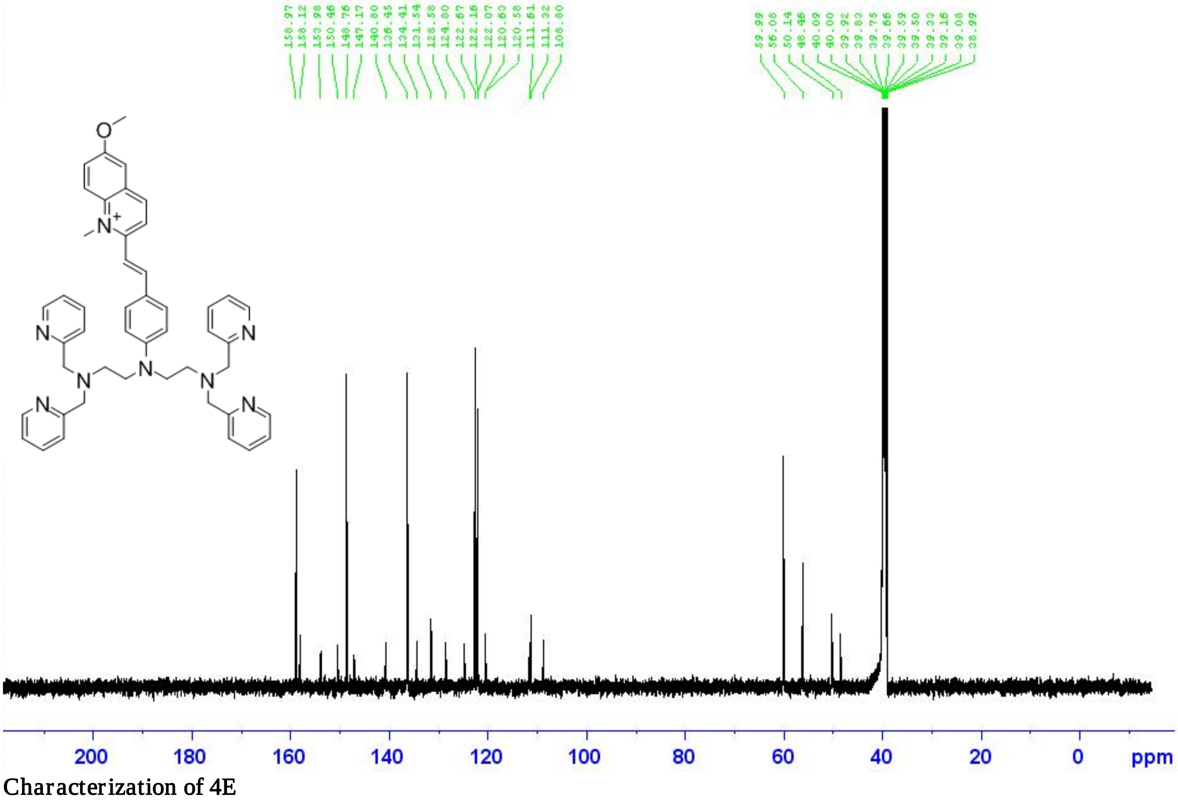




Characterization of 4D

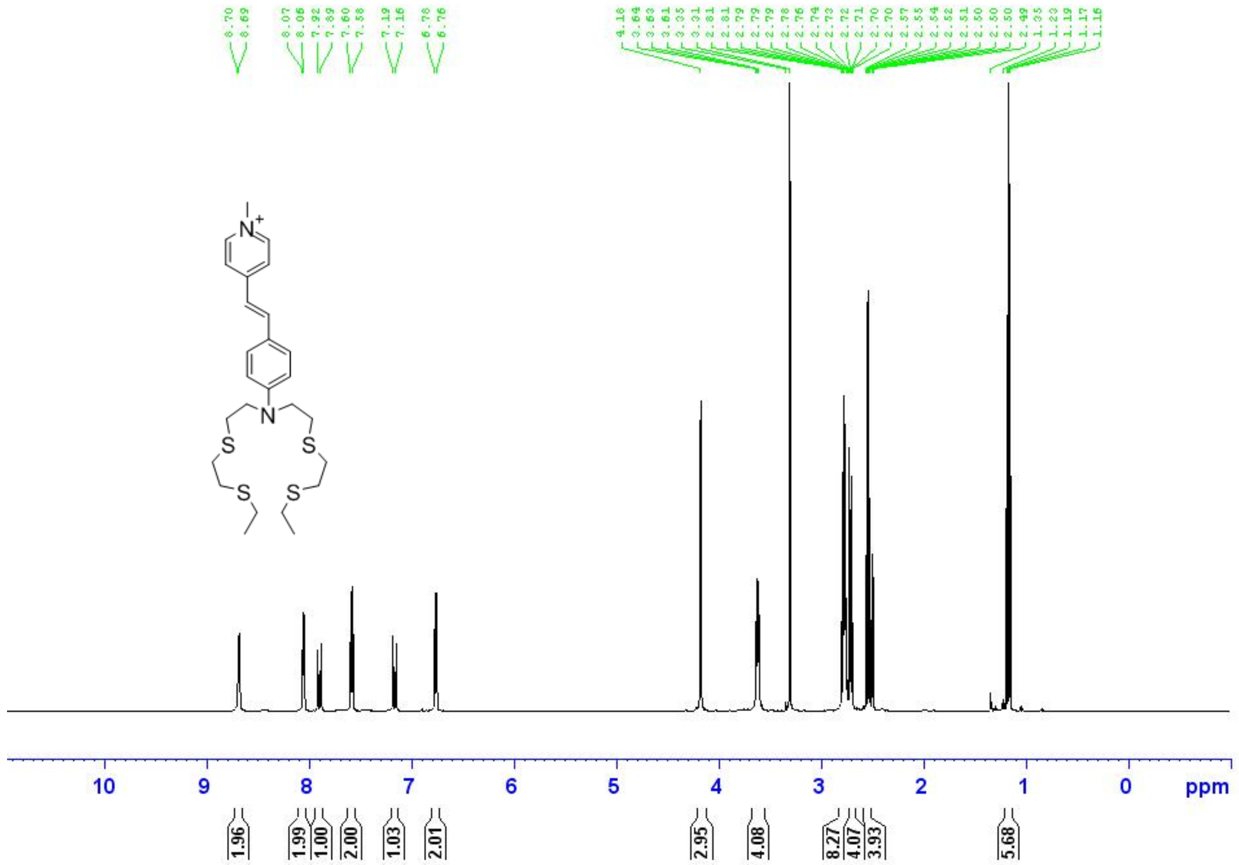
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.61 (4H, t, *J* = 7.0 Hz), 3.49 (4H, t, *J* = 7.0 Hz), 3.82 (8H, s), 4.43 (3H, s), 6.53 (2H, d, *J* = 8.7 Hz), 7.23-7.25 (4H, m), 7.48 (4H, d, *J* = 7.6 Hz), 7.65 (2H, d, *J* = 8.6 Hz), 7.71-7.74 (4H, m), 7.95-7.97 (2H, m), 8.08 (1H, d, *J* = 15 Hz), 8.20 (1H, t, *J* = 7.8 Hz), 8.30-8.34 (2H, m), 8.49 (4H, d, *J* = 4.9 Hz), 8.99 (1H, d, *J* = 8.6 Hz), 9.10 (1H, d, *J* = 6.7 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 43.926, 48.461, 50.162, 60.010, 111.338, 112.699, 113.772, 118.973, 122.159, 122.661, 125.684, 126.279, 128.484, 131.382, 134.550, 136.449, 138.771, 144.581, 146.636, 148.765, 150.130, 153.121, 158.998. HRMS (FAB): m/e calcd. For $C_{46}H_{47}N_8$ [M^+] 711.3924, found 711.3925.

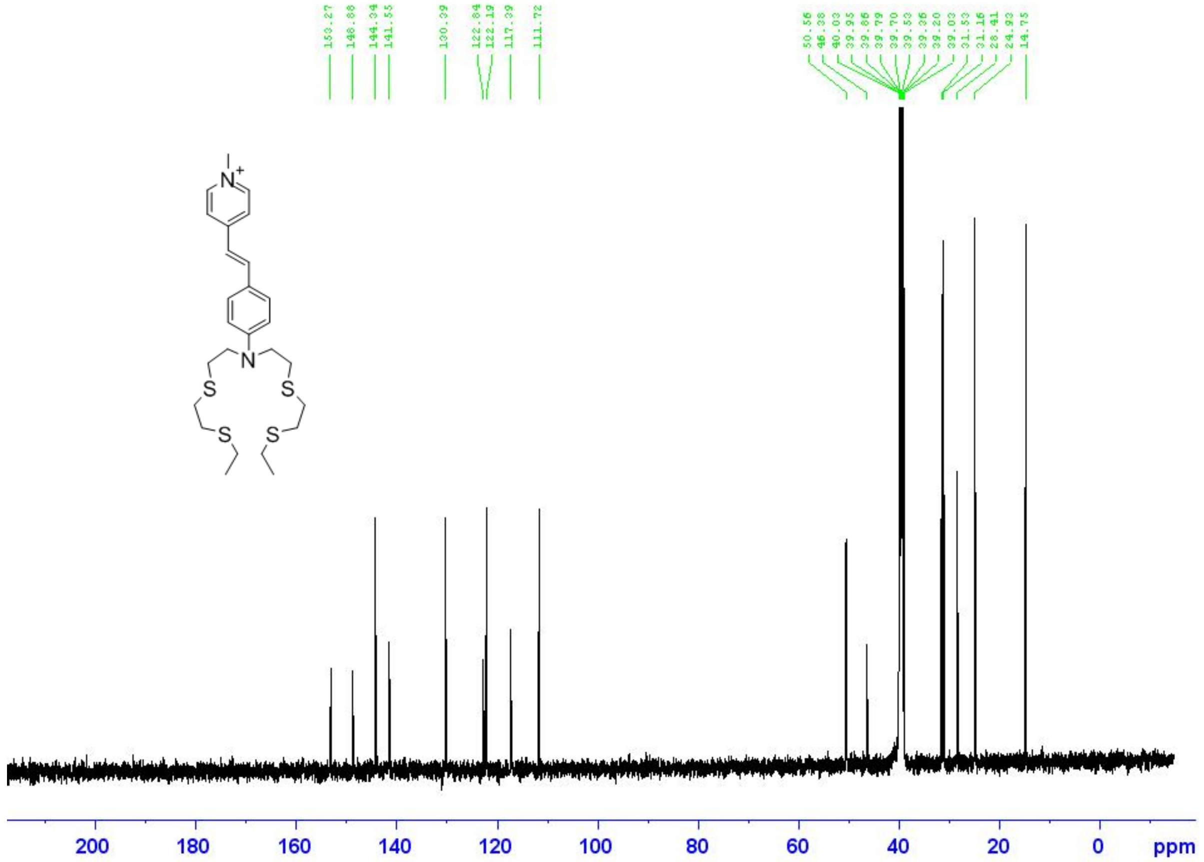




Characterization of 4E

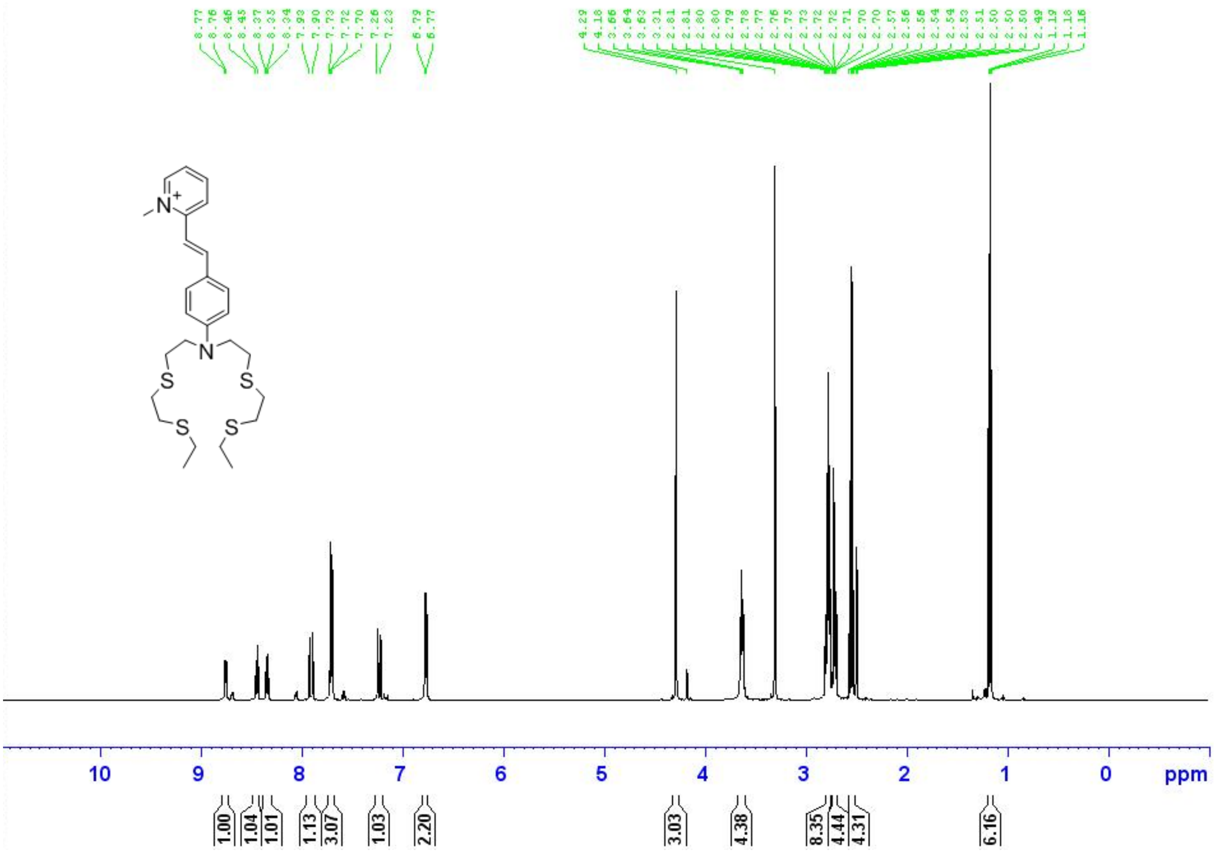
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.60 (4H, t, *J* = 7.0 Hz), 3.50 (4H, t, *J* = 7.0 Hz), 3.82 (8H, s), 3.97 (3H, s), 4.42 (3H, s), 6.53 (2H, d, *J* = 8.9 Hz), 7.23-7.26 (4H, m), 7.47-7.49 (5H, m), 7.59 (2H, d, *J* = 8.8 Hz), 7.71-7.74 (6H, m), 8.02 (1H, d, *J* = 15 Hz), 8.38 (1H, d, *J* = 9.8 Hz), 8.43 (1H, d, *J* = 9.2 Hz), 8.49-8.50 (4H, m), 8.70 (1H, d, *J* = 9.2 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 48.465, 50.144, 56.075, 59.988, 108.797, 111.322, 111.614, 120.583, 120.633, 122.074, 122.164, 122.667, 124.797, 128.579, 131.545, 134.406, 136.454, 140.804, 147.174, 148.758, 150.462, 153.976, 158.120, 158.972. HRMS (FAB): m/e calcd. For $C_{47}H_{49}N_8O$ [M$^+$] 741.4029, found 741.4043.

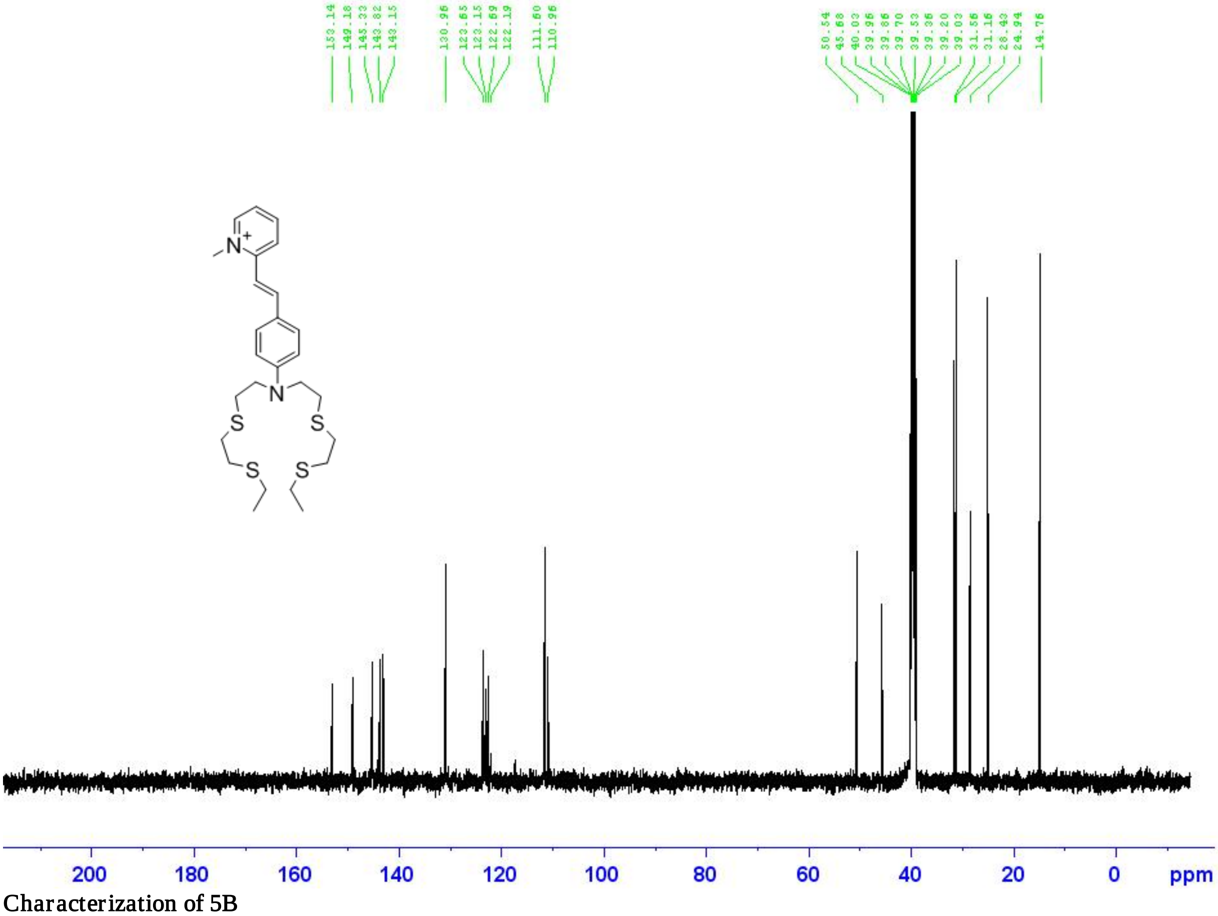




Characterization of 5A

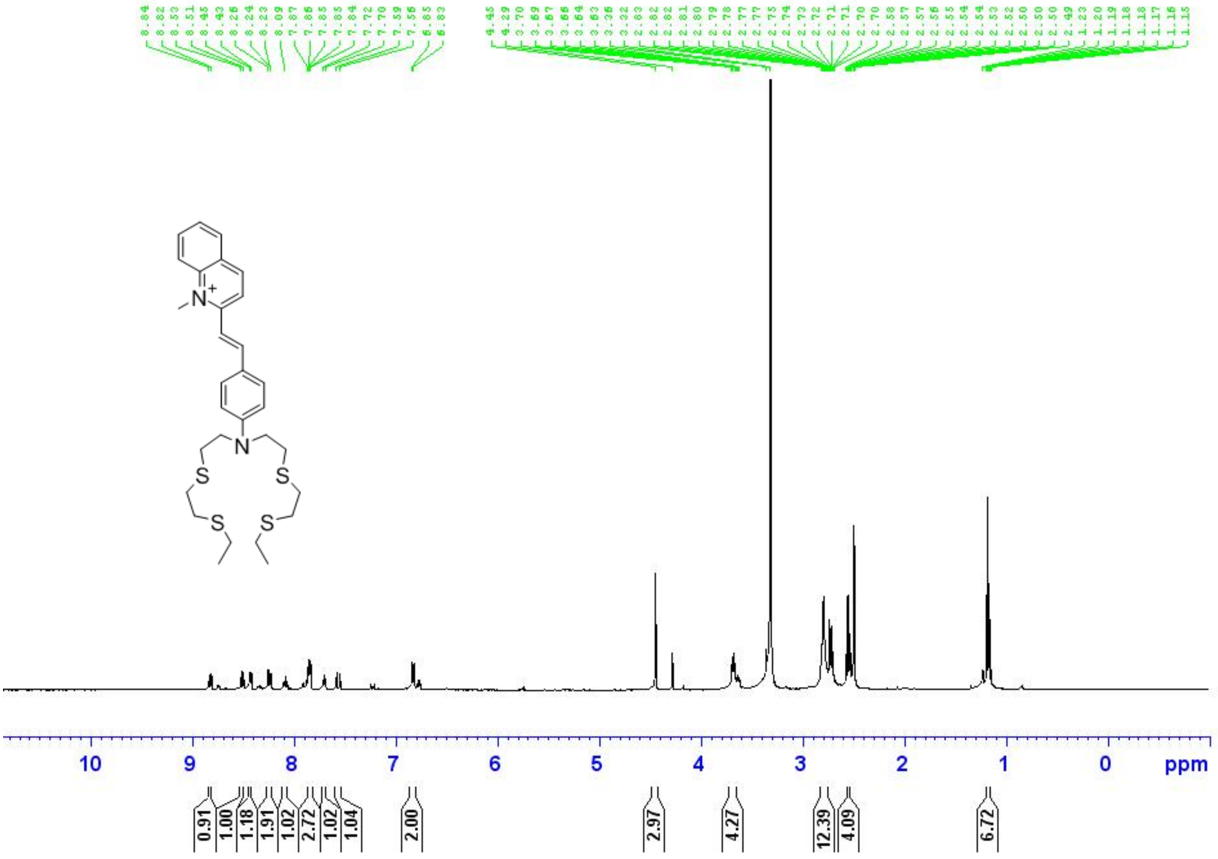
^{1}H NMR (500 MHz, DMSO-d_6): δ 1.16 (6H, t, J = 7.5 Hz), 2.52-2.56 (4H, m), 2.71-2.72 (4H, m), 2.75-2.80 (8H, m), 3.61 (4H, J = 7.6 Hz), 4.18 (3H, s), 6.76 (2H, d, J = 8.9 Hz), 7.15 (1H, d, J = 16 Hz), 7.58 (2H, d, J = 8.8 Hz), 7.89 (1H, d, J = 16 Hz), 8.05 (2H, d, J = 6.7 Hz), 8.69 (2H, d, J = 6.4 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 14.754, 24.930, 28.405, 31.162, 31.533, 46.382, 50.561, 111.725, 117.386, 122.190, 122.838, 130.385, 141.552, 144.342, 148.876, 153.269. HRMS (FAB): m/e calcd. For $C_{26}H_{39}N_2S_4$ [M^+] 507.1996, found 507.2001.

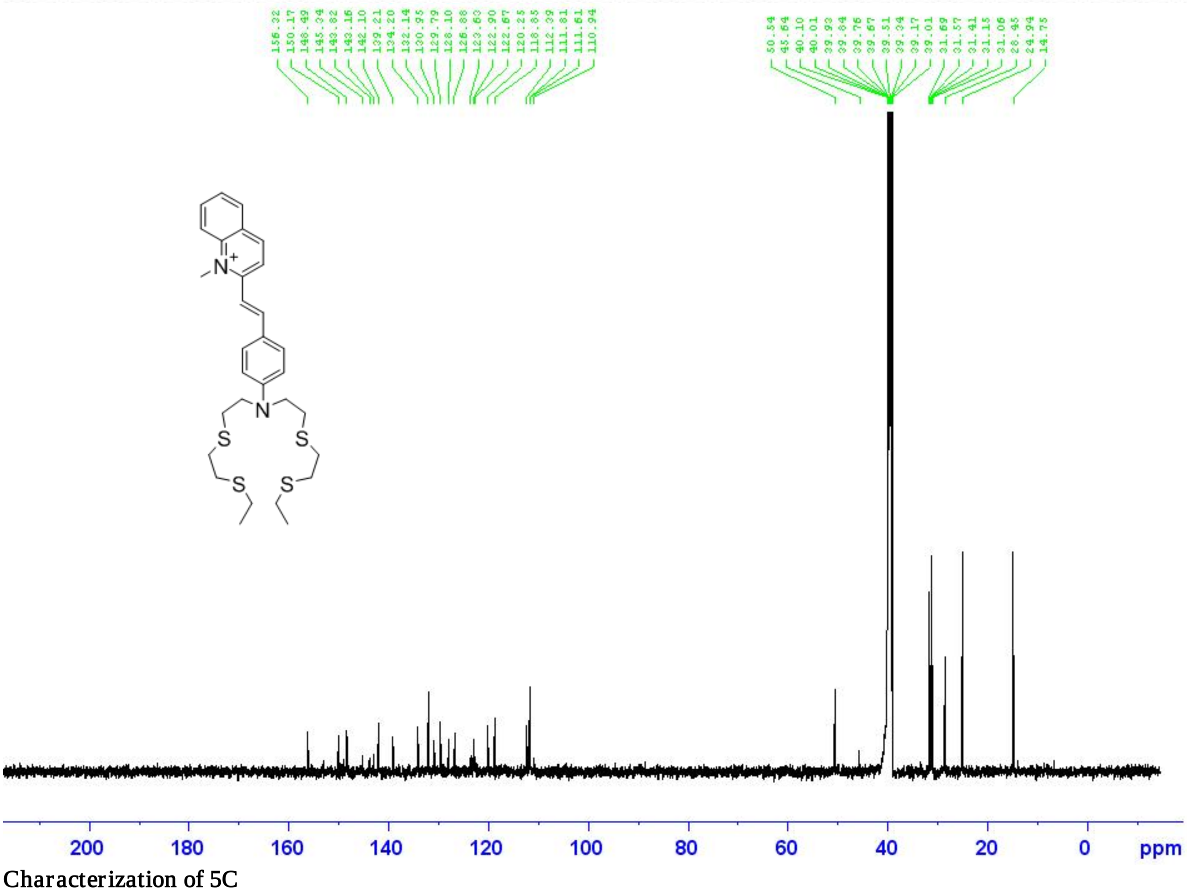




Characterization of 5B

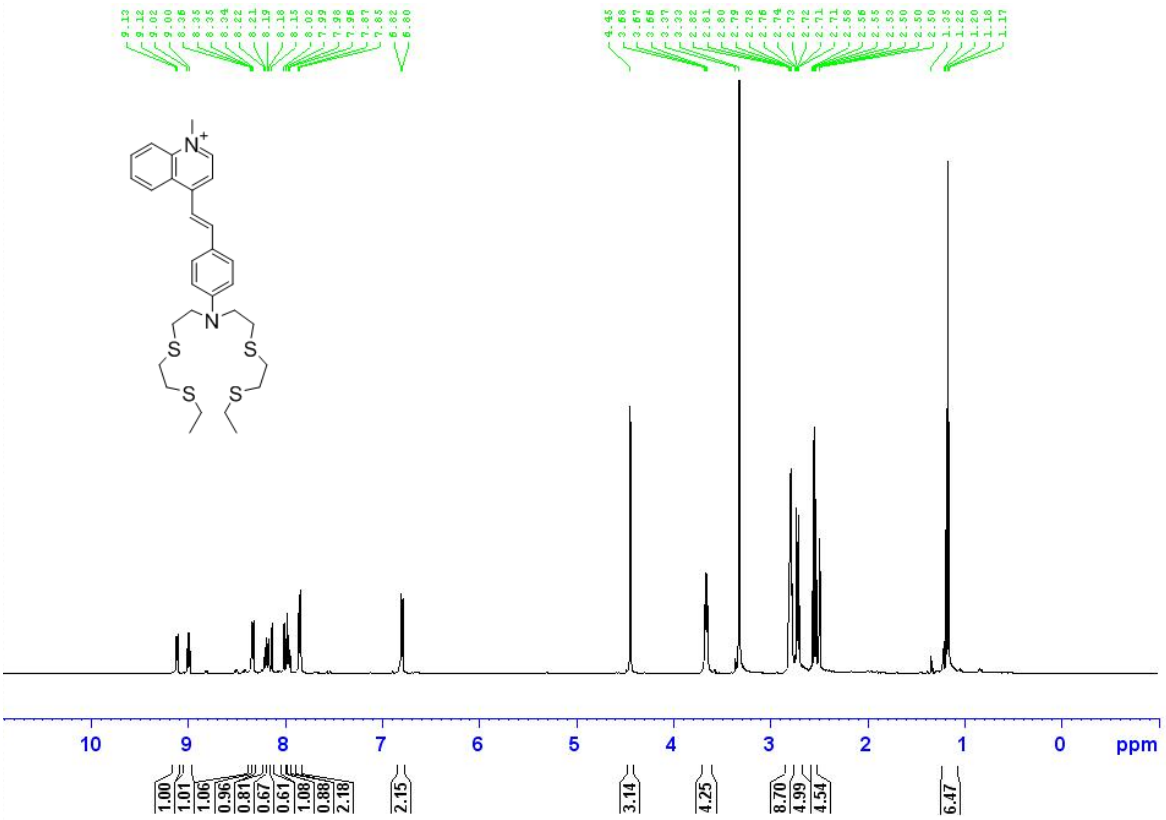
^{1}H NMR (500 MHz, DMSO-d_6): δ 1.16 (6H, t, J = 7.2 Hz), 2.52-2.57 (4H, m), 2.71-2.79 (12H, m), 3.62 (4H, t, J = 7.6 Hz), 4.29 (3H, s), 6.78 (2H, d, J = 9.0 Hz), 7.22 (1H, d, J = 15.7 Hz), 7.70-7.73 (3H, m), 7.90 (1H, d, J = 15.7 Hz), 8.33 (1H, t, J = 7.9 Hz), 8.45 (1H, d, J = 8.3 Hz), 8.76 (1H, d, J = 6.2 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 14.756, 24.938, 28.432, 31.160, 31.559, 45.676, 50.537, 110.960, 111.602, 122.689, 123.154, 123.655, 130.958, 143.148, 143.817, 145.333, 149.181, 153.136. HRMS (FAB): m/e calcd. For $C_{26}H_{39}N_2S_4$ [M$^+$] 507.1996, found 507.1999.

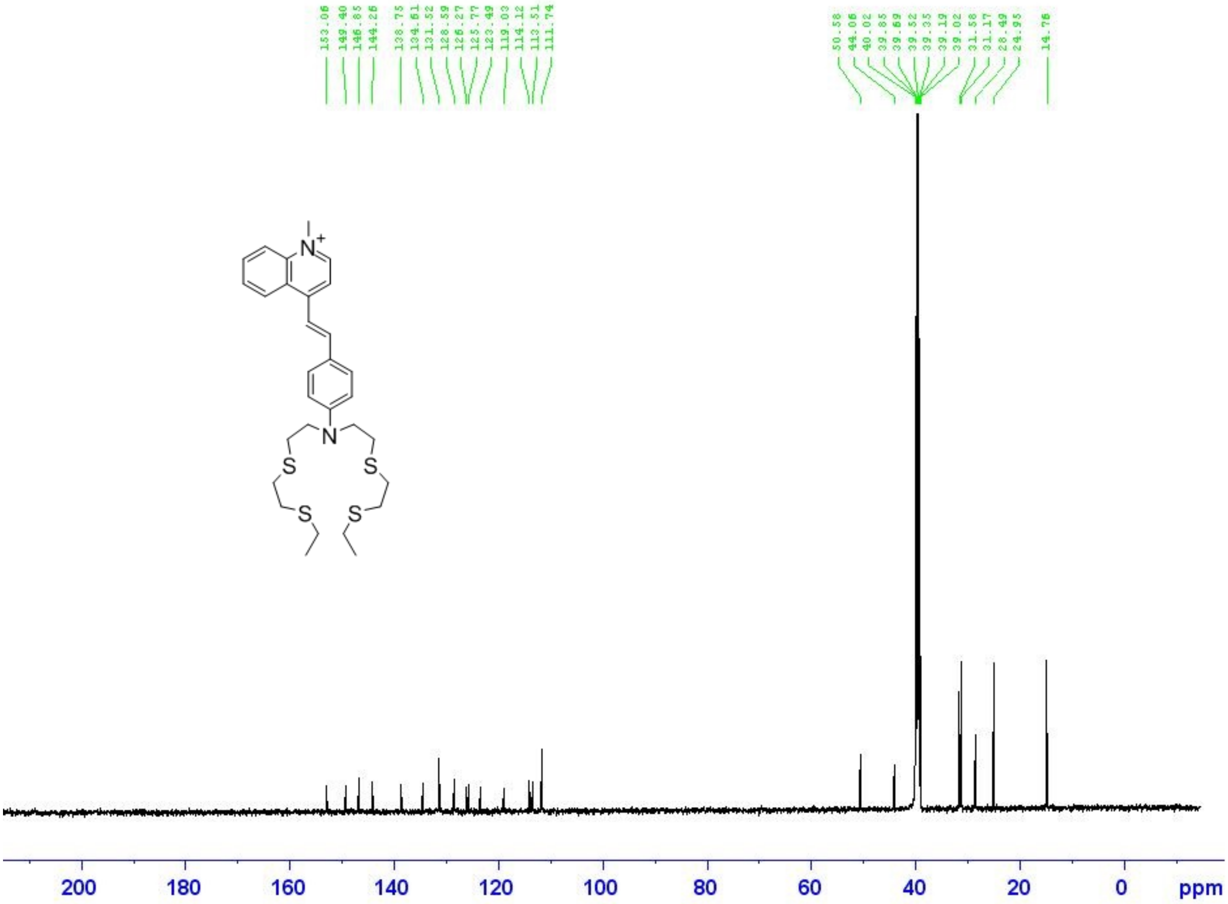




Characterization of 5C

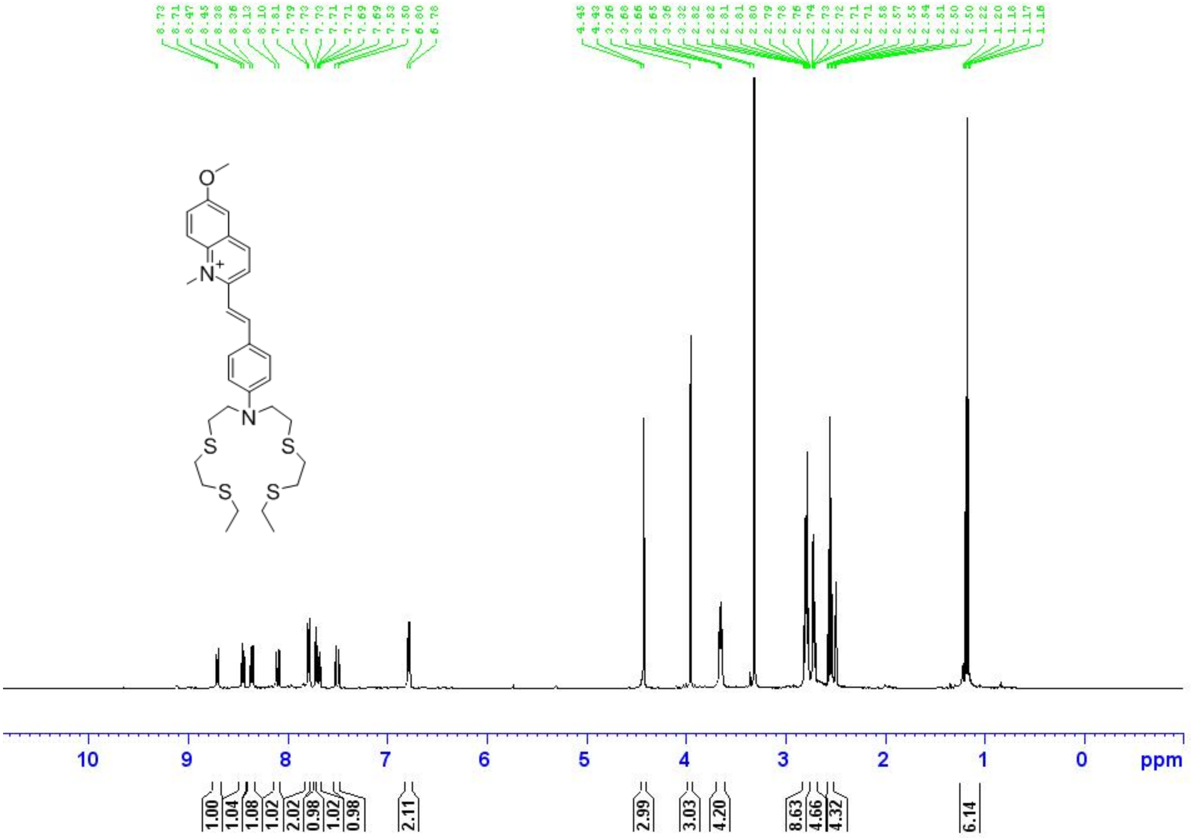
^{1}H NMR (500 MHz, DMSO-d_6): δ 1.16-1.19 (6H, m), 2.53 (4H, t, J = 7.4 Hz), 2.72-2.81 (12H, m), 3.68 (4H, t, J = 7.4 Hz), 4.45 (3H, s), 6.82 (2H, d, J = 8.9 Hz), 7.55 (1H, d, J = 15.5 Hz), 7.71 (1H, m), 7.84-7.86 (3H, m), 8.09 (1H, m), 8.23-8.26 (2H, m), 8.42 (1H, d, J = 8.9 Hz), 8.50 (1H, d, J = 9.2 Hz), 8.82 (1H, d, J = 9.1 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 14.751, 24.837, 28.455, 31.150, 31.566, 45.637, 50.542, 111.810, 112.385, 118.848, 120.253, 123.628, 126.879, 128.096, 129.795, 132.139, 134.197, 139.206, 142.100, 148.488, 150.168, 156.320. HRMS (FAB): m/e calcd. For $C_{30}H_{41}N_2S_4$ [M^+] 557.2153, found 557.2148.

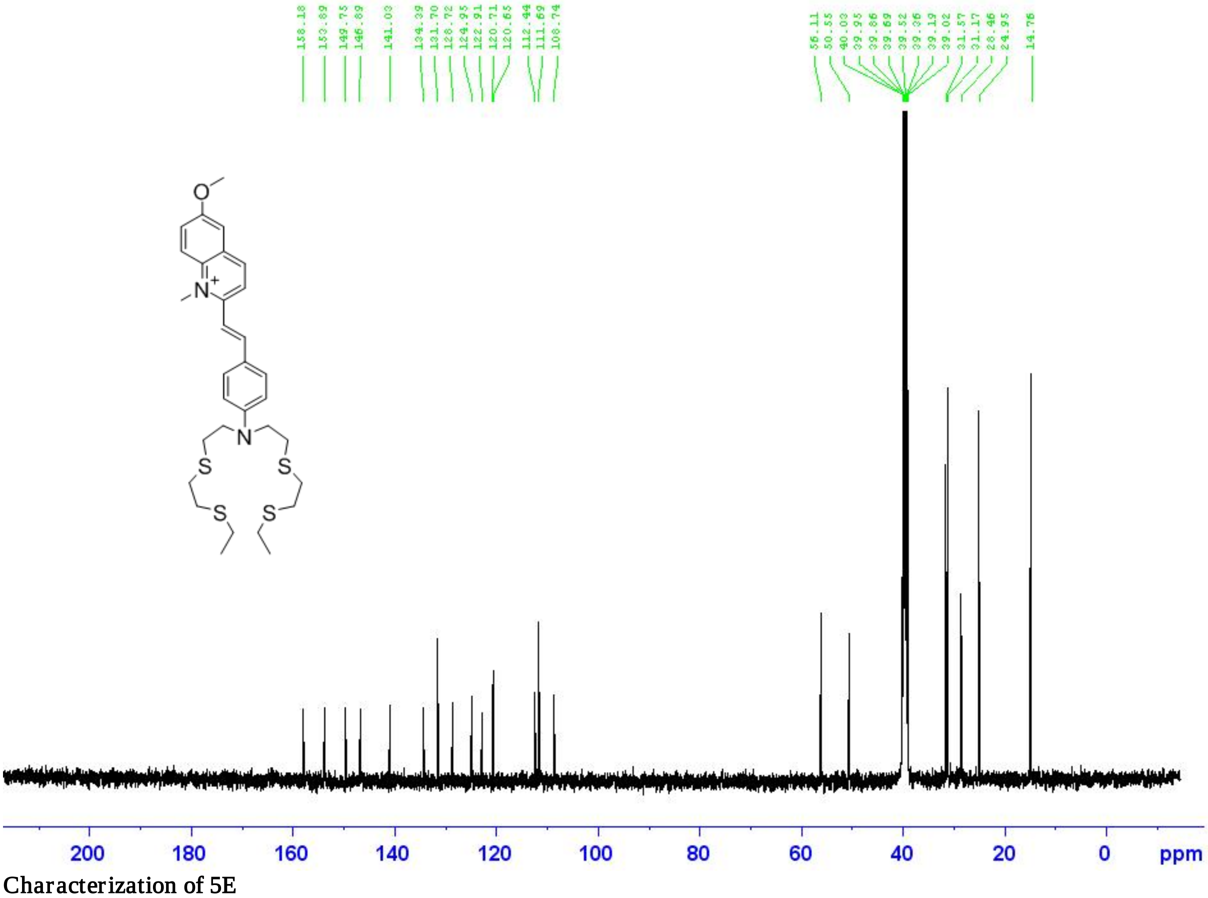




Characterization of 5D

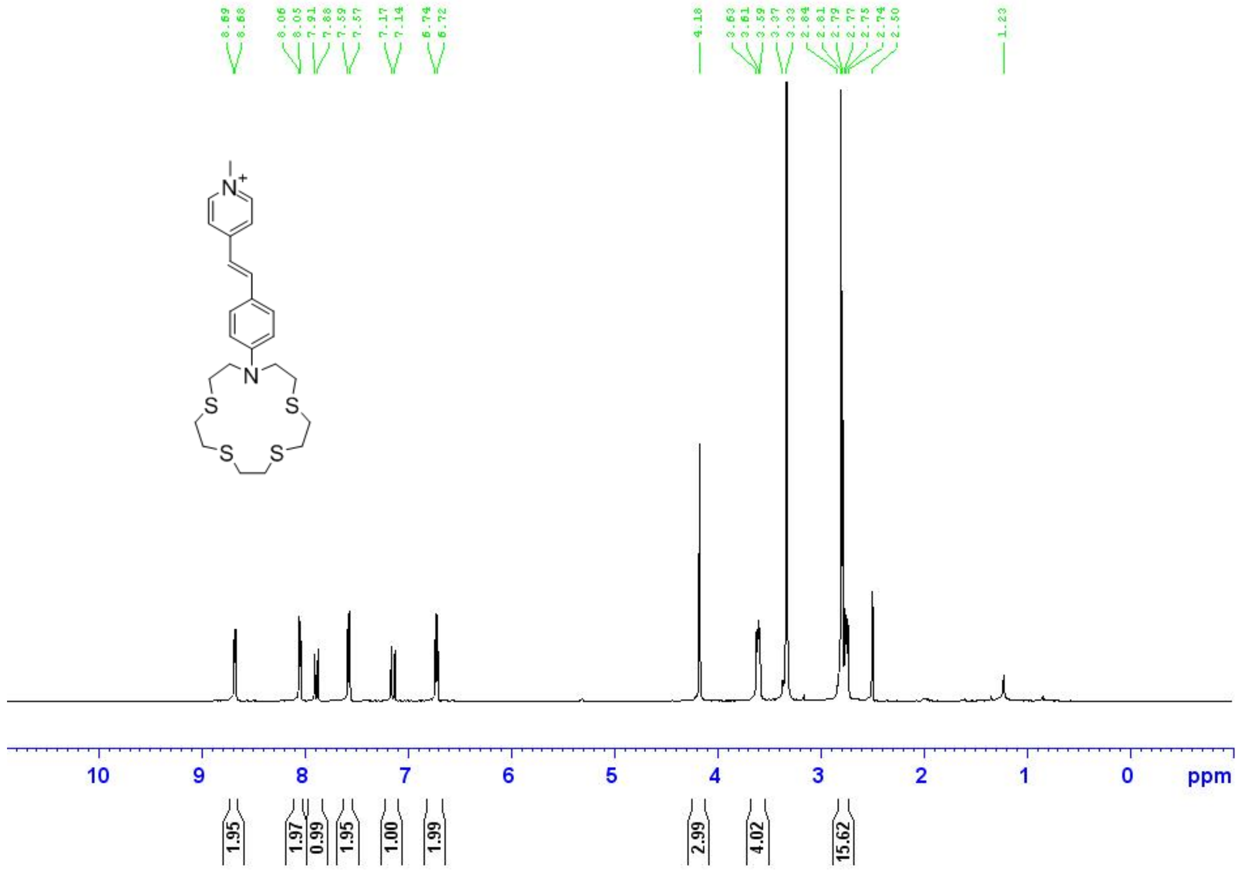
[1]H NMR (500 MHz, DMSO-d_6): δ 1.17 (6H, t, J = 7.4 Hz), 2.50 (4H, t, J = 7.3 Hz), 2.72 (4H, t, J = 3.9 Hz), 2.78-2.82 (8H, m), 3.65 (4H, t, J = 7.5 Hz), 4.45 (3H, s), 6.81 (2H, d, J = 8.9 Hz), 7.85 (2H, d, J = 8.8 Hz), 7.96-7.99 (2H, m), 8.14-8.20 (2H, m), 8.33-8.35 (2H, m), 8.99 (1H, d, J = 8.6 Hz), 9.12 (1H, d, J = 6.7 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 14.757, 24.950, 28.487, 31.167, 31.578, 44.059, 50.578, 111.744, 113.512, 114.121, 119.026, 123.487, 125.765, 126.273, 128.592, 131.525, 134.610, 138.752, 144.255, 146.847, 149.400, 153.064. HRMS (FAB): m/e calcd. For $C_{30}H_{41}N_2S_4$ [M^+] 557.2153, found 557.2156.

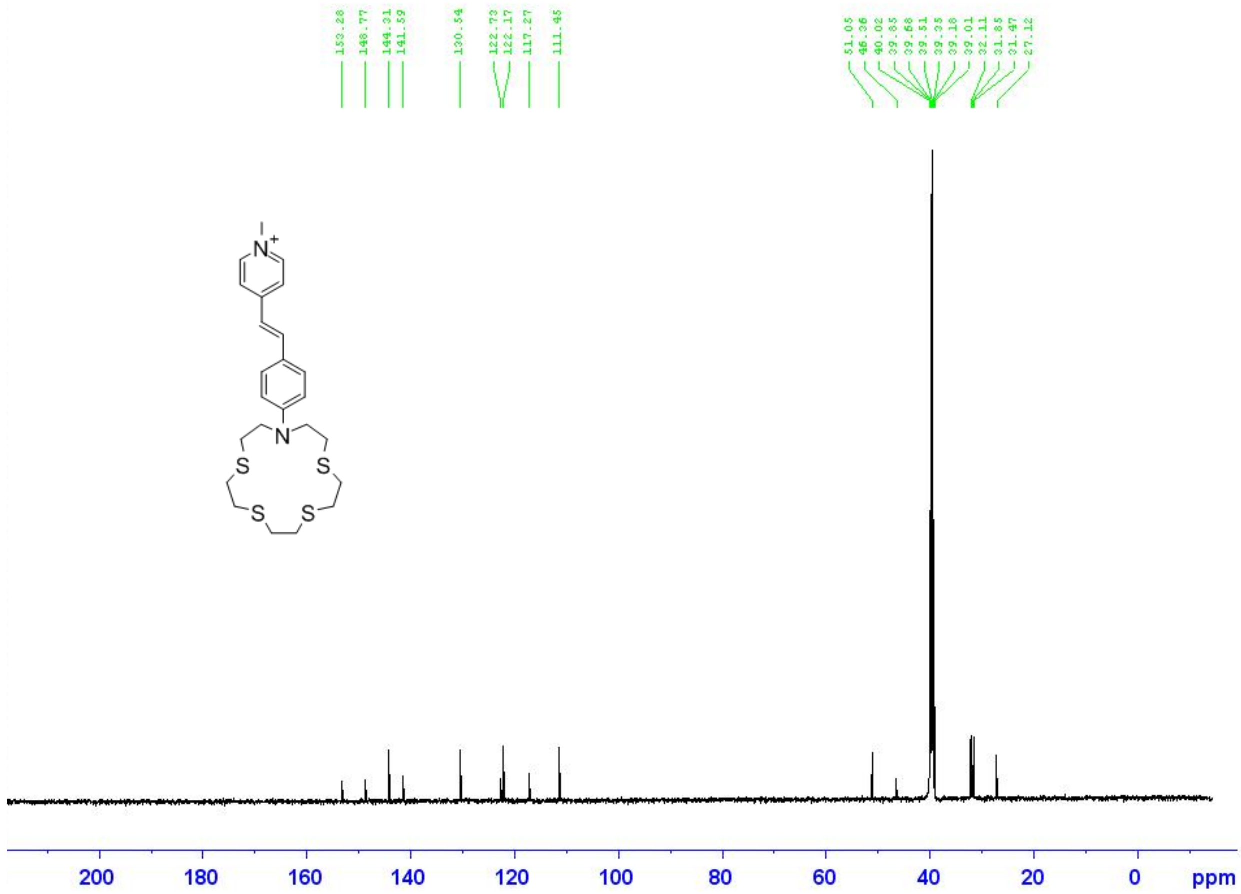




Characterization of 5E

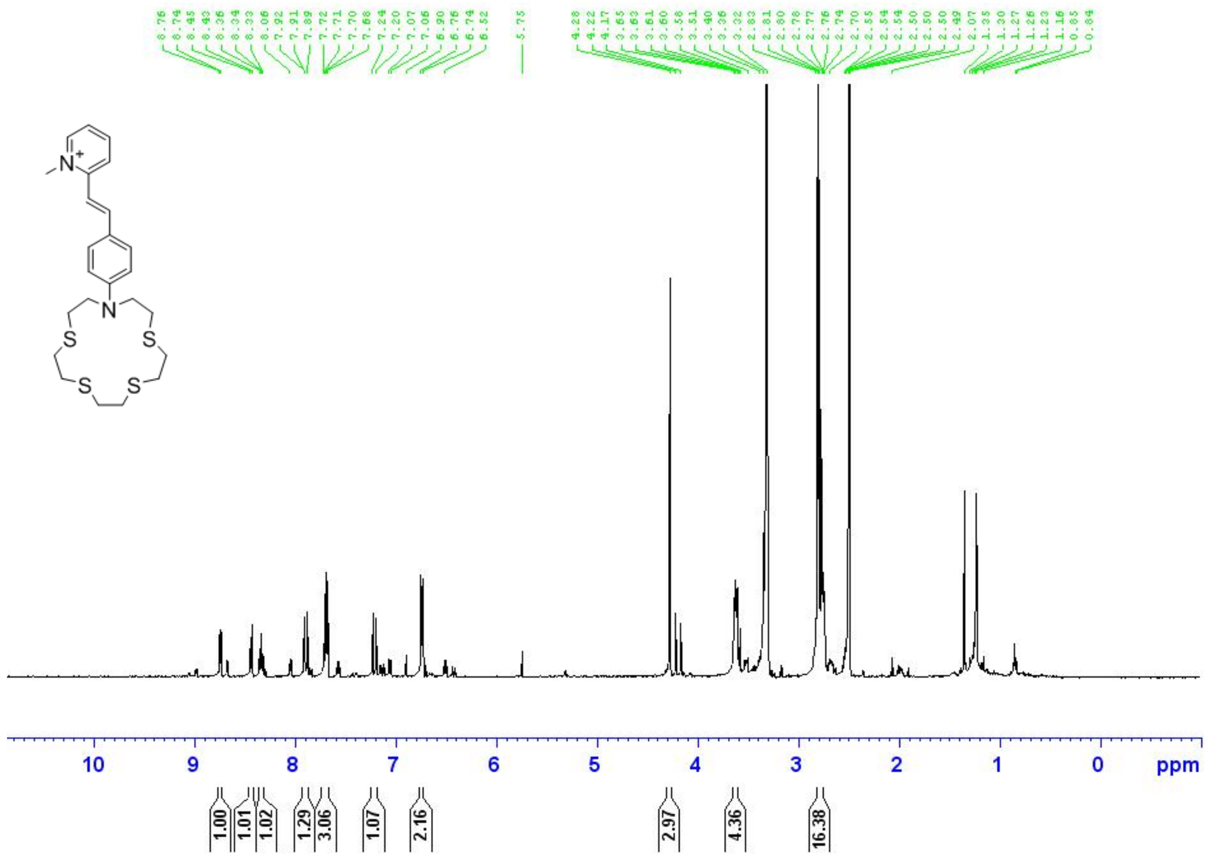
^{1}H NMR (500 MHz, DMSO-d_6): δ 1.16-1.22 (6H, m), 2.50-2.58 (4H, m), 2.70-2.74 (4H, m), 2.77-2.82 (8H, m), 3.65 (4H, t, J = 7.6 Hz), 3.96 (3H, s), 4.44 (3H, s), 6.79 (2H, d, J = 8.8 Hz), 7.50 (1H, d, J = 15.6 Hz), 7.68-7.73 (2H, m), 7.79 (2H, d, J = 8.8 Hz), 8.09 (1H, d, J = 15.4 Hz), 8.37 (1H, d, J = 9.6 Hz), 8.46 (1H, d, J = 9.2 Hz), 8.72 (1H, d, J = 9.1 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 14.762, 24.953, 28.457, 31.167, 31.573, 50.553, 56.111, 108.740, 111.691, 112.444, 120.648, 120.706, 122.913, 124.947, 128.722, 131.703, 134.386, 141.034, 146.894, 149.753, 153.893, 158.175. HRMS (FAB): m/e calcd. For $C_{31}H_{43}N_2OS_4$ [M^+] 587.2258, found 587.2265.

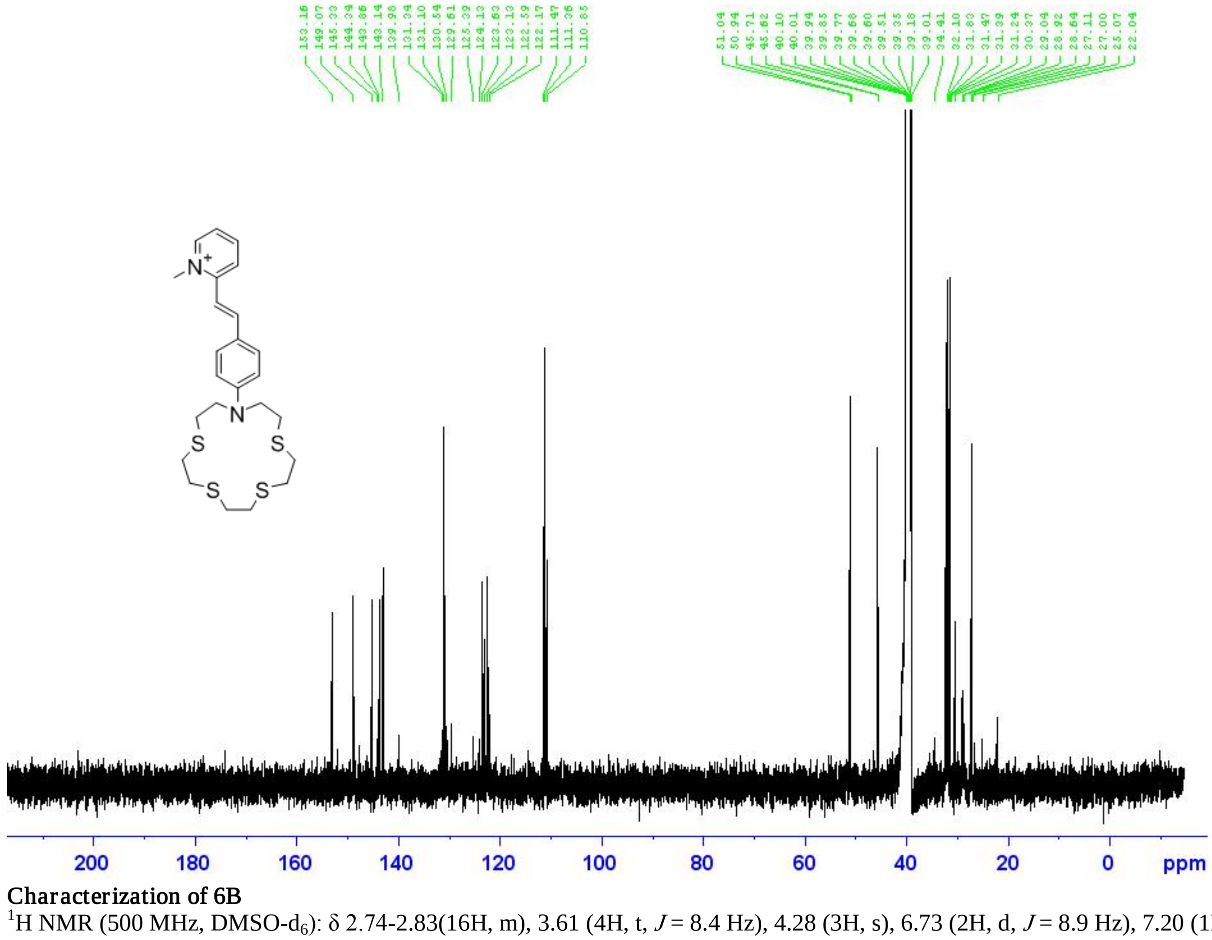




Characterization of 6A

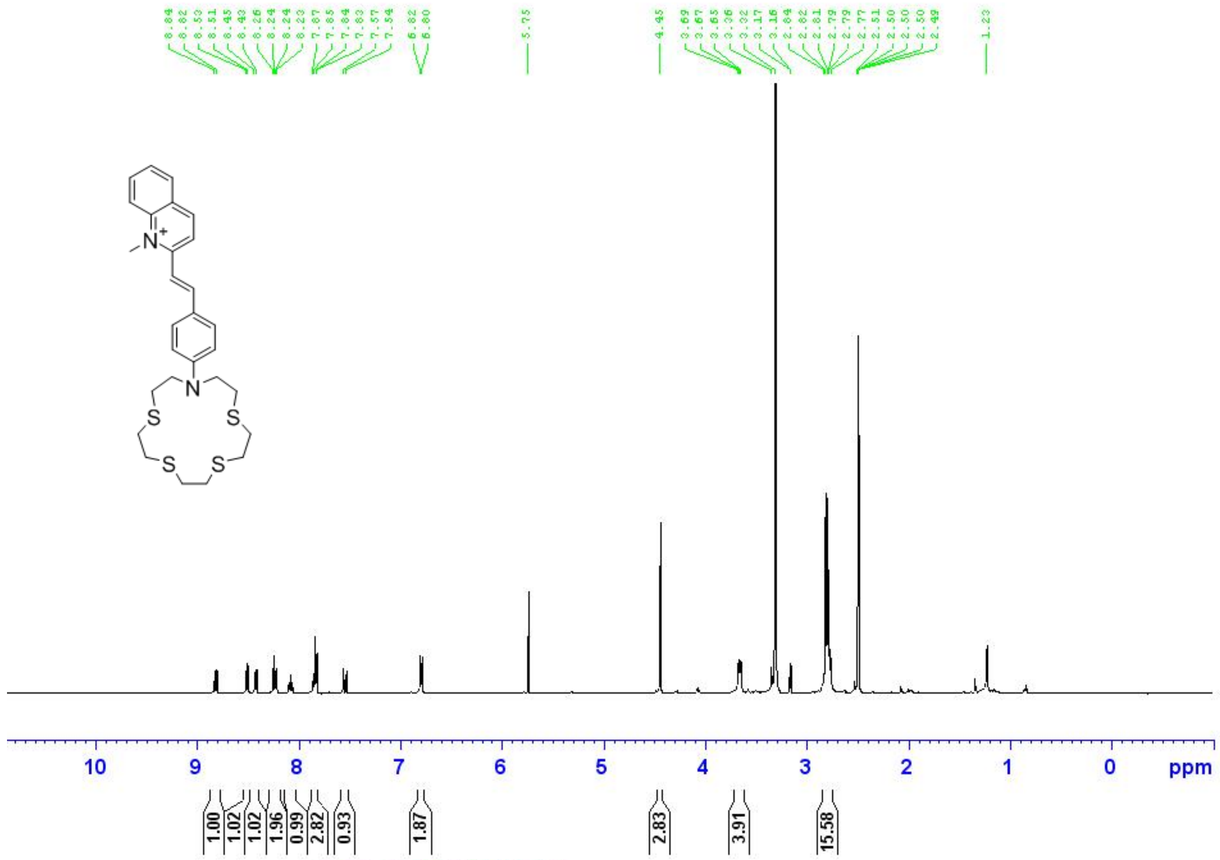
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.74-2.84 (16H, m), 3.61 (4H, t, J = 16.3 Hz), 4.18 (3H, s), 6.73 (2H, d, J = 8.8 Hz), 7.15 (1H, d, J = 16.1 Hz), 7.58 (2H, d, J = 8.7 Hz), 7.89 (1H, d, J = 16.1 Hz), 8.05 (2H, d, J = 6.5 Hz), 8.68 (2H, d, J = 6.4 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 27.116, 31.468, 31.846, 32.115, 46.365, 51.045, 111.455, 117.270, 122.170, 122.733, 130.544, 141.592, 144.314, 148.768, 153.276. HRMS (FAB): m/e calcd. For $C_{24}H_{33}N_2S_4$ [M^+] 477.1527, found 477.1533.

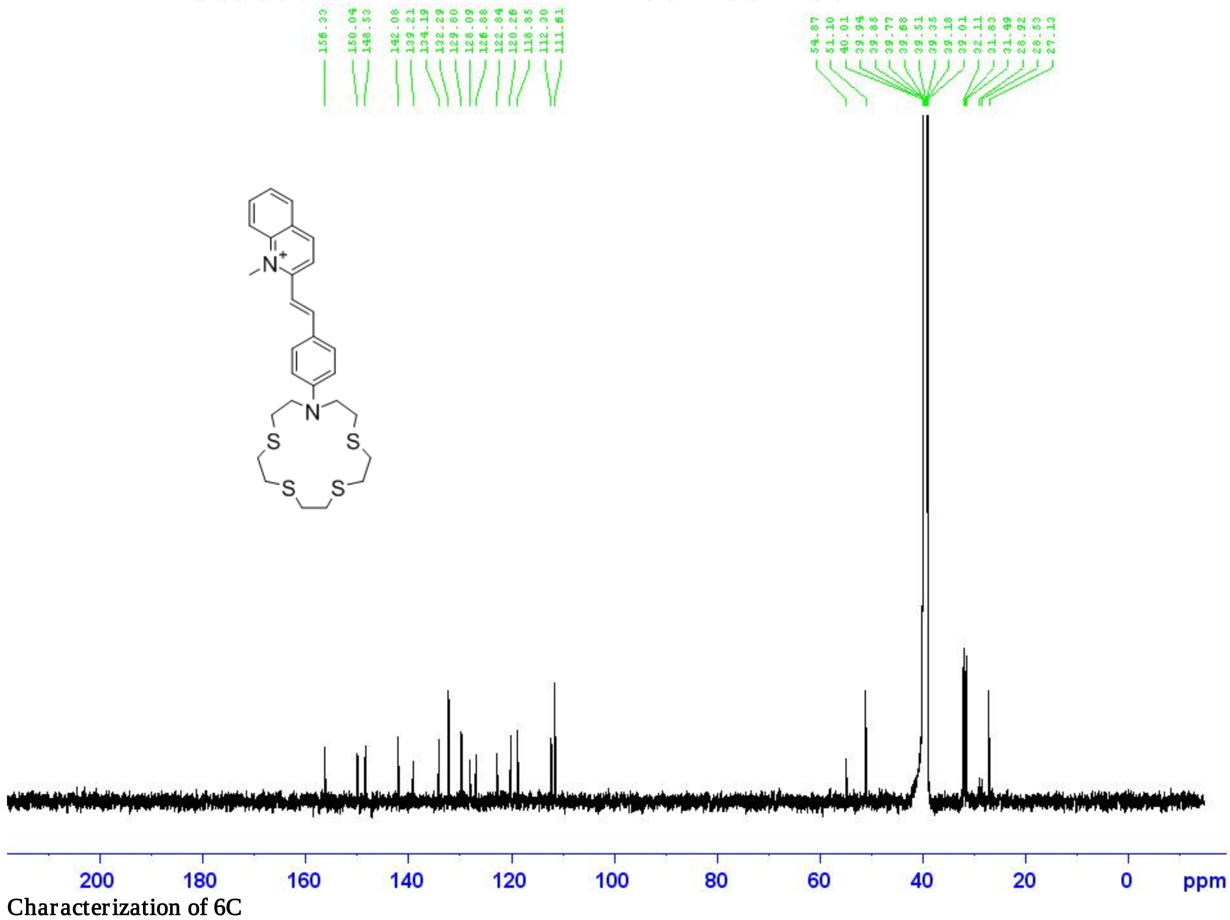




Characterization of 6B

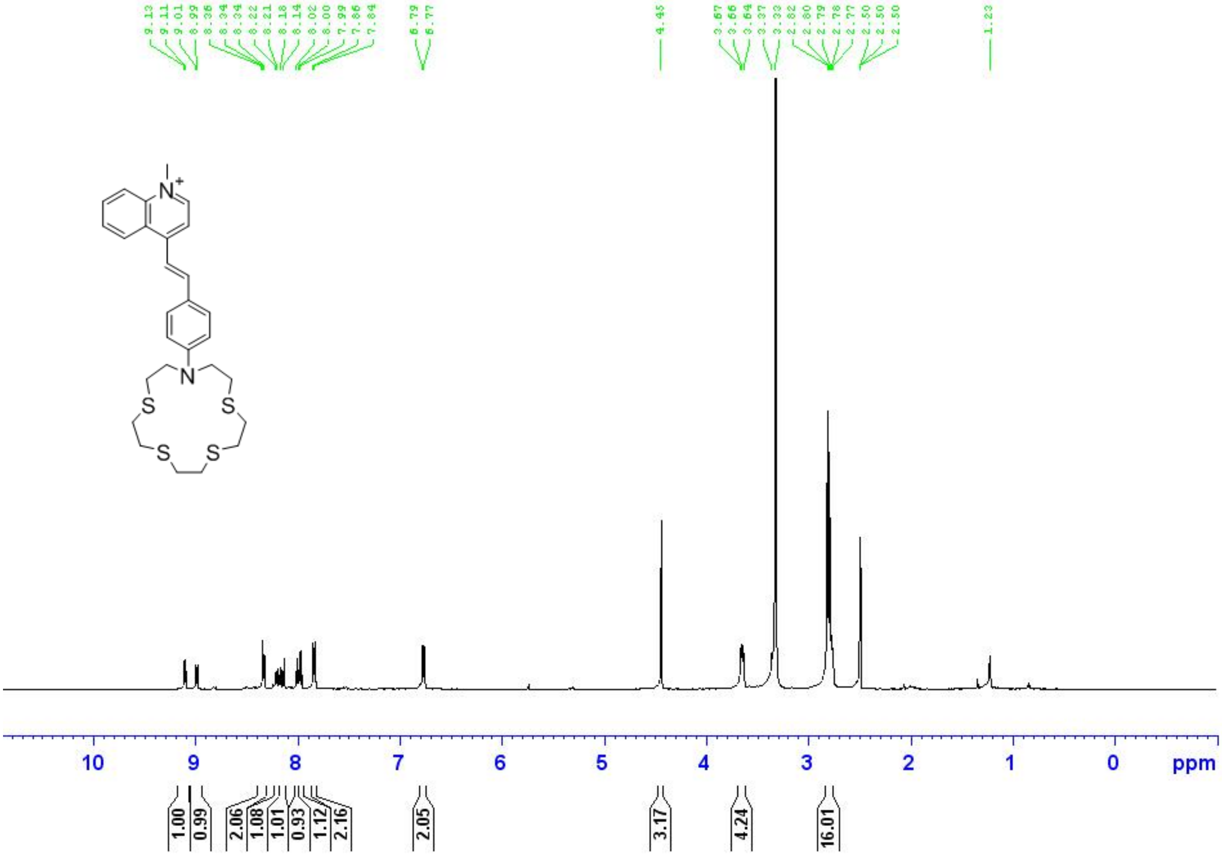
^{1}H NMR (500 MHz, DMSO-d$_6$): δ 2.74-2.83(16H, m), 3.61 (4H, t, J = 8.4 Hz), 4.28 (3H, s), 6.73 (2H, d, J = 8.9 Hz), 7.20 (1H, d, J = 15.7 Hz), 7.68-7.72 (3H, m), 7.88 (1H, d, J = 15.7 Hz), 8.32-8.36 (1H, m), 8.43 (1H, d, J = 8.3 Hz), 8.74 (1H, d, J = 6.1 Hz). ^{13}C NMR (125 MHz, DMSO-d$_6$): δ 27.114, 31.468, 31.829, 32.102, 45.617, 51.041, 110.853, 111.474, 122.594, 123.128, 123.628, 131.096, 143.138, 143.865, 145.331, 149.070, 153.156. HRMS (FAB): m/e calcd. For $C_{24}H_{33}N_2S_4$ [M^{+}] 477.1527, found 477.1529.

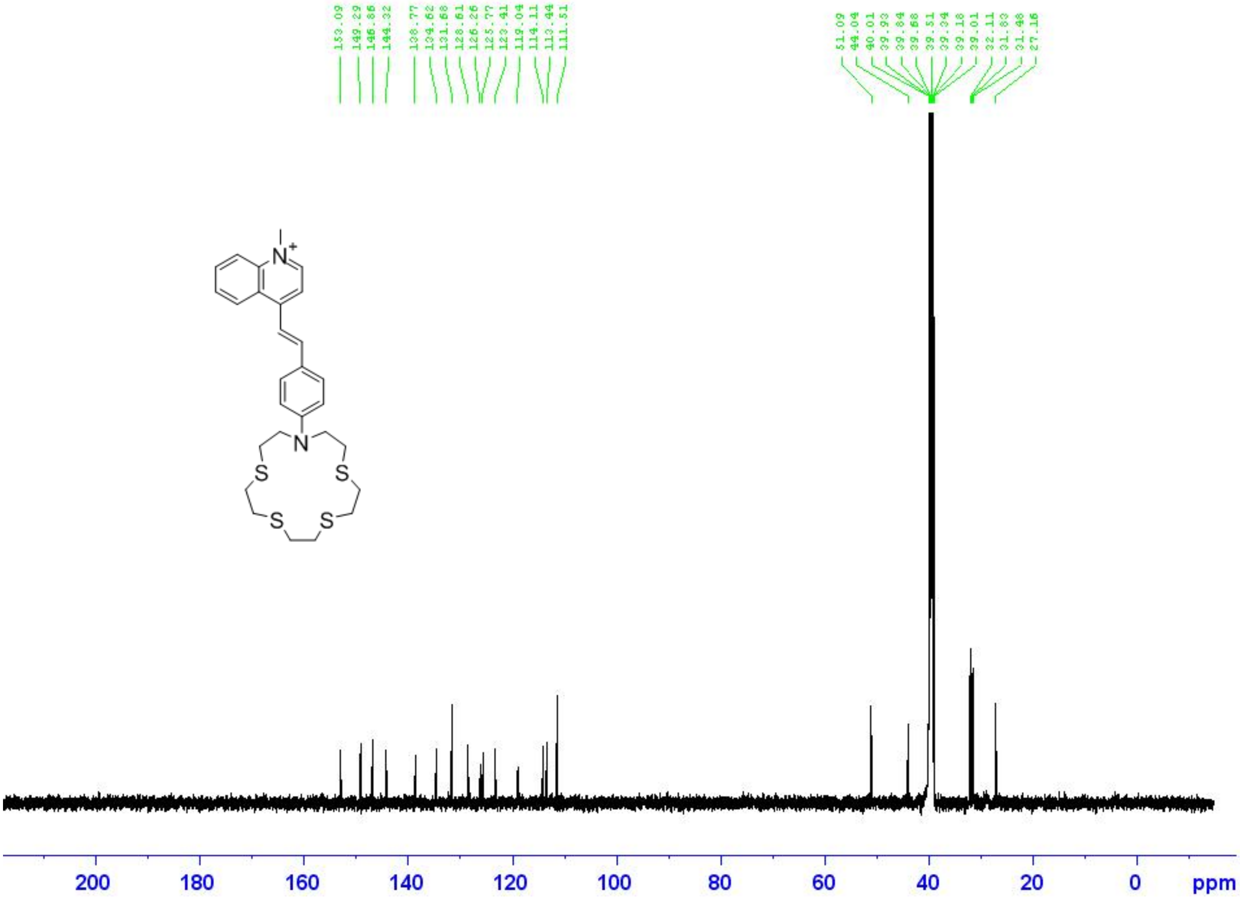




Characterization of 6C

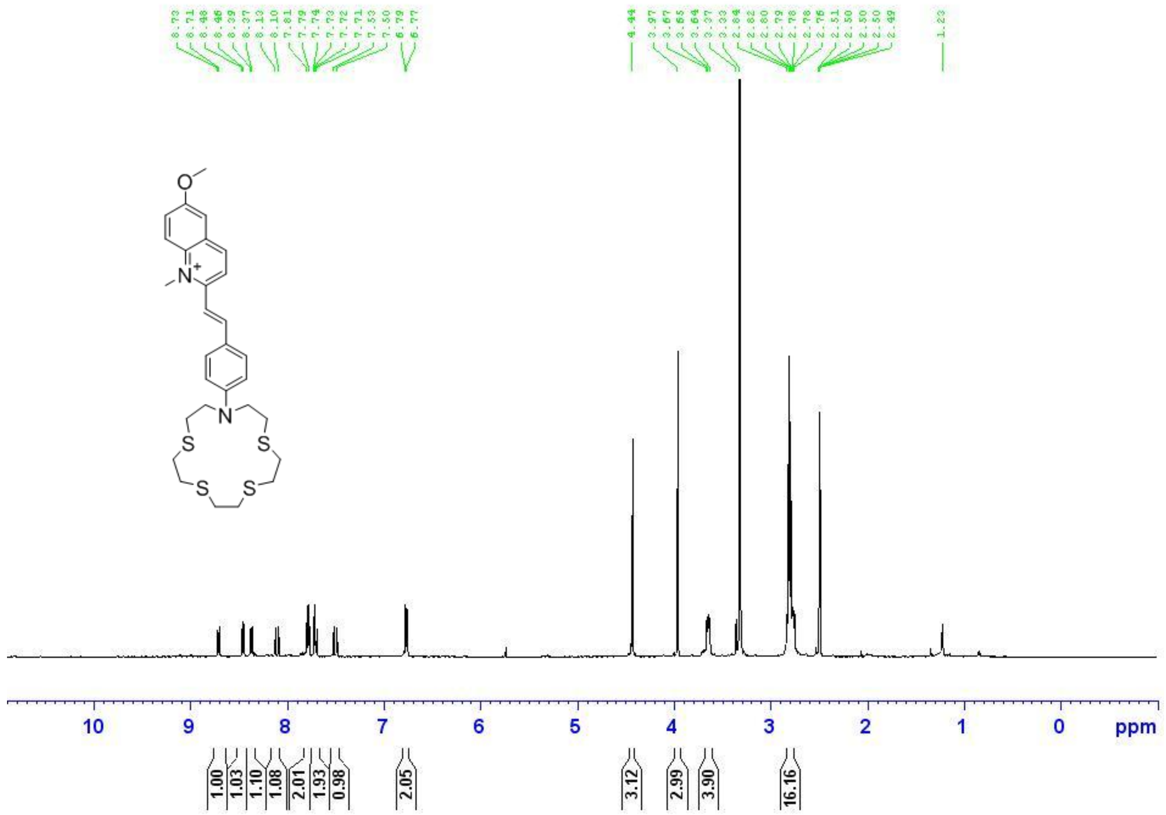
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.77-7.84 (16H, m), 3.67 (4H, t, *J* = 8.4 Hz), 4.45 (3H, s), 6.81 (2H, d, *J* = 8.9 Hz), 7.55 (1H, d, *J* = 15.5 Hz), 7.83-7.85 (3H, m), 8.09 (1H, t, *J* = 8.6 Hz), 8.23-8.26 (2H, m), 8.42 (1H, d, *J* = 9.0 Hz), 8.50 (1H, d, *J* = 9.3 Hz), 8.83 (1H, d, *J* = 9.1 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 27.132, 31.489, 31.835, 32.114, 51.098, 54.867, 111.609, 112.304, 118.847, 120.255, 122.843, 126.877, 128.094, 129.799, 132.295, 134.194, 139.210, 142.085, 148.530, 150.036, 156.328. HRMS (FAB): m/e calcd. For $C_{28}H_{35}N_2S_4$ [M^+] 527.1683, found 527.1686.

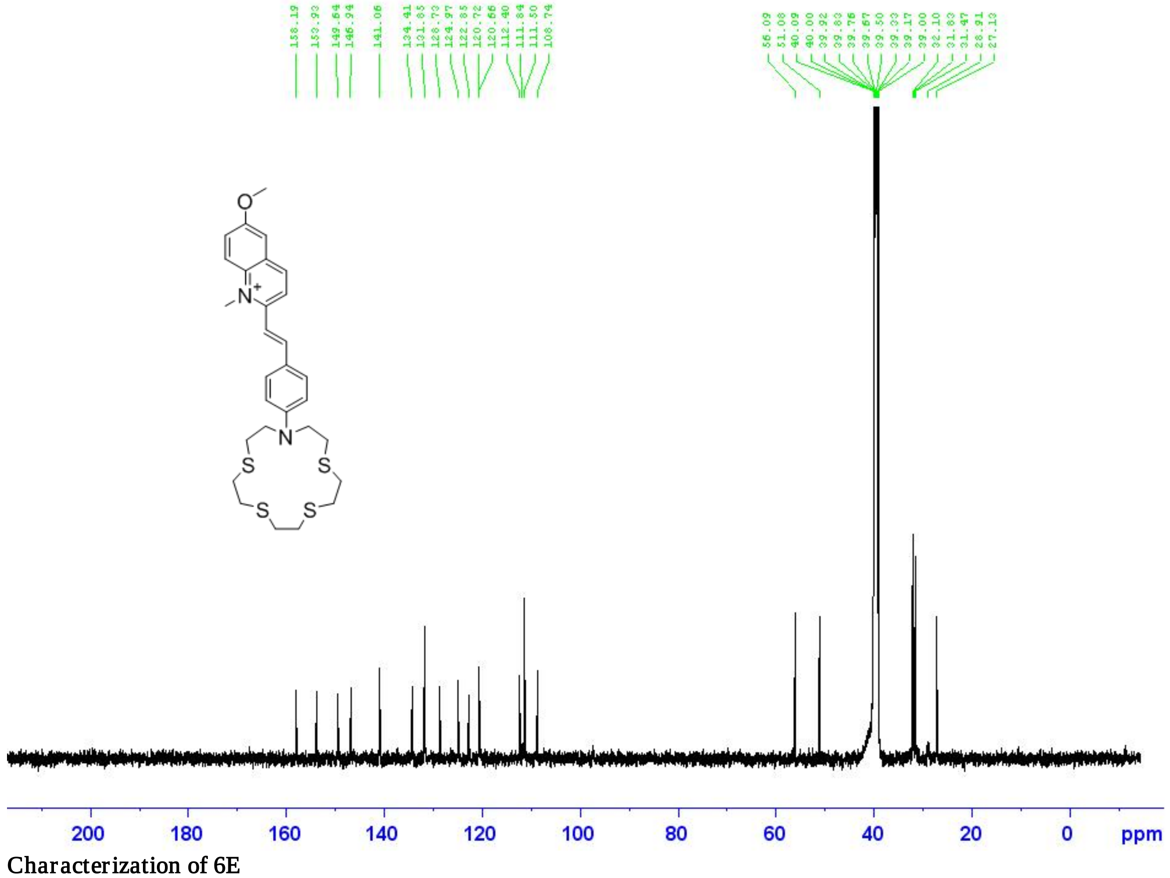




Characterization of 6D

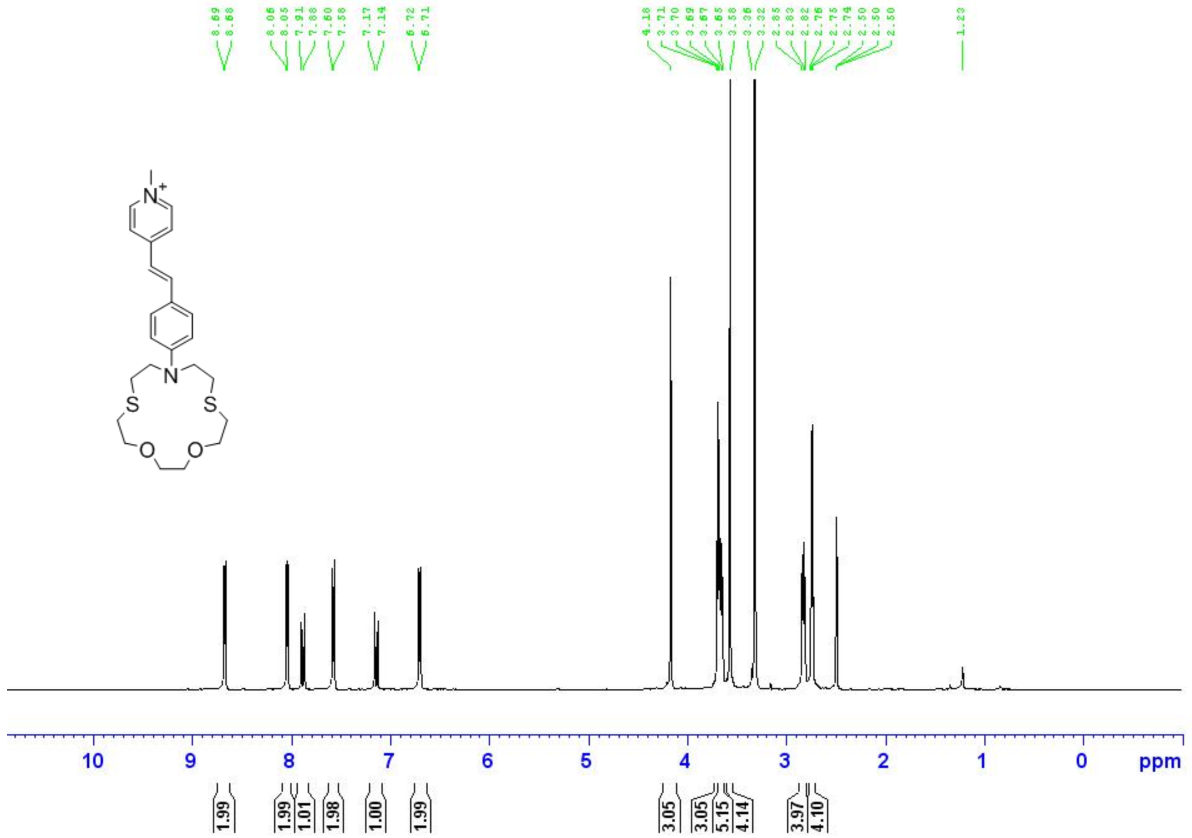
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.78-2.81 (16H, m), 3.64 (4H, t, J = 8.4 Hz), 4.45 (3H, s), 6.77 (2H, d, J = 8.9 Hz), 7.85 (2H, d, J = 8.8 Hz), 7.96-8.01 (2H, m), 8.14-8.22 (2H, m), 8.33-8.35 (2H, m), 8.99 (1H, d, J = 8.6 Hz), 9.12 (1H, d, J = 6.7 Hz) ^{13}C NMR (125 MHz, DMSO-d_6): δ 27.159, 31.477, 31.831, 32.107, 44.038, 51.089, 111.514, 113.435, 114.106, 119.043, 123.411, 125.769, 126.260, 128.609, 131.681, 134.621, 138.768, 144.317, 146.856, 149.289, 153.092. HRMS (FAB): m/e calcd. For $C_{28}H_{35}N_2S_4$ [M^+] 527.1683, found 527.1675.

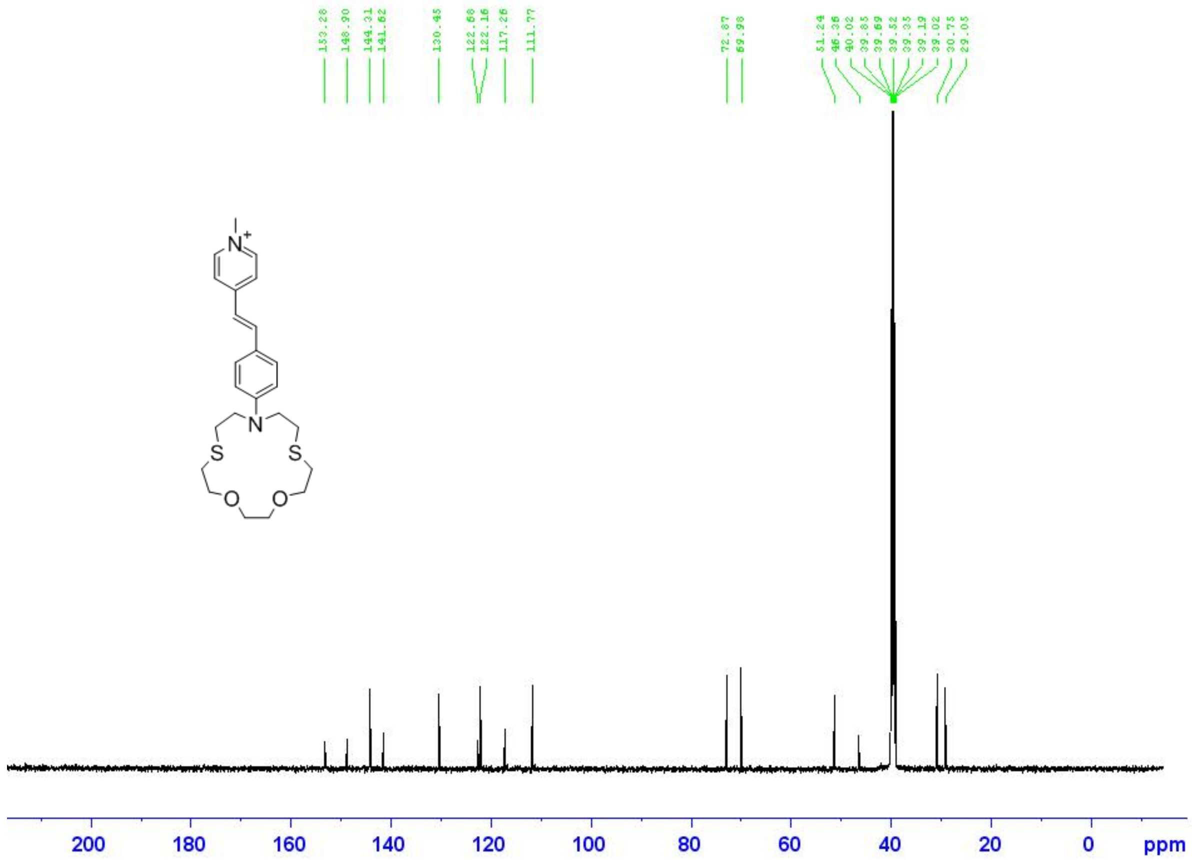




Characterization of 6E

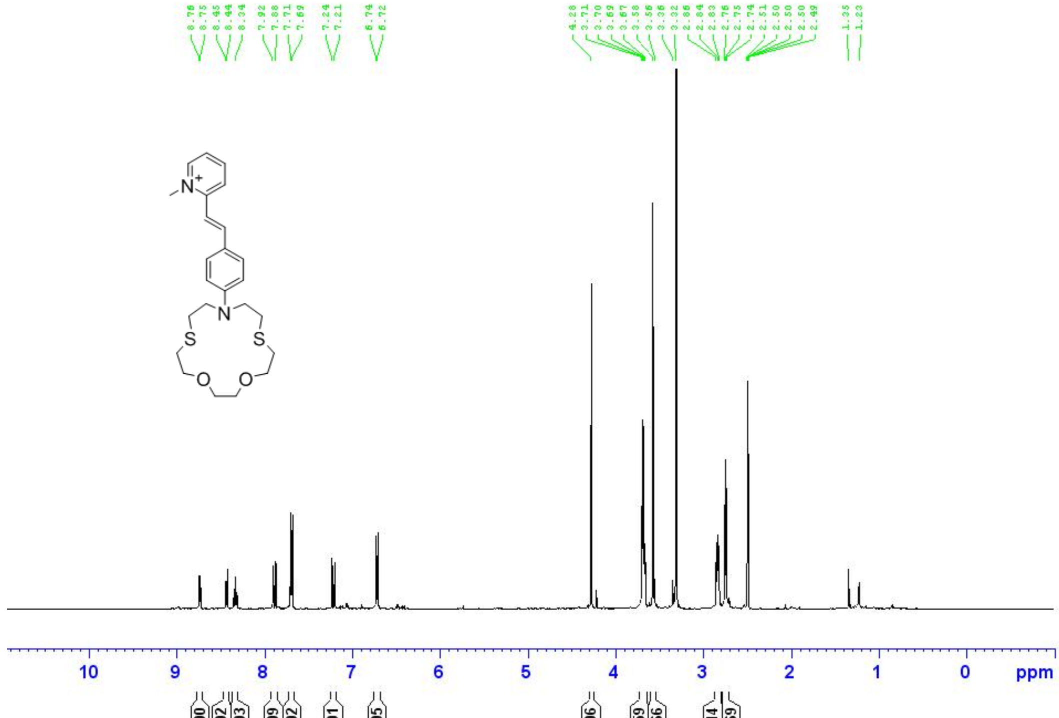
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.76-2.82 (16H, m), 3.65 (4H, t, J = 8.4 Hz), 3.97 (3H, s), 4.44 (3H, s), 6.77 (2H, d, J = 9.1 Hz), 7.50 (1H, d, J = 15.5 Hz), 7.71-7.74 (2H, m), 7.79 (2H, d, J = 8.9 Hz), 8.10 (1H, d, J = 15.5 Hz), 8.37 (1H, d, J = 9.5 Hz), 8.45 (1H, d, J = 9.3 Hz), 8.71 (1H, d, J = 9.2 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 27.126, 31.471, 31.825, 32.102, 51.076, 56.091, 108.736, 111.498, 112.395, 120.656, 120.717, 122.848, 124.967, 128.729, 131.851, 134.413, 141.056, 146.941, 149.636, 153.935, 158.195. HRMS (FAB): m/e calcd. For $C_{29}H_{37}N_2OS_4$ [M^+] 557.1789, found 557.1796.

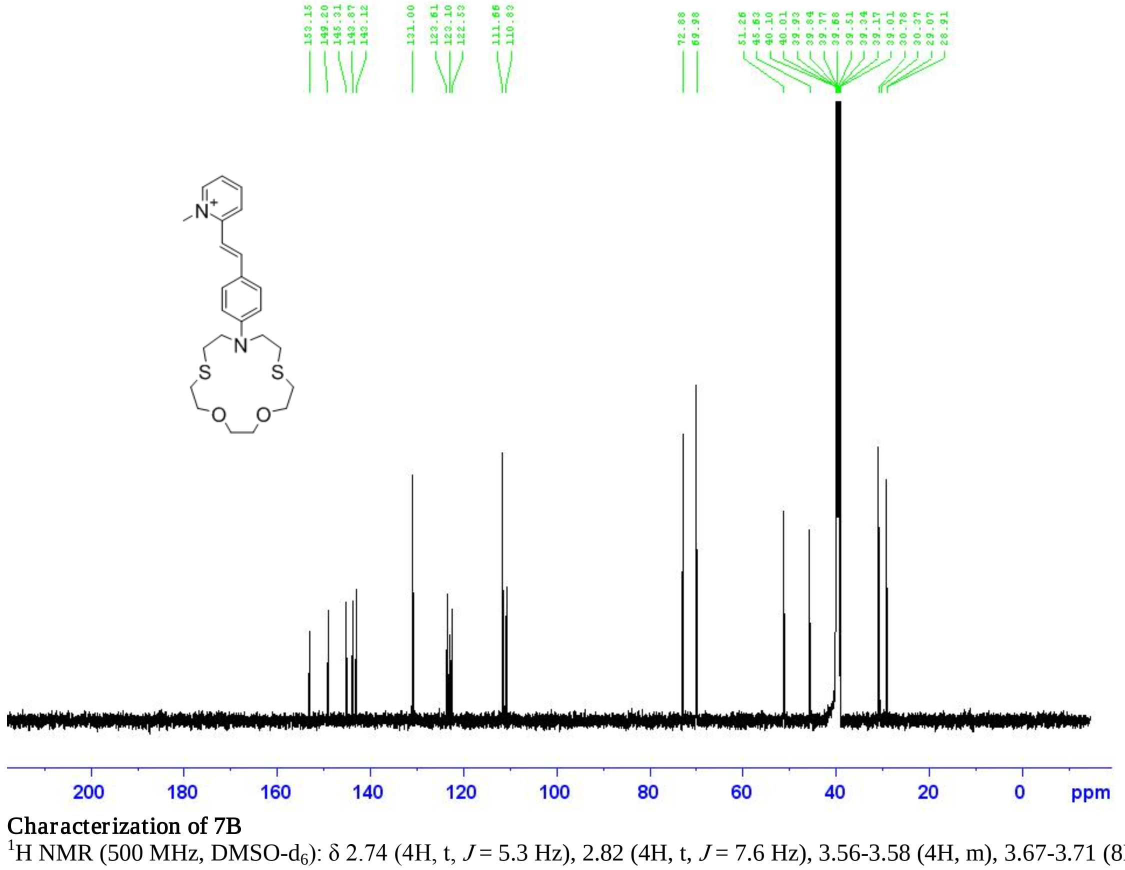




Characterization of 7A

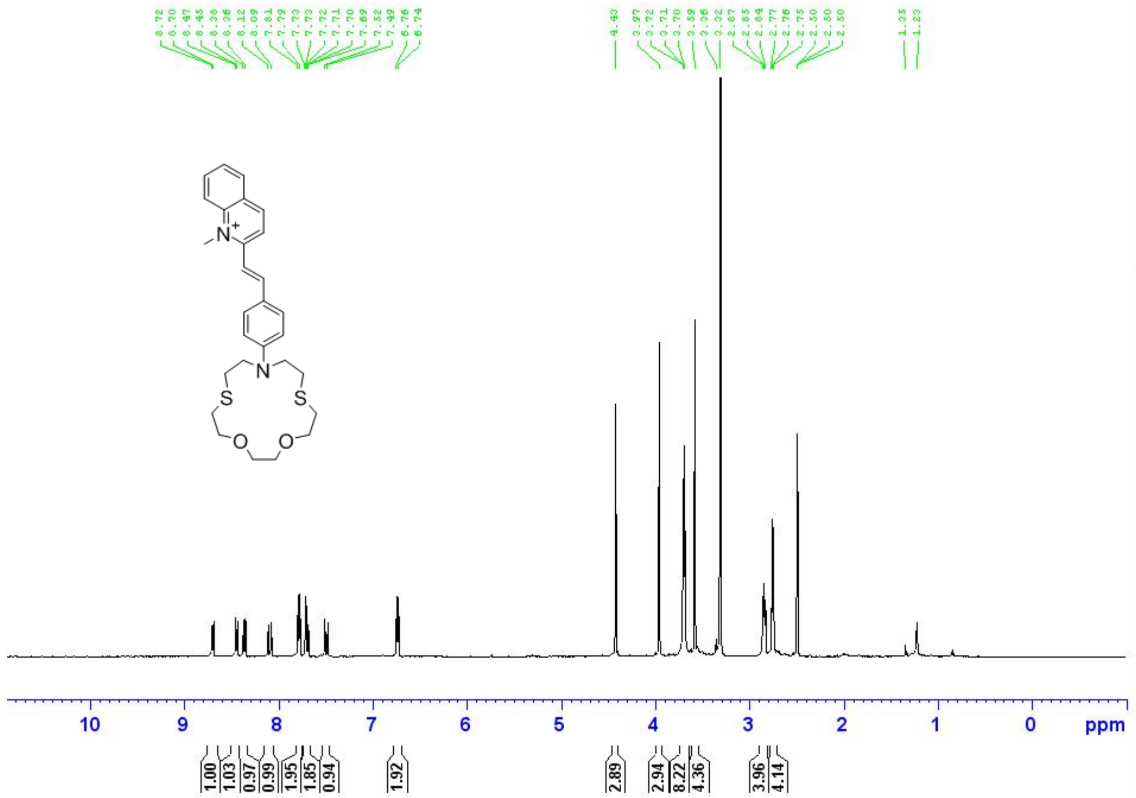
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.73 (4H, t, J = 5.3 Hz), 2.81 (4H, t, J = 7.6 Hz), 3.57 (4H, s), 3.68-3.70 (8H, m), 4.17 (3H, s), 6.70 (2H, d, J = 8.8 Hz), 7.13 (1H, d, J = 16 Hz), 7.57 (2H, d, J = 8.7 Hz), 7.87 (1H, d, J = 16 Hz), 8.04 (2H, d, J = 6.6 Hz), 8.67 (2H, d, J = 6.6 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 29.053, 30.752, 46.362, 51.239, 69.977, 72.869, 111.765, 117.265, 122.157, 122.680, 130.448, 141.623, 144.312, 148.900, 153.281. HRMS (FAB): m/e calcd. For $C_{24}H_{33}N_2O_2S_2$ [M^+] 445.1983, found 445.1977.

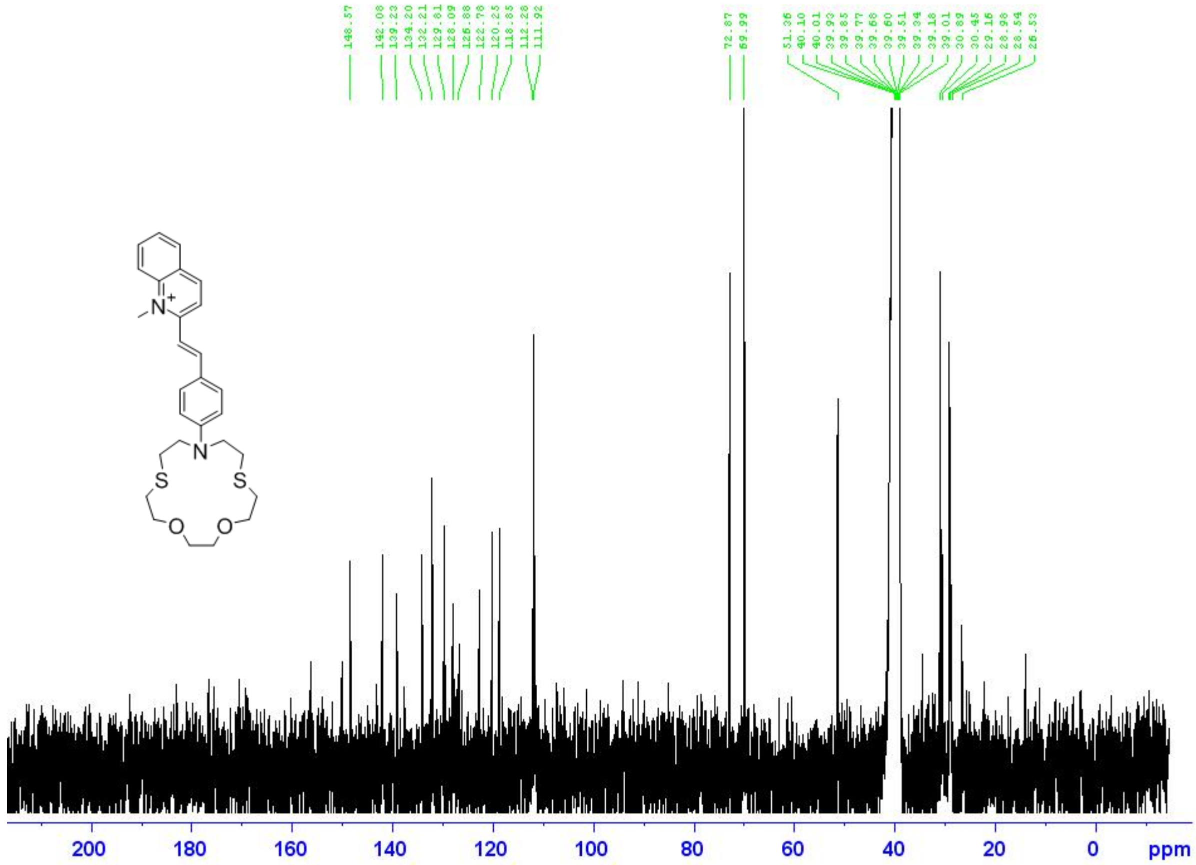




Characterization of 7B

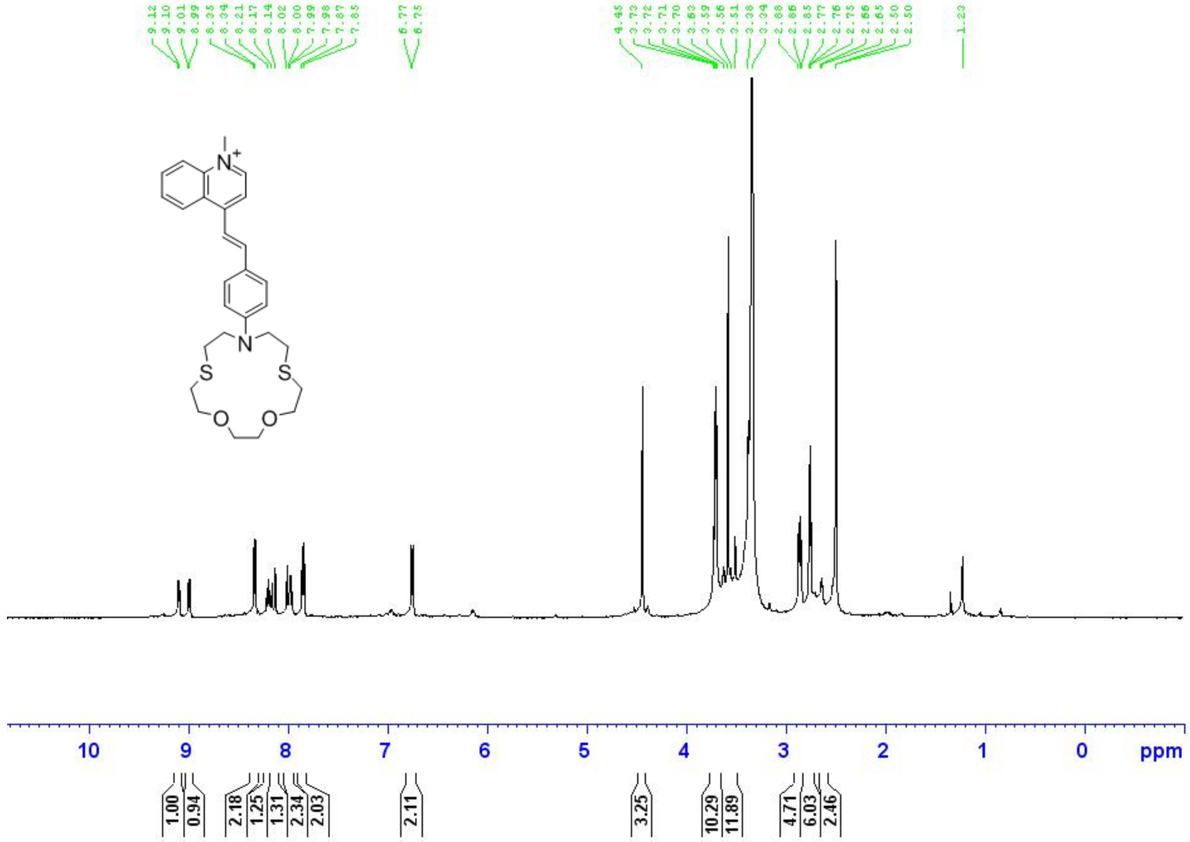
^{1}H NMR (500 MHz, DMSO-d$_6$): δ 2.74 (4H, t, J = 5.3 Hz), 2.82 (4H, t, J = 7.6 Hz), 3.56-3.58 (4H, m), 3.67-3.71 (8H, m), 4.28 (3H, s), 6.72 (2H, d, J = 8.9 Hz), 7.20 (1H, d, J = 15.7 Hz), 7.69-7.72 (3H, m), 7.88 (1H, d, J = 15.7 Hz), 8.32 (1H, t, J = 7.9 Hz), 8.43 (1H, d, J = 8.0 Hz), 8.74 (1H, d, J = 6.1 Hz). ^{13}C NMR (125 MHz, DMSO-d$_6$): δ 29.069, 30.779, 45.632, 51.256, 69.978, 72.877, 110.832, 111.663, 122.528, 123.097, 123.613, 130.996, 143.122, 143.874, 145.310, 149.201, 153.149. HRMS (FAB): m/e calcd. For $C_{24}H_{33}N_2O_2S_2$ [M^+] 445.1983, found 445.1988.

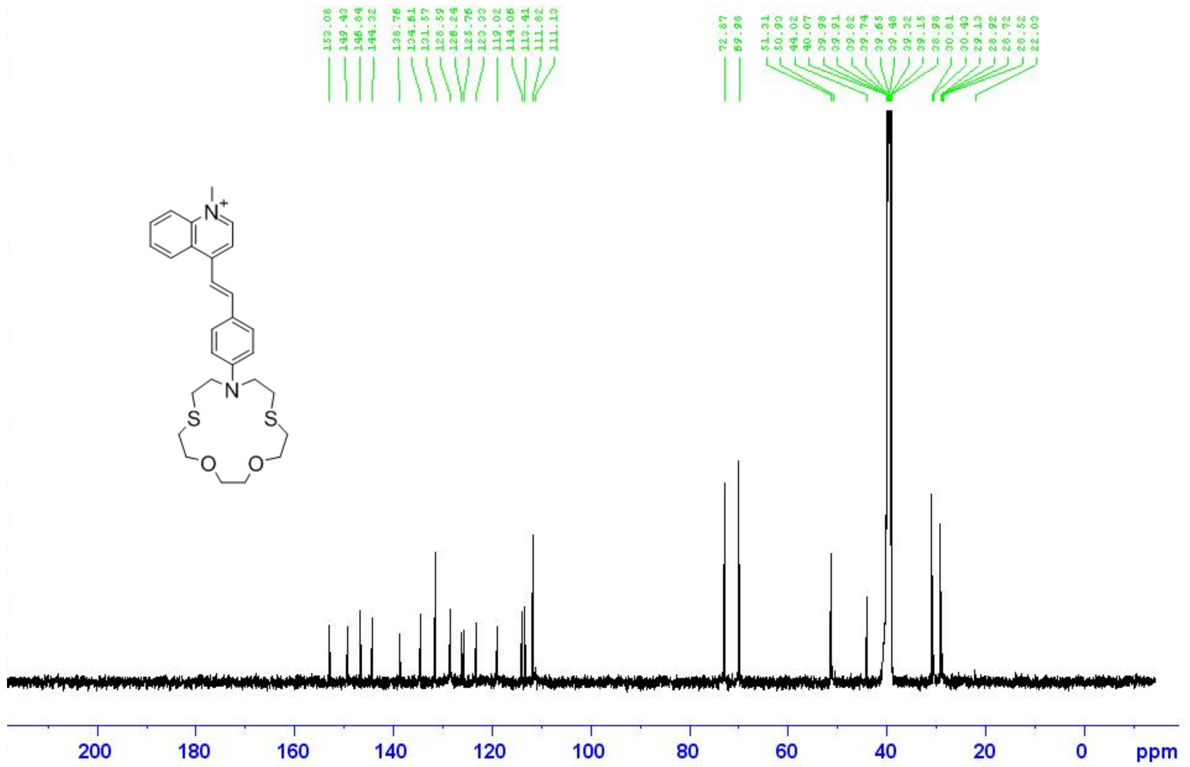




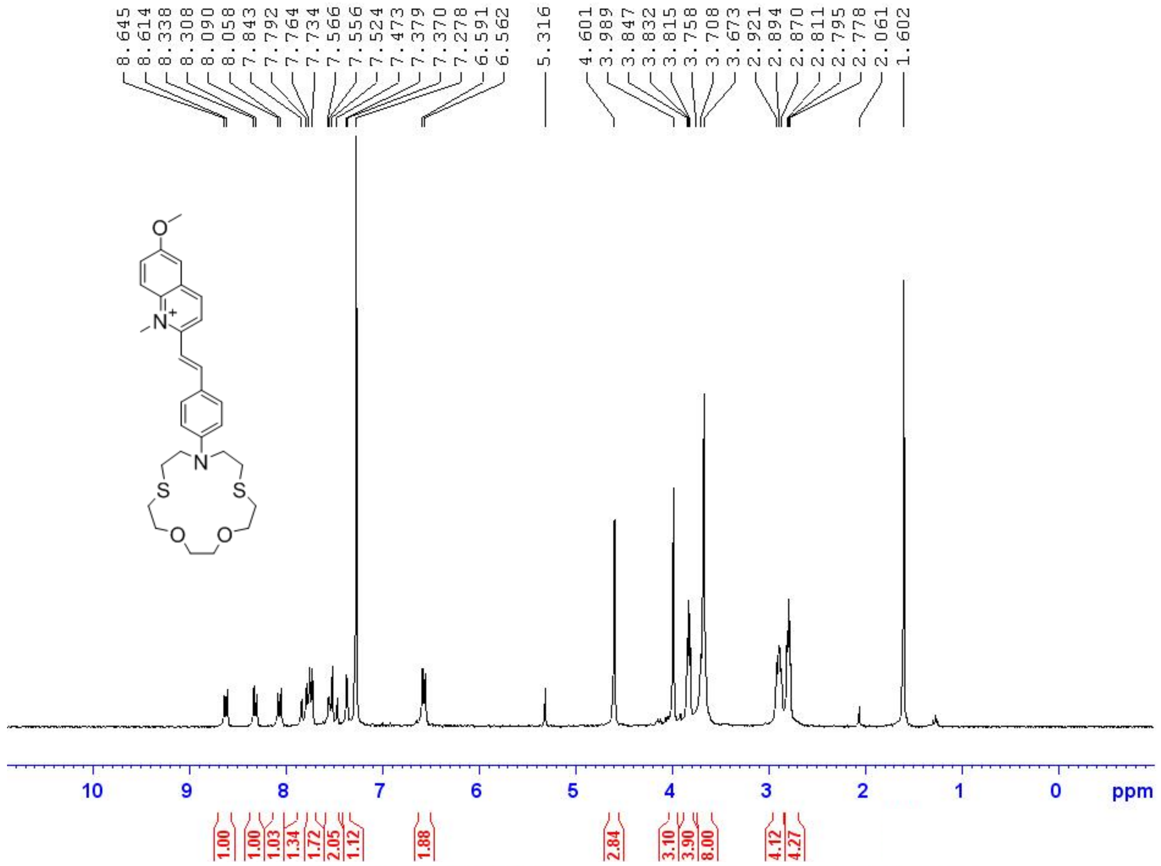
Characterization of 7C

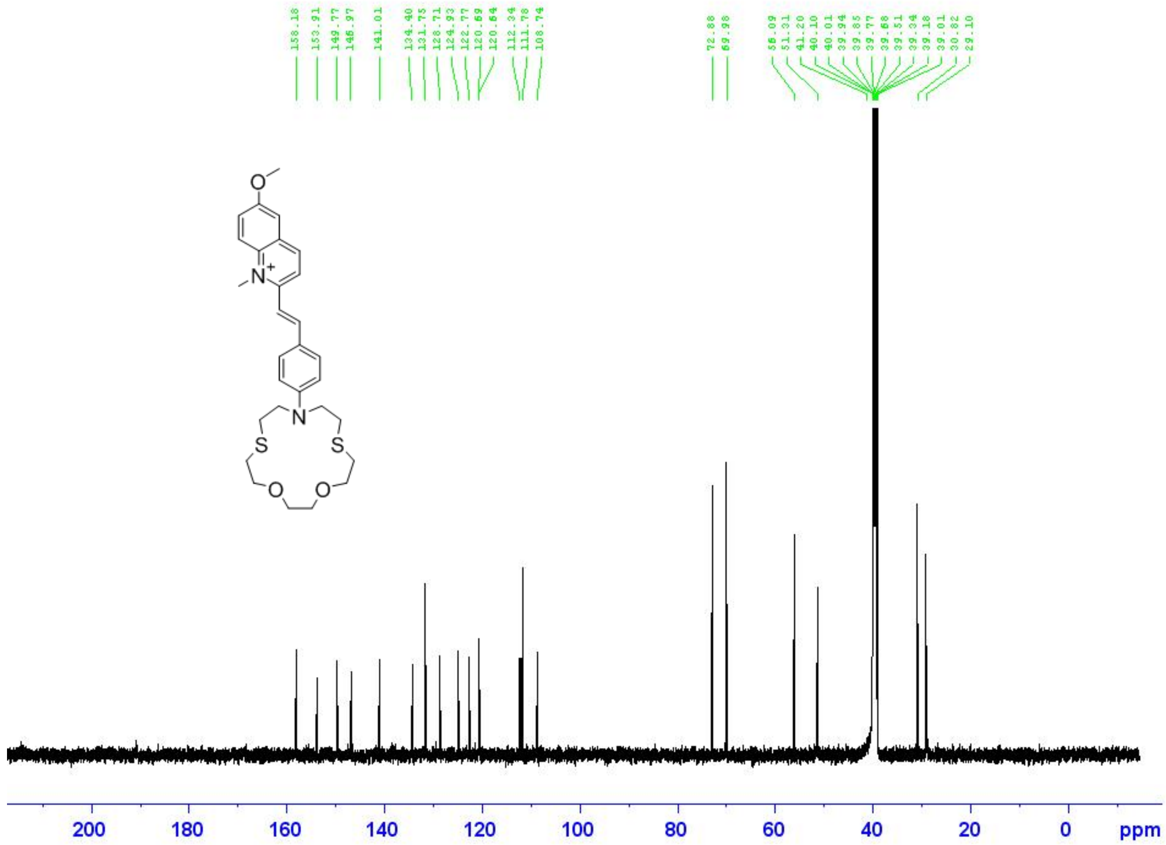
[1]H NMR (500 MHz, DMSO-d_6): δ 2.75 (4H, t, *J* = 5.2 Hz), 2.86 (4H, t, *J* = 7.7 Hz), 3.56-3.58 (4H, m), 3.69-3.75 (8H, m), 4.44 (3H, s), 6.78 (2H, d, *J* = 8.9 Hz), 7.54 (1H, d, *J* = 15.6 Hz), 7.84-7.86 (3H, m), 8.07 (1H, t, *J* = 16.3 Hz), 8.22 (2H, t, *J* = 7.4 Hz), 8.42 (1H, d, *J* = 9.0 Hz), 8.50 (1H, d, *J* = 9.3 Hz), 8.81 (1H, d, *J* = 9.1 Hz). [13]C NMR (125 MHz, DMSO-d_6): δ 29.161, 30.888, 51.358, 69.988, 72.866, 111.917, 112.277, 118.847, 120.255, 122.776, 126.879, 128.089, 129.09, 132.210, 134.201, 139.230, 142.078, 148.572. HRMS (FAB): m/e calcd. For $C_{28}H_{35}N_2O_2S_2$ [M^+] 495.2140, found 495.2139.





Characterization of 7D
^{1}H NMR (500 MHz, DMSO-d_6): δ 2.75 (2H, t, J = 5.0 Hz), 2.84 (6H, t, J = 7.6 Hz), 3.55 (4H, s), 3.63-3.73 (8H, m), 4.44 (3H, s), 6.75 (2H, d, J = 8.7 Hz), 7.84 (2H, d, J = 8.7 Hz), 7.96-8.01 (2H, m), 8.13-8.22 (2H, m), 8.33 (2H, d, J = 7.9 Hz), 8.99 (1H, d, J = 8.6 Hz), 9.10 (1H, d, J = 6.6 Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 30.428, 30.809, 50.929, 51.312, 69.979, 72.872, 111.816, 113.406, 114.064, 119.020, 123.333, 125.761, 126.242, 128.595, 131.568, 134.611, 138.763, 144.323, 146.835, 149.428, 153.078. HRMS (FAB): m/e calcd. For $C_{28}H_{35}N_2O_2S_2$ [M^+] 495.2140, found 495.2139.





Characterization of 7E

^{1}H NMR (300 MHz, $CDCl_3$): δ 2.79 (4H, t, J = 7.2 Hz), 2.90 (4H, s), 3.68 (8H, m), 3.83 (4H, t, J = 5.1 Hz), 3.99 (3H, s), 4.60 (3H, s) 6.58 (2H, d, J = 8.7 Hz), 7.37 (1H, d, J = 2.7 Hz), 7.56 (2H,t, J = 3.0 Hz), 7.73-7.84 (3H, m), 7.79 (1H, t J = 15.3 Hz), 8.07 (1H, d, J = 9.6 Hz), 8.31 (1H, d, J = 9.0Hz), 8.63 (1H, d, J = 9.3Hz). ^{13}C NMR (125 MHz, DMSO-d_6): δ 29.104, 30.818, 51.308, 56.089, 69.980, 72.881, 108.743, 111.776, 112.337, 120.641, 120.694, 122.769, 124.933, 128.708, 131.748, 134.400, 141.015, 146.967, 149.770, 153.914, 158.178. HRMS (FAB): m/e calcd. For $C_{29}H_{37}N_2O3S_2$ [M^+] 525.2246, found 525.2248.

3. Fluorescence excitation and emission spectra of the probes

All the metal cation screening and titration experiments were performed in HEPES buffer solution (10 mM, pH 7.4, 25°C).

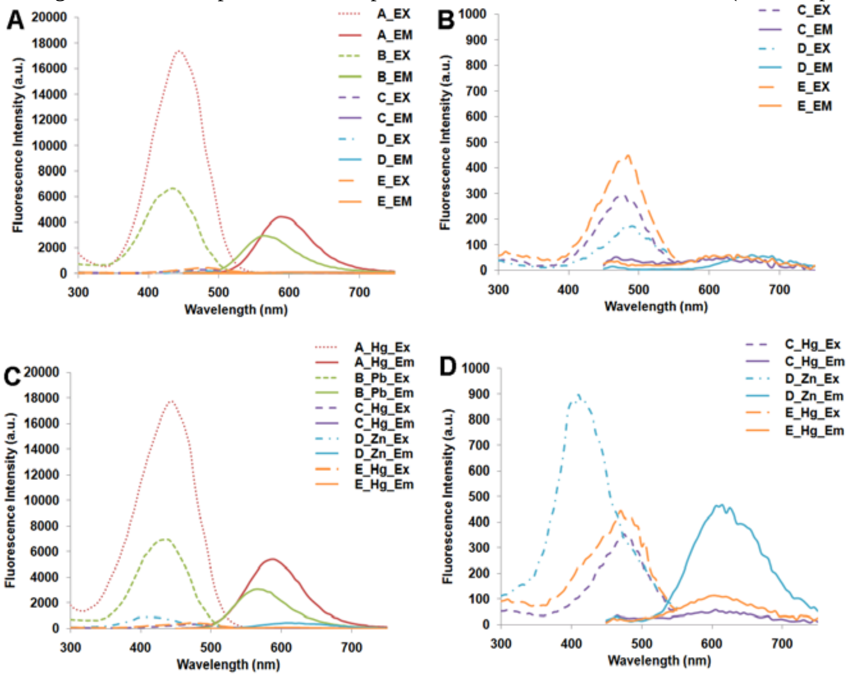


Figure S1. Fluorescence excitation spectra (emission at 580 nm) and emission spectra (excitation at 400 nm) of probe **1** series (each 5 µM, 10 mM HEPES buffer, pH 7.4) before (A, B) and after (C, D) addition of each target metal cation (50 µM). Graphs (B) and (D) for comparison of quinolinium products' spectral changes.

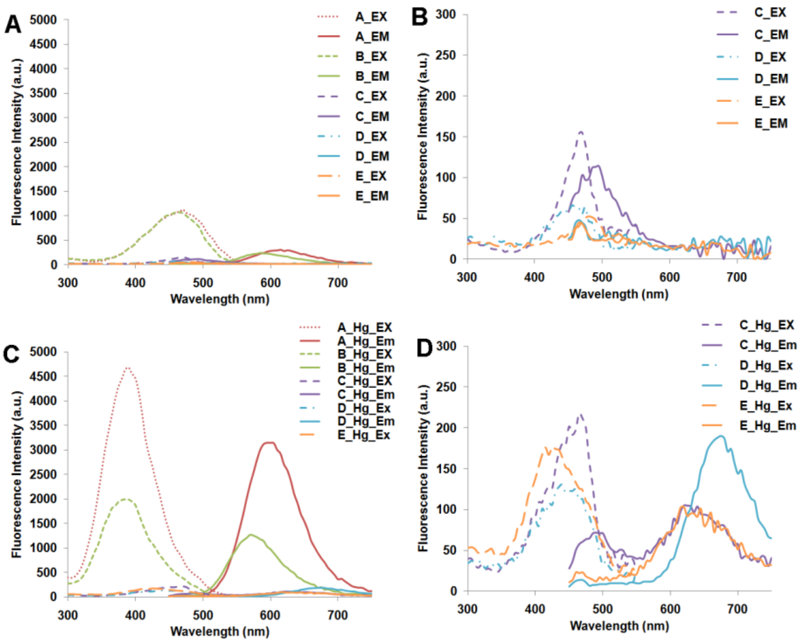


Figure S2 Fluorescence excitation spectra (emission at 580 nm) and emission spectra (excitation at 400 nm) of probe **2** series (each 5 µM, 10 mM HEPES buffer, pH 7.4) before (A,B) and after (C,D) addition of each target metal cation (50 µM). Graphs (B) and (D) for comparison of quinolinium products' spectral changes.

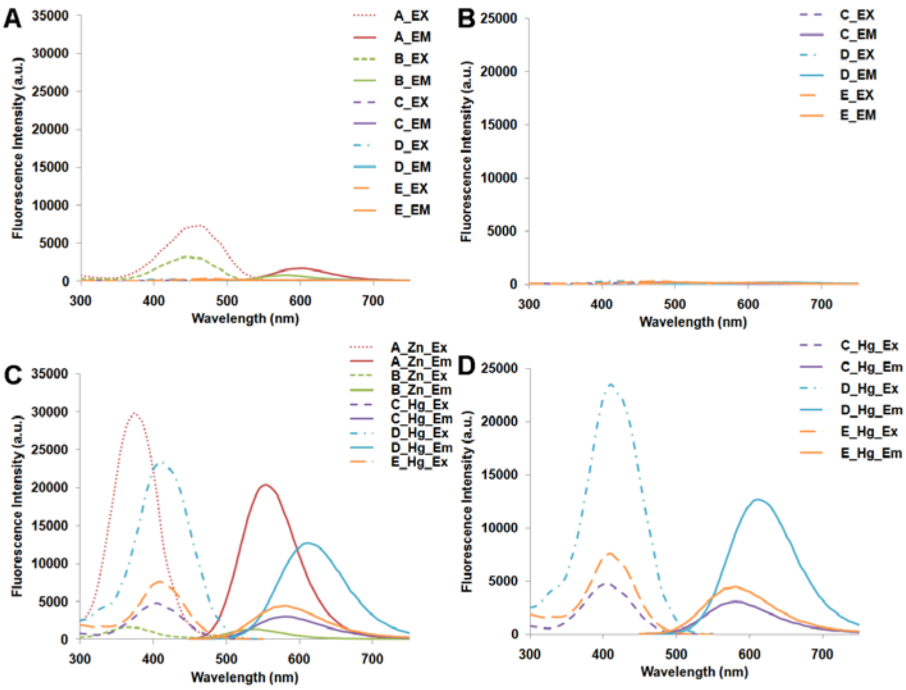


Figure S3 Fluorescence excitation spectra (emission at 580 nm) and emission spectra (excitation at 400 nm) of probe **3** series (each 5 µM, 10 mM HEPES buffer, pH 7.4) before (A,B) and after (C,D) addition of target metal cation (50 µM). Graphs (B) and (D) for comparison of quinolinium products' spectral changes.

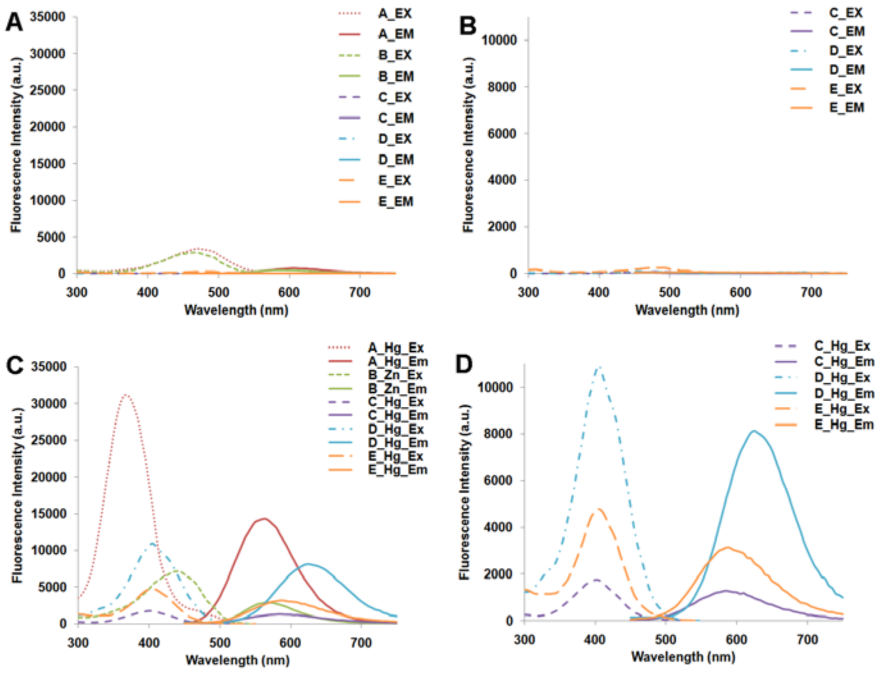


Figure S4 Fluorescence excitation spectra (emission at 580 nm) and emission spectra (excitation at 400 nm) of probe **4** series (each 5 µM, 10mM HEPES buffer, pH 7.4) before (A,B) and after (C,D) addition of target metal cation (50 µM). Graph (B) and (D) for comparison of quinolinium products' spectral changes.

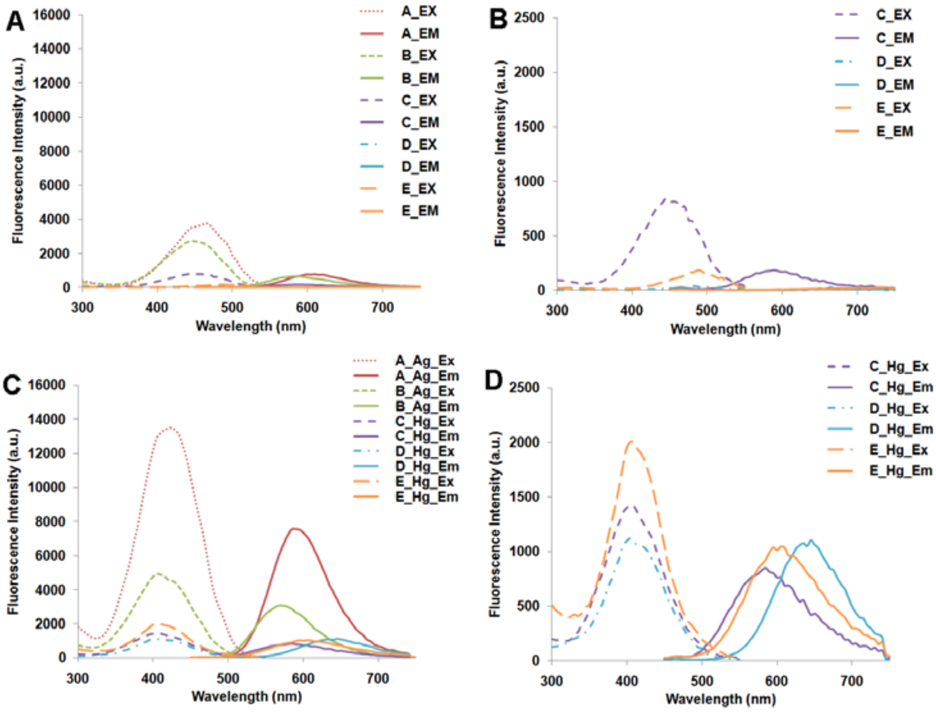


Figure S5 Fluorescence excitation spectrum (emission at 580 nm) and emission spectrum (excitation at 400 nm) of probe **5** series (each 5 µM, 10 mM HEPES buffer, pH 7.4) before (A,B) and after (C,D) addition of target metal cation (50 µM). Graphs (B) and (D) for comparison of quinolinium products' spectral changes.

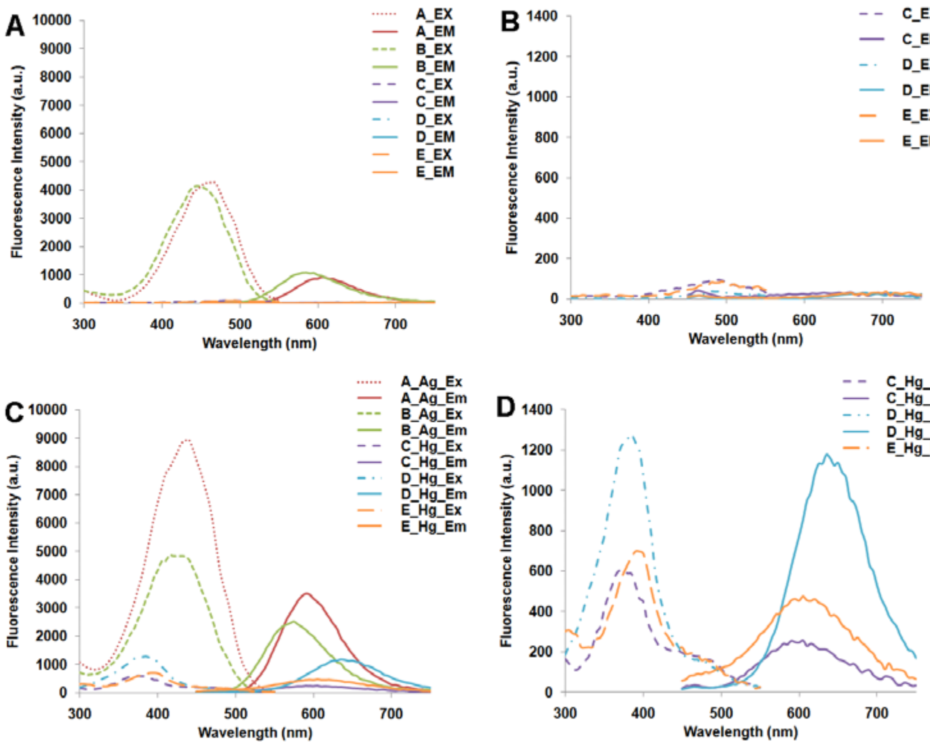


Figure S6 Fluorescence excitation spectrum (emission at 580 nm) and emission spectrum (excitation at 400 nm) of probe **6** series (each 5 µM, 10 mM HEPES buffer, pH 7.4) before (A,B) and after (C,D) addition of target metal cation (50 µM). Graphs (B) and (D) for comparison of quinolinium products' spectral changes.

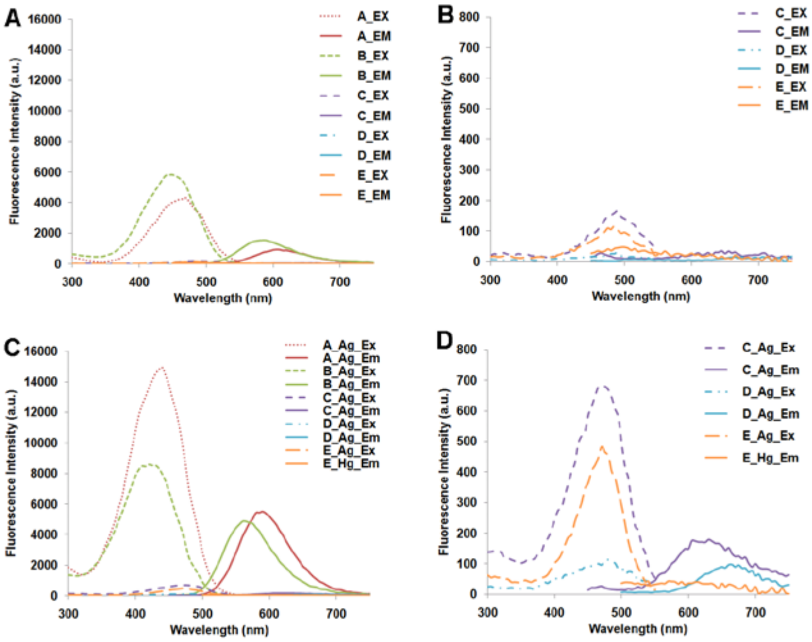


Figure S7 Fluorescence excitation spectrum (emission at 580 nm) and emission spectrum (excitation at 400 nm) of probe **7** series (each 5 μM, 10 mM HEPES buffer, pH 7.4) before (A,B) and after (C,D) addition of target metal cation (50 μM). Graph (B) and (D) for comparison of quinolinium products' spectral changes

4. Binding affinity of probes to metal cations

Table S1. Dissociation constants (K_d) between probes and metal ions

K_d (μM)	Zn^{2+}	Cd^{2+}	Pb^{2+}	Hg^{2+}	Ag^{+}
1D	.*	.	.	235	.
2A	0.0319	.	.	0.0103	.
2B	0.274	0.649	0.816	0.0888	33.6
2D	.	.	.	0.281	.
3A	0.406	0.191	0.506	2.36	.
3B	0.0951	0.0170	0.158	0.00108, (1.77)**	.
3C	0.378	0.947	2.31	7.25	.
3D	0.511	0.879	5.06	.	.
3E	0.734	0.685	2.85	.	.
4A	0.292, (2.93)	0.000211	20.6	0.205	.
4B	0.375	0.567	5.21	0.776	.
4C	0.00180, (12.8)	0.205	4.65	0.0448	.
4D	0.0505	0.259	6.02	6.69	.
4E	0.00977, (12.1)	0.0399	4.03	4.48	.
5A	.	.	.	5.90	2.80
5B	.	.	.	3.29	2.74
5C	.	.	.	4.84	0.710
5D	.	.	.	5.49	8.11
5E	.	.	.	11.9	15.3
6A	.	.	.	15.4	11.8
6B	.	.	.	0.298, (13.2)	3.86
6C	.	.	.	27.0	5.22
6D	.	.	.	37.3	13.6
6E	.	.	.	26.2	10.1
7A	.	.	.	.	7.42
7B	.	.	.	.	16.2
7C	.	.	.	859	26.7
7D	.	.	.	16.0	17.1
7E	.	.	.	.	49.3

*n.d. (not determined).
** Values in parentheses were obtained when the second metal ion was added to the 1:1 complex of the probe and metal ion (in other words, when one metal ion was removed from the 1:2 complex of the probe and metal ion).

5. Changes in the fluorescence spectral changes of **5A** and **5D** upon addition of Hg(II) and Ag(I)

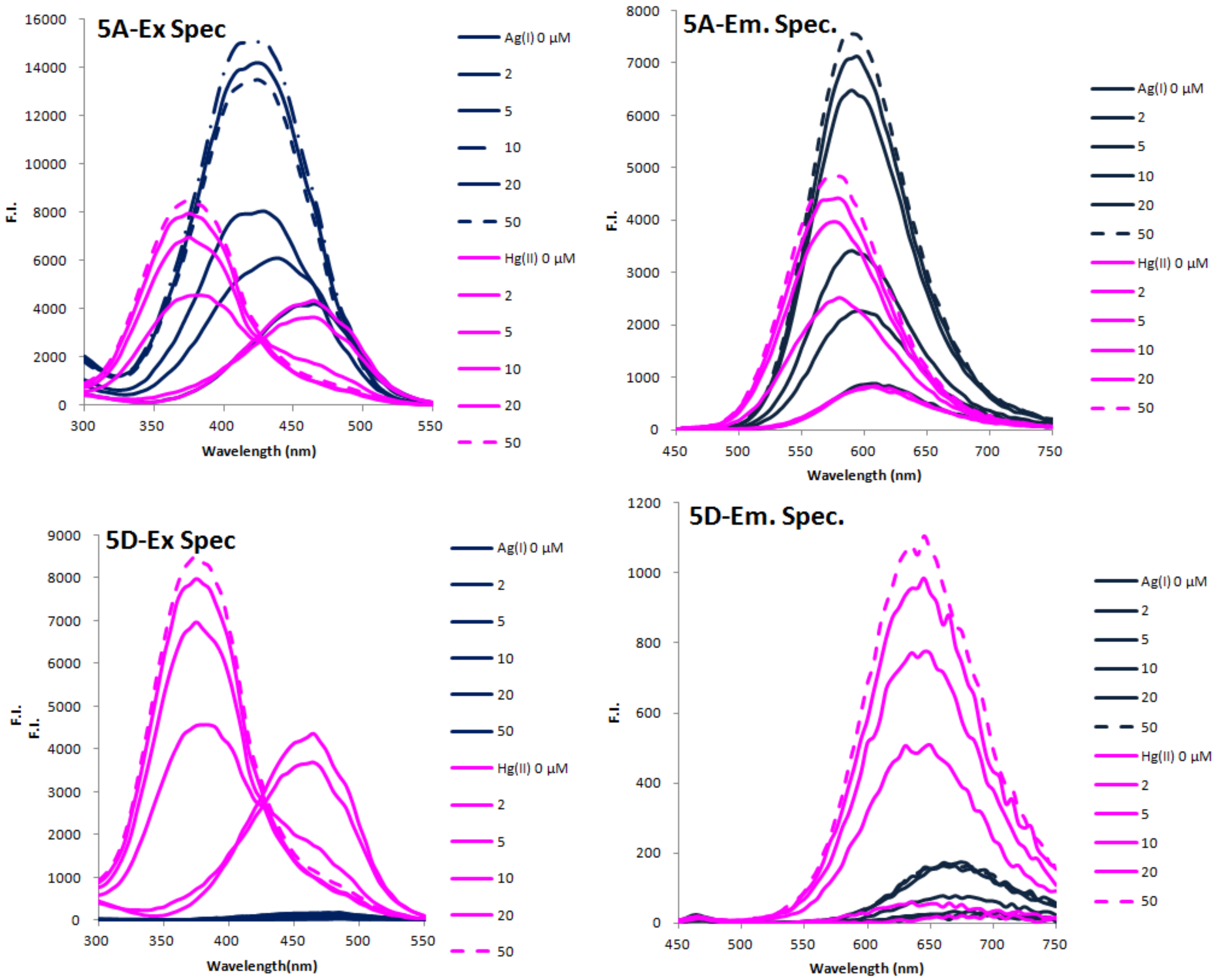


Figure S8. Distinct fluorescence changes of the excitation and emission spectra of **5A** and **5D** (each 5 µM) upon addition of Ag(I) and Hg(II). All the em. specs. were collected for a fixed excitation wavelength of 400 nm, and all the ex. specs were collected for a fixed emission wavelength of 580 nm.

6. The fluorescence response of selected metal ion probes to pH changes from pH 2 to 11

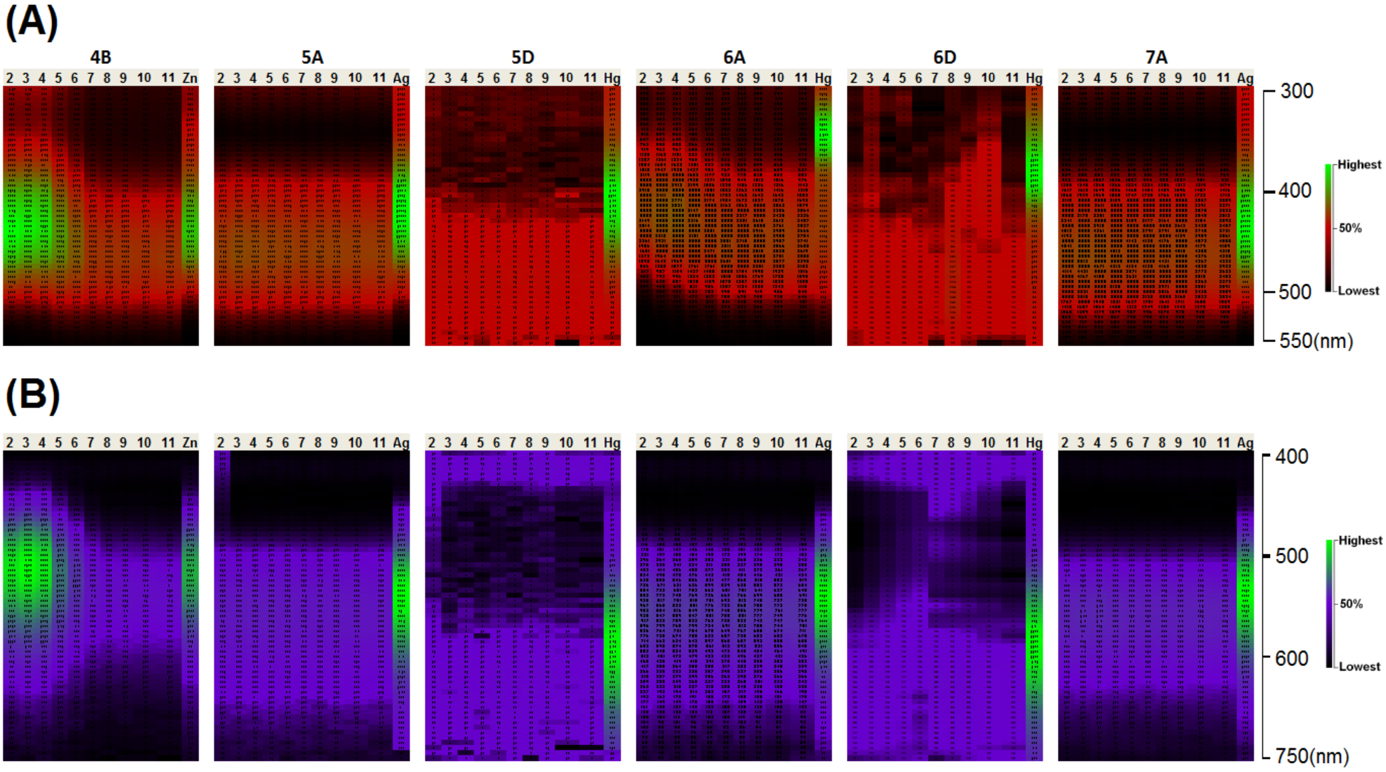


Figure S9. Fluorescence changes in the excitation and emission spectrum of selected metal ion probes (each 5 μM) in sodium phosphate buffer solution (10 mM, pH 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, left to right on the graph) are compared with fluorescence response upon the addition of a specific metal cation (50 μM) to each selected metal ion probe. (A) For the excitation spectrum: 300–550 nm. (B) For the emission spectrum: 450 (500 for 7 series)–750 nm. The fluorescence intensity can be known from the color scale, which is shown on the right side of the figure. The highest and lowest values of the fluorescence intensity were determined from the total values for each probe.

7. The fluorescence cellular imaging of 6A

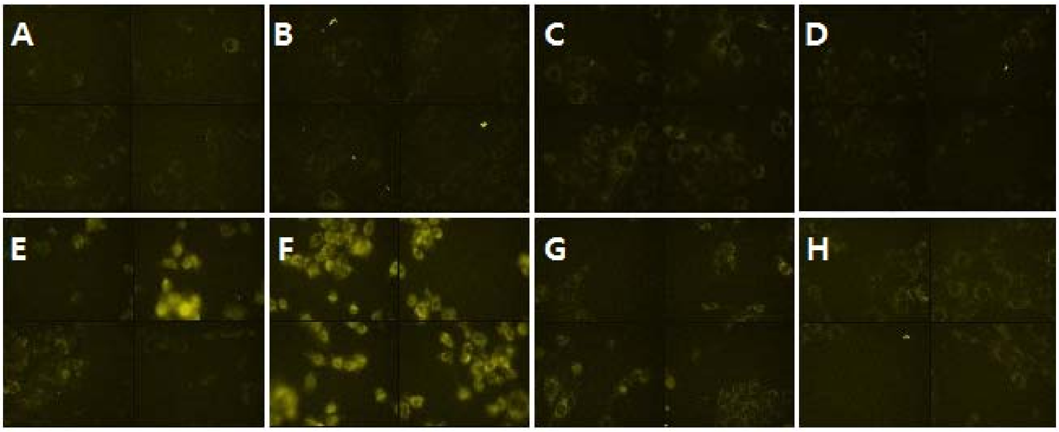
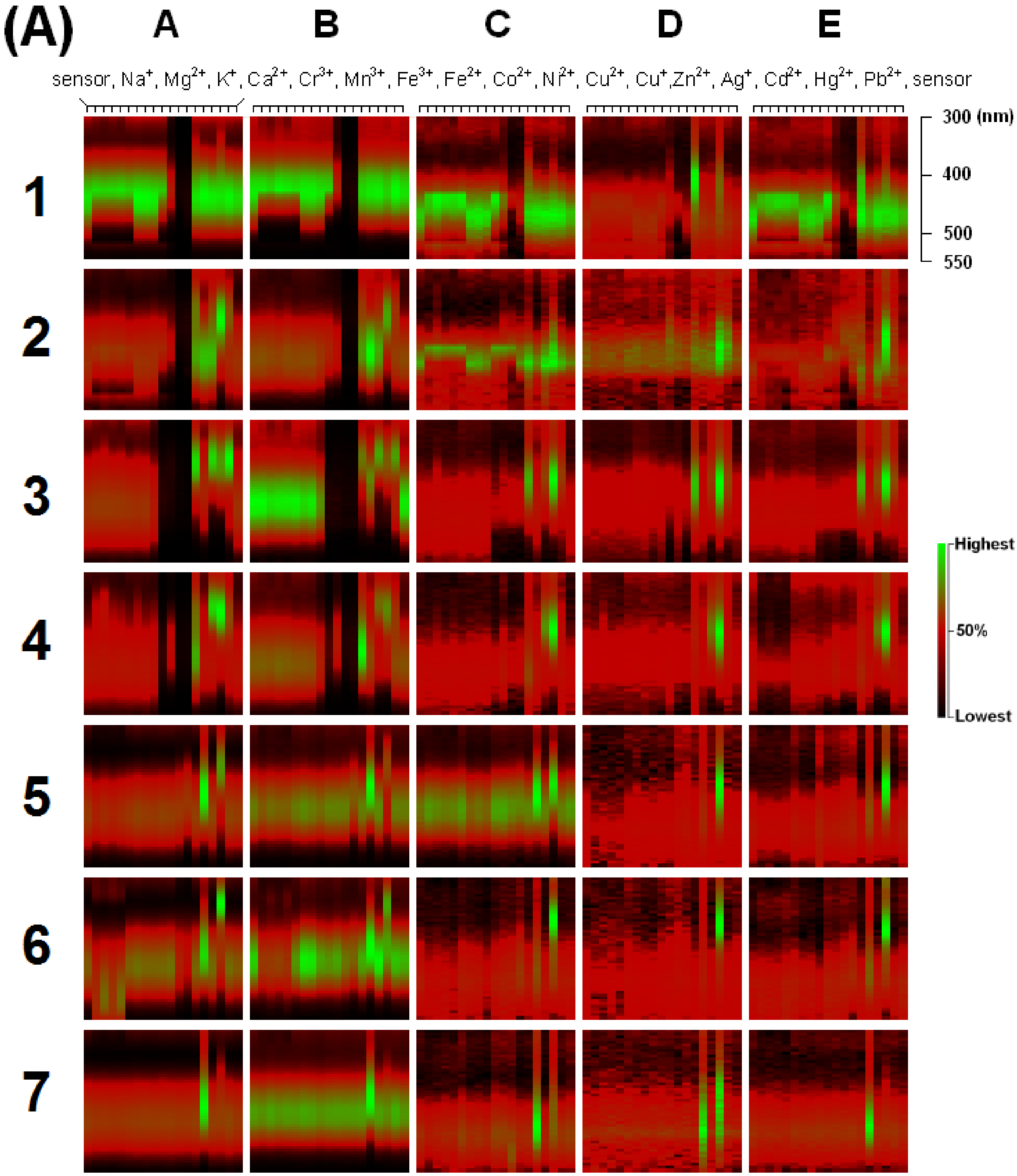
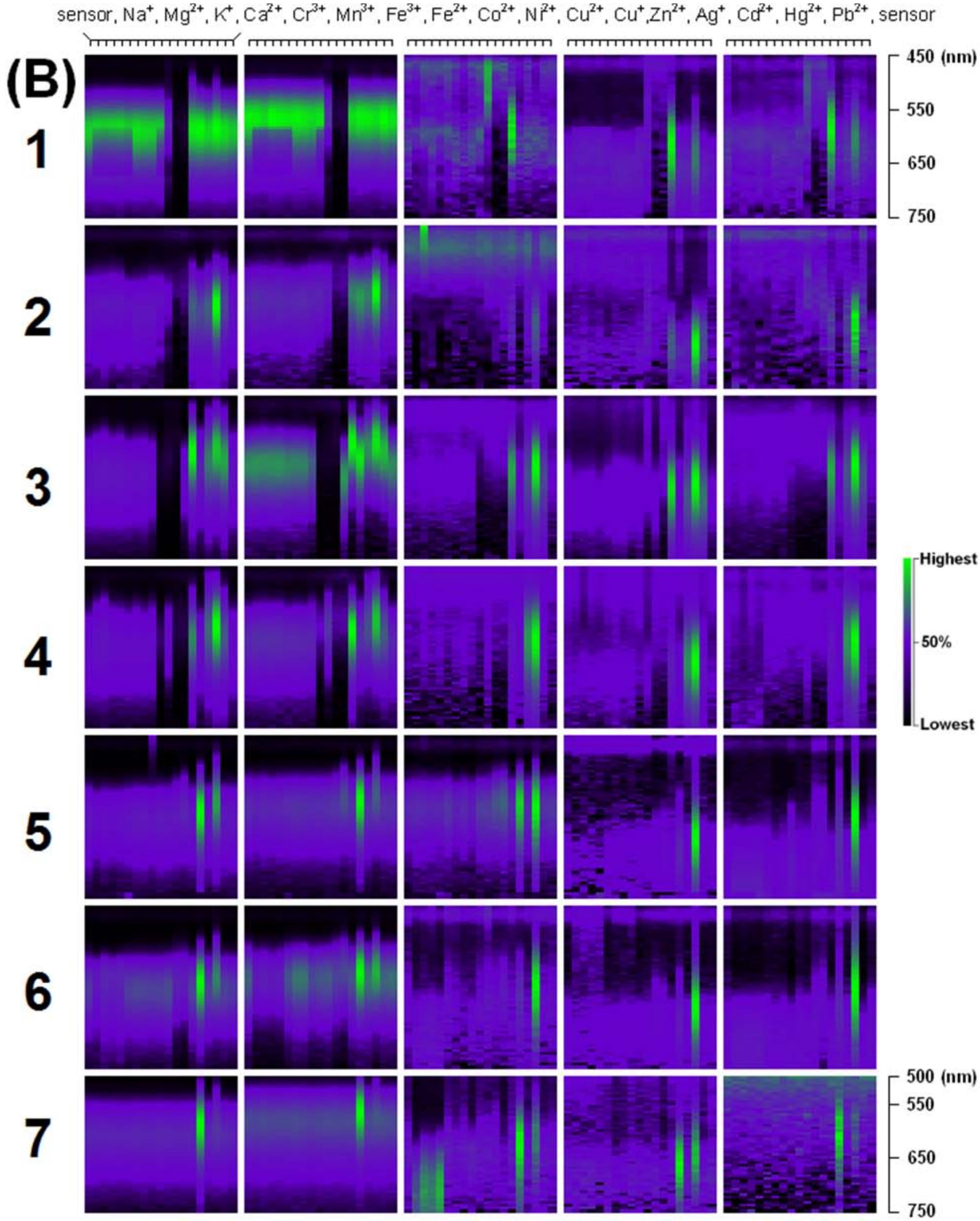


Figure S10. Fluorescence cellular imaging of **6A** (5 μM) in NIH3T3 cells incubated with (A) Zn^{2+} (B) Cd^{2+} (C) Pb^{2+} (D) Ag^{+} (E) Hg^{2+} (50 μM) (F) Hg^{2+} (100 μM) (G) TPEN (50 μM) after incubation of Hg^{2+} (100 μM), (H) is control picture of 6**A** (5 μM) in the cell. All the incubated metal concentration is 100 μM except Hg^{2+}.

8. Expanded version of Figure 2




sensor, Na^{+}, Mg^{2+}, K^{+}, Ca^{2+}, Cr^{3+}, Mn^{3+}, Fe^{3+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Cu^{+}, Zn^{2+}, Ag^{+}, Cd^{2+}, Hg^{2+}, Pb^{2+}, sensor
(B)
1
2
3
4
5
6
7
450 (nm)
550
650
750
Highest
50%
Lowest
500 (nm)
550
650
750

9. Job's plot between **6A-Hg**$^{2+}$ and dTTP

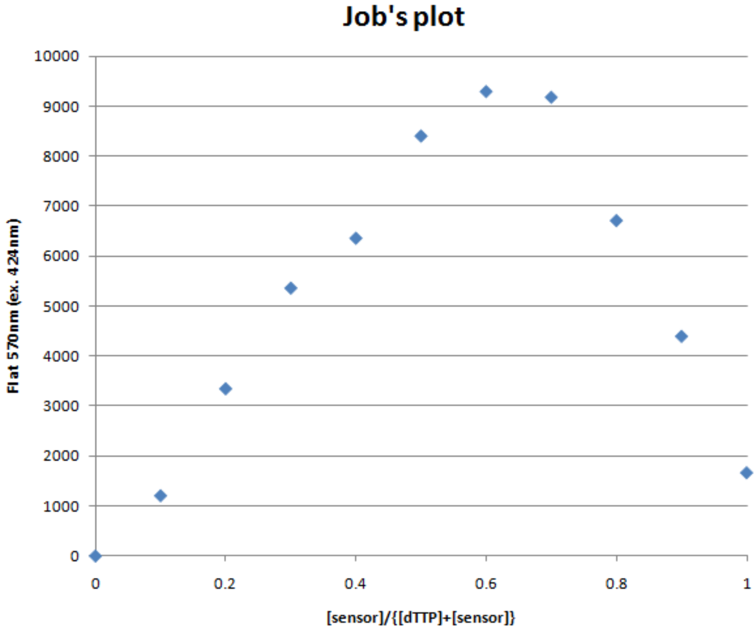


Figure S11. Job's plot between **6A-Hg**$^{2+}$ and dTTP , [**6A**-Hg^{2+}] + [dTTP] = 10 μM

10. NMR spectra of 6A–Hg^{2+}–thymidine complex

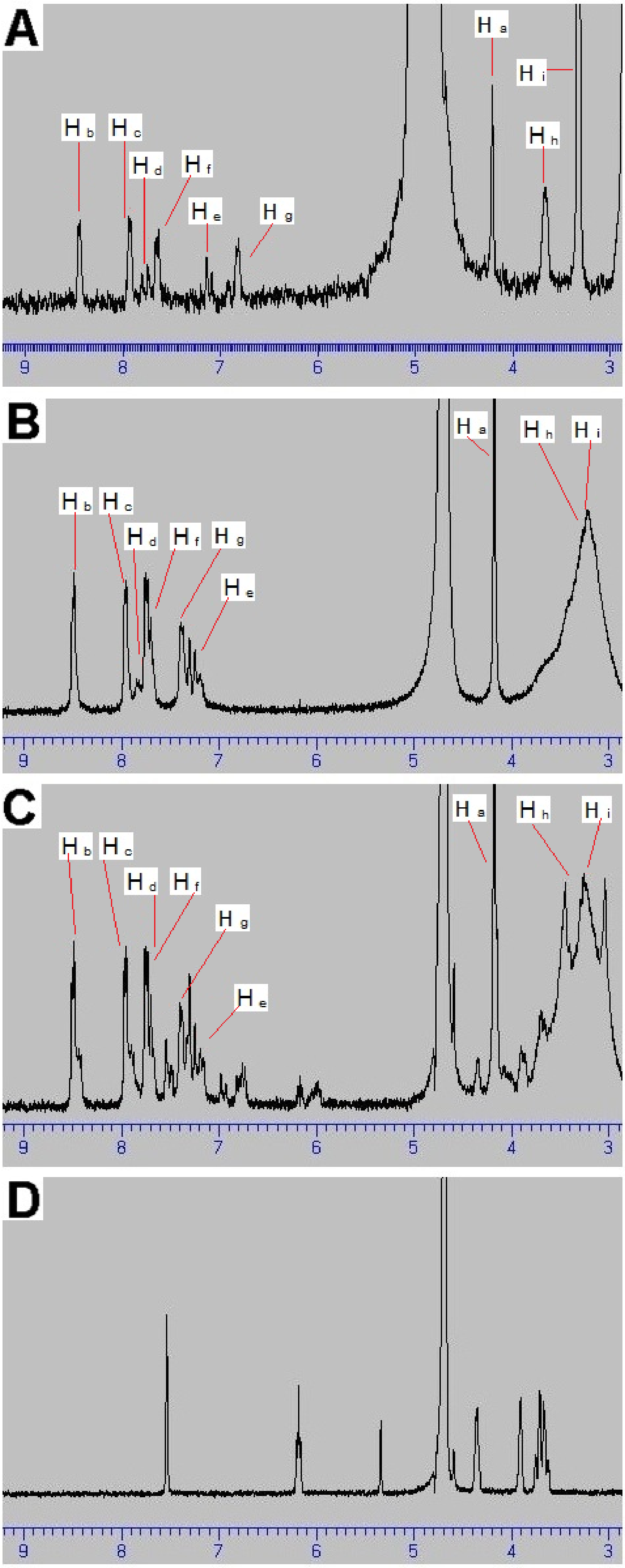
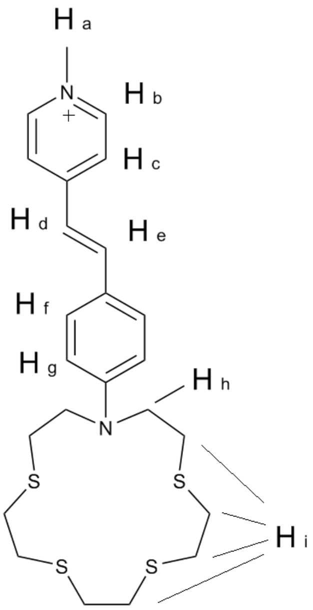


Figure S12. NMR spectra of 6A–Hg^{2+} complex in a mixture of D_2O and DMSO-d_6 (v/v, 9:1). Figure A shows NMR spectrum of 6A. A part of aromatic protons (H_b, H_c, H_f, and H_g: 6.5 ~ 8.5 ppm) exhibited changes in the chemical shifts and aliphatic protons in the azathia crown ether ring (H_h and H_i: 3.2 ~ 3.8 ppm) were broadened after 1 eq of Hg^{2+} was added to 6A–Hg^{2+} complex (Figure B). Broadened peaks of the azathia crown ether ring were split slightly after addition of 1 eq of thymidine (Figure C). Figure D shows the NMR spectrum of thymidine in D_2O.



11. Absorption spectra of 6A–Hg^{2+}–thymidine complex

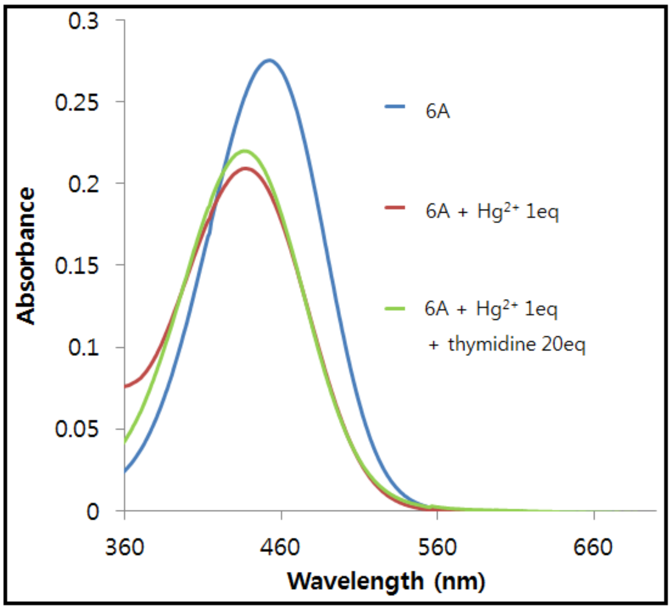


Figure S13. Absorption spectra of 6A (5 μM) in the presence of Hg^{2+} and thymidine. All these data were recorded in 10 mM HEPES buffer (pH 7.4).

12. Fluorescence spectra of 6A–Hg^{2+} in the presence of DNAs

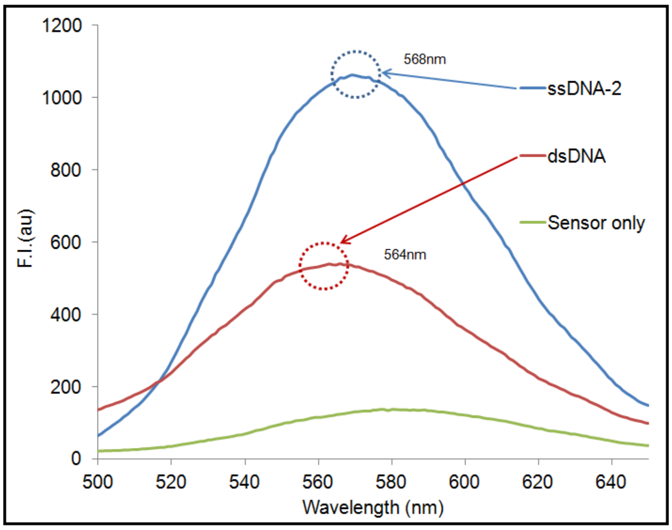


Figure S14. Fluorescence spectra of 6A-Hg^{2+} (sensor, 5 μM) in the presence of DNA. Upon the addition of 10 μM of ssDNA (sequence: **5′-(TC)$_5$-3′**), fluorescence of 6A-Hg^{2+} was enhanced with its maximum intensity at 568 nm (blue line). Fluorescence of 6A-Hg^{2+} was also increased in the presence of dsDNA (0.2 mg/mL). All these data were recorded in 10 mM HEPES buffer (pH 7.4) with excitation at 425 nm.

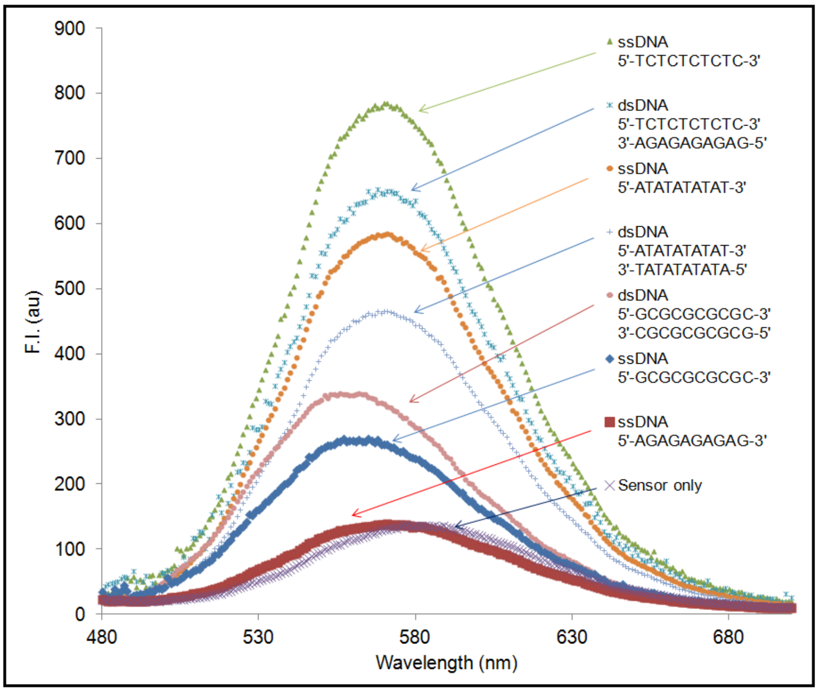


Figure S15. Fluorescence spectra of 6A-Hg^{2+} (5 μM) in the presence of various DNAs (10 μM). All these data were acquired in 10 mM HEPES buffer (pH 7.4) with excitation at 425 nm. More intense fluorescence was detected with thymine rich DNAs.