Electronic Supplementary Material (ESI) for ChemComm.

Electronic Supporting Information

for

Fluorogenic NIR-Probes Based on 1,2,4,5-Tetrazine Substituted BF_2-Azadipyrromethenes

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Experimental Details

General Information and Materials

All reactions involving air-sensitive reagents were performed under nitrogen in oven-dried glassware using syringe-septum cap technique. All solvents were purified and degassed before use. Chromatographic separation was carried out under pressure on silica gel and alumina 90 using flash-column techniques. Reactions were monitored by thin-layer chromatography (TLC) carried out on 0.25 mm silica gel coated aluminum plates using UV light (254 nm) as visualizing agent. Unless it is specified, all reagents were used as received without further purifications. ^{1}H NMR and ^{13}C NMR spectra were recorded at 400 MHz and 100 MHz respectively, and calibrated using residual non-deuterated solvent as an internal reference. Chemical shifts are reported in parts-per-million (ppm). ESI mass spectra were acquired using a microTOF-Q spectrometer in positive and negative modes as required. APCI experiments were carried out on a microTOF-Q III spectrometer in positive or negative mode as required.

Synthesis of 3-chloro-6-methoxy-1,2,4,5-tetrazine 3b.[1]

3,6-Dichloro-1,2,4,5-tetrazine **3a** (100 mg, 0.67 mmol) was dissolved in dry CH_2Cl_2 (10 mL) and dry methanol (28 µL, 0.7 mmol) under N_2 and the solution cooled to 0 °C. DIPEA (0.23 mL, 1.34 mmol) was slowly added at 0 °C, then the reaction was warmed to r.t. and allowed to stir for 1 hour. The solvent was removed under reduced pressure and the residue was purified by silica chromatography using cyclohexane / ethyl acetate (5:1) as eluent to give the product as a pink solid (68 mg, 70%), m.p. 20-21 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 4.33 (s, 3H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.0, 164.6, 57.5 ppm. ESI-MS: $[M+H]^+$ 147.1.

Synthesis of 3-chloro-6-(4-nitrophenoxy)-1,2,4,5-tetrazine 3c.[2]

3,6-Dichloro-1,2,4,5-tetrazine **3a** (100 mg, 0.67 mmol) was dissolved in dry CH_2Cl_2 (10 mL) and *p*-nitrophenol (0.11 mL, 0.7 mmol) under N_2 and the solution cooled to 0 °C. DIPEA (0.23 mL, 1.34 mmol) was slowly added at 0 °C and then the reaction was warmed to r.t. and allowed to stir for a further 1 hour. The solvent was removed under reduced pressure and the residue was purified by silica chromatography using cyclohexane / ethyl acetate (4:1) as eluent to give the product as a pink solid. (138 mg, 75%), m.p. 65-66 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.41 (d, J = 9.1 Hz, 2H), 7.50 (d, J = 9.1 Hz, 2H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.1, 166.1, 155.9, 146.1, 126.1, 121.8 ppm. ESI-MS: $[M+Na]^+$ 276.6.

1. P. Audebert, F. Miomandre, G. Clavier, M. C. Vernieres, S. Badre and R. Meallet-Renault, *Chemistry*, 2005, **11**, 5667.
2. For the synthesis of a related compound see: E. Jullien-Macchi, V. Alain-Rizzo, C. Allain, C. Dumas-Verdes and P. Audebert, *RSC Adv.*, 2014, **4**, 34127.

Synthesis of fluorogenic probe 4a.

Compounds **2** (100 mg, 0.18 mmol) and **3a** (30 mg, 0.20 mmol) were dissolved in dry CH_2Cl_2 (20 mL) under N_2 and the solution cooled to 0 °C. DIPEA (48 µL, 0.27 mmol) was slowly added into the solution at 0 °C, then the reaction was warmed to rt and allowed to stir for a further 1 hour. The solvent was removed under reduced pressure and the residue purified by silica chromatography using DCM / ethyl acetate (4:1) as eluent to give the product as a metallic red solid (71 mg, 60%), m.p. 239-240 °C. ^{1}H NMR (400 MHz, CD_2Cl_2) δ: 8.22-8.07 (m, 8H), 7.60-7.41 (m, 8H), 7.22 (s, 1H), 7.10-7.03 (m, 3H), 3.91 (s, 3H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ: 165.5, 162.8, 154.7, 153.7, 152.8, 152.2, 145.2, 144.5, 143.8, 142.7, 132.6, 132.2, 132.0, 131.5, 131.0, 129.8, 129.5, 129.2, 129.2, 128.7, 128.6, 123.4, 120.9, 119.9, 118.0, 114.5, 55.6 ppm. HRMS (APCI): calcd. for $C_{35}H_{24}BF_2ClN_7O_2$ $[M+H]^+$ 658.1741; found 658.1742.

Synthesis of fluorogenic probe 4b.

Compounds **2** (100 mg, 0.18 mmol) and **3b** (29 mg, 0.20 mmol) were dissolved in dry CH_2Cl_2 (20 mL) under N_2 and the solution cooled to 0 °C. DIPEA (48 µL, 0.27 mmol) was slowly added into the solution at 0 °C, then the reaction was warmed to r.t. and allowed to stir for a further 1 hour. The solvent was removed under reduced pressure and the residue purified by silica chromatography using DCM / ethyl acetate (5:1) as eluent to give the product as a metallic solid, (88 mg, 75%), m.p. 161-162 °C. ^{1}H NMR (400 MHz, CD_2Cl_2) δ: 8.22-8.05 (m, 8H), 7.55-7.32 (m, 8H), 7.18 (s, 1H), 7.09-6.99 (m, 3H), 4.28 (s, 3H), 3.90 (s, 3H) ppm. ^{13}C NMR (100 MHz, CD_2Cl_2) δ: 167.0, 167.0, 162.8, 160.9, 155.0, 154.1, 146.5, 144.9, 144.5, 142.2, 132.5, 132.1, 131.9, 131.3, 130.2, 129.8, 129.4, 129.2, 129.2, 128.6, 128.6, 123.3, 120.8, 120.0, 118.2, 114.4, 57.1, 55.6 ppm. HRMS (ESI): calcd. for $C_{36}H_{27}BF_2N_7O_3$ $[M+H]^+$ 654.2236; found 654.2255.

Synthesis of fluorogenic probe 4c.

Compounds **2** (100 mg, 0.18 mmol) and **3c** (51 mg, 0.20 mmol) were dissolved in dry CH_2Cl_2 (20 mL) under N_2 and the solution cooled to 0 °C. DIPEA (48 µL, 0.27 mmol) was slowly added into solution at 0 °C, then the reaction was warmed to r.t. and allowed to stir for a further 1 hour. The solvent was removed under reduced pressure and the residue purified by silica gel chromatography using CH_2Cl_2 / ethyl acetate (100 to 10:1) as eluent to give the product **4a** as a metallic red solid (97 mg, 71%), m.p. 154-155 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.36 (d, *J* = 9.1 Hz, 2H), 8.16-8.02 (m, 8H), 7.51-7.36 (m, 10H), 7.13 (s, 1H), 7.03 (d, *J* = 9.0 Hz, 2H),

6.97 (s, 1H), 3.89 (s, 3H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.5, 166.8, 162.8, 161.2, 156.8, 154.9, 153.5, 146.6, 145.7, 145.2, 144.5, 142.3, 132.6, 132.2, 132.0, 131.4, 130.7, 129.8, 129.5, 129.2, 129.2, 128.7, 128.6, 125.9, 123.5, 121.5, 120.8, 119.8, 118.0, 114.5, 55.5 ppm. HRMS (ESI): calcd. for $C_{41}H_{28}BF_2N_8O_5$ $[M+H]^+$ 761.2245; found 761.2244.

Synthesis of 6a.

Compounds **4a** (20 mg, 0.030 mmol) and **5** (5.02 mg, 0.033 mmol) were dissolved in dry CH_2Cl_2 (10 mL) under N_2 and the reaction stirred at r.t. for 0.5 hour. The solvent was removed under reduced pressure and the residue purified by silica gel chromatography using DCM / MeOH (100:1) to give the product as a dark green solid (21 mg, 88%), m.p. 180-181 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.15-8.04 (m, 8H), 7.52-7.38 (m, 6H), 7.27 (d, *J* = 9.0 Hz, 2H), 7.10 (s, 1H), 7.02 (d, *J* = 9.0 Hz, 2H), 7.00 (s, 1H), 3.89 (s, 3H), 3.78 (d, *J* = 7.7 Hz, 2H), 3.29-3.17 (m, 1H), 3.11 (t, *J* = 6.8 Hz, 2H), 3.07-2.96 (m, 1H), 2.51-2.36 (m, 2H), 1.81-1.66 (m, 2H), 1.23-1.13 (m, 1H), 0.90 (m, 2H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ: 163.7, 162.4, 159.9, 156.5, 155.9, 154.0, 146.1, 144.8, 144.4, 143.7, 142.7, 134.9, 132.6, 132.2, 132.0, 131.2, 129.5, 129.4, 129.3, 129.2, 128.6, 128.6, 123.7, 120.6, 119.3, 118.4, 114.4, 59.5, 55.5, 28.5, 24.8, 22.8, 22.1, 21.7, 18.5, 17.8 ppm. HRMS (APCI): calcd. for $C_{45}H_{38}BClF_2N_5O_3$ $[M+H]^+$ 780.2724; found 780.2745.

Synthesis of 6b.

Compounds **4b** (20 mg, 0.031 mmol) and **5** (5.05 mg, 0.034 mmol) were dissolved in dry CH_2Cl_2 (10 mL) under N_2 and the reaction stirred at r.t for 1 hour. The solvent was removed under reduced pressure and the residue purified by silica gel chromatography using DCM / MeOH (50:1) to give the product as a dark green solid (20 mg, 85%), m.p. 160-161 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.14-8.03 (m, 8H), 7.51-7.40 (m, 6H), 7.28 (d, *J* = 9.0 Hz, 2H), 7.10 (s, 1H), 7.03 (d, *J* = 9.0 Hz, 2H), 7.00 (s, 1H), 4.07 (s, 3H), 3.90 (s, 3H), 3.74 (d, *J* = 8.2 Hz, 2H), 3.09-2.92 (m, 4H), 2.36-2.18 (m, 4H), 1.35 (t, *J* = 8.4 Hz, 1H), 1.02-0.86 (m, 2H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ: 162.2, 161.9, 161.1, 159.5, 157.1, 156.9, 145.9, 144.9, 144.0, 142.8, 134.9, 134.8, 132.6, 132.3, 131.9, 131.3, 129.4, 129.4, 129.3, 129.2, 128.6, 128.6, 127.8, 123.8, 120.4, 119.1, 118.5, 114.4, 59.7, 55.5, 54.9, 24.6, 24.3, 22.9, 22.8, 21.6, 18.5, 18.4 ppm. HRMS (ESI): calcd. for $C_{46}H_{41}BF_2N_5O_4$ $[M+H]^+$ 776.3220; found 776.3198.

Synthesis of 6c.

Compounds **4c** (20 mg, 0.026 mmol) and **5** (4.34 mg, 0.029 mmol) were dissolved in dry CH_2Cl_2 (10 mL) under N_2 and the reaction stirred at r.t. for 0.5 hour. The solvent was removed

under reduced pressure and the residue purified by silica gel chromatography using DCM / MeOH (100:1) to give the product as a dark green solid (21 mg, 90%), m.p. 139-140 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.27 (d, *J* = 9.0 Hz, 2H), 8.11-8.03 (m, 8H), 7.51-7.39 (m, 6H), 7.33 (d, *J* = 9.2 Hz, 2H), 7.28 (d, *J* = 8.9 Hz, 2H), 7.10 (s, 1H), 7.02 (d, *J* = 9.0 Hz, 2H), 6.96 (s, 1H), 3.81 (d, *J* = 7.8 Hz, 2H), 3.22-3.03 (m, 4H), 2.50-2.37 (m, 2H), 1.85-1.73 (m, 2H), 1.30-1.19 (m, 1H), 1.04-0.95 (m, 2H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ: 162.4, 162.4, 161.5, 159.3, 156.6, 155.9, 146.1, 144.8, 144.3, 142.7, 136.4, 135.9, 135.1, 134.8, 134.7, 134.0, 133.8, 132.6, 132.2, 132.0, 131.2, 129.5, 129.4, 129.3, 129.2, 128.6, 128.6, 128.6, 125.5, 121.2, 120.8, 114.4, 59.6, 55.5, 24.8, 24.8, 22.9, 22.8, 21.7, 18.4, 18.4 ppm. HRMS (ESI): calcd. for $C_{51}H_{42}BF_2N_6O_6$ $[M+H]^+$ 883.3242; found 776.3198.

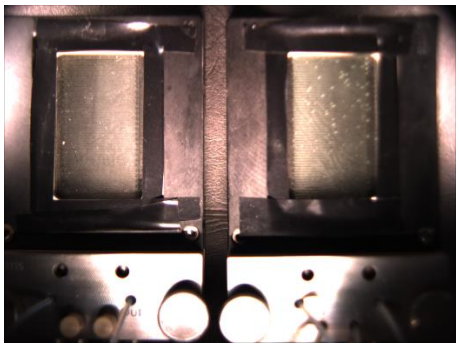
Agarose gel preparation

Agarose powder (2 g) was added to sterile PBS (100 mL) and heated in a microwave oven until all the agarose was dissolved. This agarose solution (25 mL) was poured into petri dishes (Ø =10 cm) containing a formulated aqueous solution of **4c** (200 µL, 1 mM), and kept at 4°C for 16 h for gelation. The agarose gel containing **4c** was immersed in aqueous **5** (5 mL, 2 mM) for 16 h at room temperature. The gel was removed from the solution and imaged. As positive control, the agarose solution (25 mL) was poured into petri dishes (Ø =10 cm) containing a formulated aqueous solution of **6c** (200 µL, 1 mM), and kept at 4°C for 16 h for gelation.

Continuous flow reaction of 4c and 5.

The microreactor used in this study was from Syrris Ltd and was used without modification. The flow reactor consists of two Cavro-type syringe pumps with flow rates ranging from 4 to 2500 µL/min (shown below). Reagents were loaded by using pressurized sample container. Two glass chip reactors of 1 mL volume with inner channel diameters of 0.2 mm were used and the temperature was maintained at 20 °C using a cooling/heating plate. Modules of the system were connected with 0.5 mm ID PTFE tubing. The whole system was pressurized with dry nitrogen with a back pressure regulator and computer controlled.

A $CHCl_3$ solution of **4c** (0.1 M) was pumped into chip 1 (1000 µL, 0.2 mL/min, 5 min residence time) at 20 °C. The output flow from chip 1 was linked to chip 2 (1000 µL, 0.2 mL/min, 5.0 min residence time) at 20 °C. At this stage, no NIR fluorescence could be detected from either chip 1 or 2. Next, the flow rates of **4c** were adjusted to 0.1 mL/min, and a $CHCl_3$ solution of **5** (0.6 M, 0.1 mL/min) was directly pumped into chip 2. A fluorescence signal was immediately observable at the bottom of chip 2 where the two reagents first mix. After 5 min, the whole of chip 2 showed a strong fluorescence with chip 1 remaining non-fluorescent.



Photograph of chip setup for flow experiments

Figure S1. Absorbance and fluorescence spectra of **2** and **4a-c**.

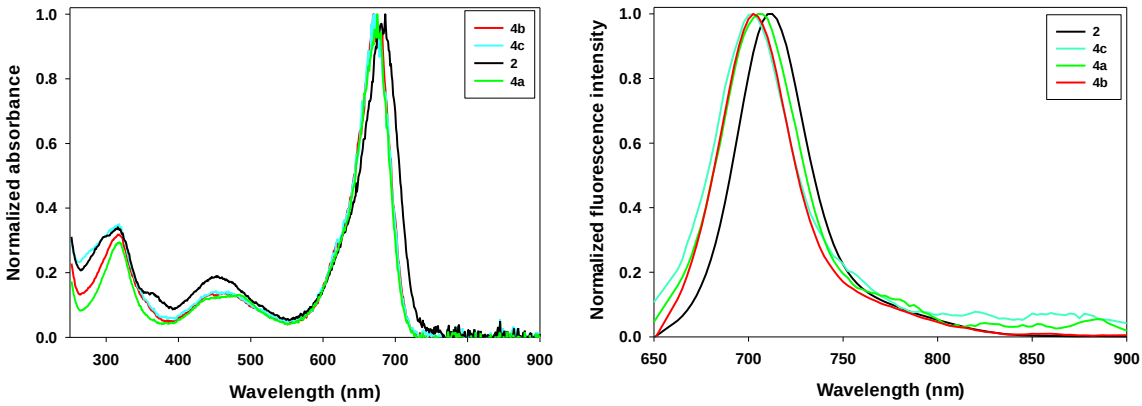


Figure S1.1 Absorption and fluorescence of **2**, **4a-c** in chloroform.

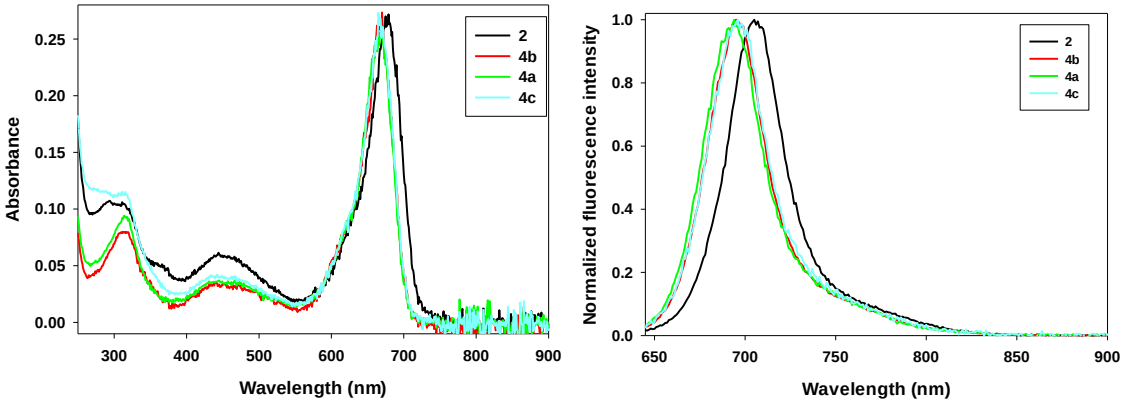


Figure S1.2 Absorption and fluorescence of **2**, **4a-c** in cyclohexane.

Figure S2: View of tetrazine/aryl dihedral angle in **4c** (four aryl rings removed from view for clarity).

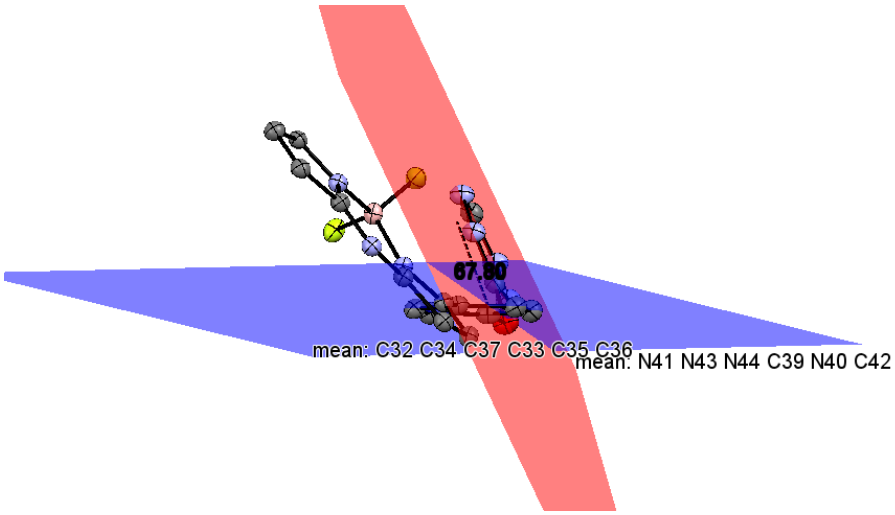
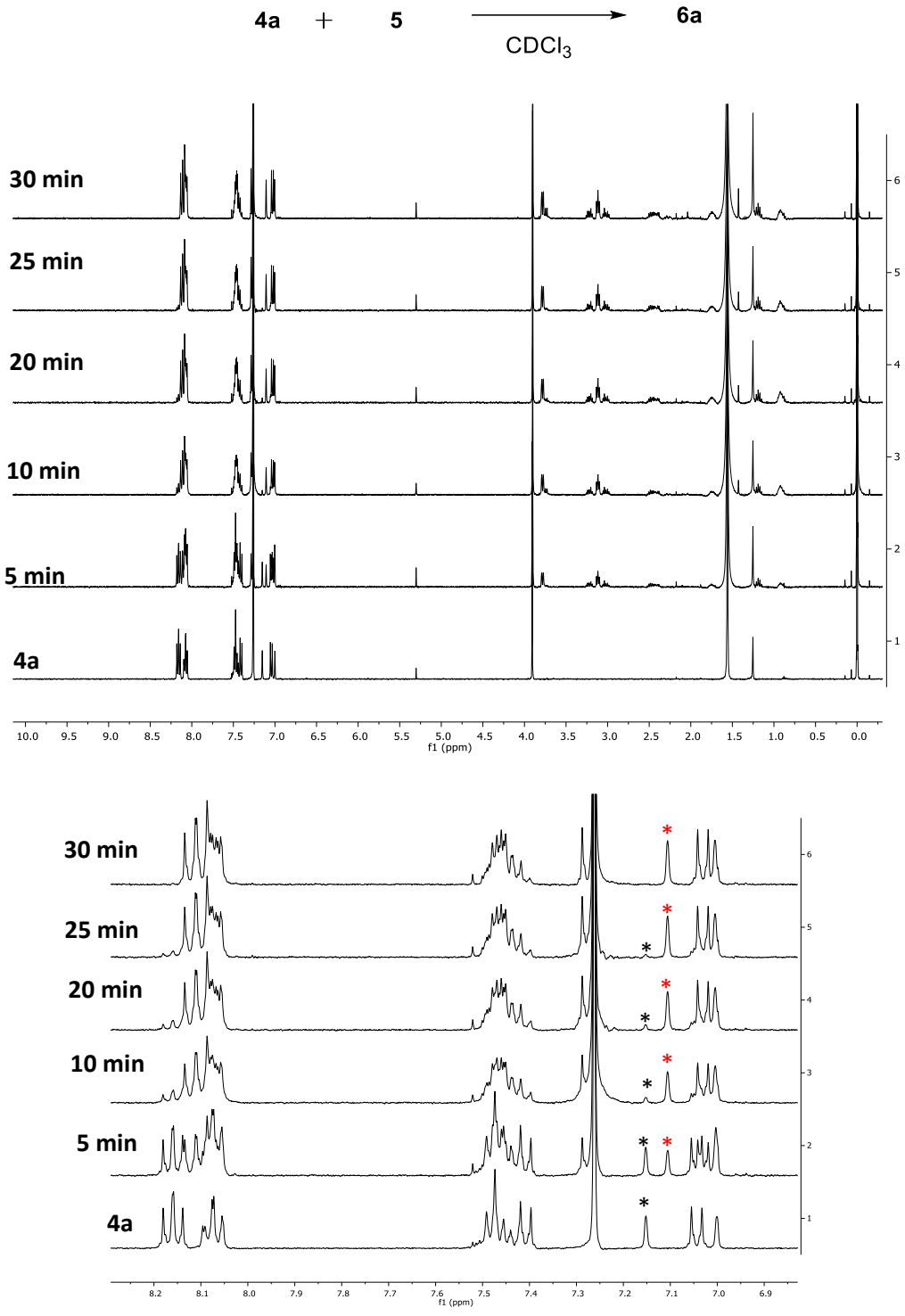


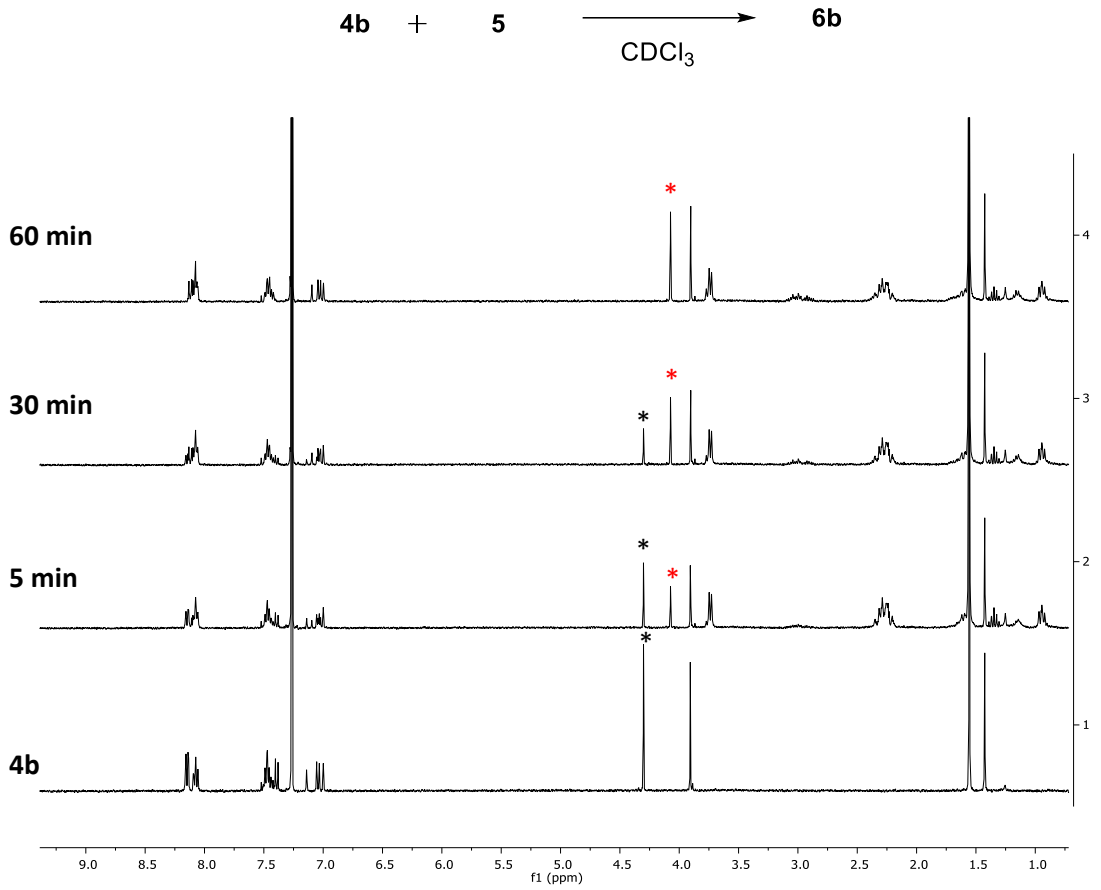
Figure S3. ^{1}H NMR monitoring of IEDDA reactions of **4a-c** with **5**.

^{1}H NMR ($CDCl_3$) at 21 °C monitoring the formation of **6a**



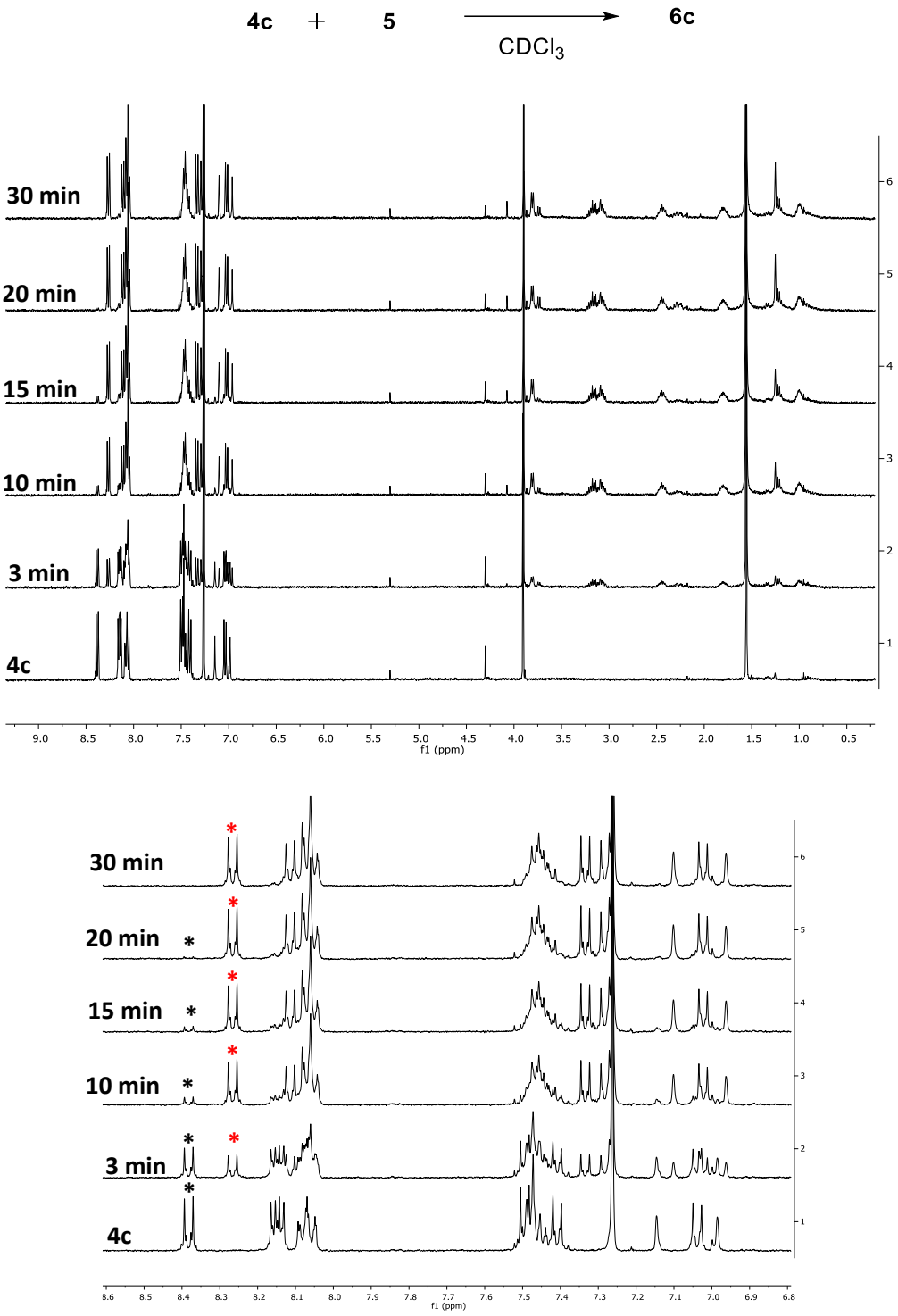
Peak marked with * = 4a; Peak marked with * = 6a.

^{1}H NMR ($CDCl_3$) at 21 °C monitoring the formations of **6b**



Peak marked with * = 4b; Peak marked with * = 6b.

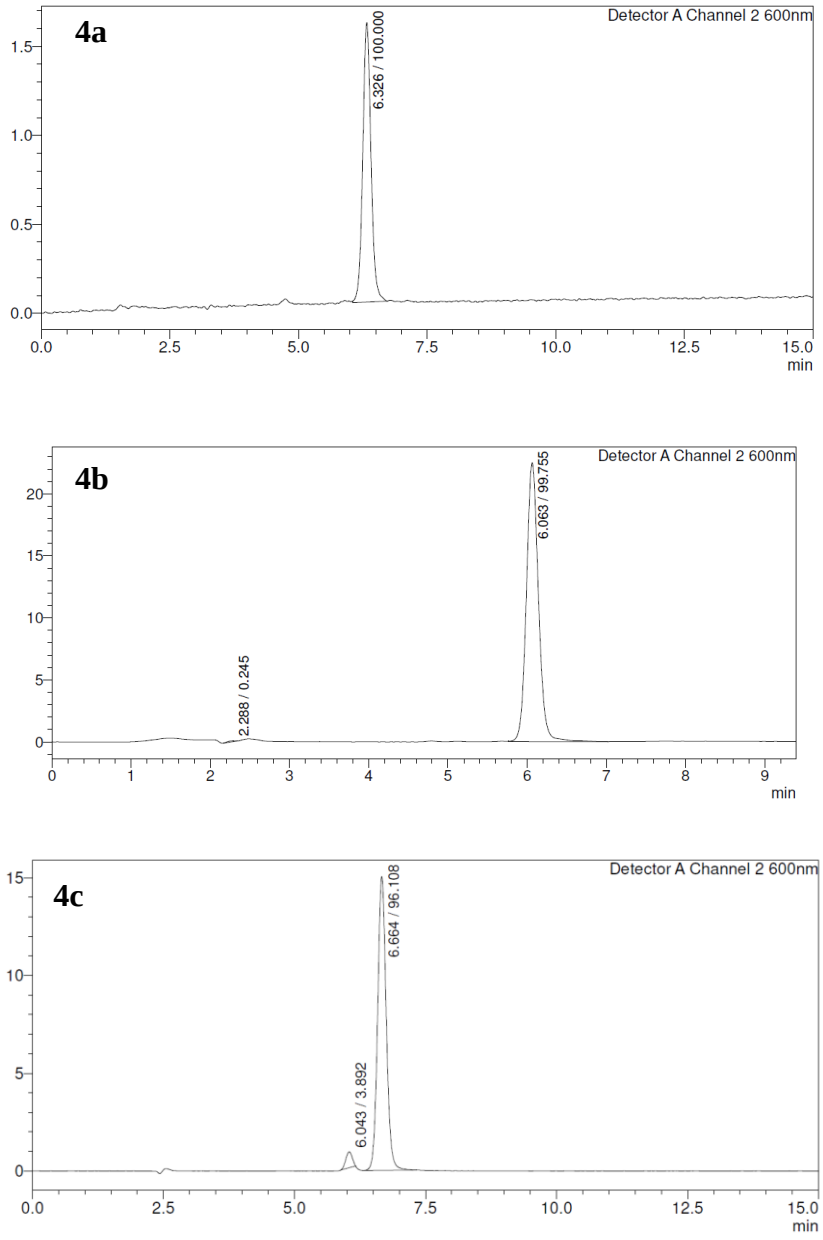
^{1}H NMR ($CDCl_3$) at 21 °C monitoring the formation of **6c**



Peak marked with * = 4c; Peak marked with * = 6c.

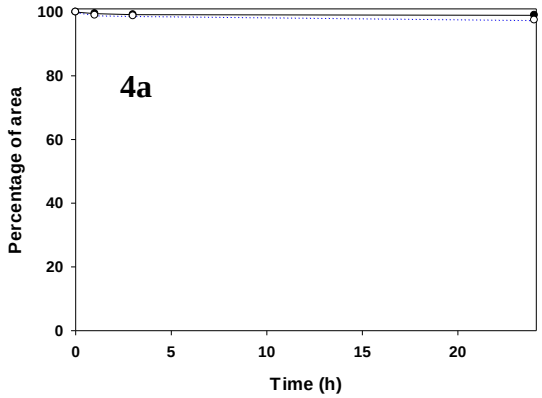
Figure S4: Preparation and stability of aqueous **4a-c** solutions

Aqueous solutions were prepared by dissolving **4a-c** (0.2 mg) in the minimum quantity of $CHCl_3$ and treating the solution with poloxamer 188 (100 mg). This mixture was sonicated for 10 min followed by removal of $CHCl_3$ under reduced pressure at room temperature. The resulting solid was dissolved in phosphate buffered saline (PBS) solution to obtain 10 µM **4a-c** stock solutions. Solutions were passed through a 0.2 µm membrane filter and analyzed by HPLC. Prior to reaction the stock solutions were 1:1 diluted with a 10% polysorbate 20/PBS solution.

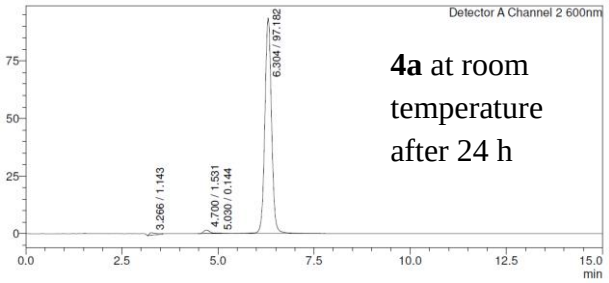


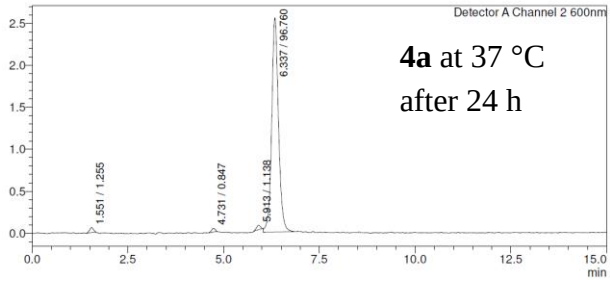
Reverse phase HPLC of **4a-c** with YMC triart phenyl column and size: 150 × 4.6mm I.D. Eluent CH_3CN : H_2O = 85:15. Flow rate=0.7 mL.

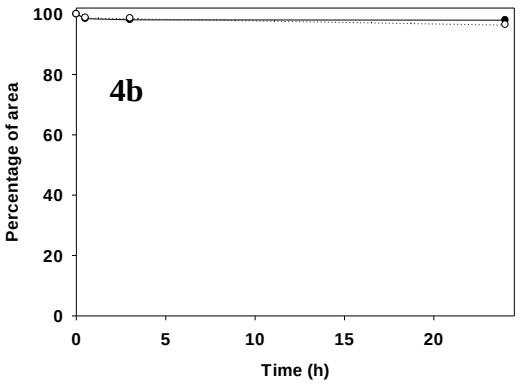
Stability of aqueous solutions of **4a-c**: Sample vials containing 1.5 mL of aqueous **4a-c** were kept at either room temperature or 37°C for 24 h and samples analysed by HPLC at different time points. Plots of percentage peak area for each experiment are shown below.



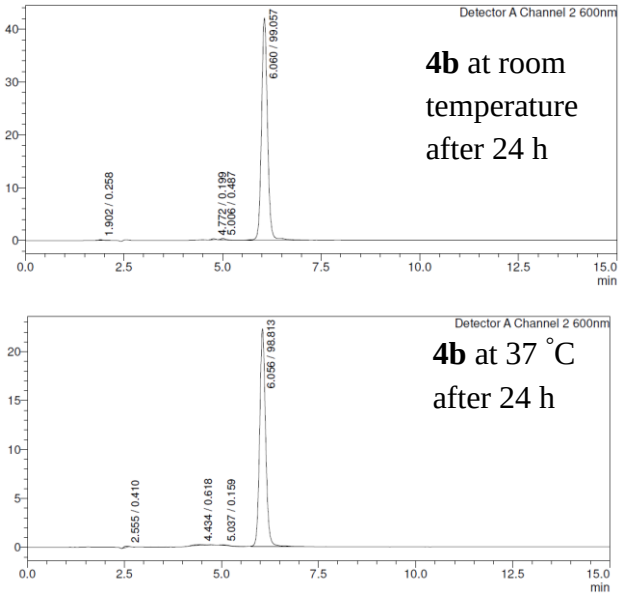
HPLC stability analysis for **4a**; room temperature (solid line) and 37 °C (dashed line).



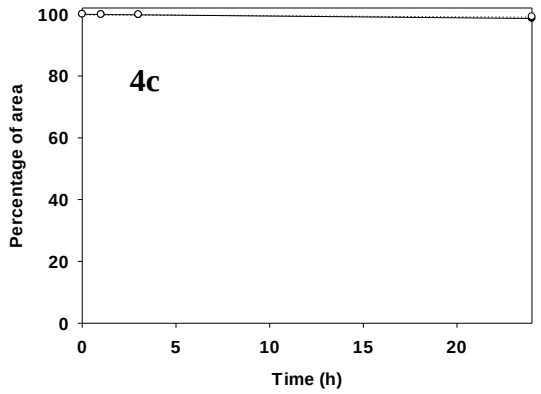




HPLC stability analysis for **4b**; room temperature (solid line) and 37 °C (dashed line).



HPLC stability analysis for **4c**; room temperature (solid line) and 37 °C (dashed line).



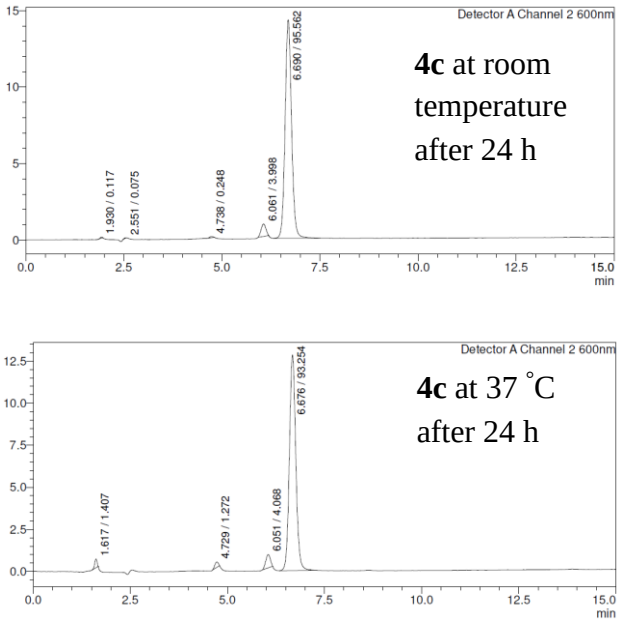
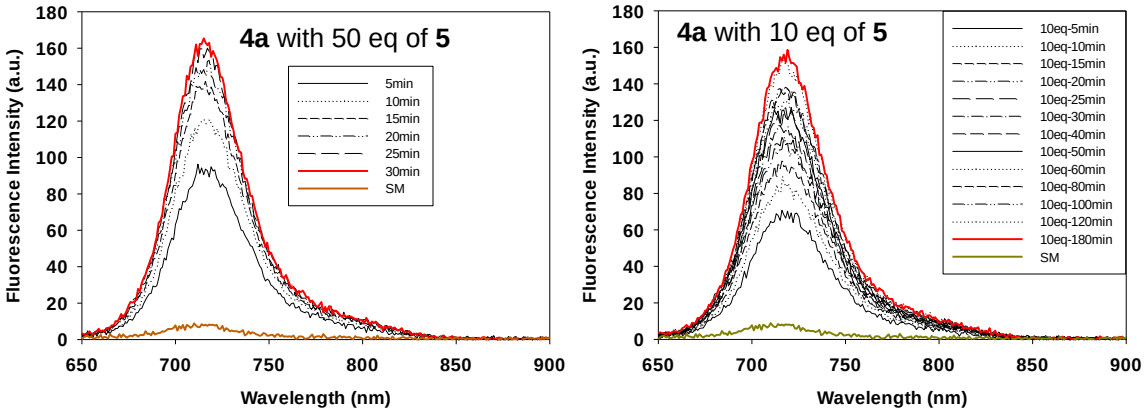
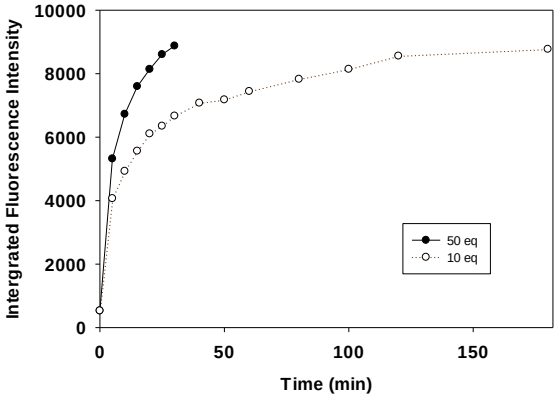


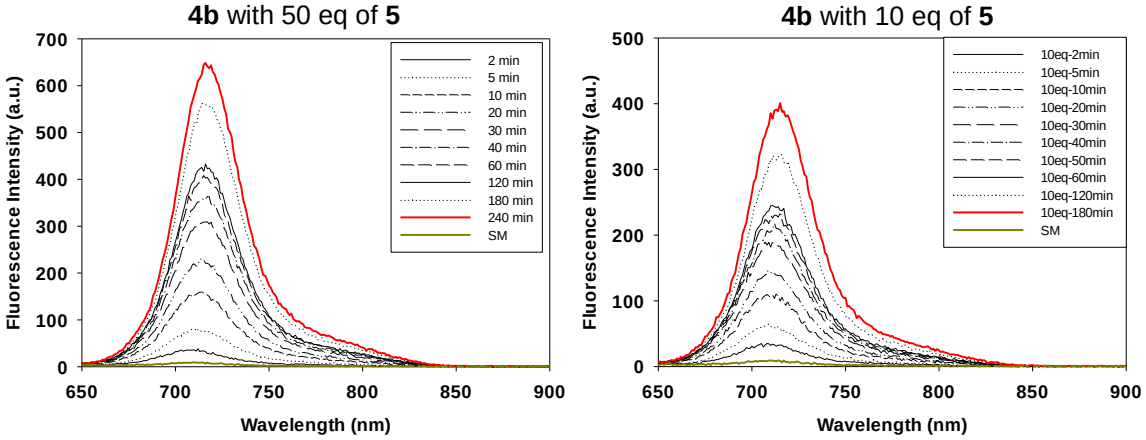
Figure S5: Fluorescence enhancement from reactions of **4a-c** with **5** in aqueous solution.

Add 2 mL sample of aqueous **4a** (0.5×10^{-6} M); **4b** (1.5×10^{-6} M); **4c** (0.7×10^{-6} M) was placed into a fluorescence quartz cuvette. The cuvette was warmed to 37 °C in water bath. The emission spectrum was recorded following which either 10 eq or 50 eq of aqueous **5** (prepared as for **4a-c** above) was added to the cuvette. Temperature was maintained at 37 °C and emmision spectra recorded over time.

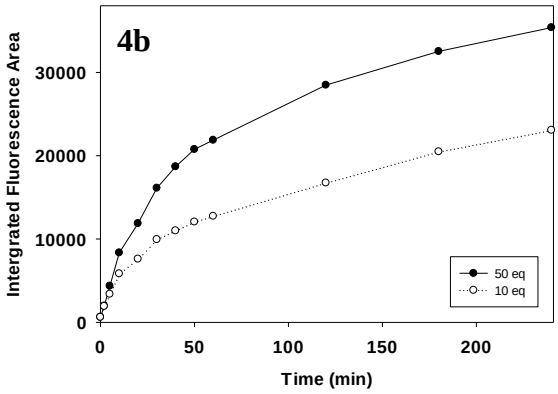


Plot of **4a** with 50 (black circle) and 10 eq (white circle)of **5** over time

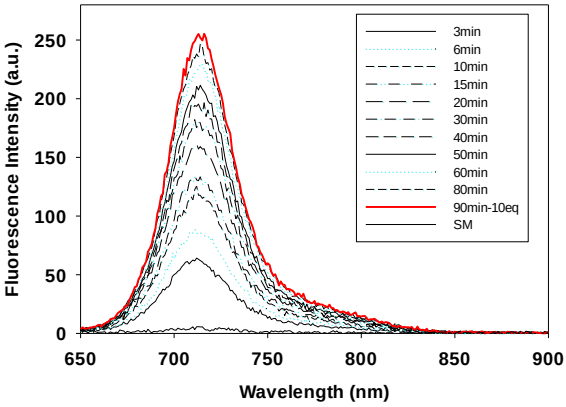




Plot of **4b** with 50 (black circles) and 10 eq (white circles) of **5** over time



4c with 10 eq of **5**



Plot of **4c** with 50 and 10 eq of **5** over time

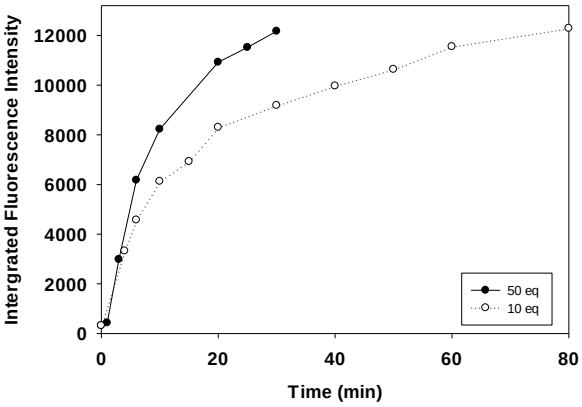
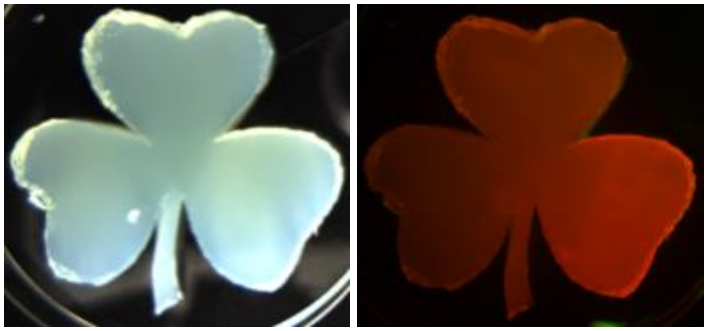
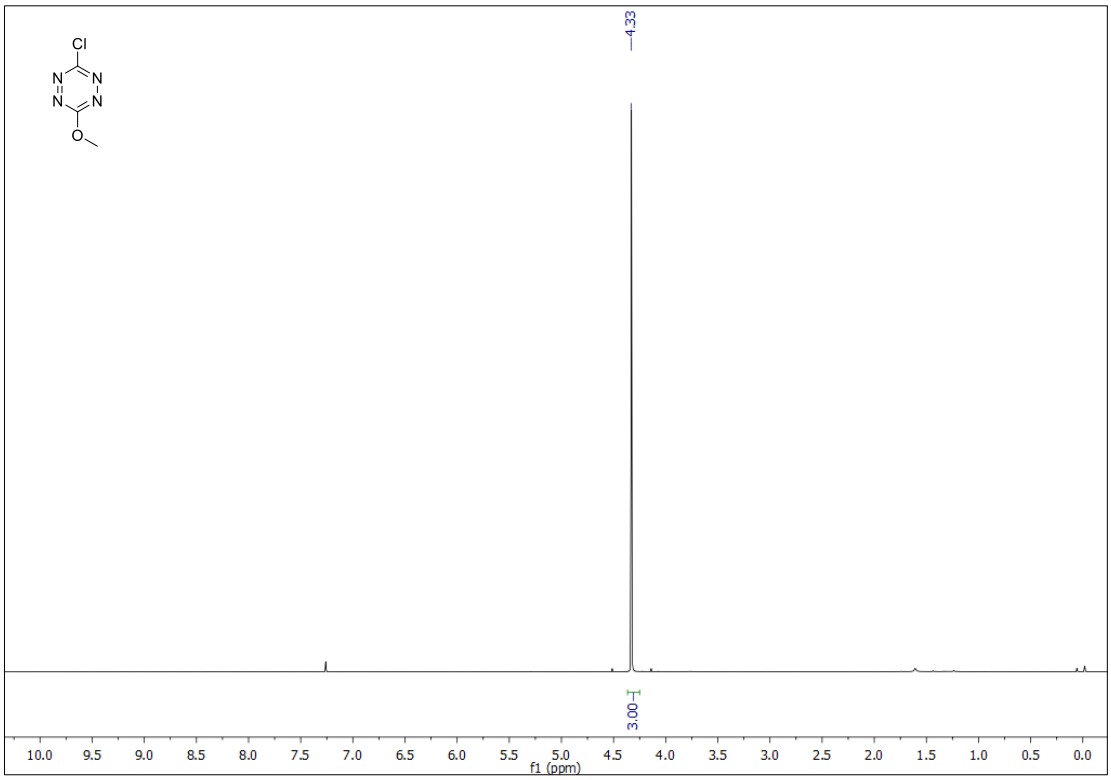


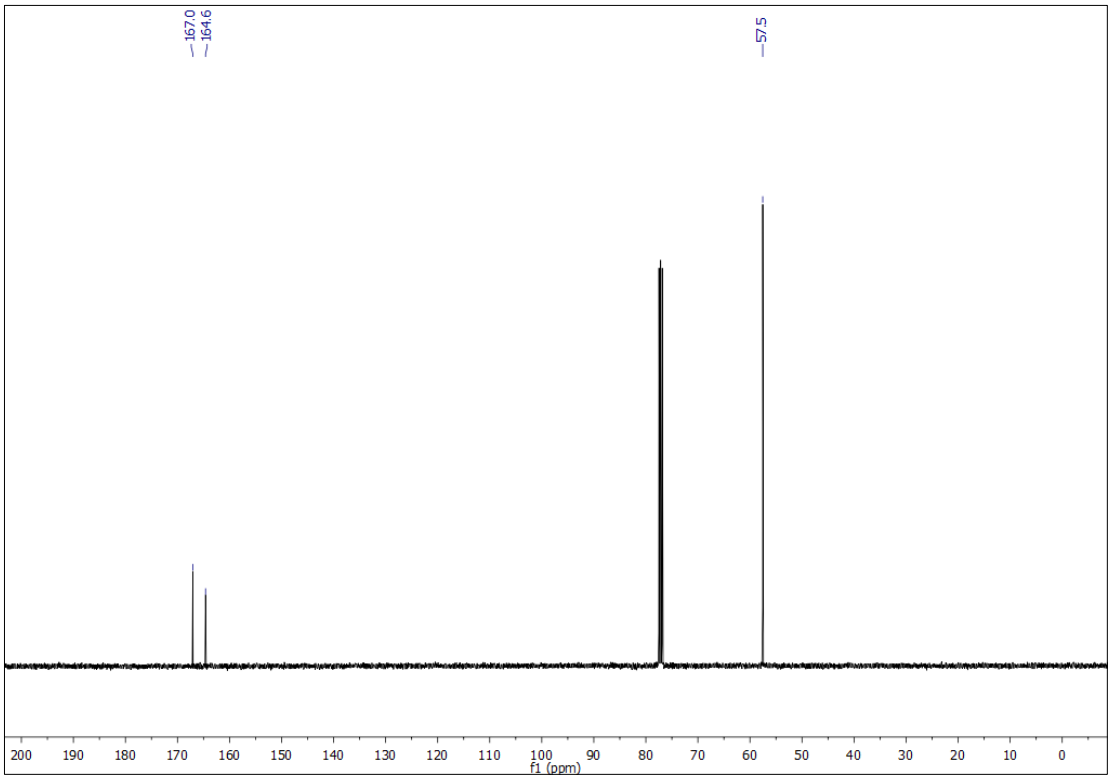
Figure S6: White light (left) and NIR-fluorescence (right) images of **6c** in agarose gel



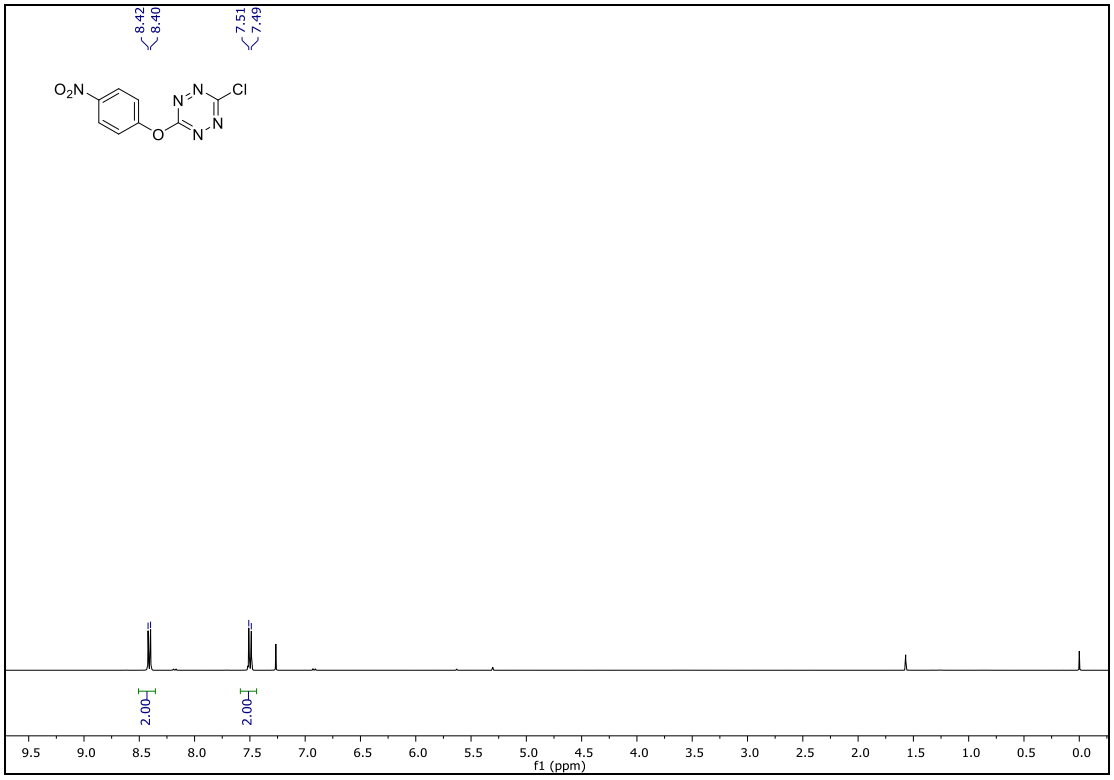
^{1}H NMR (400 MHz, $CDCl_3$) of **3b**



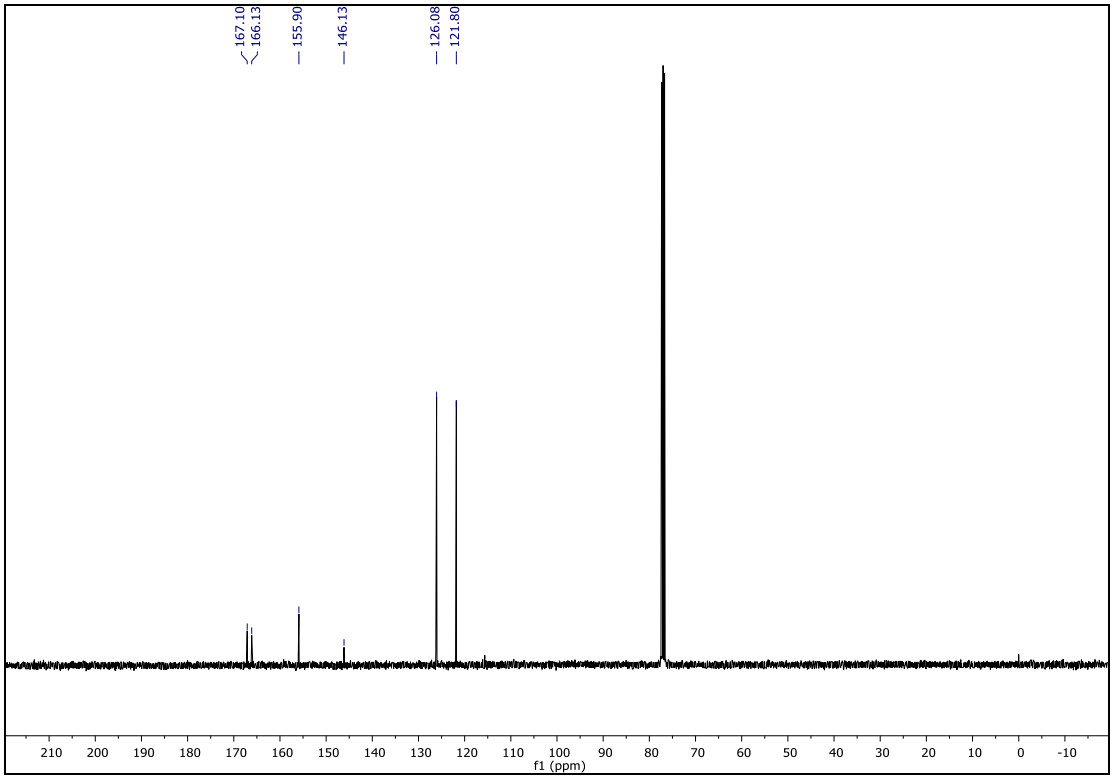
^{13}C NMR (100 MHz, $CDCl_3$) of **3b**



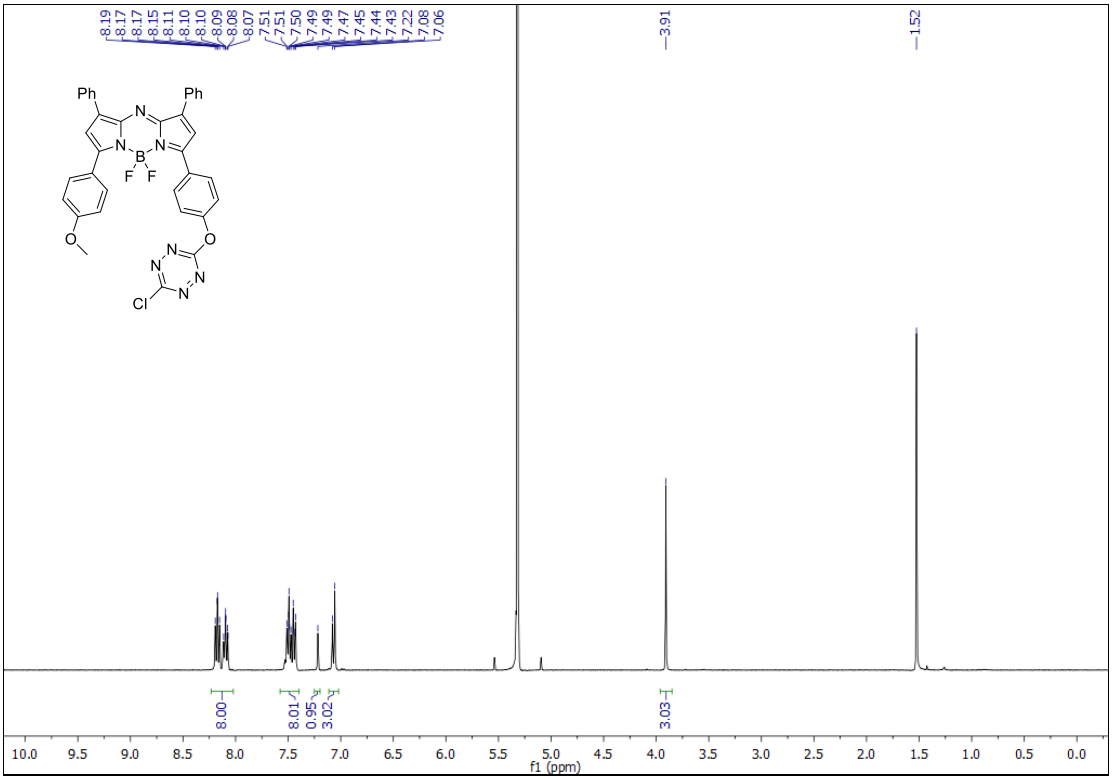
^{1}H NMR (400 MHz, $CDCl_3$) of **3c**



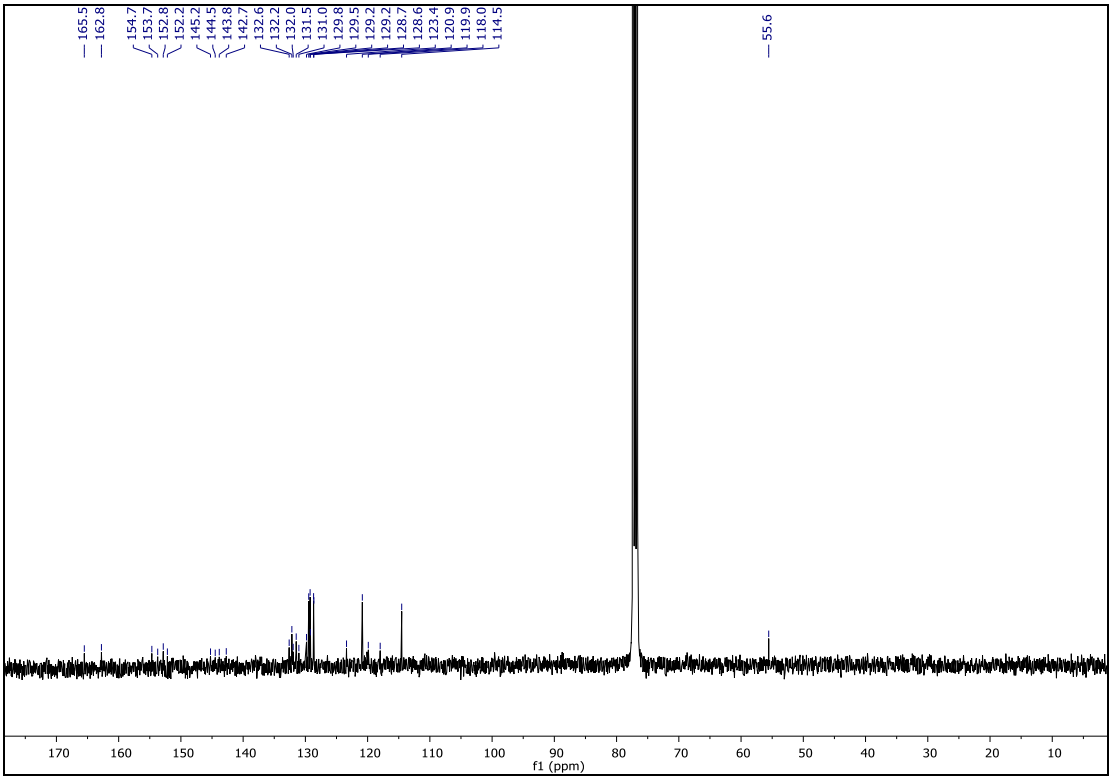
^{13}C NMR (100 MHz, $CDCl_3$) of **3c**



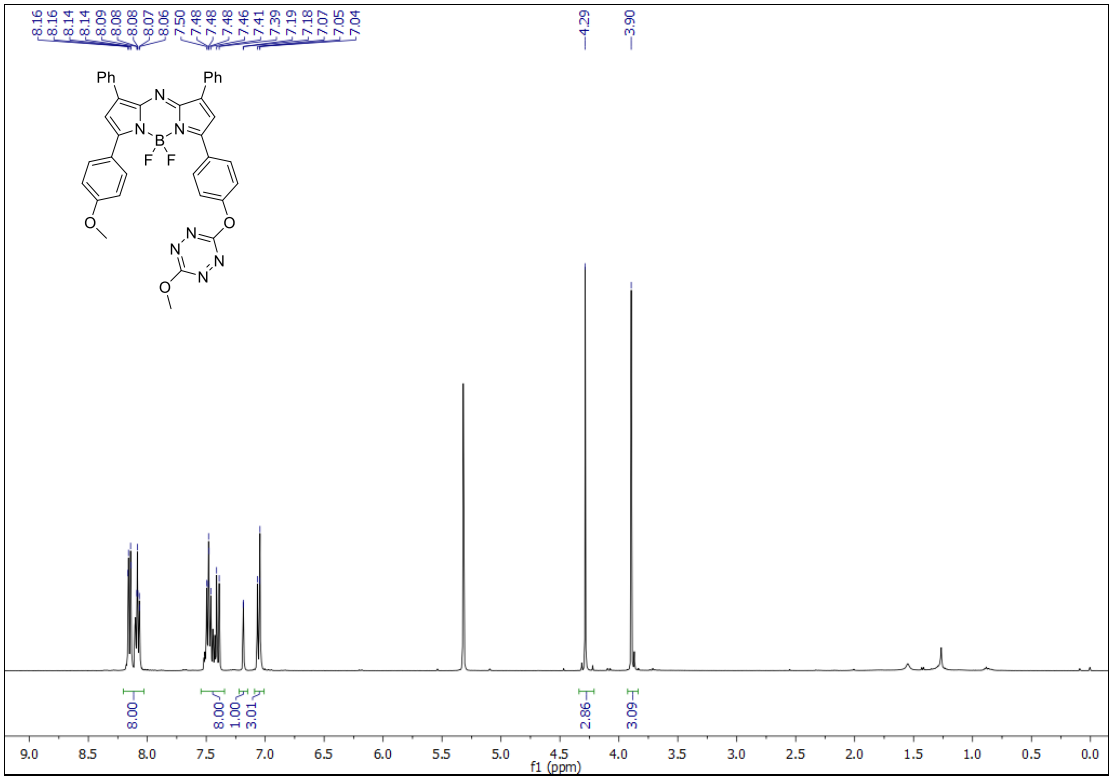
^{1}H NMR (400 MHz, CD_2Cl_2) of **4a**



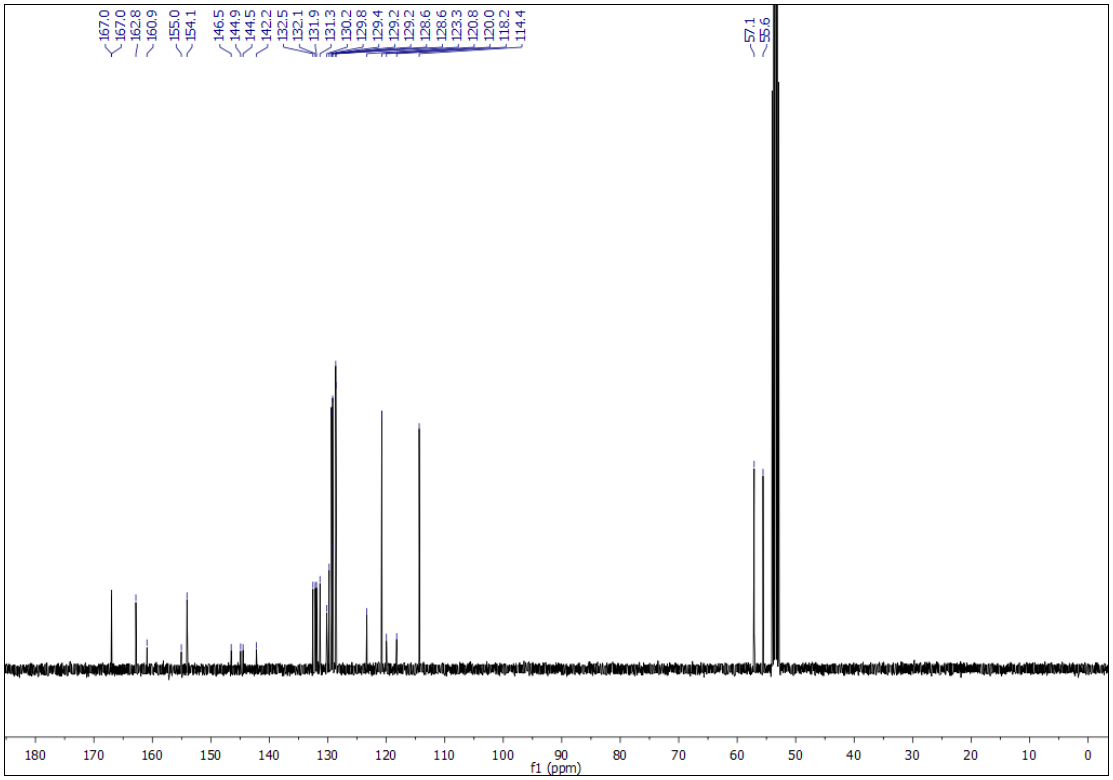
^{13}C NMR (100 MHz, $CDCl_3$) of **4a**



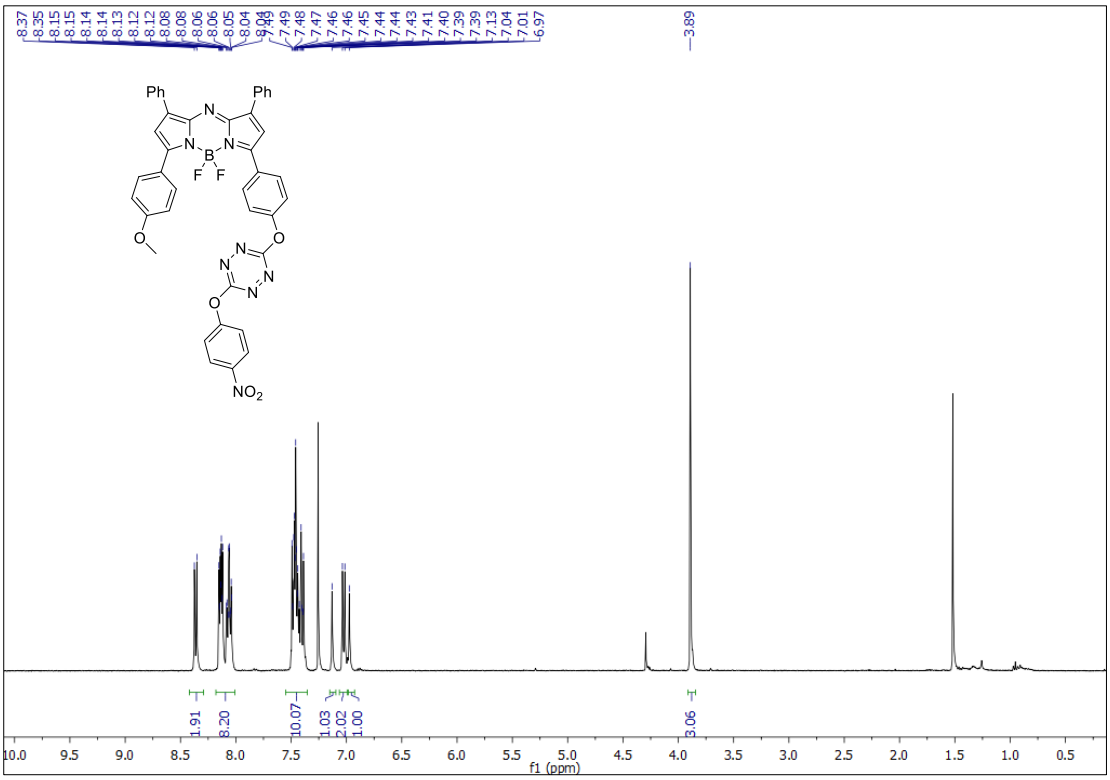
^{1}H NMR (400 MHz, CD_2Cl_2) of **4b**



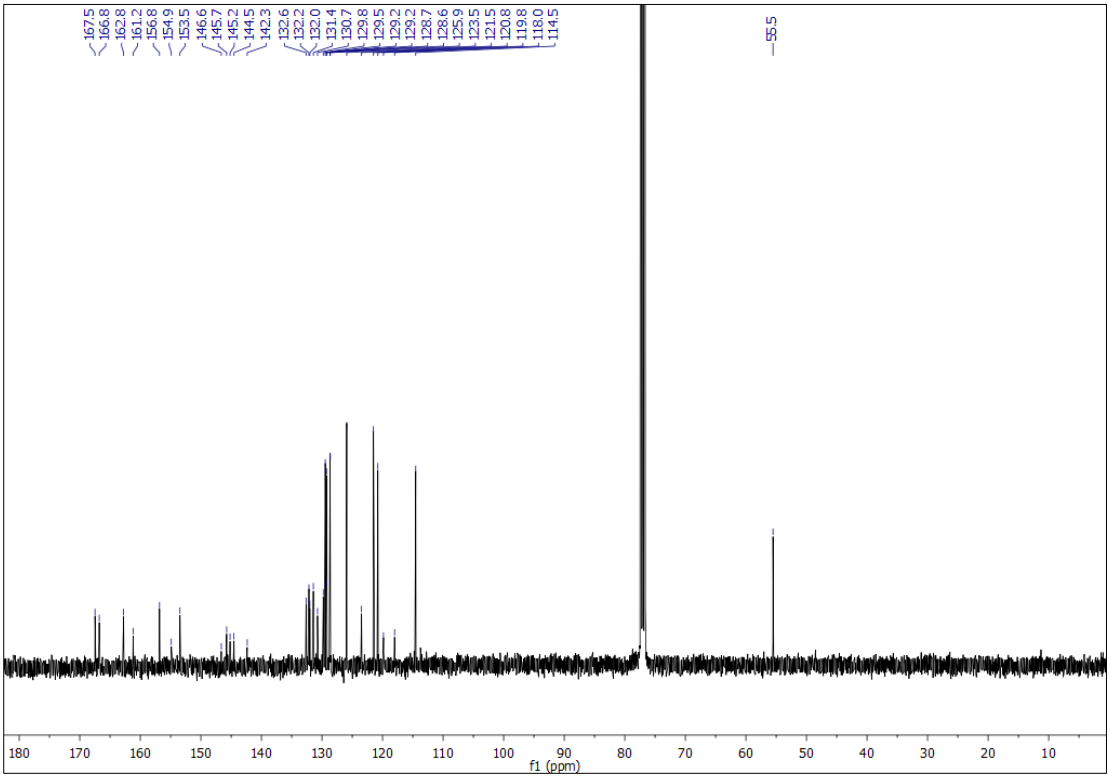
^{13}C NMR (100 MHz, CD_2Cl_2) of **4b**



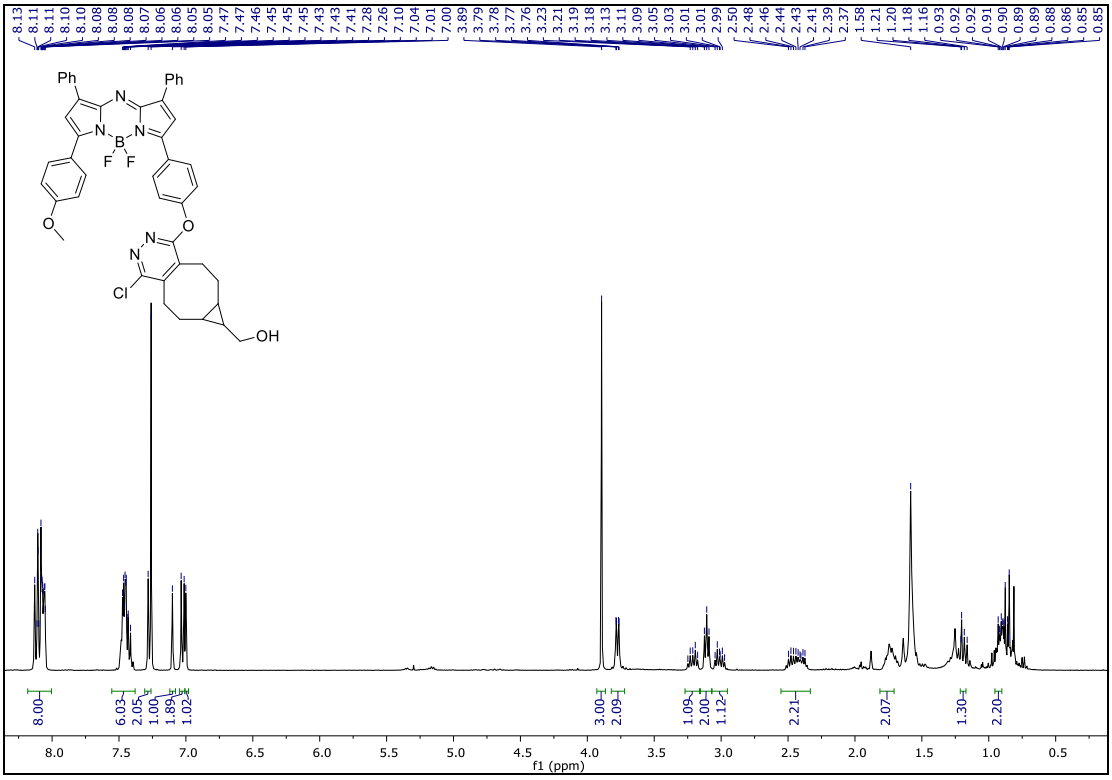
^{1}H NMR (400 MHz, $CDCl_3$) of **4c**



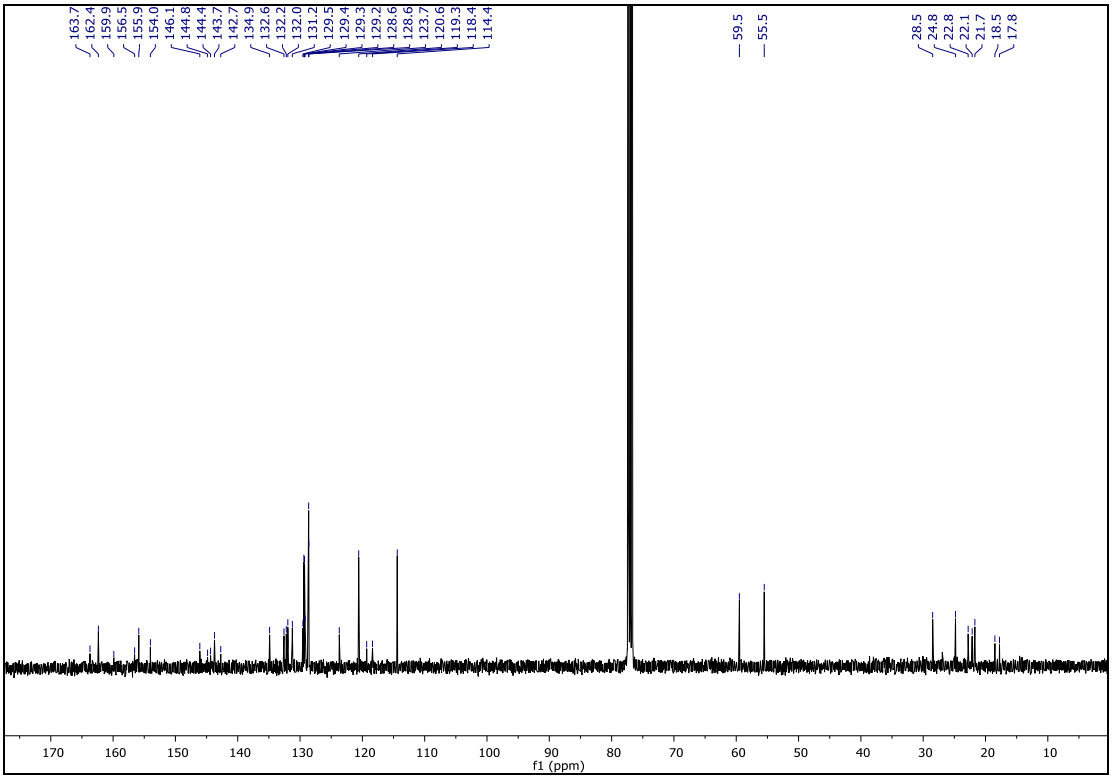
^{13}C NMR (100 MHz, $CDCl_3$) of **4c**



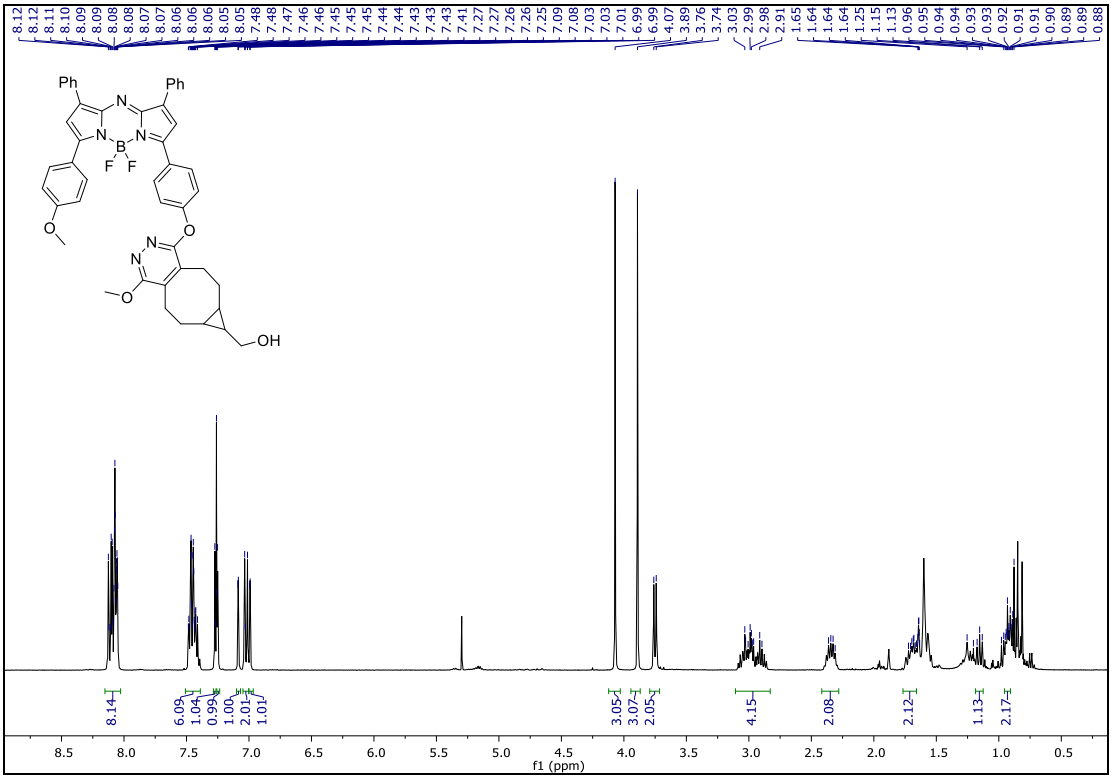
^{1}H NMR (400 MHz, $CDCl_3$) of **6a**



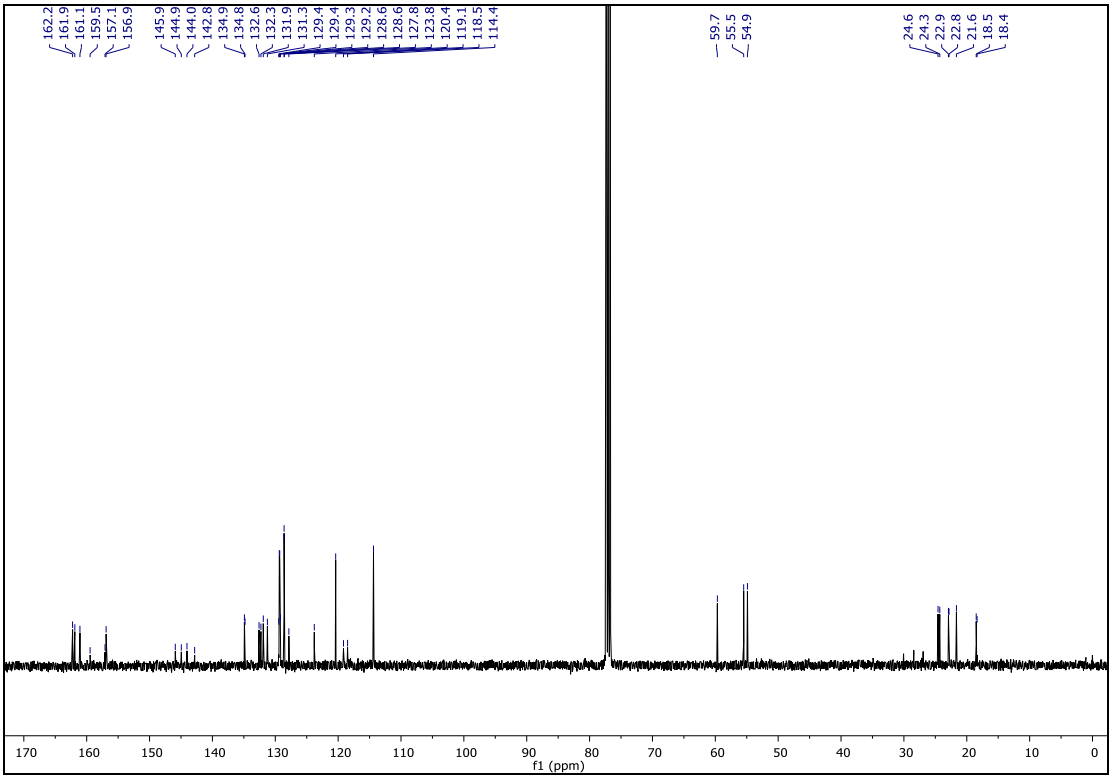
^{13}C NMR (100 MHz, $CDCl_3$) of **6a**



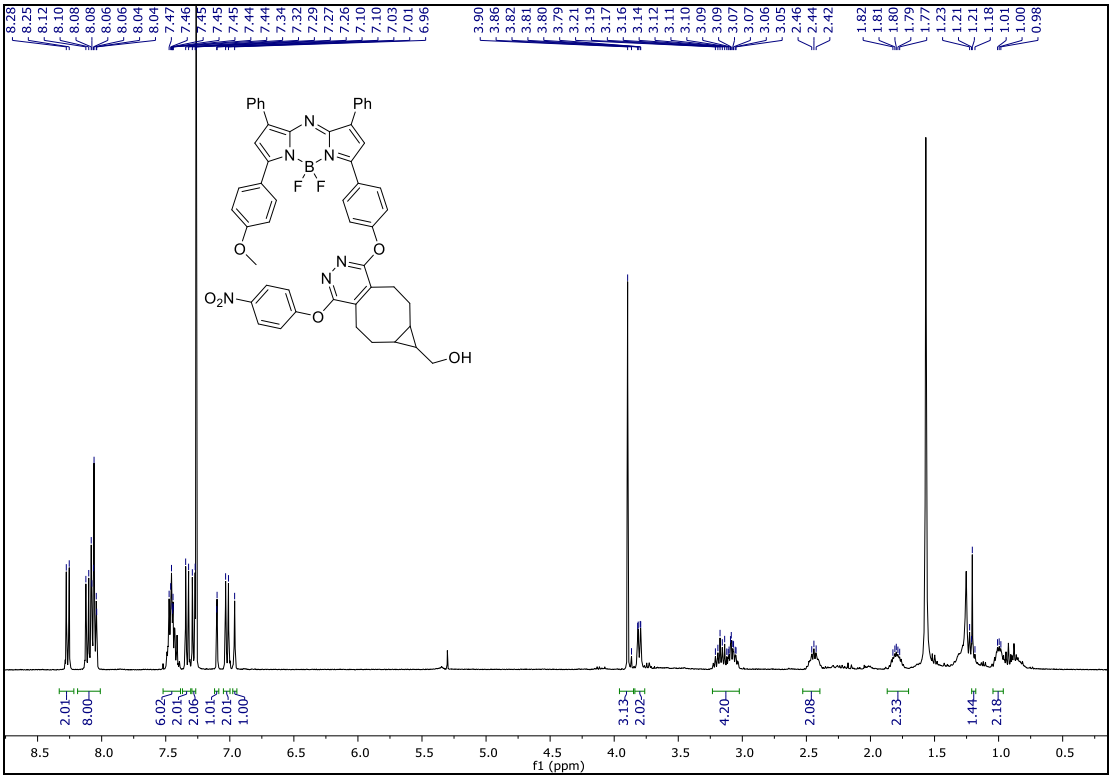
^{1}H NMR (400 MHz, $CDCl_3$) of **6b**



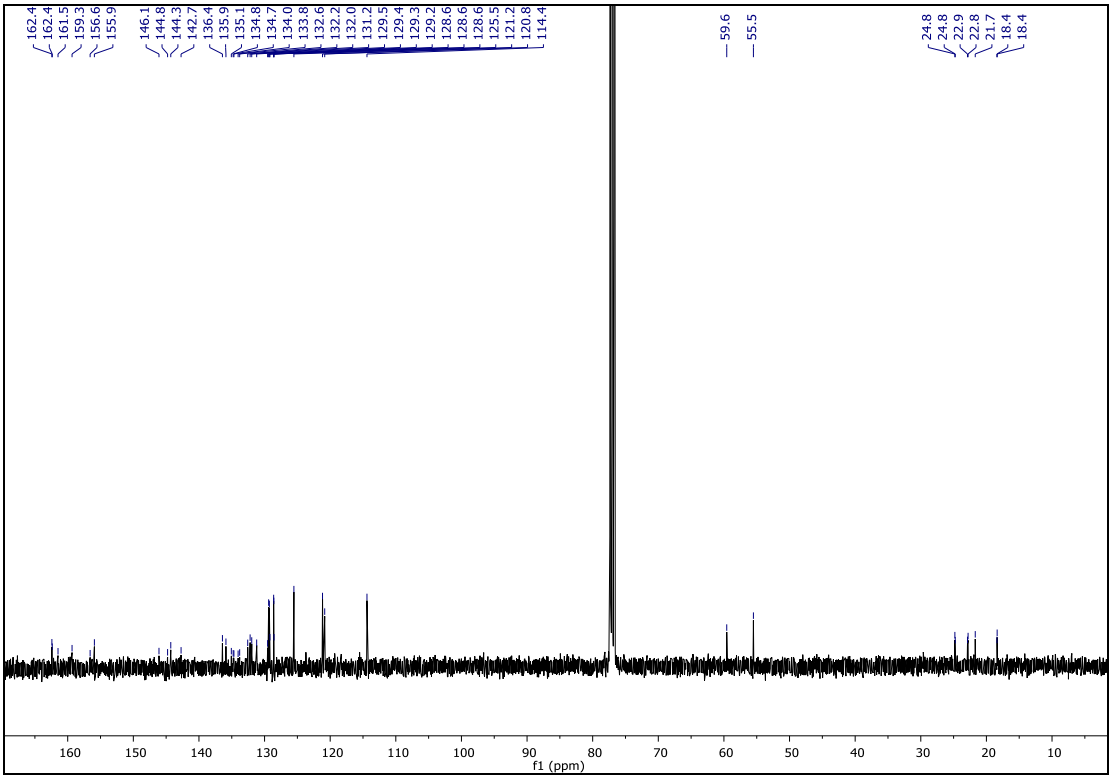
^{13}C NMR (100 MHz, $CDCl_3$) of **6b**



^{1}H NMR (400 MHz, $CDCl_3$) of **6c**



^{13}C NMR (100 MHz, $CDCl_3$) of **6c**



Crystal Structure data for 4c

A specimen of $C_{42}H_{28}BCl_3F_2N_8O_5$, approximate dimensions 0.050 mm x 0.220 mm x 0.260 mm, was used for the X-ray crystallographic analysis. The X-ray intensity data were measured at 100(2)K using an Oxford Cryosystems low temperature device using a MiTeGen micromount. See Table 1 for collection parameters and exposure time. Bruker APEX software was used to correct for Lorentz and polarization effects.

A total of 1159 frames were collected. The total exposure time was 19.32 hours. The integration of the data using a triclinic unit cell yielded a total of 22684 reflections to a maximum θ angle of 27.50° (0.77 Å resolution), of which 8858 were independent (average redundancy 2.561, completeness = 99.6%, R_{int} = 4.46%, R_{sig} = 6.83%) and 5509 (62.19%) were greater than $2\sigma(F^2)$.The final cell constants of a = 8.3123(4) Å, b = 14.6491(7) Å, c = 16.8544(7) Å, α = 101.0460(14)°, β = 91.1618(14)°, γ = 105.3224(14)°, volume = 1937.24(15) $Å^3$, are based upon the refinement of the XYZ-centroids of reflections above 20 σ(I).Data were corrected for absorption effects using the Multi-Scan method (SADABS). The ratio of minimum to maximum apparent transmission was 0.878. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.6585 and 0.7456.

The structure was solved using the Bruker APEX Software Package and refined with Olex2, using the space group $P\bar{1}$, with Z = 2 for the formula unit, $C_{42}H_{28}BCl_3F_2N_8O_5$.The final anisotropic full-matrix least-squares refinement on F^2 with 551 variables converged at R1 = 5.90%, for the observed data and wR2 = 16.02% for all data. The goodness-of-fit was 1.025. The largest peak in the final difference electron density synthesis was 1.020 $e^-/Å^3$ and the largest hole was -0.813 $e^-/Å^3$ with an RMS deviation of 0.073 $e^-/Å^3$. On the basis of the final model, the calculated density was 1.508 g/cm^3 and F(000), 900 e^-.

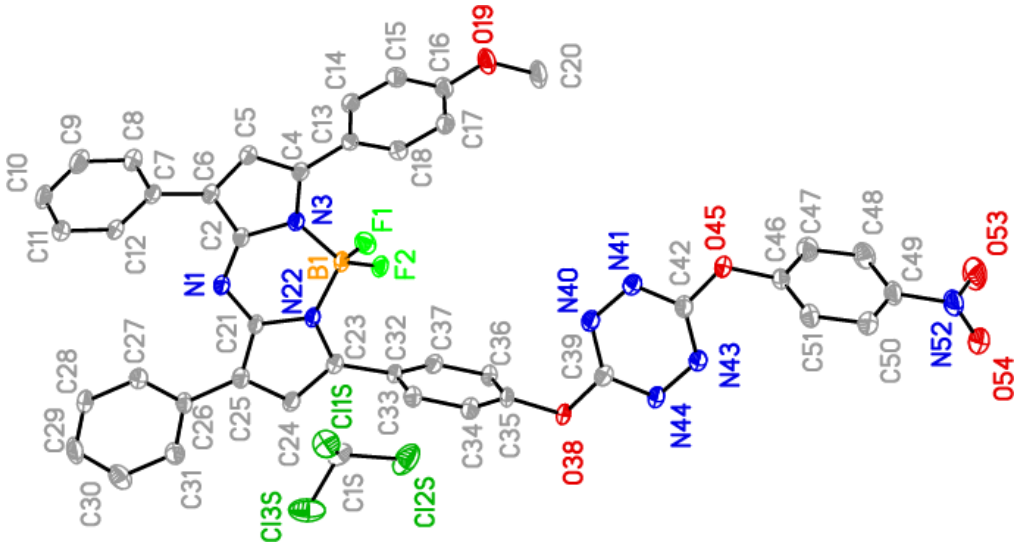


Fig. A. Asymmetric unit with atomic displacement parameters shown at 50% probability for **4c**. Hydrogen atoms omitted for clarity.

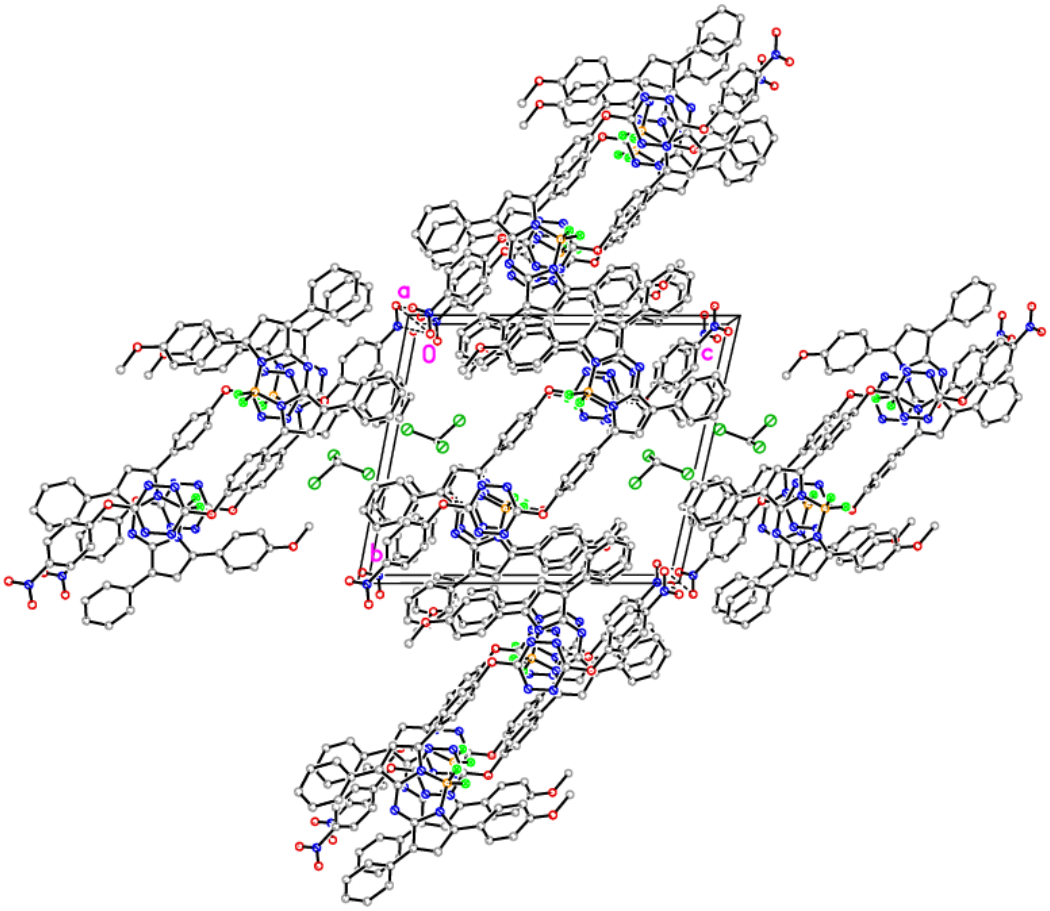


Fig. B. Packing diagram of **4c** viewed down the a-axis. Hydrogen atoms omitted for clarity

Table 1: Data collection details.

Axis	dx/mm	2θ/°	ω/°	φ/°	χ/°	Width/°	Frames	Time/s	Wavelength/Å	Voltage/kV	Current/mA	Temperature/K
Omega	50.000	25.73	13.15	102.00	-54.74	0.90	147	60.00	0.71073	50	30.0	100
Omega	50.000	25.73	13.15	0.00	-54.74	0.90	147	60.00	0.71073	50	30.0	100
Omega	50.000	25.73	13.15	204.00	-54.74	0.90	147	60.00	0.71073	50	30.0	100
Omega	50.000	25.73	13.15	255.00	-54.74	0.90	147	60.00	0.71073	50	30.0	100
Omega	50.000	25.73	13.15	306.00	-54.74	0.90	147	60.00	0.71073	50	30.0	100
Omega	50.000	10.73	356.80	0.00	-54.74	0.90	150	60.00	0.71073	50	30.0	100
Omega	45.000	22.92	14.29	153.00	-54.74	0.90	137	60.00	0.71073	50	30.0	100
Omega	45.000	22.92	14.29	51.00	-54.74	0.90	137	60.00	0.71073	50	30.0	100

Table 2. Crystal data and structure refinement for **4c**.

Identification code	tcd538	
Empirical formula	$C_{42}H_{28}BCl_3F_2N_8O_5$	
Formula weight	879.88	
Temperature	99.98 K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	$P\bar{1}$	
Unit cell dimensions	a = 8.3123(4) Å	α= 101.0460(14)°.
	b = 14.6491(7) Å	β= 91.1618(14)°.
	c = 16.8544(7) Å	γ = 105.3224(14)°.
Volume	1937.24(15) $Å^3$	
Z	2	
Density (calculated)	1.508 Mg/m^3	
Absorption coefficient	0.306 mm^{-1}	
F(000)	900	
Crystal size	0.26 x 0.22 x 0.05 mm^3	
Theta range for data collection	1.472 to 27.498°.	
Index ranges	$-10\leq h\leq 10$, $-19\leq k\leq 15$, $-21\leq l\leq 21$	
Reflections collected	22684	
Independent reflections	8858 [R(int) = 0.0446]	
Completeness to theta = 26.000°	99.8 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7456 and 0.6585	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	8858 / 0 / 551	
Goodness-of-fit on F^2	1.025	
Final R indices [$I>2\sigma(I)$]	R1 = 0.0590, wR2 = 0.1385	
R indices (all data)	R1 = 0.1115, wR2 = 0.1602	
Largest diff. peak and hole	1.020 and -0.813 $e.Å^{-3}$	

Table 3. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for **4c**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
B(1)	1811(4)	2823(2)	5894(2)	19(1)
C(2)	1139(3)	1381(2)	6627(2)	19(1)
C(4)	2030(3)	1019(2)	5395(2)	19(1)
C(5)	1768(3)	186(2)	5748(2)	22(1)
C(6)	1198(3)	383(2)	6504(2)	21(1)
C(7)	787(4)	-251(2)	7089(2)	22(1)
C(8)	1368(4)	-1074(2)	7012(2)	27(1)
C(9)	1034(4)	-1660(2)	7579(2)	32(1)
C(10)	124(4)	-1432(2)	8228(2)	34(1)
C(11)	-495(4)	-634(2)	8303(2)	34(1)
C(12)	-183(4)	-53(2)	7737(2)	28(1)
C(13)	2657(3)	1093(2)	4607(2)	20(1)
C(14)	3538(4)	438(2)	4248(2)	23(1)
C(15)	4262(4)	520(2)	3531(2)	26(1)
C(16)	4122(4)	1255(2)	3140(2)	25(1)
C(17)	3204(4)	1884(2)	3458(2)	24(1)
C(18)	2481(4)	1796(2)	4181(2)	23(1)
C(20)	4924(5)	2093(3)	2058(2)	37(1)
C(21)	884(3)	2833(2)	7349(2)	18(1)
C(23)	1290(3)	4242(2)	6968(2)	19(1)
C(24)	624(3)	4333(2)	7727(2)	20(1)
C(25)	382(3)	3460(2)	7989(2)	21(1)
C(26)	-276(3)	3241(2)	8756(2)	21(1)
C(27)	-258(4)	2386(2)	9007(2)	25(1)
C(28)	-970(4)	2176(2)	9711(2)	30(1)
C(29)	-1704(4)	2814(2)	10181(2)	33(1)
C(30)	-1701(4)	3671(3)	9953(2)	32(1)
C(31)	-983(4)	3888(2)	9253(2)	26(1)
C(32)	1753(3)	5003(2)	6496(2)	19(1)
C(33)	640(4)	5550(2)	6416(2)	23(1)
C(34)	1028(4)	6300(2)	5995(2)	24(1)
C(35)	2550(4)	6498(2)	5663(2)	22(1)
C(36)	3693(4)	5982(2)	5731(2)	23(1)

C(37)	3299(4)	5233(2)	6151(2)	22(1)
C(39)	3190(3)	7202(2)	4511(2)	22(1)
C(42)	3771(4)	7074(2)	3037(2)	24(1)
C(46)	4720(4)	7692(2)	1847(2)	25(1)
C(47)	5912(4)	7559(3)	1315(2)	33(1)
C(48)	6523(4)	8243(3)	852(2)	33(1)
C(49)	5940(4)	9051(2)	955(2)	28(1)
C(50)	4716(4)	9181(2)	1472(2)	29(1)
C(51)	4081(4)	8486(2)	1924(2)	27(1)
F(1)	640(2)	2904(1)	5336(1)	26(1)
F(2)	3436(2)	3221(1)	5701(1)	25(1)
N(1)	763(3)	1890(2)	7292(1)	20(1)
N(3)	1635(3)	1739(2)	5932(1)	18(1)
N(22)	1468(3)	3326(2)	6742(1)	19(1)
N(40)	2812(3)	6311(2)	4049(2)	24(1)
N(41)	3113(3)	6243(2)	3277(2)	26(1)
N(43)	4065(3)	7964(2)	3484(2)	26(1)
N(44)	3741(3)	8035(2)	4256(2)	25(1)
N(52)	6649(4)	9809(2)	502(2)	34(1)
O(19)	4908(3)	1295(2)	2441(1)	33(1)
O(38)	2962(3)	7318(1)	5303(1)	25(1)
O(45)	4123(3)	6926(2)	2252(1)	30(1)
O(53)	7646(4)	9651(2)	4(2)	52(1)
O(54)	6244(3)	10566(2)	655(1)	40(1)
C(1S)	6554(4)	5403(2)	8539(2)	34(1)
Cl(1S)	4403(1)	5166(1)	8292(1)	41(1)
Cl(2S)	7730(1)	6206(1)	7989(1)	61(1)
Cl(3S)	7024(1)	5856(1)	9588(1)	57(1)

Table 4. Bond lengths [Å] and angles [°] for **4c**.

B(1)-F(1)	1.383(4)	C(20)-H(20B)	0.9800
B(1)-F(2)	1.395(3)	C(20)-H(20C)	0.9800
B(1)-N(3)	1.570(4)	C(20)-O(19)	1.438(4)
B(1)-N(22)	1.546(4)	C(21)-C(25)	1.422(4)
C(2)-C(6)	1.452(4)	C(21)-N(1)	1.344(4)
C(2)-N(1)	1.313(4)	C(21)-N(22)	1.386(3)
C(2)-N(3)	1.399(4)	C(23)-C(24)	1.401(4)
C(4)-C(5)	1.426(4)	C(23)-C(32)	1.466(4)
C(4)-C(13)	1.450(4)	C(23)-N(22)	1.371(4)
C(4)-N(3)	1.368(4)	C(24)-H(24)	0.9500
C(5)-H(5)	0.9500	C(24)-C(25)	1.398(4)
C(5)-C(6)	1.372(4)	C(25)-C(26)	1.473(4)
C(6)-C(7)	1.467(4)	C(26)-C(27)	1.400(4)
C(7)-C(8)	1.398(4)	C(26)-C(31)	1.399(4)
C(7)-C(12)	1.403(4)	C(27)-H(27)	0.9500
C(8)-H(8)	0.9500	C(27)-C(28)	1.389(4)
C(8)-C(9)	1.389(4)	C(28)-H(28)	0.9500
C(9)-H(9)	0.9500	C(28)-C(29)	1.382(5)
C(9)-C(10)	1.382(5)	C(29)-H(29)	0.9500
C(10)-H(10)	0.9500	C(29)-C(30)	1.382(5)
C(10)-C(11)	1.382(5)	C(30)-H(30)	0.9500
C(11)-H(11)	0.9500	C(30)-C(31)	1.386(4)
C(11)-C(12)	1.381(4)	C(31)-H(31)	0.9500
C(12)-H(12)	0.9500	C(32)-C(33)	1.395(4)
C(13)-C(14)	1.411(4)	C(32)-C(37)	1.407(4)
C(13)-C(18)	1.398(4)	C(33)-H(33)	0.9500
C(14)-H(14)	0.9500	C(33)-C(34)	1.391(4)
C(14)-C(15)	1.372(4)	C(34)-H(34)	0.9500
C(15)-H(15)	0.9500	C(34)-C(35)	1.376(4)
C(15)-C(16)	1.395(5)	C(35)-C(36)	1.376(4)
C(16)-C(17)	1.385(4)	C(35)-O(38)	1.414(3)
C(16)-O(19)	1.361(3)	C(36)-H(36)	0.9500
C(17)-H(17)	0.9500	C(36)-C(37)	1.389(4)
C(17)-C(18)	1.382(4)	C(37)-H(37)	0.9500
C(18)-H(18)	0.9500	C(39)-N(40)	1.339(4)
C(20)-H(20A)	0.9800	C(39)-N(44)	1.341(4)

C(39)-O(38)	1.336(4)	C(6)-C(5)-C(4)	109.4(3)
C(42)-N(41)	1.338(4)	C(6)-C(5)-H(5)	125.3
C(42)-N(43)	1.332(4)	C(2)-C(6)-C(7)	126.1(3)
C(42)-O(45)	1.350(4)	C(5)-C(6)-C(2)	105.5(3)
C(46)-C(47)	1.377(4)	C(5)-C(6)-C(7)	128.4(3)
C(46)-C(51)	1.386(5)	C(8)-C(7)-C(6)	120.2(3)
C(46)-O(45)	1.408(4)	C(8)-C(7)-C(12)	118.3(3)
C(47)-H(47)	0.9500	C(12)-C(7)-C(6)	121.5(3)
C(47)-C(48)	1.386(5)	C(7)-C(8)-H(8)	119.7
C(48)-H(48)	0.9500	C(9)-C(8)-C(7)	120.6(3)
C(48)-C(49)	1.376(5)	C(9)-C(8)-H(8)	119.7
C(49)-C(50)	1.380(4)	C(8)-C(9)-H(9)	120.0
C(49)-N(52)	1.471(4)	C(10)-C(9)-C(8)	120.1(3)
C(50)-H(50)	0.9500	C(10)-C(9)-H(9)	120.0
C(50)-C(51)	1.388(4)	C(9)-C(10)-H(10)	119.9
C(51)-H(51)	0.9500	C(9)-C(10)-C(11)	120.1(3)
N(40)-N(41)	1.320(3)	C(11)-C(10)-H(10)	119.9
N(43)-N(44)	1.325(3)	C(10)-C(11)-H(11)	119.9
N(52)-O(53)	1.224(4)	C(12)-C(11)-C(10)	120.2(3)
N(52)-O(54)	1.226(4)	C(12)-C(11)-H(11)	119.9
C(1S)-H(1S)	1.0000	C(7)-C(12)-H(12)	119.6
C(1S)-Cl(1S)	1.754(3)	C(11)-C(12)-C(7)	120.7(3)
C(1S)-Cl(2S)	1.747(4)	C(11)-C(12)-H(12)	119.6
C(1S)-Cl(3S)	1.760(4)	C(14)-C(13)-C(4)	118.8(3)
		C(18)-C(13)-C(4)	123.9(3)
F(1)-B(1)-F(2)	111.2(2)	C(18)-C(13)-C(14)	117.2(3)
F(1)-B(1)-N(3)	111.6(2)	C(13)-C(14)-H(14)	119.4
F(1)-B(1)-N(22)	107.9(2)	C(15)-C(14)-C(13)	121.2(3)
F(2)-B(1)-N(3)	107.6(2)	C(15)-C(14)-H(14)	119.4
F(2)-B(1)-N(22)	111.6(2)	C(14)-C(15)-H(15)	120.0
N(22)-B(1)-N(3)	106.7(2)	C(14)-C(15)-C(16)	120.1(3)
N(1)-C(2)-C(6)	126.2(3)	C(16)-C(15)-H(15)	120.0
N(1)-C(2)-N(3)	124.9(3)	C(17)-C(16)-C(15)	120.1(3)
N(3)-C(2)-C(6)	108.8(2)	O(19)-C(16)-C(15)	116.1(3)
C(5)-C(4)-C(13)	125.4(3)	O(19)-C(16)-C(17)	123.8(3)
N(3)-C(4)-C(5)	108.6(2)	C(16)-C(17)-H(17)	120.3
N(3)-C(4)-C(13)	125.9(3)	C(18)-C(17)-C(16)	119.4(3)
C(4)-C(5)-H(5)	125.3	C(18)-C(17)-H(17)	120.3

C(13)-C(18)-H(18)	119.0	C(30)-C(31)-H(31)	119.5
C(17)-C(18)-C(13)	121.9(3)	C(33)-C(32)-C(23)	118.4(2)
C(17)-C(18)-H(18)	119.0	C(33)-C(32)-C(37)	118.6(3)
H(20A)-C(20)-H(20B)	109.5	C(37)-C(32)-C(23)	123.0(3)
H(20A)-C(20)-H(20C)	109.5	C(32)-C(33)-H(33)	119.4
H(20B)-C(20)-H(20C)	109.5	C(34)-C(33)-C(32)	121.1(3)
O(19)-C(20)-H(20A)	109.5	C(34)-C(33)-H(33)	119.4
O(19)-C(20)-H(20B)	109.5	C(33)-C(34)-H(34)	120.8
O(19)-C(20)-H(20C)	109.5	C(35)-C(34)-C(33)	118.4(3)
N(1)-C(21)-C(25)	127.2(3)	C(35)-C(34)-H(34)	120.8
N(1)-C(21)-N(22)	122.9(2)	C(34)-C(35)-C(36)	122.5(3)
N(22)-C(21)-C(25)	109.8(2)	C(34)-C(35)-O(38)	116.8(3)
C(24)-C(23)-C(32)	125.9(3)	C(36)-C(35)-O(38)	120.5(3)
N(22)-C(23)-C(24)	108.8(2)	C(35)-C(36)-H(36)	120.6
N(22)-C(23)-C(32)	125.3(2)	C(35)-C(36)-C(37)	118.9(3)
C(23)-C(24)-H(24)	125.5	C(37)-C(36)-H(36)	120.6
C(25)-C(24)-C(23)	109.0(3)	C(32)-C(37)-H(37)	119.8
C(25)-C(24)-H(24)	125.5	C(36)-C(37)-C(32)	120.5(3)
C(21)-C(25)-C(26)	127.9(3)	C(36)-C(37)-H(37)	119.8
C(24)-C(25)-C(21)	105.0(2)	N(40)-C(39)-N(44)	126.3(3)
C(24)-C(25)-C(26)	127.1(3)	O(38)-C(39)-N(40)	119.8(3)
C(27)-C(26)-C(25)	122.3(3)	O(38)-C(39)-N(44)	113.8(2)
C(31)-C(26)-C(25)	120.0(3)	N(41)-C(42)-O(45)	112.1(3)
C(31)-C(26)-C(27)	117.7(3)	N(43)-C(42)-N(41)	126.8(3)
C(26)-C(27)-H(27)	119.5	N(43)-C(42)-O(45)	121.2(3)
C(28)-C(27)-C(26)	120.9(3)	C(47)-C(46)-C(51)	121.9(3)
C(28)-C(27)-H(27)	119.5	C(47)-C(46)-O(45)	114.5(3)
C(27)-C(28)-H(28)	119.8	C(51)-C(46)-O(45)	123.4(3)
C(29)-C(28)-C(27)	120.3(3)	C(46)-C(47)-H(47)	120.3
C(29)-C(28)-H(28)	119.8	C(46)-C(47)-C(48)	119.5(3)
C(28)-C(29)-H(29)	120.2	C(48)-C(47)-H(47)	120.3
C(28)-C(29)-C(30)	119.5(3)	C(47)-C(48)-H(48)	120.8
C(30)-C(29)-H(29)	120.2	C(49)-C(48)-C(47)	118.4(3)
C(29)-C(30)-H(30)	119.8	C(49)-C(48)-H(48)	120.8
C(29)-C(30)-C(31)	120.4(3)	C(48)-C(49)-C(50)	122.6(3)
C(31)-C(30)-H(30)	119.8	C(48)-C(49)-N(52)	118.9(3)
C(26)-C(31)-H(31)	119.5	C(50)-C(49)-N(52)	118.5(3)
C(30)-C(31)-C(26)	121.0(3)	C(49)-C(50)-H(50)	120.6

C(49)-C(50)-C(51)	118.9(3)	N(44)-N(43)-C(42)	116.7(2)
C(51)-C(50)-H(50)	120.6	N(43)-N(44)-C(39)	116.5(2)
C(46)-C(51)-C(50)	118.6(3)	O(53)-N(52)-C(49)	117.6(3)
C(46)-C(51)-H(51)	120.7	O(53)-N(52)-O(54)	123.9(3)
C(50)-C(51)-H(51)	120.7	O(54)-N(52)-C(49)	118.5(3)
C(2)-N(1)-C(21)	120.2(2)	C(16)-O(19)-C(20)	117.9(2)
C(2)-N(3)-B(1)	121.3(2)	C(39)-O(38)-C(35)	119.3(2)
C(4)-N(3)-B(1)	130.8(2)	C(42)-O(45)-C(46)	122.4(2)
C(4)-N(3)-C(2)	107.7(2)	Cl(1S)-C(1S)-H(1S)	108.1
C(21)-N(22)-B(1)	123.4(2)	Cl(1S)-C(1S)-Cl(3S)	110.45(19)
C(23)-N(22)-B(1)	127.5(2)	Cl(2S)-C(1S)-H(1S)	108.1
C(23)-N(22)-C(21)	107.4(2)	Cl(2S)-C(1S)-Cl(1S)	111.4(2)
N(41)-N(40)-C(39)	116.8(2)	Cl(2S)-C(1S)-Cl(3S)	110.51(18)
N(40)-N(41)-C(42)	116.6(2)	Cl(3S)-C(1S)-H(1S)	108.1

Table 5. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for **4c**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[\ h^2\ a^{*2}U^{11} + ...\ + 2\ h\ k\ a^*\ b^*\ U^{12}\ ]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
B(1)	21(2)	18(2)	22(2)	10(1)	6(1)	6(1)
C(2)	18(1)	19(1)	21(1)	6(1)	4(1)	2(1)
C(4)	17(1)	18(1)	21(1)	5(1)	1(1)	2(1)
C(5)	23(1)	18(1)	23(2)	6(1)	3(1)	4(1)
C(6)	19(1)	18(1)	24(2)	6(1)	2(1)	2(1)
C(7)	25(2)	17(1)	22(2)	7(1)	2(1)	0(1)
C(8)	27(2)	23(2)	31(2)	10(1)	3(1)	4(1)
C(9)	35(2)	24(2)	38(2)	14(2)	-2(2)	2(1)
C(10)	45(2)	26(2)	27(2)	16(1)	-3(2)	-5(2)
C(11)	46(2)	24(2)	24(2)	5(1)	8(2)	-4(1)
C(12)	36(2)	17(2)	27(2)	6(1)	8(1)	0(1)
C(13)	19(1)	18(1)	18(1)	3(1)	2(1)	0(1)
C(14)	25(2)	19(1)	25(2)	6(1)	1(1)	4(1)
C(15)	29(2)	25(2)	26(2)	5(1)	5(1)	10(1)
C(16)	23(2)	30(2)	22(2)	7(1)	4(1)	4(1)
C(17)	26(2)	22(2)	25(2)	9(1)	4(1)	6(1)
C(18)	25(1)	22(2)	21(2)	5(1)	2(1)	6(1)
C(20)	46(2)	39(2)	33(2)	21(2)	19(2)	15(2)
C(21)	19(1)	16(1)	19(1)	7(1)	2(1)	2(1)
C(23)	19(1)	17(1)	22(2)	7(1)	2(1)	3(1)
C(24)	21(1)	16(1)	25(2)	7(1)	5(1)	4(1)
C(25)	18(1)	21(1)	22(2)	7(1)	2(1)	3(1)
C(26)	19(1)	22(2)	20(1)	8(1)	3(1)	2(1)
C(27)	29(2)	22(2)	23(2)	6(1)	4(1)	3(1)
C(28)	38(2)	23(2)	26(2)	12(1)	7(1)	1(1)
C(29)	34(2)	38(2)	26(2)	15(2)	11(1)	2(1)
C(30)	33(2)	40(2)	27(2)	7(2)	10(1)	14(2)
C(31)	29(2)	25(2)	25(2)	8(1)	7(1)	8(1)
C(32)	22(1)	16(1)	19(1)	6(1)	4(1)	1(1)
C(33)	24(2)	21(2)	22(2)	7(1)	6(1)	4(1)
C(34)	27(2)	21(2)	25(2)	9(1)	3(1)	6(1)
C(35)	31(2)	17(1)	16(1)	9(1)	2(1)	1(1)
C(36)	27(2)	21(2)	23(2)	9(1)	6(1)	4(1)

C(37)	24(1)	18(1)	24(2)	6(1)	4(1)	4(1)
C(39)	21(1)	19(1)	26(2)	7(1)	0(1)	3(1)
C(42)	25(2)	24(2)	23(2)	9(1)	1(1)	3(1)
C(46)	33(2)	22(2)	20(2)	8(1)	1(1)	2(1)
C(47)	42(2)	32(2)	31(2)	10(2)	6(2)	15(2)
C(48)	32(2)	42(2)	30(2)	13(2)	11(1)	13(2)
C(49)	30(2)	29(2)	23(2)	12(1)	4(1)	2(1)
C(50)	35(2)	26(2)	28(2)	9(1)	6(1)	7(1)
C(51)	31(2)	29(2)	24(2)	10(1)	6(1)	7(1)
F(1)	33(1)	29(1)	21(1)	8(1)	1(1)	14(1)
F(2)	25(1)	19(1)	30(1)	9(1)	13(1)	3(1)
N(1)	19(1)	18(1)	21(1)	7(1)	3(1)	3(1)
N(3)	18(1)	17(1)	20(1)	6(1)	3(1)	3(1)
N(22)	20(1)	16(1)	21(1)	8(1)	4(1)	3(1)
N(40)	26(1)	19(1)	24(1)	8(1)	1(1)	2(1)
N(41)	29(1)	20(1)	25(1)	7(1)	2(1)	1(1)
N(43)	34(1)	20(1)	22(1)	7(1)	1(1)	2(1)
N(44)	31(1)	19(1)	24(1)	10(1)	3(1)	2(1)
N(52)	38(2)	35(2)	28(2)	13(1)	8(1)	3(1)
O(19)	42(1)	37(1)	28(1)	16(1)	18(1)	18(1)
O(38)	37(1)	16(1)	22(1)	10(1)	5(1)	4(1)
O(45)	46(1)	20(1)	25(1)	9(1)	8(1)	4(1)
O(53)	60(2)	55(2)	48(2)	25(1)	32(1)	13(1)
O(54)	54(2)	29(1)	34(1)	13(1)	6(1)	3(1)
C(1S)	31(2)	25(2)	44(2)	4(2)	0(2)	7(1)
Cl(1S)	27(1)	49(1)	44(1)	9(1)	-1(1)	7(1)
Cl(2S)	51(1)	35(1)	99(1)	20(1)	38(1)	10(1)
Cl(3S)	57(1)	57(1)	50(1)	-13(1)	-18(1)	25(1)

Table 6. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for **4c**.

	x	y	z	U(eq)
H(5)	1958	-412	5500	26
H(8)	1997	-1234	6567	32
H(9)	1432	-2219	7521	39
H(10)	-76	-1824	8624	41
H(11)	-1137	-485	8745	41
H(12)	-630	487	7788	33
H(14)	3632	-69	4507	28
H(15)	4860	76	3302	31
H(17)	3072	2371	3183	29
H(18)	1845	2226	4395	27
H(20A)	3774	2072	1895	55
H(20B)	5567	2048	1578	55
H(20C)	5442	2702	2439	55
H(24)	377	4897	8017	24
H(27)	249	1944	8690	30
H(28)	-953	1591	9871	36
H(29)	-2208	2664	10658	39
H(30)	-2194	4114	10277	39
H(31)	-971	4486	9109	31
H(33)	-402	5408	6652	27
H(34)	261	6666	5937	29
H(36)	4733	6135	5494	28
H(37)	4079	4874	6205	27
H(47)	6312	7002	1267	40
H(48)	7326	8157	472	40
H(50)	4315	9738	1518	35
H(51)	3227	8553	2278	33
H(1S)	6863	4779	8397	40

Table 7. Torsion angles [°] for **4c**.

C(2)-C(6)-C(7)-C(8)	-160.2(3)	C(21)-C(25)-C(26)-C(31)	-168.7(3)
C(2)-C(6)-C(7)-C(12)	19.6(4)	C(23)-C(24)-C(25)-C(21)	-1.5(3)
C(4)-C(5)-C(6)-C(2)	-1.2(3)	C(23)-C(24)-C(25)-C(26)	179.3(3)
C(4)-C(5)-C(6)-C(7)	-179.0(3)	C(23)-C(32)-C(33)-C(34)	178.2(3)
C(4)-C(13)-C(14)-C(15)	-175.2(3)	C(23)-C(32)-C(37)-C(36)	-177.9(3)
C(4)-C(13)-C(18)-C(17)	175.2(3)	C(24)-C(23)-C(32)-C(33)	-45.8(4)
C(5)-C(4)-C(13)-C(14)	-19.8(4)	C(24)-C(23)-C(32)-C(37)	131.4(3)
C(5)-C(4)-C(13)-C(18)	161.8(3)	C(24)-C(23)-N(22)-B(1)	166.7(3)
C(5)-C(4)-N(3)-B(1)	174.8(3)	C(24)-C(23)-N(22)-C(21)	1.2(3)
C(5)-C(4)-N(3)-C(2)	0.5(3)	C(24)-C(25)-C(26)-C(27)	-171.2(3)
C(5)-C(6)-C(7)-C(8)	17.2(5)	C(24)-C(25)-C(26)-C(31)	10.3(4)
C(5)-C(6)-C(7)-C(12)	-163.0(3)	C(25)-C(21)-N(1)-C(2)	173.7(3)
C(6)-C(2)-N(1)-C(21)	174.7(3)	C(25)-C(21)-N(22)-B(1)	-168.4(2)
C(6)-C(2)-N(3)-B(1)	-176.2(2)	C(25)-C(21)-N(22)-C(23)	-2.2(3)
C(6)-C(2)-N(3)-C(4)	-1.2(3)	C(25)-C(26)-C(27)-C(28)	-176.4(3)
C(6)-C(7)-C(8)-C(9)	177.8(3)	C(25)-C(26)-C(31)-C(30)	176.0(3)
C(6)-C(7)-C(12)-C(11)	-177.1(3)	C(26)-C(27)-C(28)-C(29)	-0.4(5)
C(7)-C(8)-C(9)-C(10)	-0.2(5)	C(27)-C(26)-C(31)-C(30)	-2.6(4)
C(8)-C(7)-C(12)-C(11)	2.7(4)	C(27)-C(28)-C(29)-C(30)	-1.1(5)
C(8)-C(9)-C(10)-C(11)	1.8(5)	C(28)-C(29)-C(30)-C(31)	0.6(5)
C(9)-C(10)-C(11)-C(12)	-1.1(5)	C(29)-C(30)-C(31)-C(26)	1.2(5)
C(10)-C(11)-C(12)-C(7)	-1.2(5)	C(31)-C(26)-C(27)-C(28)	2.1(4)
C(12)-C(7)-C(8)-C(9)	-2.0(4)	C(32)-C(23)-C(24)-C(25)	-178.7(3)
C(13)-C(4)-C(5)-C(6)	178.8(3)	C(32)-C(23)-N(22)-B(1)	-14.3(4)
C(13)-C(4)-N(3)-B(1)	-3.5(5)	C(32)-C(23)-N(22)-C(21)	-179.8(3)
C(13)-C(4)-N(3)-C(2)	-177.8(3)	C(32)-C(33)-C(34)-C(35)	-0.6(4)
C(13)-C(14)-C(15)-C(16)	-0.6(4)	C(33)-C(32)-C(37)-C(36)	-0.8(4)
C(14)-C(13)-C(18)-C(17)	-3.2(4)	C(33)-C(34)-C(35)-C(36)	0.2(4)
C(14)-C(15)-C(16)-C(17)	-2.2(5)	C(33)-C(34)-C(35)-O(38)	-174.5(2)
C(14)-C(15)-C(16)-O(19)	178.7(3)	C(34)-C(35)-C(36)-C(37)	-0.1(4)
C(15)-C(16)-C(17)-C(18)	2.3(4)	C(34)-C(35)-O(38)-C(39)	-117.7(3)
C(15)-C(16)-O(19)-C(20)	-174.4(3)	C(35)-C(36)-C(37)-C(32)	0.4(4)
C(16)-C(17)-C(18)-C(13)	0.5(4)	C(36)-C(35)-O(38)-C(39)	67.5(4)
C(17)-C(16)-O(19)-C(20)	6.4(4)	C(37)-C(32)-C(33)-C(34)	0.9(4)
C(18)-C(13)-C(14)-C(15)	3.2(4)	C(39)-N(40)-N(41)-C(42)	0.3(4)
C(21)-C(25)-C(26)-C(27)	9.8(5)	C(42)-N(43)-N(44)-C(39)	1.6(4)

C(46)-C(47)-C(48)-C(49)	1.6(5)	N(22)-B(1)-N(3)-C(4)	-169.7(3)
C(47)-C(46)-C(51)-C(50)	-2.5(5)	N(22)-C(21)-C(25)-C(24)	2.3(3)
C(47)-C(46)-O(45)-C(42)	141.8(3)	N(22)-C(21)-C(25)-C(26)	-178.5(3)
C(47)-C(48)-C(49)-C(50)	-3.2(5)	N(22)-C(21)-N(1)-C(2)	-3.0(4)
C(47)-C(48)-C(49)-N(52)	176.5(3)	N(22)-C(23)-C(24)-C(25)	0.2(3)
C(48)-C(49)-C(50)-C(51)	1.9(5)	N(22)-C(23)-C(32)-C(33)	135.4(3)
C(48)-C(49)-N(52)-O(53)	5.4(4)	N(22)-C(23)-C(32)-C(37)	-47.4(4)
C(48)-C(49)-N(52)-O(54)	-173.0(3)	N(40)-C(39)-N(44)-N(43)	-5.6(4)
C(49)-C(50)-C(51)-C(46)	0.9(5)	N(40)-C(39)-O(38)-C(35)	8.8(4)
C(50)-C(49)-N(52)-O(53)	-174.9(3)	N(41)-C(42)-N(43)-N(44)	3.2(5)
C(50)-C(49)-N(52)-O(54)	6.8(4)	N(41)-C(42)-O(45)-C(46)	175.6(3)
C(51)-C(46)-C(47)-C(48)	1.3(5)	N(43)-C(42)-N(41)-N(40)	-4.2(5)
C(51)-C(46)-O(45)-C(42)	-42.9(4)	N(43)-C(42)-O(45)-C(46)	-3.9(4)
F(1)-B(1)-N(3)-C(2)	-113.8(3)	N(44)-C(39)-N(40)-N(41)	4.6(4)
F(1)-B(1)-N(3)-C(4)	72.6(4)	N(44)-C(39)-O(38)-C(35)	-173.5(2)
F(1)-B(1)-N(22)-C(21)	111.7(3)	N(52)-C(49)-C(50)-C(51)	-177.8(3)
F(1)-B(1)-N(22)-C(23)	-51.6(3)	O(19)-C(16)-C(17)-C(18)	-178.7(3)
F(2)-B(1)-N(3)-C(2)	123.9(3)	O(38)-C(35)-C(36)-C(37)	174.4(2)
F(2)-B(1)-N(3)-C(4)	-49.8(4)	O(38)-C(39)-N(40)-N(41)	-178.0(3)
F(2)-B(1)-N(22)-C(21)	-125.7(3)	O(38)-C(39)-N(44)-N(43)	176.9(2)
F(2)-B(1)-N(22)-C(23)	70.9(4)	O(45)-C(42)-N(41)-N(40)	176.3(2)
N(1)-C(2)-C(6)-C(5)	-175.4(3)	O(45)-C(42)-N(43)-N(44)	-177.3(3)
N(1)-C(2)-C(6)-C(7)	2.5(5)	O(45)-C(46)-C(47)-C(48)	176.6(3)
N(1)-C(2)-N(3)-B(1)	0.8(4)	O(45)-C(46)-C(51)-C(50)	-177.5(3
N(1)-C(2)-N(3)-C(4)	175.7(3)		
N(1)-C(21)-C(25)-C(24)	-174.7(3)		
N(1)-C(21)-C(25)-C(26)	4.5(5)		
N(1)-C(21)-N(22)-B(1)	8.7(4)		
N(1)-C(21)-N(22)-C(23)	174.9(3)		
N(3)-B(1)-N(22)-C(21)	-8.4(3)		
N(3)-B(1)-N(22)-C(23)	-171.7(2)		
N(3)-C(2)-C(6)-C(5)	1.5(3)		
N(3)-C(2)-C(6)-C(7)	179.4(3)		
N(3)-C(2)-N(1)-C(21)	-1.8(4)		
N(3)-C(4)-C(5)-C(6)	0.4(3)		
N(3)-C(4)-C(13)-C(14)	158.2(3)		
N(3)-C(4)-C(13)-C(18)	-20.1(4)		
N(22)-B(1)-N(3)-C(2)	3.9(3)		

Table 8. Hydrogen bonds for **4c** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
C(34)-H(34)...F(1)#1	0.95	2.50	3.169(4)	127
C(50)-H(50)...O(19)#2	0.95	2.43	3.173(4)	136
C(1S)-H(1S)...O(45)#3	1.00	2.44	3.309(4)	145

Symmetry transformations used to generate equivalent atoms:

#1 -x,-y+1,-z+1 #2 x,y+1,z #3 -x+1,-y+1,-z+1