Rational Design and Facile Synthesis of a Highly Tunable Quinoline-Based Fluorescent Small Molecule Scaffold for Live Cell Imaging

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Table of Contents

General Information.

Materials. All commercial reagents and solvents were used as received. trans-dichlorobis(triphenylphosphine)palladium(II) was purchased from Strem Chemicals, Inc. (Newburyport, MA). 4-(Boc-aminomethyl)benzeneboronic acid was purchased from Alfa Aesar (Haverhill, MA). 2-methoxyphenylboronic acid, 3-methoxypehnylboronic acid, 4-methoxyphenylboronic acid, and 2,4-difluorophenylboronic acid were purchased from Acros (Waltham, MA). Phenylboronic acid was purchased from Fluka (Muskegon, Michigan). All other reagents and solvents were purchased from Sigma-Aldrich (St. Louis, MO) unless otherwise specified. Flash column chromatography was performed using Silicycle silica gel (40-63 μm (230-400 mesh), 60 Å irregular pore diameter). Thin-layer chromatography was performed on TLC Silica gel 60G F_{254} plate from Millipore Sigma. Reagents were purchased at the highest commercial quality and used without further purification, unless otherwise stated. Dulbecco's Modified Eagle Medium (DMEM) was purchased from Invitrogen (Carlsbad, CA). Fetal bovine serum (FBS) was purchased from Gibco, Life Technologies (Gaithersburg, MD). Penicillin/streptomycin were purchased from Corning Cellgro (Corning, NY).

Instruments. Accurate mass measurement analyses were conducted on either a Waters GCT Premier, time-of-flight, GCMS with electron ionization (EI), or an LCT Premier XE, time-of-flight, LCMS with electrospray ionization (ESI). The signals were measured against an internal lock mass reference of perfluorotributylamine (PFTBA) for EI-GCMS, and leucine enkephalin for ESI-LCMS. Waters software calibrates and reports by use of neutral atom mass. The mass of an electron is not included. High-resolution mass spectra were obtained by Joomyung Vicky Jun and Dr. Charles Ross III at the University of Pennsylvania's Mass Spectrometry Service Center on a Micromass AutoSpec electrospray/chemical ionization spectrometer. X-ray diffraction data obtained and solved by Dr. Patrick Carroll at the University of Pennsylvania. UV-Vis absorption spectra were acquired on a Hewlett-Packard 8452A diode array spectrophotometer (currently Agilent Technologies; Santa Clara, CA, USA) using quartz cells with a 1 cm cell path length (Starna Cells, Inc 120ul UV cells) or disposable UV cuvettes. Fluorescence spectra were acquired on a Tecan M1000 plate reader (Mannedorf, Switzerland). Nuclear magnetic resonance (NMR) spectra were obtained on a Bruker UNI-500 and AVII-500B instrument and are calibrated using

deuterated solvent (CD_2Cl_2 at 53.84 ppm ^{13}C NMR. The following abbreviations were used to explain multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad). High-performance liquid chromatography (HPLC) chromatograms were recorded and compounds **4l'**, **5b,** and **5d** were purified on an Agilent Technology 1260 infinity II equipped with a Gemini NX 5µm C18 110A; 250 x 21.2 mm LC column. Analytical HPLC studies were done with a JASCO-FC-2088-30 HPLC equipped with a Phenomenex Luna Omega 5µm PS C18(2) 100A; 250 x 4.60 mm column using aqueous (H_2O + 0.1% CF_3CO_2H) and organic (CH_3CN) phases. Purification conditions via combiflash Teledyne ISCO were also recorded. Melting points were determined on a Thomas-Hoover "UNI-MELT" capillary melting point apparatus and are uncorrected. The infrared (IR) spectra were obtained with Perkin Elmer Spectrum Two FT-IR by dissolving a small amount of compound in dichloromethane to mount the sample. For certain experiments, anhydrous solvents are obtained from Meyer Solvent Dispensing System (Laguna Beach, CA).

Cell Culture and Imaging. HeLa cells were maintained in a humidified incubator at 37 °C in 5% CO_2. HeLa cells were cultured in DMEM supplemented with 10% fetal bovine serum (Gibco, Life Technologies) and penicillin and streptomycin (Corning Cellgro). For live cell imaging, cells were plated in glass-bottom 35-mm dishes (MatTEK) 48 h before experiments. 48 h after plating, 2 µL of compound (stock solution 5 mM) was added to 2 mL of media. Cells were incubated for 2-5 h with compounds at 37 °C, followed by washing with fresh media 2 times. During imaging, cells were maintained in DMEM without phenol red, supplemented with 10% FBS. A Leica TCS SP8 confocal microscope equipped with a 40x and 63x/1.4 NA oil immersion objective lens was used. Compounds **4a**-**4n** were excited at 405 nm and emission was observed in various wavelength filter sets with a consistent range of 50 nm. Compounds **5a**-**5i** were excited at both 405 nm and 488 nm and emissions were observed in various wavelength filter sets with a consistent range of 50 nm. Images were processed using Fiji ImageJ.

Experimental Procedure for Key Precursor 3

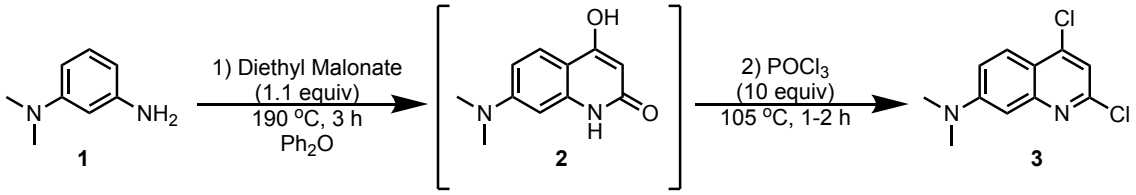


Figure S1. Synthesis of *2,4-dichloro-N,N-dimethylquinolin-7-amine **3***

Optimized Gram Scale Synthesis of Compound 3 (This Work)

N,N-Dimethyl-1,3-phenylenediamine dihydrochloride (5.70 g, 270 mmole, 1.0 equiv) purchased from Acros Organics™ was dissolved in 100 mL of water and neutralized with neat K_2CO_3 until pH 9-10 was reached. The aqueous mixture was then extracted with EtOAc three times and washed with brine. Organic layers were combined, dried over Na_2SO_4 and concentrated *in vacuo* to give a brownish oil (3.63 g). In a 20 mL or 40 mL scintillation vial, free-based *N,N*-dimethyl-1,3-phenylenediamine (**1**) was added (1.20 g, 8.81 mmol, 1.0 equiv) to diphenylether (2.0 mL). Diethyl malonate (1.55 g, 9.69 mmol, 1.1 equiv) was added to the reaction vial, and capped tightly with Green Open Top SURE-Link™ Polypropylene Cap (Chemglass Life Sciences CG-4904-05) to allow self-condensation. The reaction vial, and the reaction mixture was vigorously stirred and heated at 160 °C for 3 h until the solution turned orange (Figure S3A). The reaction was then heated to 200 °C for approximately 12 h until TLC indicated the complete formation of 7-(dimethylamino)-4-hydroxyquinolin-2(1*H*)-one **2** (Rf=0.34 in 10% MeOH in DCM, or Figure S3B). The reaction vial turned brown and cooled to room temperature. Without any wash or purification, phosphorous oxychloride (13.5 g, 88.1 mmol, 10.0 equiv) was added to the reaction vial. The reaction mixture was stirred and refluxed at 105 °C (external temperature of silicon oil bath) for 3 h. The reaction was cooled to 0 °C over the course of 30 min, and ice deionized water was slowly added to the reaction mixture to quench excess phosphorous oxychloride. The resulting mixture was poured into a larger Erlenmeyer flask and neutralized with neat K_2CO_3. Then the mixture was poured into a separatory funnel and extracted with EtOAc 3 times. Finally, the organic layer was washed with brine, dried with Na_2SO_4, and concentrated *in vacuo*. Residual diphenylether was filtered out by silica column with 100% hexane, as it is the most non-polar component (Ph_2O= 1.14D). The crude mixture was purified by flash column chromatography (0% to 30% EtOAc in Hexane) to yield the yellow crystalline compound (2.03 g, 95.6% yield).

Reproducibility of Previously Reported Synthesis of Compound 3

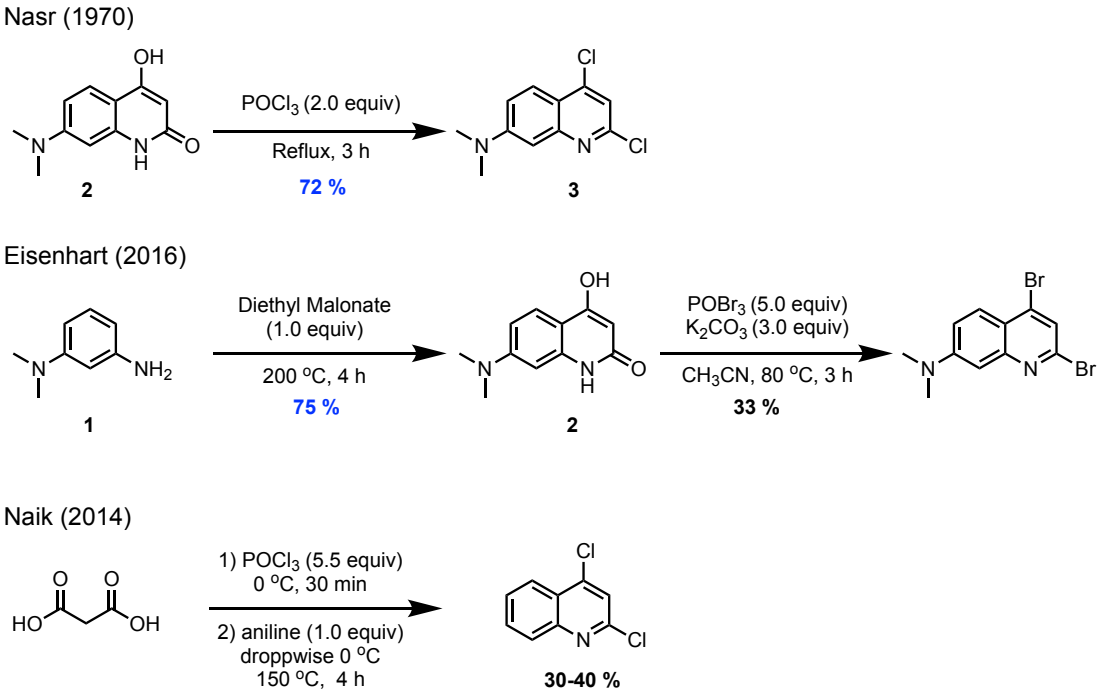


Figure S2. Previously reported synthetic conditions for 2,4-dihaloquinoline.[1-3]

Method 1. The synthesis of 2,4-dihydroxy-7-(dimethylamino)quinolone (**2**) was adapted from Nasr and Eisenhart.[1,2] Diethylmalonate (0.72 mL, 1.1 equiv) was added to the round-bottom flask containing the *N,N*-dimethyl-*m*-phenylenediamine (**1**) (0.58 g, 4.26 mmol, 1.0 equiv). A Dean-Stark apparatus was fitted to the flask to distill off ethanol, and the mixture was refluxed in an oil bath at 180 ˚C for 3 h. The reaction mixture was then heated on a heating mantle at 270 ˚C for 2 h. After the reaction and upon cooling, solids were left behind in the reaction flask. The resulting solid was cooled and washed with acetone, giving a crude mixture containing 4-hydroxyquinolone (641 mg, 74% crude yield). Chlorination of crude 4-hydroxyquinolone (**2**) was accomplished by addition of phosphorous oxychloride (1.71 mL, 18.4 mmol, 6.0 equiv) to 641 mg of **2** (3.06 mmol, 1.0 equiv). The reaction was refluxed for 2 h and then cooled to 0 ˚C. Ice water was then slowly added, and the reaction mixture was transferred to larger flask and neutralized with K_2CO_3. The mixture was poured into a separatory funnel and extracted with EtOAc three times followed by brine wash. The organic layer was dried over Na_2SO_4 and concentrated under reduced pressure in a water bath. The crude product was purified by column chromatography (100 % DCM) to yield

the title compound (640 mg, 81% yield). Overall yield was 62.3 % but was not reproducible. Moreover, at larger scale (1-2g of **1**), the reaction yield dropped down to less than 26 %. In general, a lack of reproducibility was observed, which is attributed to the nature of heterogeneity of the reaction mixture. Hence, variations of yields are evidently reported in the literature.[1-3]

Method 2. Adapting the one-pot two-step synthesis of substituted 2,4-dichloroquinoline,[3] malonic acid (420 mg, 4.04 mmol, 1.1 equiv) was dissolved in phosphorous oxychloride (3.5 ml, 37.5 mmol, 10 equiv) in a round bottom flask. The reaction mixture was heated at 50 °C for 30 min, 150 ˚C for 2 h, and then cooled down to 0 ˚C in the ice bath. In a separate vial, *N,N*-dimethyl-*m*-phenylenediamine (500 mg, 3.67 mmol, 1.0 equiv) was dissolved in dry toluene from the Meyer Solvent Dispensing System (3 mL) and added dropwise via syringe pump (1 mL per 10 min) to the reaction mixture in the ice bath. The reaction was heated at 150 ˚C for additional 2 h. The reaction mixture was cooled, poured onto ice with vigorous stirring, neutralized with sodium carbonate, filtered, dried and purified by column chromatography (100 % DCM) to afford the desired substituted 2,4-dichloroquinoline **3** (203 mg, 23 % yield).

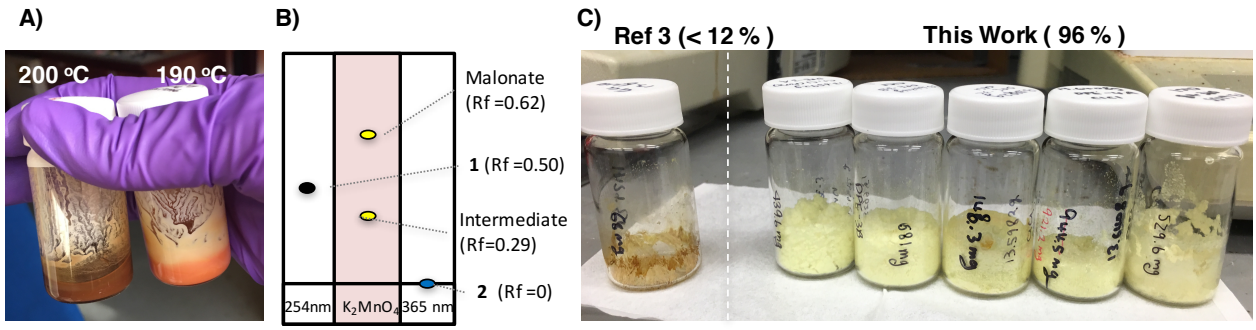


Figure S3. A) Formation of 4-hydroxyquinolone **2** based on color of the solution B) Indication of the product formation of **2** via TLC in 1:1 Hexane: EtOAc C) Product from identical scale reaction under previously reported condition[3] (left) and from our work (right)

[1] Nasr, M.; Drach, J. C.; Smith, S. H.; Shipman, C. Jr.; Burckhaltert, J. H. *Eur. J. Med. Chem.* **1988**, 31, 1351-1355.
[2] Eisenhart, T. T; Howland, W. C.; Dempsey, J.L. *J. Phys. Chem. B.* **2016**, 120, 7896−7905.
[3] Naik, M.; Humnabadkar, V.; Tantry, S.; Panda, M.; Narayan, A.; Guptha, S.; Panduga, V.; Manjrekar, P.; Jena, L.; Koushik, K.; Shanbhag, G.; Jatheendranath, S.; Manjunatha, M.; Gorai, G.; Bathula, C.; Rudrapatna, S.; Achar, V.; Sharma, S.; Ambady, A.; Hegde, N.; Mahadevaswamy, J.; Kaur, P.; Sambandamurthy, V.; Awasthy, D.; Narayan, C.; Ravishankar, S.; Madhavapeddi, P.; Reddy, J.; Prabhakar, KR.; Saralaya, R.; Chatterji, M.; Whiteaker, J.; McLaughlin, B.; Chiarelli, L.; Riccardi, G.; Pasca, M.; Binda, C.; Neres, J.; Dhar, N.; Signorino-Gelo, F.; McKinney, J.; Ramachandran, V.; Shandil, R.; Tommasi, R.; Iyer, P.; Narayanan, S.; Hosagrahara, V.; Kavanagh, S.; Dinesh, N.; Ghorpade. S., *J. Med. Chem.* **2014**, 57, 5419-5434

Characterization Data of 2,4-dichloro-*N*,*N*-dimethylquinolin-7-amine (Compound 3)

Physical State: yellow needle crystal, blue emissive under 365 nm UV lamp, m. p. = 108-110 °C[1]

TLC: R*f* = 0.47 (20% EtOAc in Hexanes).

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.67 (d, *J* = 9.3 Hz, 1H), 6.92 (s, 1H), 6.87 (dd, *J* = 9.3, 2.6 Hz, 1H), 6.76 (d, *J* = 2.5 Hz, 1H), 2.92 (s, 6H).

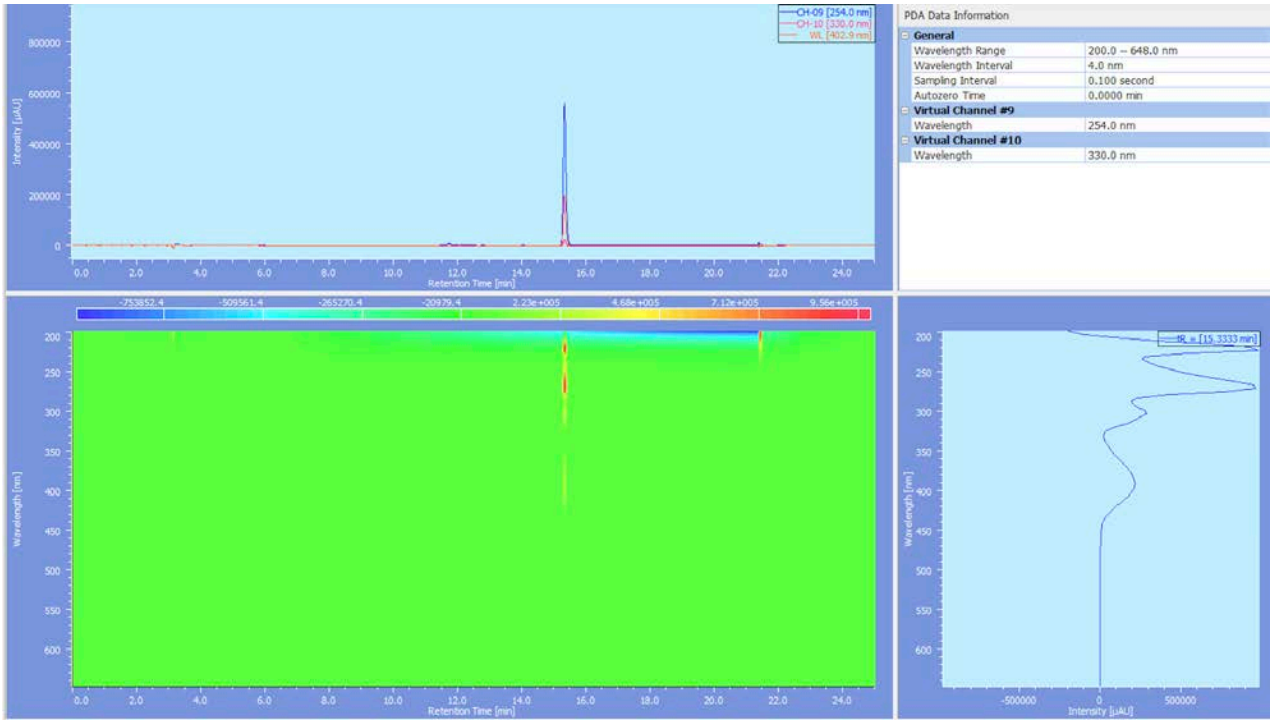
^{13}C NMR (126 MHz, $CDCl_3$): δ 151.73, 149.75, 149.54, 143.31, 124.40, 116.54, 116.05, 105.45, and 39.90

HRMS (ESI-TOF): calc'd for $C_{11}H_{11}Cl_2N_2$ $[M+H]^+$ 241.0299; found 241.0309.

IR (neat): 1623.18, 1573.16, 1546.81, 1502.41, 1446.51, 1416.61, 1361.15, 1312.18, 1270.84, 1231.87, 1195.14, 1157.87, 1087.42, 1056.86, 964.79, 893.15, 843.1, 816.4, 801.57, 719.72 cm^{-1}

Analytical HPLC:

Method: 10-100% MeCN in 0.1% H_2O over 15min (retention time: 2 min -17 min)



High-Throughput Experimentation (HTE) Screenings for Pd-catalyzed Regioselective Cross-Coupling Reaction.

Screening Set Up:

Ligands: XantPhos, DPPP, DPPF, DPEPhos, DIPPF, PPh_3, and PCy_3 ;
[Stock Solution] = 0.01 or 0.02 M
R-BINAP was not soluble in THF so stock solution was diluted;
[Stock Solution] = 0.05 M

Solvents: THF, Dioxane; [Final Concentration] = 0.1M

Base: K_2CO_3, Cs_2CO_3 ; [Stock Solution] = 1.2 M

Boronic Acid: 4-(dimethylamino)phenylboronic acid, 4-cyanophenylboronic acid, phenylboronic acid; [Stock Solution] = 0.11M

General Procedure:

Experiments were set up inside a glovebox under a nitrogen atmosphere. Solvents were all degassed and stored in the glovebox. A 96-well aluminum block containing 250 μL glass vials was first predosed with $Pd(OAc)_2$ (0.125 μmol, 5 mol %) and the phosphine ligands (0.25 μmol for monodentate ligands and 0.125 μmol for bidentate ligands) in THF. The solvent was dried overnight and a parylene stir bar was then added to each reaction vial. Dichloroquinoline **3** (2.5 μmol, 1.0 equiv) and the boronic acid (2.75 μmol, 1.1 equiv) were dosed into each reaction vial as a solution in of two different solvent (25 μL of THF or dioxane). Base (0.75 μmol, 3.0 equiv) in H_2O (6.25 μL) was added to give a final concentration of 0.1M. The 96-well plate was then sealed and stirred for 18 h at 70 ºC.

Work up:

Upon opening the plate to air, 250 μL of a solution of biphenyl (used as internal standard to measure HPLC yields) in acetonitrile (0.001 mol/L) was added to each vial. The plate was covered again, and the vials stirred for 10 min. to ensure good homogenization. Into a separate 96-well LC block was added 700 μL of acetonitrile, followed by 25 μL of the diluted reaction mixtures. The LC block was then sealed with a silicon-rubber storage mat and mounted on an automated UP-LCMS instrument for analysis.

Screening Results:

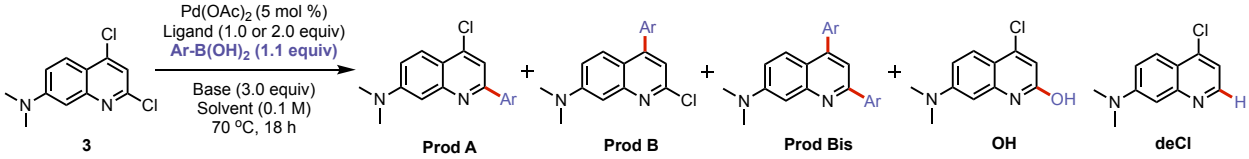


Figure S4. Possible product distribution from Suzuki cross-coupling reaction of **3**

Notes:

- **Prod A** refers to compound **4**, **Prod B** refers to compound **4'**, and **Prod Bis** refers to **5** (Table 2).

- HPLC yield of each product is calculated based on the area of corresponding HPLC chromatogram peak divided by the area of internal standard (100 % = area of **Prod A** + **Prod B** + **Prod Bis** + **OH** + **deCl** + **3**).

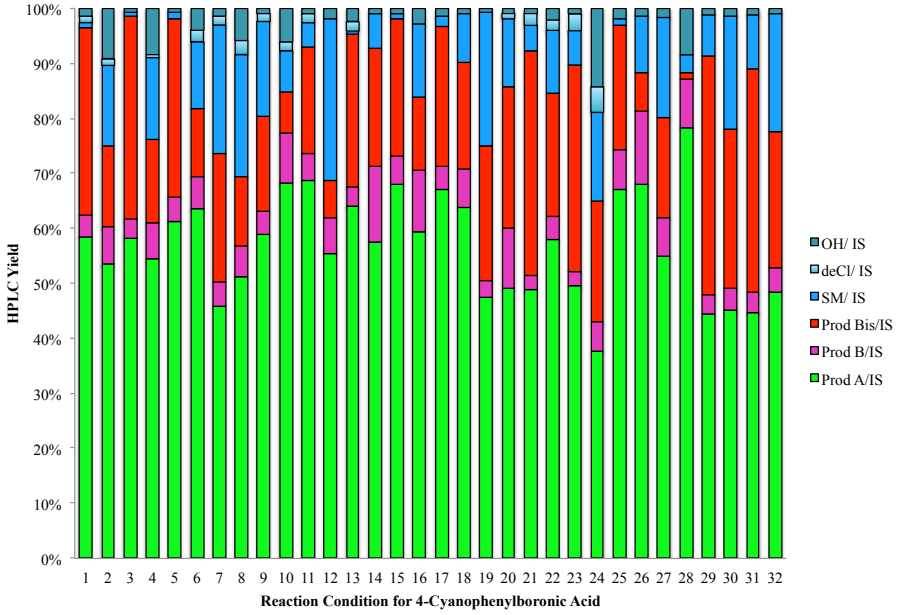
- Prod A/B quantitatively demonstrate regioselectivity of the reaction condition (**Prod A** / **Prod B**).

- Conversion (%) of the reaction was calculated as 100 (%) - percent yield of **3** (%).

Table S1. Product distribution based on HPLC yield of 4-cyanophenylboronic acid

Condition	ligand	solvent	base	Prod A/IS	Prod B/IS	Prod Bis/IS	SM/ IS	deCl/ IS	OH/ IS	Prod A/B	Conv. (%)
1	XantPhos	Dioxane	Cs2CO3	58.4	3.9	34.2	1.0	1.2	1.4	15.0	99.0
2	XantPhos	THF	Cs2CO3	53.6	6.6	14.7	14.7	1.2	9.2	8.1	85.3
3	XantPhos	Dioxane	K2CO3	58.2	3.4	36.9	0.7	0.0	0.7	16.9	99.3
4	XantPhos	THF	K2CO3	54.4	6.7	15.0	15.0	0.6	8.3	8.1	85.0
5	R-BINAP	Dioxane	Cs2CO3	61.3	4.4	32.4	1.1	0.0	0.8	13.9	98.9
6	R-BINAP	THF	Cs2CO3	63.6	5.9	12.2	12.2	2.1	3.9	10.7	87.8
7	R-BINAP	Dioxane	K2CO3	45.9	4.3	23.4	23.4	1.6	1.4	10.7	76.6
8	R-BINAP	THF	K2CO3	51.1	5.6	12.7	22.2	2.6	5.8	9.0	77.8
9	DPPP	Dioxane	Cs2CO3	59.0	4.1	17.3	17.3	1.5	0.9	14.5	82.7
10	DPPP	THF	Cs2CO3	68.1	9.1	7.5	7.5	1.6	6.1	7.5	92.5
11	DPPP	Dioxane	K2CO3	68.8	4.7	19.4	4.4	1.6	0.9	14.5	95.6
12	DPPP	THF	K2CO3	55.4	6.4	6.9	29.4	0.0	1.9	8.7	70.6
13	DPPF	Dioxane	Cs2CO3	64.1	3.5	27.6	0.7	1.7	2.4	18.4	99.3
14	DPPF	THF	Cs2CO3	57.4	14.0	21.3	6.5	0.0	0.9	4.1	93.5
15	DPPF	Dioxane	K2CO3	68.0	5.2	24.9	0.9	0.0	1.0	13.1	99.1
16	DPPF	THF	K2CO3	59.3	11.2	13.3	13.3	0.0	2.9	5.3	86.7
17	DPEPhos	Dioxane	Cs2CO3	67.1	4.1	25.6	1.9	0.0	1.3	16.3	98.1
18	DPEPhos	THF	Cs2CO3	63.8	6.9	19.5	9.0	0.0	0.8	9.2	91.0
19	DPEPhos	Dioxane	K2CO3	47.5	3.1	24.4	24.4	0.0	0.7	15.5	75.6
20	DPEPhos	THF	K2CO3	49.1	11.0	25.6	12.4	1.0	0.8	4.5	87.6
21	DIPPF	Dioxane	Cs2CO3	48.8	2.5	41.0	4.7	2.3	0.8	19.3	95.3
22	DIPPF	THF	Cs2CO3	57.9	4.2	22.4	11.5	1.9	2.0	13.7	88.5
23	DIPPF	Dioxane	K2CO3	49.5	2.7	37.7	6.1	3.0	1.0	18.4	93.9
24	DIPPF	THF	K2CO3	37.7	5.2	22.1	16.1	4.6	14.2	7.2	83.9
25	PPh3	Dioxane	Cs2CO3	67.1	7.2	22.6	1.1	0.0	1.9	9.3	98.9
26	PPh3	THF	Cs2CO3	68.0	13.3	7.1	10.4	0.0	1.3	5.1	89.6
27	PPh3	Dioxane	K2CO3	54.9	7.1	18.2	18.2	0.0	1.6	7.7	81.8
28	**PPh3**	**THF**	**K2CO3**	**78.4**	**8.7**	**1.2**	**3.3**	**0.0**	**8.4**	**9.0**	**96.7**
29	PCy3	Dioxane	Cs2CO3	44.3	3.5	43.4	7.7	0.0	1.1	12.7	92.3
30	PCy3	THF	Cs2CO3	45.0	4.0	28.9	20.7	0.0	1.3	11.3	79.3
31	PCy3	Dioxane	K2CO3	44.7	3.6	40.6	10.0	0.0	1.1	12.4	90.0
32	PCy3	THF	K2CO3	48.3	4.5	24.8	21.5	0.0	0.9	10.8	78.5

2-D Column Visualization of Table S1



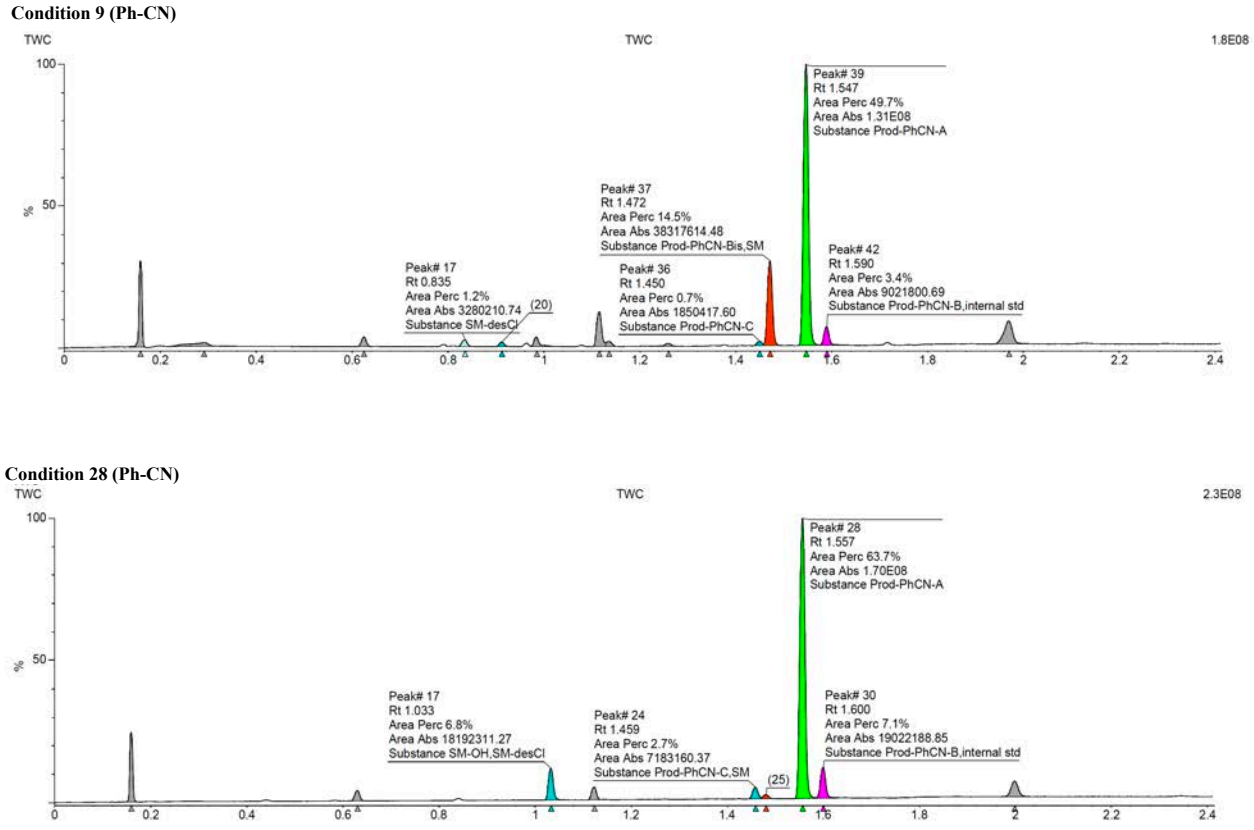
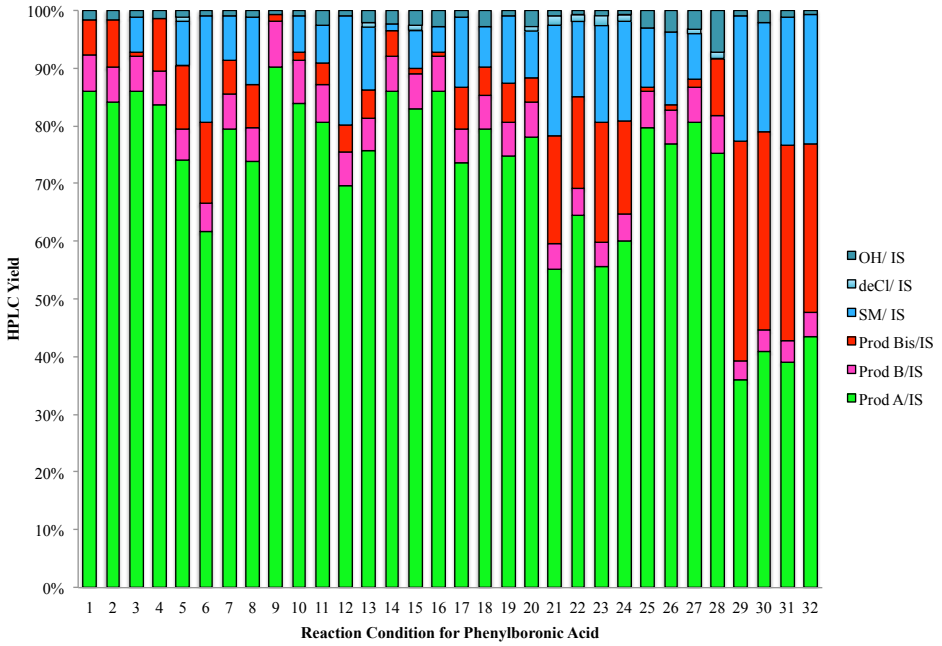


Figure S5. Crude UP-LCMS chromatogram of Conditions 9 and 28 (4-Cyanophenylboronic Acid)

Table S2. Product distribution based on HPLC yield of phenylboronic acid

Condition	ligand	solvent	base	Prod A/IS	Prod B/IS	Prod Bis/IS	SM/ IS	deCl/ IS	OH/ IS	Prod A/B	Conv. (%)
1	XantPhos	Dioxane	Cs2CO3	85.9	6.3	6.2	0.0	0.0	1.5	13.6	100.0
2	XantPhos	THF	Cs2CO3	84.1	6.0	8.3	0.0	0.0	1.6	13.9	100.0
3	XantPhos	Dioxane	K2CO3	86.0	6.1	0.8	5.9	0.0	1.3	14.1	94.1
4	XantPhos	THF	K2CO3	83.5	5.9	9.1	0.0	0.0	1.5	14.2	100.0
5	R-BINAP	Dioxane	Cs2CO3	74.2	5.3	11.1	7.6	0.8	1.1	14.1	92.4
6	R-BINAP	THF	Cs2CO3	61.7	4.8	14.1	18.4	0.0	1.0	12.8	81.6
7	R-BINAP	Dioxane	K2CO3	79.4	6.0	6.0	7.6	0.0	1.1	13.2	92.4
8	R-BINAP	THF	K2CO3	73.9	5.9	7.4	11.7	0.0	1.1	12.6	88.3
9	**DPPP**	**Dioxane**	**Cs2CO3**	**90.2**	**7.8**	**1.2**	**0.0**	**0.0**	**0.7**	**11.5**	**100.0**
10	DPPP	THF	Cs2CO3	84.0	7.4	1.4	6.4	0.0	0.9	11.4	93.6
11	DPPP	Dioxane	K2CO3	80.6	6.6	3.6	6.6	0.0	2.6	12.2	93.4
12	DPPP	THF	K2CO3	69.6	5.9	4.8	18.8	0.0	0.9	11.8	81.2
13	DPPF	Dioxane	Cs2CO3	75.7	5.6	4.9	11.0	0.8	2.1	13.6	89.0
14	DPPF	THF	Cs2CO3	86.0	6.2	4.3	1.1	0.0	2.4	13.9	98.9
15	DPPF	Dioxane	K2CO3	83.0	5.9	1.1	6.5	0.9	2.6	14.0	93.5
16	DPPF	THF	K2CO3	86.0	6.1	0.7	4.4	0.0	2.7	14.0	95.6
17	DPEPhos	Dioxane	Cs2CO3	73.6	5.8	7.3	12.1	0.0	1.1	12.6	87.9
18	DPEPhos	THF	Cs2CO3	79.4	5.8	5.0	6.9	0.0	2.8	13.7	93.1
19	DPEPhos	Dioxane	K2CO3	74.8	5.9	6.6	11.7	0.0	1.0	12.6	88.3
20	DPEPhos	THF	K2CO3	78.1	6.0	4.2	8.1	0.8	2.7	13.0	91.9
21	DIPPF	Dioxane	Cs2CO3	55.2	4.4	18.6	19.2	1.6	0.9	12.5	80.8
22	DIPPF	THF	Cs2CO3	64.5	4.7	15.8	13.1	1.1	0.8	13.7	86.9
23	DIPPF	Dioxane	K2CO3	55.6	4.1	20.8	16.8	1.8	0.8	13.5	83.2
24	DIPPF	THF	K2CO3	60.1	4.6	16.1	17.3	1.1	0.8	13.0	82.7
25	PPh3	Dioxane	Cs2CO3	79.8	6.1	0.8	10.3	0.0	3.0	13.0	89.7
26	PPh3	THF	Cs2CO3	76.8	5.9	0.9	12.7	0.0	3.7	13.0	87.3
27	PPh3	Dioxane	K2CO3	80.6	6.1	1.4	7.8	0.9	3.2	13.2	92.2
28	PPh3	THF	K2CO3	75.3	6.5	9.9	0.0	1.2	7.2	11.7	100.0
29	PCy3	Dioxane	Cs2CO3	35.9	3.3	38.0	21.9	0.0	0.9	11.0	78.1
30	PCy3	THF	Cs2CO3	41.0	3.7	34.3	18.9	0.0	2.1	11.1	81.1
31	PCy3	Dioxane	K2CO3	39.1	3.8	33.7	22.2	0.0	1.3	10.3	77.8
32	PCy3	THF	K2CO3	43.6	4.2	29.1	22.4	0.0	0.8	10.4	77.6

2-D Column Visualization of Table S2



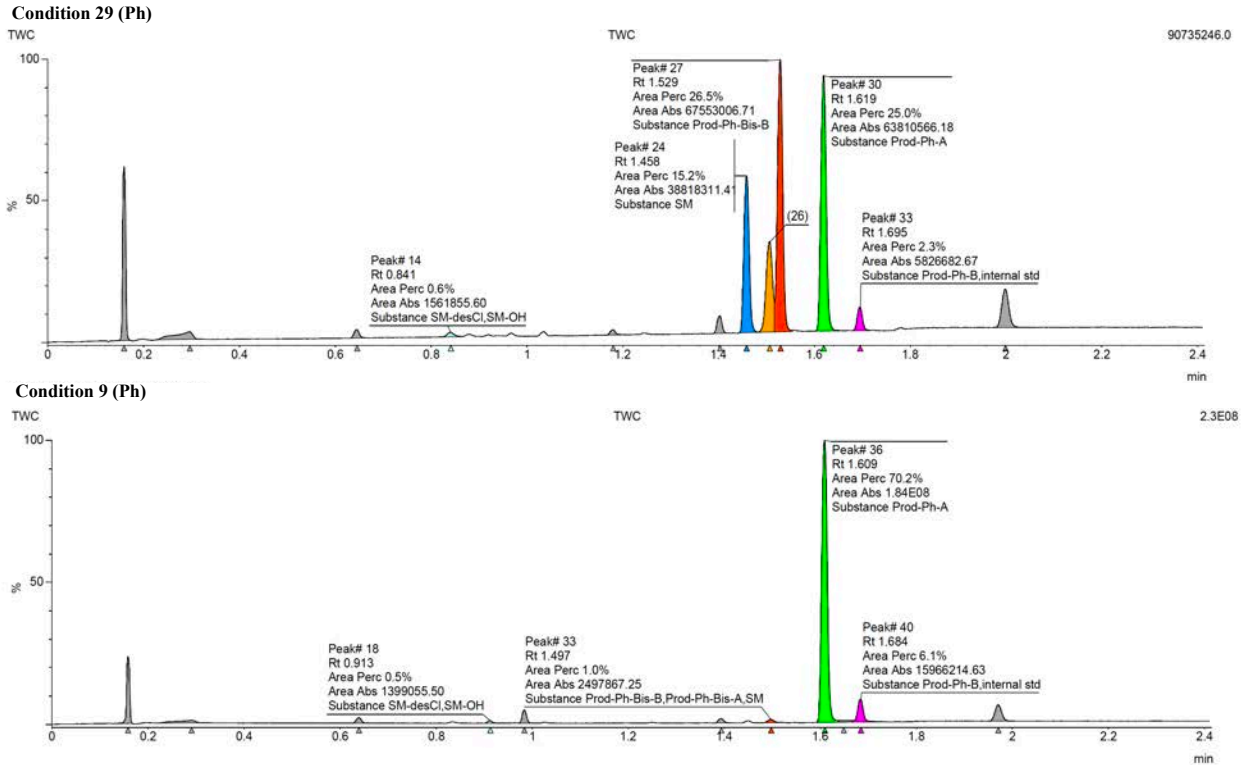
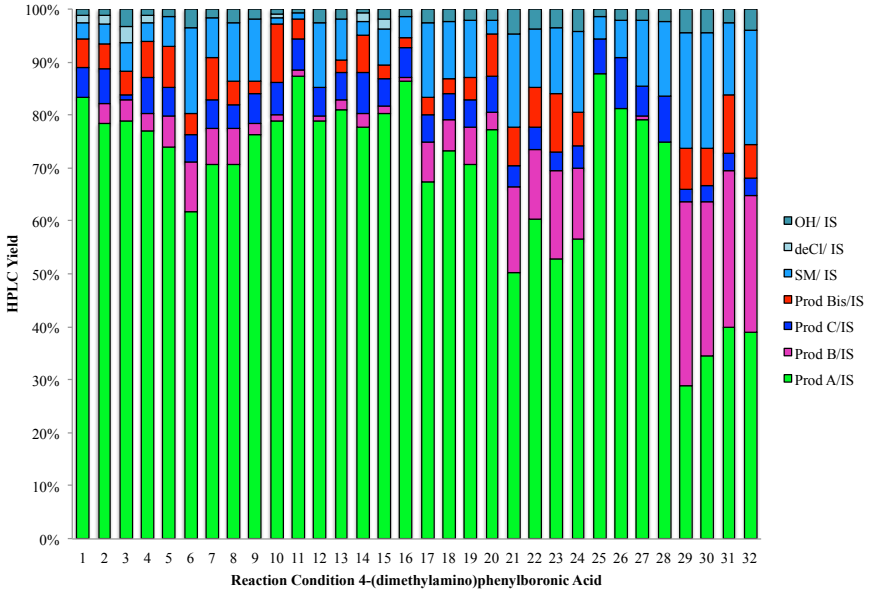


Figure S6. Crude UP-LCMS chromatogram of Conditions 29 and 9 (Phenylboronic Acid)

Table S3. Product distribution based on HPLC yield of 4-(dimethylamino)phenylboronic acid

Condition	ligand	solvent	base	Prod A/IS	Prod B/IS	Prod C/IS	Prod Bis/IS	SM/ IS	deCl/ IS	OH/ IS	Prod A/B	Conv. (%)
1	XantPhos	Dioxane	Cs2CO3	83.4	0.0	5.7	5.3	3.2	1.4	1.1	complete	96.8
2	XantPhos	THF	Cs2CO3	78.3	3.7	6.6	4.7	3.7	1.6	1.2	21.0	96.3
3	XantPhos	Dioxane	K2CO3	78.8	3.9	1.1	4.5	5.4	2.9	3.4	20.0	94.6
4	XantPhos	THF	K2CO3	77.0	3.4	6.7	6.9	3.4	1.5	1.1	22.5	96.6
5	R-BINAP	Dioxane	Cs2CO3	73.9	5.8	5.5	7.6	5.8	0.0	1.4	12.6	94.2
6	R-BINAP	THF	Cs2CO3	61.7	9.5	5.1	4.0	16.2	0.0	3.5	6.5	83.8
7	R-BINAP	Dioxane	K2CO3	70.6	6.9	5.4	8.0	7.5	0.0	1.6	10.2	92.5
8	R-BINAP	THF	K2CO3	70.8	6.7	4.4	4.6	11.1	0.0	2.5	10.6	88.9
9	DPPP	Dioxane	Cs2CO3	76.4	2.0	5.6	2.5	11.6	0.0	2.0	38.5	88.4
10	DPPP	THF	Cs2CO3	78.9	1.1	6.3	11.0	1.1	0.7	1.0	74.8	98.9
11	DPPP	Dioxane	K2CO3	87.4	1.1	5.9	3.8	1.1	0.0	0.8	81.6	98.9
12	DPPP	THF	K2CO3	78.9	0.8	5.6	0.0	12.2	0.0	2.5	94.7	87.8
13	DPPF	Dioxane	Cs2CO3	81.0	1.8	5.4	2.2	7.7	0.0	1.9	45.3	92.3
14	DPPF	THF	Cs2CO3	77.6	2.6	7.8	7.0	2.6	1.7	0.7	29.9	97.4
15	DPPF	Dioxane	K2CO3	80.3	1.5	5.1	2.5	6.9	1.8	1.8	54.6	93.1
16	DPPF	THF	K2CO3	86.4	0.8	5.6	1.9	4.0	0.0	1.4	113.3	96.0
17	DPEPhos	Dioxane	Cs2CO3	67.4	7.5	5.1	3.3	14.0	0.0	2.7	9.0	86.0
18	DPEPhos	THF	Cs2CO3	73.3	5.7	5.1	2.7	10.7	0.0	2.4	12.9	89.3
19	DPEPhos	Dioxane	K2CO3	70.7	7.0	5.1	4.2	11.0	0.0	2.0	10.1	89.0
20	DPEPhos	THF	K2CO3	77.3	3.2	6.9	7.9	2.5	0.0	2.2	24.0	97.5
21	DIPPF	Dioxane	Cs2CO3	50.3	16.1	4.1	7.1	17.6	0.0	4.7	3.1	82.4
22	DIPPF	THF	Cs2CO3	60.2	13.2	4.2	7.6	11.1	0.0	3.7	4.6	88.9
23	DIPPF	Dioxane	K2CO3	52.7	16.8	3.5	11.0	12.4	0.0	3.6	3.1	87.6
24	DIPPF	THF	K2CO3	56.6	13.5	4.2	6.3	15.1	0.0	4.3	4.2	84.9
25	**PPh3**	**Dioxane**	**Cs2CO3**	**87.7**	**0.0**	**6.6**	**0.0**	**4.3**	**0.0**	**1.4**	**complete**	**95.7**
26	PPh3	THF	Cs2CO3	81.3	0.0	9.5	0.0	7.1	0.0	2.1	complete	92.9
27	PPh3	Dioxane	K2CO3	79.2	0.6	5.6	0.0	12.5	0.0	2.1	124.0	87.5
28	PPh3	THF	K2CO3	74.9	0.0	8.7	0.0	13.9	0.0	2.5	complete	86.1
29	PCy3	Dioxane	Cs2CO3	28.8	34.8	2.4	7.8	21.7	0.0	4.5	0.8	78.3
30	PCy3	THF	Cs2CO3	34.5	29.2	2.9	7.0	22.0	0.0	4.4	1.2	78.0
31	PCy3	Dioxane	K2CO3	40.0	29.4	3.4	11.0	13.5	0.0	2.7	1.4	86.5
32	PCy3	THF	K2CO3	39.1	25.6	3.4	6.2	21.7	0.0	3.9	1.5	78.3

2-D Column Visualization of Table S3



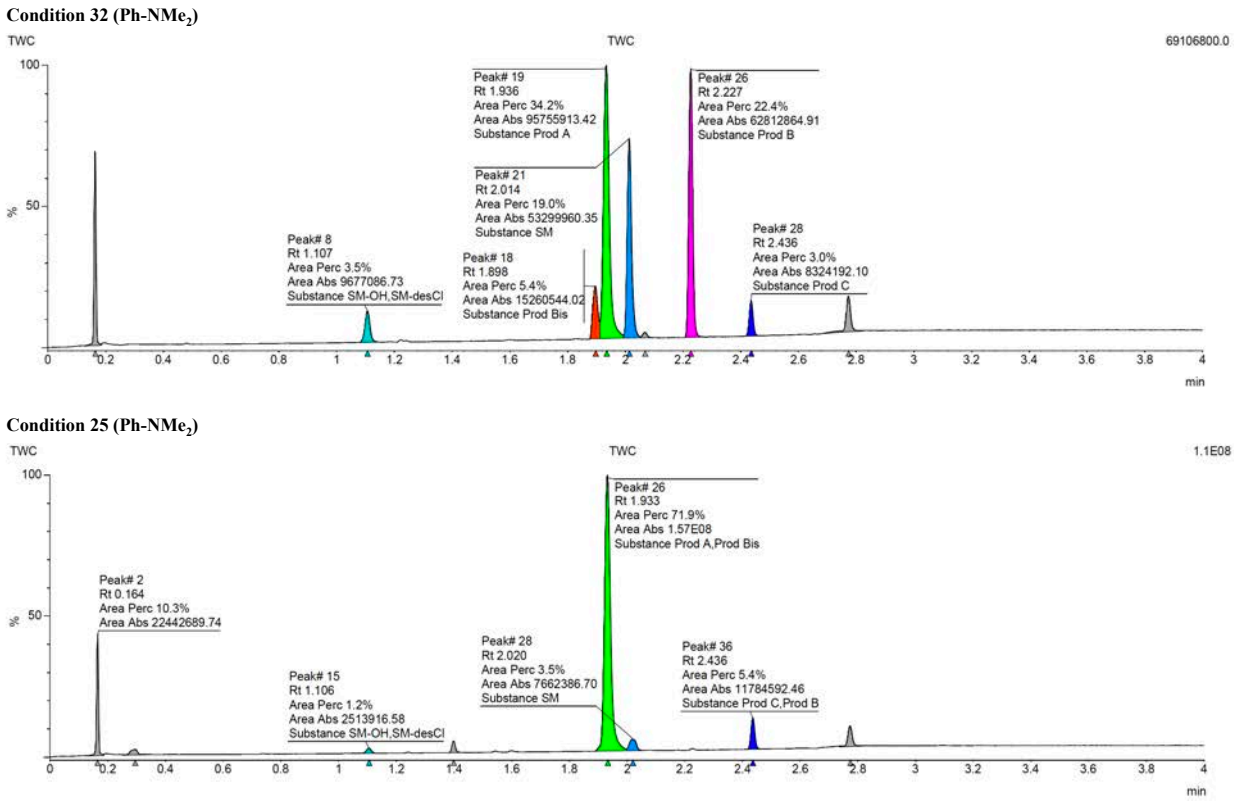


Figure S7. Crude UP-LCMS chromatogram of Condition 32 and 25 (4-dimethylamino) phenylboronic acid

Table S4. General Conditions with Average HPLC Yield and Standard Deviation.

condition	ligand	solvent	base	PhNMe2	Ph	PhCN	avg	std
1	XantPhos	Dioxane	Cs2CO3	83.4	79.8	58.4	73.9	13.5
2	XantPhos	THF	Cs2CO3	78.3	76.5	53.6	69.5	13.8
3	XantPhos	Dioxane	K2CO3	78.8	84.9	57.8	73.9	14.2
4	XantPhos	THF	K2CO3	77.0	75.5	54.4	69.0	12.7
5	R-BINAP	Dioxane	Cs2CO3	72.9	74.2	60.8	69.3	7.4
6	R-BINAP	THF	Cs2CO3	59.7	61.1	63.6	61.4	2.0
7	R-BINAP	Dioxane	K2CO3	69.5	78.6	45.9	64.6	16.9
8	R-BINAP	THF	K2CO3	69.1	73.1	51.1	64.4	11.7
9	**DPPP**	**Dioxane**	**Cs2CO3**	**74.9**	**88.6**	**59.0**	**74.2**	**14.8**
10	DPPP	THF	Cs2CO3	78.9	83.3	68.1	76.8	7.8
11	DPPP	Dioxane	K2CO3	86.7	78.6	68.8	78.0	9.0
12	DPPP	THF	K2CO3	77.0	68.9	54.4	66.8	11.4
13	DPPF	Dioxane	Cs2CO3	79.4	75.7	64.1	73.1	8.0
14	DPPF	THF	Cs2CO3	77.6	83.9	56.9	72.8	14.1
15	DPPF	Dioxane	K2CO3	80.3	83.0	67.4	76.9	8.4
16	DPPF	THF	K2CO3	85.1	83.7	57.6	75.5	15.5
17	DPEPhos	Dioxane	Cs2CO3	65.7	72.9	66.2	68.3	4.0
18	DPEPhos	THF	Cs2CO3	71.6	77.3	63.3	70.7	7.0
19	DPEPhos	Dioxane	K2CO3	69.3	74.0	47.2	63.5	14.3
20	DPEPhos	THF	K2CO3	75.6	78.1	49.1	67.6	16.1
21	DIPPF	Dioxane	Cs2CO3	48.1	55.2	48.8	50.7	4.0
22	DIPPF	THF	Cs2CO3	58.1	64.5	57.9	60.2	3.8
23	DIPPF	Dioxane	K2CO3	50.9	55.6	49.5	52.0	3.2
24	DIPPF	THF	K2CO3	54.2	60.1	37.7	50.7	11.6
25	**PPh3**	**Dioxane**	**Cs2CO3**	**86.5**	**79.1**	**65.9**	**77.1**	**10.4**
26	PPh3	THF	Cs2CO3	79.6	74.1	67.2	73.6	6.2
27	PPh3	Dioxane	K2CO3	77.5	80.6	54.1	70.7	14.5
28	**PPh3**	**THF**	**K2CO3**	**73.1**	**68.6**	**72.3**	**71.3**	**2.4**
29	PCy3	Dioxane	Cs2CO3	27.5	35.6	43.9	35.7	8.2
30	PCy3	THF	Cs2CO3	33.1	40.1	44.4	39.2	5.7
31	PCy3	Dioxane	K2CO3	39.0	38.6	44.3	40.6	3.2
32	PCy3	THF	K2CO3	37.6	43.2	47.8	42.9	5.1

Top three general conditions 9, 25, and 28 with high average yields with small standard deviations are highlighted. Condition 28 (pink highlight) was chosen as final general condition for scope study.

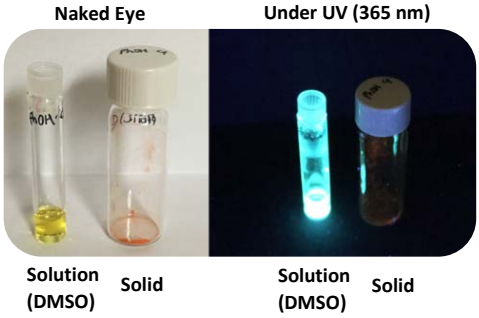
General Procedure A and Characterization Data for Monoarylated Quinolines.

General Procedure A.

Experiments were set up inside a glovebox under a nitrogen atmosphere. Tetrahydrofuran (THF) and dioxane were obtained from Meyer solvent system, and water was degassed prior to use in the glovebox. A stock solution of 2,4-dichloro-*N,N*-dimethylquinolin-7-amine (**3**) was prepared by dissolving 696 mg (2.88 mmol) in 1.6 ml of THF in the glovebox. To a 4.0 mL scintillation vial, 100 µL (43.5 mg, 0.18 mmol, 1 equiv) of compound **3** from the stock solution was added. $PdCl_2(PPh_3)_2$ (6.3 mg, 0.009 mmol, 0.05 equiv), and boronic acid (0.198 mmol, 1.1 equiv) were added and dissolved in a total 1443.4 µL of THF. K_2CO_3 (74.8 mg, 0.541 mmol, 3.0 equiv) dissolved in 360.8 mL of H_2O was added to the vial, which was capped in the glovebox. Under nitrogen, the mixture was stirred for 5 to 48 h at 65 ˚C. Upon completion of the reaction, 30 mL of EtOAc and water were added to the reaction mixture. The organic layer was extracted, dried with anhydrous Na_2SO_4, concentrated *in vacuo*. The desired product was purified by column chromatography or using the ISCO system. Standard ISCO condition: 0 to 100% EtOAc in Hexane over 10 min.

Characterization Data Notes.

Image Interpretation: The left vial has the corresponding compound in DMSO (5mM) and right the vial has dry compound. The photo with the dark background is taken under a handheld UV lamp. Solid state emission can vary depending on packing of residual solvent molecules.

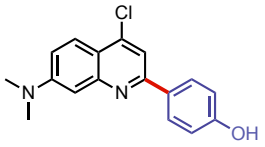


Analytical HPLC sample: Compound dissolved in 100% methanol
Analytical HPLC gradient: 10%_2min_10-100% over 15min (total 25min)

0	- 2 min	10 % solvent B (Acetonitrile) in solvent A (0.1% TFA in H_2O)
2	- 17 min	10% to 100% solvent B in A
17	- 18 min	100% solvent B in A
18	- 25 min	10% solvent B in A

Characterization Data for Compounds 4a-4n.

Table of Compounds



4-(4-chloro-7-(dimethylamino)quinolin-2-yl)phenol (4a): Following the General Procedure A with 4-hydroxyphenylboronic acid (27 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 48 h afforded 21 mg (39 % isolated yield) of the title compound after purification by the standard ISCO method. The desired product was eluted with 50-70% ethyl acetate.

Physical Property: dark orange brownish solid, m. p. = 200-205 °C

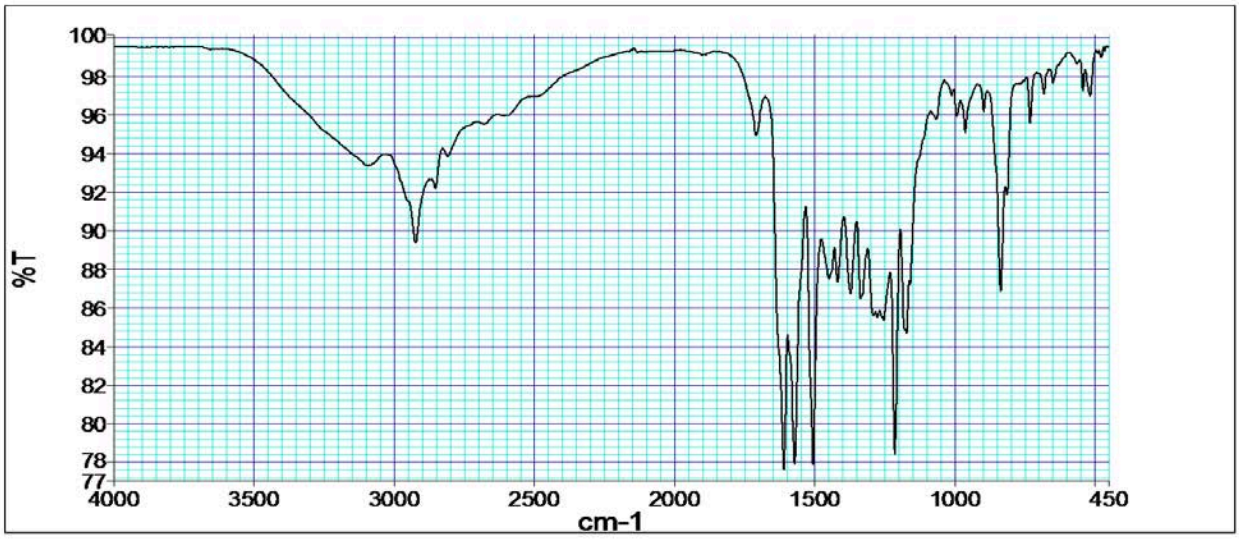
TLC: R*f* = 0.13 (20% EtOAc in Hexanes).

^{1}H NMR (500 MHz, Acetone-d_6) δ 8.19 – 8.16 (m, 2H), 7.98 (d, J = 9.2 Hz, 1H), 7.77 (s, 1H), 7.33 (dd, J = 9.2, 2.6 Hz, 1H), 7.17 (d, J = 2.6 Hz, 1H), 7.00 – 6.97 (m, 2H), 3.15 (s, 6H).

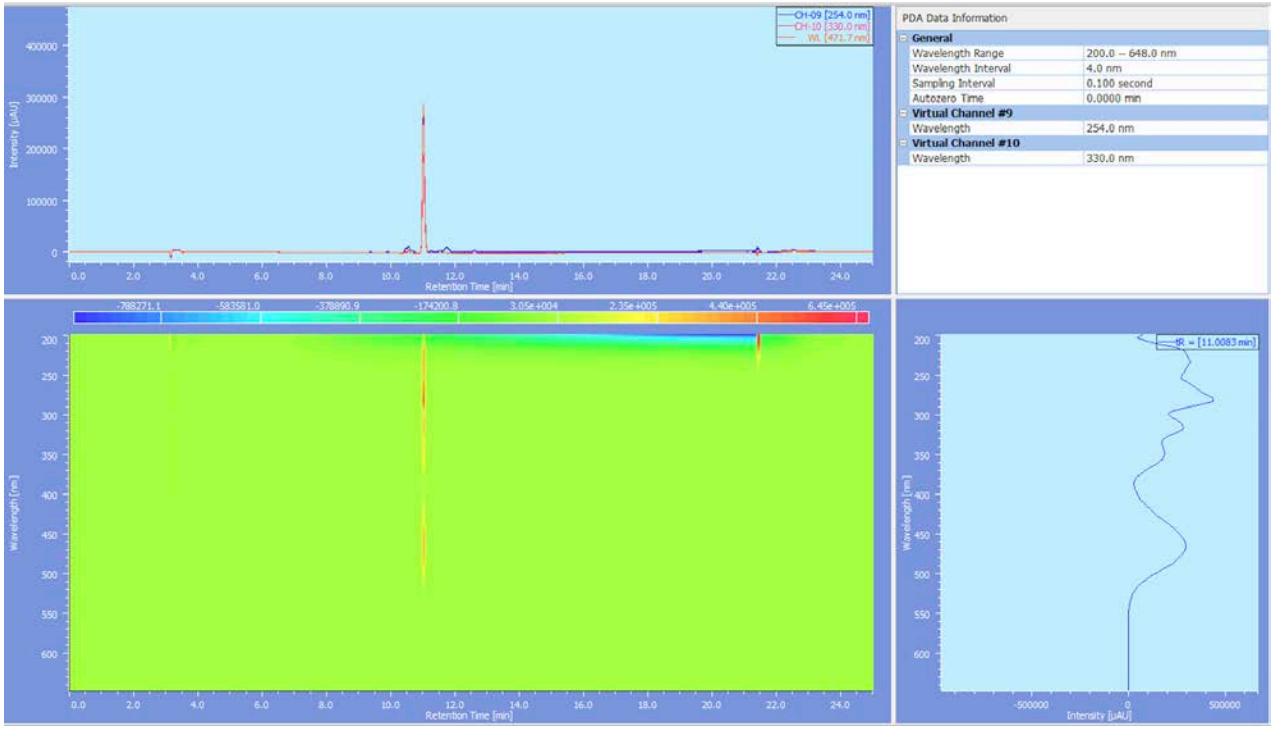
^{13}C NMR (126 MHz, Acetone-d_6) δ 157.57, 152.99, 151.81, 142.69, 131.04, 129.66, 128.21, 124.97, 117.56, 117.33, 116.33, 114.53, 107.60, and 40.42.

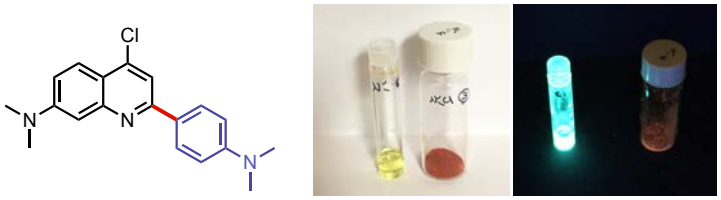
HRMS (ESI-TOF): calc'd for $C_{17}H_{16}ClN_2O^+$ $[M+H]^+$ 299.0951; found 299.0942.

IR (neat): 2925.83, 1709.77, 1609.94, 1571.48, 1506.11, 1448.61, 1418.73, 1371.68, 1336.1, 1253.13, 1213.51, 1171.68, 961.9, 896.22, 835.5, 730.08, 680.88, 541.4, 515.82 cm^{-1}



Analytical HPLC and UV trace of 4a:





4-chloro-2-(4-(dimethylamino)phenyl)-*N,N*-dimethylquinolin-7-amine (4b): Following General Procedure A with 4-(dimethylamino)phenylboronic acid (33 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 36 h afforded 57 mg (97 % isolated yield) of the title compound after purification by column chromatography (1:1 dichloromethane:EtOAc).

Physical Property: dark orange/brown solid, m. p. = 188-191 °C

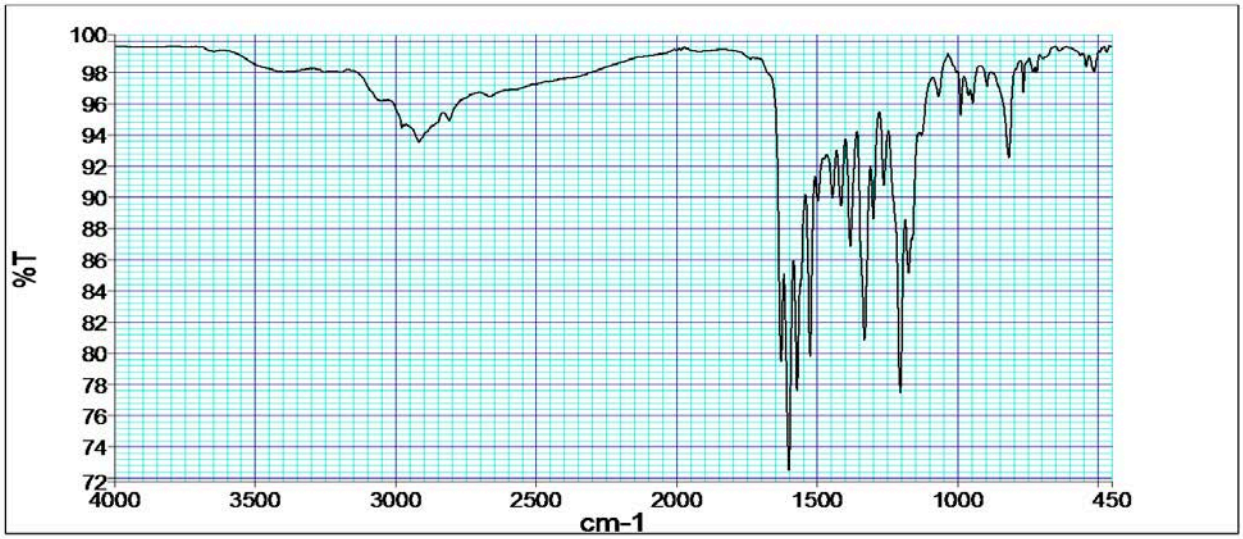
TLC: R*f* = 0.26 (20% EtOAc in Hexanes).

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.08 – 8.04 (m, 2H), 7.99 (d, *J* = 9.2 Hz, 1H), 7.63 (s, 1H), 7.18 (dd, *J* = 9.2, 2.6 Hz, 1H), 7.15 (d, *J* = 2.6 Hz, 1H), 6.85 – 6.80 (m, 2H), 3.14 (s, 6H), 3.06 (s,6H).

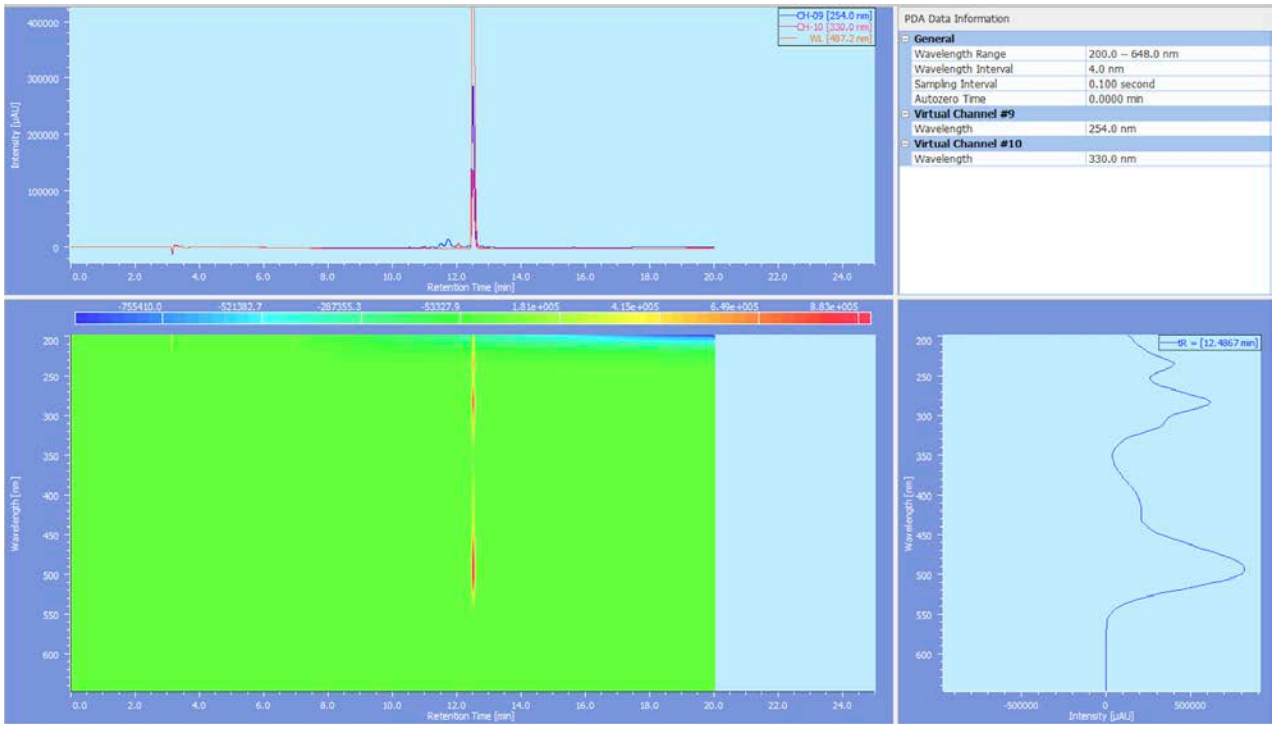
^{13}C NMR (126 MHz, CD_2Cl_2): δ 157.64, 152.31, 151.96, 151.41, 142.35, 128.50, 126.73, 124.74, 117.20, 116.02, 114.30, 112.32, 107.18, 40.64, and 40.47.

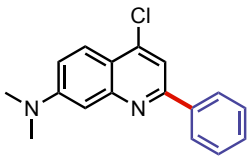
HRMS (ESI-TOF): calc'd for $C_{19}H_{21}ClN_3^+$ $[M+H]^+$ 326.1424; found 326.1410.

IR (neat): 2919.68, 1628.9, 1600.98, 1571.45, 1525.2, 1497.78, 1445.42, 1414.33, 1381.95, 1331.15, 1299.53, 1262.73, 1203.59, 1174.01, 1067.49, 988.14, 945.63, 816.77, 765.55, 512.43 cm^{-1}



Analytical HPLC and UV trace of 4b:







4-chloro-*N,N*-dimethyl-2-phenylquinolin-7-amine (4c): Following the General Procedure A with phenylboronic acid (33 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 36 h afforded 47 mg (93 % isolated yield) of the title compound after purification by column chromatography (8:1:1 Hex:DCM:EtOAc). With standard ISCO conditions, the desired product eluted at 30-38% EtOAc.

Physical Property: red film (DCM dry) or yellow solid, m. p. = 98-101 °C

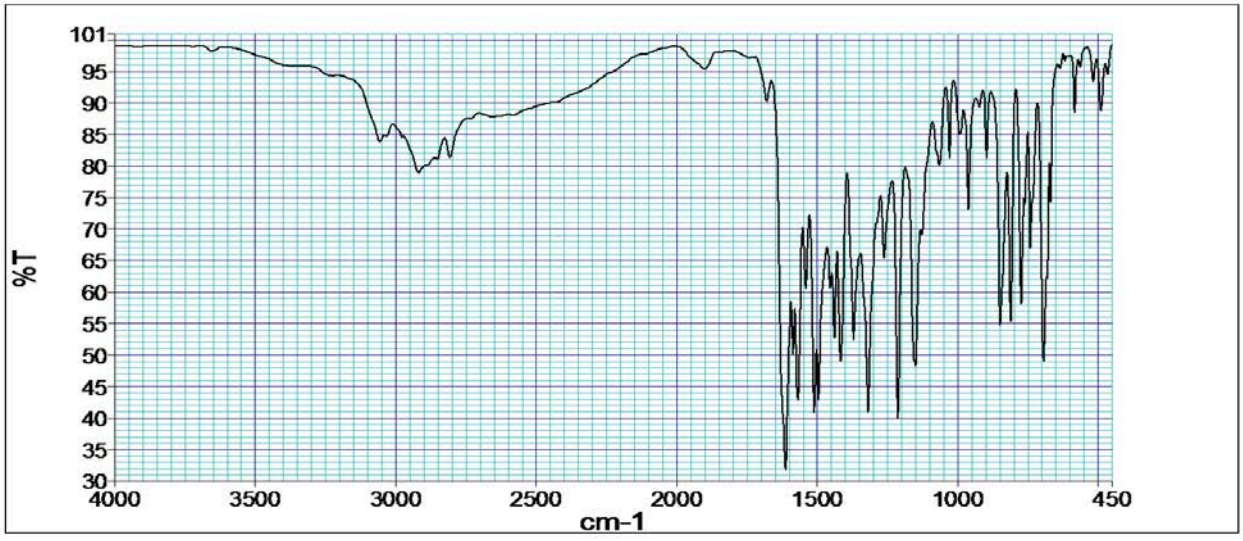
TLC: R*f* =0.45 (20% EtOAc in Hexanes).

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.16 (dt, *J* = 9.1, 2.5 Hz, 2H), 8.02 (d, *J* = 9.3 Hz, 1H), 7.63 (s, 1H), 7.57 – 7.49 (m, 3H), 7.48 – 7.44 (m, 1H), 7.23 (dd, *J* = 9.3, 2.6 Hz, 1H), 3.16 (s, 6H).

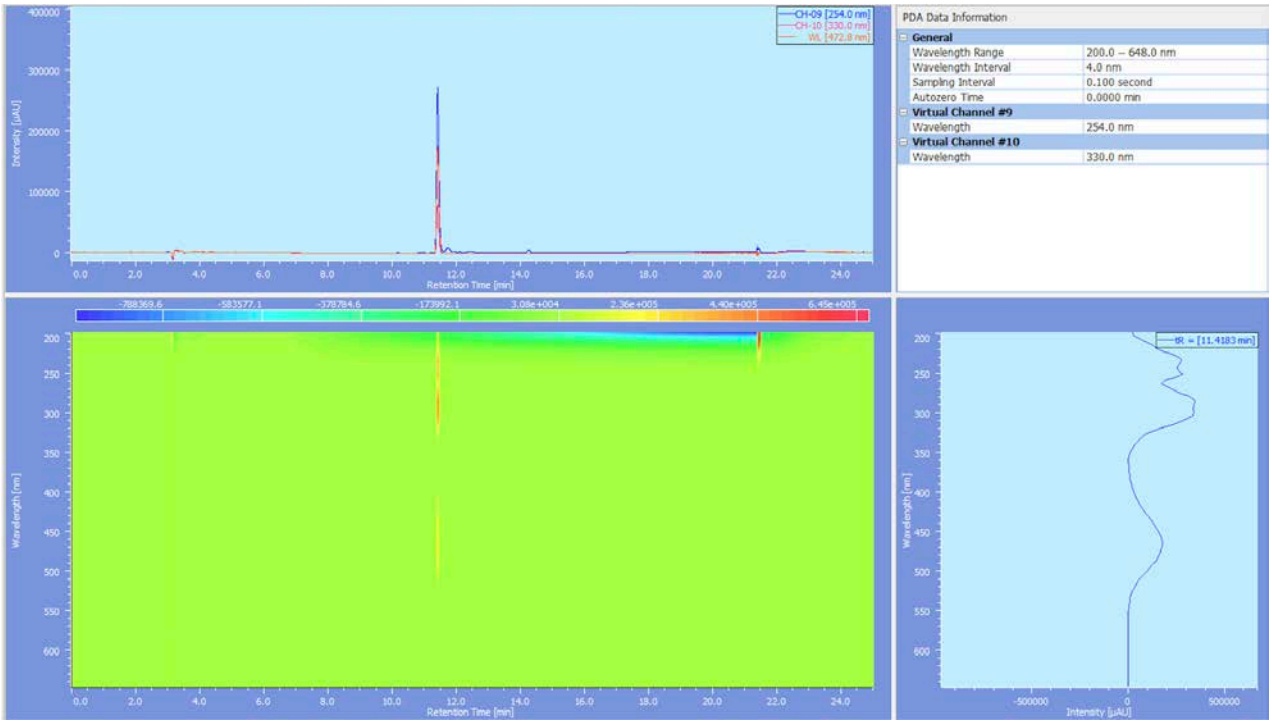
^{13}C NMR (126 MHz, CD_2Cl_2): δ156.52, 152.77, 149.46, 144.39, 137.46, 130.46, 129.18, 128.07, 125.02, 117.87, 117.38, 115.01, 105.18, and 40.56.

HRMS (ESI-TOF): calc'd for $C_{17}H_{16}ClN_2^+$ $[M+H]^+$ 283.1002; found 283.1011.

IR (neat): 1612.97, 1585.94, 1568.61, 1540.52, 1510.74, 1494.95, 1453.87, 1438.05, 1416.41, 1370.2, 1318.58, 1261.58, 1212.32, 1149.46, 960.88, 847.78, ,809.48, 772.67, 740.48, 692.67 cm^{-1}



Analytical HPLC and UV trace of 4c:



4-chloro-2-(4-fluorophenyl)-*N*,*N*-dimethylquinolin-7-amine (4d): Following the General Procedure A with 4-fluorophenylboronic acid (28 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 12 h afforded 49 mg (91 % isolated yield) of the title compound after purification by the ISCO standard purification method. The desired product eluted at 25-30% EtOAc.

Physical Property: yellow solid, m. p. = 149-151 °C

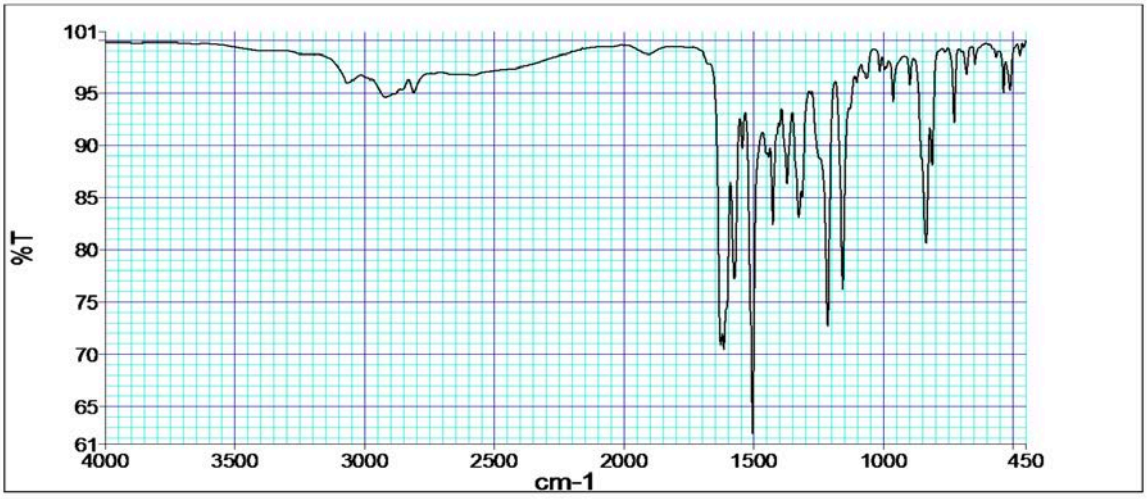
TLC: R*f* = 0.5 (20% EtOAc in Hexanes) / 0.27 (40% Hexanes in CH_2Cl_2)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.18 – 8.11 (m, 2H), 8.02 (d, J = 9.2 Hz, 1H), 7.62 (s, 1H), 7.26 – 7.18 (m, 3H), 7.17 (d, J = 2.7 Hz, 1H), 3.14 (s, 6H).

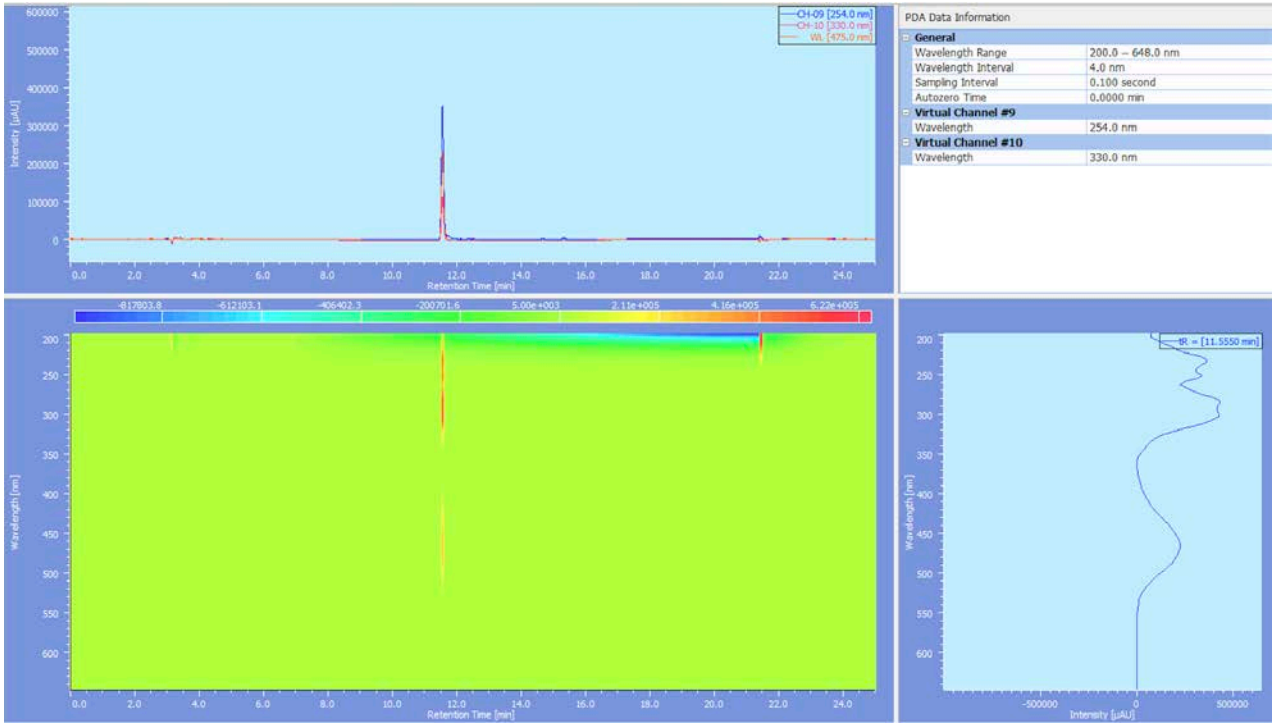
^{13}C NMR (126 MHz, CD_2Cl_2): δ 164.21 (d, $^1J_{FC}$ = 248.3 Hz, 1C), 156.40, 152.39, 151.30, 142.92, 135.74 (d, $^4J_{FC}$ = 3.3 Hz, 1C), 129.55 (d, $^3J_{FC}$ = 8.7 Hz, 1C), 124.80, 117.63, 117.03, 115.93 (d, $^2J_{FC}$ = 21.5 Hz, 1C), 114.72, 107.17, and 40.56.

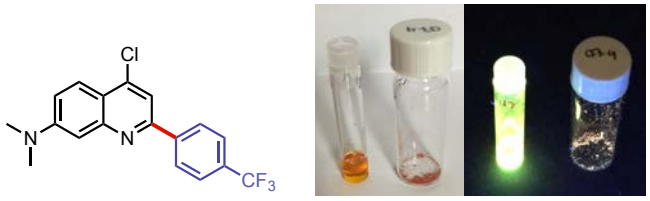
HRMS (ESI-TOF): calc'd for $C_{17}H_{15}ClFN_2^+$ $[M+H]^+$ 301.0908; found 301.0895.

IR (neat): 2922.12, 2812.66, 1627.87, 1615.19, 1574.61, 1543.95, 1504.04, 1426.26, 1371.56, 1326.18, 1214.47, 1156.52, 1063.88, 961.69, 896.99, 834.65, 810.82, 725.67, 535.29, 510 cm^{-1}



Analytical HPLC and UV trace of 4d:





4-chloro-*N*,*N*-dimethyl-2-(4-(trifluoromethyl)phenyl)quinolin-7-amine (4e): Following the General Procedure A with 4-(trifluoromethyl)phenylboronic acid (38 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 48 h afforded 61 mg (96 % isolated yield) of the title compound after purification by the standard ISCO purification. The desired product eluted at 24-28% EtOAc.

Physical Property: red solid, m. p. = 108-110 °C

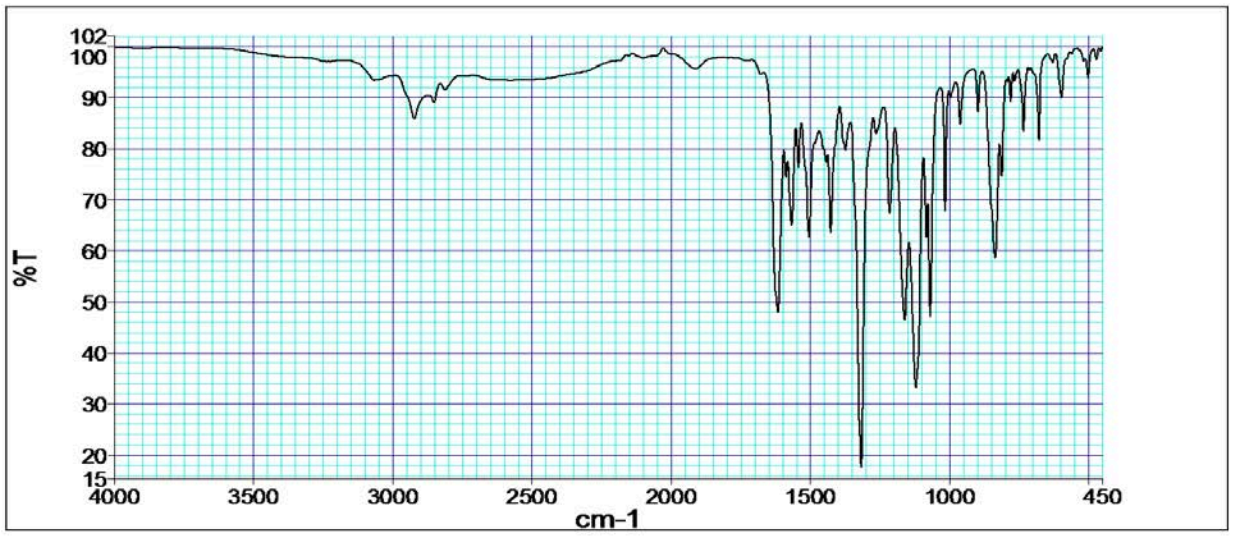
TLC: R*f* = 0.54 (20% EtOAc in Hexanes).

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.32 (d, *J* = 8.1 Hz, 2H), 8.09 (d, *J* = 9.5 Hz, 1H), 7.82 (d, *J* = 8.1 Hz, 2H), 7.66 (s, 1H), 7.33 (dd, *J* = 9.4, 2.7 Hz, 1H), 3.20 (s, 6H).

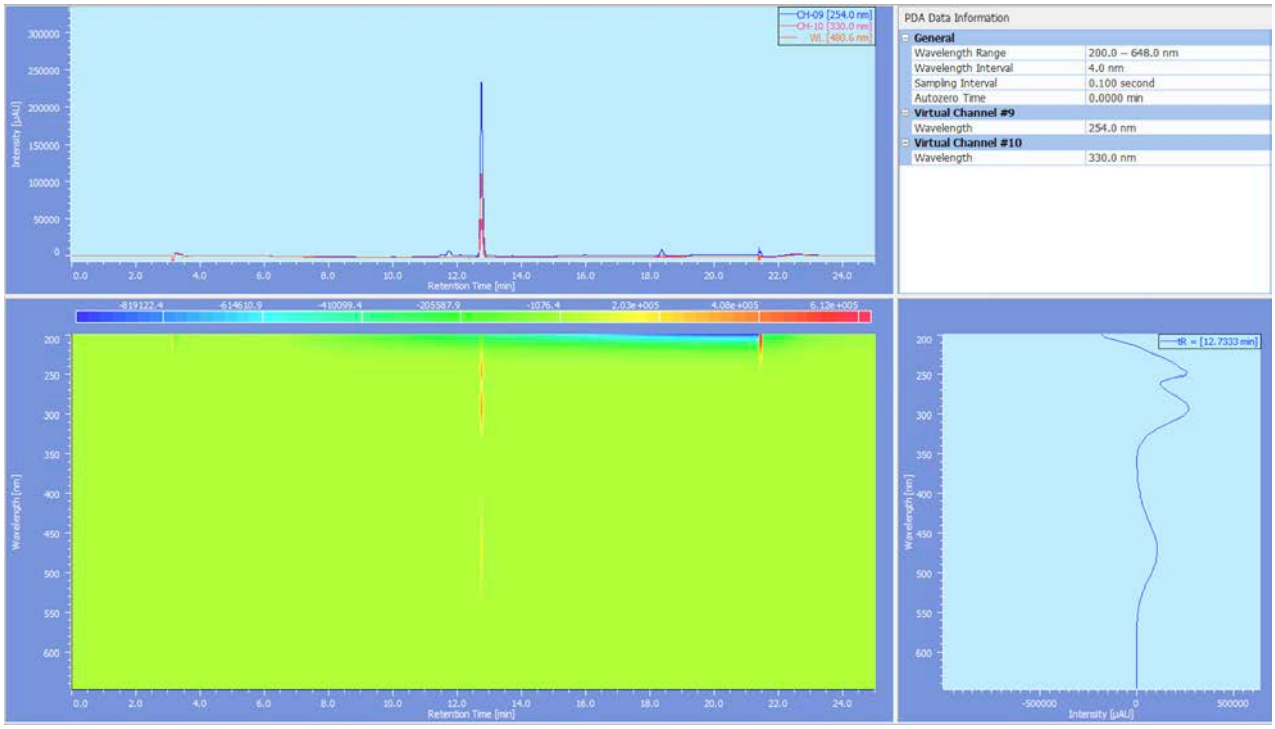
^{13}C NMR (126 MHz, CD_2Cl_2): δ 155.91, 152.49, 151.39, 143.16, 142.98, 131.10, 128.00, 126.05, 126.02, 125.99, 124.87, 118.04, 117.58, 115.02, 107.19, and 40.57.

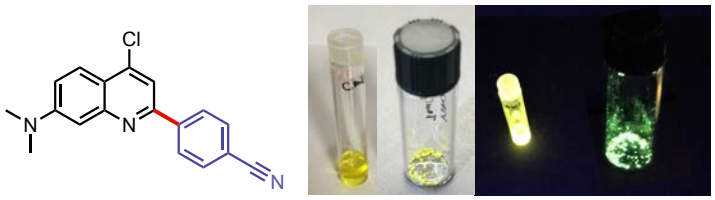
HRMS (ESI-TOF): calc'd for $C_{18}H_{15}ClF_3N_2^+$ $[M+H]^+$ 351.0876; found 351.0867.

IR (neat): 1616.11, 1587.85, 1567.08, 1543.04, 1505.05, 1442.89, 1426.76, 1373.48, 1316.55, 1263.72, 1214.98, 1160.71, 120.27, 1082.47, 1068.77, 1015.16, 835.19, 811.67, 733.19, 677.4 cm^{-1}



Analytical HPLC and UV trace of 4e:





4-(4-chloro-7-(dimethylamino)quinolin-2-yl)benzonitrile (4f) Following the General Procedure A with 4-cyanophenylboronic acid (29 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 5 h afforded 55 mg (99 % isolated yield) of the title compound after purification by column chromatography (1:1 DCM : EtOAc). Using the ISCO standard method, the desired compound eluted at 30-38% EtOAc.

Physical Property: yellow solid, m. p. = 225-230 °C

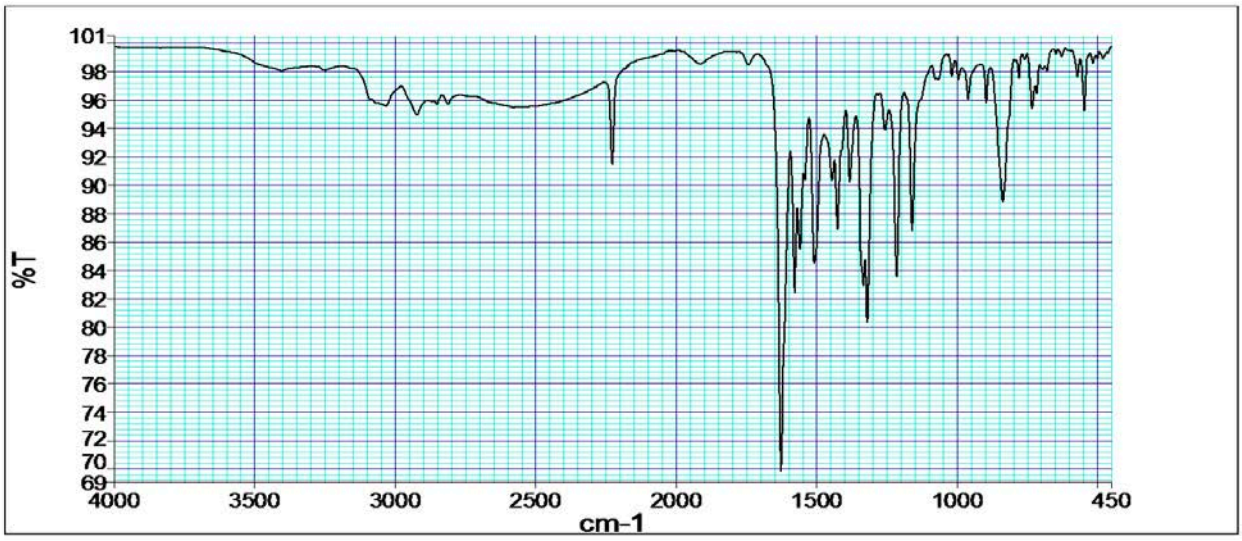
TLC: R*f* = 0.38 (20% EtOAc in Hexanes).

^{1}H NMR (500 MHz, $CDCl_3$): δ 8.24 – 8.16 (m, 2H), 8.04 (d, *J* = 9.3 Hz, 1H), 7.81 – 7.74 (m, 2H), 7.61 (s, 1H), 7.24 (dd, *J* = 9.3, 2.6 Hz, 1H), 7.18 (d, *J* = 2.5 Hz, 1H), 3.15 (s, 6H).

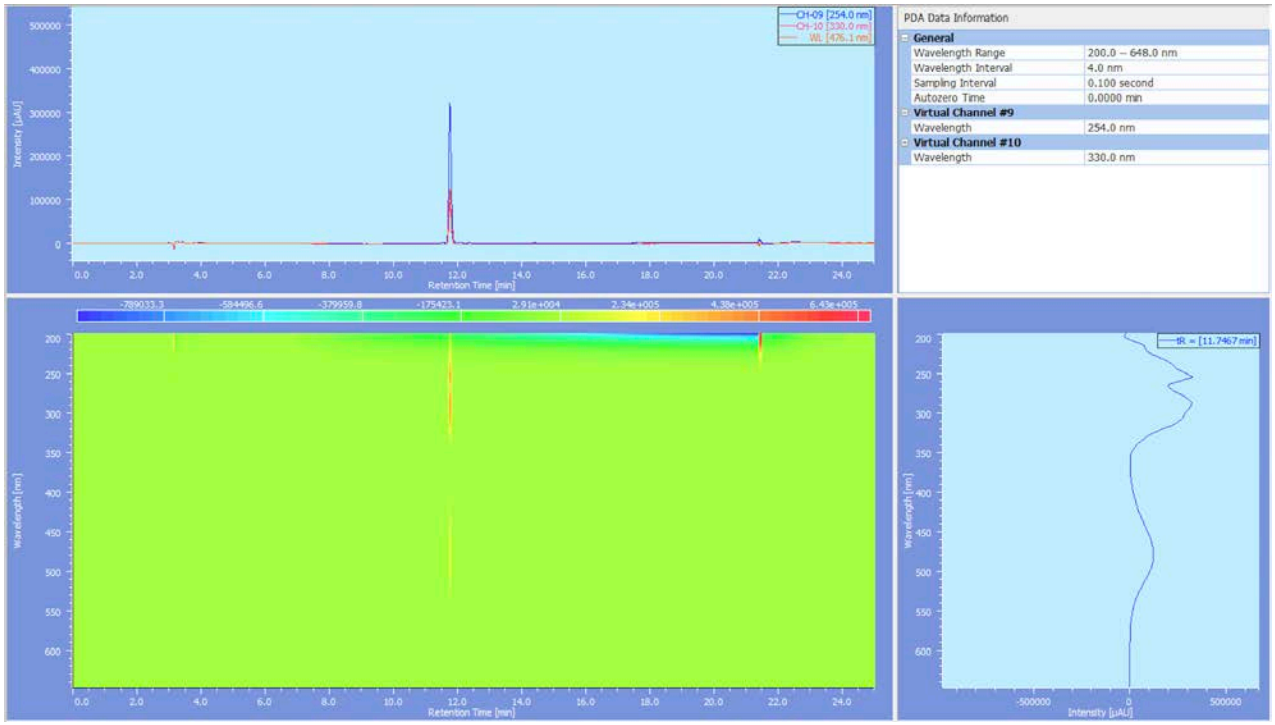
^{13}C NMR (126 MHz, $CDCl_3$): δ 155.38, 152.16, 151.10, 143.52, 143.24, 132.66, 128.06, 124.83, 118.93, 118.02, 117.50, 114.93, 112.88, 107.04, 40.50.

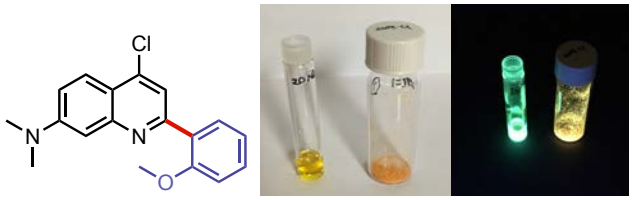
HRMS (ESI-TOF): calc'd for $C_{18}H_{15}ClN_3^+$ $[M+H]^+$ 308.0955 found 308.0954.

IR (neat): 3035.08, 2924.56, 2228.48, 1626.96, 1578.11, 1559.22, 1508.5, 1444.88, 1425.84, 1381.99, 1333.5, 1319.39, 1256.73, 1214.19, 1159.71, 960.16, 895.49, 836.37, 732.04, 545.79 cm^{-1}



Analytical HPLC and UV trace of 4f:





4-chloro-2-(2-methoxyphenyl)-*N,N*-dimethylquinolin-7-amine (4g): Following the General Procedure A with 2-methoxyphenylboronic acid (30.1 mg, 0.198 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 48 h afforded 52 mg (92 % isolated yield) of the title compound after purification by column chromatography (6:1 hexanes:EtOAc). Using the standard ISCO method, the desired compound eluted at 18-22% EtOAc.

Physical Property: orange solid, bright yellow solid state fluorescence, m. p. = 136-140 °C

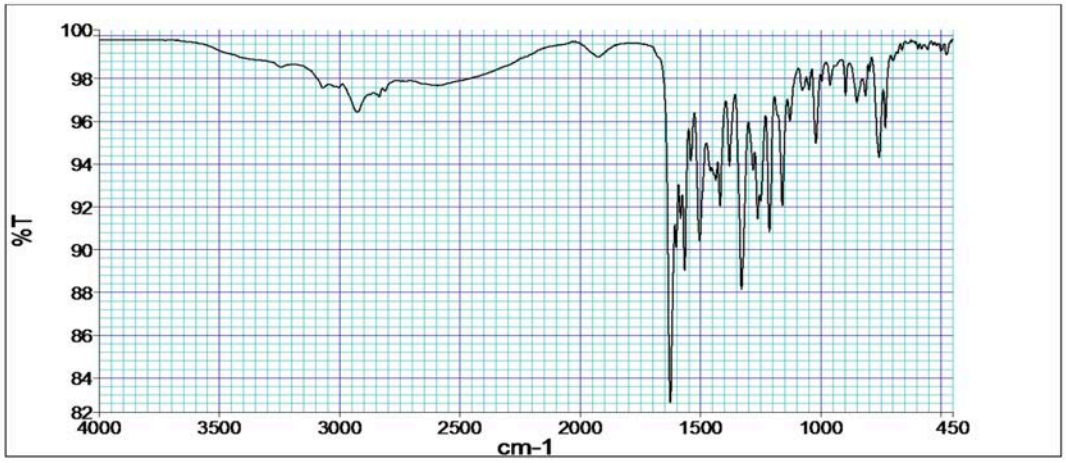
TLC: R*f* = 0.26 (20% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.05 (d, *J* = 9.3 Hz, 1H), 7.84 (dd, *J* = 7.6, 1.8 Hz, 1H), 7.72 (s, 1H), 7.45 – 7.40 (m, 1H), 7.27 (dd, *J* = 9.2, 2.6 Hz, 1H), 7.20 (d, *J* = 2.7 Hz, 1H), 7.12 – 7.05 (m, 2H), 3.90 (s, 3H), 3.14 (s, 6H).

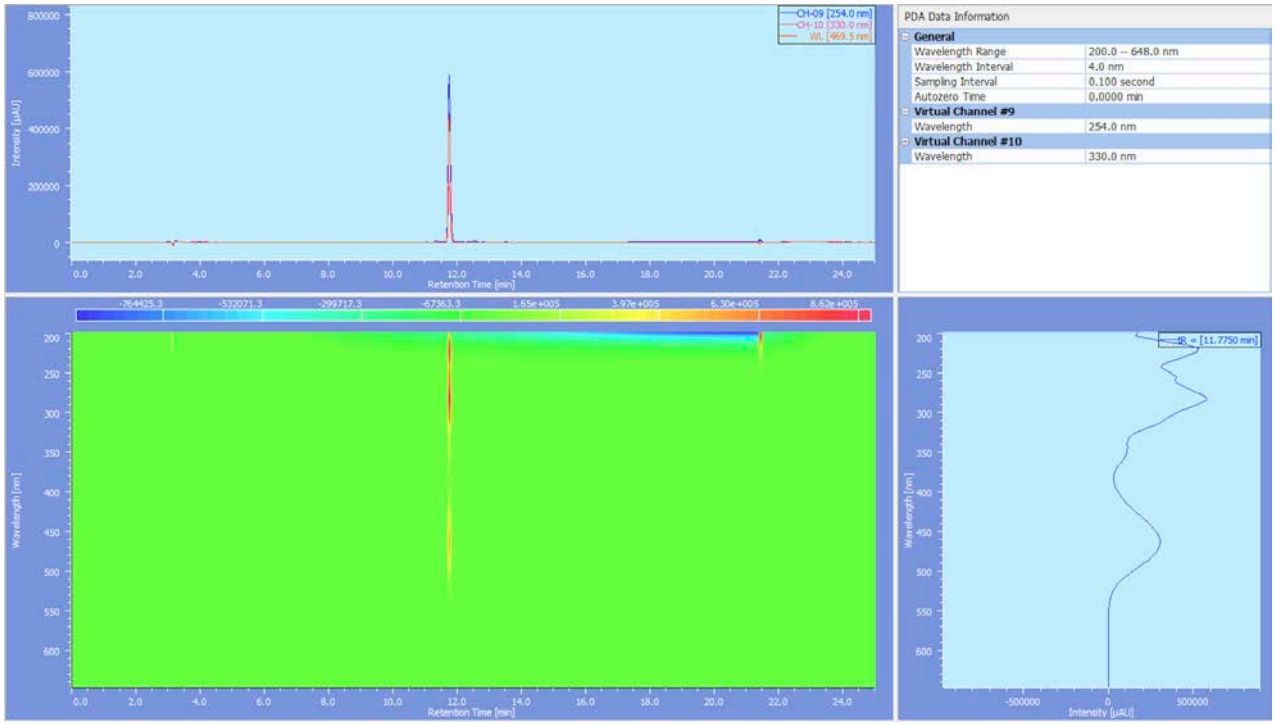
^{13}C NMR (126 MHz, CD_2Cl_2): δ 157.72, 157.20, 152.12, 151.24, 141.18, 131.63, 130.76, 129.40, 124.69, 121.21, 119.60, 117.56, 116.98, 111.87, 107.42, 56.01, 40.63.

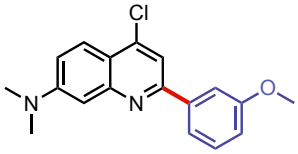
HRMS (ESI-TOF): calc'd for $C_{18}H_{18}ClN_2O^+$ $[M+H]^+$ 312.1108; found 313.1129.

IR (neat): 2924.16, 2853.79, 1624.92, 1601.61, 1566.72 ,1541.9, 1503.3, 1463.66, 1416.88, 1380.43, 1321.25, 1290.55, 1264.42, 1240.85, 1210.53, 1156.86, 1036.02, 818.61, 787.81, 723.88 cm^{-1}

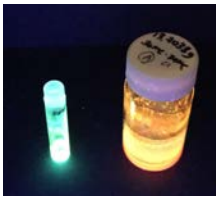


Analytical HPLC and UV trace of 4f:









4-chloro-2-(3-methoxyphenyl)-*N,N*-dimethylquinolin-7-amine (4h): Following the General Procedure A 3-methoxyphenylboronic acid (30 mg, 0.20 mmol, 1.1 equiv) purchased from Aldrich) at 65 °C for 48 h afforded 47mg (83 % isolated yield) of the title compound after purification by column chromatography (12:1 hexanes:EtOAc).

Physical Property: red film, orange-yellowish fluorescence film

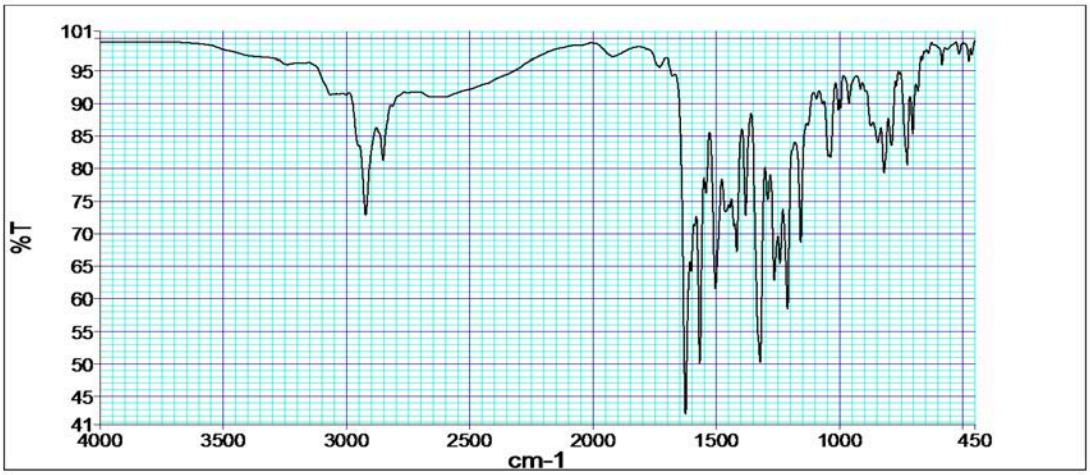
TLC: R*f* = 0.39 (20% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.02 (d, *J* = 9.3 Hz, 1H), 7.77 (dd, *J* = 2.6, 1.7 Hz, 1H), 7.67 (ddd, *J* = 7.6, 1.7, 0.9 Hz, 1H), 7.63 (s, 1H), 7.45 – 7.39 (m, 2H), 7.24 (dd, *J* = 9.3, 2.6 Hz, 1H), 7.03 (ddd, *J* = 8.2, 2.6, 0.9 Hz, 1H), 3.94 (s, 3H), 3.15 (s, 6H).

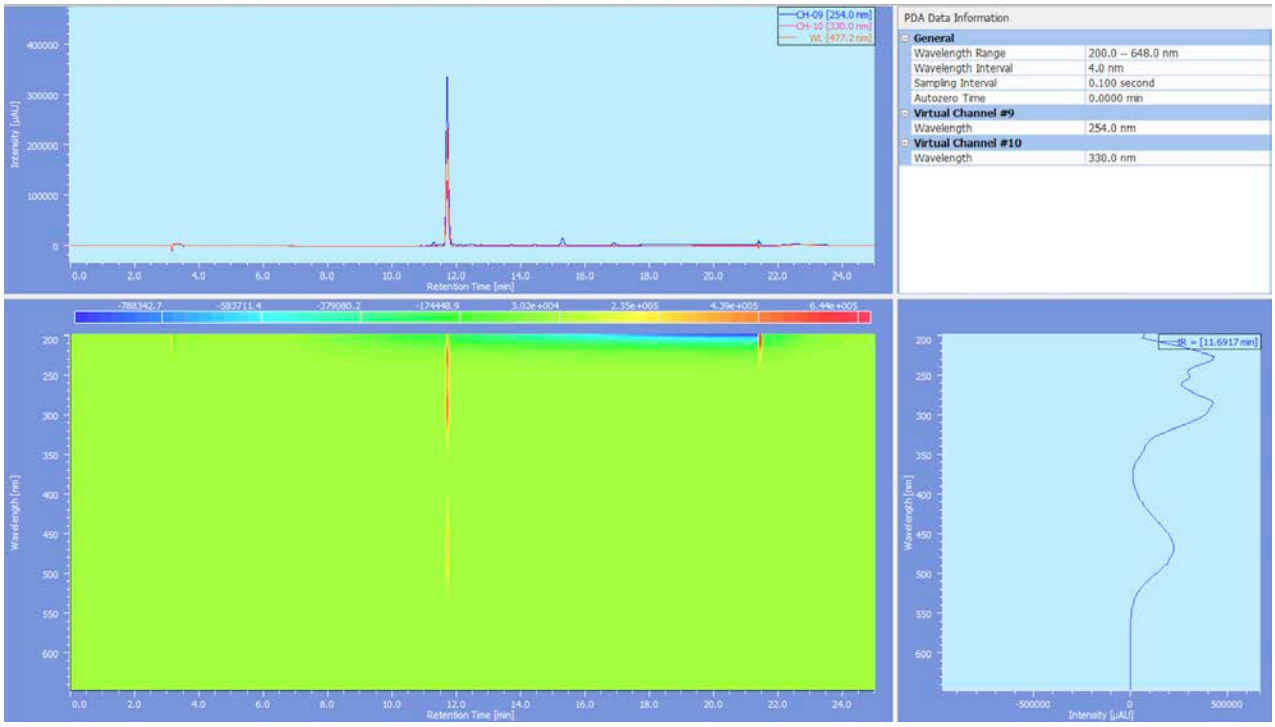
^{13}C NMR (126 MHz, CD_2Cl_2): δ 160.50, 156.52, 152.67, 149.82, 144.00, 139.35, 130.12, 124.96, 120.22, 117.91, 117.33, 116.37, 115.11, 113.02, 108.41, 105.60, 101.86, 55.86, and 40.55.

HRMS (ESI-TOF): calc'd for $C_{18}H_{18}ClN_2O^+$ $[M+H]^+$ 313.1108; found 313.1094.

IR (neat): 2929.2, 1626.04, 1600.41, 1583.21, 1566.04, 1540.05, 1503.19, 1418.79, 1379.86, 1329.61, 1262.03, 1213.36, 1159.04, 1127.57, 1076.3, 1019.51, 895.83, 848.88, 755.93, 729.99 cm^{-1}



Analytical HPLC and UV trace of 4h:



4-chloro-2-(4-methoxyphenyl)-*N,N*-dimethylquinolin-7-amine (4i): Following the General Procedure A with 4-methoxyphenylboronic acid (30 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 15 h afforded 53 mg (94 % isolated yield) of the title compound after purification by column chromatography (10:1 hexanes:EtOAc).

Physical Property: orange solid, orange fluorescence, m. p. = 112-115 °C

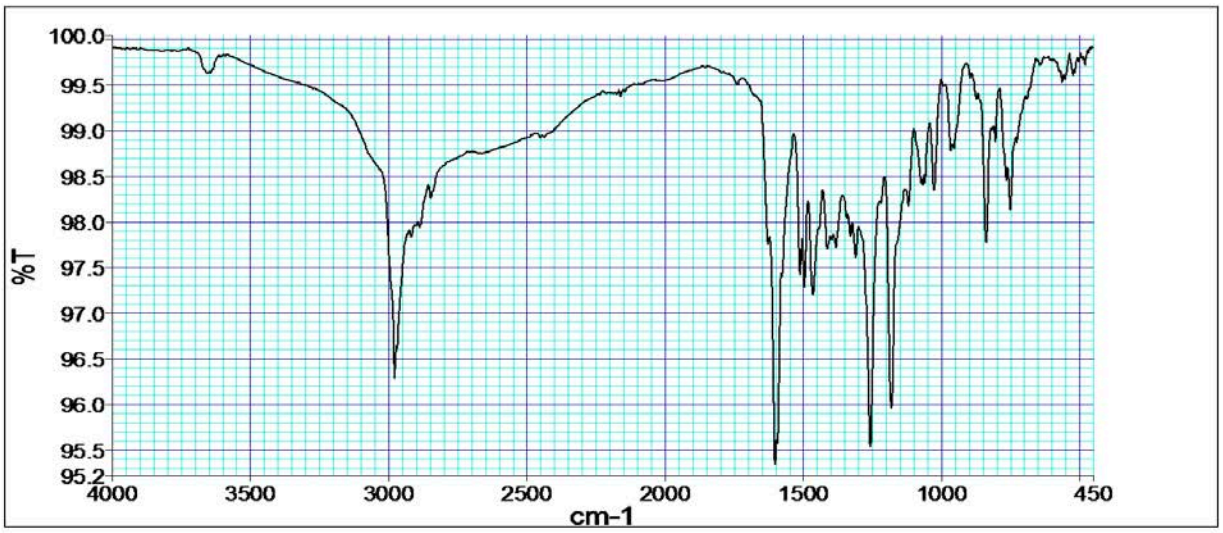
TLC: R*f* = 0.34 (20% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.11 (dd, *J* = 9.4, 2.6 Hz, 2H), 8.02 (d, *J* = 9.2 Hz, 1H), 7.64 (s, 1H), 7.22 (dd, *J* = 9.3, 2.6 Hz, 1H), 7.17 (d, *J* = 2.6 Hz, 1H), 7.07 – 7.01 (m, 2H), 3.89 (s, 3H), 3.15 (s, 6H).

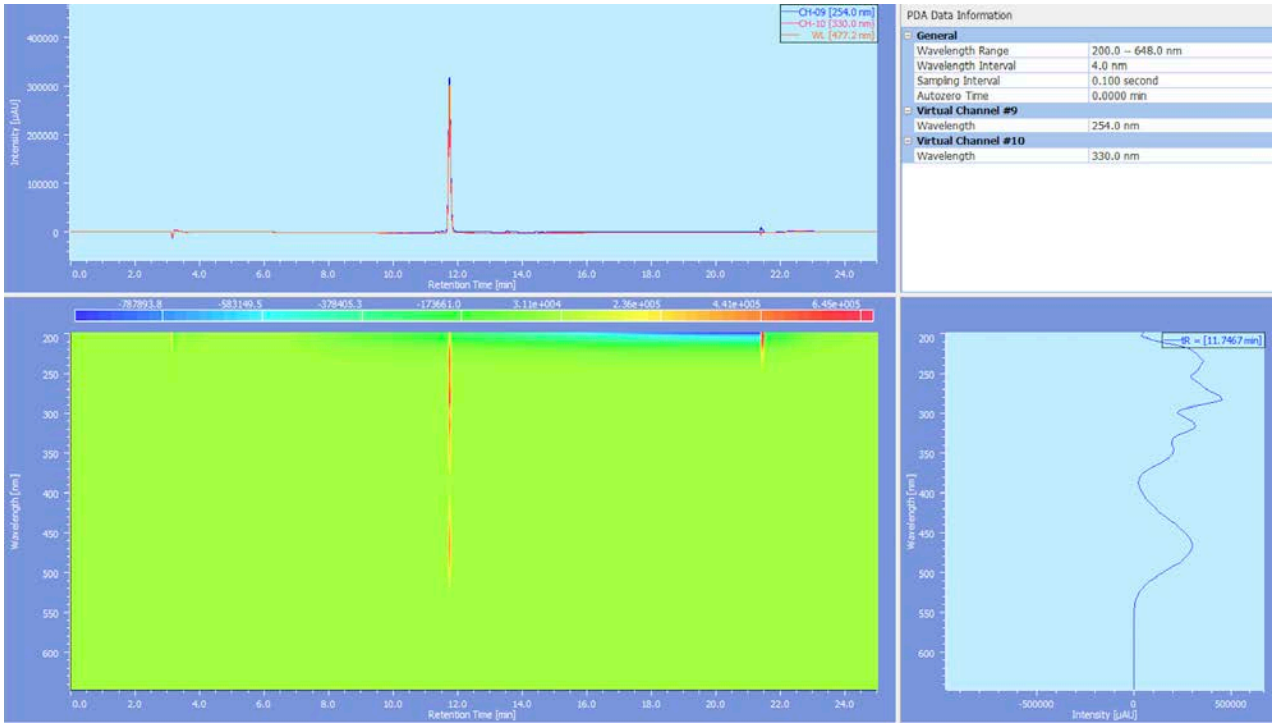
^{13}C NMR (126 MHz, CD_2Cl_2): δ 161.40, 157.15, 152.35, 151.35, 142.66, 131.95, 128.96, 124.77, 117.45, 116.61, 114.62, 114.44, 107.21, 55.76, and 40.60.

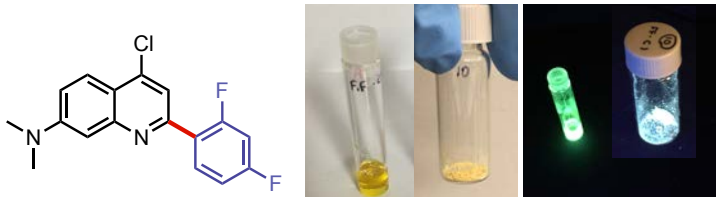
HRMS (ESI-TOF): calc'd for $C_{18}H_{18}ClN_2O^+$ $[M+H]^+$ 313.1108; found 313.1101.

IR (neat): 2932.43, 1607.24, 1586.09, 1573.95, 1505.24, 1452.87, 1427.54, 1403.59, 1370.15, 1306.73, 1282.65, 1250.42, 1212.87, 1173.31, 1150.83, 1030.84, 961.64, 831.47, 810.17, 678.88 cm^{-1}



Analytical HPLC and UV trace of 4i:





4-chloro-2-(2,4-difluorophenyl)-*N,N*-dimethylquinolin-7-amine (4j): Following the General Procedure A with 2,4-difluorophenylboronic acid (31 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 12 h afforded 50 mg (87 % isolated yield) of the title compound after purification by the standard ISCO purification method. The desired product eluted at 16-20% EtOAc.

Physical Property: yellow solid, m. p. = 168-172 °C

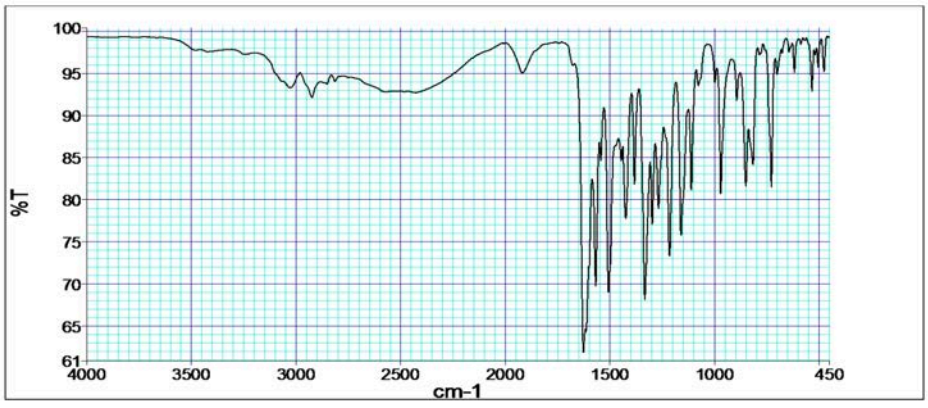
TLC: R*f* = 0.5 (20% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.16 (td, *J* = 8.8, 6.6 Hz, 1H), 8.08 – 8.02 (m, 1H), 7.62 (d, *J* = 2.3 Hz, 1H), 7.33 – 7.25 (m, 2H), 7.08 (dddd, *J* = 8.8, 7.9, 2.6, 1.0 Hz, 1H), 6.99 (ddd, *J* = 11.3, 8.9, 2.5 Hz, 1H), 3.16 (s, 6H).

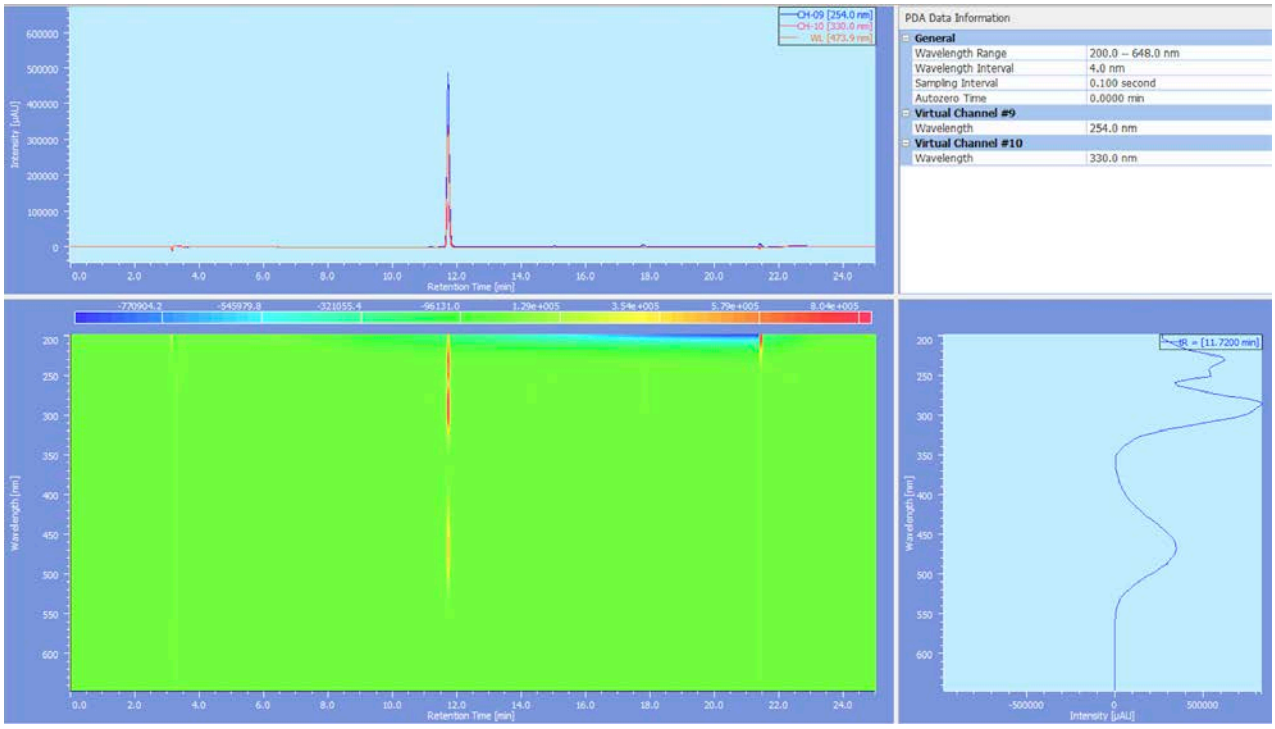
^{13}C NMR (126 MHz, CD_2Cl_2): δ 165.15-163.05 (dd, $^{1}J_{CF}$ = 11.7, 253.7 Hz, 1C), 162.30-160.19 (dd, $^{5}J_{CF}$ = 12.1, 251.3 Hz, 1C), 152.57, 152.45, 150.25, 143.27, 133.19-133.07 (dd, $^{2}J_{CF}$ = 4.3, 9.7 Hz, 1C), 124.95, 118.04-117.87 (t, $^{3}J_{CF}$ = 10.4 Hz, 1C), 117.69, 112.42-112.22 (dd, $^{4}J_{CF}$ = 3.5, 21.3 Hz, 1C), 105.86, 104.99-104.57 (t, $^{6}J_{CF}$ = 26.4 Hz, 1C), and 40.56.

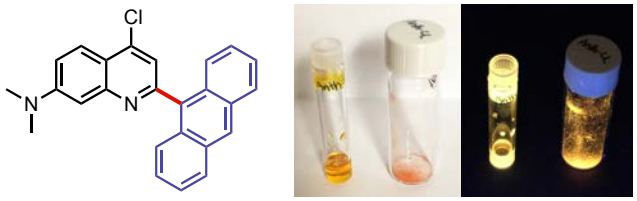
HRMS (ESI-TOF): calc'd for $C_{17}H_{14}ClF_2N_2^+$ $[M+H]^+$ 319.0814; found 319.0823.

IR (neat): 2925.79, 2428.79, 1626.26, 1567.77, 1542.89, 1506.89, 1445.47, 1423.95, 1382.07, 1332.82, 1296.95, 1267.03, 1214.5, 1159.09, 1109.9, 968.97, 892.25, 849.06, 815.15, 726.48 cm^{-1}



Analytical HPLC and UV trace of 4j:





2-(anthracen-9-yl)-4-chloro-*N*,*N*-dimethylquinolin-7-amine (4k): Following the General Procedure A with 4-(dimethylamino)phenylboronic acid (44 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 48 h afforded 14 mg (20 % isolated yield) of the title compound after purification by column chromatography (16:1 hexanes:EtOAc).

Physical Property: dark orange solid, m. p. = 225-228 °C

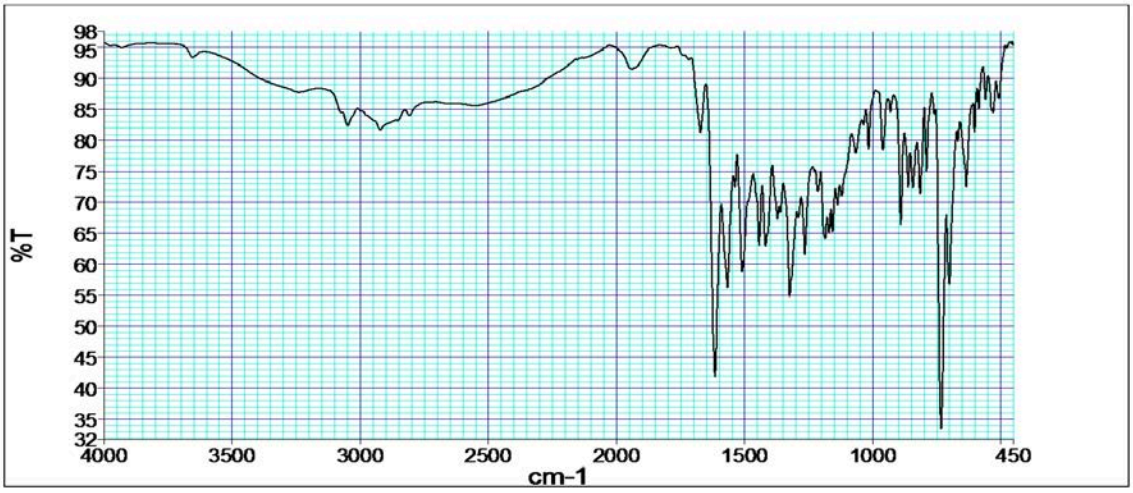
TLC: R*f* = 0.34 (20% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.60 (s, 1H), 8.22 (d, *J* = 9.3 Hz, 1H), 8.11 (d, *J* = 8.5 Hz, 2H), 7.69 – 7.60 (m, 2H), 7.50 (dd, *J* = 8.2, 6.8 Hz, 2H), 7.42 – 7.37 (m, 4H), 7.24 (d, *J* = 2.5 Hz, 1H), 3.16 (d, *J* = 0.9 Hz, 6H).

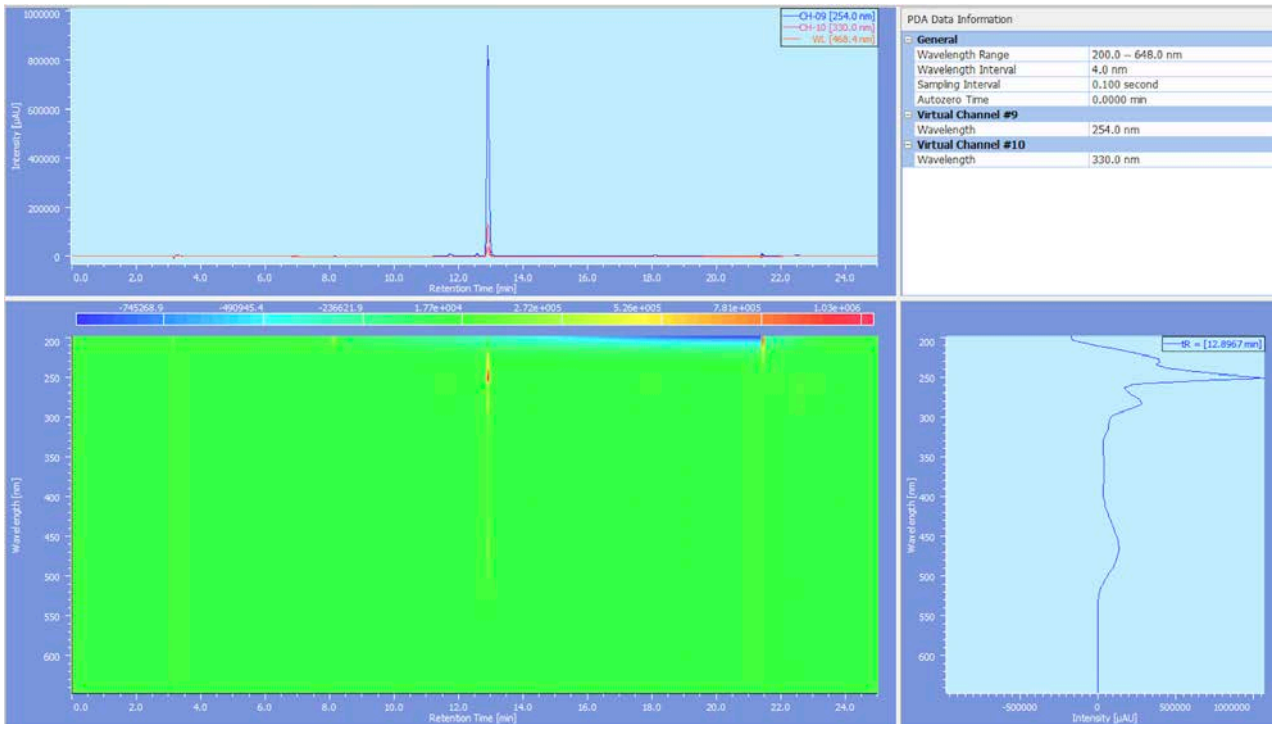
^{13}C NMR (126 MHz, CD_2Cl_2): δ 159.06, 152.49, 151.60, 142.41, 135.48, 131.79, 130.21, 128.85, 127.94, 126.38, 126.34, 125.64, 125.00, 120.68, 117.73, 117.53, 107.39, 40.60.

HRMS (ESI-TOF): calc'd for $C_{25}H_{20}ClN_2^+$ $[M+H]^+$ 383.1315; found 383.1332.

IR (neat) :1615.06, 1567.15, 1509.93, 1442.78, 1418.13, 1371.86, 1359.41, 1323.58, 1289.47, 1264.03, 1214.32, 1184.65, 1170, 1155.69, 1136.64, 1119.75, 888.99, 813.62, 731.66, 699.56 cm^{-1}



Analytical HPLC and UV trace of 4k:



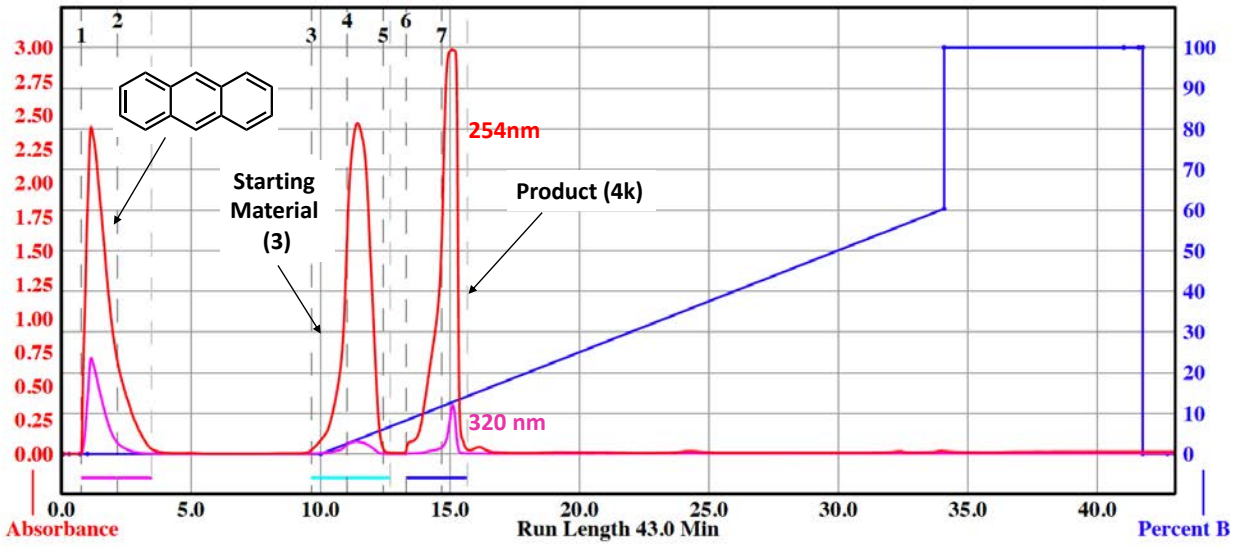
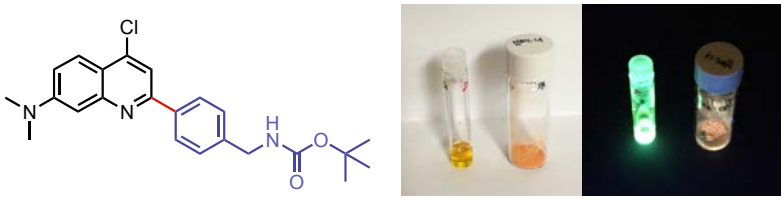


Figure S8. Crude run on ISCO is shown to show presence of decomposed deborylated anthracene boronic acid, starting material (**3**), and the desired product (**4k**) from left to right.



***tert*-butyl (4-(4-chloro-7-(dimethylamino)quinolin-2-yl)benzyl)carbamate (4l):** Following the General Procedure A with 4-(Boc-aminomethyl)benzeneboronic acid (50 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 48 h afforded 62 mg (84 % isolated yield) of the title compound after purification by column chromatography (4:1 hexanes:EtOAc).

Physical Property: orange solid, orange solid state fluorescence m. p. = 148-151 °C

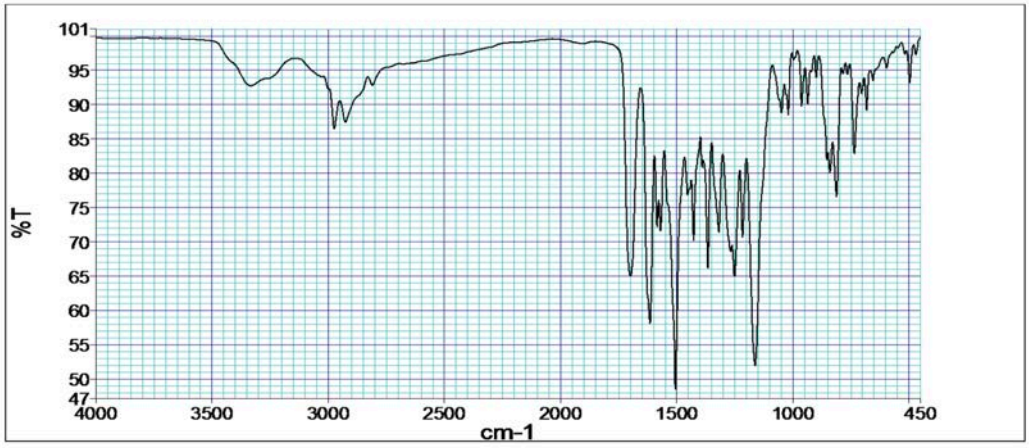
TLC: R*f* = 0.16 (20% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.13 – 8.09 (m, 2H), 8.03 (d, *J* = 9.2 Hz, 1H), 7.67 (s, 1H), 7.46 – 7.40 (m, 2H), 7.24 (dd, *J* = 9.2, 2.6 Hz, 1H), 7.19 (d, *J* = 2.7 Hz, 1H), 5.08 (s, 1H), 4.38 (d, *J* = 6.1 Hz, 2H), 3.15 (s, 6H), 1.48 (s, 9H).

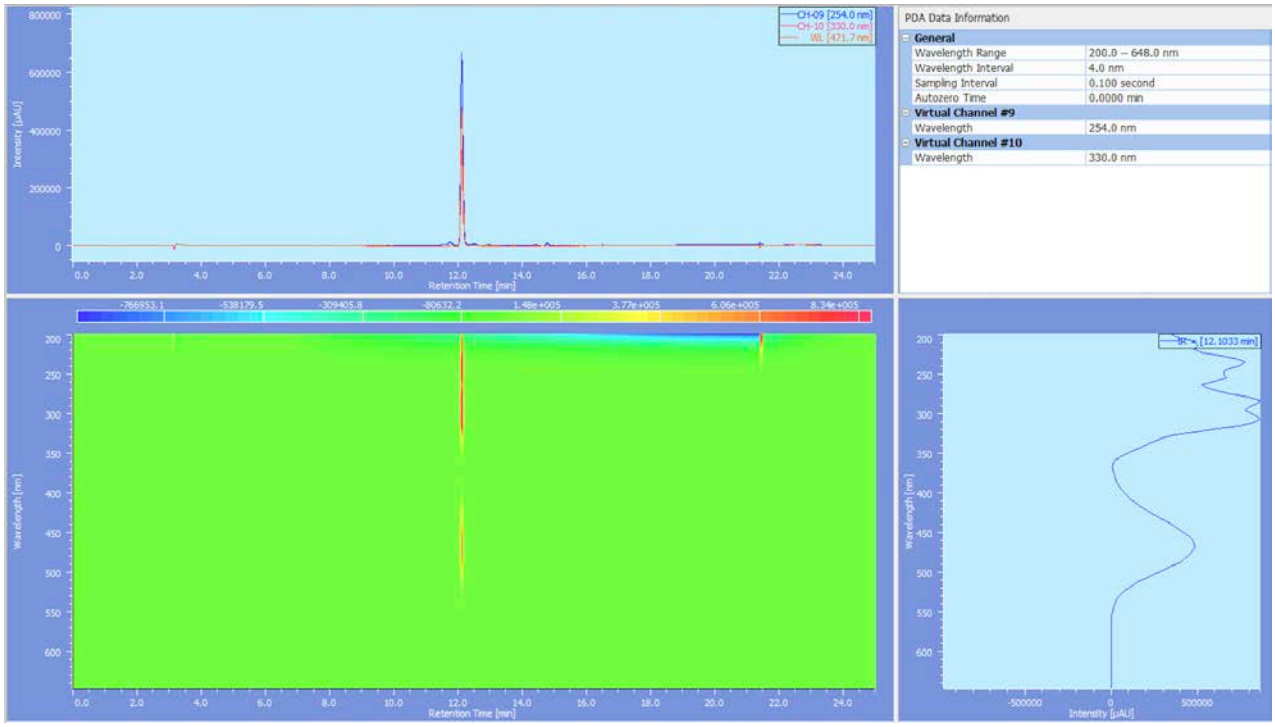
^{13}C NMR (126 MHz, CD_2Cl_2): δ 157.16, 156.27, 152.38, 151.32, 142.84, 141.28, 138.35, 128.10, 127.95, 127.79, 124.80, 117.75, 117.01, 114.99, 107.22, 79.64, 44.65, 40.60, 28.55.

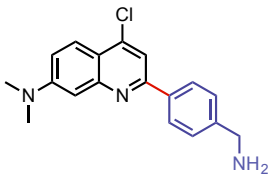
HRMS (ESI-TOF): calc'd for $C_{23}H_{27}ClN_3O_2^+$ $[M+H]^+$ 412.1792; found 412.1778.

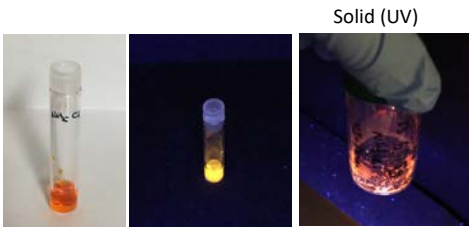
IR (neat): 2976.3, 2928.4, 1698.5, 1614.81, 1584.24, 1569.14, 1505.04, 1452.08, 1426.87, 1389.77, 1365.22, 1317.72, 1266.45, 1250.17, 1215.65, 1160.86, 851.94, 838.85, 810.51, 733.75 cm^{-1}



Analytical HPLC and UV trace of 4l:







2-(4-(aminomethyl)phenyl)-4-chloro-*N*,*N*-dimethylquinolin-7-amine (4l'): To 20 mL scintillation vial, **4l** (7.0 mg, 0.017 mmol) was added and stirred in anhydrous dichloromethane (0.84 mL) at 0°C for 10 min. Anhydrous $AlCl_3$ (11 mg, 5.0 equiv) was slowly added and the reaction was stirred at room temperature overnight. Dichloromethane in crude reaction was removed *in vacuo* and dissolved in 80:20 MeCN: H_2O. After filtering out insoluble residues, the crude reaction was purified via Agilent HPLC (10-40% MeCN in H_2O over 30 min) and fractions eluting at 22.5-23.5% MeCN were lyophilized to give 7.1 mg (99% isolated yield) of the title compound in trifluoroacetic acid salt form (product mass calculated as 425.83g/mol).

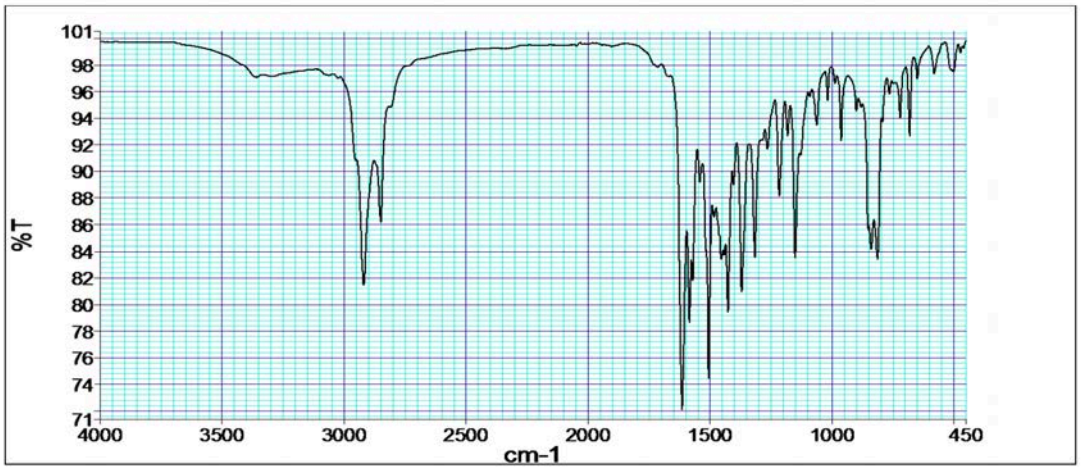
Physical Property: red solid, m. p. = 275-278 °C

^{1}H NMR (500 MHz, D_2O): δ 8.14 (d, J = 9.6 Hz, 1H), 8.05 – 7.97 (m, 2H), 7.81 – 7.71 (m, 3H), 7.46 (dd, J = 9.7, 2.5 Hz, 1H), 6.88 (d, J = 2.4 Hz, 1H), 4.37 (s, 2H), 3.20 (s, 6H).

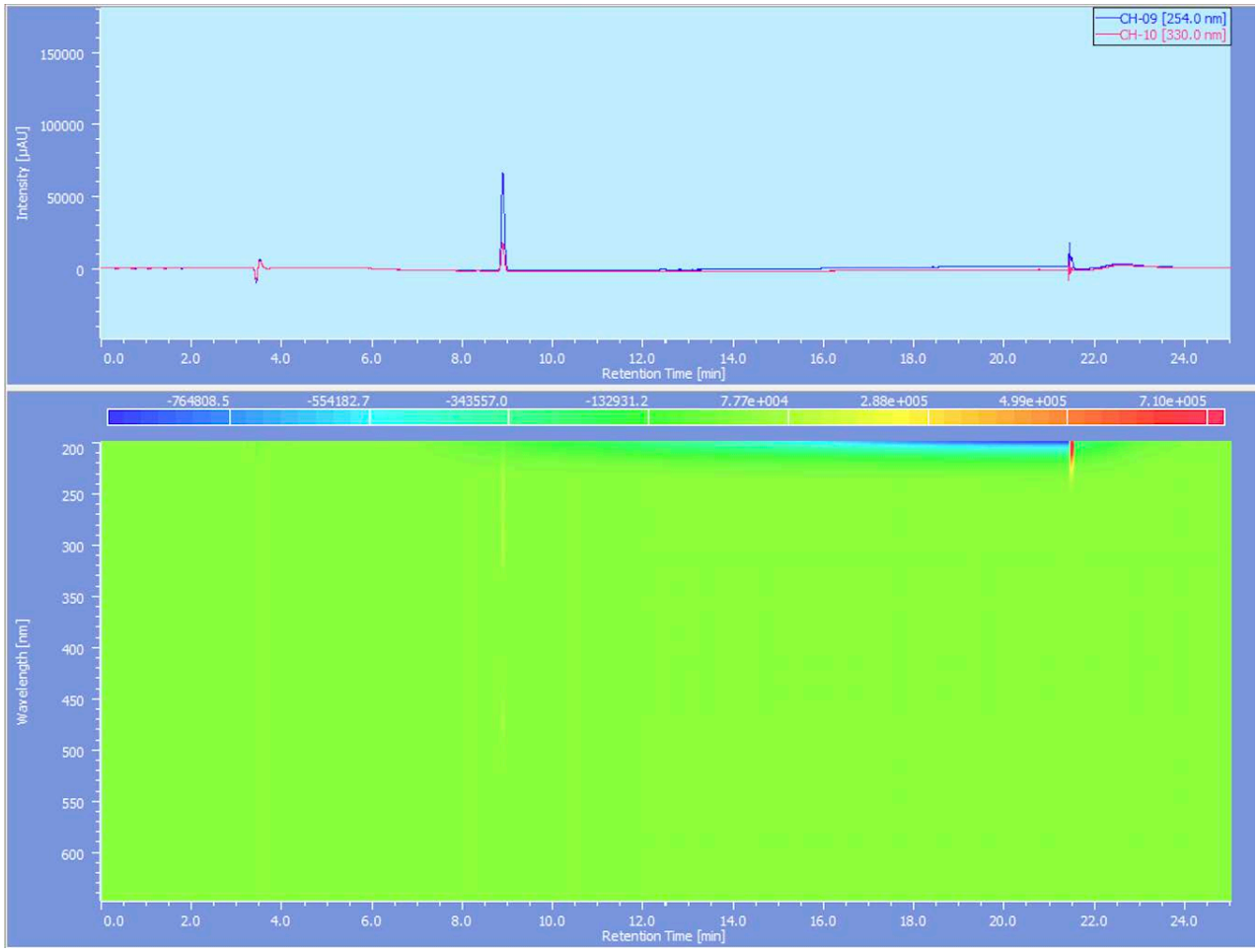
^{13}C NMR (126 MHz, D_2O): δ 155.31, 152.95, 150.76, 143.76, 138.03, 133.39, 131.13, 130.04, 127.17, 121.16, 120.17, 119.26, 118.84, 116.12, 114.20, 43.85, 40.78.

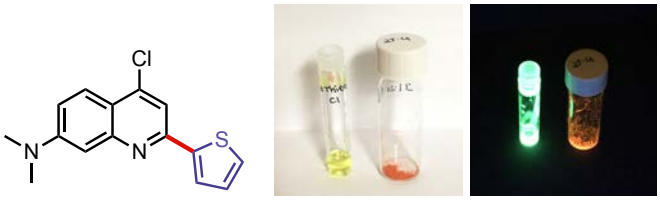
HRMS (ESI-TOF): calc'd for $C_{18}H_{19}ClN_3^+$ $[M+H]^+$ 312.1268; found 312.1281.

IR (neat): 2921.36, 2851.33, 1614.73, 1584.28, 1570.3, 1541.65, 1505.22, 1453.78, 1426.19, 1402.8, 1369.93, 1315.92, 1263.82, 1215.67, 1181.34, 1150.23, 961.52, 838.31, 811.59, 679.8 cm^{-1}



Analytical HPLC and UV trace of 4l':





4-chloro-*N*,*N*-dimethyl-2-(thiophen-2-yl)quinolin-7-amine (4m): Following the General Procedure A with 2-thienylboronic acid (25 mg, 0.20 mmol, 1.1 equiv) purchased from Aldrich) at 65 °C for 5 h afforded 44 mg (85 % isolated yield) of the title compound after purification by column chromatography (3:4 DCM:Hexanes). Using the standard ISCO purification method, the desired product eluted at 18-22% EtOAc.

Physical Property: dark orange solid, orange solid state fluorescence, m. p. = 155-158 °C

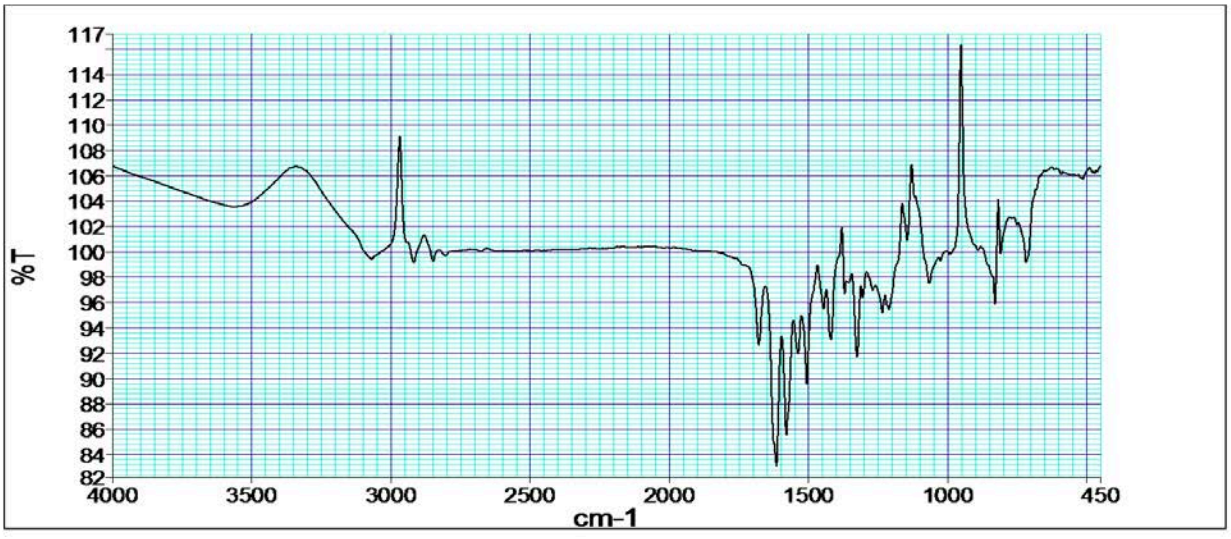
TLC: R*f* = 0.57 (20% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.09 (s, 1H), 8.02 – 7.98 (m, 1H), 7.83 (dd, *J* = 5.1, 1.3 Hz, 1H), 7.57 (d, *J* = 1.4 Hz, 1H), 7.46 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.21 (dd, *J* = 9.2, 1.9 Hz, 2H), 3.14 (s, 6H).

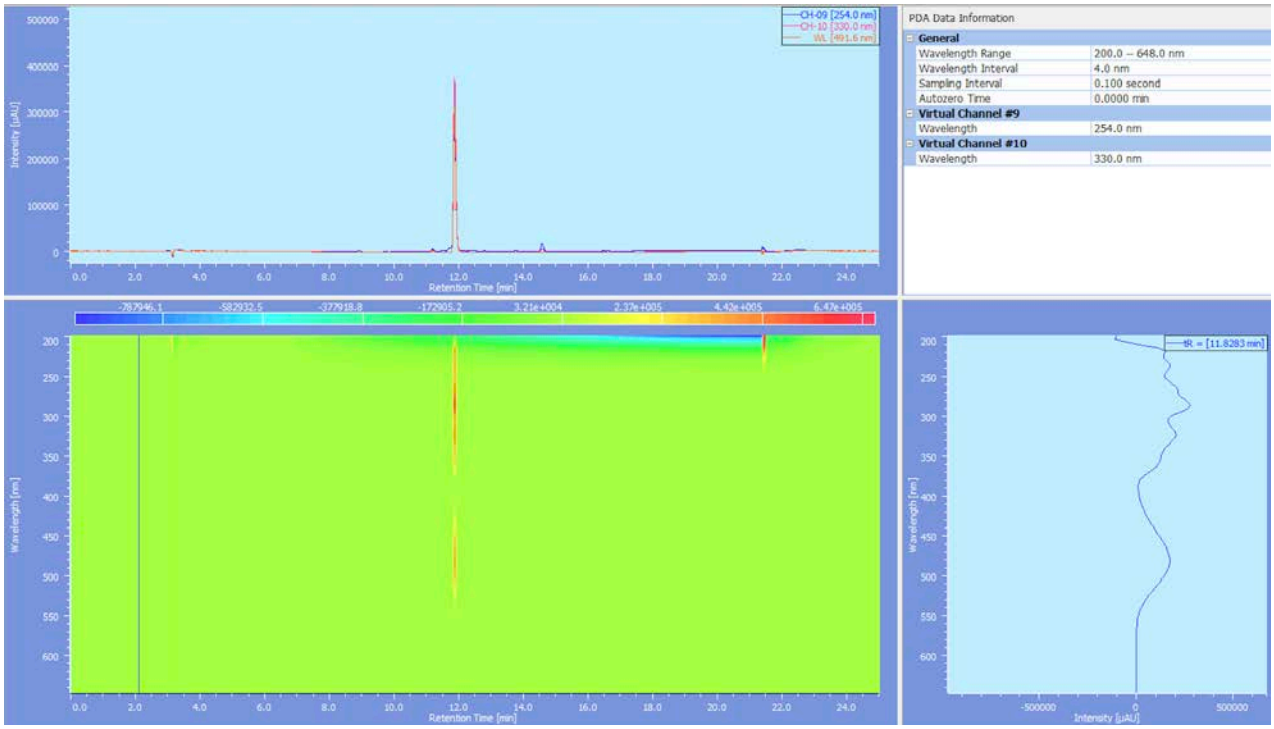
^{13}C NMR (126 MHz, CD_2Cl_2): δ 153.25, 152.44, 150.86, 142.99, 142.05, 127.01, 126.76, 125.34, 124.85, 117.63, 116.79, 115.09, 106.54, and 40.56.

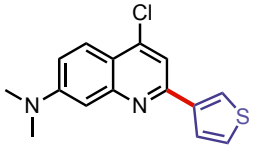
HRMS (ESI-TOF): calc'd for $C_{15}H_{14}ClN_2S^+$ $[M+H]^+$ 289.0566; found 289.0562.

IR (neat): 3567.18, 3072.69, 2919.65, 2850.28, 1678.59, 1615.14, 1579.27, 1536.71, 1506.27, 1445.42, 1418.28, 1369.81, 1325.43, 1233.96, 1210.01, 1144.52, 1065.12, 828.42, 808.46, 717.09 cm^{-1}



Analytical HPLC and UV trace of 4m:





4-chloro-*N*,*N*-dimethyl-2-(thiophen-3-yl)quinolin-7-amine (4n): Following the General Procedure A with 3-thienylboronic acid (25 mg, 0.20 mmol, 1.1 equiv, purchased from Aldrich) at 65 °C for 12 h afforded 50 mg (97 % isolated yield) of the title compound after purification by column chromatography (4:6 DCM:Hexane). Using the standard ISCO purification, the desired product eluted at 18-22% EtOAc.

Physical Property: orange solid, m. p. = 132-135 °C

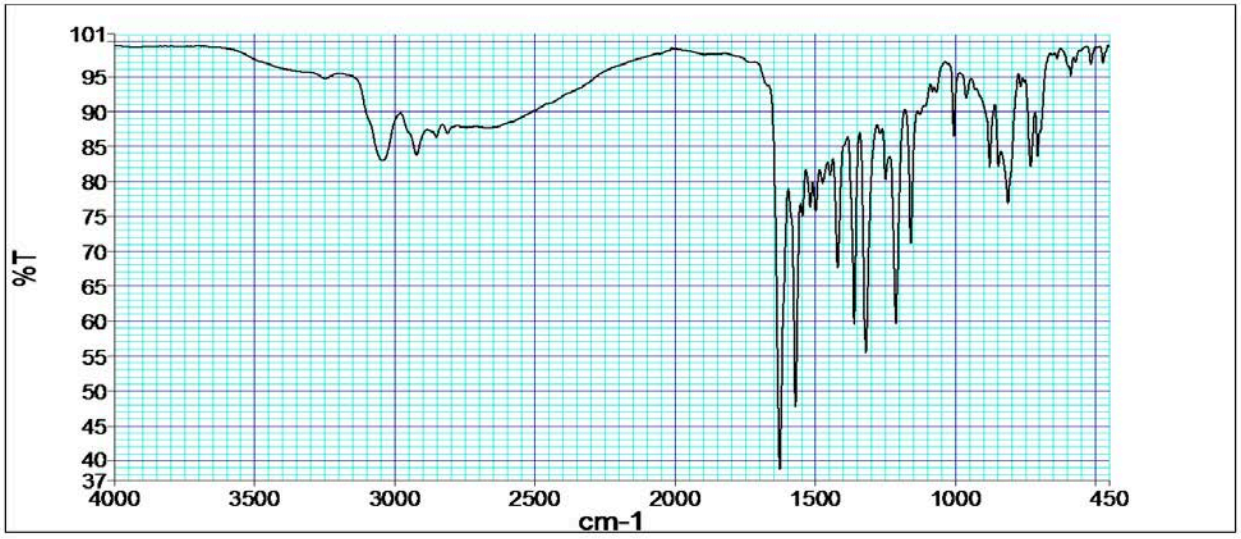
TLC: R*f* = 0.47 (20% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 7.98 (d, *J* = 9.2 Hz, 1H), 7.75 (d, *J* = 4.7 Hz, 1H), 7.59 (s, 1H), 7.49 (dd, *J* = 5.0, 1.2 Hz, 1H), 7.20 – 7.16 (m, 2H), 7.14 (d, *J* = 4.2 Hz, 1H), 3.14 (s, 6H).

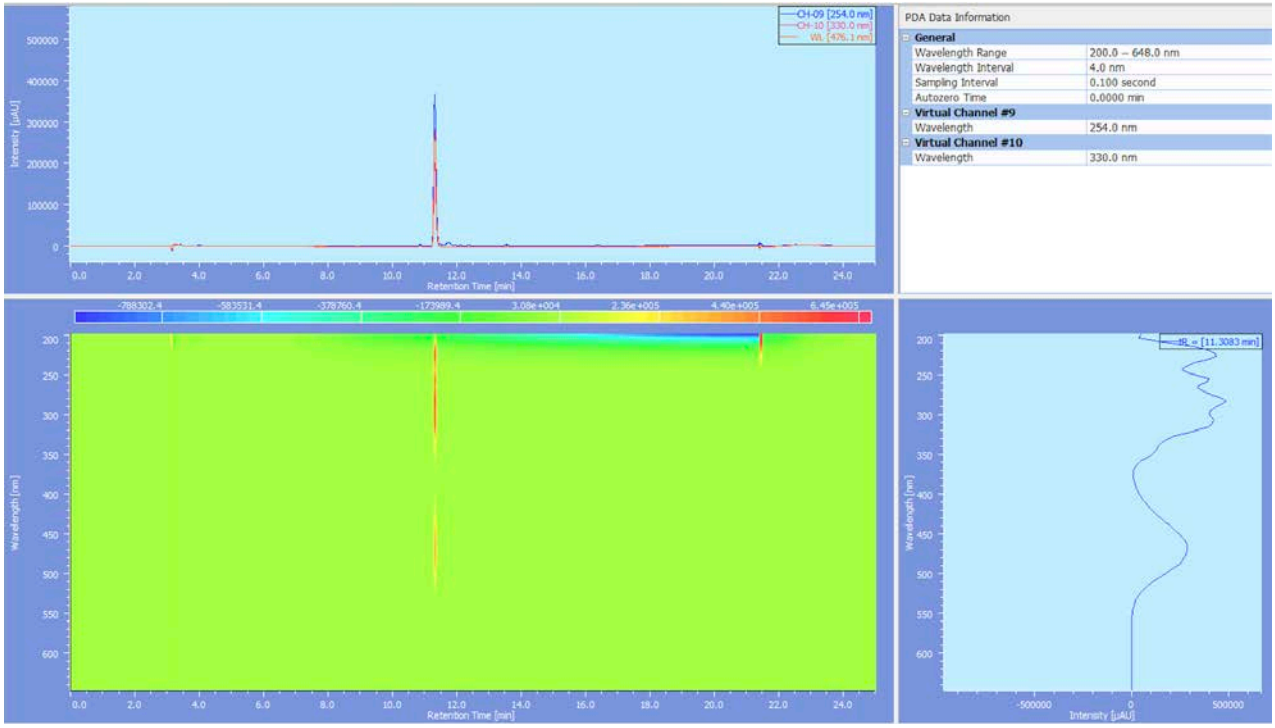
^{13}C NMR (126 MHz, CD_2Cl_2): δ 152.52, 152.38, 150.70, 144.85, 142.96, 129.10, 128.55, 126.51, 124.92, 117.66, 116.68, 113.60, 106.21, and 40.56.

HRMS (ESI-TOF): calc'd for $C_{15}H_{14}ClN_2S^+$ $[M+H]^+$ 289.0566; found 289.0573.

IR (neat): 3048.4, 2924.67, 1626.65, 1570.36, 1545.51, 1517.92, 1498.52, 1473.43, 1446.36, 1419.71, 1360.77, 1319.02, 1248.87, 1211.84, 1158.15, 876.8, 845.72, 811.21, 730.51, 705.59 cm^{-1}



Analytical HPLC and UV trace of 4n:

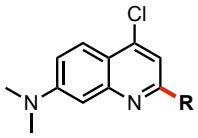


Fluorescence Spectra Analysis of Monoarylated DMAQs (4a-4n) via Plate Reader.

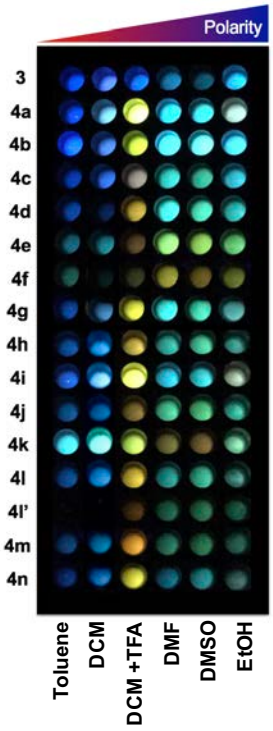
Experiments were set up using two types of 96 well plates with black flat bottoms. Organic solvents (polarity screening) were screened on Greiner Bio-One 96 well non-treated polypropylene microplates, and aqueous solutions (pH screening) were screened on Greiner Bio 96 Well non-treated polystyrene microplates. A 5 mM DMSO stock solution (**4a-4n**) and a 5 mM water stock solution (**4l'**) were placed in a separate plate and dosed to each well using a multichannel pipette. Polarity and pH screenings were done in two different sets. Regardless of their optimal maximum absorption, every compound was excited at 405 nm. Due to possible errors in pipetting and evaporation of solvents, the intensity is only treated as an estimate. For polarity screening, DCM and DCM+TFA columns were run separately to minimize solvent evaporation. DCM was filtered with basic activated alumina and DCM+TFA was made by adding 0.1% TFA v/v to alumina filtered DCM.

Application: **Tecan i-control**
Device**: infinite M1000Pro**
Plate: Greiner 96 Flat Bottom Black Polypropylene or Polystyrene
Target Temperature: 20 °C
Shaking (Linear) Duration: 5s
Shaking (Linear) Amplitude: 2 mm
Shaking (Linear) Frequency: 654 rpm
Mode: **Fluorescence Top Reading**
Emission Wavelength Start: **420 nm**
Emission Wavelength End: **780 nm**
Emission Wavelength Step Size: 1 nm (pH screening) 2 nm (polarity screening)
Excitation Wavelength: **405 nm**
Gain: 80% Manual
Number of Flashes: 50
Flash Frequency: 400 Hz

Maximum emission wavelength of each compound and its relative intensity



(a)



(b) Emission

Compound	R	Toluene (nm)	DCM (nm)	DCM+TFA (nm)	DMF (nm)	DMSO (nm)	EtOH (nm)
3	Cl	448	465	468	476	478	474
4a	Ph-OH	448	456	546	482	486	486
4b	Ph-NMe2	442	453	543	480	482	476
4c	Ph	452	471	478, 598	496	500	494
4d	Ph-F	456	474	567	498	502	496
4e	Ph-CF3	480	495	588	528	534	524
4f	Ph-CN	494	516	600	564	576	552
4g	Ph-2OMe	456	474	558	496	502	498
4h	Ph-3OMe	470	537	636	500	508	498
4i	Ph-4OMe	452	471	552	484	492	492
4j	Ph-2,4FF	472	477	552	508	516	502
4k	9-Anthracene	480	504	546	560	574	510
4l	Ph-CH2-NHBoc	454	471	564	498	502	500
4l'	Ph-CH2-NH2	458	-	573	510	516	510
4m	2Thienyl	470	480	576	506	514	506
4n	3Thienyl	450	474	555	490	498	496

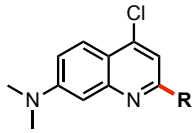
(c) Intensity

Compound	R	Toluene	DCM	DCM+TFA	DMF	DMSO	EtOH
3	Cl	5938	3724	3723	3014	1602	10043
4a	Ph-OH	3711	162	2712	7811	6405	3846
4b	Ph-NMe2	14145	446	2252	10914	8509	5296
4c	Ph	2509	9	160	6463	4757	5829
4d	Ph-F	3193	1283	12	10245	7527	5615
4e	Ph-CF3	2905	11	12	7370	5002	5141
4f	Ph-CN	1518	12	12	2167	924	1312
4g	Ph-2OMe	1478	12	25	8479	5656	3789
4h	Ph-3OMe	2215	550	529	3792	4912	4161
4i	Ph-4OMe	2928	1384	1413	5080	5219	3408
4j	Ph-2,4FF	2580	207	59	5590	5753	6349
4k	9-Anthracene	7002	9	335	857	867	4355
4l	Ph-CH2-NHBoc	2321	12	12	4028	5128	3621
4l'	Ph-CH2-NH2	18	11	11	2016	2659	2351
4m	2Thienyl	1262	12	12	1439	1363	1209
4n	3Thienyl	1671	12	12	3155	4450	2120

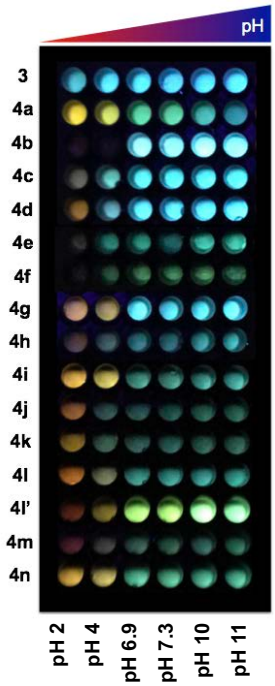
Intensity color code:

>12500	12500-10000	10000-5000	5000-2500	2500-1000	1000-500	500-100	100-0

Figure S9. Maximum λ_{em} of **4a-4n** and **3** in organic solvents of different polarity. (a) platereader image under handheld UV lamp (365 nm), (b) maximum emission wavelength (λ_{em}) under excitation at 405 nm, and (c) relative intensity. Darker red represents higher fluorescence intensity while darker blue represents lower intensity. Stock solution of **4l'** is in water, fluorescence emission measurements in toluene, DCM, and DCM+TFA showed minimal to no fluorescence due to immiscibility. Compound **4l'** stayed in the water droplet even after vigorous mixing. Compound **4c** gave two emission peaks in DCM+TFA (0.1% TFA in DCM), possibly due to mixture of protonated and unprotonated compounds.



(a)



(b) Emission

Compound	R	pH 2 (nm)	pH 4 (nm)	pH 6.9 (nm)	pH 7.3 (nm)	pH 10 (nm)	pH 11 (nm)
3	Cl	494	490	485	482	482	487
4a	Ph-OH	575	573	513	512	502	497
4b	Ph-NMe2	609?	563	487	483	486	483
4c	Ph	583	511	486	488	484	483
4d	Ph-F	590	474	475	471	477	476
4e	Ph-CF3	609?	515	510	504	515	507
4f	Ph-CN	-	-	-	-	-	-
4g	Ph-2OMe	582	576	482	493	474	476
4h	Ph-3OMe	588	577	500	503	503	502
4i	Ph-4OMe	577	577	494	497	487	486
4j	Ph-2,4FF	585	501	498	499	503	503
4k	9-Anthracene	569	503	503	495	499	500
4l	Ph-CH2-NHBoc	583	498	486	490	488	488
4l'	Ph-CH2-NH2	606	561	542	536	523	519
4m	2Thienyl	599	532	492	492	497	494
4n	3Thienyl	577	563	509	510	503	511

(c) Intensity

Compound	R	pH 2	pH 4	pH 6.9	pH 7.3	pH 10	pH 11
3	Cl	392	1029	1206	1170	1296	1094
4a	Ph-OH	817	859	498	416	664	569
4b	Ph-NMe2	35	24	847	885	1466	1575
4c	Ph	209	391	1403	830	1589	1109
4d	Ph-F	348	137	224	215	289	234
4e	Ph-CF3	47	358	431	443	780	830
4f	Ph-CN	8	8	8	8	10	10
4g	Ph-2OMe	512	457	711	441	126	128
4h	Ph-3OMe	152	130	271	234	386	546
4i	Ph-4OMe	753	606	379	318	613	712
4j	Ph-2,4FF	193	87	106	110	137	115
4k	9-Anthracene	166	239	280	276	326	347
4l	Ph-CH2-NHBoc	236	149	462	494	694	815
4l'	Ph-CH2-NH2	56	155	840	1119	1393	1434
4m	2Thienyl	56	109	136	140	196	210
4n	3Thienyl	409	348	329	328	408	317

Intensity color code:

>1000	1000-800	800-600	600-400	499-200	200-100	100-50	50-0

Figure S10. Maximum λ_{em} of **4a-4n** and **3** in aqueous solutions of varying pH (a) platereader image under handheld UV lamp (365 nm), (b) maximum emission wavelength (λ_{em}) under excitation at 405 nm, and (c) relative intensity. Darker red represents higher fluorescence intensity while darker blue represents lower intensity. Compound **4f** has poor solubility in water, and thus showed minimal to no fluorescence. However, aggregated solids of **4f** were observed to fluoresce in the wells.

General Procedure B for Sequential Cross-Coupling (Bisarylated DMAQ).

General Procedure B

Experiments were set up inside a glovebox under a nitrogen atmosphere. Solvents were obtained from the solvent system, degassed and kept in the glove box. A stock solution of 2,4-dichloro-*N,N*-dimethylquinolin-7-amine (**3**) was prepared by dissolving 200 mg (0.83 mmol) in 1.0 mL of dioxane in the glovebox. To a 4 mL scintillation vial, 100 µL (20 mg, 0.083 mmol, 1 equiv) of compound **3** from the stock solution was added. $PdCl_2(PPh_3)$ (2.9 mg, 0.004 mmol, 0.05 equiv), and the first boronic acid (0.087 mmol, 1.05 equiv) were added and dissolved in total 663.6 µL of dioxane. K_2CO_3 (34.4 mg, 0.249 mmol, 3.0 equiv) dissolved in 165.9 mL H_2O was added to the vial, which was capped in the glovebox. Under nitrogen, the mixture was stirred for 24 hr at 65˚C under nitrogen gas. Upon completion of the first coupling, the reaction vial was cooled down to rt and second boronic acid (0.249 mmol, 3.0 equiv) was added. The mixture was stirred for 24 hr at 85˚C. Upon completion, 30 mL of EtOAc and water were added to the reaction mixture. The organic layer was extracted from the solution, dried with anhydrous Na_2SO_4, concentrated in vacuo. Purity was checked by JASCO analytical HPLC (30-100% MeCN over 20min)

Crude UP-LCMS (Figure S11-13): The desired product is colored based on the retention time of previously synthesized standard and expected m/z. Background solvent (light grey) elutes at 0.1 min and the internal standard (biphenyl, dark grey) elutes at 1.95 min. Standard compounds were confirmed by column purification and NMR analysis.

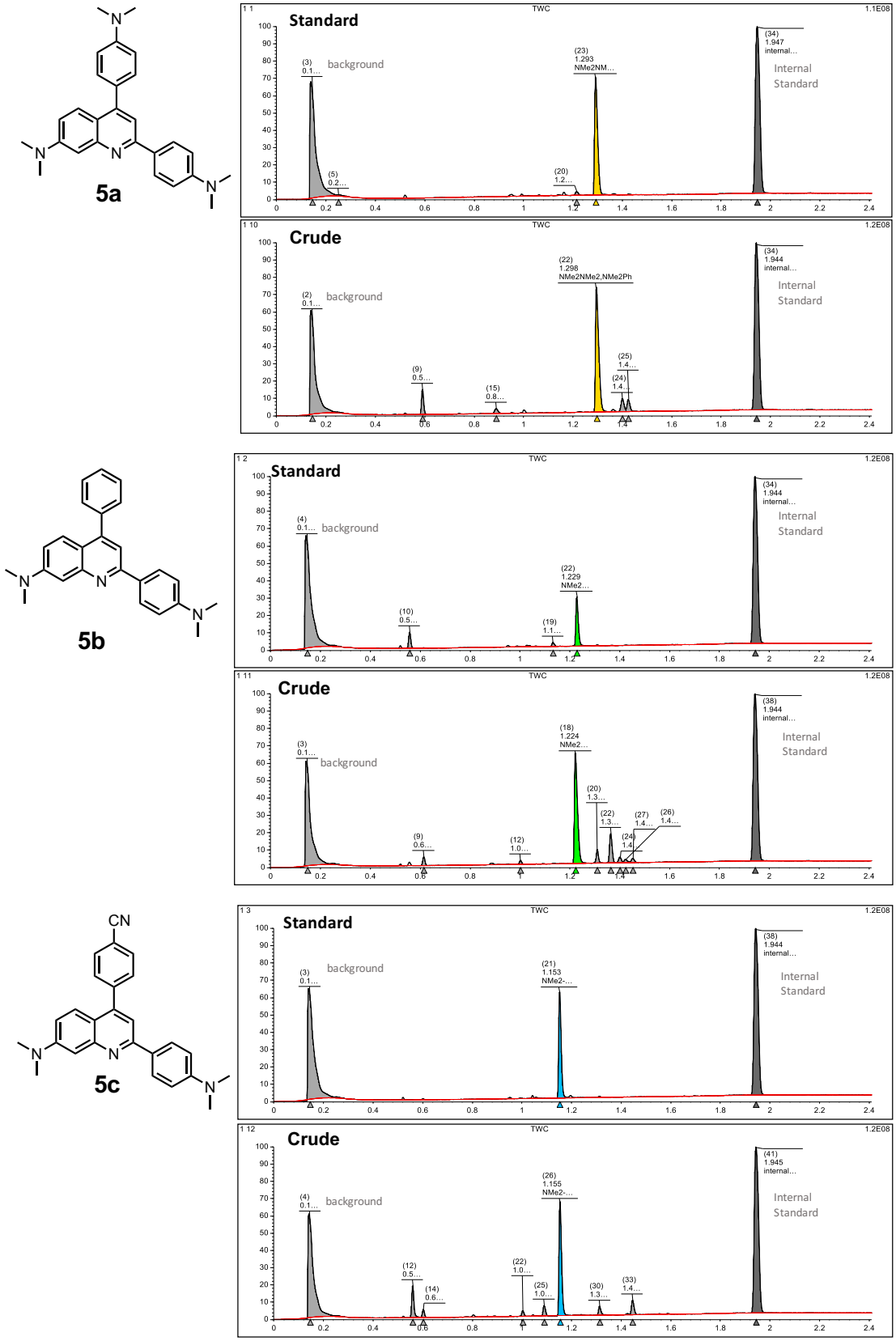


Figure S11. Crude UP-LCMS of bisarylated DMAQ with **4b** core (**5a-5c**)

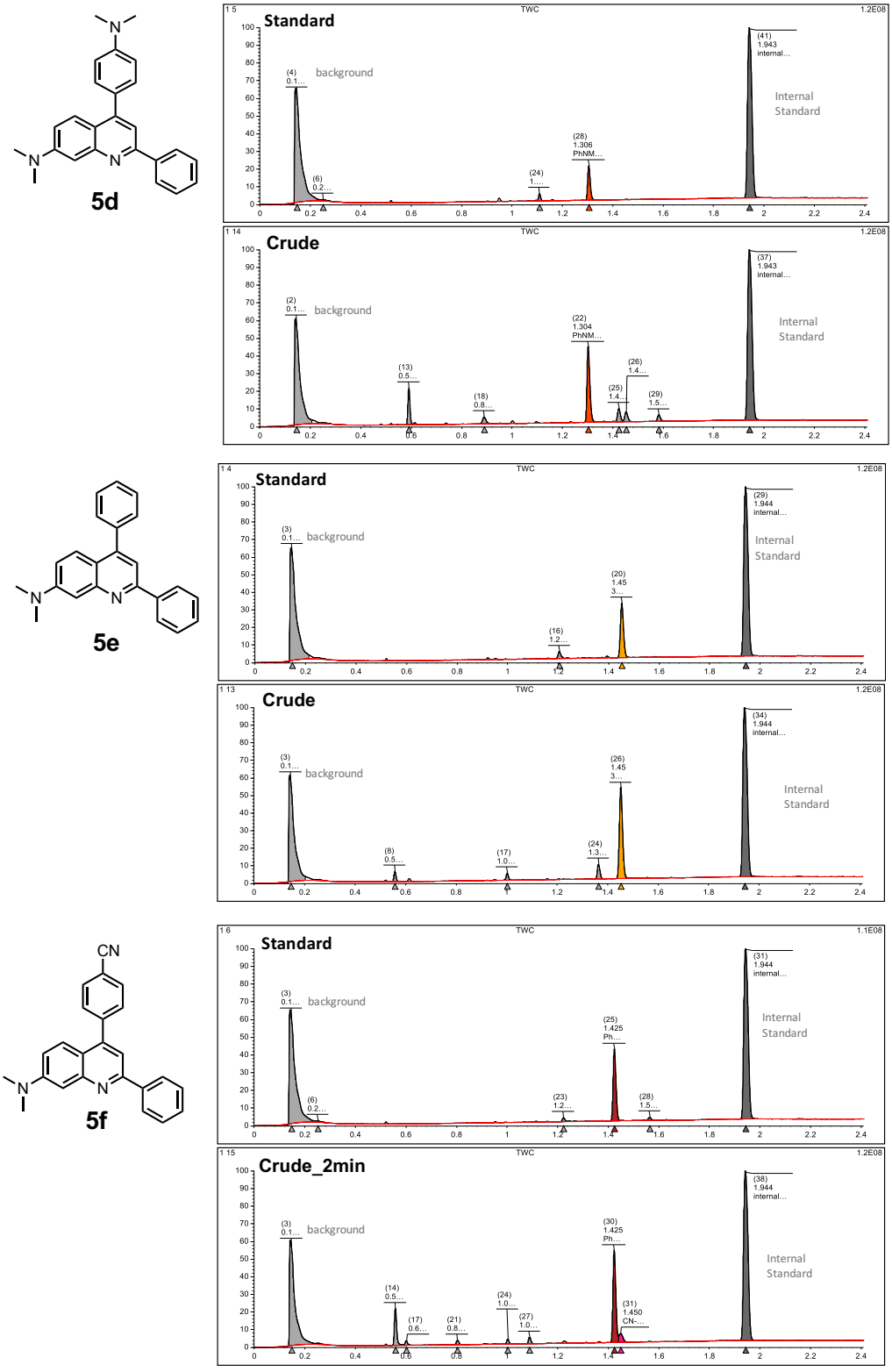


Figure S12. Crude UP-LCMS of bisarylated DMAQ with **4c** core (**5d-5f**)

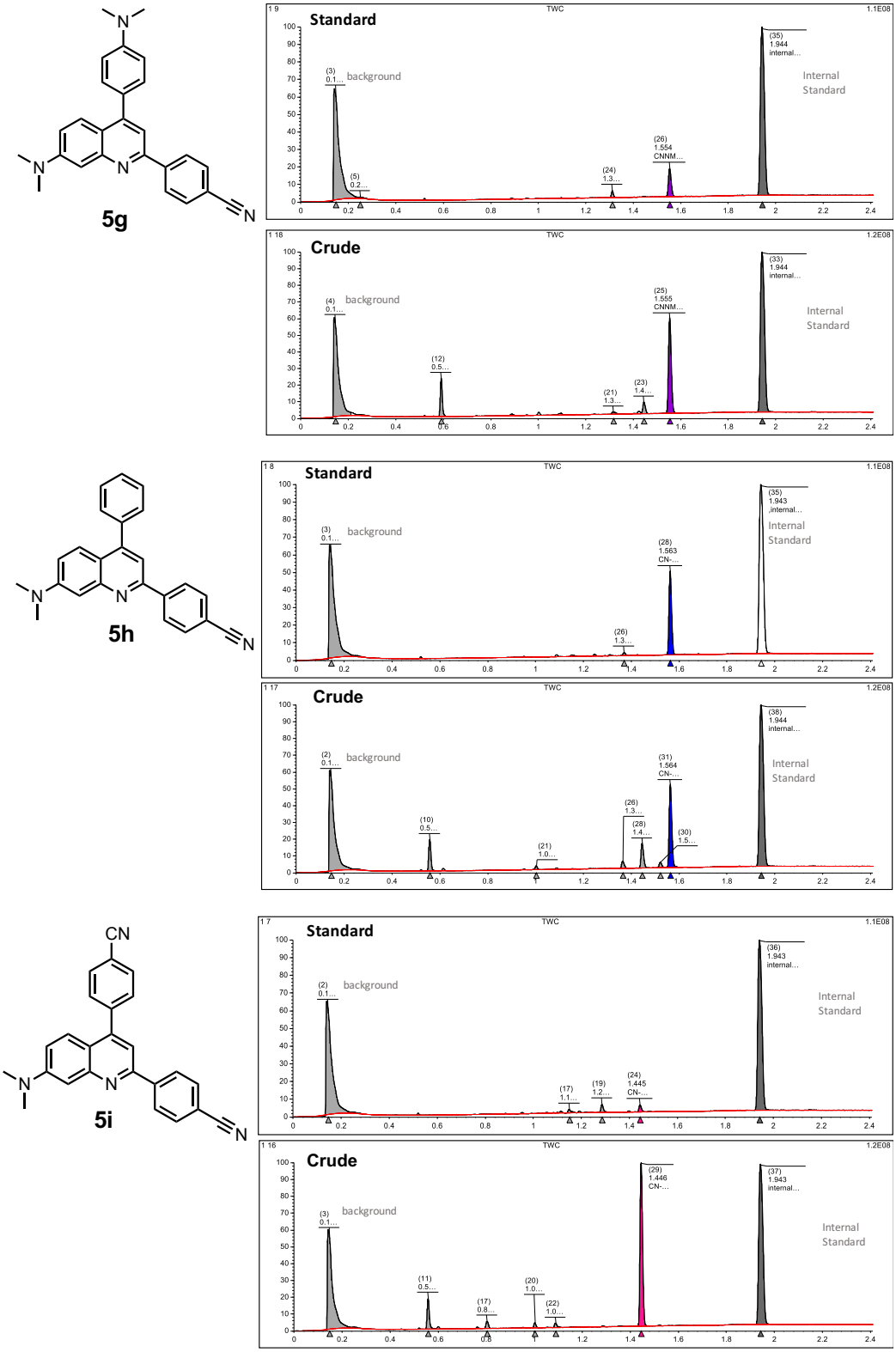
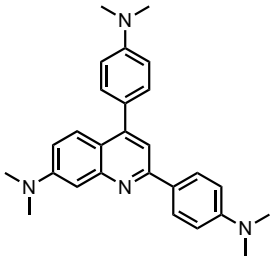


Figure S13. Crude UP-LCMS of bisarylated DMAQ with **4f** core (**5g-5i**)

Characterization Data for Compounds 5a-5i

Table of Compounds

Note. Analytical HPLC characterization was done with a gradient of 30% ACN for 5min followed by 30-100% ACN over 20 min, unless otherwise noted.



4,4'-(7-(dimethylamino)quinoline-2,4-diyl)bis(*N,N*-dimethylaniline) (5a): Following the General Procedure B with 4-(dimethylamino)phenylboronic acid (14 mg, 0.087 mmol, 1.05 equiv) as the first boronic acid and 4-(dimethylamino)phenylboronic acid (41mg, 0.25 mmol, 3.0 equiv) as the second boronic acid afforded 28 mg (83 % isolated yield) of the title compound after purification by column chromatography (1:1 hexanes : EtOAc).

Physical Property: orange solid, m. p. = 200-205 °C

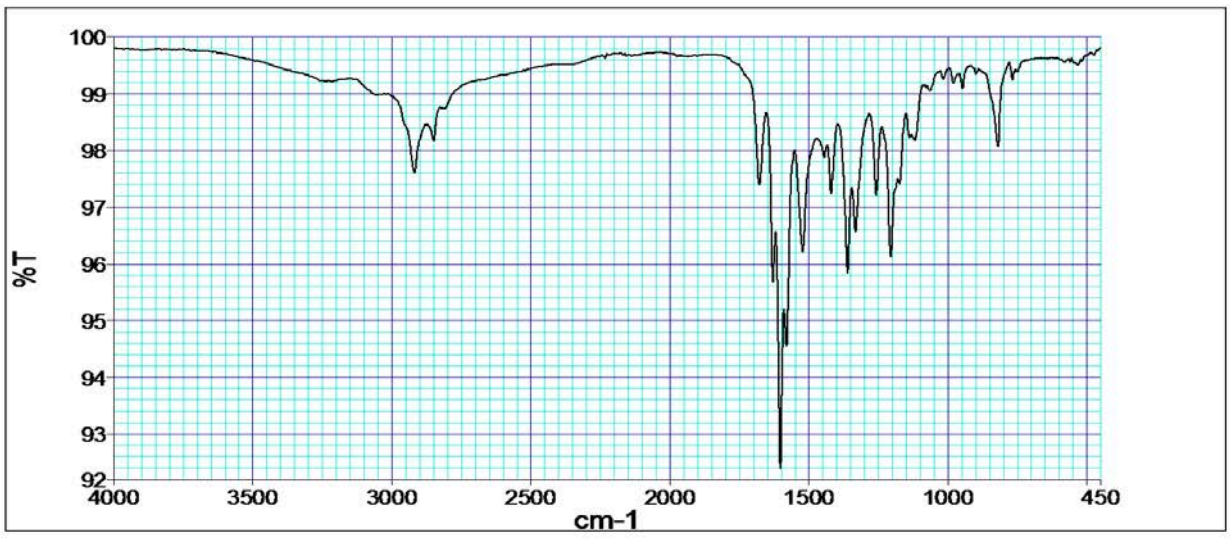
TLC: R*f* = 0.31 (100% EtOAc)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.20 – 8.13 (m, 2H), 7.84 (d, *J* = 9.3 Hz, 1H), 7.48 (dd, *J* = 6.5, 2.3 Hz, 4H), 7.07 (dd, *J* = 9.3, 2.7 Hz, 1H), 6.89 – 6.81 (m, 4H), 3.14 (s, 6H), 3.05 (d, *J* = 0.9 Hz, 12H).

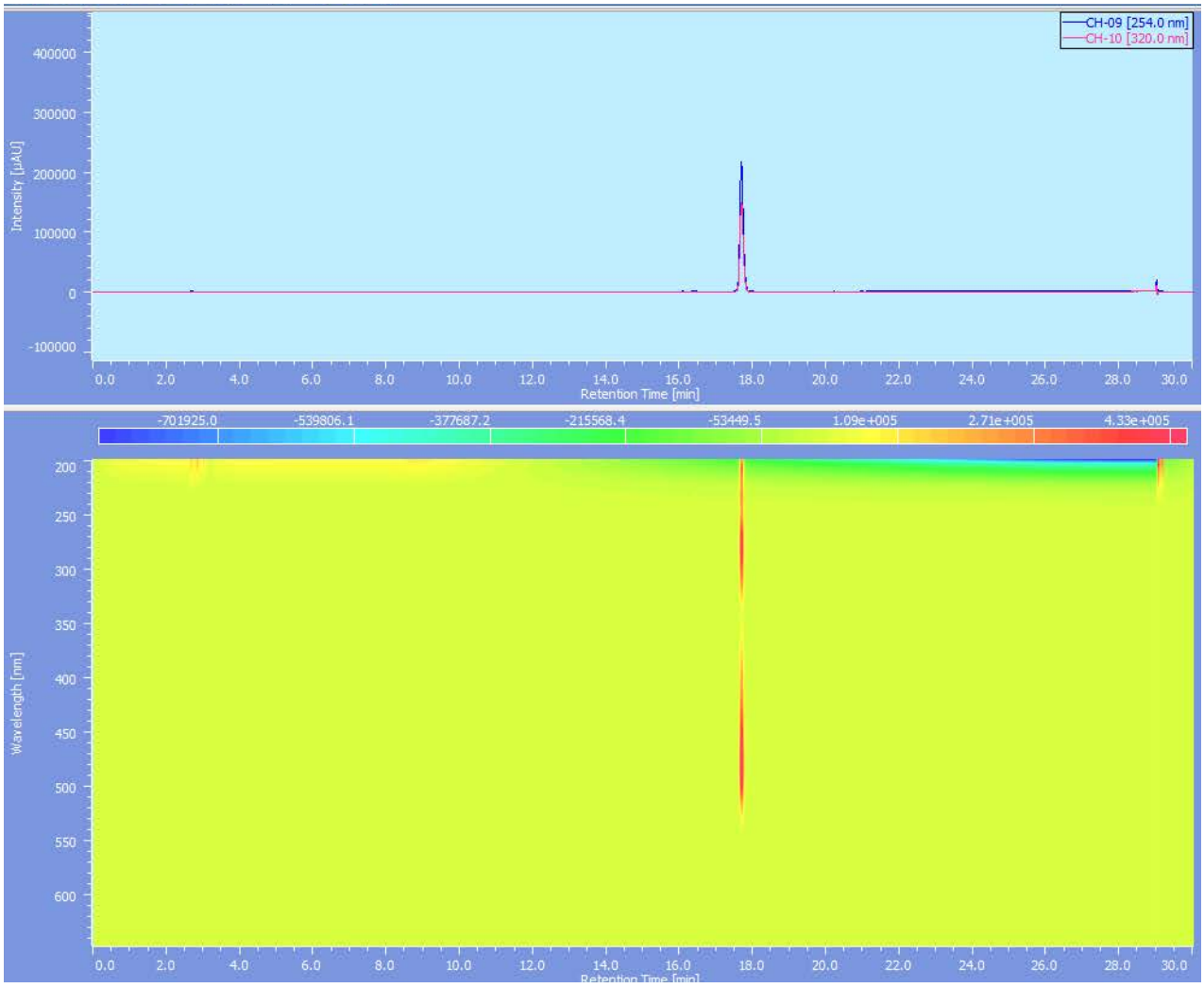
^{13}C NMR (126 MHz, CD_2Cl_2): δ 156.16, 151.87, 151.80, 151.07, 149.89, 130.79, 128.83, 126.99, 126.56, 118.07, 112.42, 112.29, 106.38, 40.68, 40.61, 40.47.

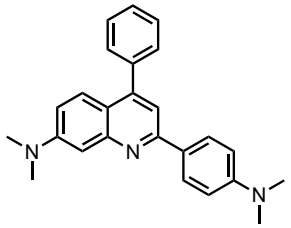
HRMS (ESI-TOF): calc'd for $C_{27}H_{31}N_4^+$ $[M+H]^+$ 411.2549; found 411.2571.

IR (neat): 2920.72, 1678.57, 1602.84, 1522.05, 1360.53, 1257.37, 1204.93, 818.68 cm^{-1}



Analytical HPLC of 5a:





2-(4-(dimethylamino)phenyl)-*N*,*N*-dimethyl-4-phenylquinolin-7-amine (5b): Following the General Procedure B with 4-(dimethylamino)phenylboronic acid (14 mg, 0.087 mmol, 1.05 equiv) as the first boronic acid and phenylboronic acid (30 mg, 0.25 mmol, 3.0 equiv) as the second boronic acid afforded 26 mg (86 % isolated yield) of the title compound after purification by Agilent Prep HPLC chromatography (40-50% over 40min). The desired product was eluted at 42.5-43% MeCN. The product was also crystallized in DCM.

Physical Property: red solid, yellowish green crystal, m.p. = 238-240 °C

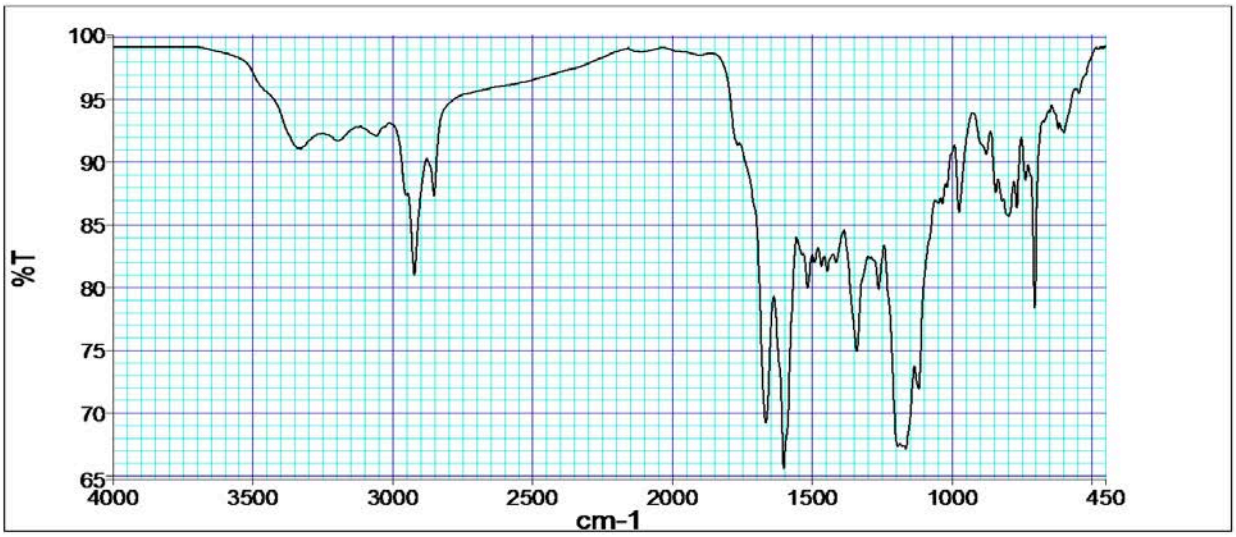
TLC: R*f* = 0.20 (25% EtOAc in Hexanes).

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.17 – 8.07 (m, 2H), 7.69 (d, *J* = 9.2 Hz, 1H), 7.62 – 7.47 (m, 6H), 7.25 (d, *J* = 2.7 Hz, 1H), 7.07 (dd, *J* = 9.3, 2.7 Hz, 1H), 6.86 – 6.80 (m, 2H), 3.13 (s, 6H), 3.05 (s, 6H).

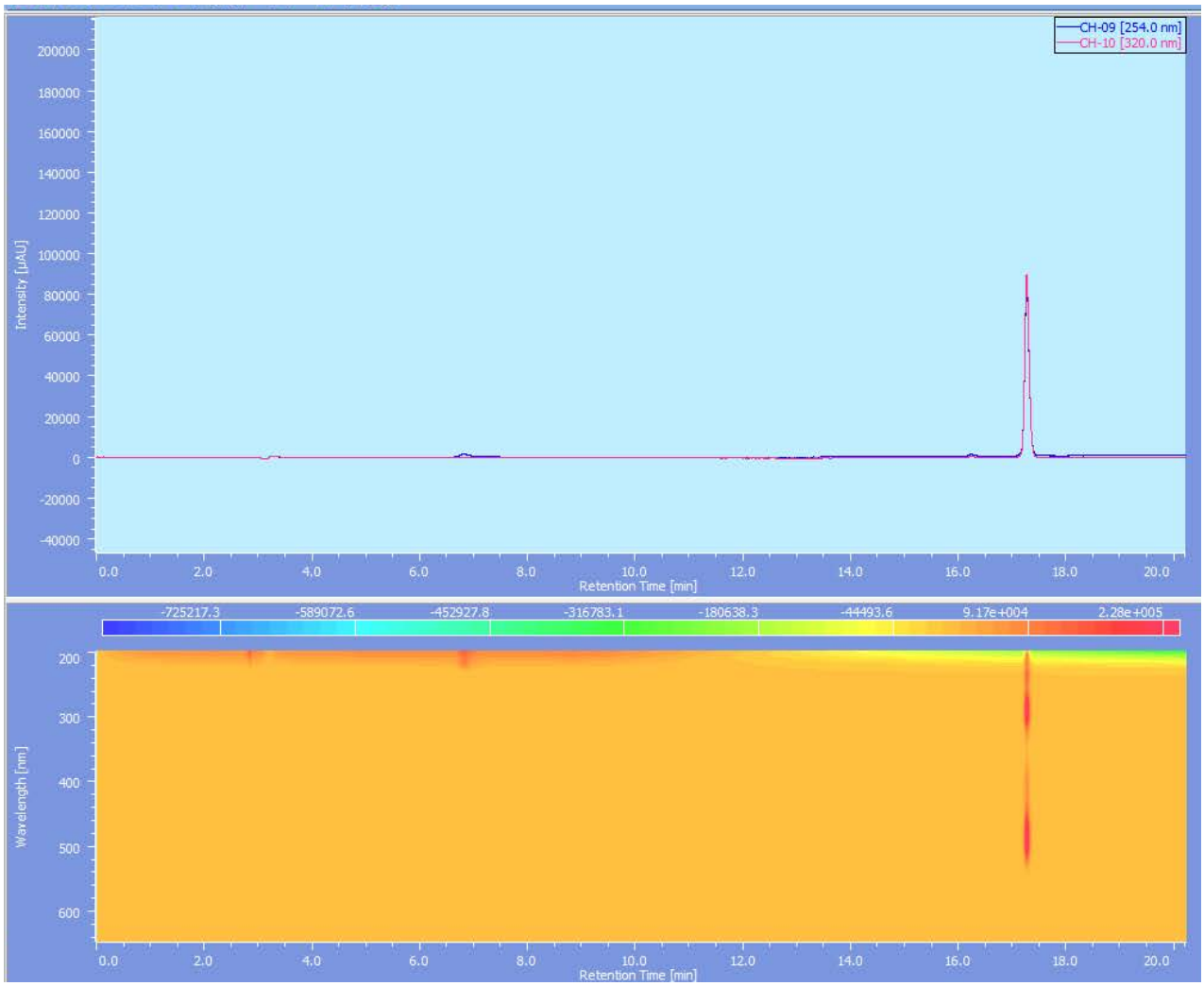
^{13}C NMR (126 MHz, CD_2Cl_2): δ (126 MHz, CD_2Cl_2) δ 157.97, 152.76, 152.70, 151.97, 149.60, 140.67, 130.90, 129.80, 129.52, 129.40, 128.75, 127.48, 118.94, 116.46, 115.98, 113.39, 113.32, 108.65, 41.72, 41.52.

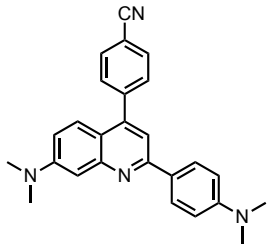
HRMS (ESI-TOF): calc'd for $C_{25}H_{26}N_3^+$ $[M+H]^+$ 368.2127; found 368.2127.

IR (neat): 3567.17, 3044.89, 1603.34, 1443.43, 1352.85, 1208.48, 1145.41, 1047.57, 892.22, 795.01/3332.75, 2924.88, 2854.42, 1666.52, 1602.14, 1516.83, 1446.5, 1340.35, 1262.22, 1164.64, 1118.37, 974.01, 876.97, 843.02, 796.96, 767.55, 736.66, 702.97, 598.69 cm^{-1}



Analytical HPLC of 5b:





4-(7-(dimethylamino)-2-(4-(dimethylamino)phenyl)quinolin-4-yl)benzonitrile (5c): Following the General Procedure B with 4-(dimethylamino)phenylboronic acid (14 mg, 0.087 mmol, 1.05 equiv) as the first boronic acid and 4-cyanophenylboronic acid (37 mg, 0.25 mmol, 3.0 equiv) as the second boronic acid afforded 27 mg (84 % isolated yield) of the title compound after purification by ISCO (method: 10-70% EtOAc in Hexane over 10 min). The desired compound was eluted at 45-50% EtOAc.

Physical Property: reddish orange solid, m. p. = 200-205 °C

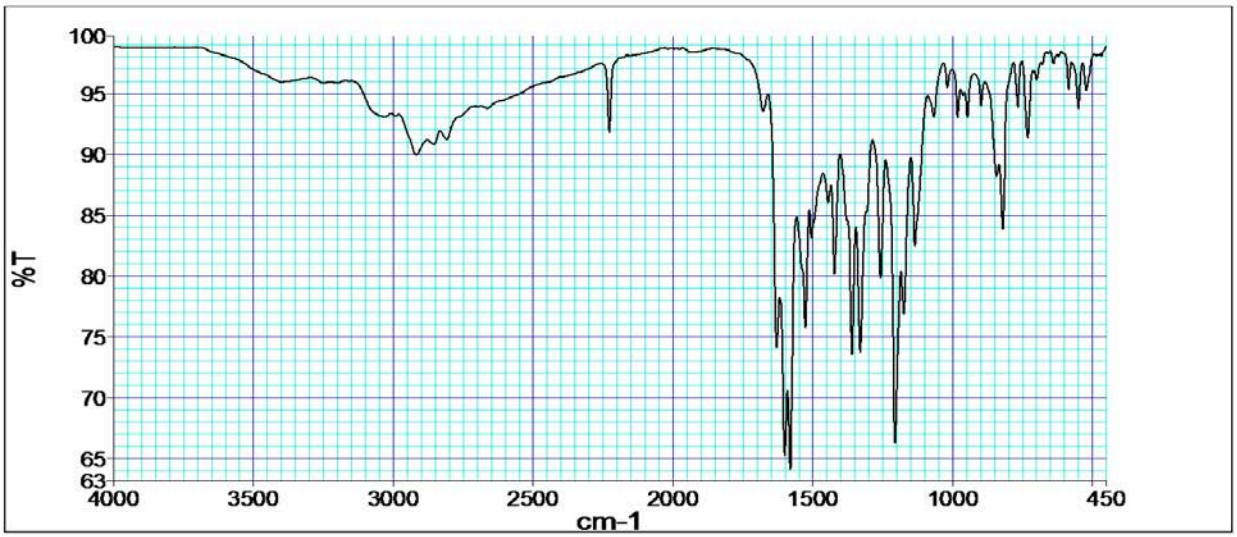
TLC: R*f* = 0.18 (33% EtOAc in Hexanes).

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.14 – 8.09 (m, 2H), 7.86 – 7.80 (m, 2H), 7.69 – 7.65 (m, 2H), 7.55 (d, *J* = 9.3 Hz, 1H), 7.47 (s, 1H), 7.25 (d, *J* = 2.7 Hz, 1H), 7.07 (dd, *J* = 9.3, 2.7 Hz, 1H), 6.87 – 6.80 (m, 2H), 3.13 (s, 6H), 3.05 (s, 6H).

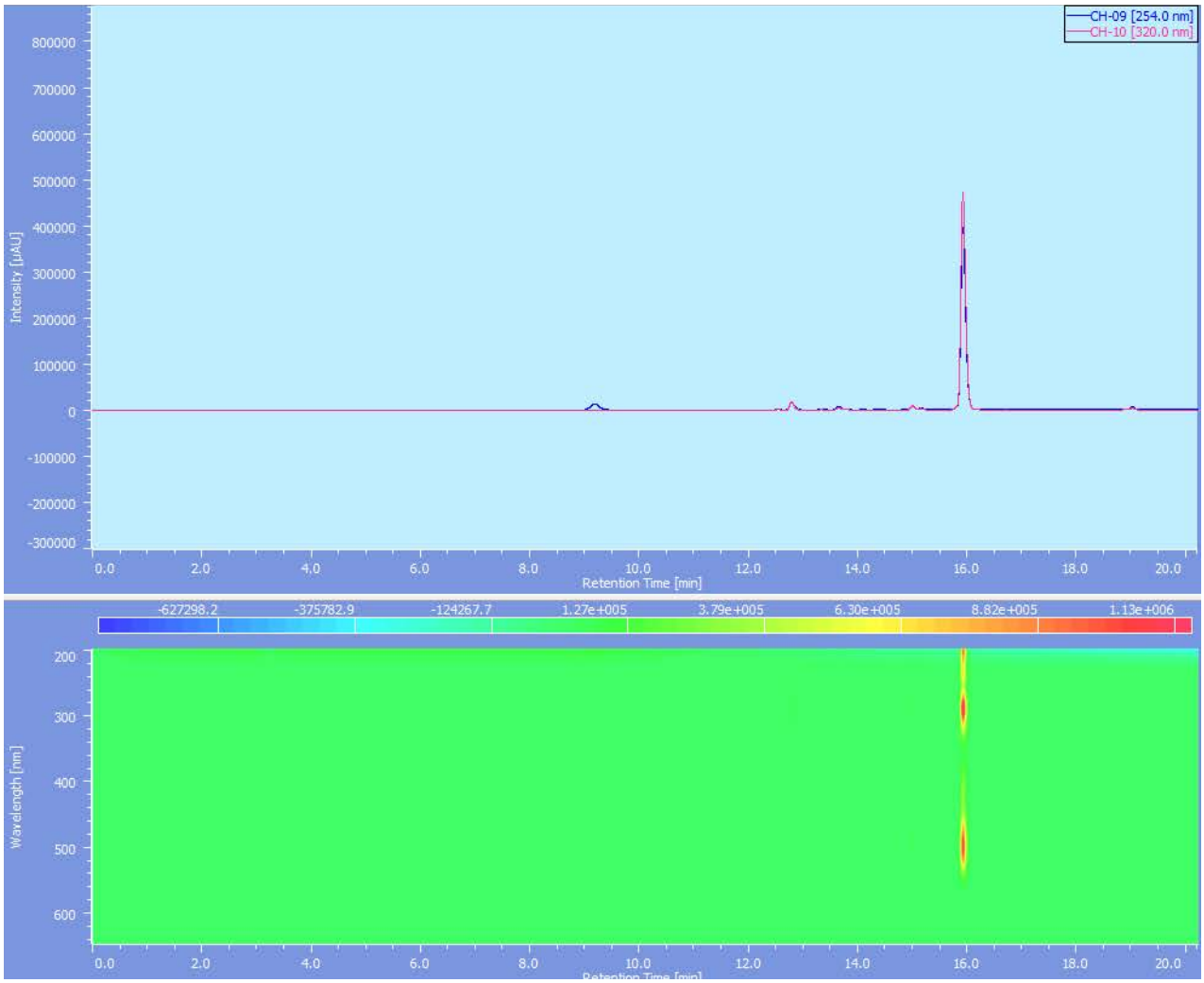
^{13}C NMR (126 MHz, CD_2Cl_2): δ 157.01, 151.80, 151.75, 151.05, 146.48, 144.40, 132.63, 130.66, 128.49, 127.42, 125.73, 119.11, 117.06, 115.75, 114.65, 112.34, 112.24, 107.69, 40.63, 40.47.

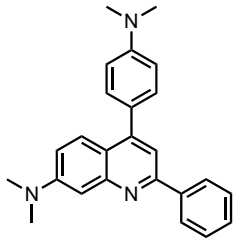
HRMS (ESI-TOF): calc'd for $C_{26}H_{25}N_4^+$ $[M+H]^+$ 393.2079; found 393.2087.

IR (neat): 2920.17, 2228.26, 1628.8, 1,599.93 1580.21, 1526.07, 1504.84, 1444.96, 1421.97, 1359.46, 1329.81, 1257.19, 1204.82, 1173.36, 1134.11, 980.97, 945.84, 841.47, 818.86, 730.29 cm^{-1}



Analytical HPLC of 5c:





4-(4-(dimethylamino)phenyl)-*N,N*-dimethyl-2-phenylquinolin-7-amine (5d): Following the General Procedure B with phenylboronic acid (11 mg, 0.087 mmol, 1.05 equiv) as the first boronic acid and 4-(dimethylamino)phenylboronic acid (41 mg, 0.25 mmol, 3.0 equiv) as the second boronic acid afforded 16 mg (51 % isolated yield) of the title compound after precipitation with 50% MeCN/50% Water. Further purification was done by HPLC (30-65% over 20 min, retention time 9.5-10.5)

Physical Property: dark brown solid, m. p. = 197-199 °C

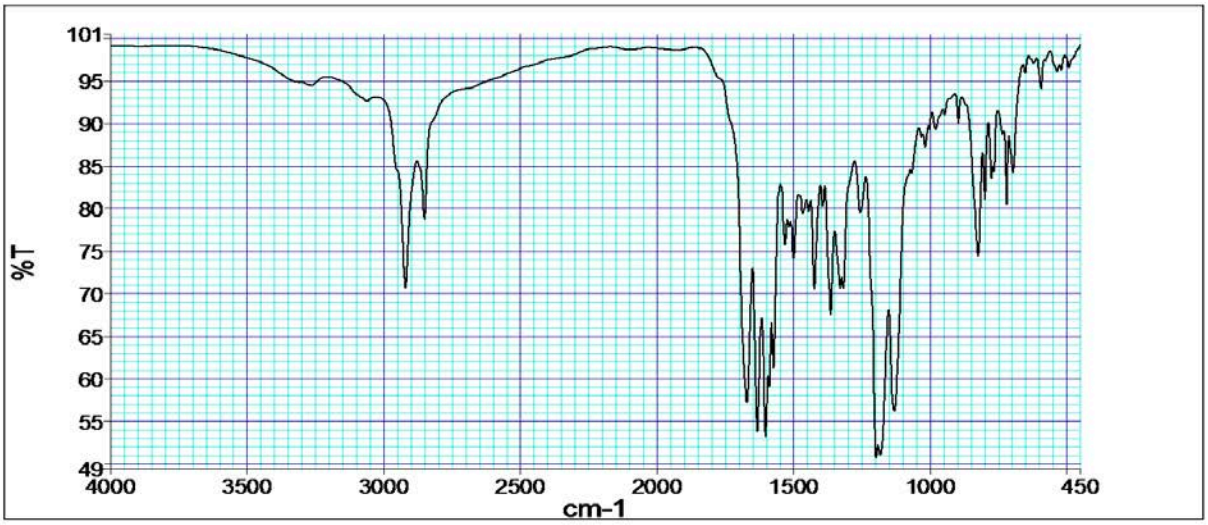
TLC: R*f* = 0.37 (33% EtOAc in Hexanes).

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.26 – 8.22 (m, 2H), 7.93 (d, *J* = 9.3 Hz, 1H), 7.58 – 7.48 (m, 7H), 7.16 (dd, *J* = 9.4, 2.4 Hz, 1H), 6.90 – 6.87 (m, 2H), 3.18 (s, 6H), 3.07 (s, 6H).

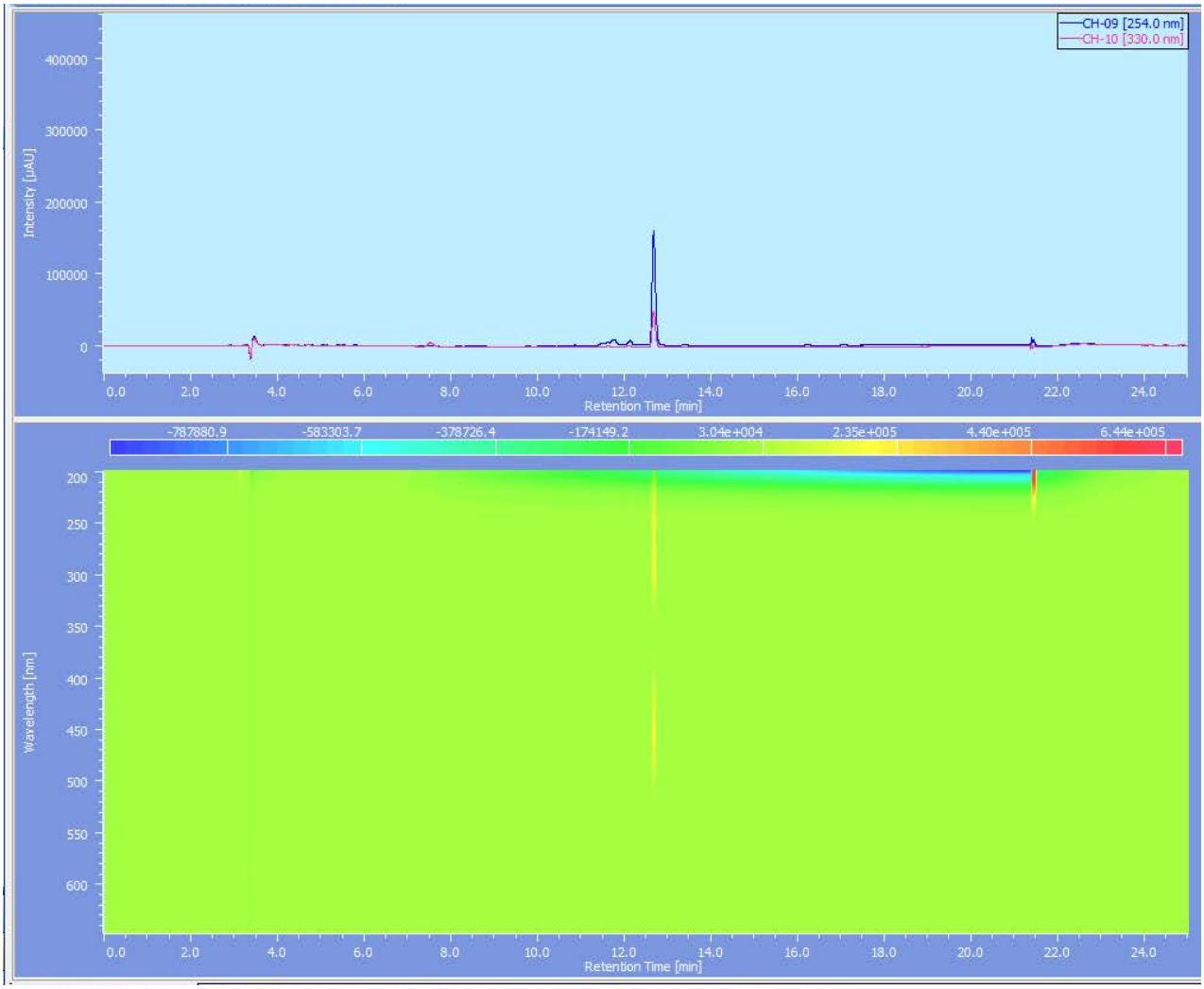
^{13}C NMR (126 MHz, CD_2Cl_2): δ 152.35, 151.45, 131.01, 130.88, 130.35, 129.79, 129.13, 129.08, 128.45, 127.61, 127.49, 118.64, 117.03, 116.54, 115.28, 112.40, 107.21, 40.61, 40.54.

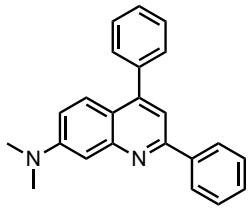
HRMS (ESI-TOF): calc'd for $C_{25}H_{26}N_3^+$ $[M+H]^+$ 368.2127; found 368.2120.

IR (neat): 2922.65, 2853.01, 1671.69, 1632.84, 1602.85, 1589.09, 1573.61, 1531.7, 1500.16, 1466.74, 1444.73, 1424.23, 1363.64, 1329.25, 1317.42, 1256.17, 1197.64, 1181.8, 1130.46, 823.24 cm^{-1}



Analytical HPLC of 5d: 10% MeCN for 2min followed by 10-100% over 15min





***N,N*-dimethyl-2,4-diphenylquinolin-7-amine (5e):** Following the General Procedure B with phenylboronic acid (11 mg, 0.087 mmol, 1.05 equiv) as the first boronic acid and phenylboronic acid (30 mg, 0.25 mmol, 3.0 equiv) as the second boronic acid afforded 21 mg (78 % isolated yield) of the title compound after purification by precipitation with DCM:Hex (1:1). Under ISCO standard purification method, the desired product was eluted at 38-42% EtOAc.

Physical Property: yellow solid (red film), m. p. = 144-147 °C

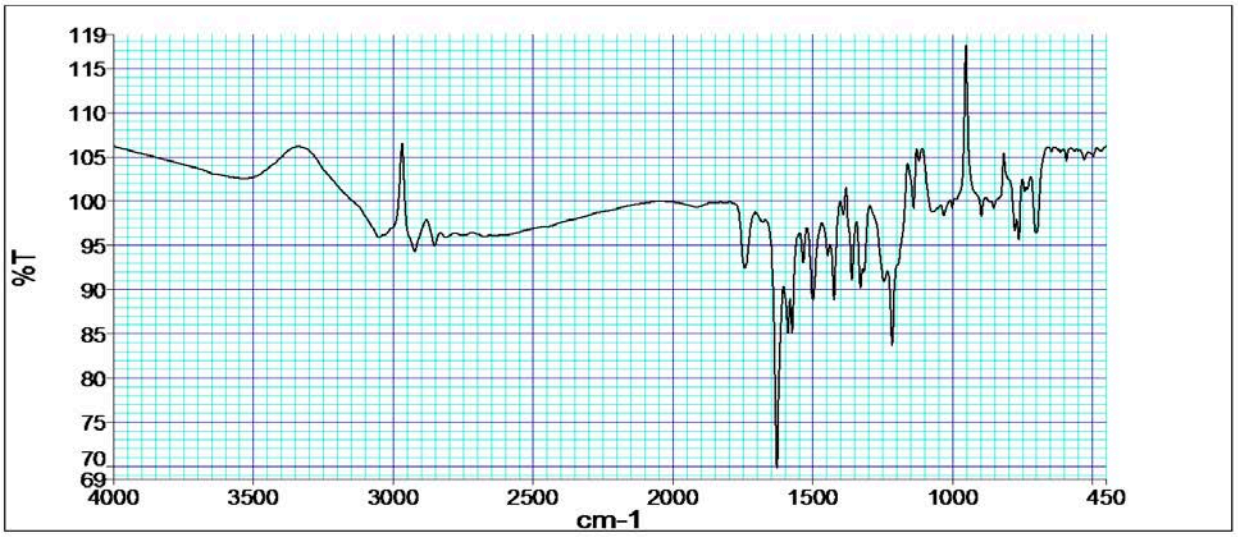
TLC: R*f* = 0.47 (33% EtOAc in Hexanes).

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.29 – 8.24 (m, 2H), 7.80 (d, J = 9.5 Hz, 1H), 7.59 (q, J = 4.4 Hz, 9H), 7.51 (s, 1H), 7.20 (dd, J = 9.5, 2.7 Hz, 1H), 3.21 (s, 6H).

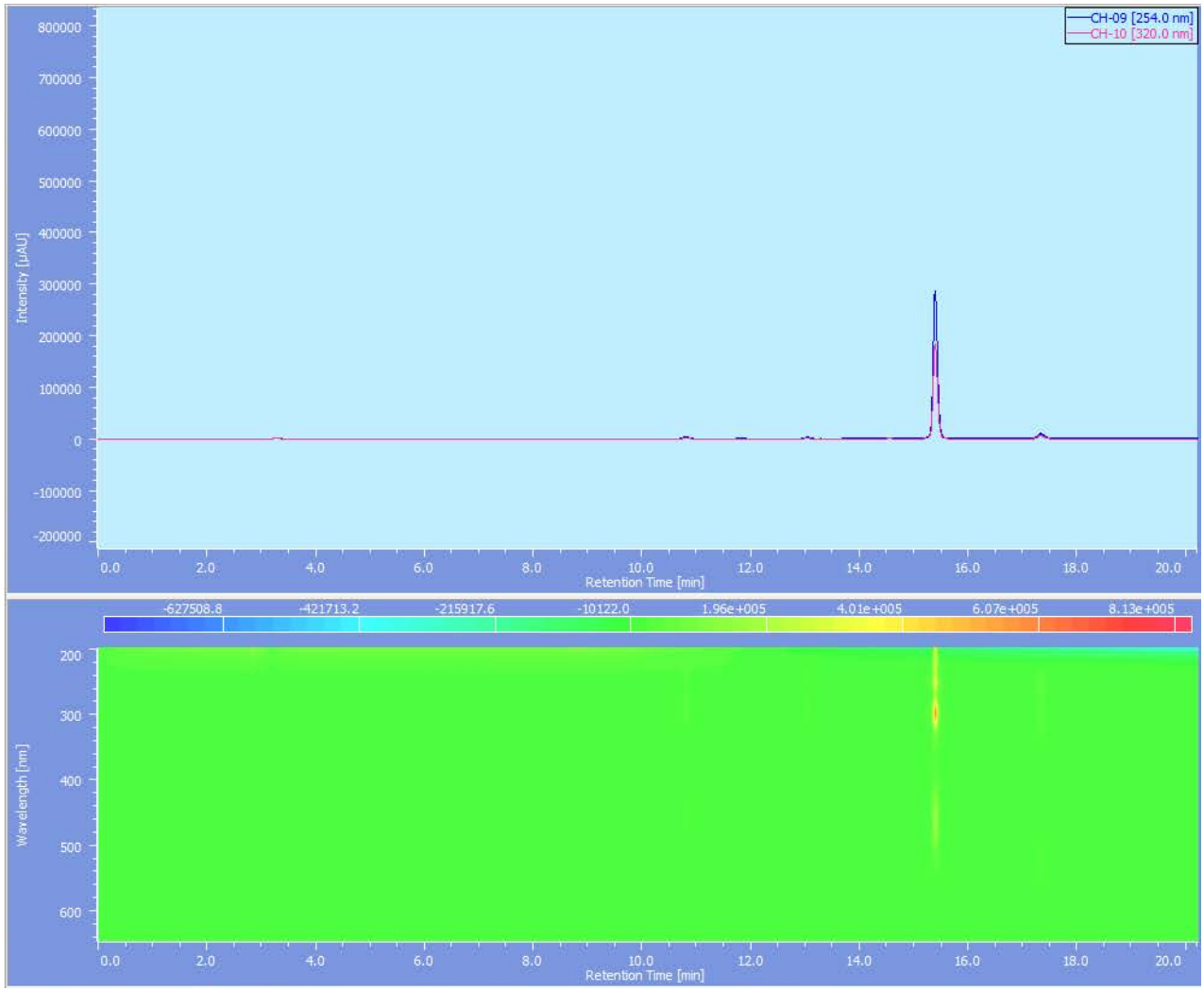
^{13}C NMR (126 MHz, CD_2Cl_2): δ 157.08, 154.18, 152.44, 143.05, 136.60, 132.50, 131.88, 130.49, 129.71, 129.66, 129.43, 129.14, 128.40, 119.11, 118.36, 115.72, 97.46, 40.48.

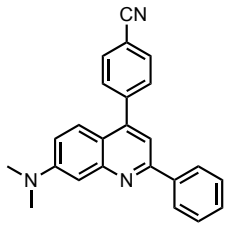
HRMS (ESI-TOF): calc'd for $C_{23}H_{21}N_2^+$ $[M+H]^+$ 325.1705; found 325.1705.

IR (neat): 3054.14, 2925.52, 2854.05, 1743.65, 1628.27, 1588.09, 1573.9, 1534.03,1499.32, 1446.5,1423.95, 1359.79, 1329.14, 1244.87, 1215.26, 1030.41, 895.9, 775.83, 761.7, 701.18 cm^{-1}



Analytical HPLC of 5e:





4-(7-(dimethylamino)-2-phenylquinolin-4-yl)benzonitrile (5f): Following the General Procedure B with phenylboronic acid (11 mg, 0.087 mmol, 1.05 equiv) as the first boronic acid and 4-cyanophenylboronic acid (36 mg, 0.25 mmol, 3.0 equiv) as the second boronic acid afforded 17 mg (58 % isolated yield) of the title compound after purification by standard ISCO purification method. The desired product was eluted at 45-50% EtOAc.

Physical Property: yellow solid (red film), m. p. = 205-208 °C

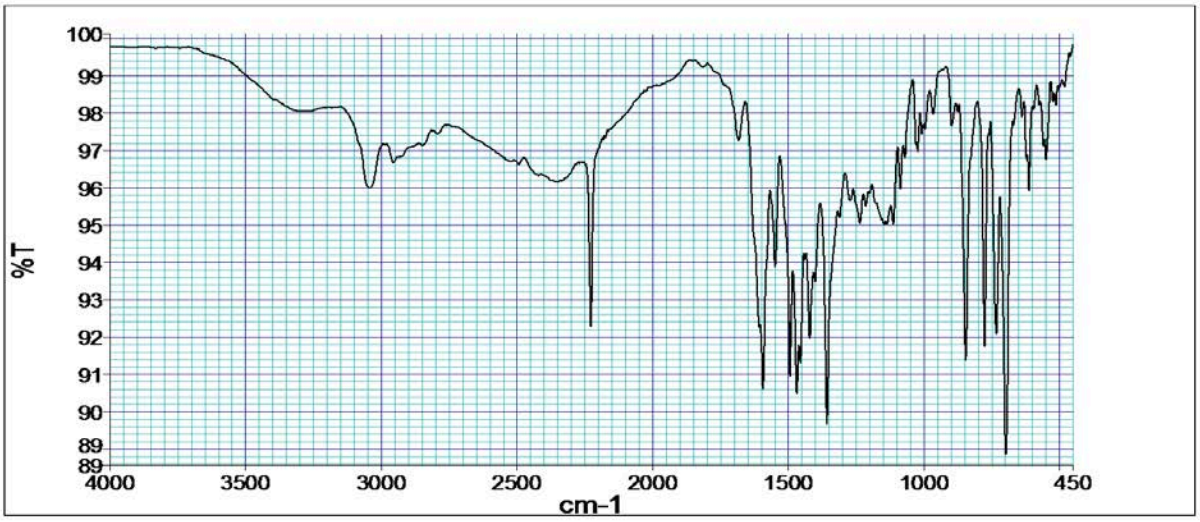
TLC: R*f* = 0.42 (33% EtOAc in Hexanes).

^{1}H NMR (500 MHz, CD_2Cl_2): 8.24 – 8.16 (m, 2H), 7.90 – 7.80 (m, 2H), 7.72 – 7.67 (m, 2H), 7.61 (d, *J* = 9.3 Hz, 1H), 7.57 – 7.51 (m, 3H), 7.48 (dd, *J* = 6.9, 1.7 Hz, 1H), 7.30 (d, *J* = 2.7 Hz, 1H), 7.15 (dd, *J* = 9.3, 2.7 Hz, 1H), 3.15 (s, 6H).

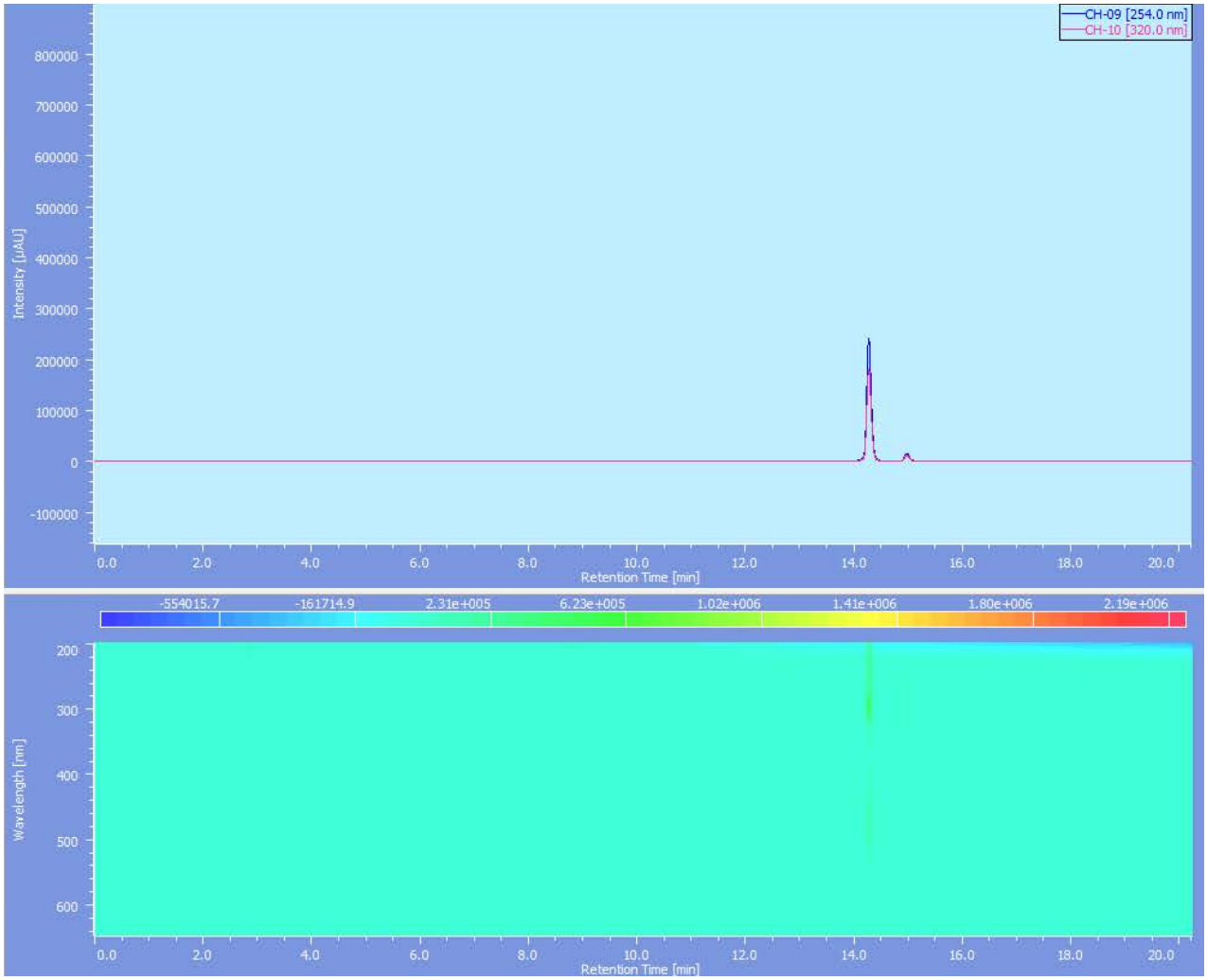
^{13}C NMR (126 MHz, CD_2Cl_2): δ 157.03, 151.84, 151.09, 146.95, 144.10, 140.16, 132.70, 130.68, 129.57, 129.07, 127.65, 125.81, 119.05, 117.60, 116.76, 115.38, 112.44, 107.82, 40.61.

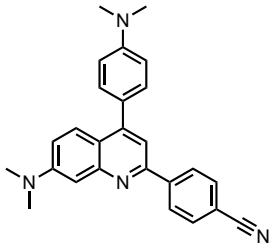
HRMS (ESI-TOF): calc'd for $C_{24}H_{20}N_3^+$ $[M+H]^+$ 350.1657; found 350.1667.

IR (neat): 3045.38, 2228.74, 1683.25, 1593.2, 1548.22, 1493.28, 1468.76, 1420.65, 1356.93, 1235.41, 1146.19, ,1086.22, 1022.01, 844.7, 775.01, 731.97, 696.11, 610.89, 548.57 cm^{-1}



Analytical HPLC of 5f:





4-(7-(dimethylamino)-4-(4-(dimethylamino)phenyl)quinolin-2-yl)benzonitrile (5g): Following the General Procedure B with 4-cyanophenylboronic acid (13 mg, 0.087 mmol, 1.05 equiv) as the first boronic acid and 4-(dimethyamino)phenylboronic acid (41 mg, 0.25 mmol, 3.0 equiv) as the second boronic acid afforded 24 mg (75 % isolated yield) of the title compound after purification by standard ISCO method. The desired product was eluted at 70-75% EtOAc.

Physical Property: yellow solid, m. p. = 275-278 °C

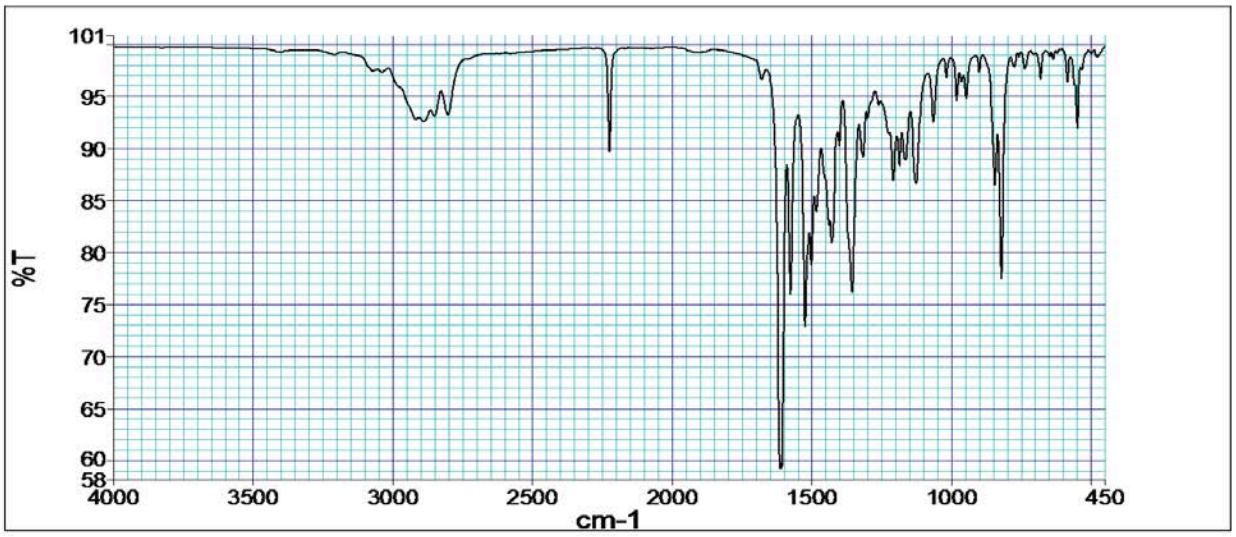
TLC: R*f* = 0.34 (33% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.34 (d, *J* = 8.1 Hz, 2H), 7.94 (d, *J* = 9.4 Hz, 1H), 7.82 (d, *J* = 8.1 Hz, 2H), 7.60 – 7.53 (m, 1H), 7.51 – 7.45 (m, 3H), 7.19 (dd, *J* = 9.4, 2.6 Hz, 1H), 6.91 – 6.86 (m, 2H), 3.17 (s, 6H), 3.07 (s, 6H).

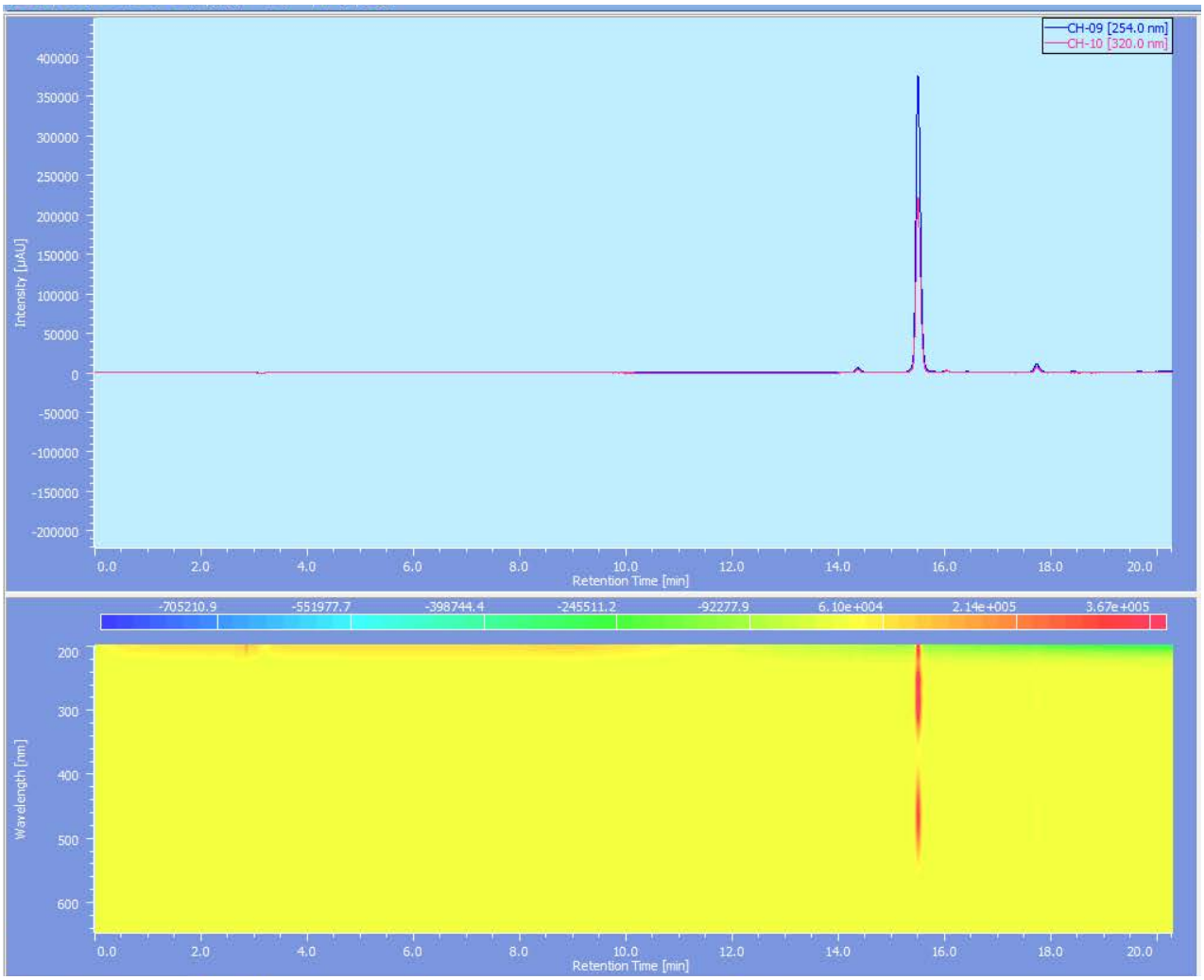
^{13}C NMR (126 MHz, CD_2Cl_2): δ 153.18, 152.36, 151.44, 142.35, 132.86, 132.76, 131.00, 128.76, 128.18, 127.48, 125.35, 119.07, 119.01, 117.12, 115.18, 113.34, 112.41, 104.81, 40.58, 40.53.

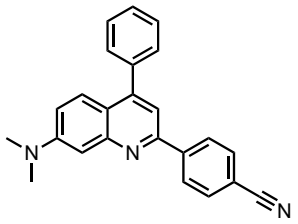
HRMS (ESI-TOF): calc'd for $C_{26}H_{25}N_4^+$ $[M+H]^+$ 393.2079; found 393.2087.

IR (neat): 2891.42, 2804.81, 2225.66, 1614.77, 1576.67, 1523.98, 1501.52, 1483.96, 1429, 1401.21, 1355.78, 1316.05, 1208.72, 1185.7, 1164.73, 1125.68, 1063.75, 843.62, 820.02, 547.91 cm^{-1}



Analytical HPLC of 5g:





4-(7-(dimethylamino)-4-phenylquinolin-2-yl)benzonitrile (5h): Following the General Procedure B with 4-cyanophenylboronic acid (13 mg, 0.087 mmol, 1.05 equiv) as the first boronic acid and phenylboronic acid (30 mg, 0.25 mmol, 3.0 equiv) as the second boronic acid afforded 21 mg (72 % isolated yield) of the title ncompound after purification by ISCO (method: 0-40% EtOAc in Hexane over 8 min). The desired product was eluted at 28-32% EtOAc.

Physical Property: red solid, m. p. = 195-198 °C

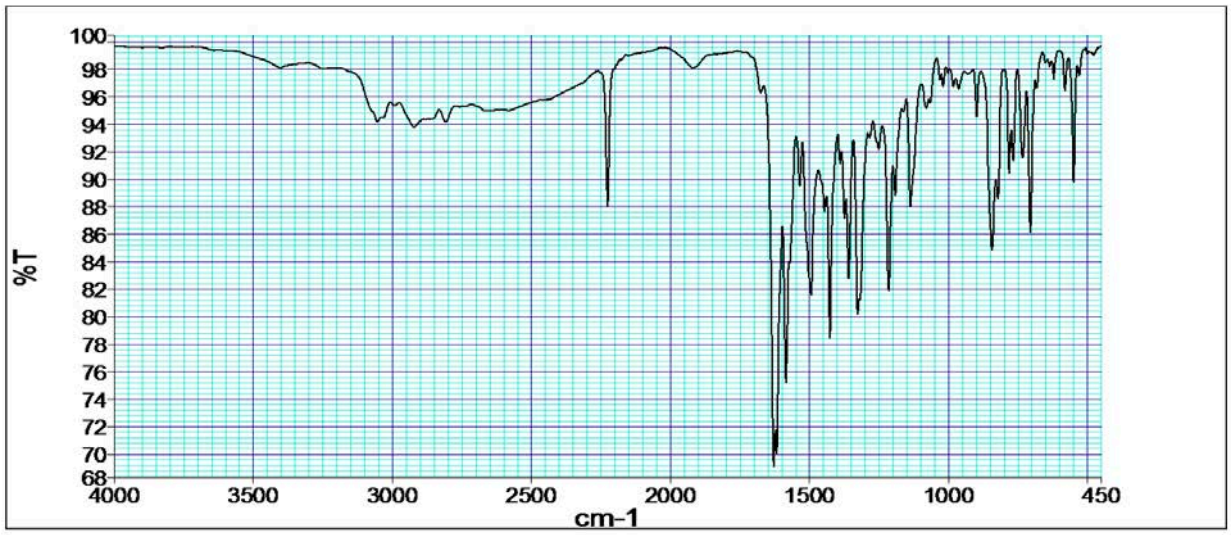
TLC: R*f* = 0.49 (33% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.34 – 8.29 (m, 2H), 7.81 – 7.77 (m, 2H), 7.76 (d, *J* = 9.2 Hz, 1H), 7.58 – 7.51 (m, 6H), 7.27 (d, *J* = 2.6 Hz, 1H), 7.16 (dd, *J* = 9.3, 2.7 Hz, 1H), 3.14 (s, 6H).

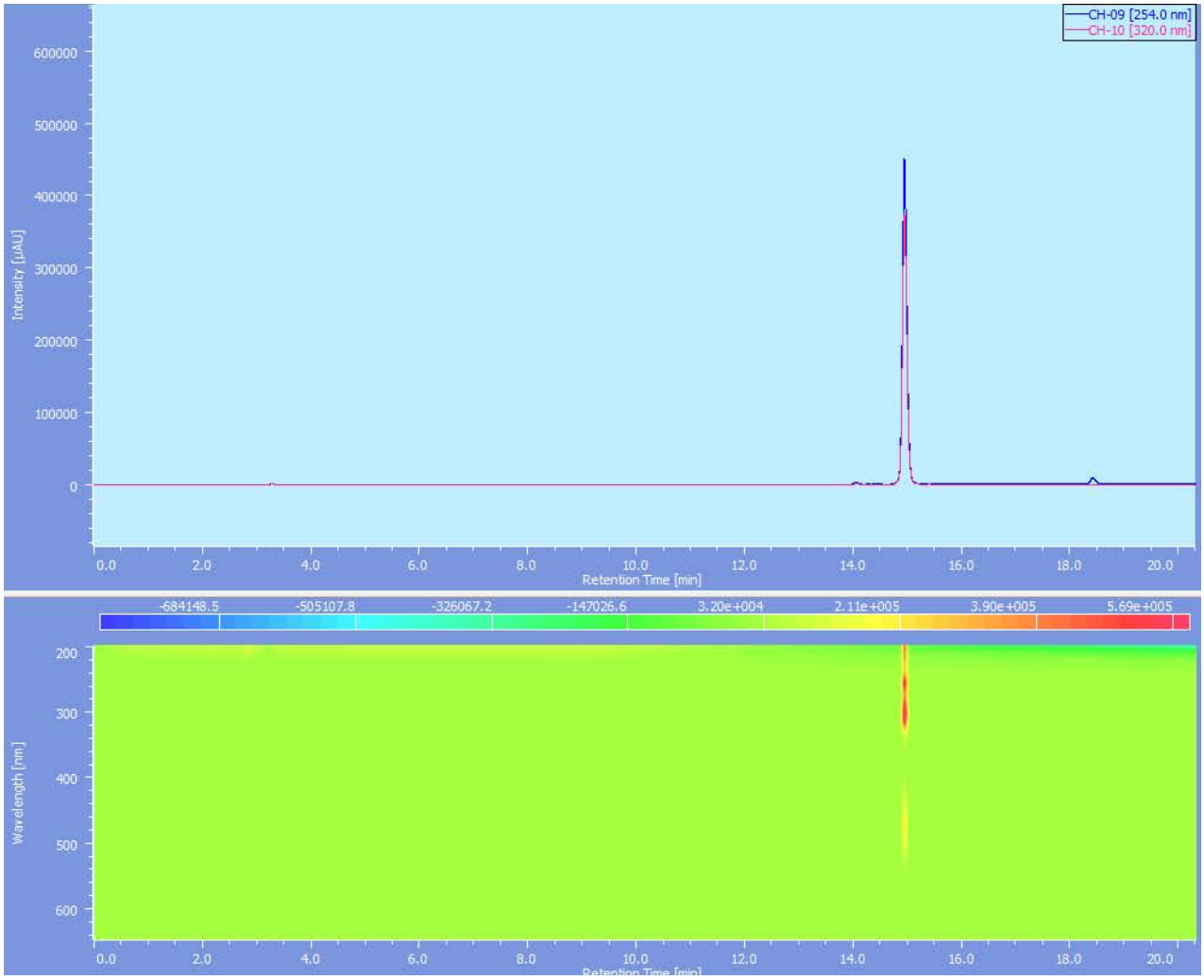
^{13}C NMR (126 MHz, CD_2Cl_2): δ 154.73, 151.82, 151.13, 149.40, 144.54, 139.03, 133.20, 132.80, 129.86, 128.92, 128.71, 128.26, 128.14, 126.60, 119.29, 118.74, 117.10, 115.44, 112.67, 107.58, 40.57.

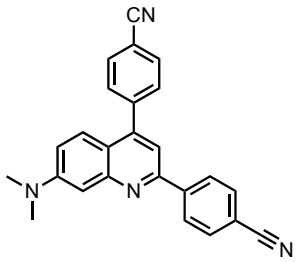
HRMS (ESI-TOF): calc'd for $C_{24}H_{20}N_3^+$ $[M+H]^+$ 350.1657; found 350.1678.

IR (neat): 2226.87, 1628.15, 1617.51, 1584.21, 1534.42, 1493.73, 1445.59, 1426.44,1373.45, 1358.71, 1326.36, 1214.53, 1190.88, 1135.94, 842.1, 820.51, 780.99, 765.21, 703.94, 547.99 cm^{-1}



Analytical HPLC of 5h:





4,4'-(7-(dimethylamino)quinoline-2,4-diyl)dibenzonitrile (5i): Following the General Procedure B with 4-cyanophenylboronic acid (13 mg, 0.087 mmol, 1.05 equiv) as first boronic acid and 4-cyanophenylboronic acid (37 mg, 0.25 mmol, 3.0 equiv) as second boronic acid afforded 27 mg (88 % isolated yield) of the title compound after purification by standard ISCO method. The desired product was eluted at 50-55% EtOAc.

Physical Property: red solid, m. p. = 196-200 °C

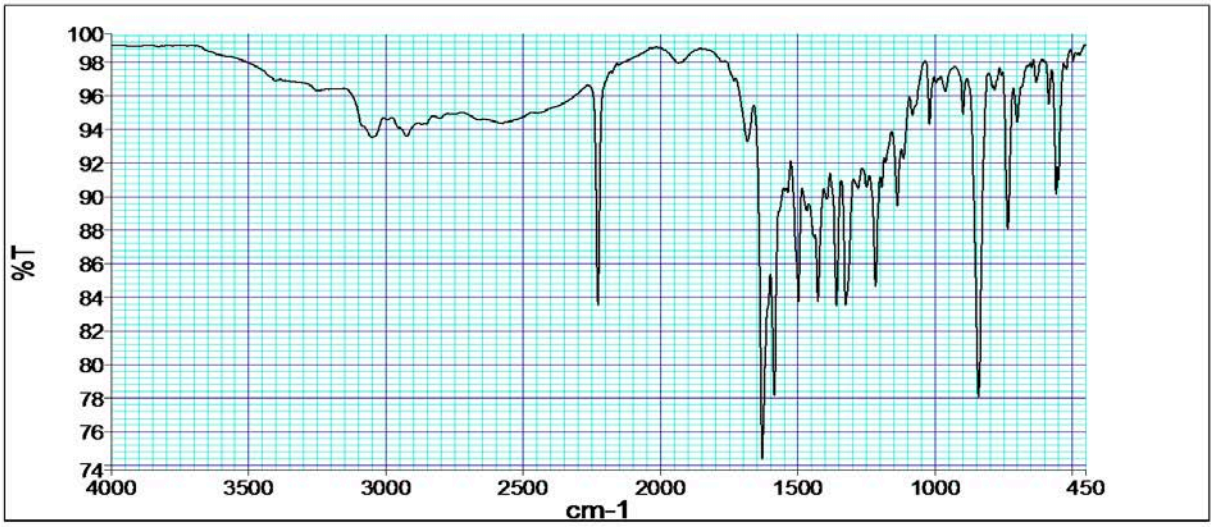
TLC: R*f* = 0.36 (33% EtOAc in Hexanes)

^{1}H NMR (500 MHz, CD_2Cl_2): δ 8.34 – 8.29 (m, 2H), 7.88 – 7.80 (m, 4H), 7.71 – 7.66 (m, 2H), 7.63 (d, *J* = 9.3 Hz, 1H), 7.52 (d, *J* = 1.3 Hz, 1H), 7.28 (d, *J* = 2.7 Hz, 1H), 7.20 (dd, *J* = 9.3, 2.7 Hz, 1H), 3.16 (s, 6H).

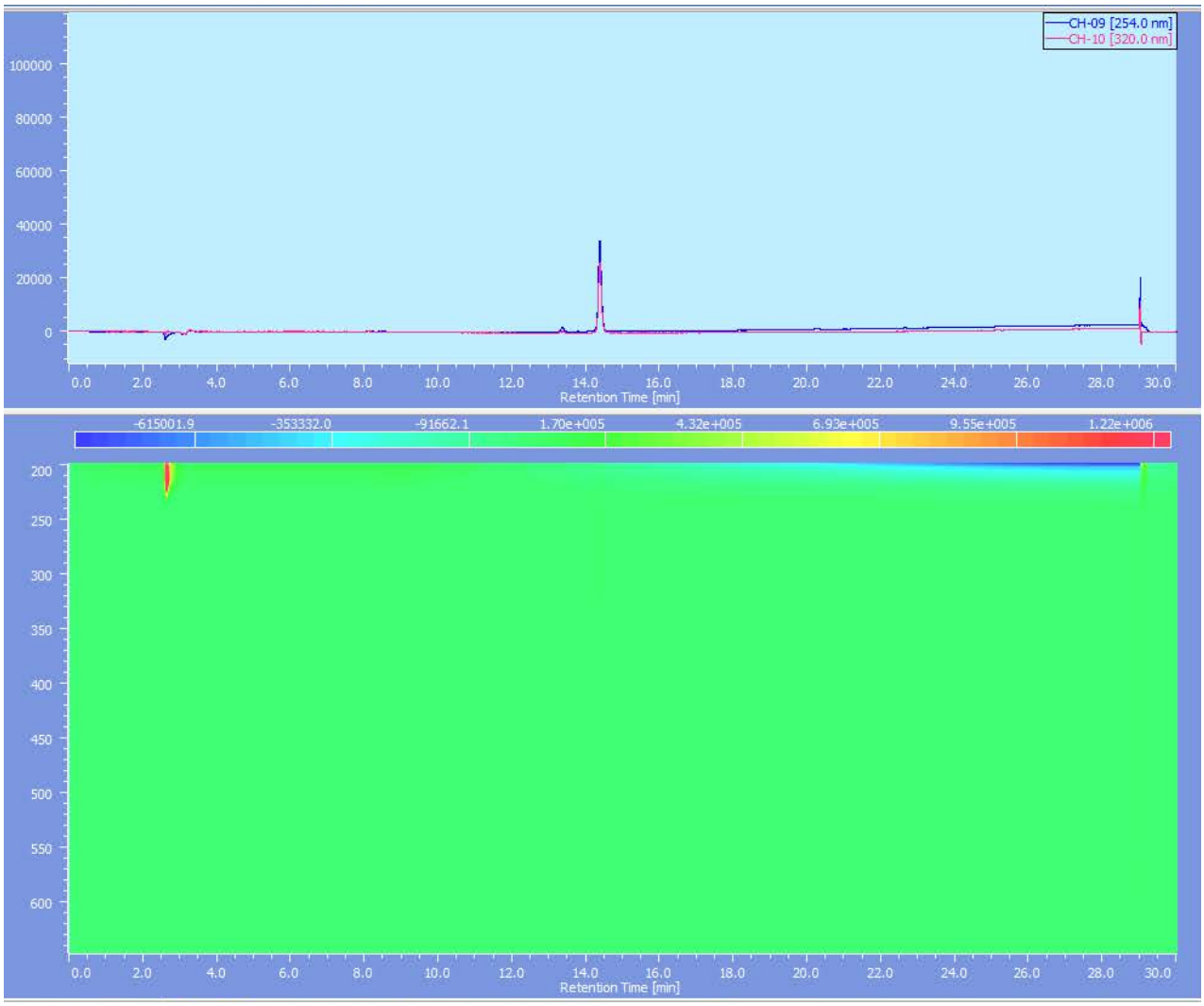
^{13}C NMR (126 MHz, CD_2Cl_2): δ 154.89, 152.01, 151.12, 147.45, 144.25, 143.74, 132.91, 132.79, 130.66, 128.19, 125.93, 119.21, 118.97, 117.99, 117.53, 115.15, 112.96, 112.67, 107.55, 40.56.

HRMS (ESI-TOF): calc'd for $C_{25}H_{19}N_4^+$ $[M+H]^+$ 375.1610; found 365.1600.

IR (neat): 3053.54, 2926.57, 2228.44, 1683.66, 1628.68, 1585.25, 1497.08, 1426.14, 1358.37, 1324.86, 1215.78, 1136.43, 1081.22, 1018.99, 896.81, 839.76, 733.07, 699.47, 583.57, 557.15 cm^{-1}



Analytical HPLC of 5i:



Fluorescence Spectra Analysis of bisarylated DMAQs (5a-5i) via Plate reader

General Procedure C

Application: **Tecan i-control**

Device**: infinite M1000Pro**

Plate: Greiner 96 Flat Bottom Black Polystyrene

Target Temperature: 25 °C

Shaking (Linear) Duration: 5s

Shaking (Linear) Amplitude: 2 mm

Shaking (Linear) Frequency: 654 rpm

Mode: **Fluorescence Top Reading**

Emission Wavelength Start: **420 nm**

Emission Wavelength End: **800 nm**

Emission Wavelength Step Size: 1 nm (pH screening)

Excitation Wavelength: **405 nm**

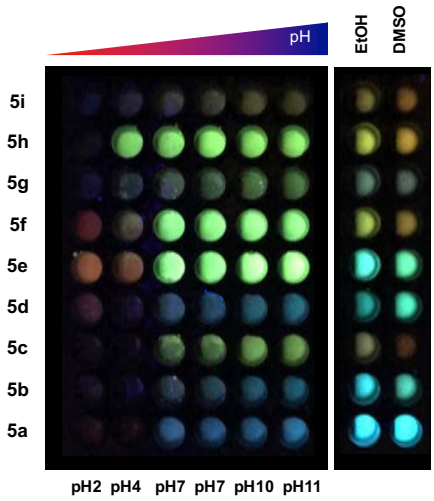
Gain: 100% Manual

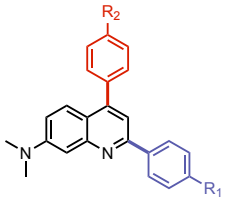
Number of Flashes: 50

Flash Frequency: 400 Hz

Maximum emission wavelength of 5a-5i and their relative intensity

A)





B)

		Emission							
	R_1-R_2	pH 2 (nm)	pH 4 (nm)	pH 6.9 (nm)	pH 7.3 (nm)	pH 10 (nm)	pH 11 (nm)	EtOH (nm)	DMSO (nm)
5a	NMe2-NMe2	618	637	469	473	472	475	480	490
5b	NMe2-H	610	603	472	475	478	479	488	503
5c	NMe2-CN	633	703	525	526	531	527	563	597
5d	H-NMe2	602	598	476	476	483	479	500	507
5e	H-H	591	594	523	525	525	531	505	510
5f	H-CN	613	530	527	524	525	526	545	565
5g	CN-NMe2	533	536	534	536	539	526	544	486
5h	CN-H	631	531	526	526	529	527	555	568
5i	CN-CN	470	547	550	550	553	554	571	588

C)

		Intensity							
	R_1-R_2	pH 2 (nm)	pH 4 (nm)	pH 6.9 (nm)	pH 7.3 (nm)	pH 10 (nm)	pH 11 (nm)	EtOH (nm)	DMSO (nm)
5a	NMe2-NMe2	256	323	2910	2667	3181	5205	21059	63820
5b	NMe2-H	164	73	1465	1173	2727	3980	12216	19949
5c	NMe2-CN	106	77	1768	1990	4004	4351	2016	1125
5d	H-NMe2	676	150	1273	1318	1896	3110	2866	12568
5e	H-H	2765	1889	11661	11813	25923	30805	30017	39902
5f	H-CN	733	1165	9919	10888	15094	16656	8527	7072
5g	CN-NMe2	111	354	980	1135	1749	2027	1457	3683
5h	CN-H	104	5597	6592	8113	7863	9546	8200	8724
5i	CN-CN	91	309	591	733	795	793	2896	3506

>50000	50000-30000	30000-10000	10000-5000	5000-2500	2500-1000	1000-500	500-100	100-0

Figure S14. 5mM stock solution in DMSO was used to screen have final 50uM of dyes in each well (1% DMSO in aqueous buffer). Compound is labeled with corresponding number as well as R_1 and R_2, which are the substituent in 2-position and 4-position of aryl rings, respectively. A) Image of plate reader under handheld UV lamp (254 nm), B) maximum emission wavelength (λ_{em}) under excitation at 405 nm, and C) relative intensity. Darker red represents higher fluorescence intensity while darker blue represents lower intensity.

Table S5. UV Absorption Spectra Analysis of DMAQs **4a-4n, 5a-5i**

	UV Abs in Methanol (nm)
3	302,390
4a	296,390
4b	306,400,494
4c	290,398
4d	290,398
4e	290,406
4f	298,412
4g	298,394
4h	298,398
4i	298,398
4j	290,398
4k	288,346,364,384,462
4l	298,398
4l'	296,394
4m	300,402
4n	294,396
5a	274,478
5b	292,490
5c	292,408,498
5d	450
5e	290,400
5f	290,406
5g	296,376
5h	298,412
5i	296,416

4l' in water with residual trifluoroacetic acid from HPLC gave red-shifted absorption 302nm and 470 nm.

Live HeLa Cell Imaging of Monoarylated DMAQ (4a-4n)

Cell imaging was done with final concentration of 5uM of dye in 0.1% DMSO in media. Each plate was incubated for 2-5 hrs. Excited with 405 nm laser with various emission filter set.

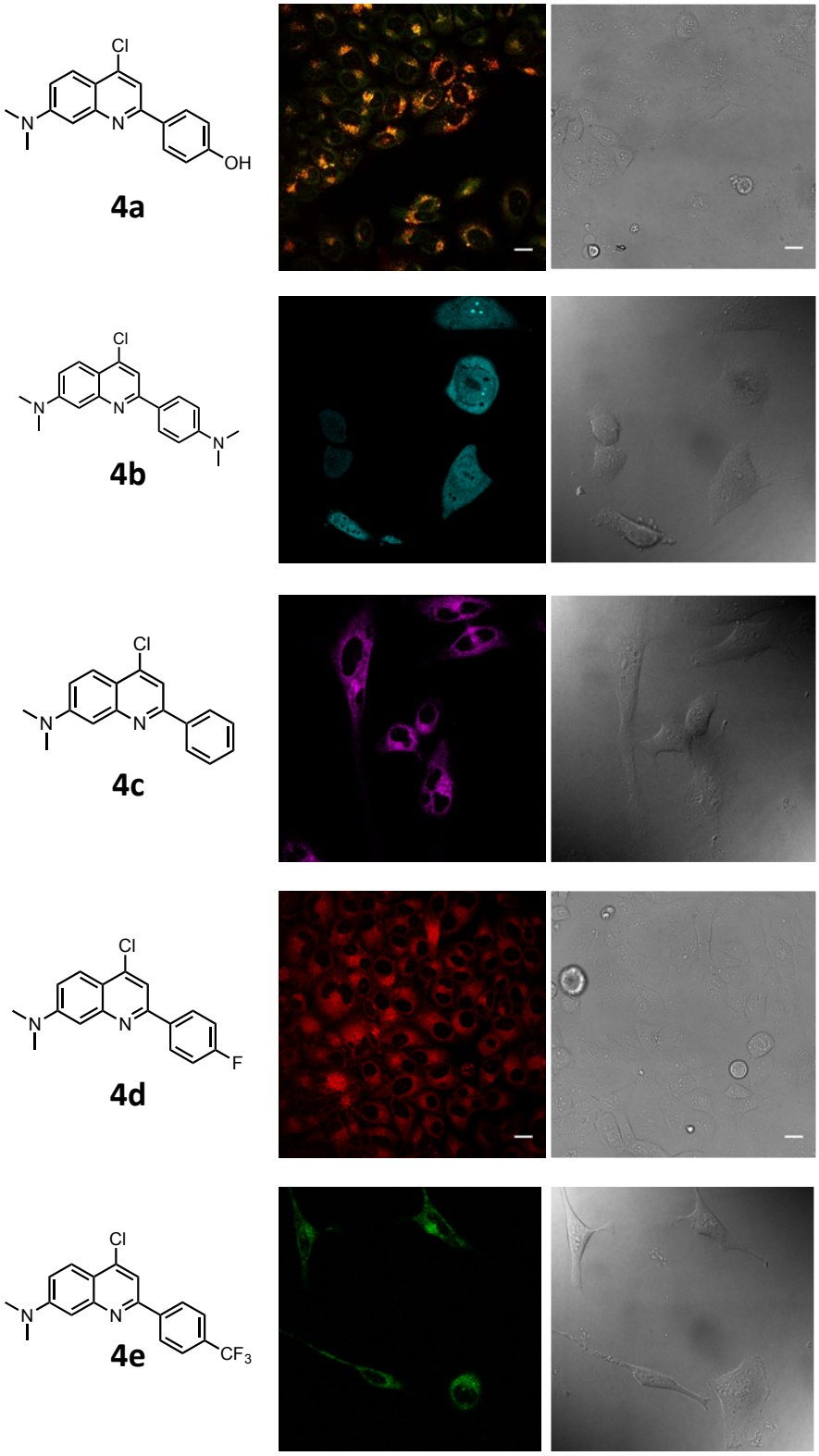


Figure S15. Live Cell imaging of monoarylated DMAQ **4a-4e.**

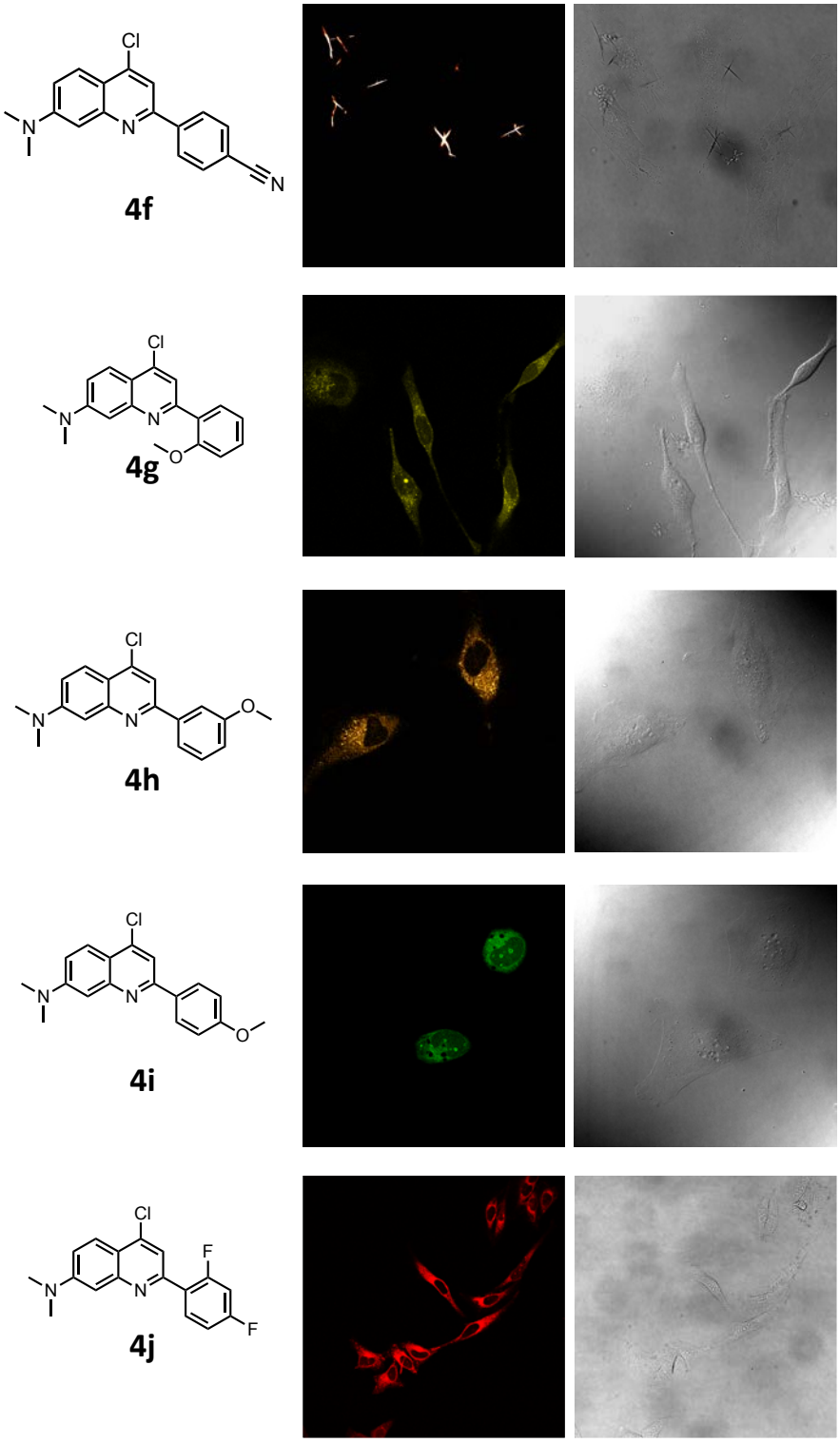


Figure S16. Live Cell imaging of monoarylated DMAQ **4f-4j.**

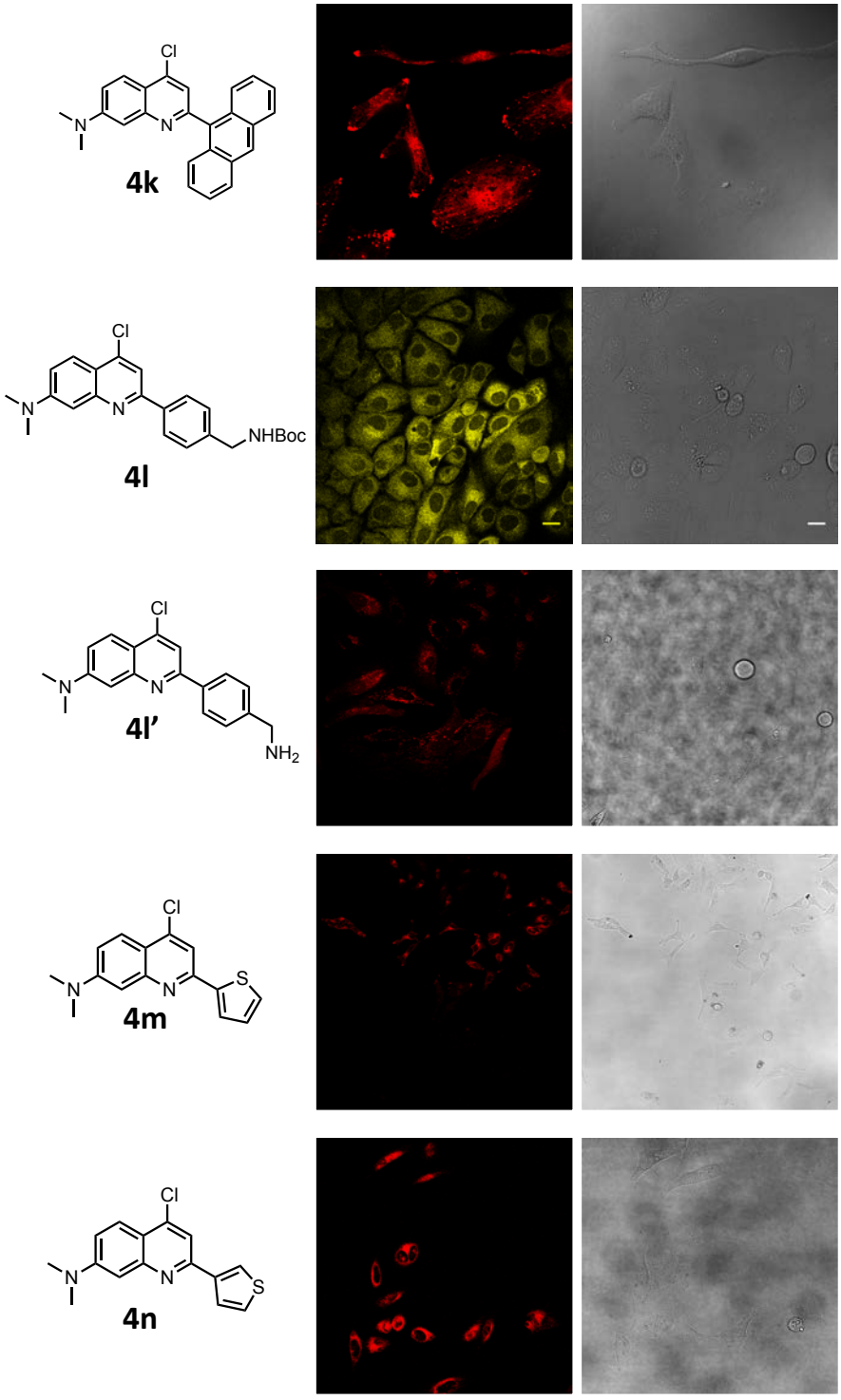


Figure S17. Live Cell imaging of monoarylated DMAQ **4k-4n.**

Selected Dual-Emissive dyes

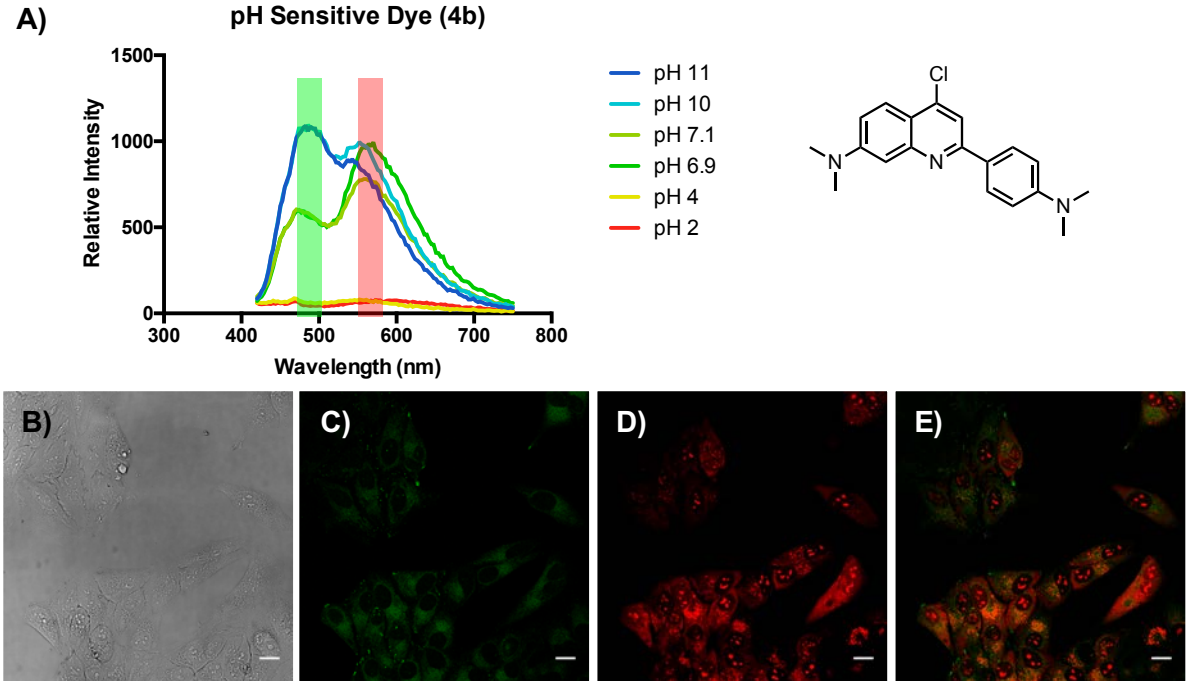


Figure S18. pH sensitive dye **4b** was irradiated with a 405 nm excitation laser A) fluorescence emission spectra from plate reader (Figure 3), B) bright field image, C) emission filter at 450-500 nm, D) emission filter at 550-600 nm, and E) merged image.

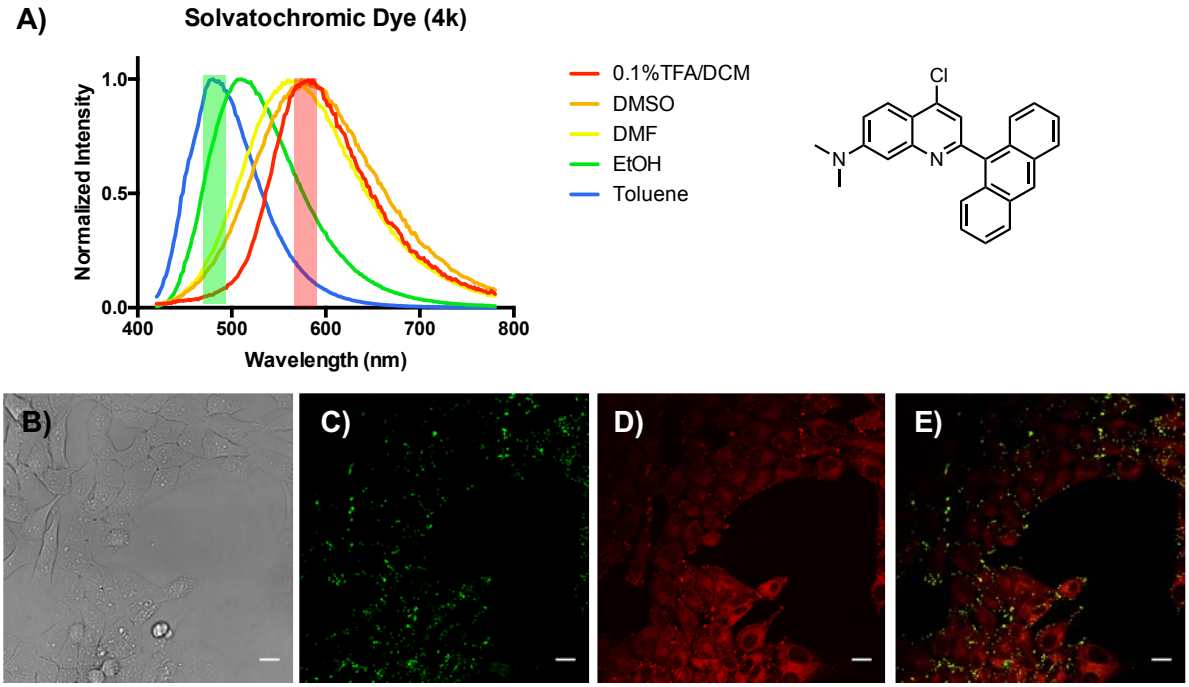


Figure S19. Solvatochromic dye **4k** was irradiated with a 405 nm excitation laser. A) fluorescence emission spectra from plate reader (Figure 3), B) bright field image, C) emission filter at 450-500 nm, D) emission filter at 550-600 nm, and E) merged image.

Live HeLa Cell Imaging of Bisarylated DMAQ (5a-5i)

Top spectra are extracted from the plate reader (excitation at 405 nm). Cell imaging was done with a 405 nm laser. Each emission filter set is highlighted in the spectra above.

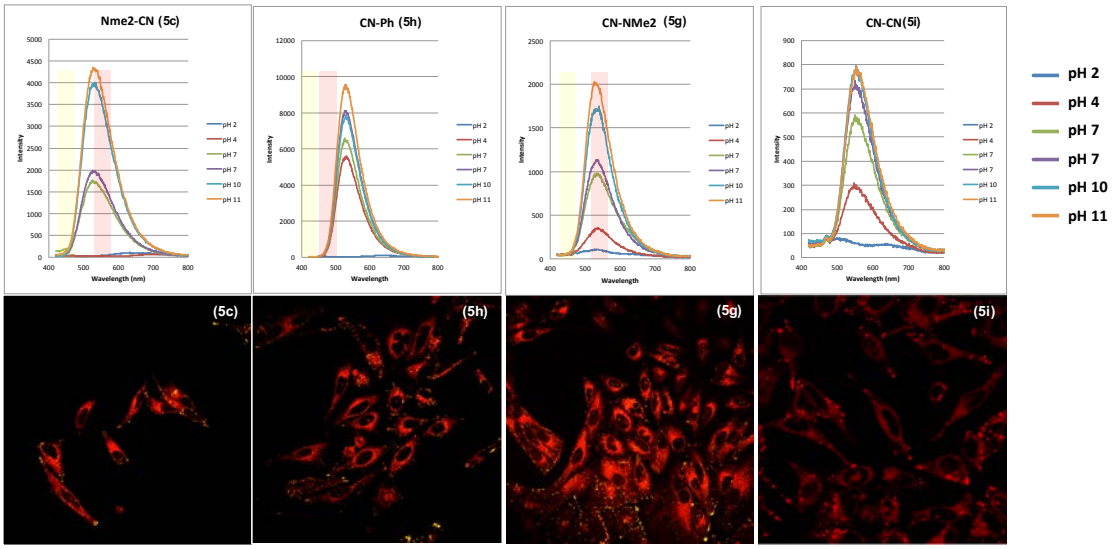


Figure S20. pH dependent intensity sensitive dyes **5c, 5h, 5g,** and **5i**

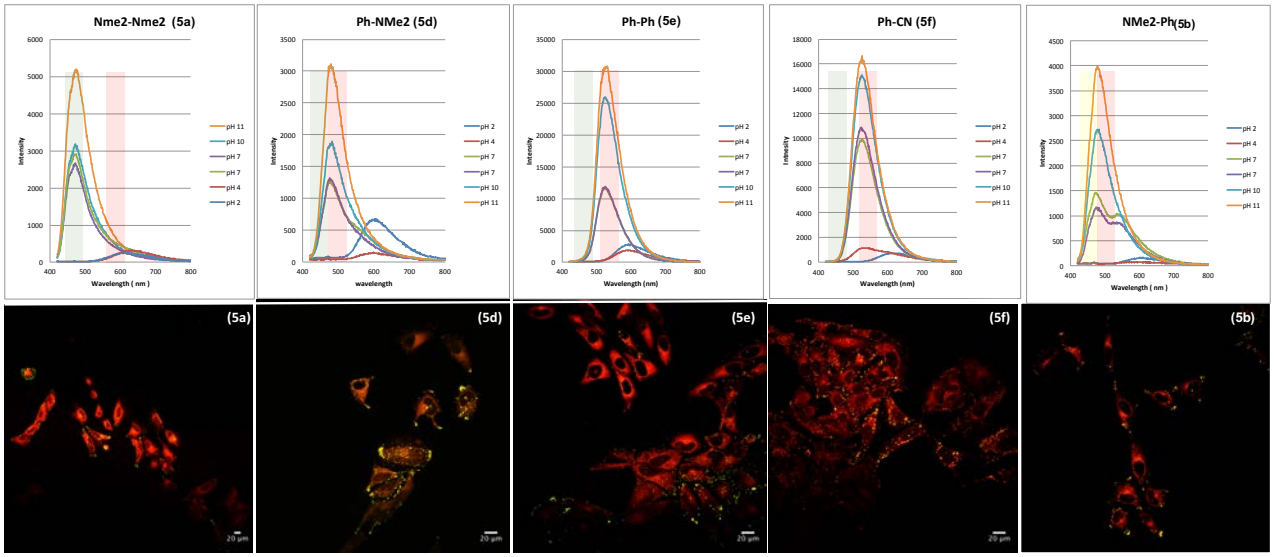


Figure S21. pH dependent dual emissive dyes **5a, 5d, 5e, 5f,** and **5b**

Cell Cytotoxicity

Experiments followed the alamarBlue® Cell Viability Assay Protocol. Compounds were measured in quadruplicate. Positive controls were made with 0 to 1% DMSO, and negative controls were made by treating with hydrogen peroxide. Cells were incubated for 64 h in 0.1% DMSO in two different final concentration. The plate reader was used.

Reading: excitation at 570 nm, emission at 600 nm, Top reading, 37 °C.

Table S6. Cell cytotoxicity of selected compounds in two different concentration

Compounds	5μM (%)	1μM (%)
4a	83	86
4b	81	84
4k	92	93
5a	88	112

Solid State Emission

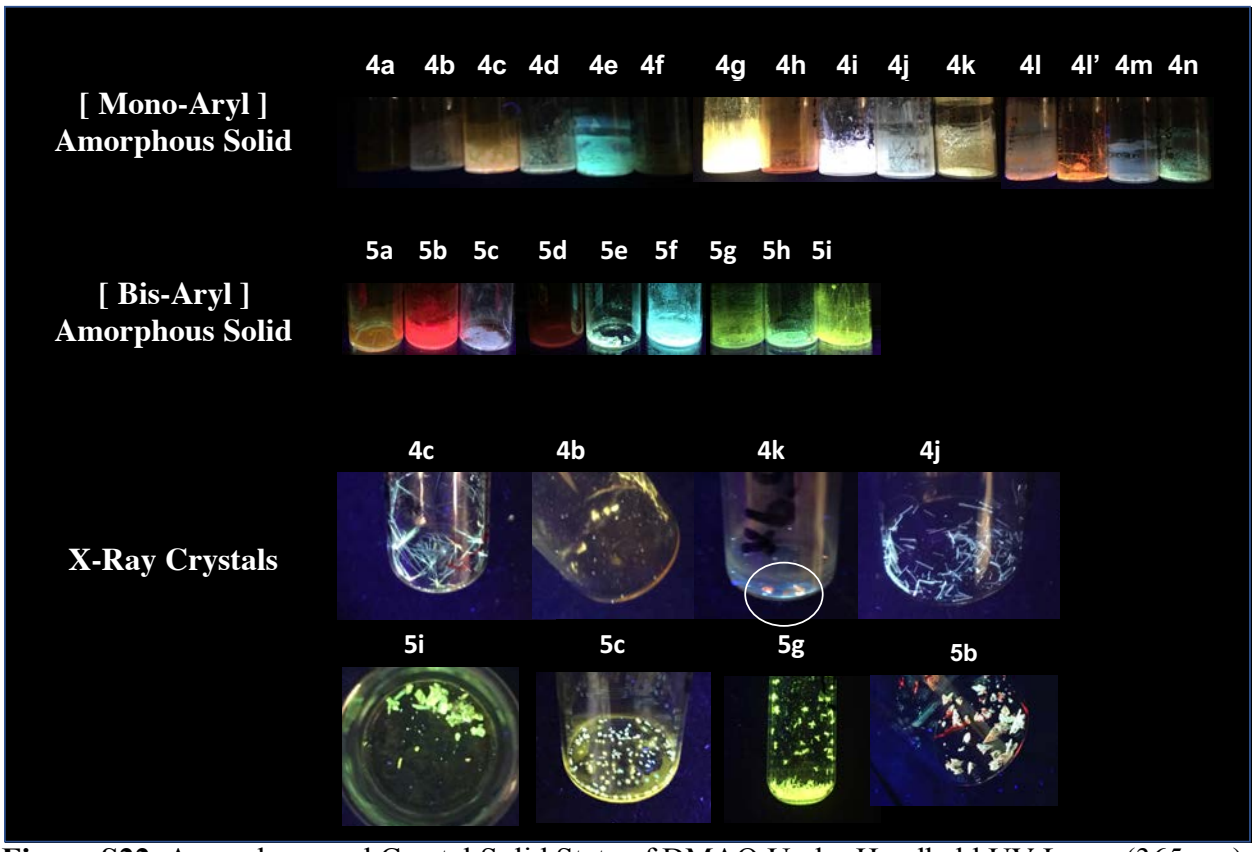


Figure S22. Amorphous and Crystal Solid State of DMAQ Under Handheld UV Lamp (365 nm)

X-ray Structure Determination.

Table of Compounds

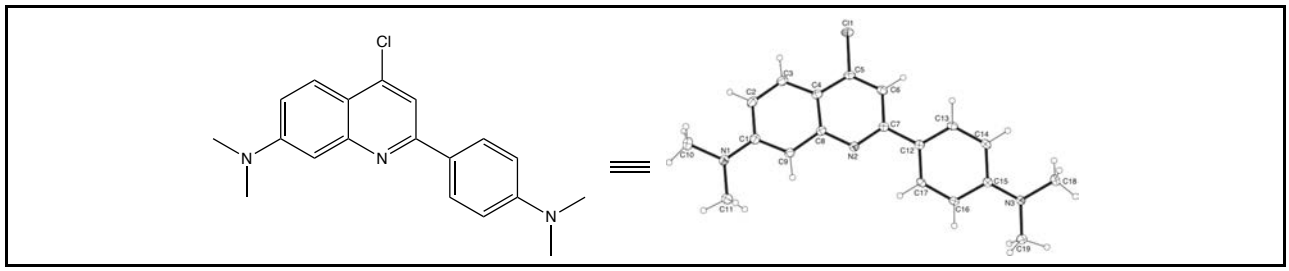


Figure S23. ORTEP drawing of the title compound **4b** with 50% thermal ellipsoids.

Table S7. Summary of Structure Determination of Compound **4b**

Empirical formula	$C_{38}H_{40}Cl_2N_6$
Formula weight	651.66
Temperature/K	100
Crystal system	triclinic
Space group	P$\bar{1}$
a	7.2999(3)Å
b	11.4015(4)Å
c	19.5644(9)Å
α	102.4030(10)°
β	92.022(2)°
γ	90.205(2)°
Volume	1589.24(11)Å^3
Z	2
d_{calc}	1.362 g/cm^3
μ	0.244 mm^{-1}
F(000)	688.0
Crystal size, mm	0.48 × 0.35 × 0.02
2θ range for data collection	5.904 - 55.13°
Index ranges	$-9 \le h \le 9$, $-14 \le k \le 13$, $-25 \le l \le 25$
Reflections collected	66713
Independent reflections	7344[R(int) = 0.0335]
Data/restraints/parameters	7344/0/423
Goodness-of-fit on F^2	1.036
Final R indexes [I>=2σ (I)]	R_1 = 0.0327, wR_2 = 0.0841
Final R indexes [all data]	R_1 = 0.0384, wR_2 = 0.0881
Largest diff. peak/hole	0.34/-0.33 eÅ^{-3}

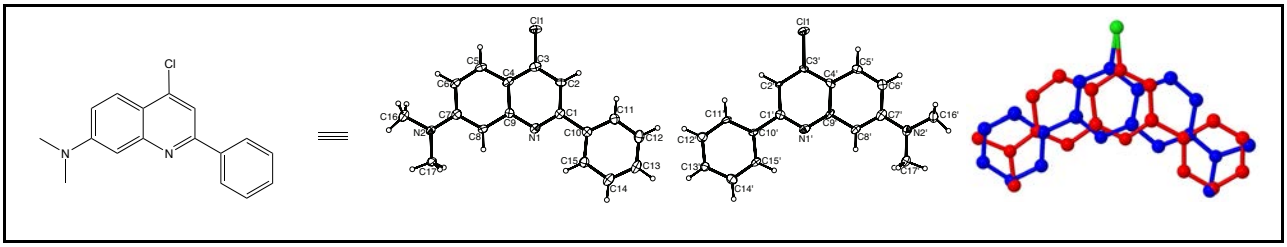


Figure S24. ORTEP drawing of the title compound **4c** with 50% thermal ellipsoids.

Table S8. Summary of Structure Determination of Compound **4c**

Empirical formula	$C_{17}H_{15}N_2Cl$
Formula weight	282.76
Temperature/K	100
Crystal system	monoclinic
Space group	$P2_1/c$
a	14.8016(6)Å
b	3.8248(2)Å
c	24.8987(10)Å
β	106.0000(10)°
Volume	1354.99(11)$Å^3$
Z	4
d_{calc}	1.386 g/cm^3
μ	0.272 mm^{-1}
F(000)	592.0
Crystal size, mm	0.45 × 0.12 × 0.02
2θ range for data collection	5.8 - 50.76°
Index ranges	$-17 \le h \le 17$, $-4 \le k \le 4$, $-30 \le l \le 25$
Reflections collected	34694
Independent reflections	2485[R(int) = 0.0389]
Data/restraints/parameters	2485/336/285
Goodness-of-fit on F^2	1.117
Final R indexes [I>=2σ (I)]	R_1 = 0.0385, wR_2 = 0.0982
Final R indexes [all data]	R_1 = 0.0446, wR_2 = 0.1107
Largest diff. peak/hole	0.29/-0.48 e$Å^{-3}$

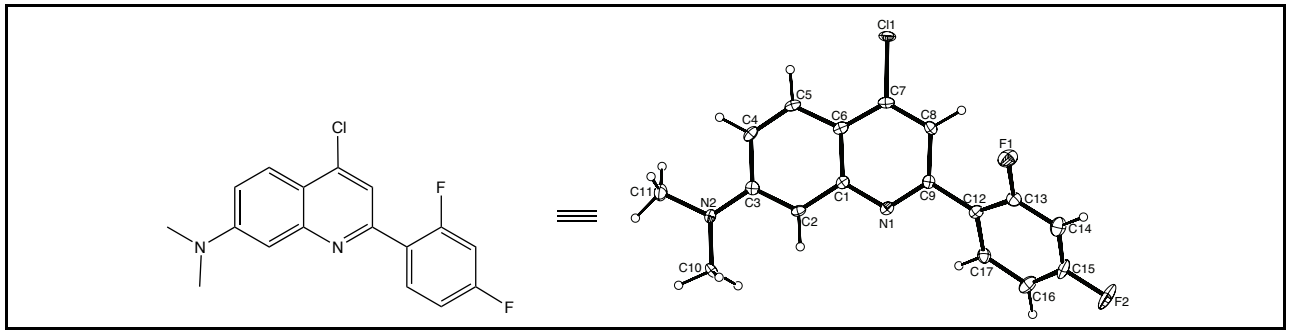


Figure S25. ORTEP drawing of the title compound **4j** with 50% thermal ellipsoids.

Table S9. Summary of Structure Determination of Compound **4j**

Empirical formula	$C_{17}H_{13}ClF_2N_2$
Formula weight	318.74
Temperature/K	100
Crystal system	monoclinic
Space group	$P2_1/n$
a	16.2916(14)Å
b	3.7822(3)Å
c	22.808(2)Å
β	96.651(3)°
Volume	1395.9(2)Å^3
Z	4
d_{calc}	1.517 g/cm^3
μ	0.293 mm^{-1}
F(000)	656.0
Crystal size, mm	0.29 × 0.05 × 0.05
2θ range for data collection	2.918 - 50.812°
Index ranges	$-19 \le h \le 19$, $-3 \le k \le 4$, $-27 \le l \le 27$
Reflections collected	8584
Independent reflections	2539[R(int) = 0.0410]
Data/restraints/parameters	2539/0/201
Goodness-of-fit on F^2	1.109
Final R indexes [I>=2σ (I)]	R_1 = 0.0435, wR_2 = 0.1266
Final R indexes [all data]	R_1 = 0.0636, wR_2 = 0.1432
Largest diff. peak/hole	0.33/-0.29 eÅ^{-3}

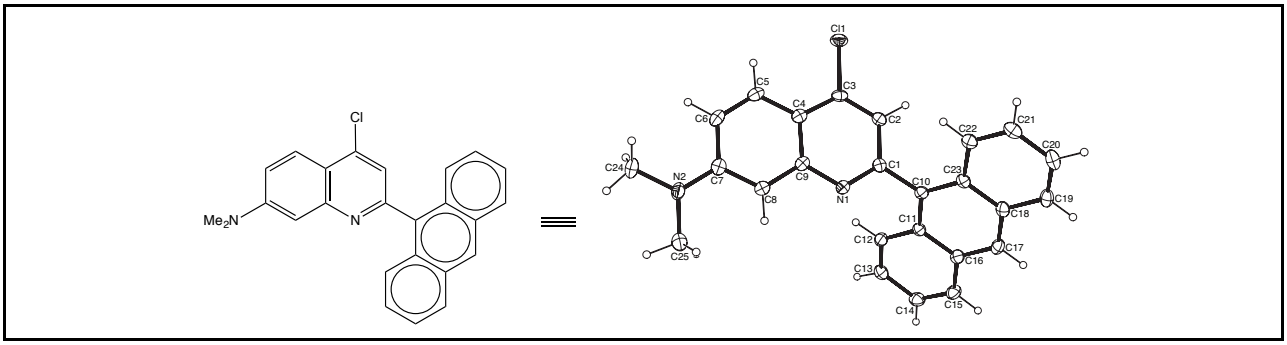


Figure S26 ORTEP drawing of the title compound **4k** with 50% thermal ellipsoids.

Table S10. Summary of Structure Determination of Compound **4k**

Empirical formula	$C_{25}H_{19}ClN_2$
Formula weight	382.87
Temperature/K	100
Crystal system	monoclinic
Space group	$P2_1/c$
a	15.3538(4)Å
b	7.8662(2)Å
c	15.3729(4)Å
β	98.639(2)°
Volume	1835.61(8)Å^3
Z	4
d_{calc}	1.385 g/cm^3
μ	0.222 mm^{-1}
F(000)	800.0
Crystal size, mm	0.38 × 0.25 × 0.15
2θ range for data collection	5.36 - 50.892°
Index ranges	$-17 \le h \le 18$, $-9 \le k \le 9$, $-18 \le l \le 18$
Reflections collected	17086
Independent reflections	3384[R(int) = 0.0241]
Data/restraints/parameters	3384/0/255
Goodness-of-fit on F^2	1.036
Final R indexes [I>=2σ (I)]	R_1 = 0.0339, wR_2 = 0.0891
Final R indexes [all data]	R_1 = 0.0390, wR_2 = 0.0933
Largest diff. peak/hole	0.29/-0.23 eÅ^{-3}

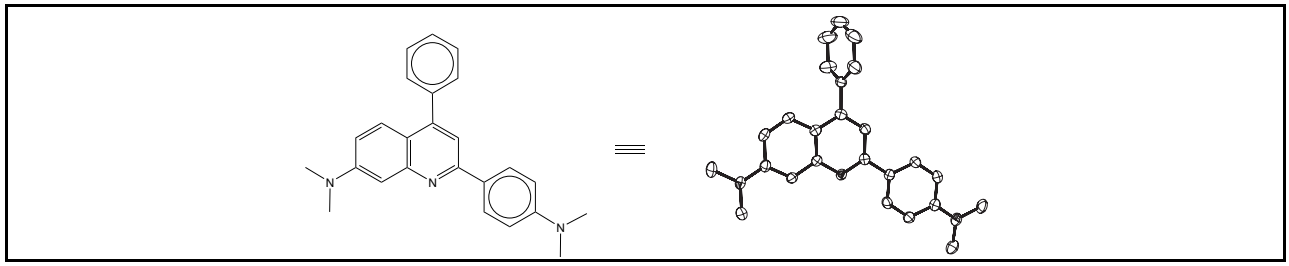


Figure S27. ORTEP drawing of the title compound **5b** with 50% thermal ellipsoids.

Table S11. Summary of Structure Determination of Compound **5b.**

Empirical formula	$C_{25}H_{25}N_3$
Formula weight	367.48
Temperature/K	173
Crystal system	monoclinic
Space group	$P2_1/c$
a	15.9363(7)Å
b	10.7056(5)Å
c	12.5061(6)Å
β	112.986(2)°
Volume	1964.23(16)$Å^3$
Z	4
d_{calc}	1.243 g/cm^3
μ	0.074 mm^{-1}
F(000)	784.0
Crystal size, mm	0.23 × 0.15 × 0.07
2θ range for data collection	6.512 - 50.826°
Index ranges	$-19 \le h \le 19$, $-12 \le k \le 12$, $-15 \le l \le 15$
Reflections collected	25815
Independent reflections	3597[R(int) = 0.0505]
Data/restraints/parameters	3597/0/257
Goodness-of-fit on F^2	1.044
Final R indexes [I>=2σ (I)]	$R_1 = 0.0506$, $wR_2 = 0.1140$
Final R indexes [all data]	$R_1 = 0.0768$, $wR_2 = 0.1277$
Largest diff. peak/hole	0.16/-0.23 $eÅ^{-3}$

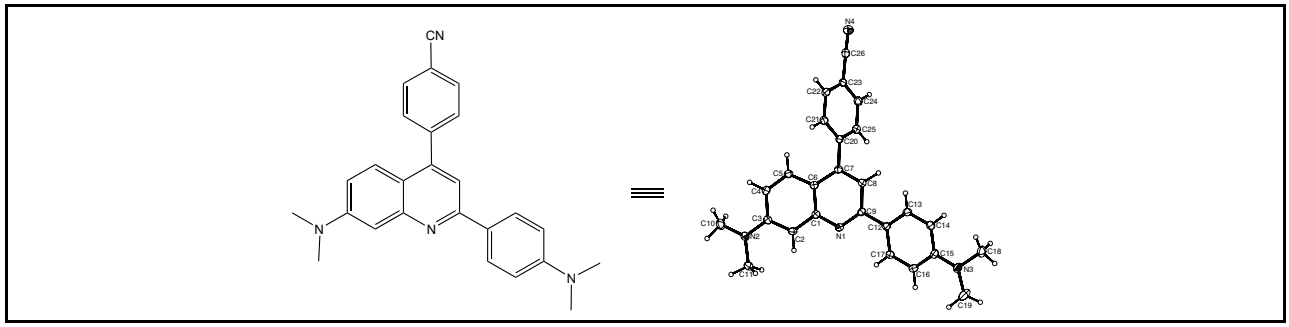


Figure S28. ORTEP drawing of the title compound **5c** with 50% thermal ellipsoids.

Table S12. Summary of Structure Determination of Compound **5c**

Empirical formula	$C_{26}H_{24}N_4$
Formula weight	392.49
Temperature/K	100
Crystal system	monoclinic
Space group	$P2_1/c$
a	14.4066(9)Å
b	10.7927(7)Å
c	13.7564(8)Å
β	108.248(3)°
Volume	2031.4(2)Å^3
Z	4
d_{calc}	1.283 g/cm^3
μ	0.077 mm^{-1}
F(000)	832.0
Crystal size, mm	0.21 × 0.19 × 0.16
2θ range for data collection	4.808 - 55.062°
Index ranges	$-18 \leq h \leq 18$, $-14 \leq k \leq 14$, $-16 \leq l \leq 17$
Reflections collected	39603
Independent reflections	4684[R(int) = 0.0332]
Data/restraints/parameters	4684/0/275
Goodness-of-fit on F^2	1.037
Final R indexes [I>=2σ (I)]	$R_1 = 0.0395$, $wR_2 = 0.1069$
Final R indexes [all data]	$R_1 = 0.0483$, $wR_2 = 0.1137$
Largest diff. peak/hole	0.34/-0.23 eÅ^{-3}

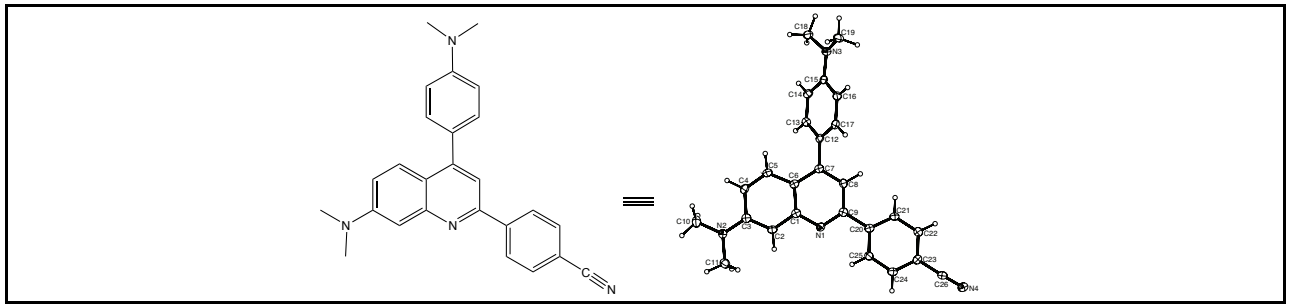


Figure S29. ORTEP drawing of the title compound **5g** with 50% thermal ellipsoids.

Table S13. Summary of Structure Determination of Compound **5g**

Empirical formula	$C_{26}H_{24}N_4$
Formula weight	392.49
Temperature/K	100
Crystal system	monoclinic
Space group	$P2_1/c$
a	7.9594(6)Å
b	23.7805(14)Å
c	10.9661(8)Å
β	104.779(3)°
Volume	2007.0(2)Å^3
Z	4
d_{calc}	1.299 g/cm^3
μ	0.078 mm^{-1}
F(000)	832.0
Crystal size, mm	0.28 × 0.12 × 0.03
2θ range for data collection	3.426 - 50.976°
Index ranges	$-9 \le h \le 9$, $-28 \le k \le 28$, $-13 \le l \le 13$
Reflections collected	14855
Independent reflections	3708[R(int) = 0.0407]
Data/restraints/parameters	3708/0/275
Goodness-of-fit on F^2	1.110
Final R indexes [I>=2σ (I)]	R_1 = 0.0400, wR_2 = 0.1073
Final R indexes [all data]	R_1 = 0.0665, wR_2 = 0.1349
Largest diff. peak/hole	0.25/-0.30 eÅ^{-3}

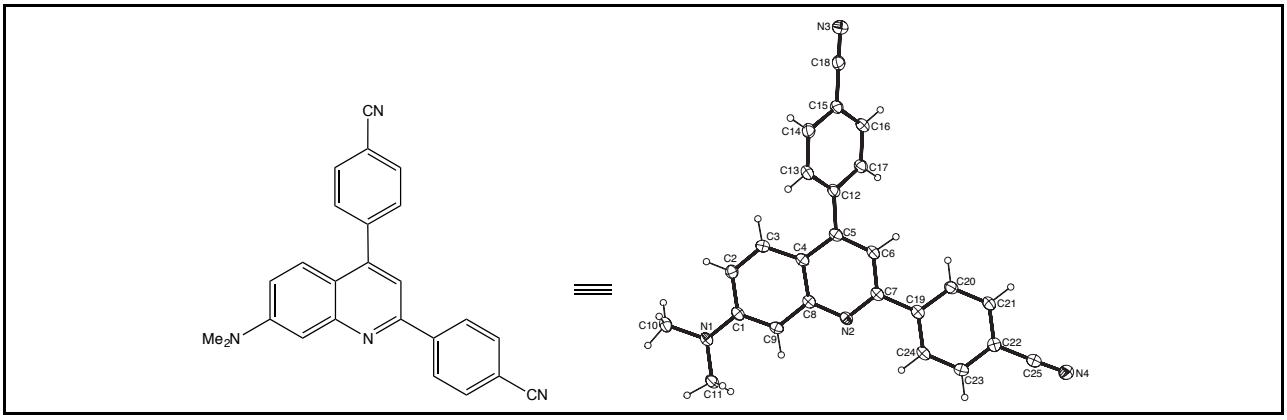


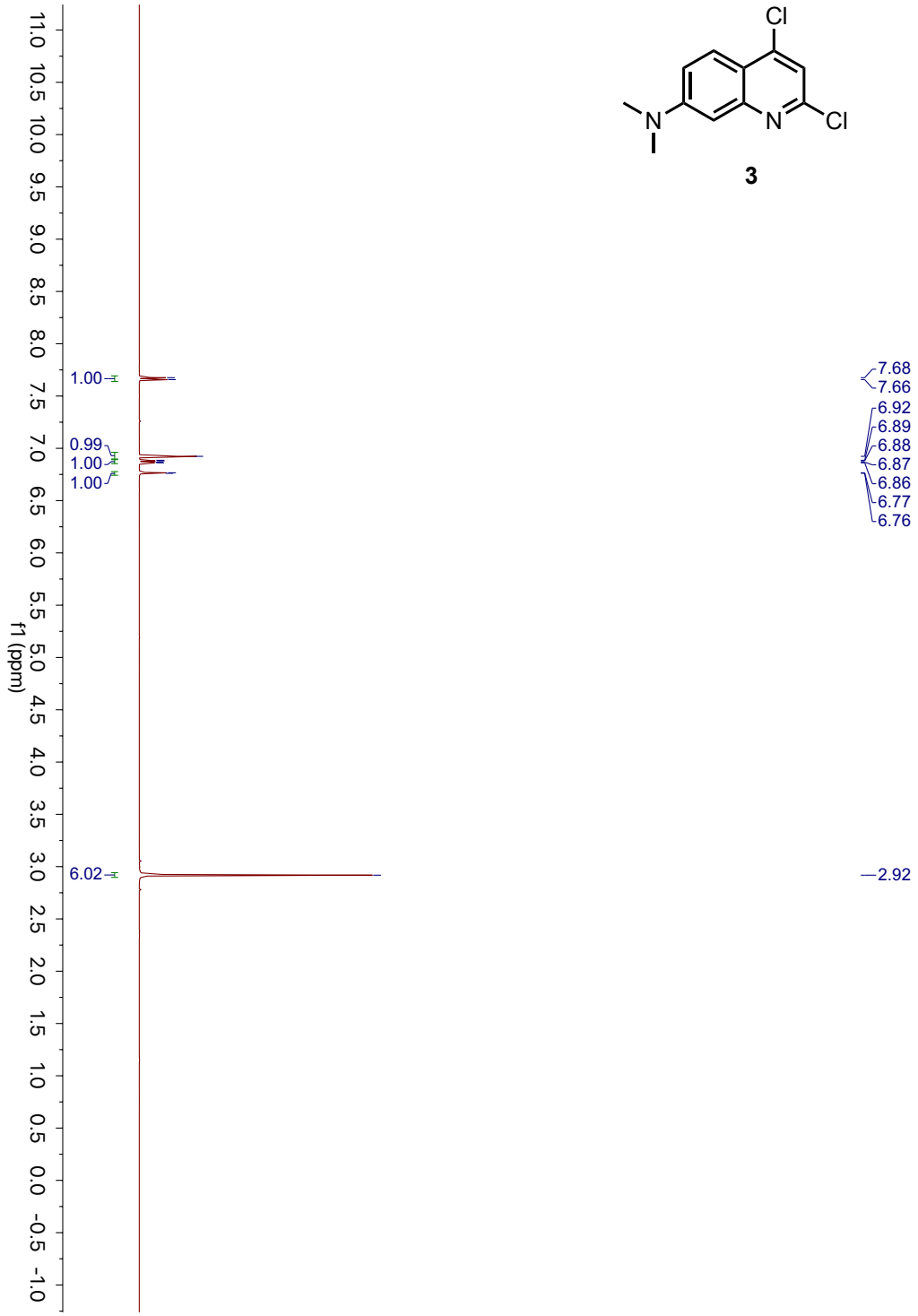
Figure S30. ORTEP drawing of the title compound **5i** with 50% thermal ellipsoids.

Table S14. Summary of Structure Determination of Compound **5i**

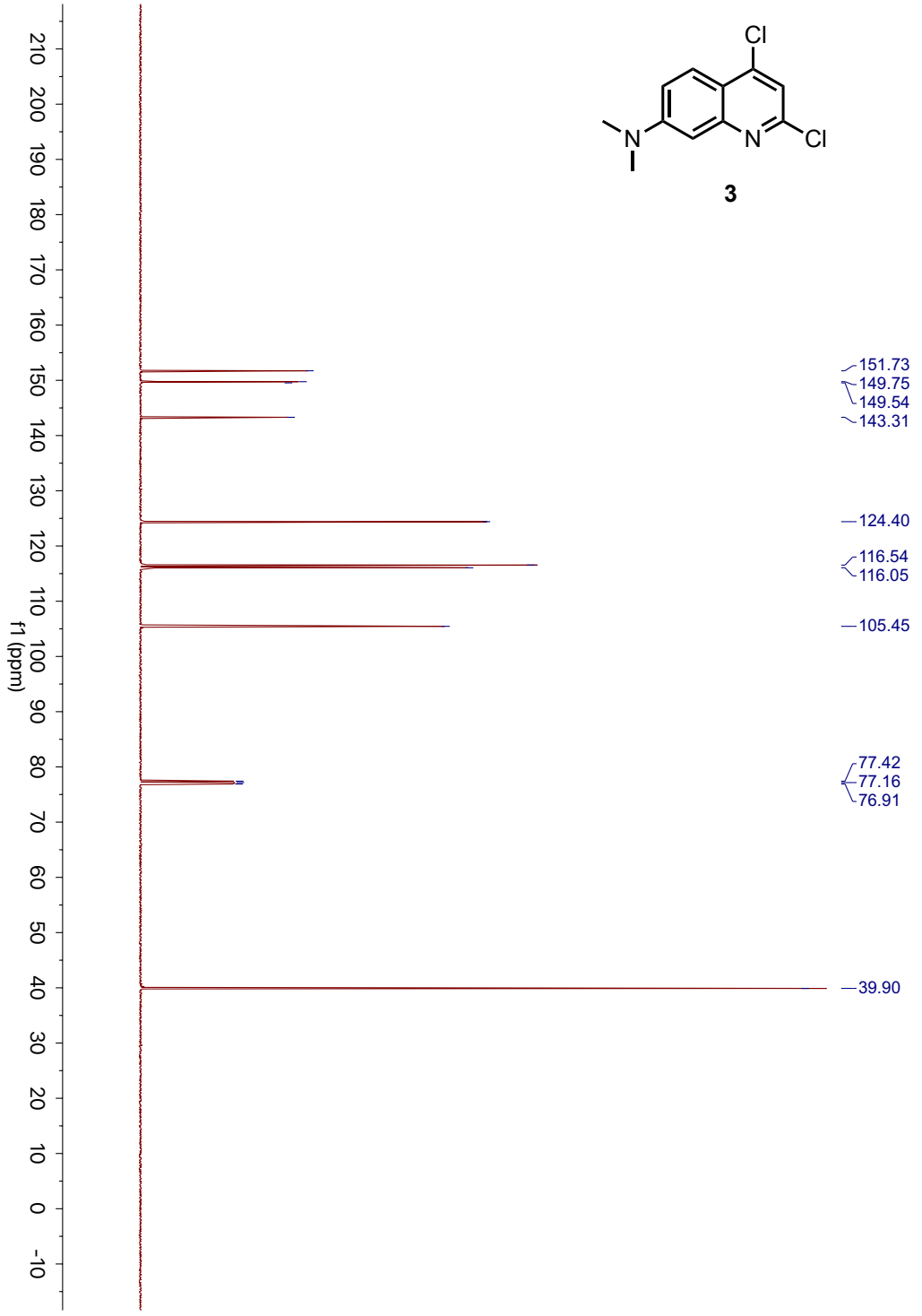
Empirical formula	$C_{25}H_{18}N_4$
Formula weight	374.43
Temperature/K	100
Crystal system	monoclinic
Space group	$P2_1/c$
a	12.1596(3)Å
b	18.6109(5)Å
c	8.2523(2)Å
β	91.7830(10)°
Volume	1866.60(8)Å^3
Z	4
d_{calc}	1.332 g/cm^3
μ	0.081 mm^{-1}
F(000)	784.0
Crystal size, mm	0.38 × 0.23 × 0.18
2θ range for data collection	3.352 - 50.8°
Index ranges	$-14 \le h \le 14$, $-22 \le k \le 22$, $-9 \le l \le 9$
Reflections collected	61870
Independent reflections	3424[R(int) = 0.0184]
Data/restraints/parameters	3424/0/264
Goodness-of-fit on F^2	1.029
Final R indexes [I>=2σ (I)]	R_1 = 0.0320, wR_2 = 0.0844
Final R indexes [all data]	R_1 = 0.0344, wR_2 = 0.0871
Largest diff. peak/hole	0.17/-0.20 eÅ^{-3}

Table of Compounds for ^{1}H and ^{13}C NMR Analysis

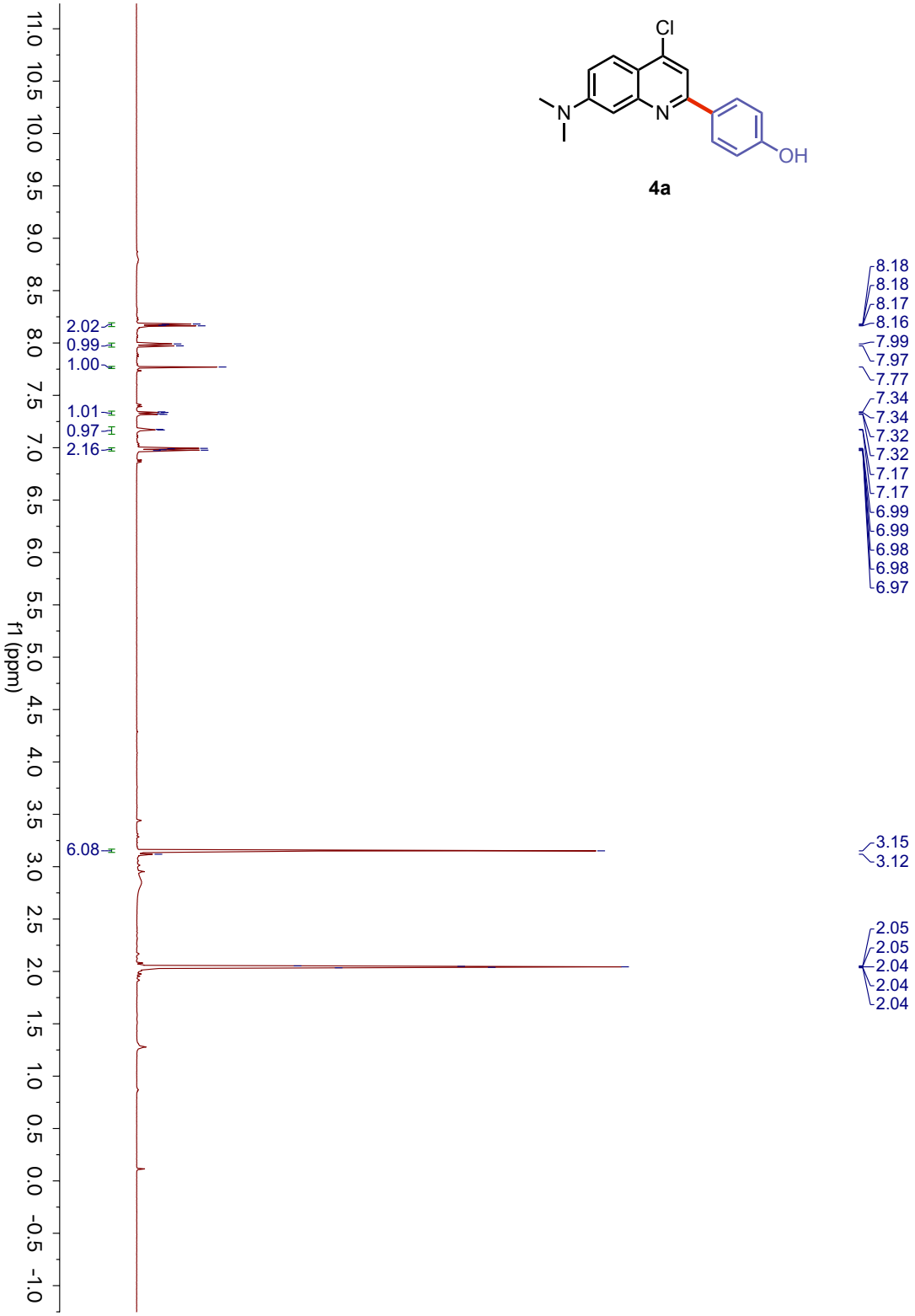
^{1}H NMR spectrum of **3** in $CDCl_3$ (500 MHz).



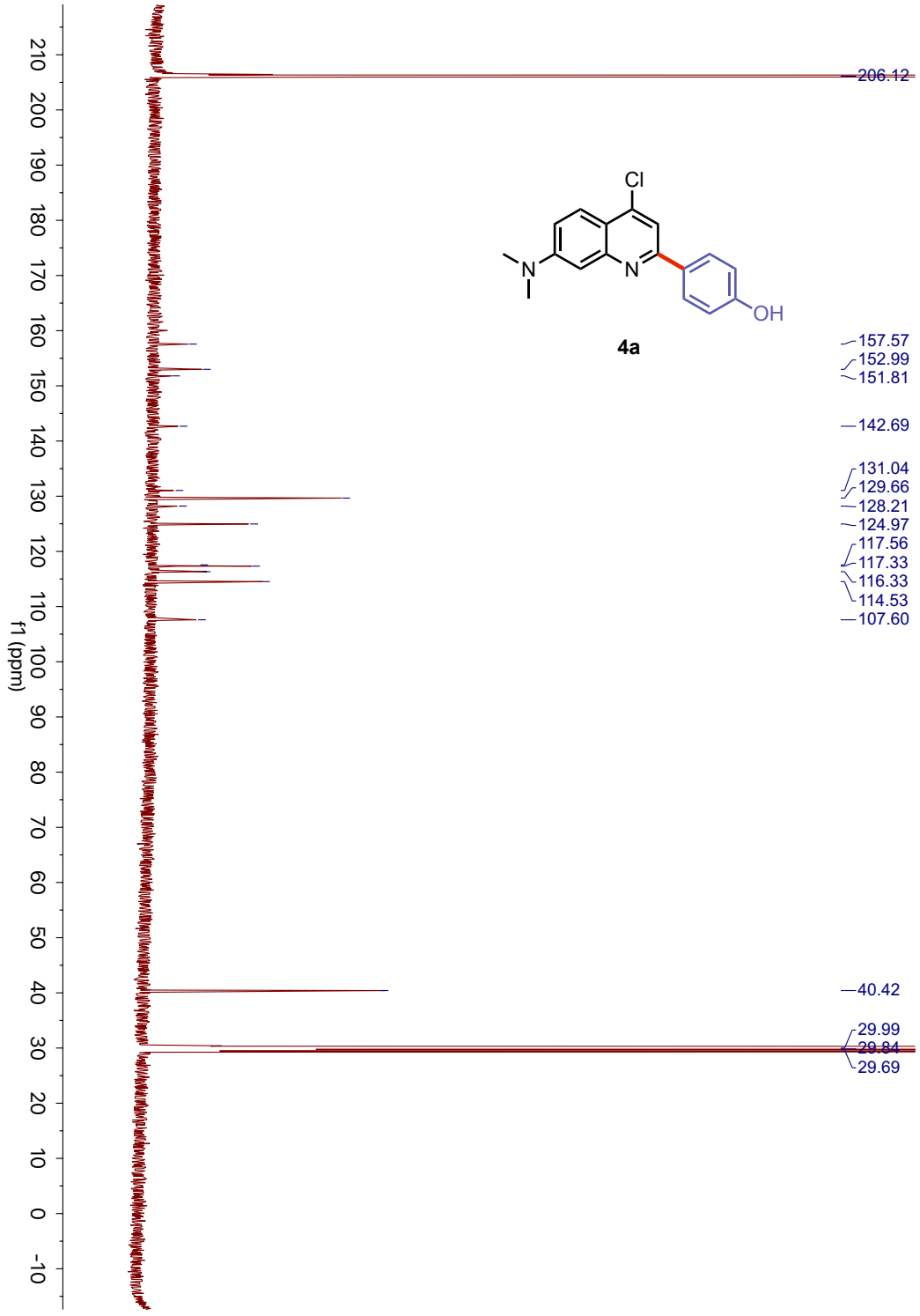
^{13}C NMR spectrum of **3** in $CDCl_3$ (126 MHz).



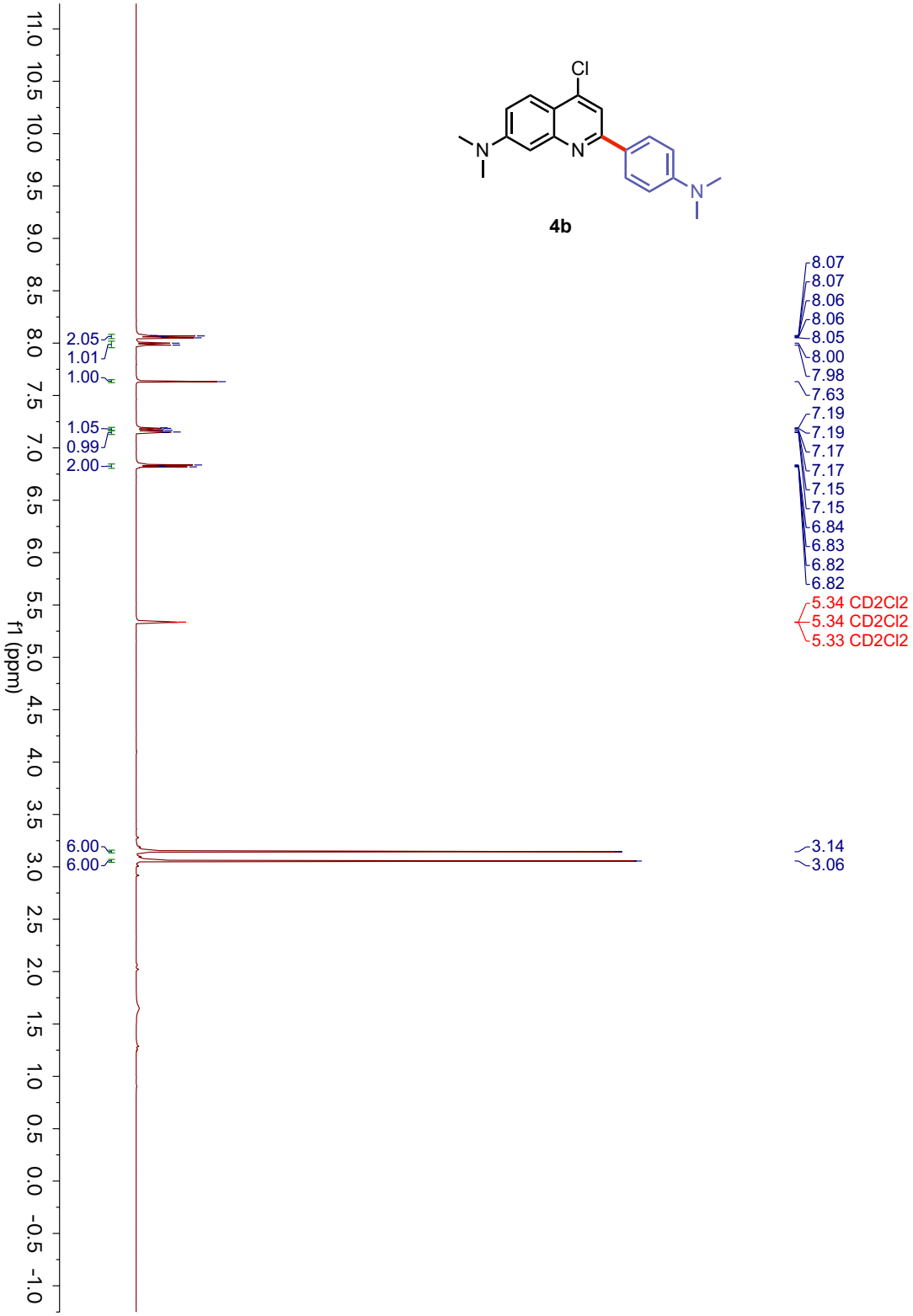
^{1}H NMR spectrum of **4a** in $(CD_3)_2CO$ (500 MHz).



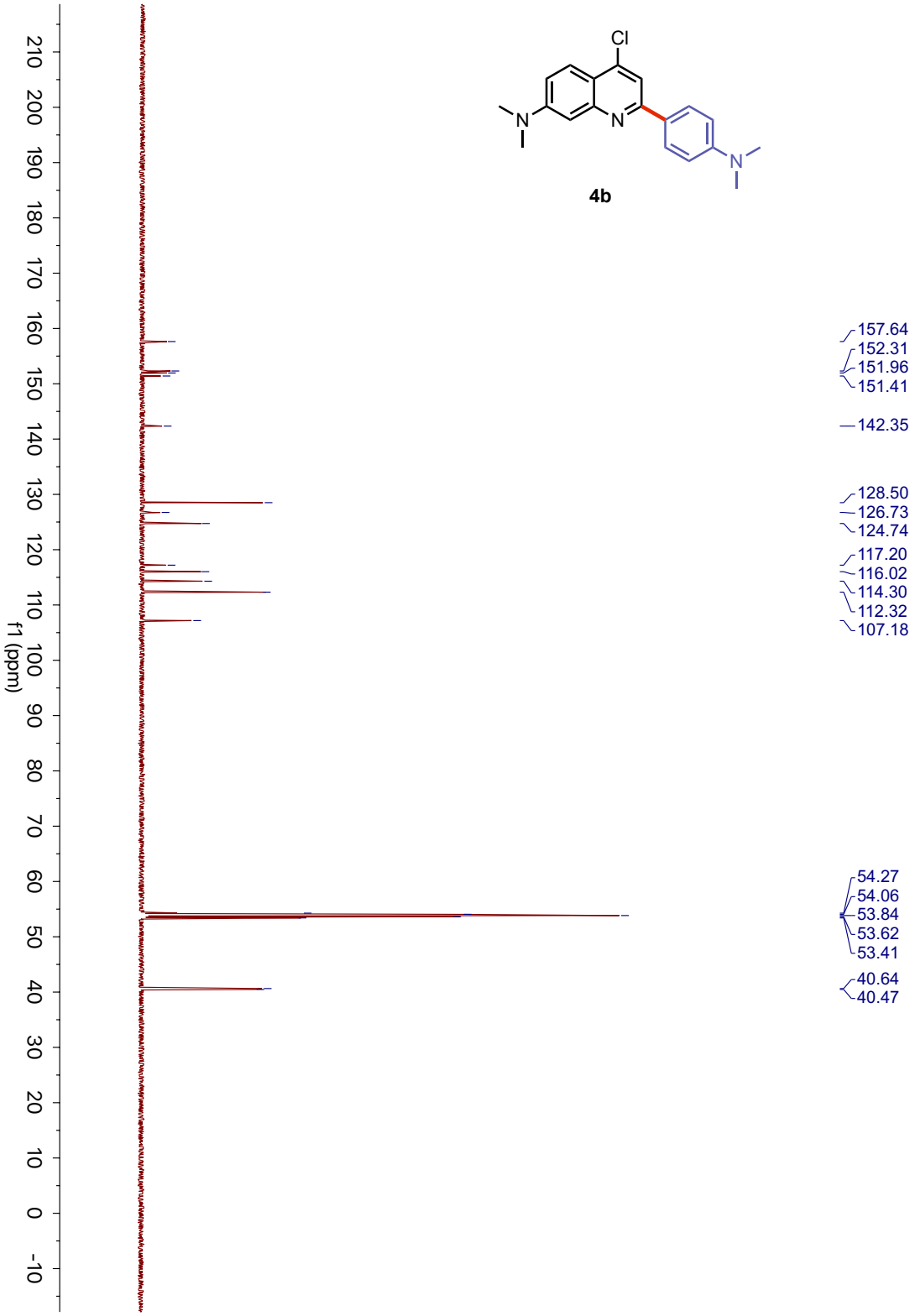
^{13}C NMR spectrum of **4a** in $(CD_3)_2CO$ (126 MHz).



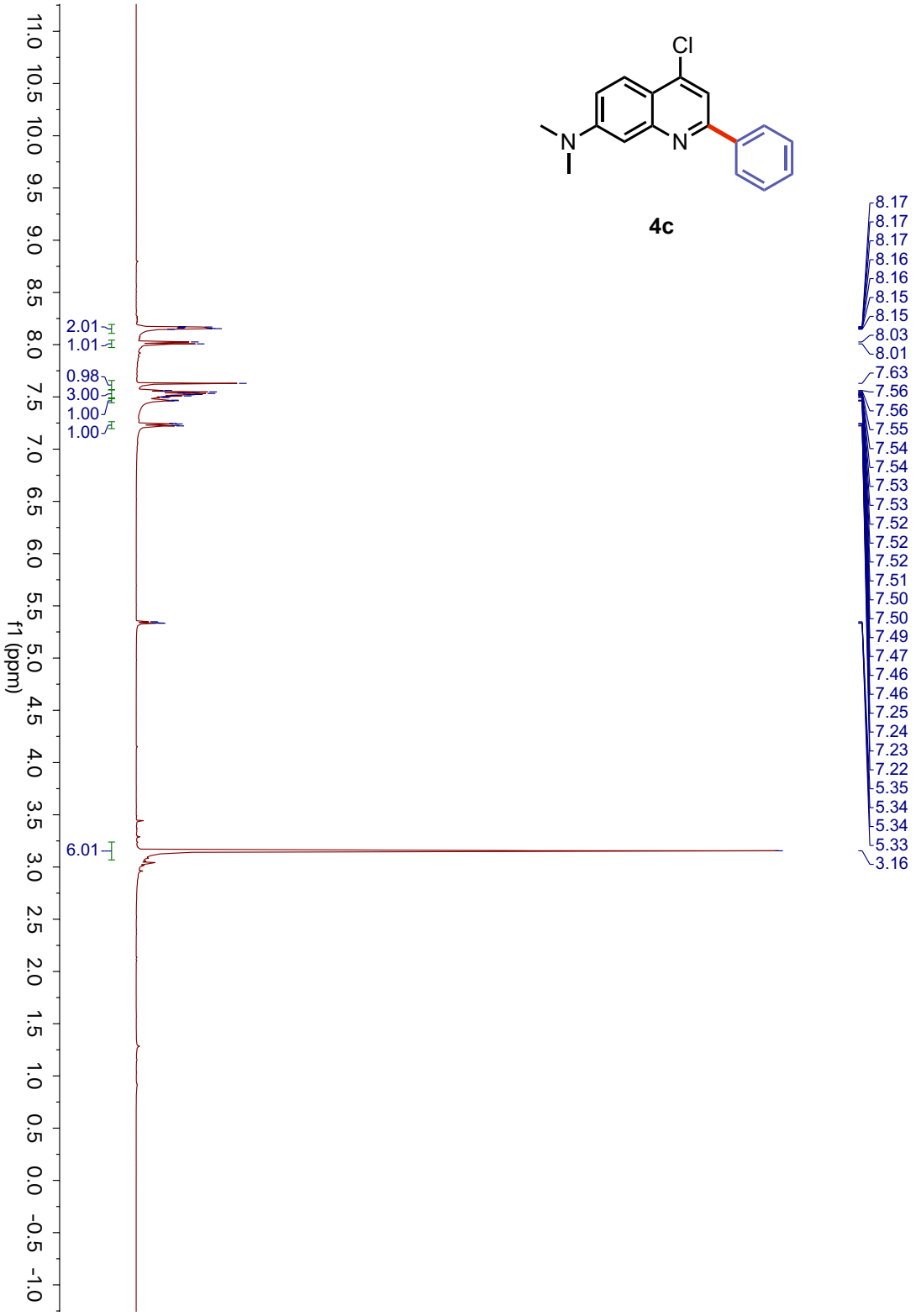
^{1}H NMR spectrum of **4b** in CD_2Cl_2 (500 MHz).



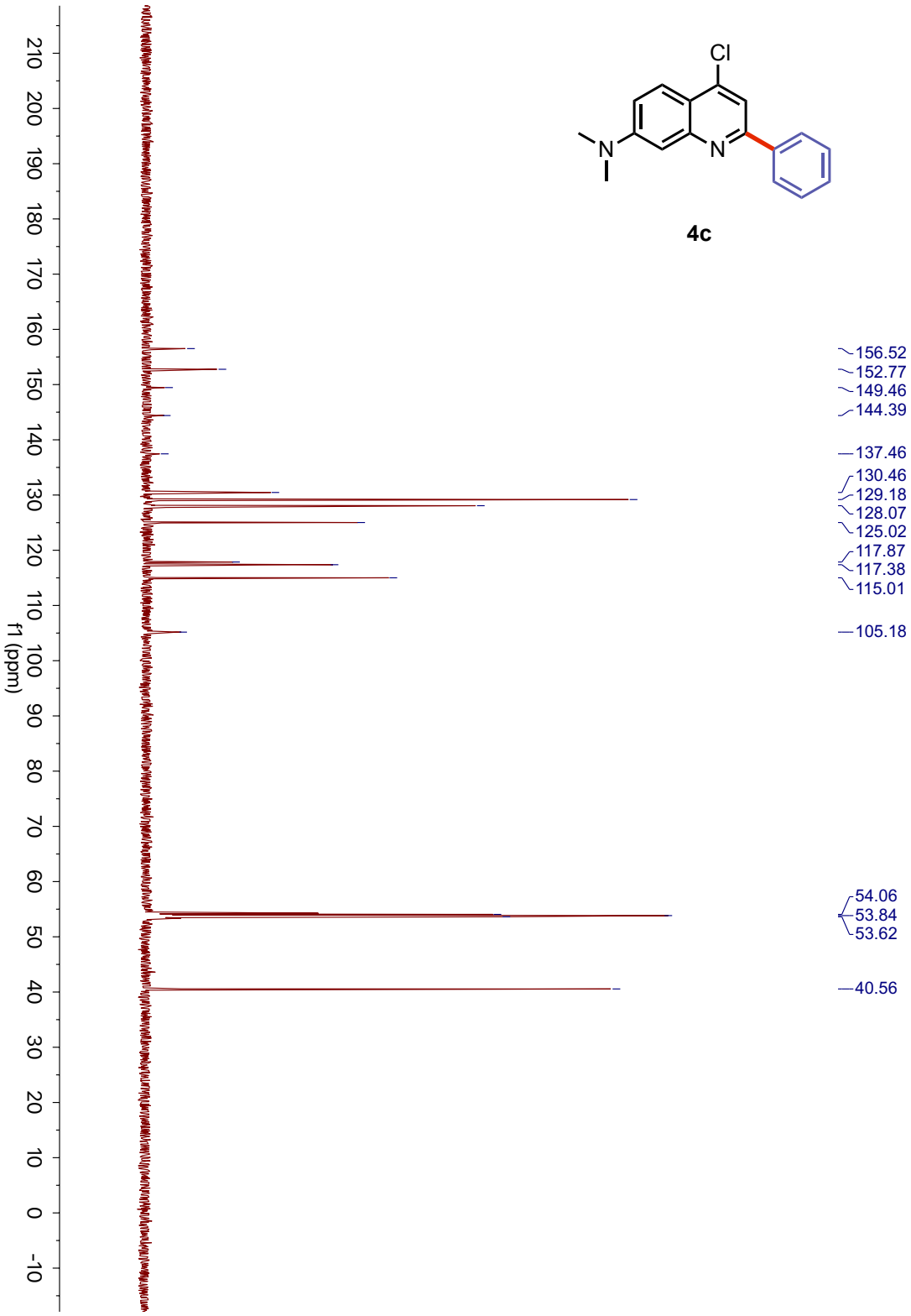
^{13}C NMR spectrum of **4b** in CD_2Cl_2 (126 MHz).



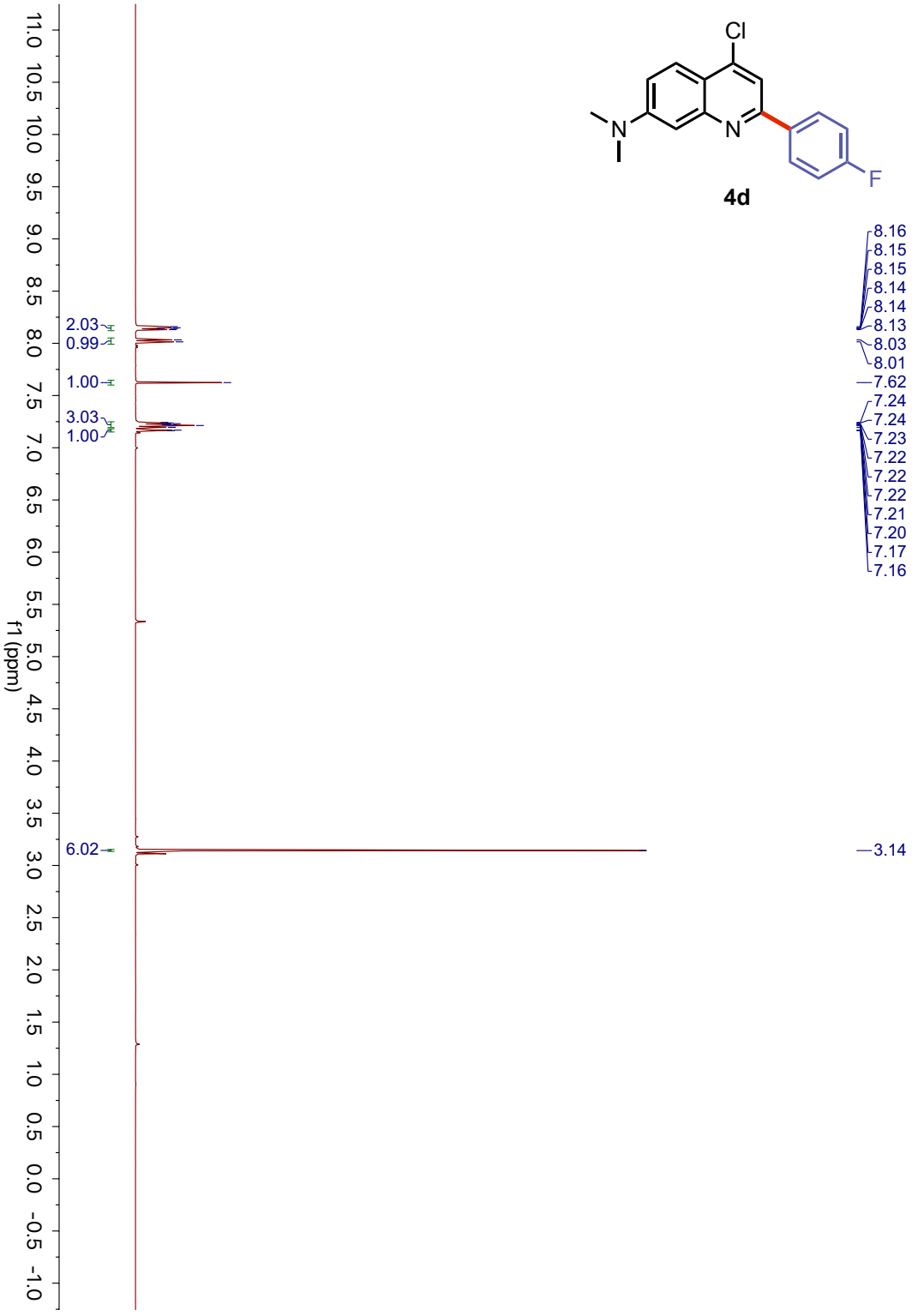
^{1}H NMR spectrum of **4c** in in CD_2Cl_2 (500 MHz).



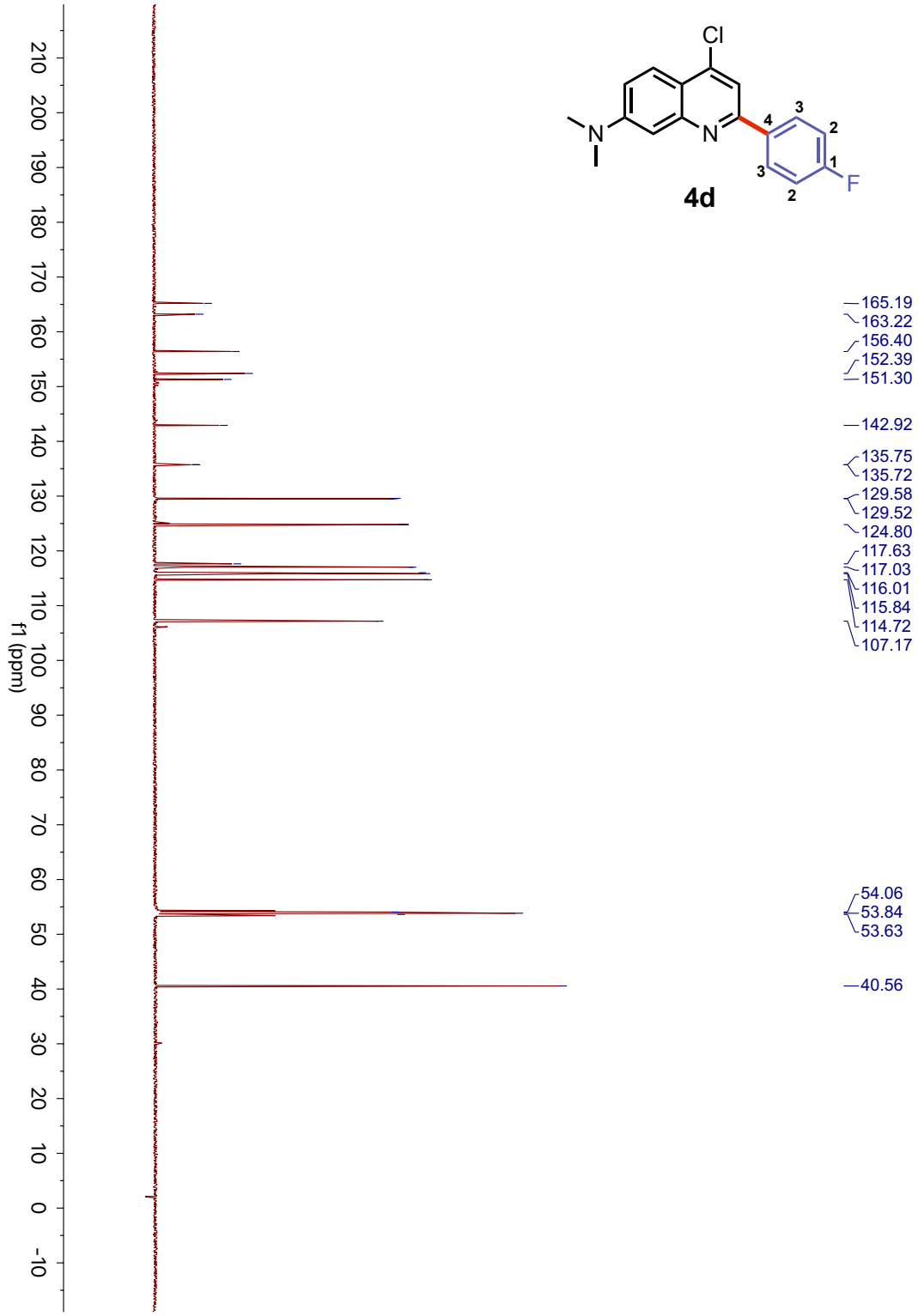
^{13}C NMR spectrum of **4c** in CD_2Cl_2 (126 MHz).



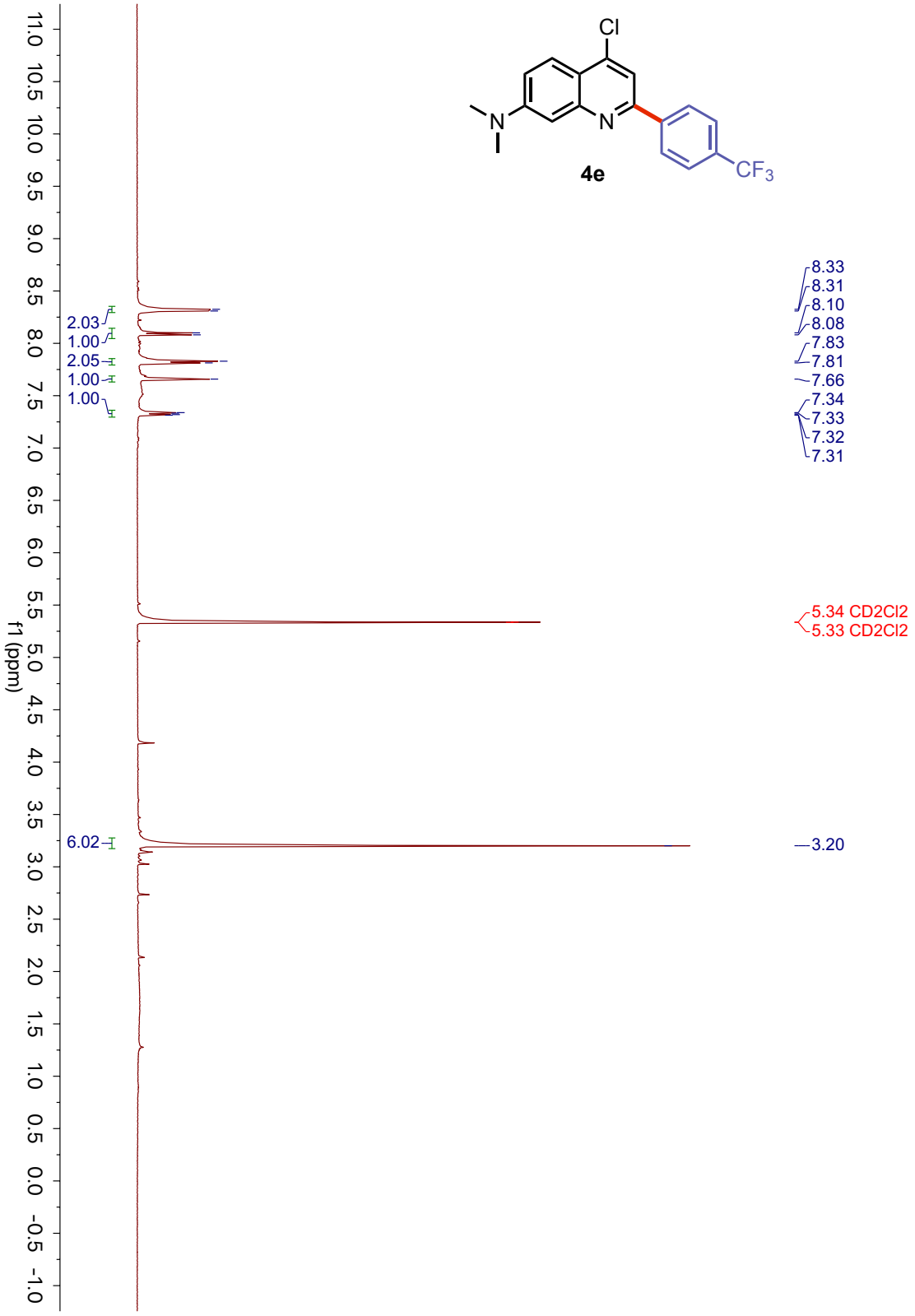
^{1}H NMR spectrum of **4d** in CD_2Cl_2 (500 MHz).



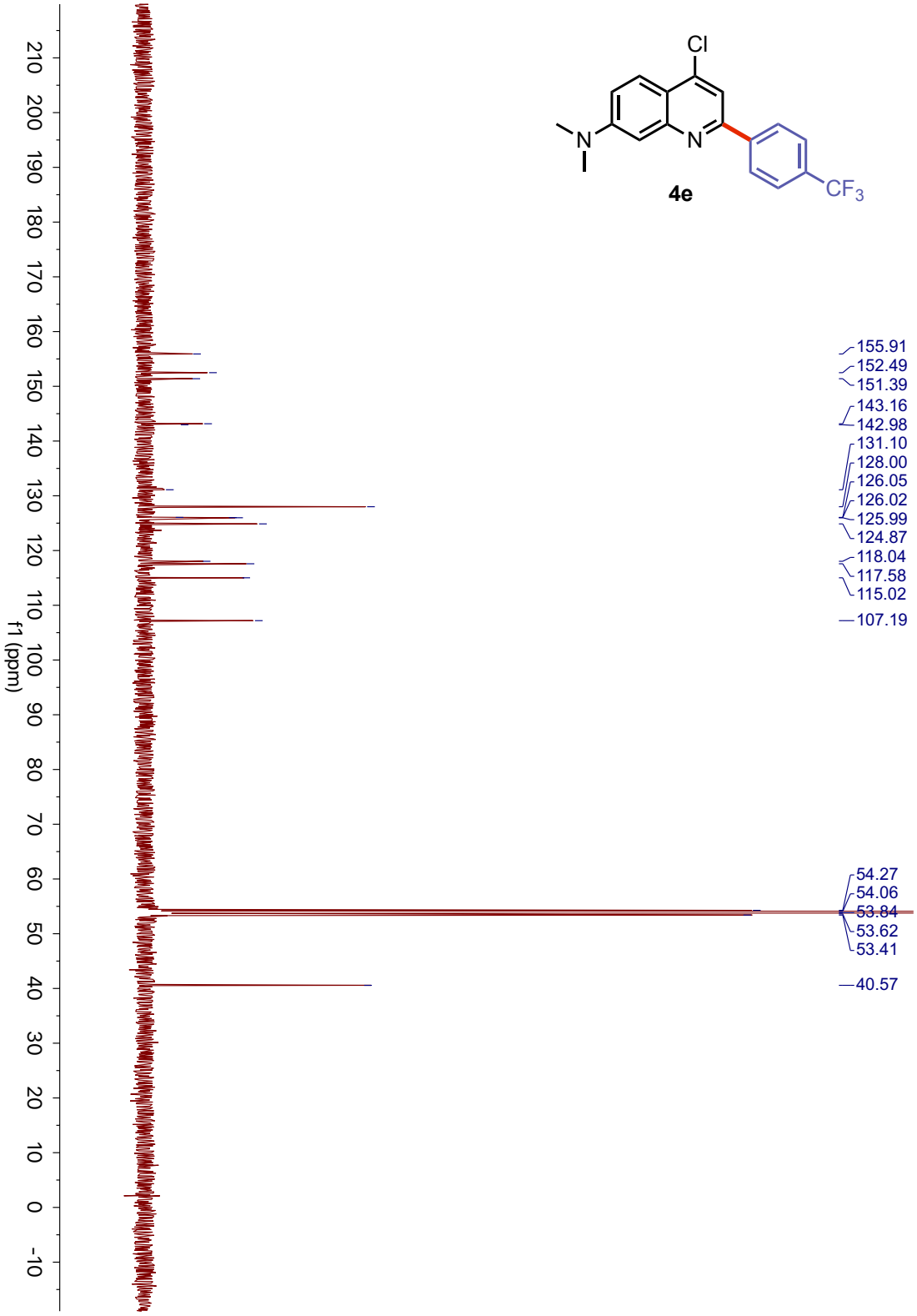
^{13}C NMR spectrum of **4d** in CD_2Cl_2 (126 MHz).



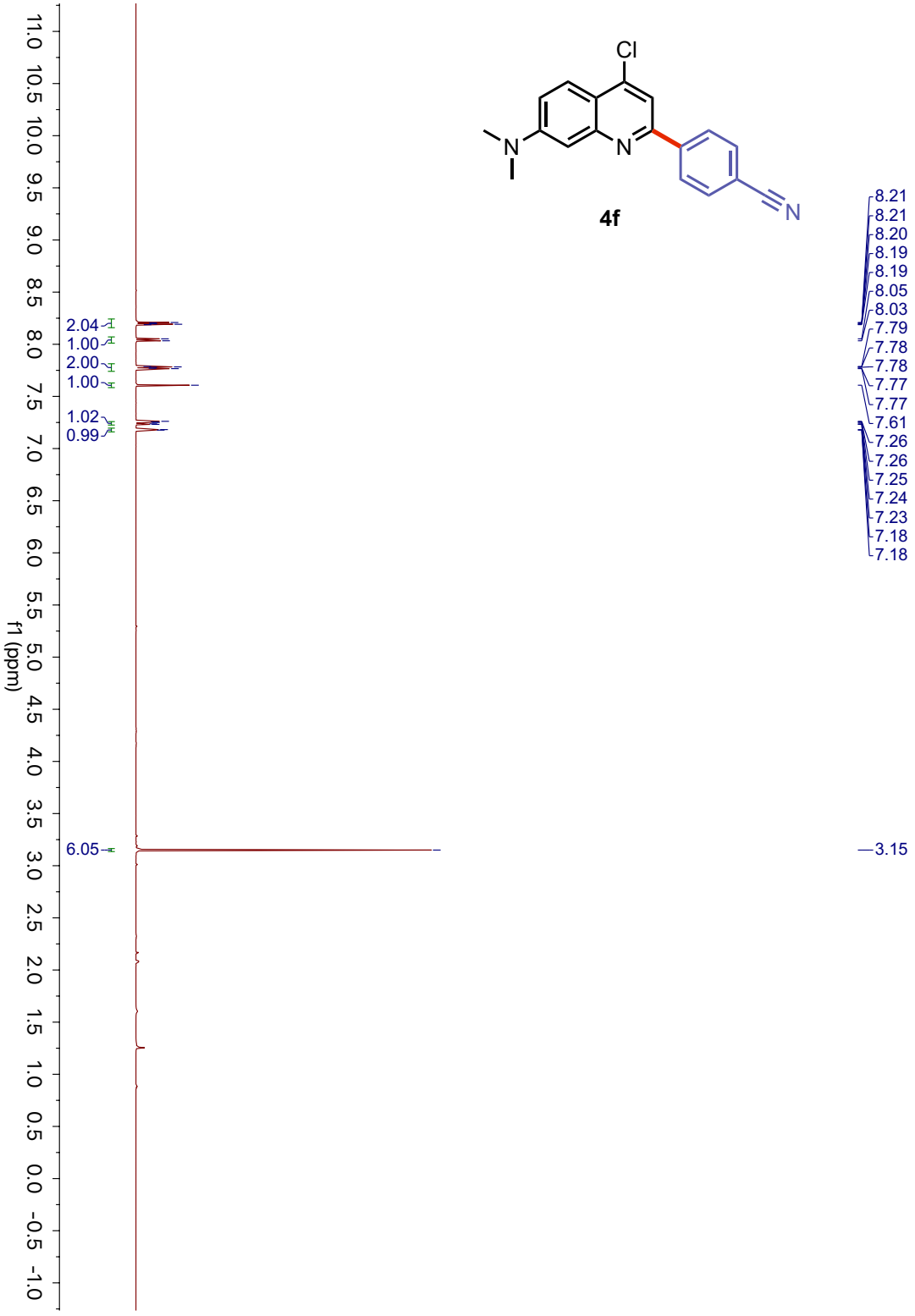
^{1}H NMR spectrum of **4e** in CD_2Cl_2 (500 MHz).



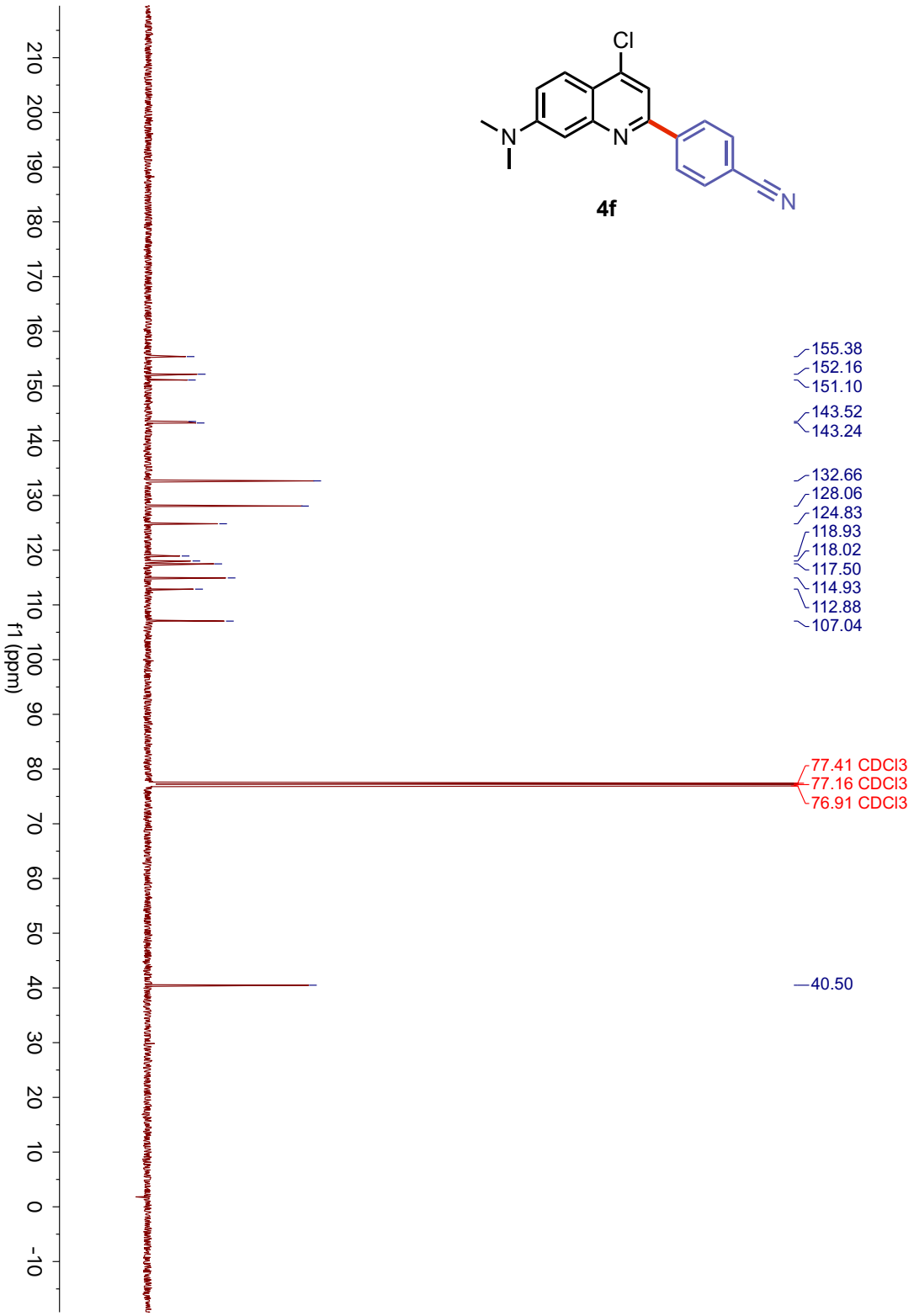
^{13}C NMR spectrum of **4e** in CD_2Cl_2 (126 MHz).



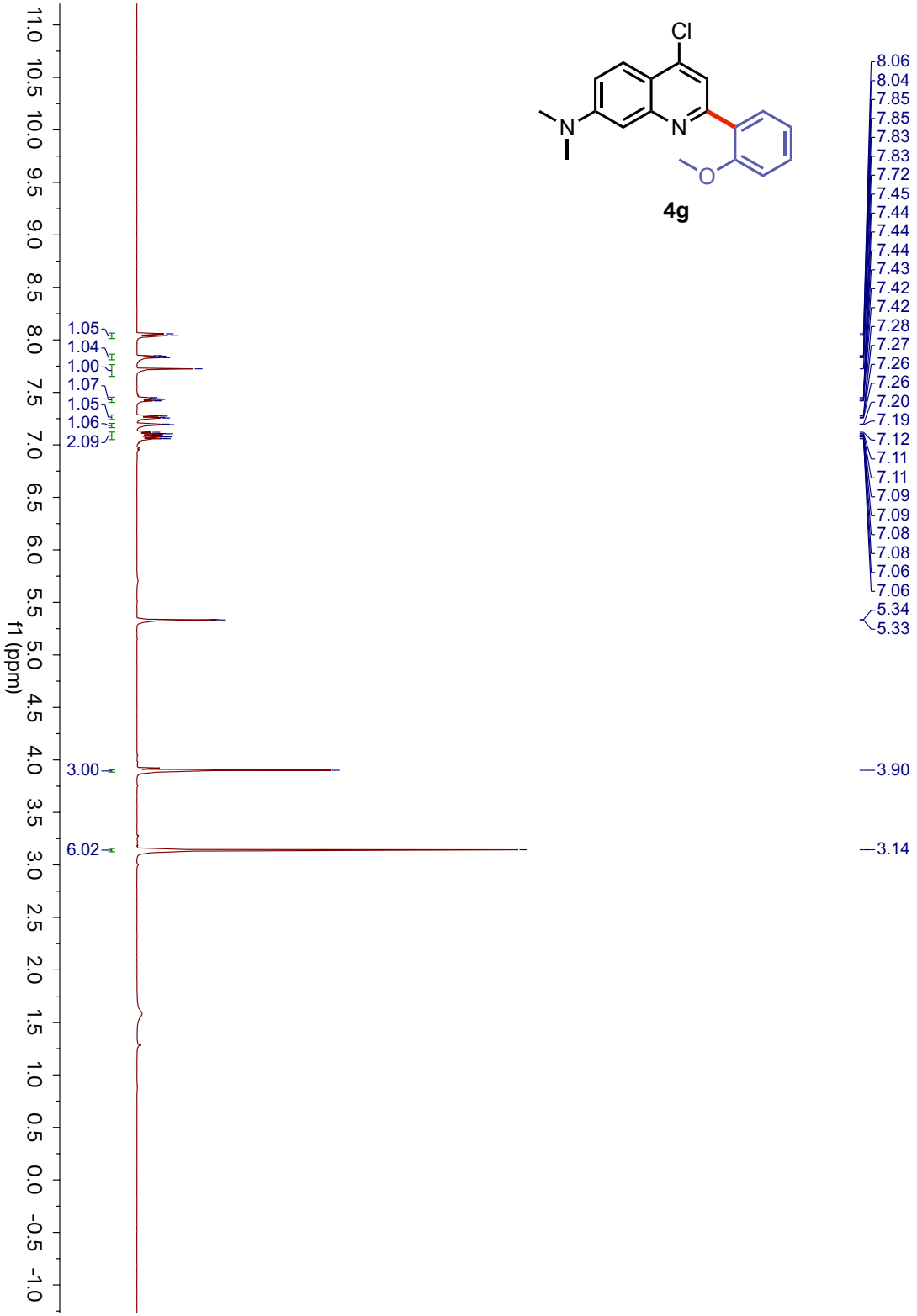
^{1}H NMR spectrum of **4f** in $CDCl_3$ (500 MHz).



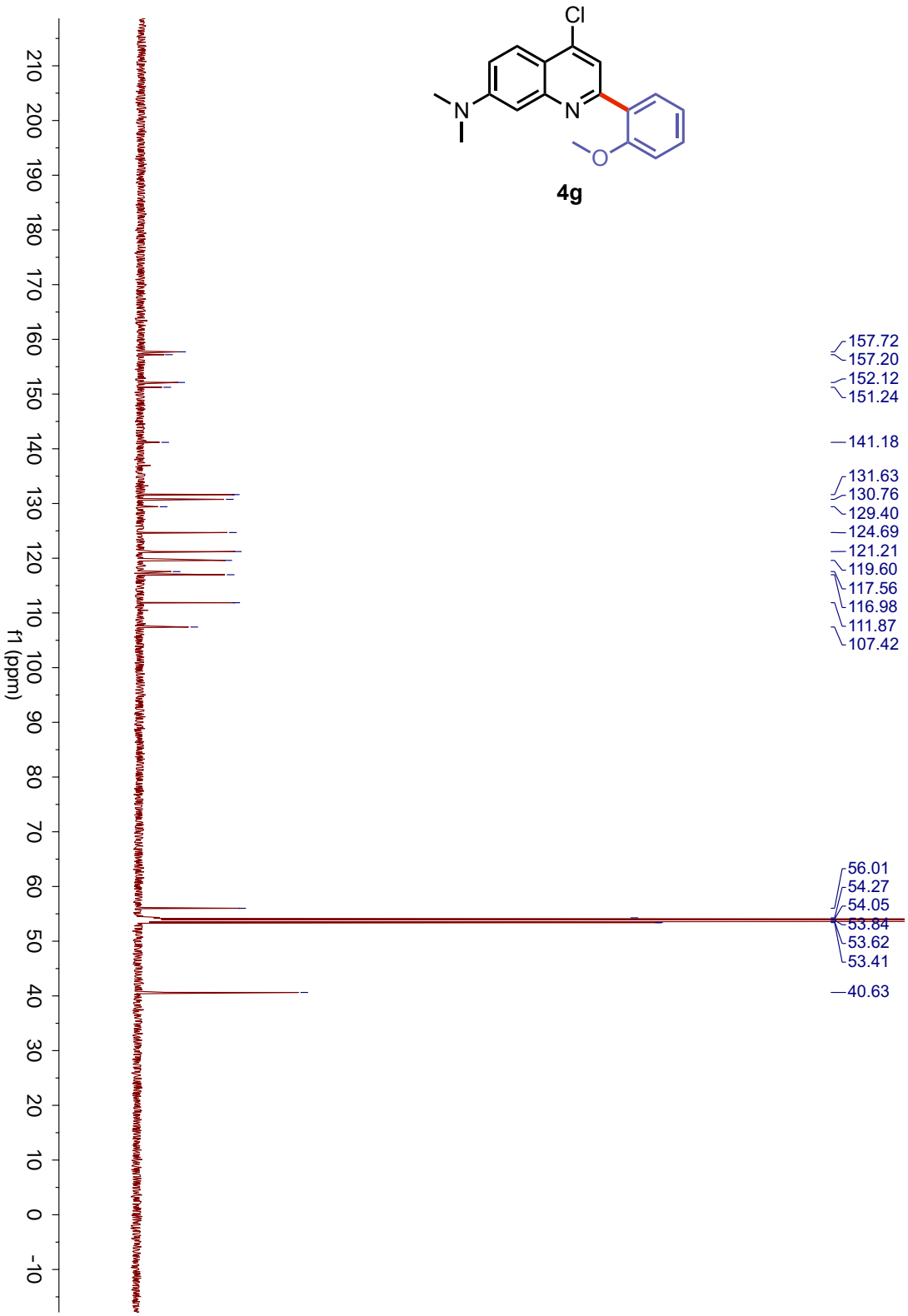
^{13}C NMR spectrum of **4e** in $CDCl_3$ (126 MHz).



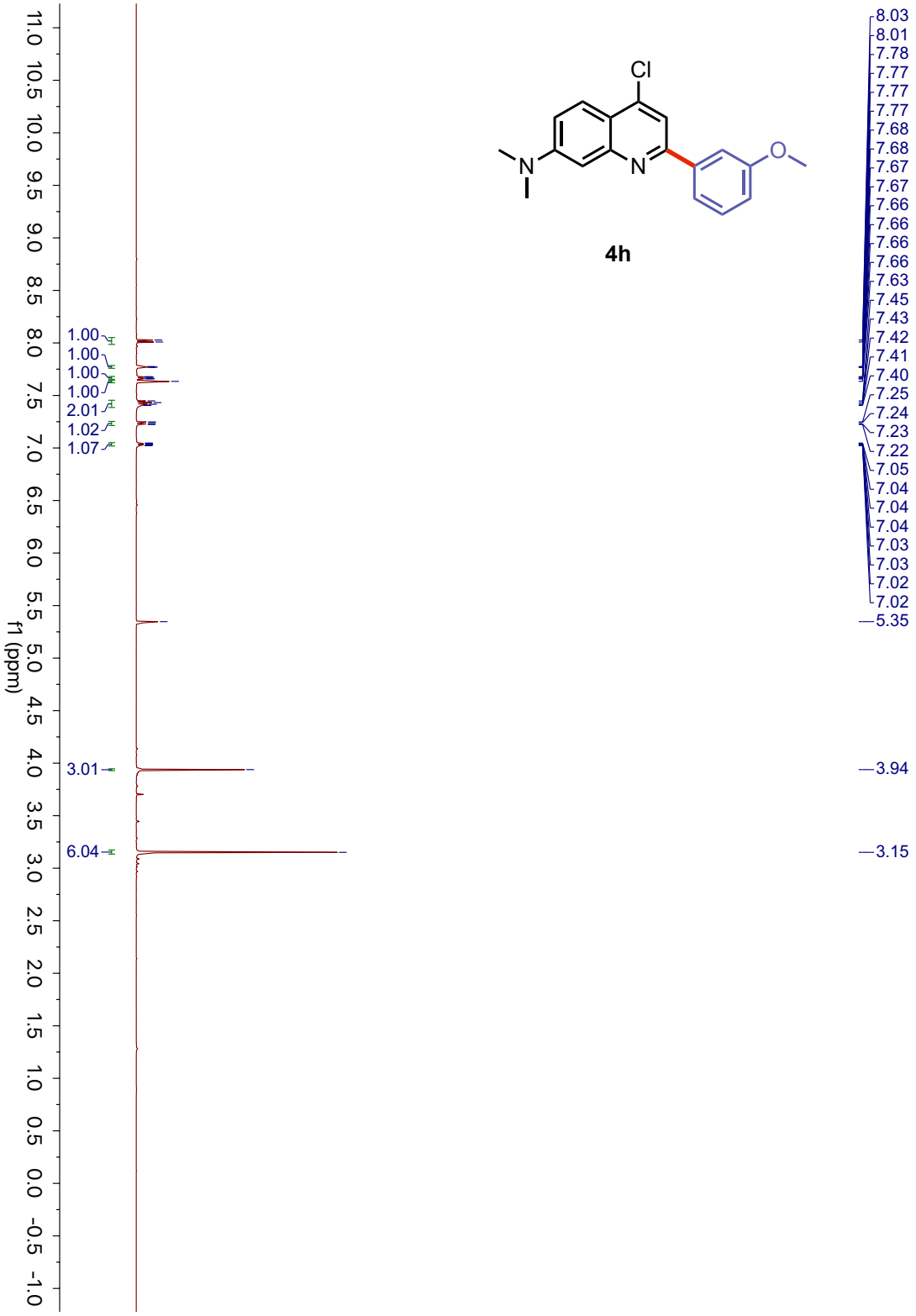
^{1}H NMR spectrum of **4g** in CD_2Cl_2 (500 MHz).



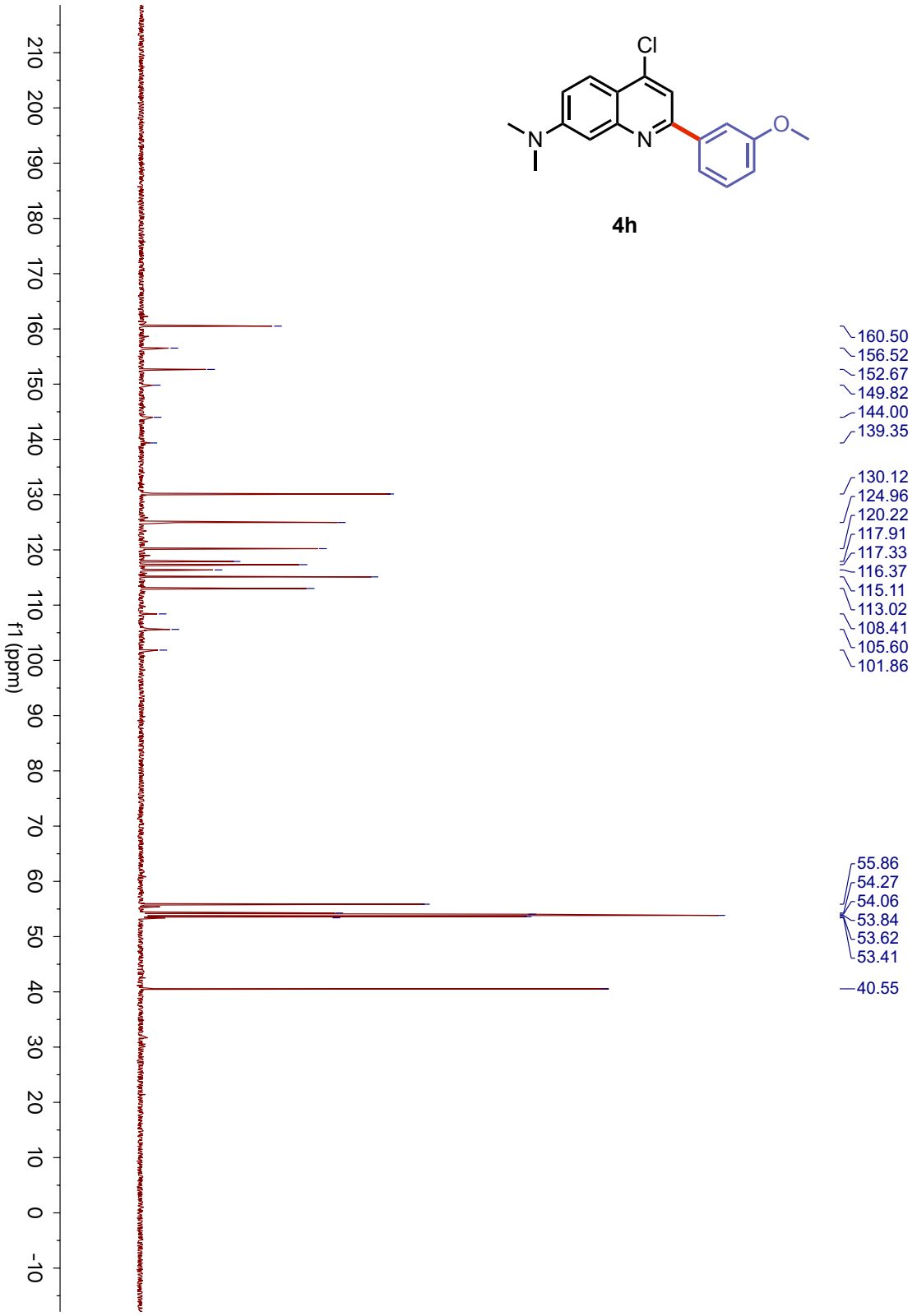
^{13}C NMR spectrum of **4g** in CD_2Cl_2 (126 MHz).



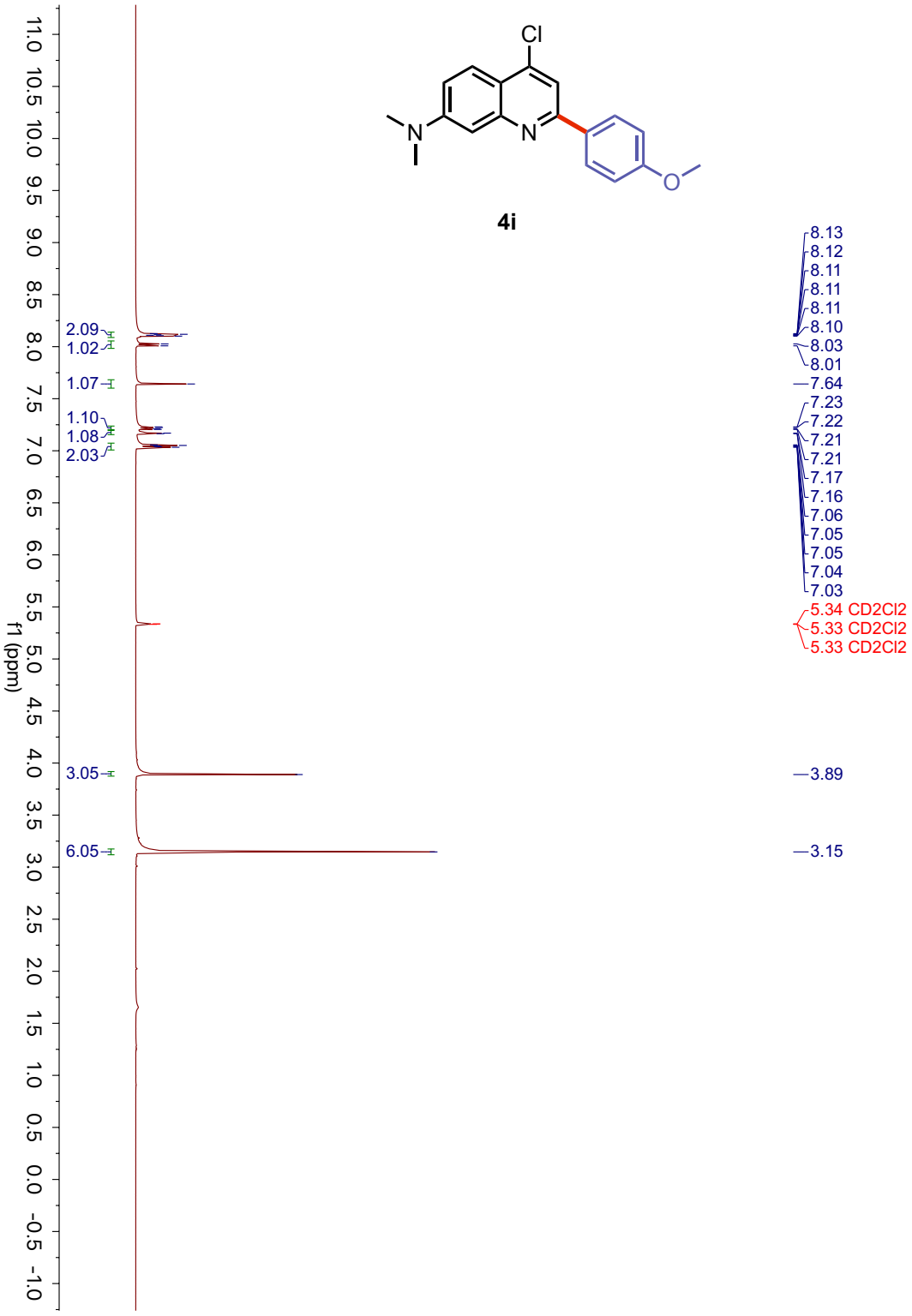
^{1}H NMR spectrum of **4h** in CD_2Cl_2 (500 MHz).



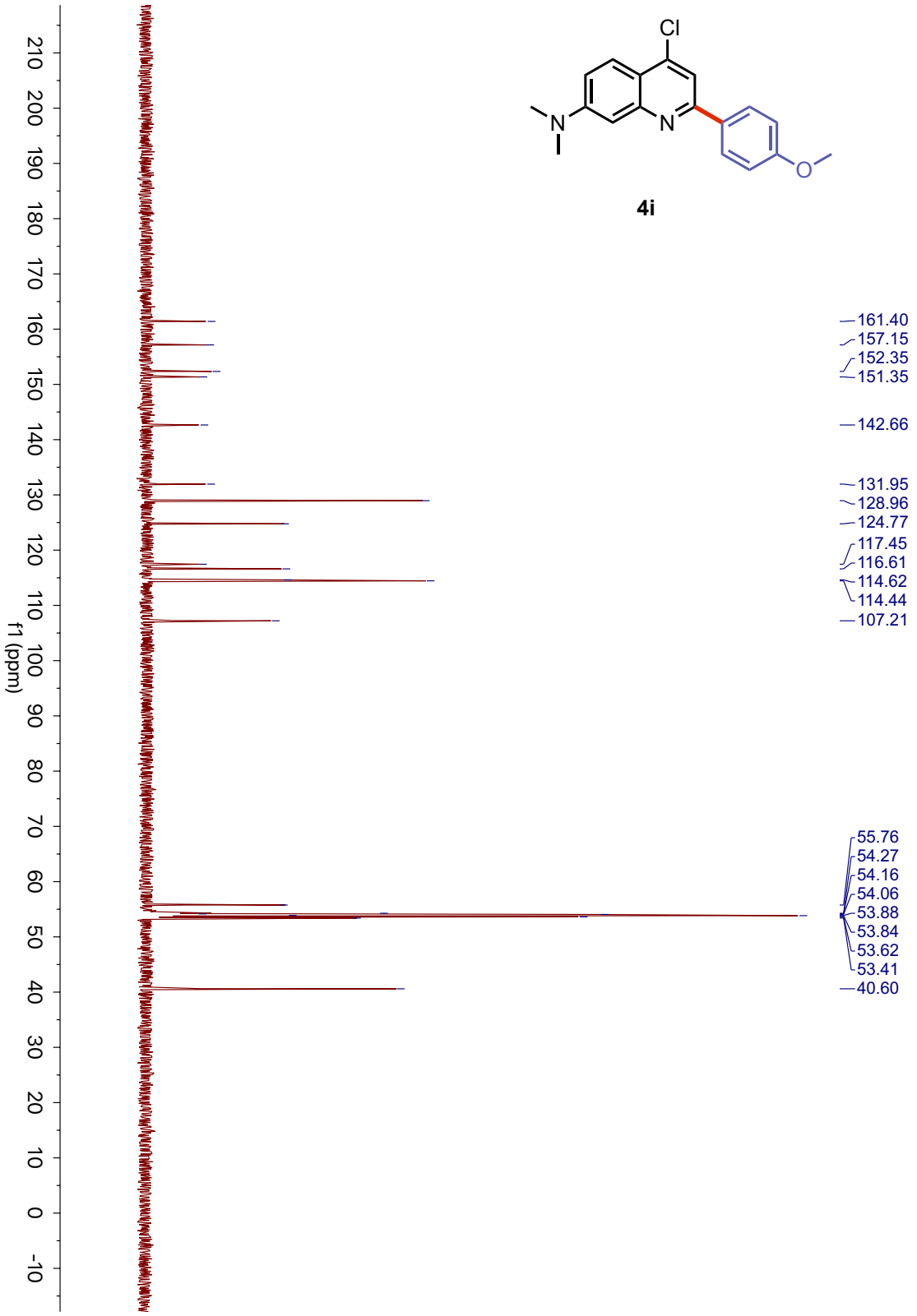
^{13}C NMR spectrum of **4h** in CD_2Cl_2 (126 MHz).



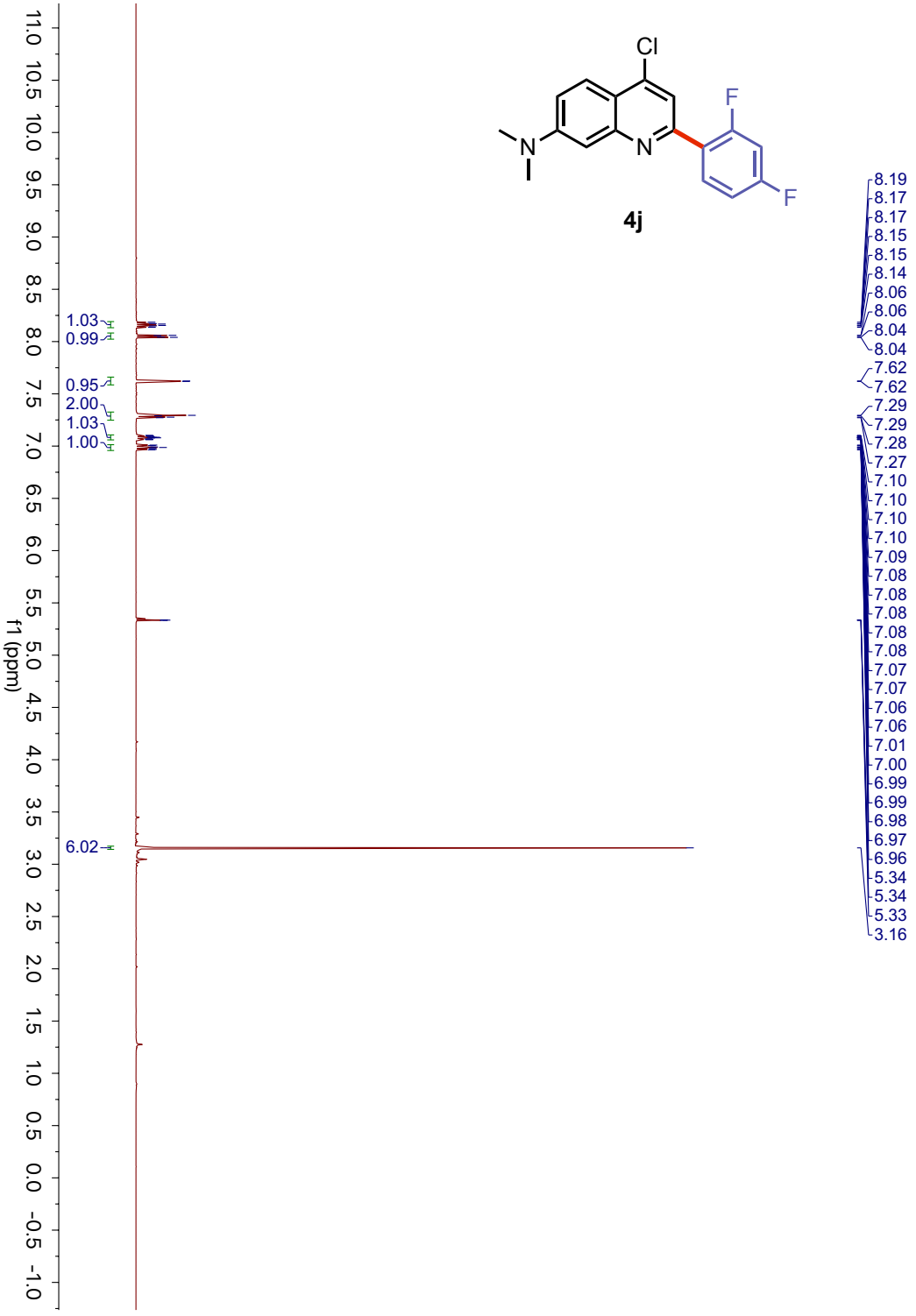
^{1}H NMR spectrum of **4i** in CD_2Cl_2 (500 MHz).



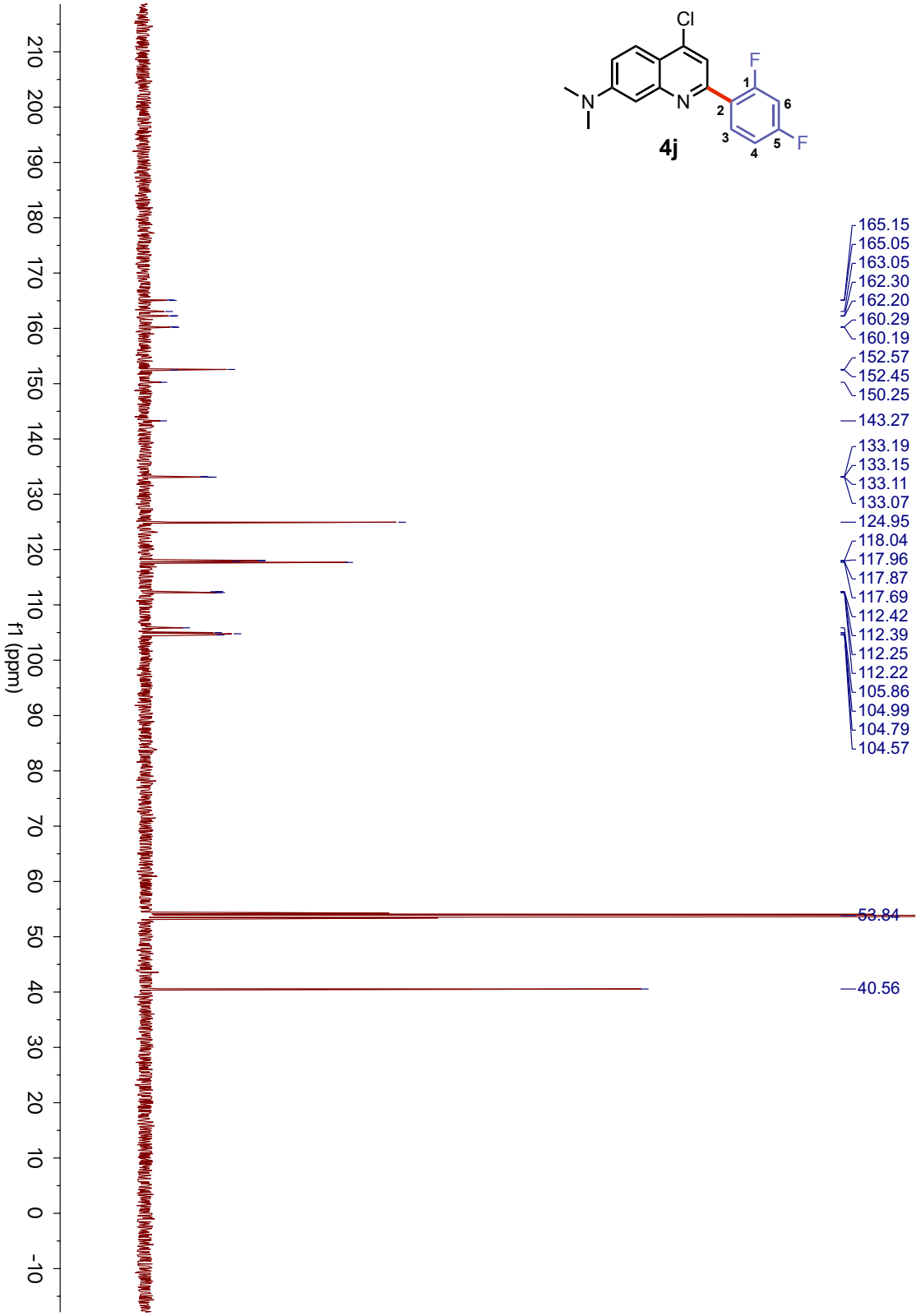
^{13}C NMR spectrum of **4i** in CD_2Cl_2 (126 MHz).



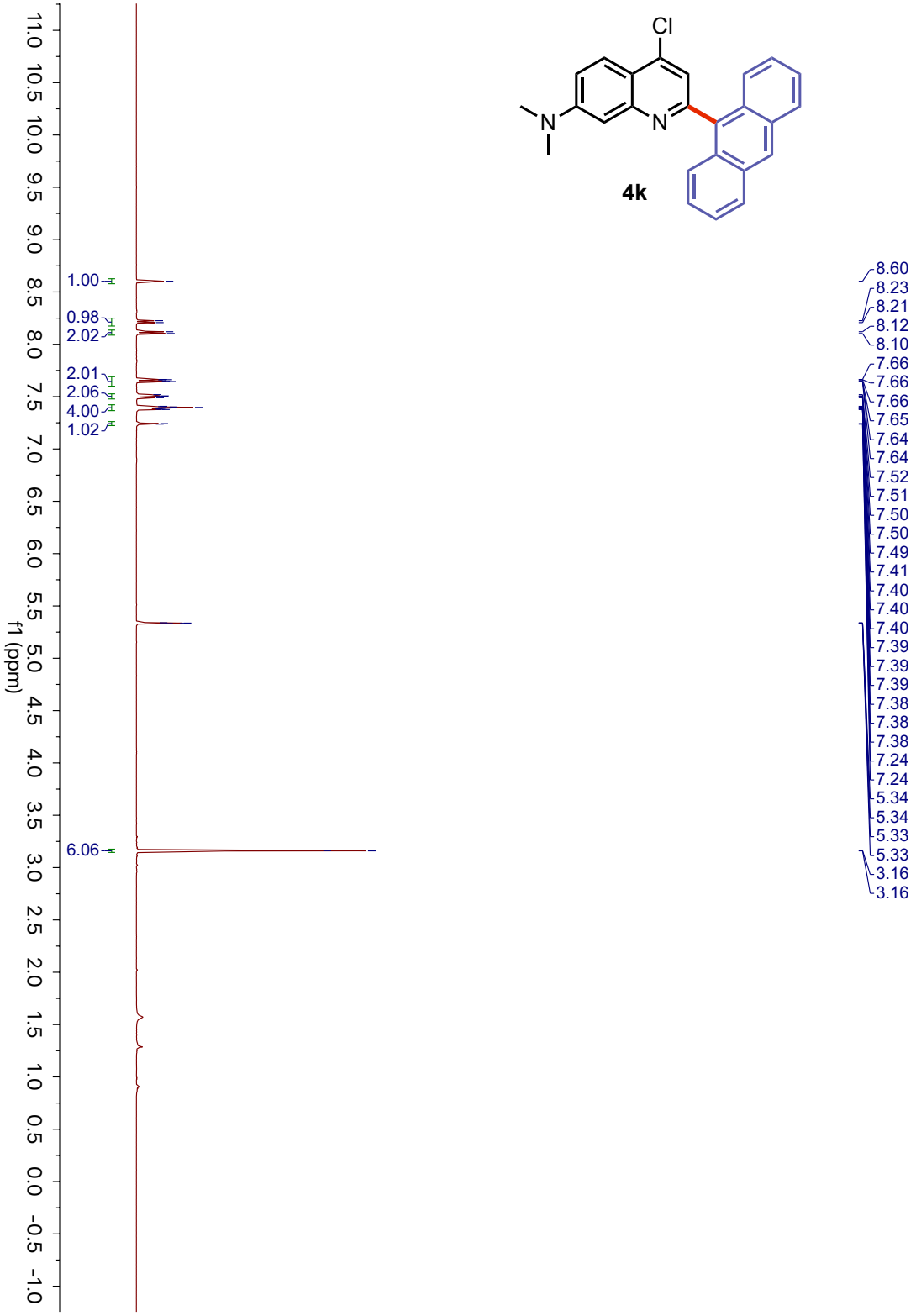
^{1}H NMR spectrum of **4j** in CD_2Cl_2 (500 MHz).



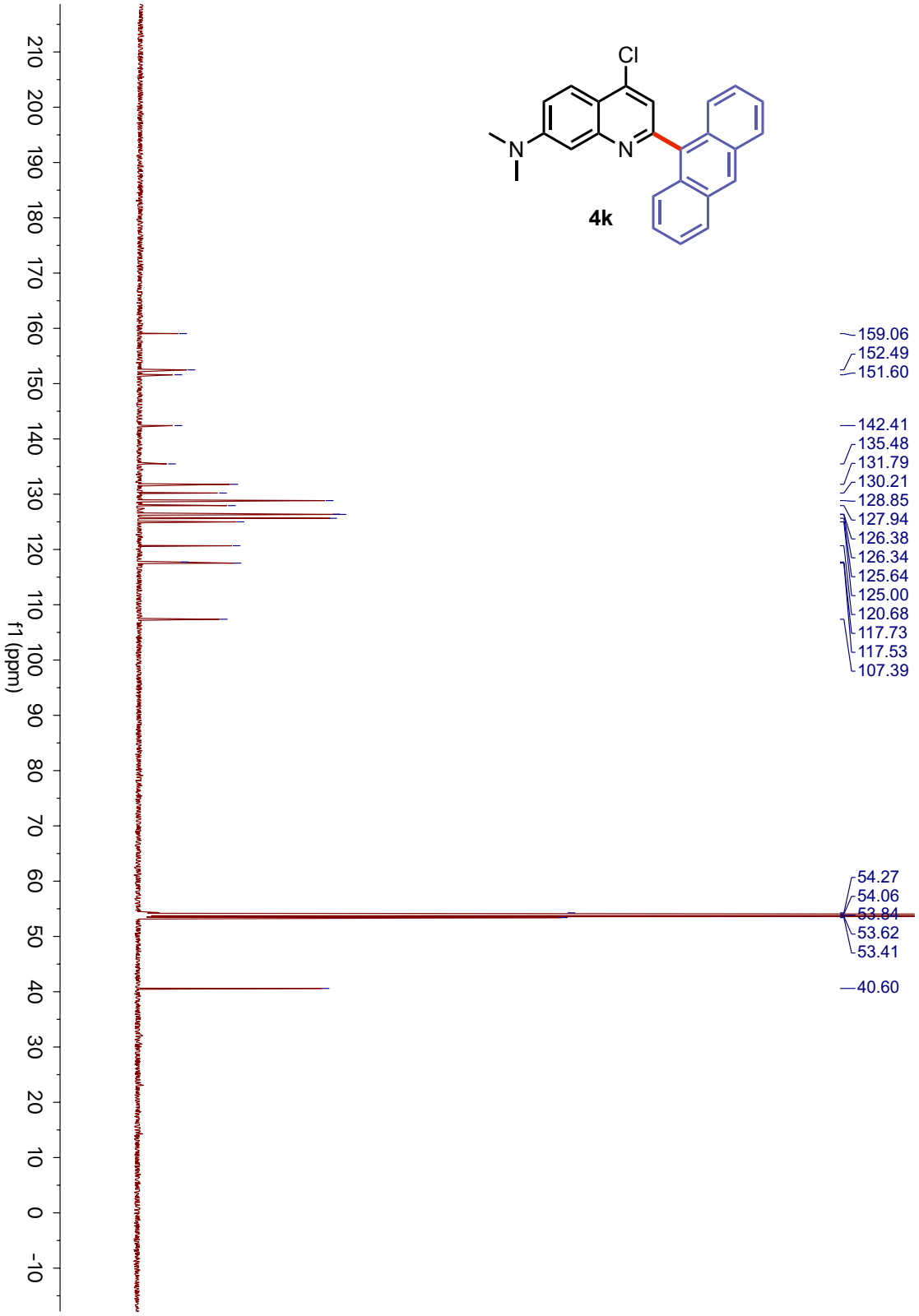
^{13}C NMR spectrum of **4j** in CD_2Cl_2 (126 MHz).



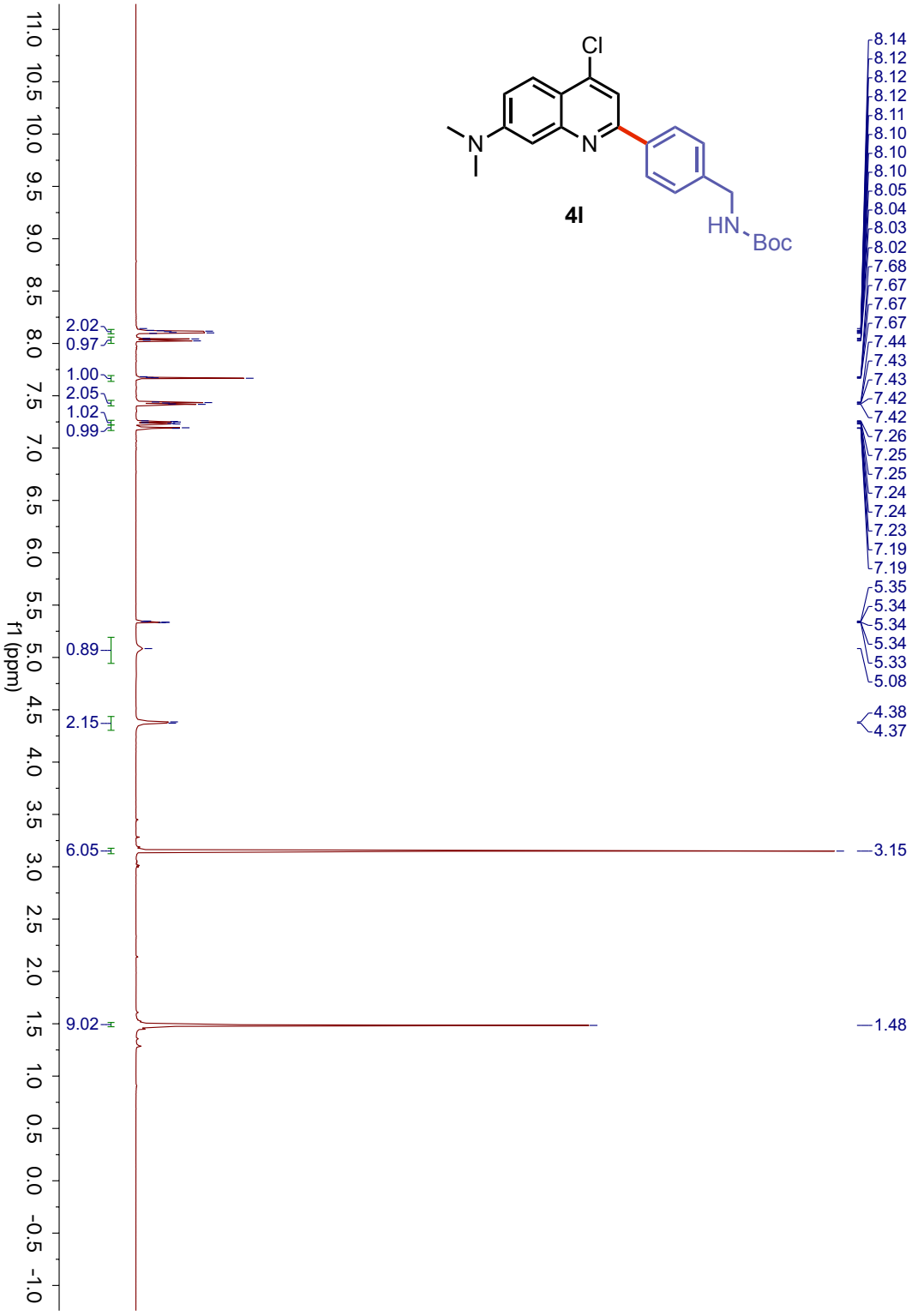
^{1}H NMR spectrum of **4k** in CD_2Cl_2 (500 MHz).



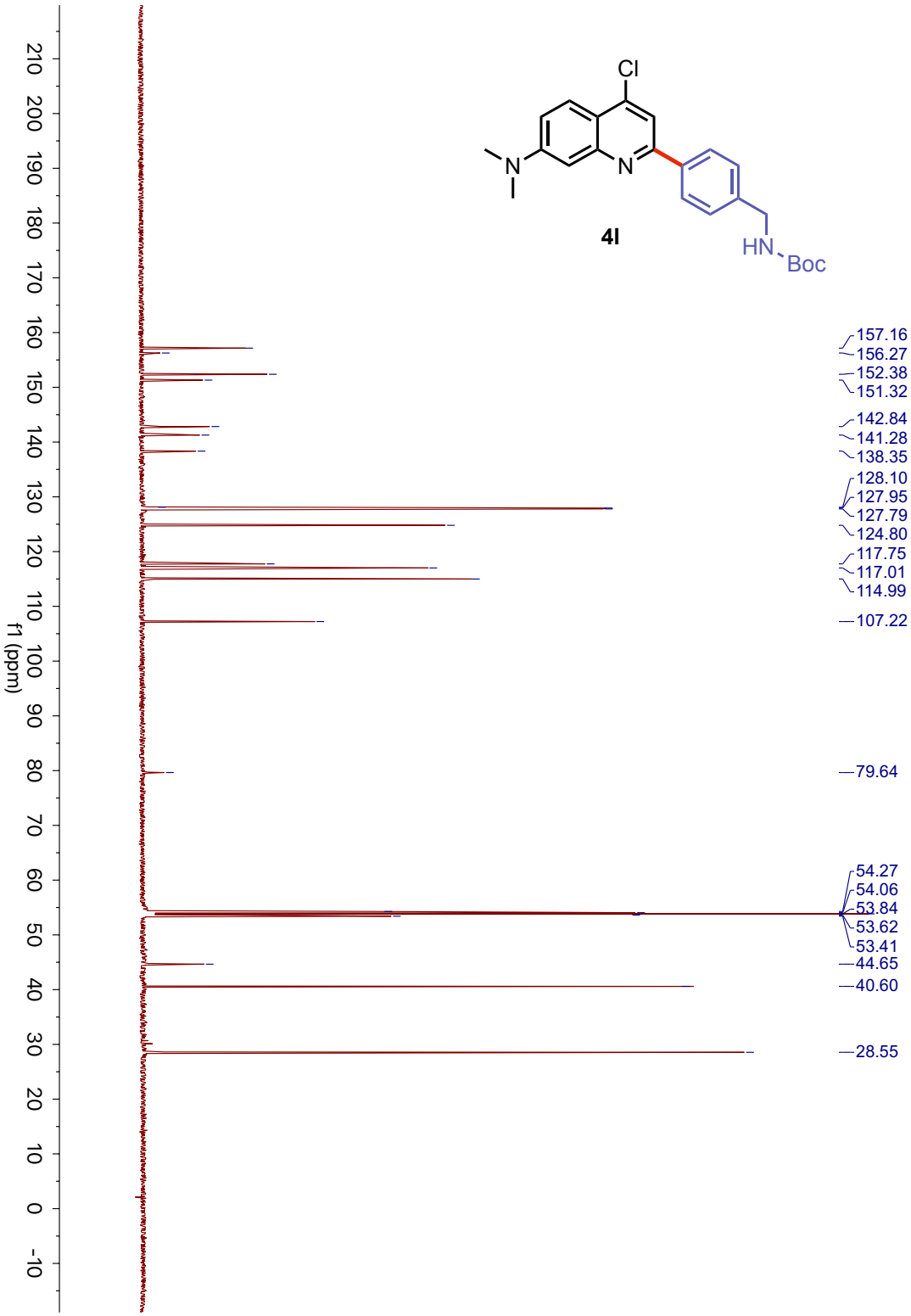
^{13}C NMR spectrum of **4k** in CD_2Cl_2 (126 MHz).



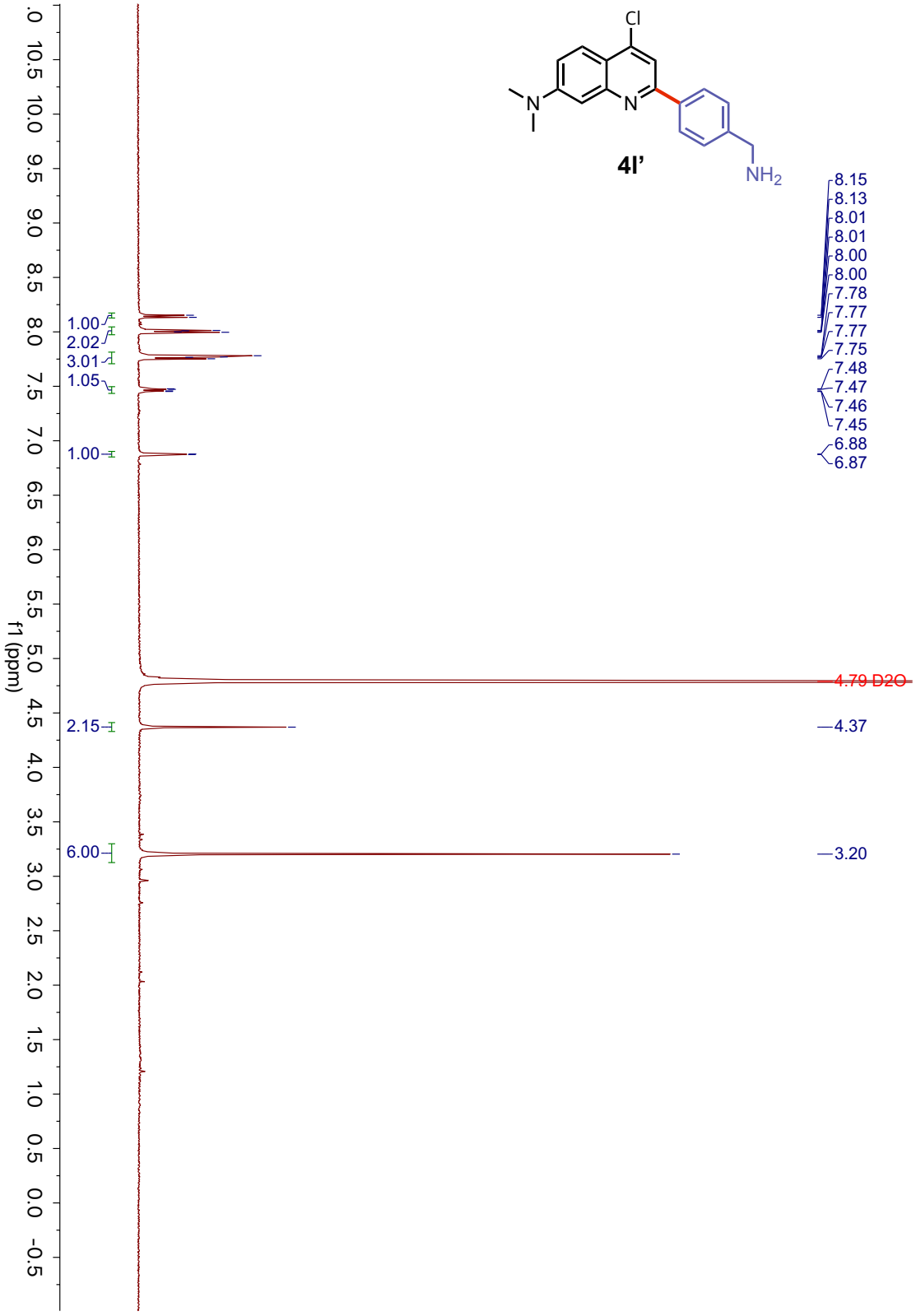
^{1}H NMR spectrum of **4l** in CD_2Cl_2 (500 MHz).



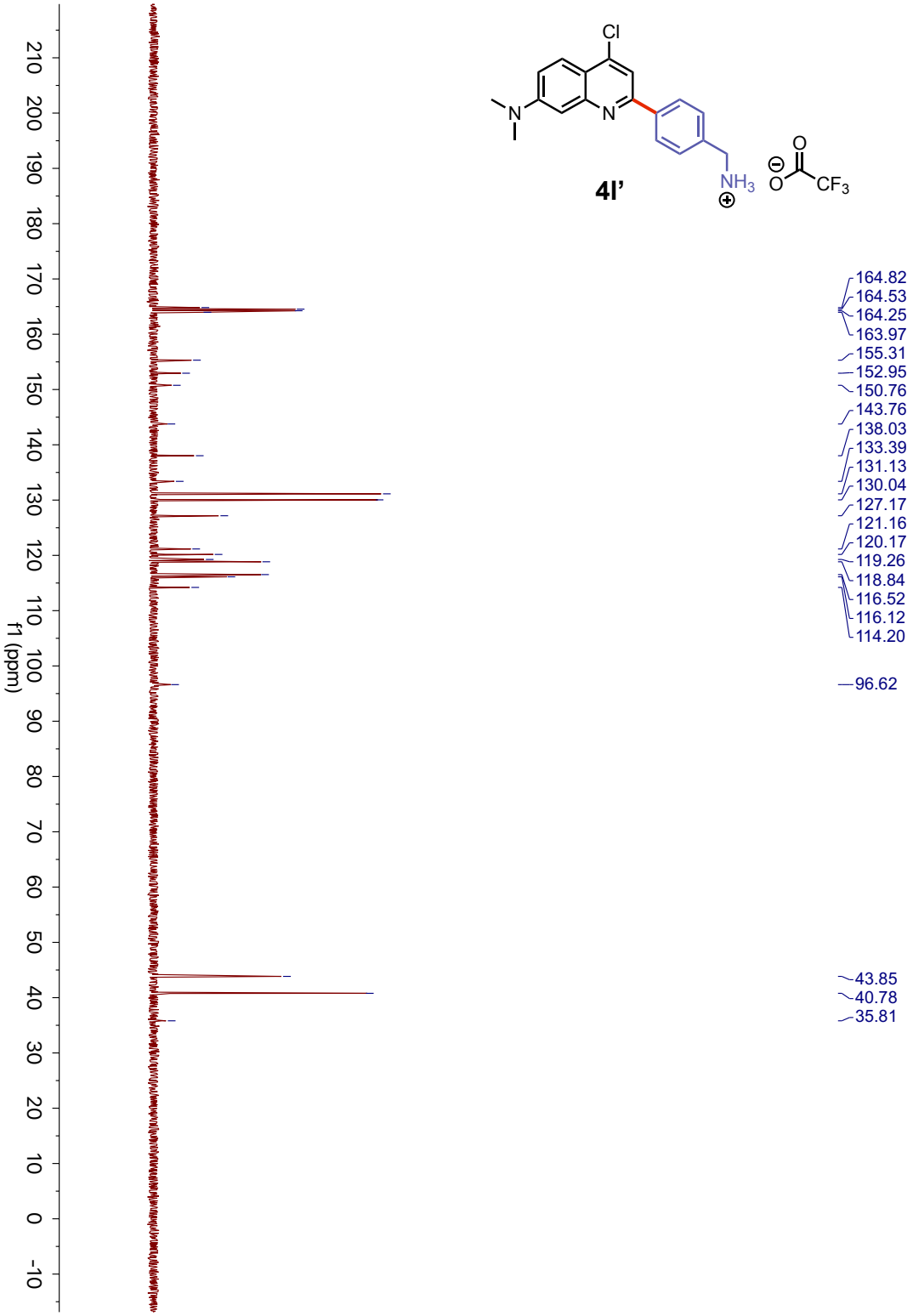
^{13}C NMR spectrum of **4l** in CD_2Cl_2 (126 MHz).



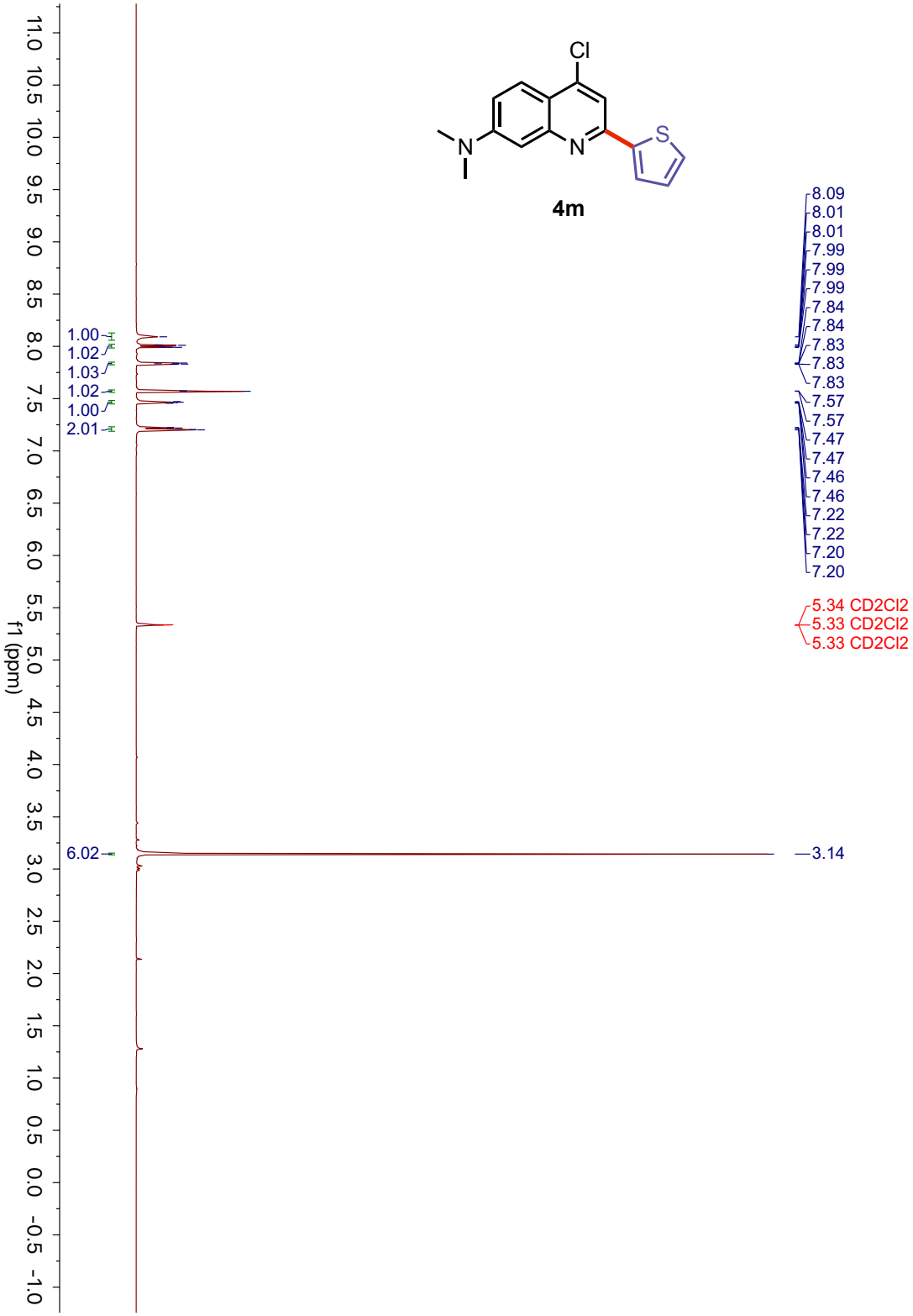
^{1}H NMR spectrum of **4l'** in D_2O (500 MHz).



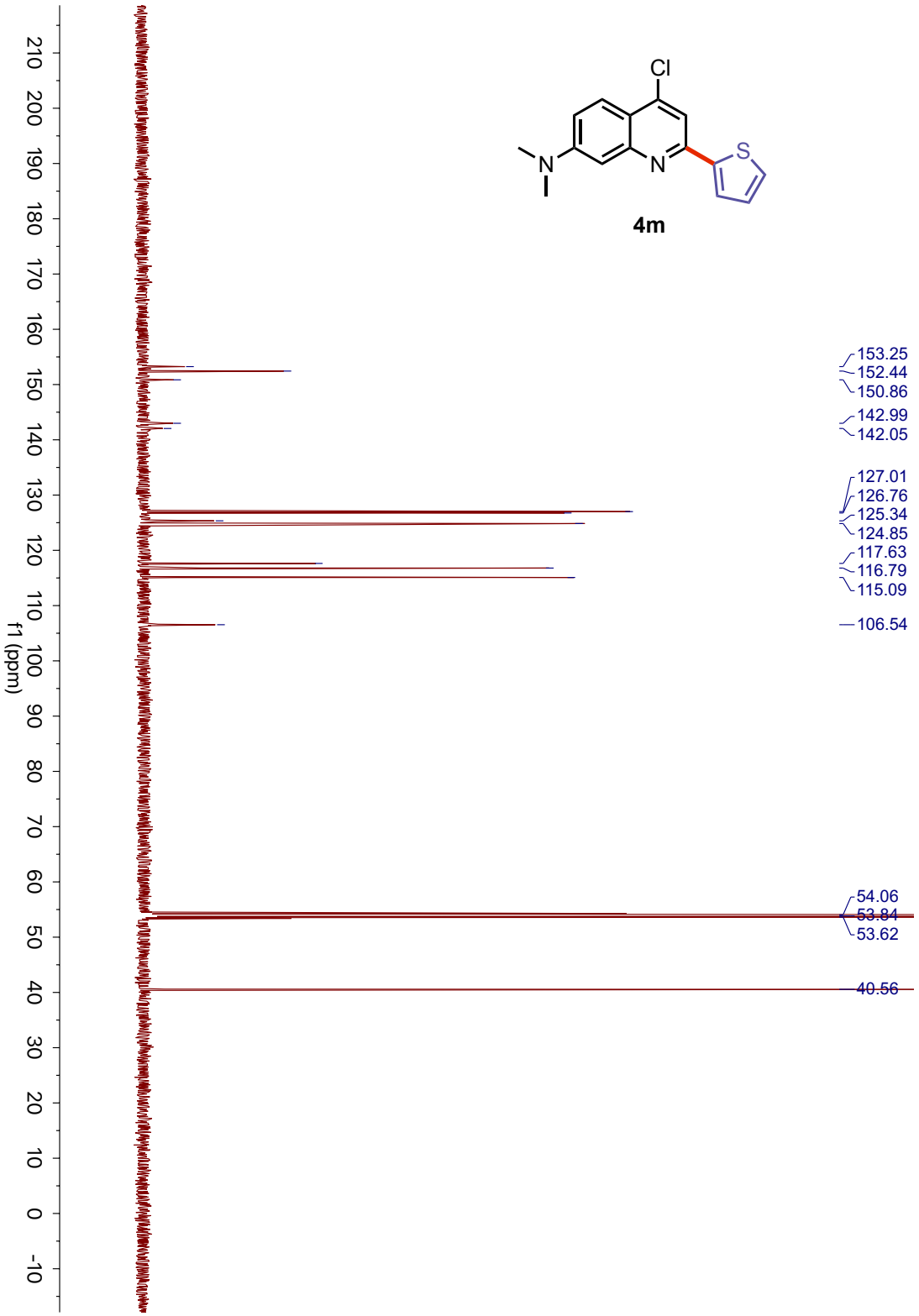
^{13}C NMR spectrum of **4l'** in D_2O (Cryo 126 MHz).



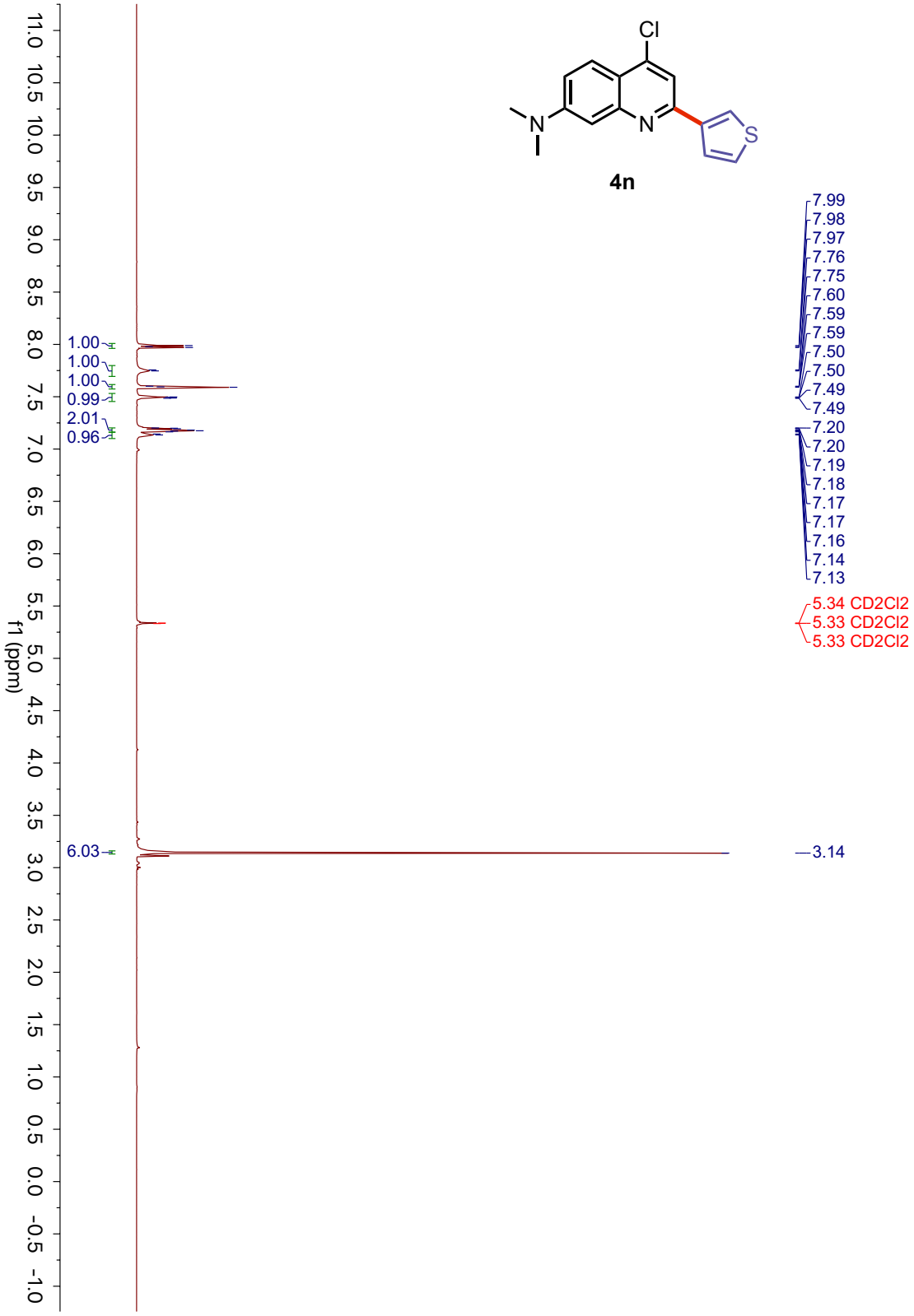
^{1}H NMR spectrum of **4m** in CD_2Cl_2 (500 MHz).



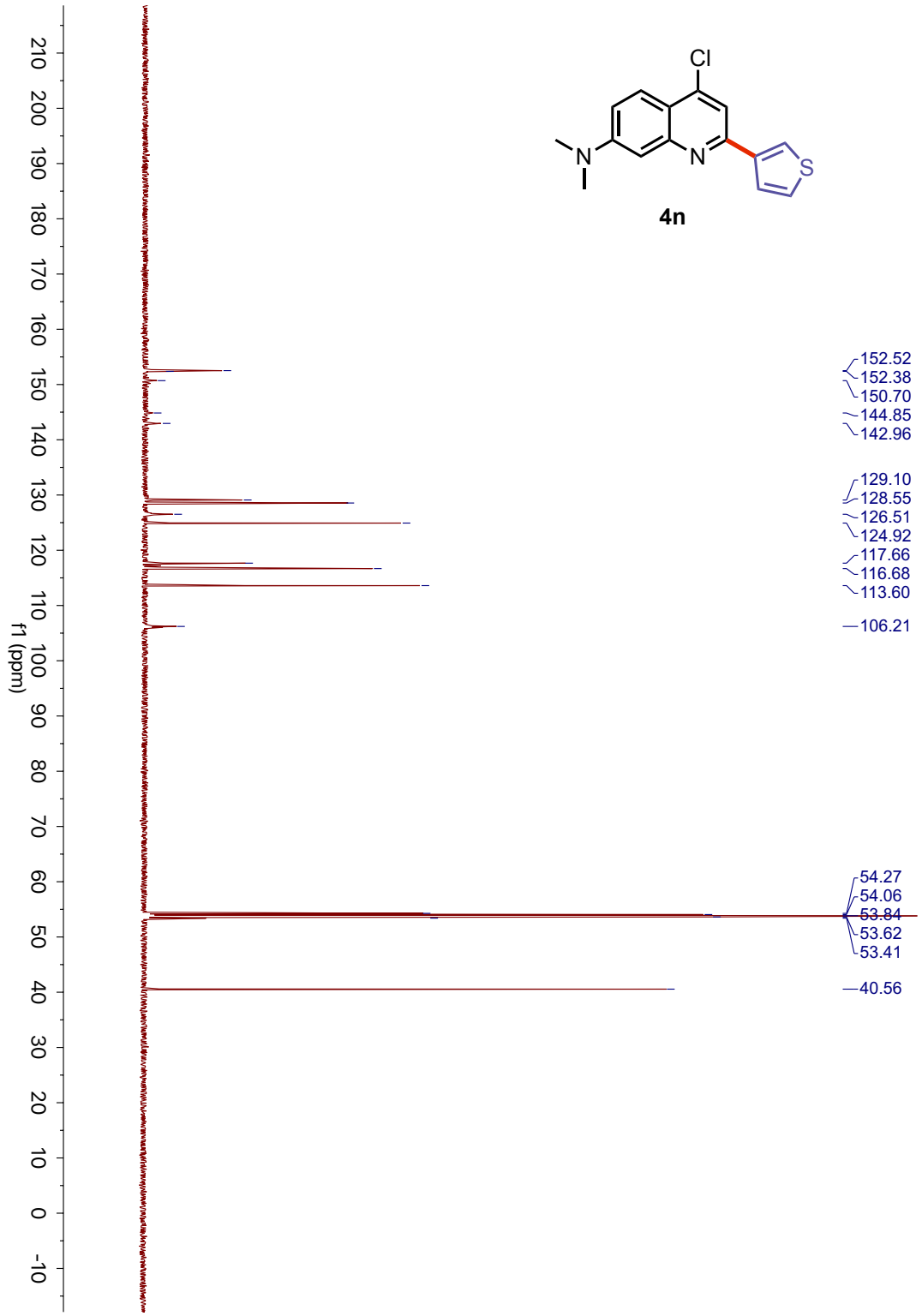
^{13}C NMR spectrum of **4m** in CD_2Cl_2 (126 MHz).



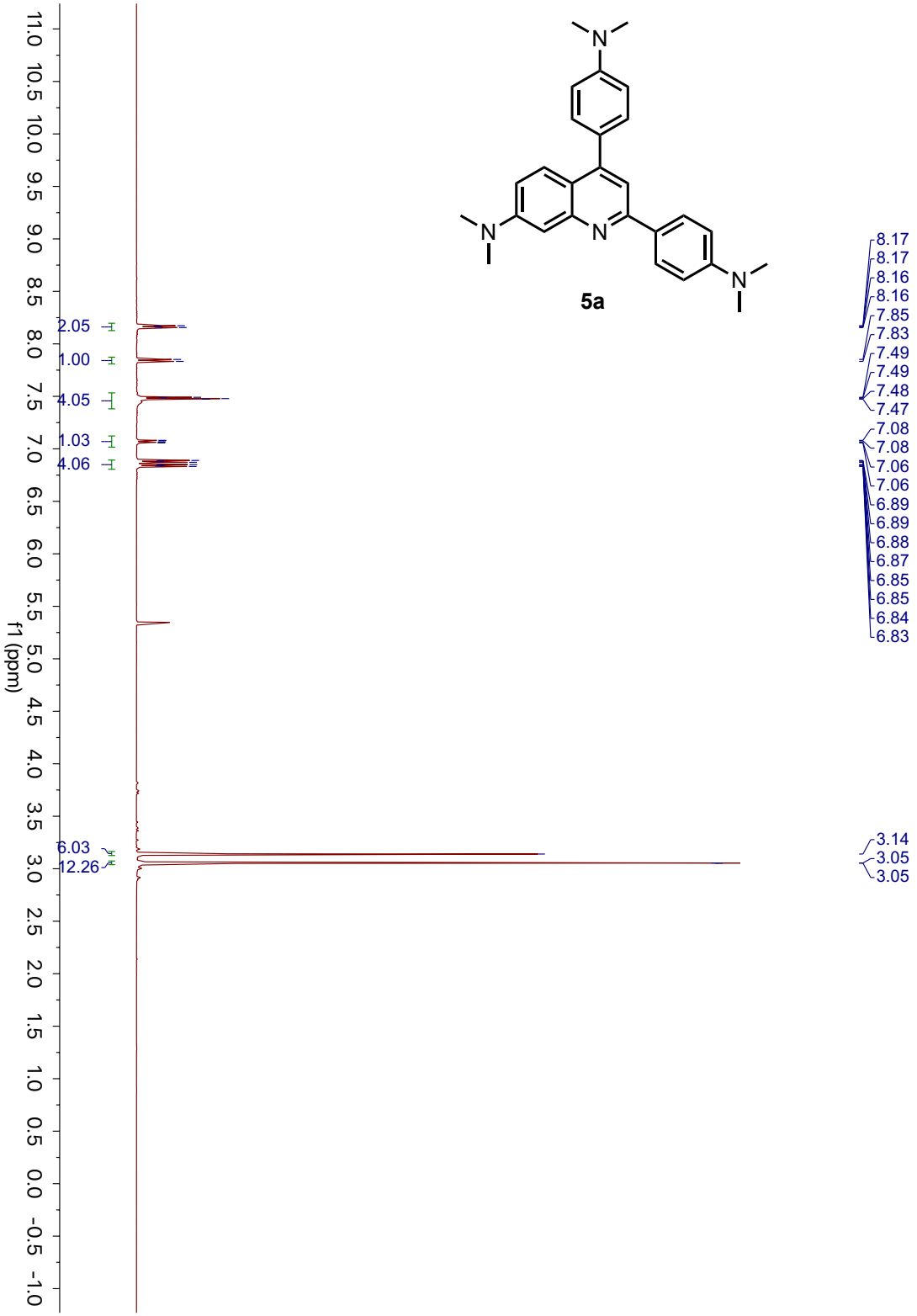
^{1}H NMR spectrum of **4n** in CD_2Cl_2 (500 MHz).



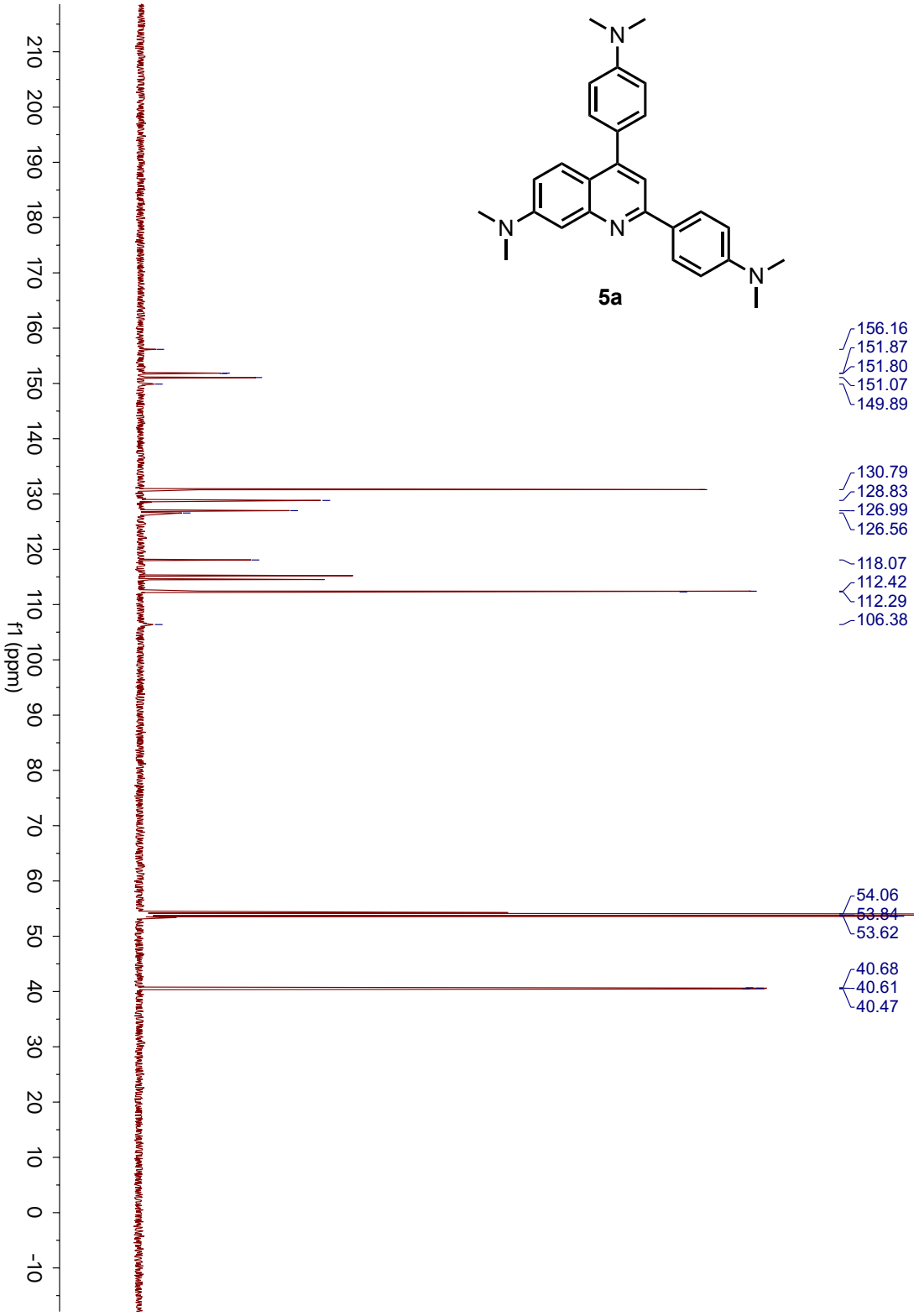
^{13}C NMR spectrum of **4n** in CD_2Cl_2 (126 MHz).



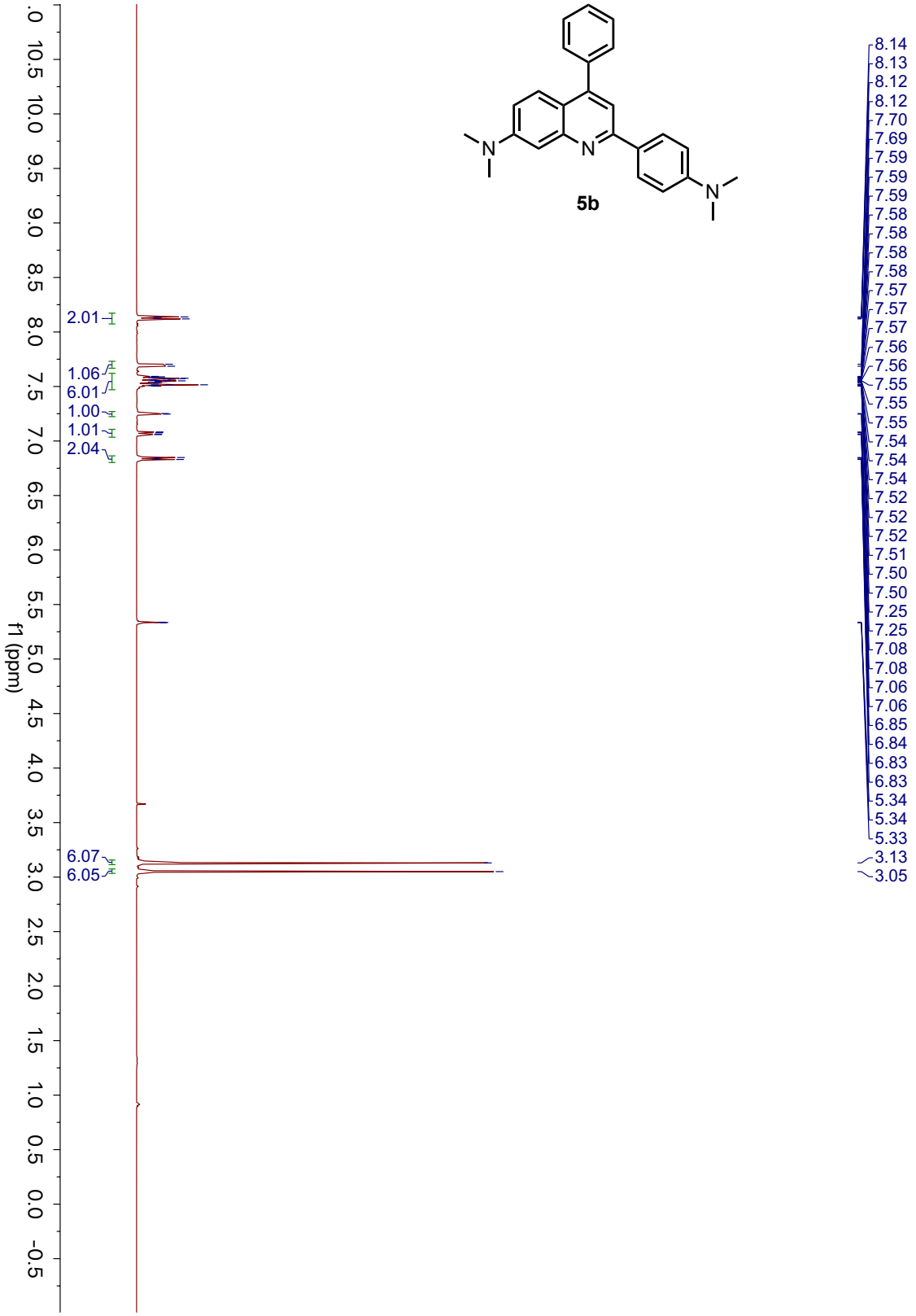
^{1}H NMR spectrum of **5a** in CD_2Cl_2 (500 MHz).



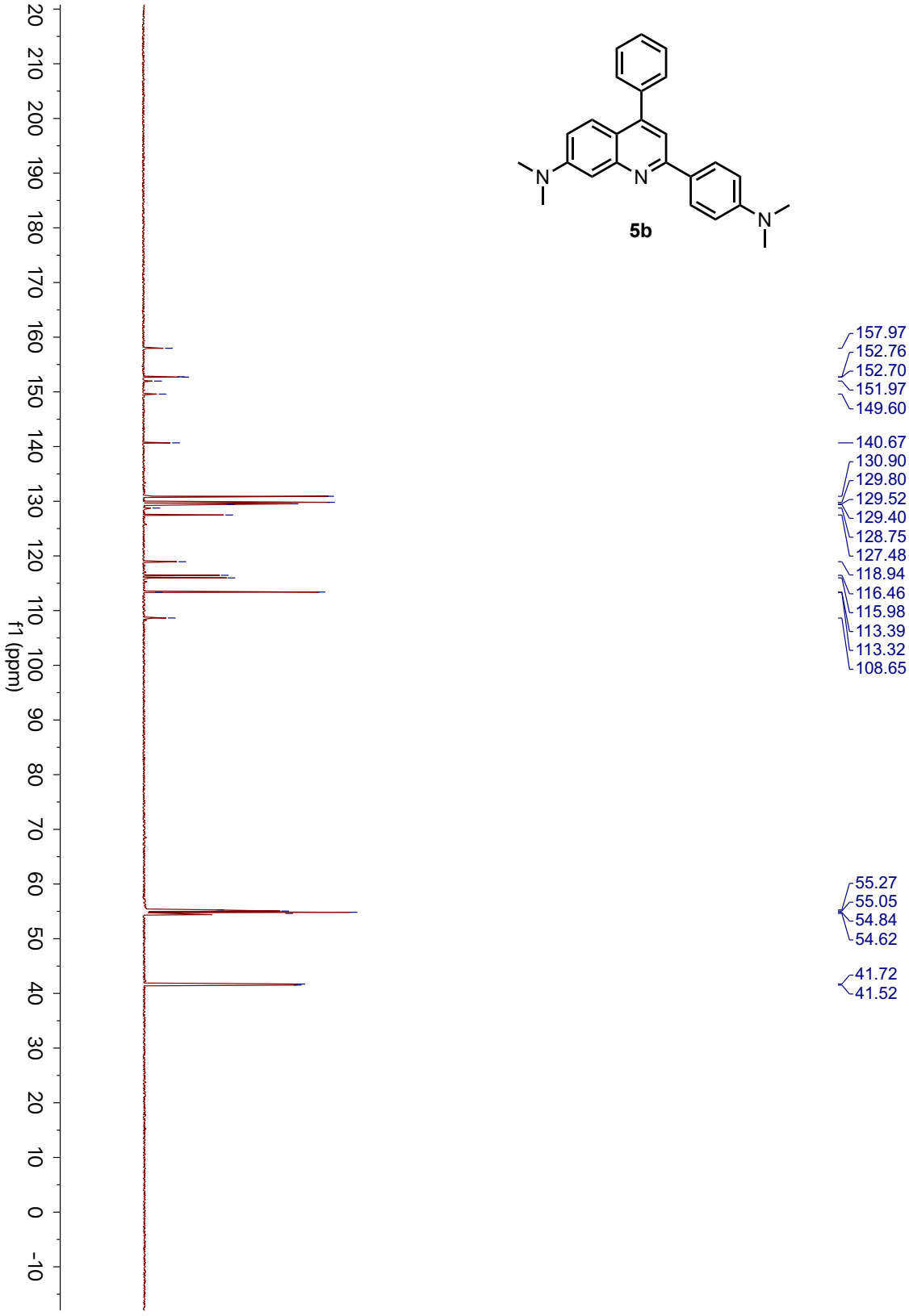
^{13}C NMR spectrum of **5a** in CD_2Cl_2 (126 MHz).



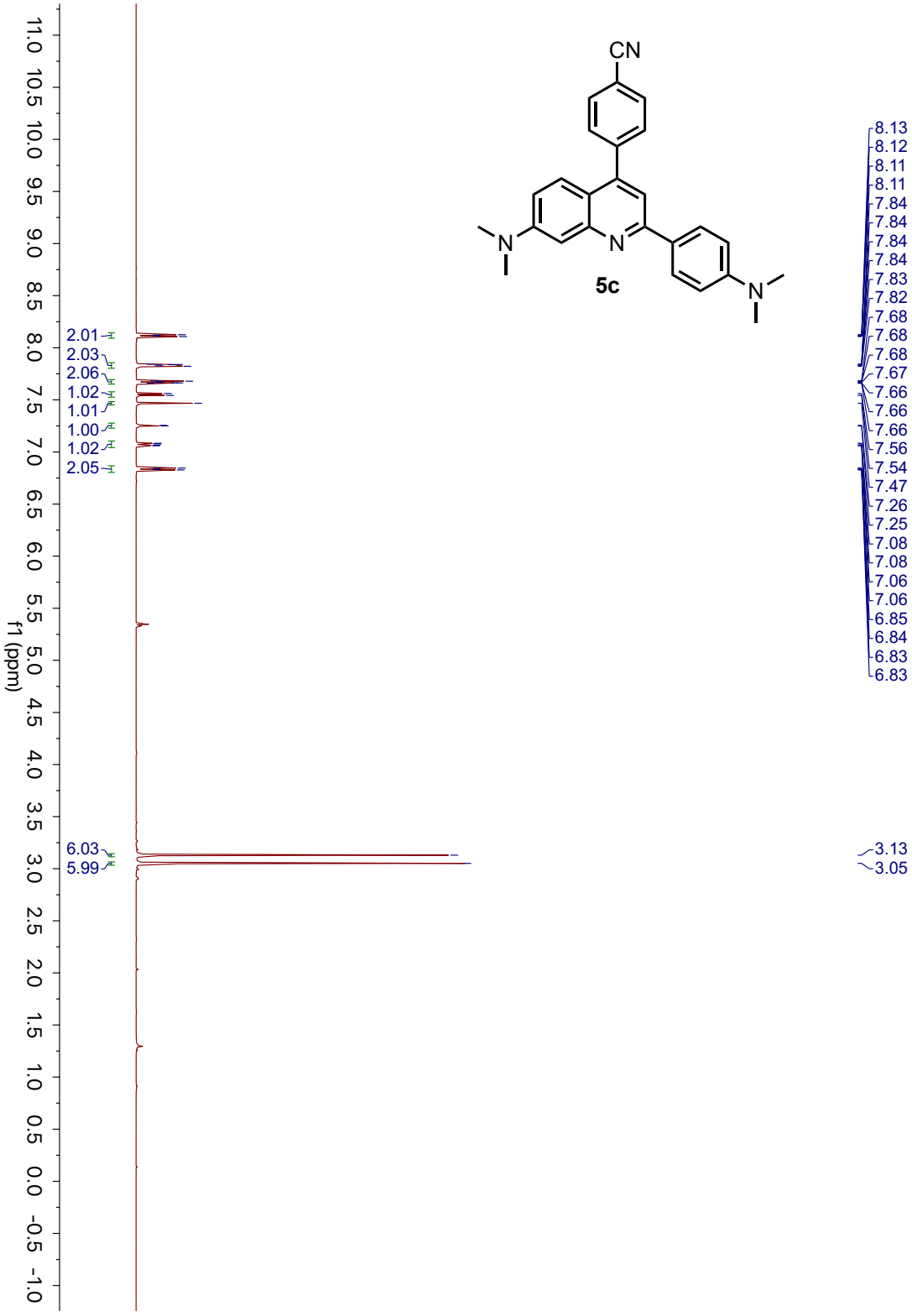
^{1}H NMR spectrum of **5b** in CD_2Cl_2 (500 MHz).



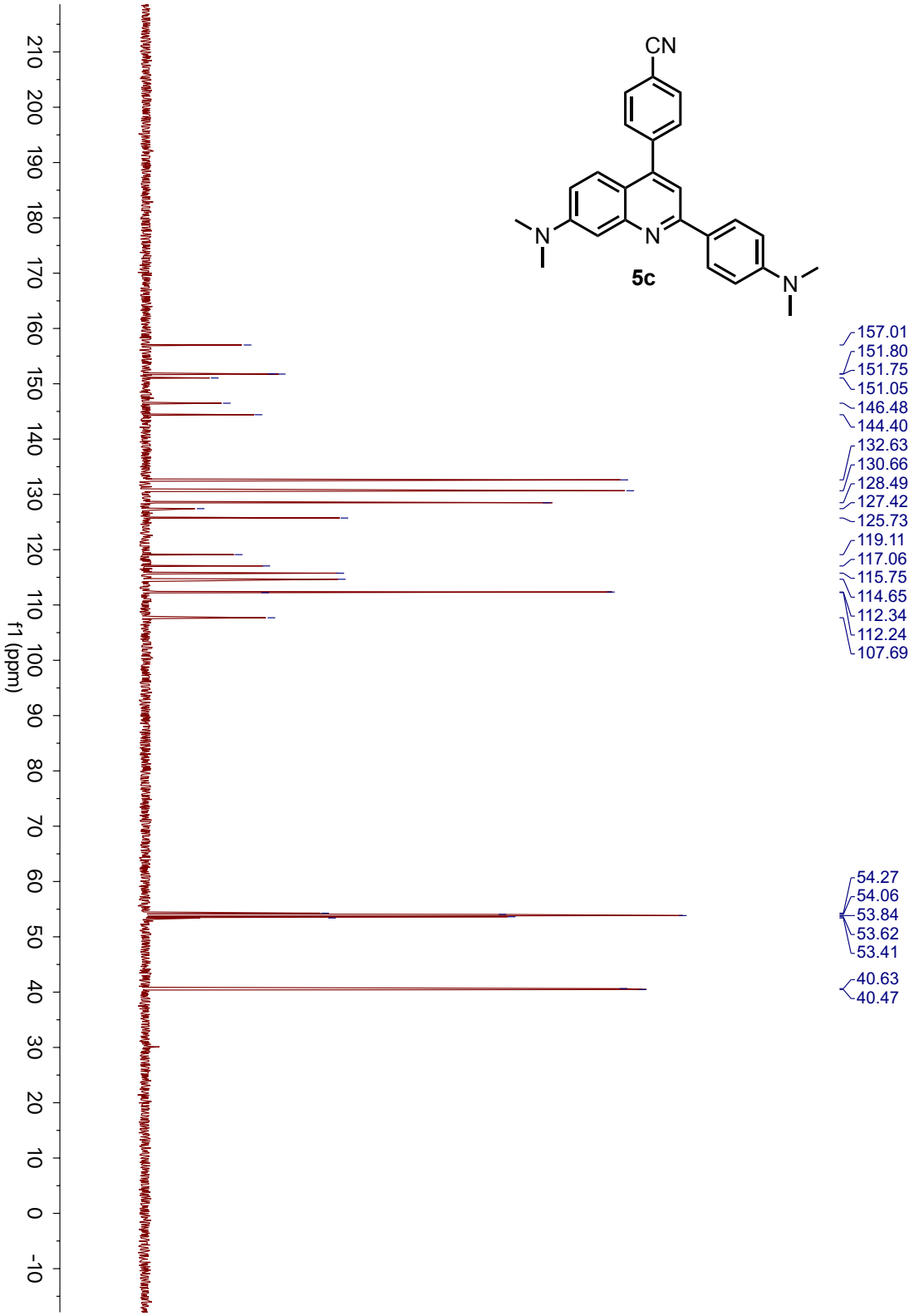
^{13}C NMR spectrum of **5b** in CD_2Cl_2 (126 MHz).



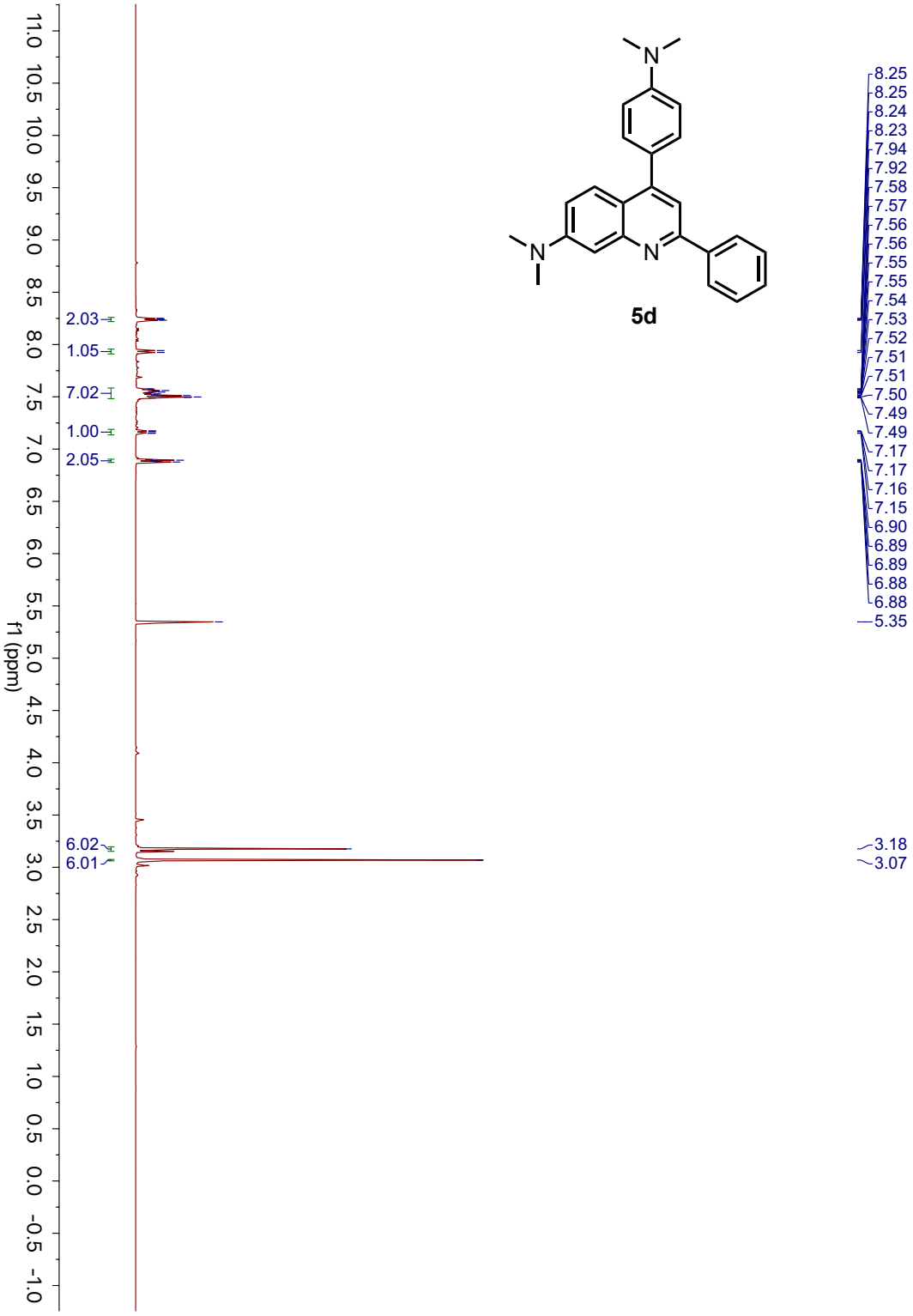
^{1}H NMR spectrum of **5c** in CD_2Cl_2 (500 MHz).



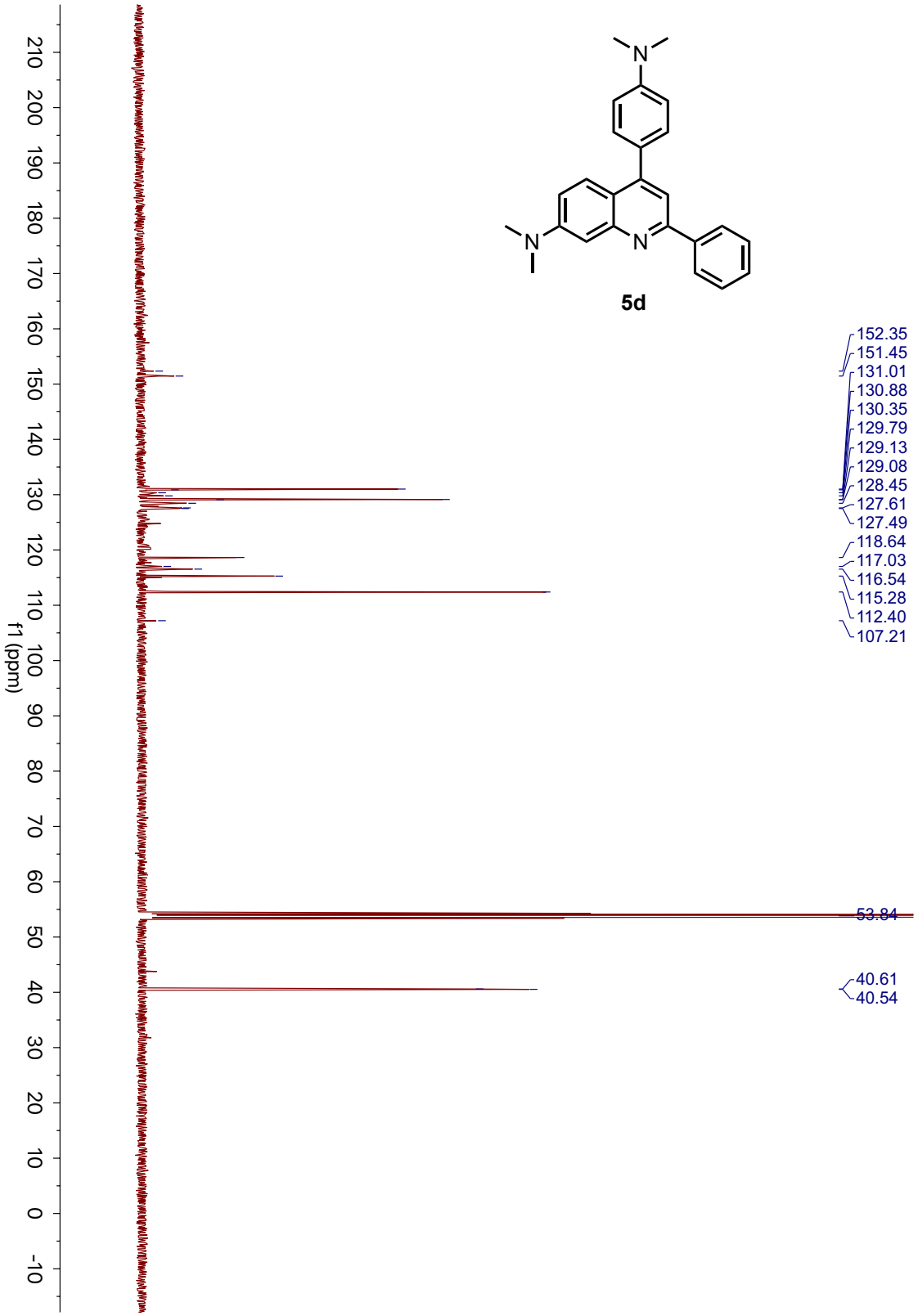
^{13}C NMR spectrum of **5c** in CD_2Cl_2 (126 MHz).



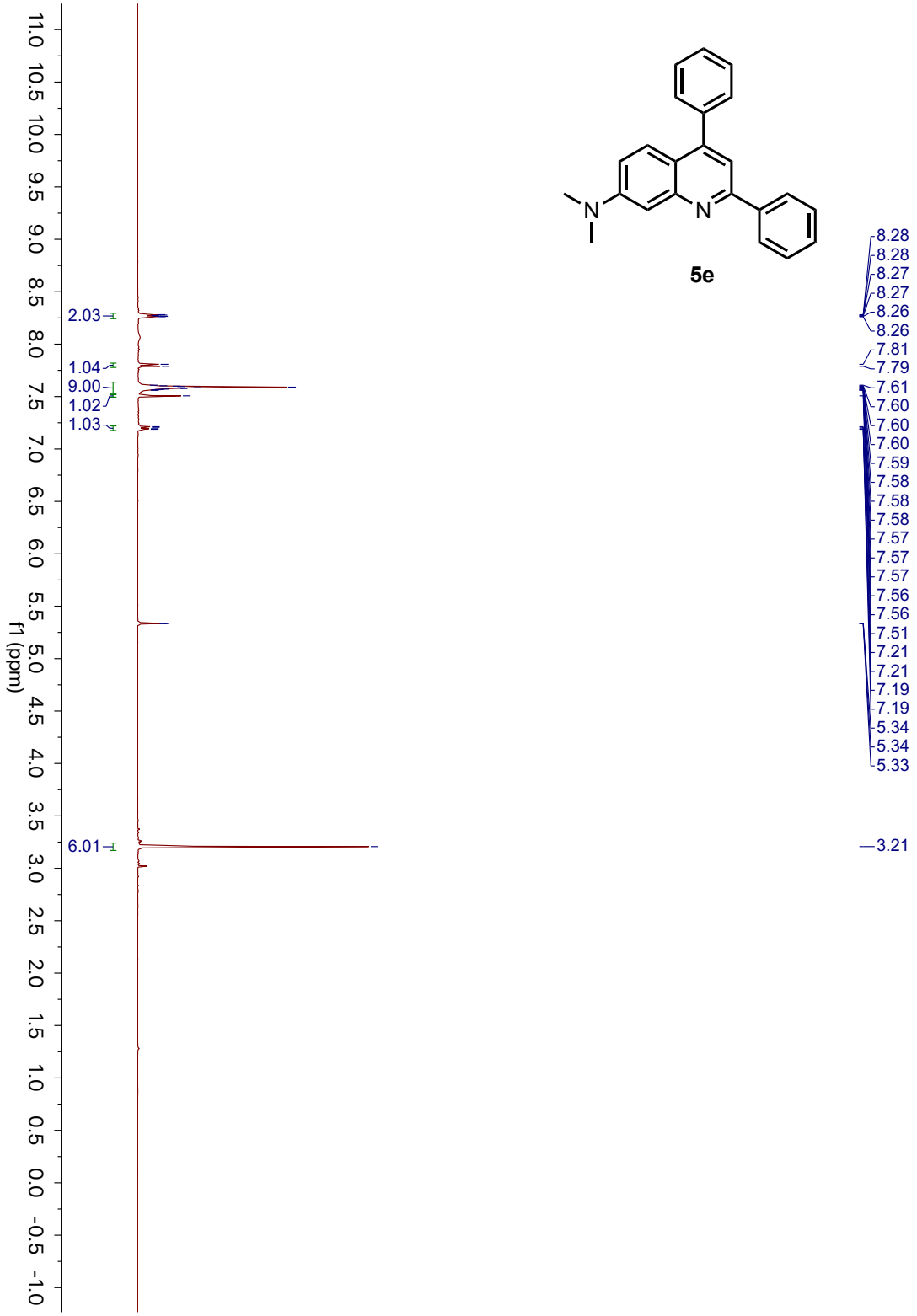
^{1}H NMR spectrum of **5d** in CD_2Cl_2 (500 MHz).



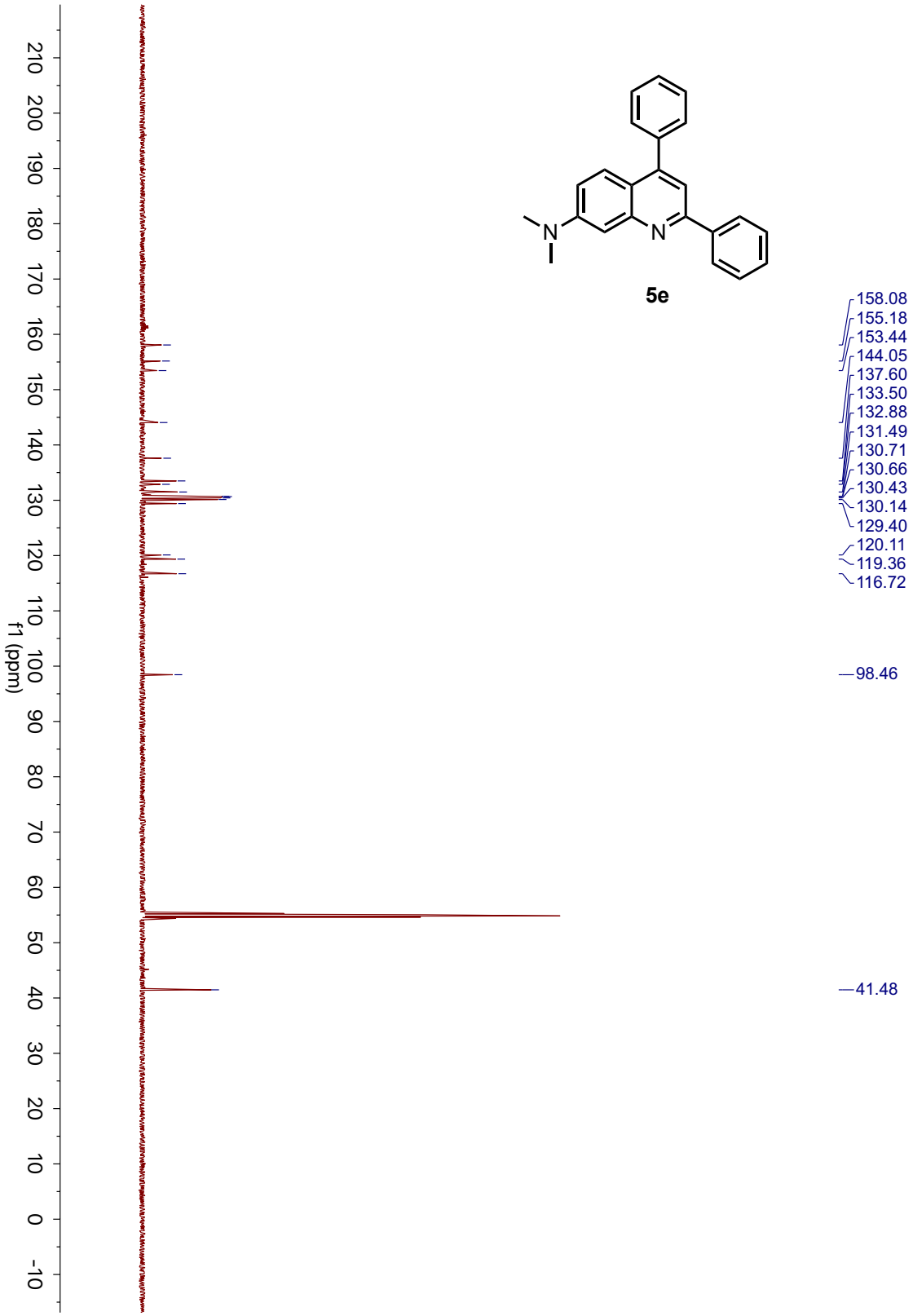
^{13}C NMR spectrum of **5d** in CD_2Cl_2 (126 MHz).



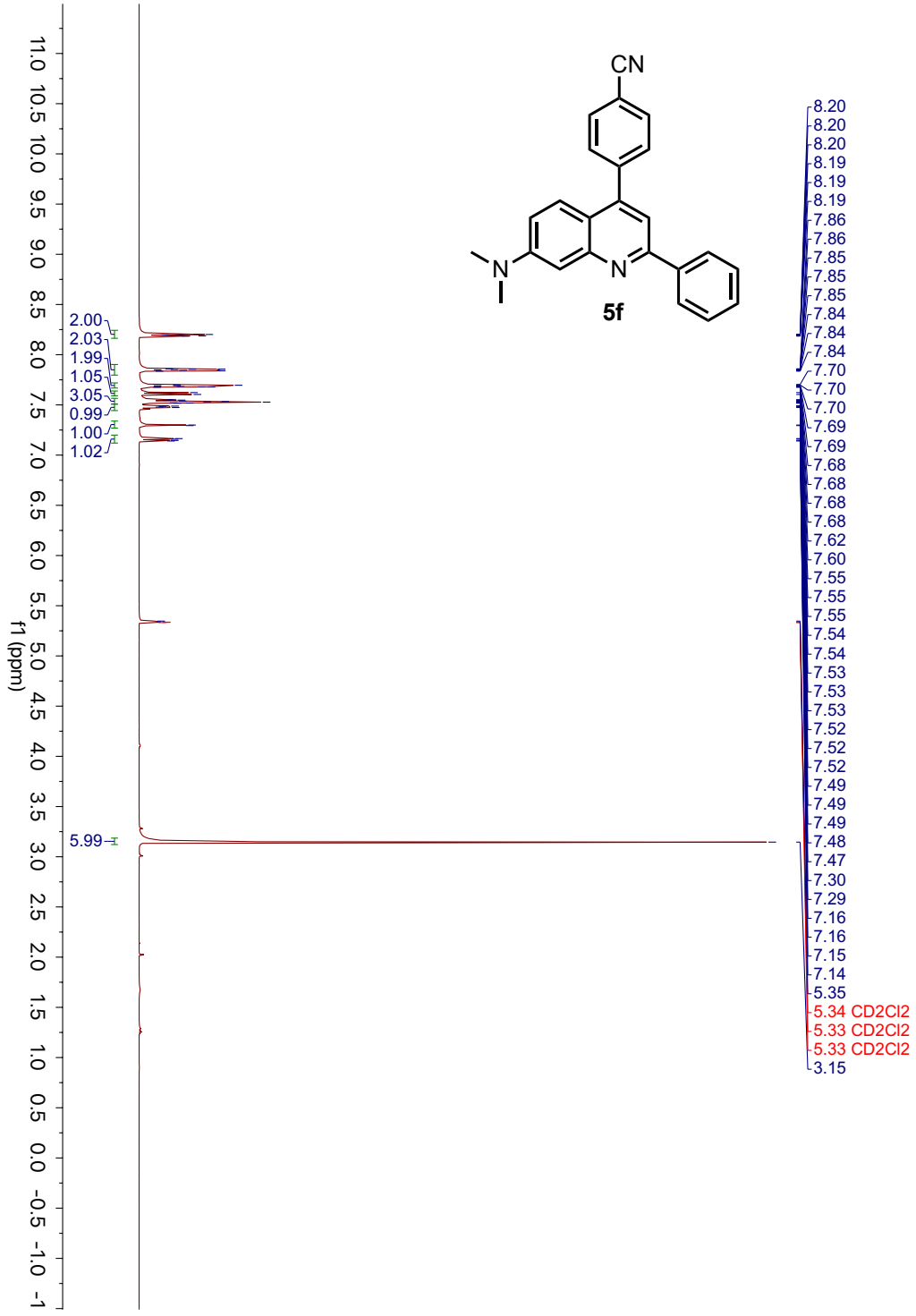
^{1}H NMR spectrum of **5e** in CD_2Cl_2 (500 MHz).



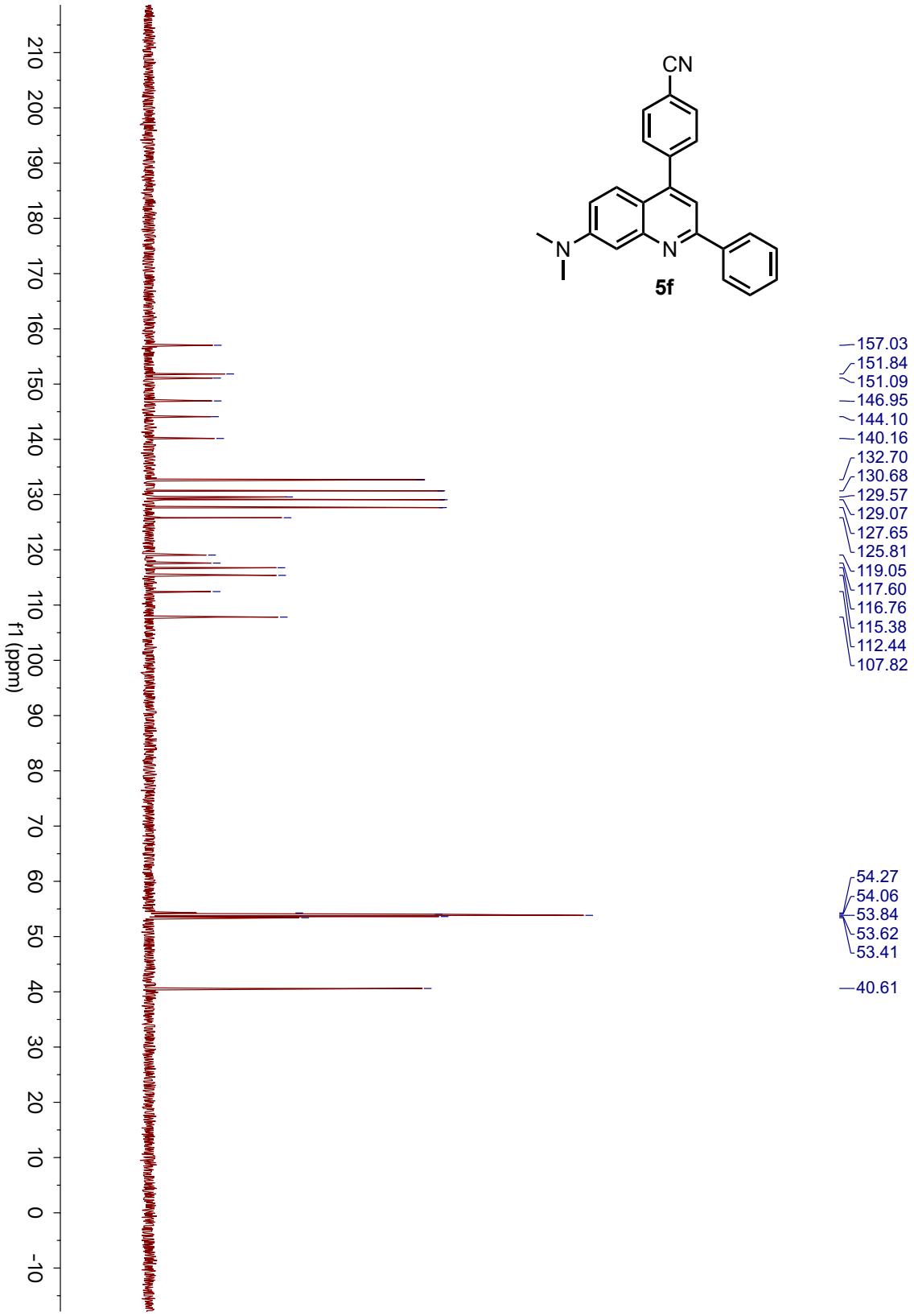
^{13}C NMR spectrum of **5e** in CD_2Cl_2 (126 MHz).



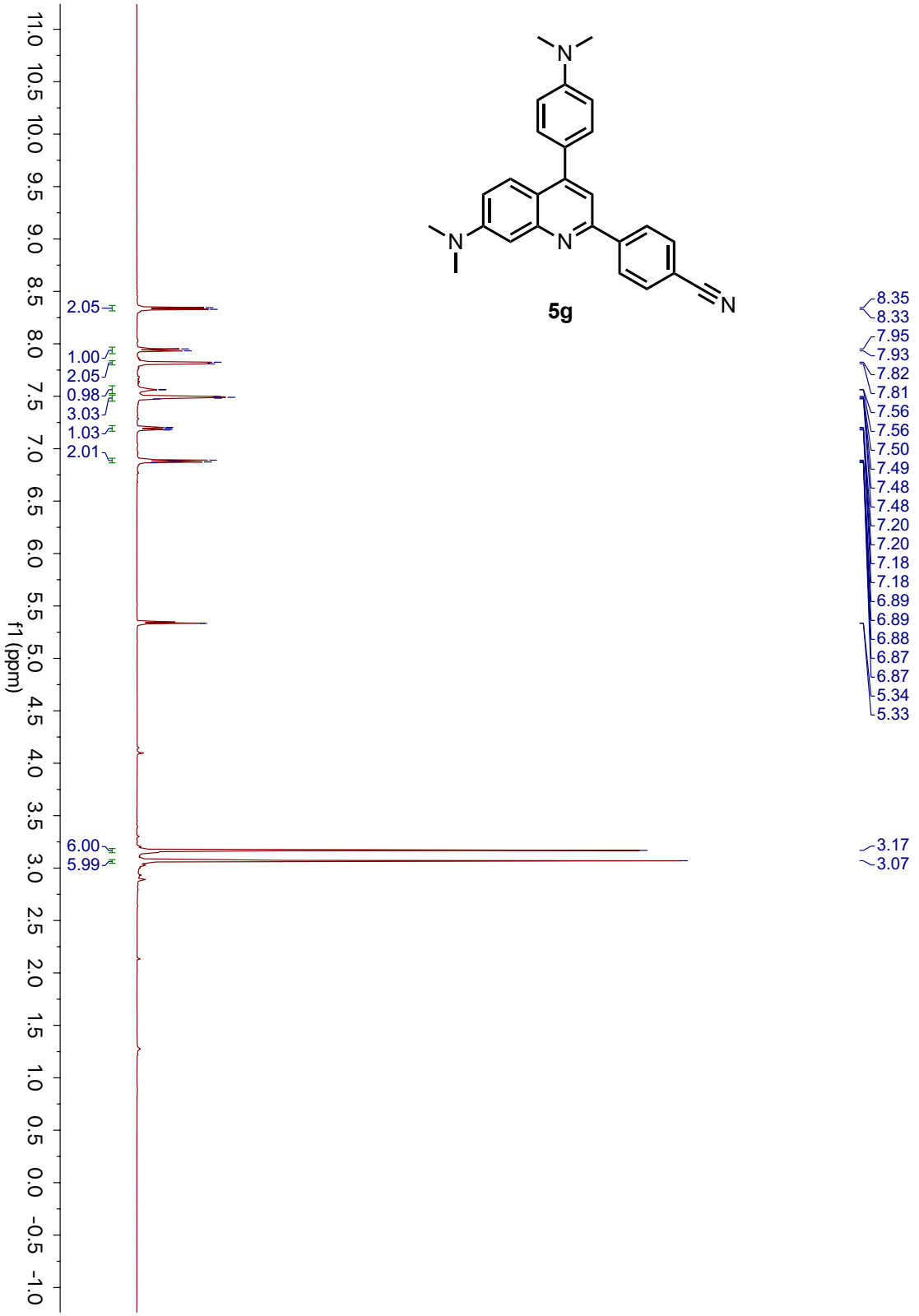
^{1}H NMR spectrum of **5f** in CD_2Cl_2 (500 MHz).



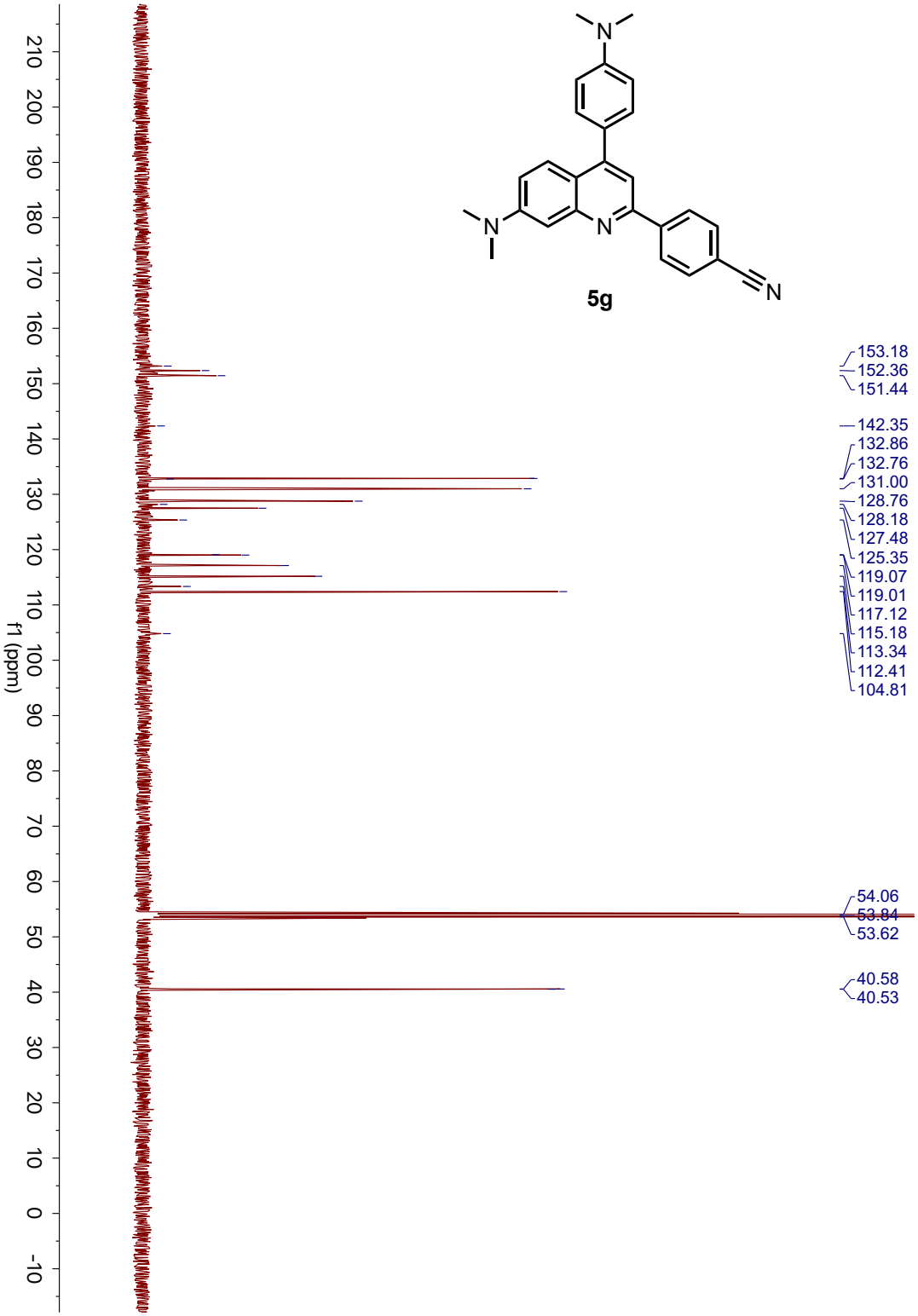
^{13}C NMR spectrum of **5f** in CD_2Cl_2 (126 MHz).



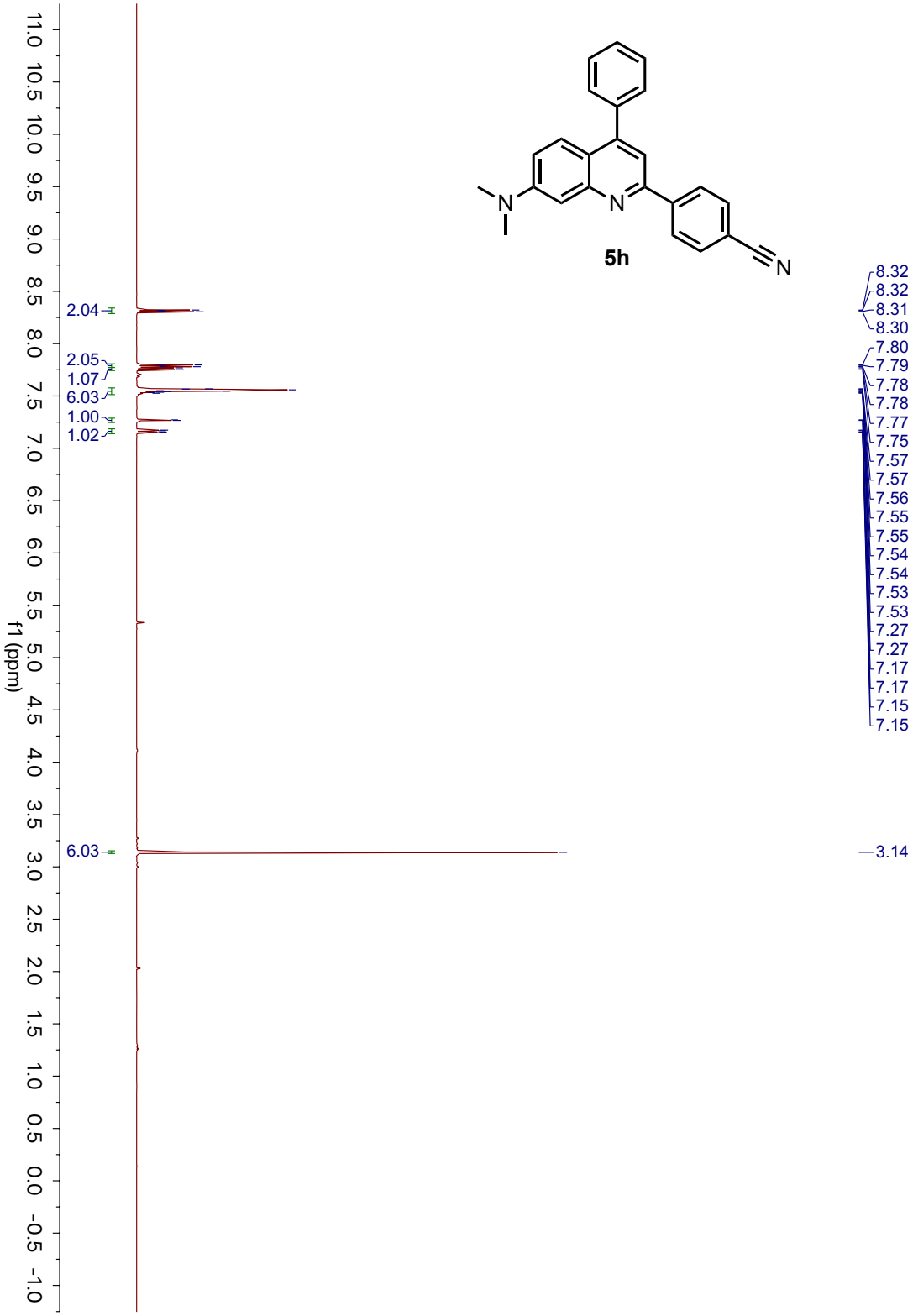
^{1}H NMR spectrum of **5g** in CD_2Cl_2 (500 MHz).



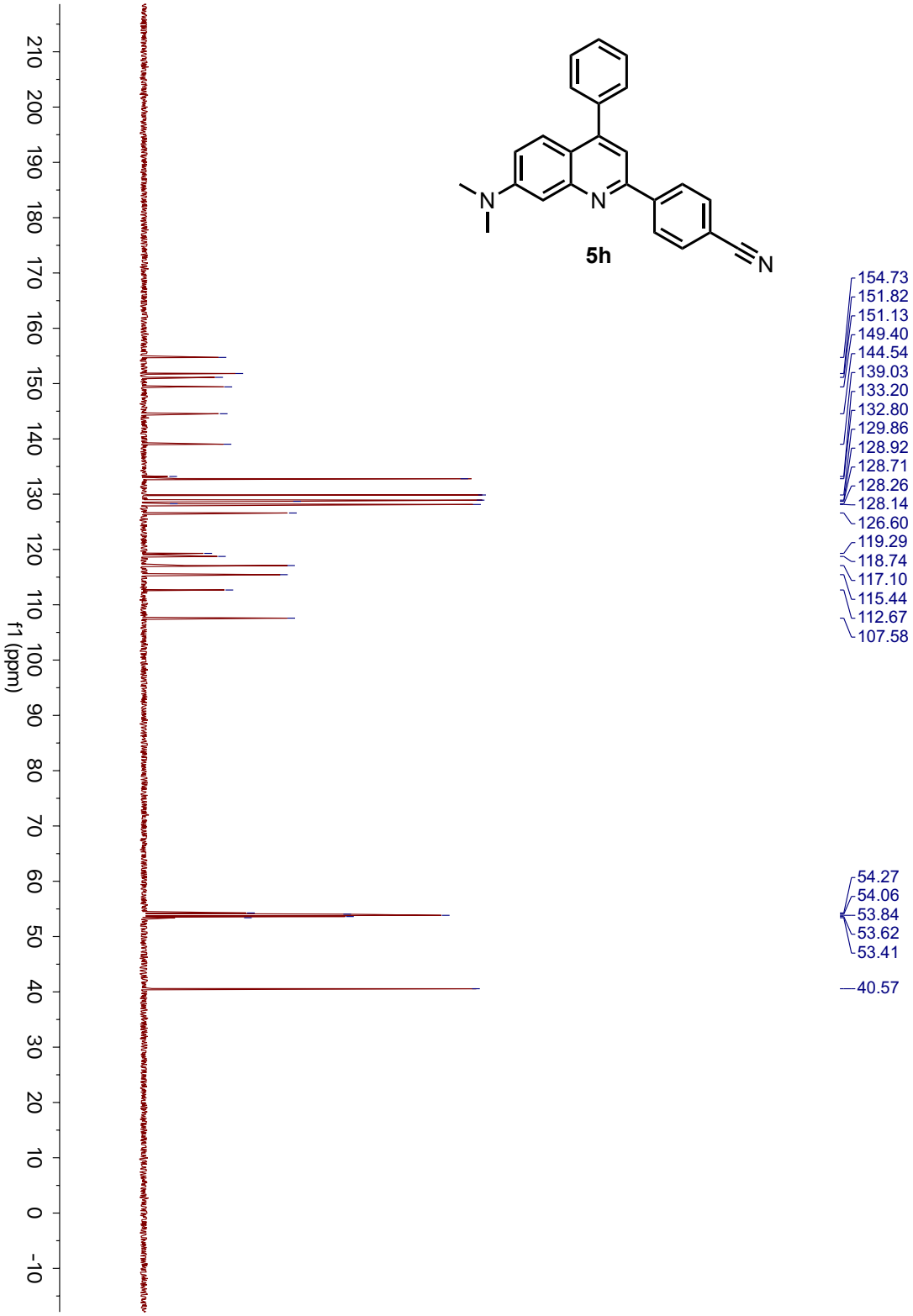
^{13}C NMR spectrum of **5g** in CD_2Cl_2 (126 MHz).



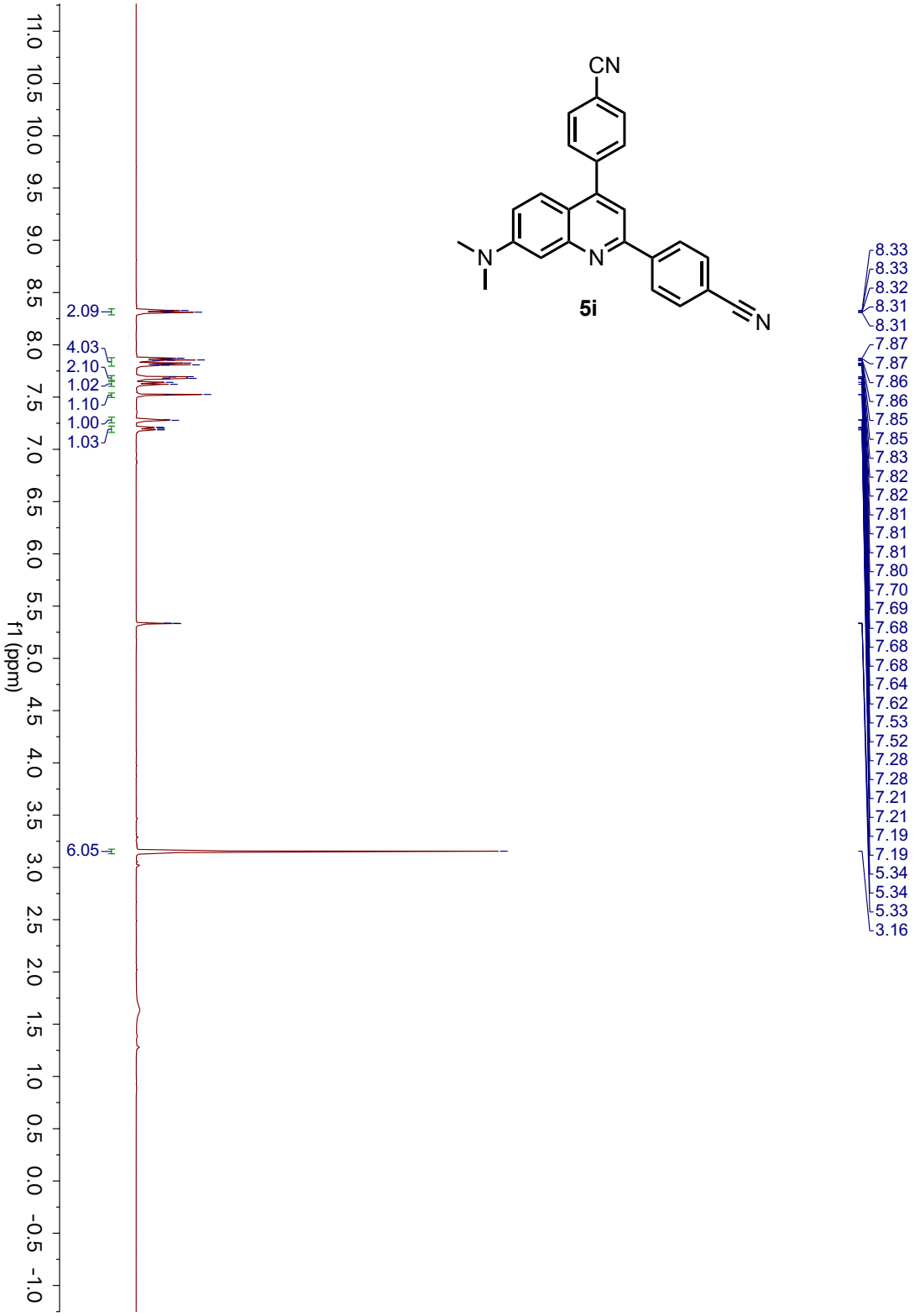
^{1}H NMR spectrum of **5h** in CD_2Cl_2 (500 MHz).



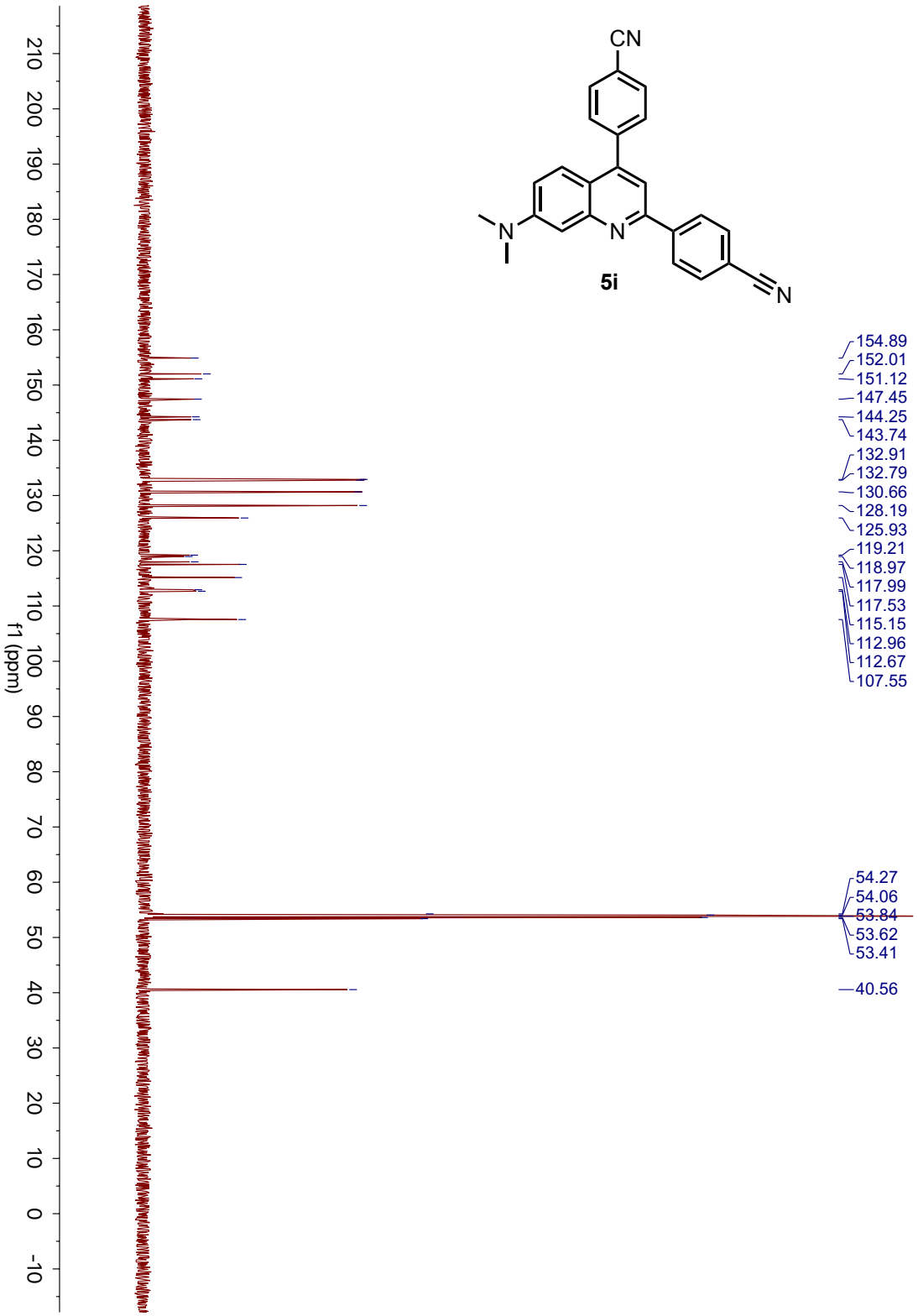
^{13}C NMR spectrum of **5h** in CD_2Cl_2 (126 MHz).



^{1}H NMR spectrum of **5i** in CD_2Cl_2 (500 MHz).



^{13}C NMR spectrum of **5i** in CD_2Cl_2 (126 MHz).



Computational Studies

Methods. All calculations were performed using the Gaussian 09[4] / WebMO program (B3LYP/6-31G*). Geometry optimizations and energies were calculated for a series of monoaryl-DMAQ (**4b, 4a, 4i, 4c, 4d, 4e, 4f**) and selected bisaryl-DMAQ (**5a, 5b, 5c, 5g, 5h, 5i)** compounds using density functional theory (DFT). The HOMO-LUMO energy gaps between the ground state (S_0) and the first excited state (S_1) of the DMAQs were calculated and are shown below. All structures are ground-state minima according to the analysis of their vibrational frequencies, which showed no negative value.

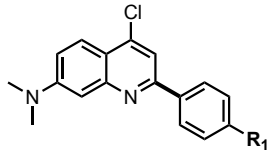


Table S15. Calculation of the Energy Gaps of Monoaryl DMAQ Based on Optimized Ground-State Geometries.

Compound	R_1	Hammett Constant (σ_p)	Absorbance Wavelength (nm)[a]	Electronic Transition	HOMO (eV)	LUMO (eV)	LUMO-HOMO Δ(eV)
4b	**$N(CH_3)_2$**	-0.83	400[b]	$S_0 \rightarrow S_1$	-11.709	-9.783	1.926
4a	**OH**	-0.37	390	$S_0 \rightarrow S_1$	-11.799	-9.801	1.998
4i	**OCH_3**	-0.27	398	$S_0 \rightarrow S_1$	-11.802	-9.803	1.999
4c	**H**	0.00	398	$S_0 \rightarrow S_1$	-11.812	-9.851	1.961
4d	**F**	0.06	398	$S_0 \rightarrow S_1$	-11.803	-9.809	1.994
4e	**CF_3**	0.54	406	$S_0 \rightarrow S_1$	-11.804	-9.850	1.954
4f	**CN**	0.66	412	$S_0 \rightarrow S_1$	-11.804	-10.036	1.768

Table S16. Calculation of the Energy Gaps of Bisaryl DMAQ Based on Optimized Ground-State Geometries.

Compound	Hammett Constant (σp)	Absorbance Wavelength (nm)[c]	Electronic Transition	HOMO (eV)	LUMO (eV)	LUMO-HOMO Δ(eV)
5a	-0.83	478	LUMO - HOMO	-11.716	-9.88	1.836
5b	0	490	LUMO - HOMO	-11.717	-9.894	1.823
5c	0.66	498	LUMO - HOMO	-11.709	-9.968	1.741
5g	-0.83	376	LUMO - HOMO (ΔE^1)	-11.748	-10.082	1.666
5g	-0.83	376	LUMO - HOMO-1 (ΔE^2)	-11.823	-10.082	1.741
5g	-0.83	376	LUMO+1 - HOMO (ΔE^3)	-11.748	-9.457	2.291
5g*	-0.83	376	LUMO+1 - HOMO-1 (ΔE^4)	-11.823	-9.457	2.366
5h	0	412	LUMO - HOMO	-11.819	-10.097	1.722
5i	0.66	416	LUMO - HOMO	-11.802	-10.116	1.686

Computational Analysis of Monoaryl DMAQ (Table S15).

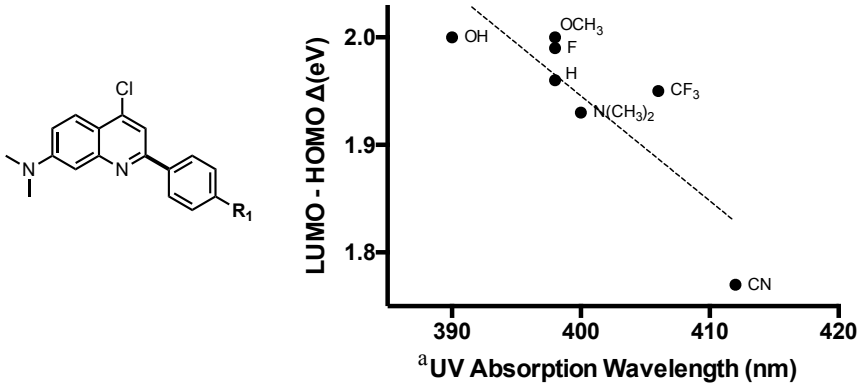


Figure S31. Correlation between HOMO-LUMO energy gap (eV) compared to experimentally measured UV absorption maximum (nm). [a]Maximum UV absorption wavelengths above 300 nm were obtained in methanol (Table S5). [b]UV absorbance value for **4b** was chosen as 400 nm since 494 nm was a minor peak, which can be due to protonation of the compound (R^2 =0.71).

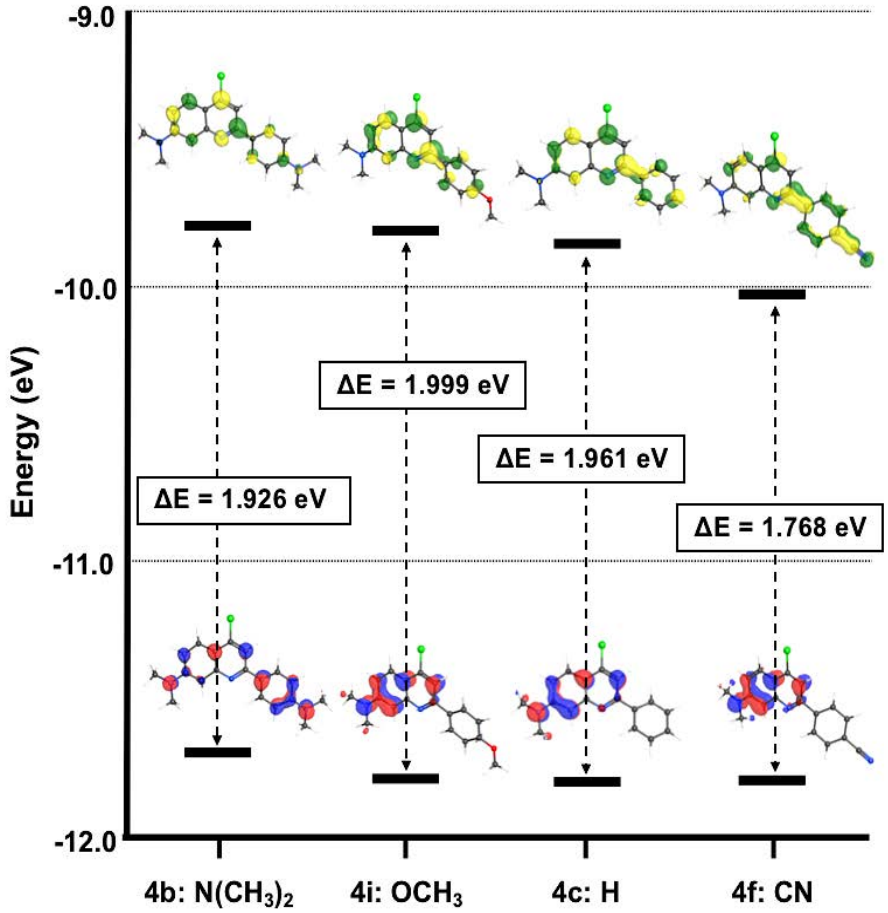


Figure S32. Relative HOMO-LUMO energy gap (eV) of selected monoaryl DMAQ.

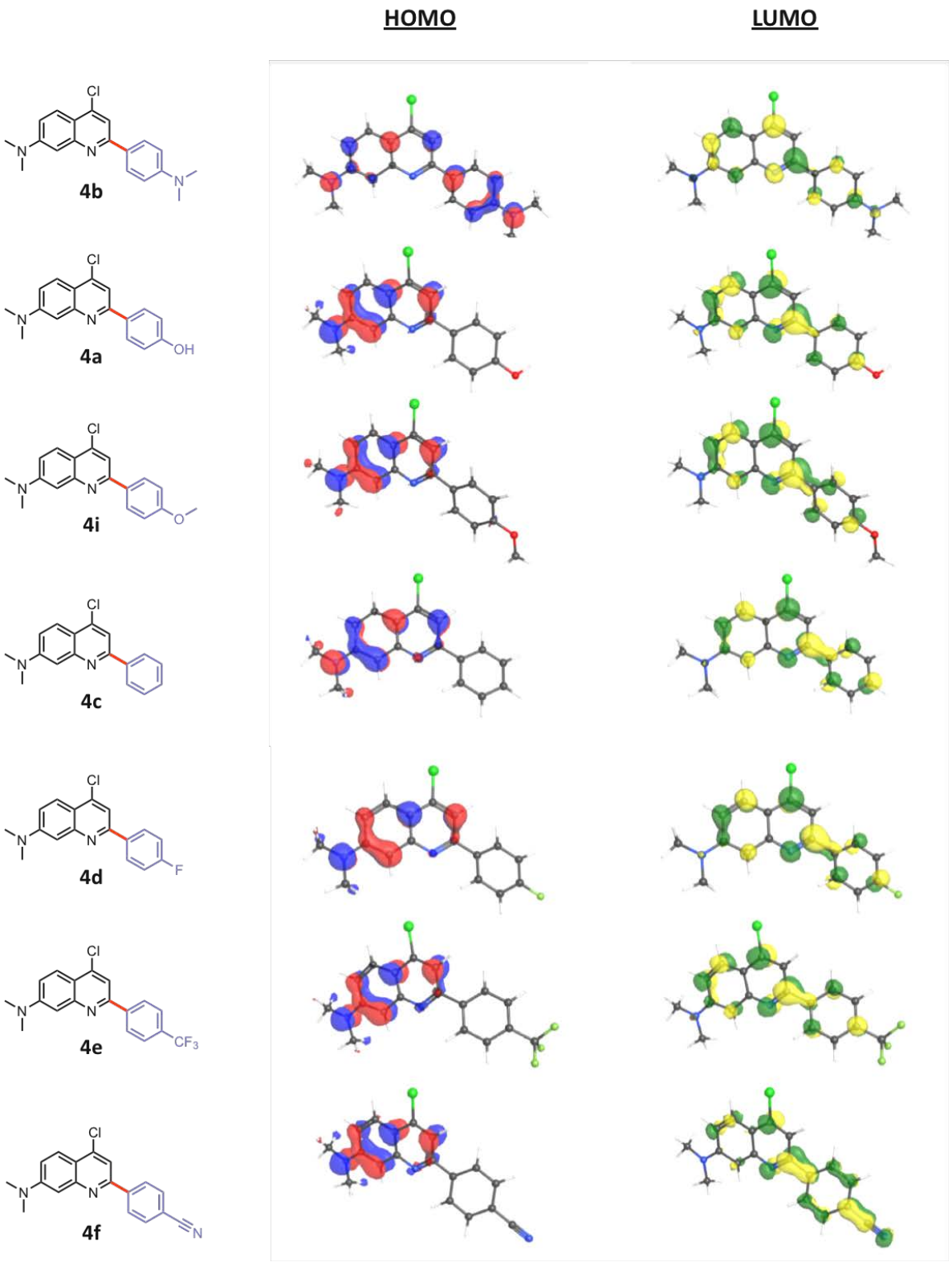


Figure S33. Schematic representation of contour surface of HOMO & LUMO of representative monoaryl DMAQ compounds.

Computational Analysis of Bisaryl DMAQ (Table S16).

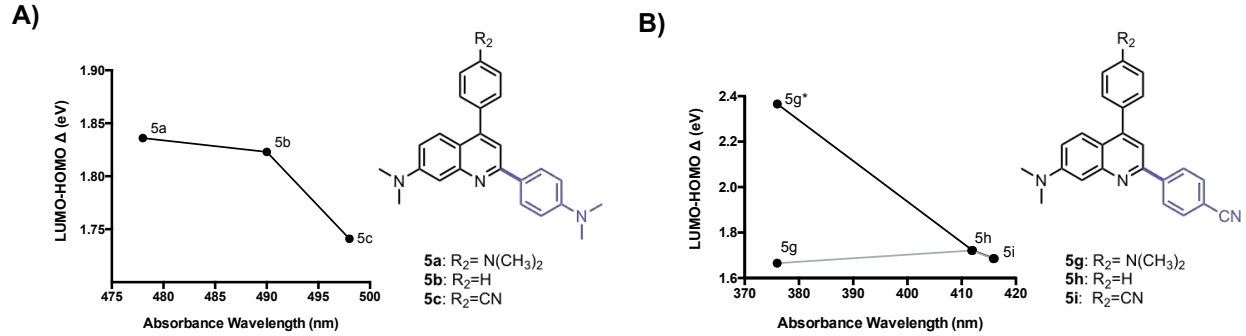


Figure S34. Correlation between HOMO-LUMO energy gaps and experimentally measured UV absorption maximum in methanol (Table S5). [c]Most red-shifted UV absorption wavelengths were chosen for analysis. Effects of C-4 substituents on HOMO-LUMO gap were investigated by grouping bisaryl DMAQs into A) correlation among derivatives of **4b** and B) correlation among derivatives of **4f**. Among four possible electronic transitions for **5g**, the largest and smallest values are shown as **5g** and **5g*** in Table S16.

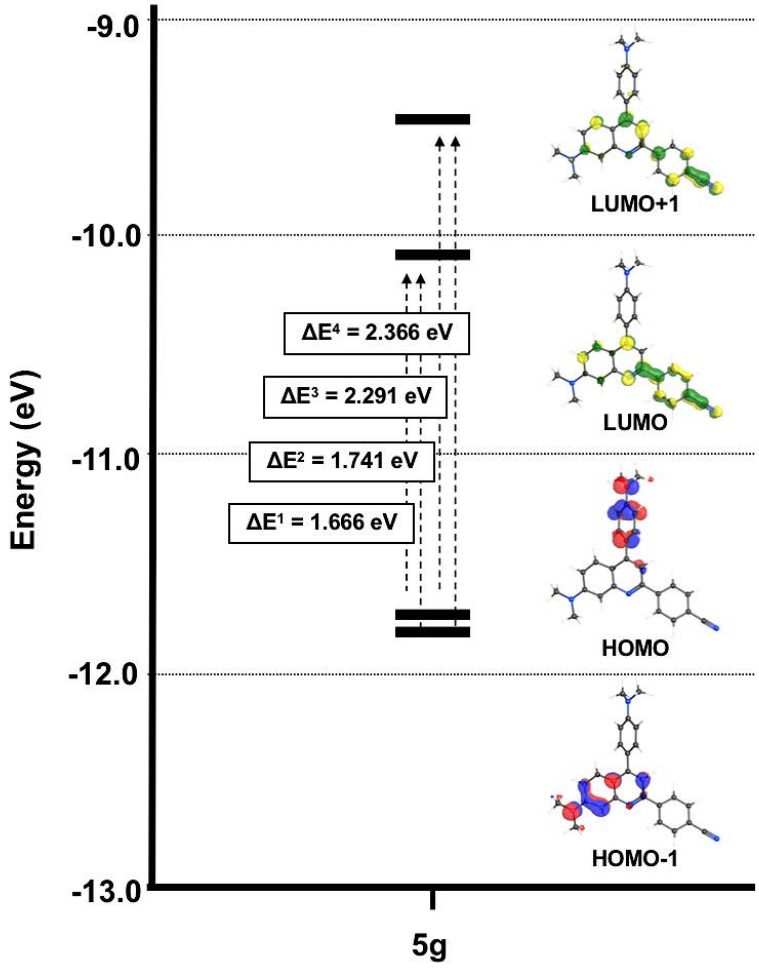


Figure S35. Possible MO energy gaps of **5g.**

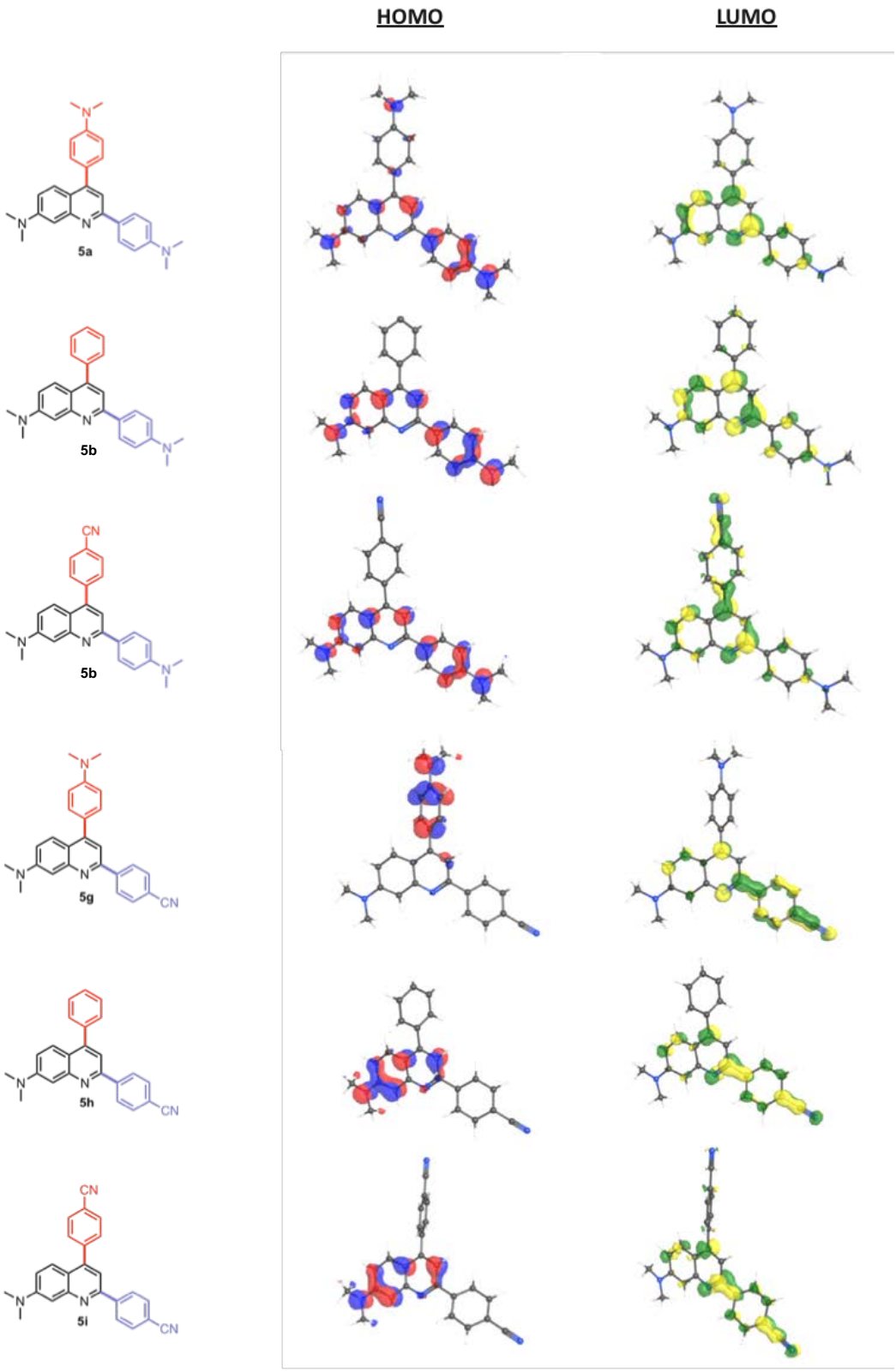
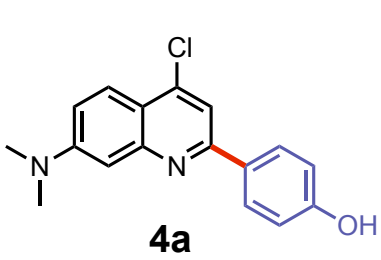


Figure S36. Schematic Representation of HOMO & LUMO of Representative bisaryl DMAQ Compounds.

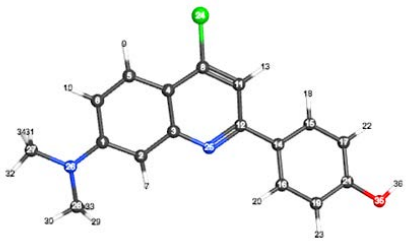
Discussion of Computational Modeling. The correlation between the photophysical properties of DMAQ derivatives and the electronic characteristics of the substituents were quantitatively analyzed to demonstrate the rational design of the DMAQ scaffold. It is generally accepted that the absorption wavelength (λ_{abs}) correlates well with the energy gap between the HOMO and LUMO determined using simple electronic structure calculations, but that determining the emission wavelength requires more complex methods due to the nature of the fluorescence process (e.g., Stokes shifts).[5-7] With regard to the emission wavelength (λ_{em}) of DMAQ, we clearly demonstrated a positive linear correlation between λ_{em} and the Hammett constant in Figure 2 in the main text.

Relative energy levels of HOMO and LUMO were calculated using DFT calculations (B3LYP/6-31+G*). Model compounds were chosen based on various functional groups at the *para*-position in the C-2 aryl substituent of DMAQ derivatives. Generally, a decrease in HOMO-LUMO gap was observed with more electron withdrawing substituents, which matched well with red-shifts of the UV-absorbance (Table S15/Figure S31 for monoaryl, Table S16/Figure S34 for bisaryl DMAQ). Interestingly, **4b** had a higher HOMO-LUMO gap than derivatives with more electron withdrawing substituents (**4a**,**4c,4d,** and **4i**). This outlier behavior can be explained by examination of the HOMO of **4b** as the electrons are donated by the dimethylamino group on the C-2 phenyl ring rather than the C-7 dimethylamino group (Figure S32 and S33). Moreover, **4b** has the HOMO energy level at -11.7 eV while rest have around -11.8 eV. In general, the HOMO level stays constant and the LUMO level decreases from -9.8 eV to -10.0 eV, lowering the HOMO-LUMO energy gap with more electron withdrawing substitution at C-2 aryl. Figure S36 shows a schematic representation of the HOMOs and LUMOs of selected bisaryl DMAQs. While most of the electron transitions in DMAQs occur through the core monoaryl moiety, **5g** exhibited a different electronic transition. Hence, the LUMO+1 and HOMO-1 energy levels of **5g** were also considered (Figure S35). With this, correlations between the HOMO-LUMO energy gap and the UV absorption of two extreme cases (**5g**, **5g*)** were shown (Figure S4B).

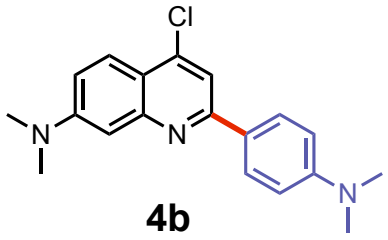
Optimized Geometry Coordinates.



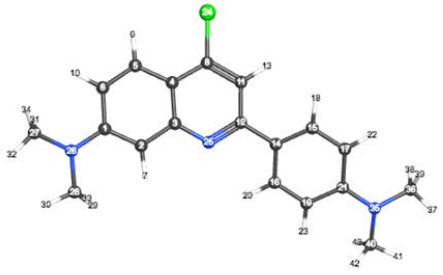
4a



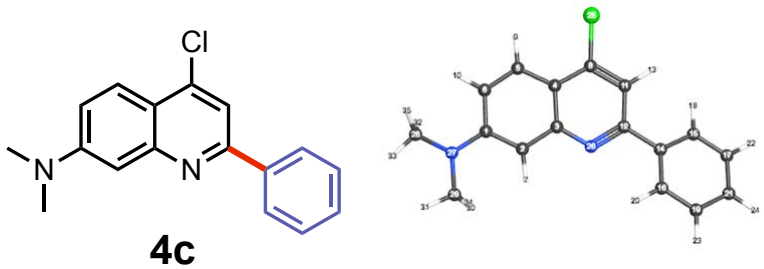
4a (OH)	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	3.426504	-0.865082	-0.024593	C	6	-4.187363	-1.966612	-0.382863
C	6	2.064592	-1.178636	-0.005059	H	1	-2.064488	-2.115197	-0.681854
C	6	1.067473	-0.175637	-0.016215	C	6	-5.244138	-1.138919	0.015381
C	6	1.454947	1.206796	-0.035208	H	1	-5.799329	0.821023	0.739618
C	6	2.837928	1.514212	-0.036418	H	1	-4.40275	-2.985333	-0.69153
C	6	3.790229	0.522745	-0.028115	Cl	17	0.743557	3.869473	-0.107531
H	1	1.710055	-2.201081	0.020232	N	7	-0.236041	-0.575851	-0.000041
C	6	0.394474	2.145007	-0.054026	N	7	4.403727	-1.847336	-0.049569
H	1	3.150368	2.553507	-0.042231	C	6	5.798285	-1.497481	0.18143
H	1	4.834452	0.811372	-0.025095	C	6	4.009553	-3.237817	0.117297
C	6	-0.916377	1.73589	-0.044934	H	1	3.300789	-3.537057	-0.663569
C	6	-1.197499	0.33699	-0.006829	H	1	4.892472	-3.873489	0.026514
H	1	-1.712671	2.467681	-0.094527	H	1	5.966576	-1.053	1.175597
C	6	-2.601162	-0.152869	0.008408	H	1	6.406	-2.401175	0.105357
C	6	-3.675276	0.657593	0.408841	H	1	3.541318	-3.428171	1.09667
C	6	-2.887165	-1.476264	-0.379497	H	1	6.162454	-0.794452	-0.576696
C	6	-4.984769	0.175406	0.415229	O	8	-6.506116	-1.672564	-0.005716
H	1	-3.5018	1.674919	0.746665	H	1	-7.150216	-1.009706	0.288894



4b

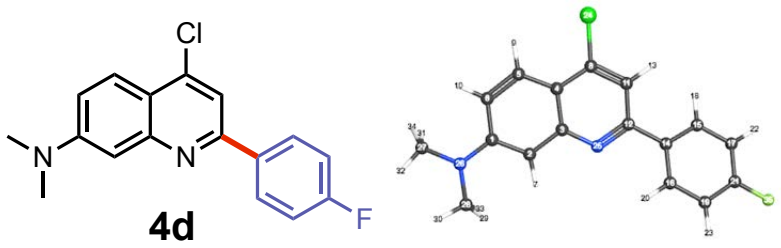


4b (NMe2)	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	4.037249	-1.064313	-0.100284	H	1	-3.885501	-2.51977	0.406041
C	6	2.652209	-1.247631	-0.096755	Cl	17	1.816872	3.897149	0.159452
C	6	1.75335	-0.155413	-0.05102	N	7	0.418826	-0.430366	-0.063805
C	6	2.272392	1.181763	0.007586	N	7	4.918356	-2.133971	-0.183384
C	6	3.677647	1.356211	0.020227	C	6	6.330782	-1.935972	0.111151
C	6	4.532181	0.279791	-0.028241	C	6	4.390232	-3.486072	-0.087915
H	1	2.202455	-2.231494	-0.131953	H	1	3.650052	-3.668684	-0.875077
C	6	1.304141	2.214534	0.061917	H	1	5.205577	-4.199013	-0.226931
H	1	4.086608	2.36009	0.07297	H	1	6.506237	-1.580978	1.139852
H	1	5.599073	0.466759	-0.013071	H	1	6.853871	-2.885941	-0.01563
C	6	-0.038648	1.932321	0.051302	H	1	3.912338	-3.68632	0.885445
C	6	-0.456099	0.567257	-0.020835	H	1	6.784352	-1.219179	-0.582708
H	1	-0.758476	2.737767	0.119622	N	7	-6.000139	-0.91224	-0.101436
C	6	-1.896004	0.21319	-0.03611	C	6	-7.025793	0.11744	-0.158961
C	6	-2.912871	1.150109	-0.285946	H	1	-8.00704	-0.358939	-0.208384
C	6	-2.301468	-1.112497	0.202581	H	1	-7.007713	0.784169	0.719056
C	6	-4.257799	0.793757	-0.299025	H	1	-6.913178	0.733919	-1.058603
H	1	-2.667655	2.187266	-0.495113	C	6	-6.387734	-2.237892	0.355714
C	6	-3.638919	-1.484706	0.199813	H	1	-7.464878	-2.359199	0.223838
H	1	-1.538486	-1.857954	0.400138	H	1	-5.893282	-3.017435	-0.235476
C	6	-4.663462	-0.541519	-0.063722	H	1	-6.147164	-2.407679	1.418206
H	1	-4.991622	1.564982	-0.501397					



4c

4c (H)	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	3.140066	-0.682495	-0.023032	C	6	-4.36208	-2.420185	-0.413104
C	6	1.811123	-1.114213	-0.000478	H	1	-2.229008	-2.381639	-0.749367
C	6	0.730339	-0.201978	-0.014607	C	6	-5.478882	-1.701557	0.026614
C	6	0.994761	1.209409	-0.039388	H	1	-6.177746	0.179443	0.822712
C	6	2.345851	1.63677	-0.043608	H	1	-4.475627	-3.445383	-0.757089
C	6	3.380596	0.732157	-0.032689	H	1	-6.462569	-2.164343	0.029117
H	1	1.548092	-2.163665	0.030103	Cl	17	0.052999	3.798953	-0.119931
C	6	-0.143267	2.051386	-0.06012	N	7	-0.533167	-0.714788	0.004339
H	1	2.566415	2.699325	-0.054039	N	7	4.200198	-1.574286	-0.04542
H	1	4.395733	1.110413	-0.033	C	6	5.557525	-1.102597	0.192261
C	6	-1.413606	1.528204	-0.04699	C	6	3.929715	-2.994608	0.117952
C	6	-1.569253	0.111216	-0.003722	H	1	3.247943	-3.351968	-0.662457
H	1	-2.272374	2.185547	-0.096989	H	1	4.86464	-3.550238	0.022773
C	6	-2.928212	-0.500184	0.014718	H	1	5.679125	-0.64091	1.185235
C	6	-4.056638	0.210301	0.458982	H	1	6.242133	-1.950145	0.124648
C	6	-3.099942	-1.828023	-0.415	H	1	3.482493	-3.228591	1.097737
C	6	-5.319708	-0.385195	0.466621	H	1	5.863983	-0.373795	-0.567044
H	1	-3.953775	1.226809	0.827591					



4d

4d (F)	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
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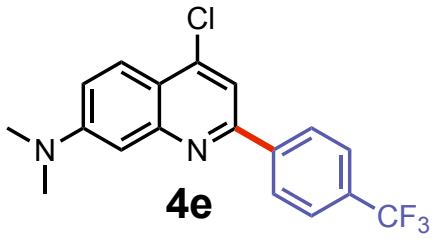
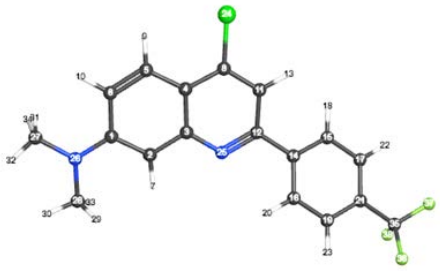
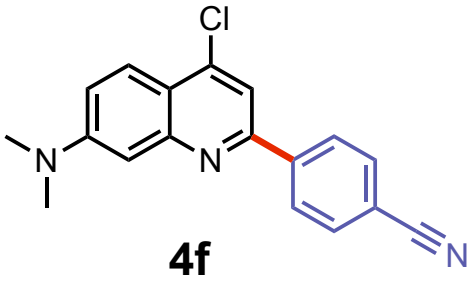
C	6	2.058168	-1.17808	0.000114	H	1	-2.067486	-2.096383	-0.740683
C	6	1.060757	-0.175938	-0.01442	C	6	-5.218348	-1.131822	0.019738
C	6	1.445722	1.207398	-0.036608	H	1	-5.813665	0.778837	0.799376
C	6	2.828811	1.516349	-0.037732	H	1	-4.417676	-2.972062	-0.746574
C	6	3.781573	0.525926	-0.026177	Cl	17	0.732544	3.868484	-0.116525
H	1	1.704982	-2.200912	0.028025	N	7	-0.242848	-0.57685	0.001337
C	6	0.385525	2.145137	-0.058594	N	7	4.39781	-1.842667	-0.038964
H	1	3.140199	2.555878	-0.046132	C	6	5.793933	-1.49002	0.179314
H	1	4.825535	0.815481	-0.023326	C	6	4.006118	-3.234744	0.121137
C	6	-0.925856	1.734446	-0.048795	H	1	3.302556	-3.533584	-0.664745
C	6	-1.202822	0.336442	-0.007519	H	1	4.891007	-3.868006	0.034138
H	1	-1.72369	2.4645	-0.100783	H	1	5.967288	-1.034409	1.16725
C	6	-2.60811	-0.15695	0.008571	H	1	6.40116	-2.394493	0.110694
C	6	-3.675673	0.646541	0.444753	H	1	3.532871	-3.42851	1.097212
C	6	-2.889282	-1.4691	-0.413171	H	1	6.153765	-0.795684	-0.589004
C	6	-4.98655	0.166286	0.454836	F	9	-6.49251	-1.607273	0.022247
H	1	-3.492738	1.653305	0.807595					

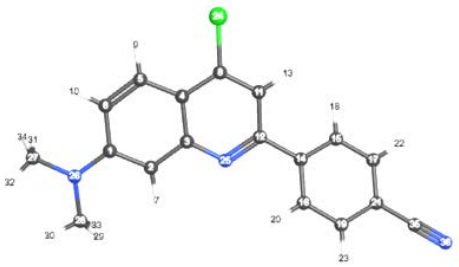




4e (CF3)	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	4.28143	-1.119454	-0.009781	H	1	-1.308075	-1.682198	-0.797401
C	6	2.891736	-1.271694	-0.002429	C	6	-4.352421	-0.372632	-0.021596
C	6	2.021072	-0.158137	-0.020748	H	1	-4.669962	1.602564	0.787143
C	6	2.566671	1.17086	-0.036037	H	1	-3.71824	-2.275365	-0.821136
C	6	3.976865	1.31384	-0.027972	Cl	17	2.175974	3.897134	-0.109168
C	6	4.804766	0.217423	-0.012204	N	7	0.679111	-0.401093	-0.015808
H	1	2.420375	-2.24573	0.02022	N	7	5.136509	-2.206192	-0.022087
C	6	1.626408	2.22828	-0.060143	C	6	6.564395	-2.020557	0.198
H	1	4.409092	2.309111	-0.032311	C	6	4.582266	-3.544945	0.112586
H	1	5.87572	0.38037	-0.002456	H	1	3.863036	-3.750972	-0.688992
C	6	0.274562	1.975763	-0.057008	H	1	5.388593	-4.276226	0.032615
C	6	-0.163551	0.620873	-0.024267	H	1	6.786526	-1.577647	1.181565
H	1	-0.431325	2.795327	-0.107179	H	1	7.059143	-2.991883	0.143761
C	6	-1.618261	0.294409	-0.015759	H	1	4.072099	-3.692212	1.077845
C	6	-2.583927	1.211009	0.431797	H	1	7.007761	-1.383149	-0.57626
C	6	-2.050159	-0.968213	-0.457841	C	6	-5.807907	-0.750268	0.021377
C	6	-3.939033	0.882764	0.432747	F	9	-6.147982	-1.608205	-0.973626
H	1	-2.285204	2.184644	0.807505	F	9	-6.62588	0.327001	-0.085278
C	6	-3.401625	-1.299943	-0.464869	F	9	-6.138378	-1.369149	1.190135



4f



4f (CN)	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
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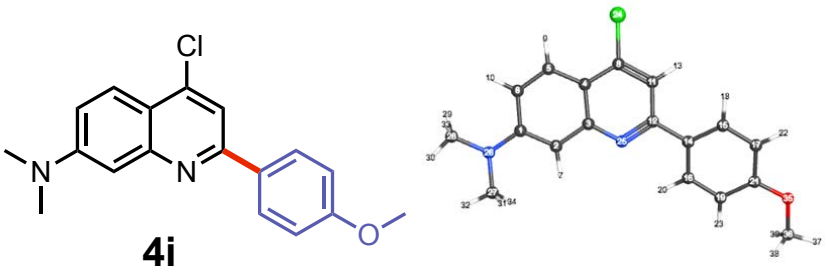
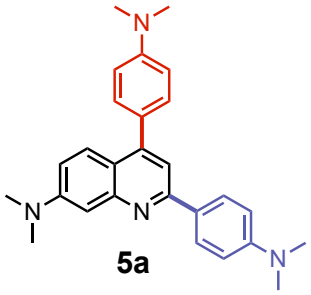
C	6	2.215278	-1.229131	0.0043	H	1	-1.940635	-1.937686	-0.74435
C	6	1.270475	-0.17799	-0.013571	C	6	-5.074905	-0.834639	0.016403
C	6	1.723266	1.185474	-0.036041	H	1	-5.527756	1.126885	0.799247
C	6	3.12043	1.425043	-0.03563	H	1	-4.307192	-2.70181	-0.753861
C	6	4.021661	0.388164	-0.020494	Cl	17	1.146777	3.878064	-0.116026
H	1	1.812423	-2.233351	0.031613	N	7	-0.051682	-0.511705	-0.002341
C	6	0.713146	2.176157	-0.059033	N	7	4.518243	-2.006651	-0.021086
H	1	3.483144	2.447627	-0.045587	C	6	5.934564	-1.722345	0.166227
H	1	5.079047	0.623718	-0.016458	C	6	4.058319	-3.380105	0.119419
C	6	-0.618498	1.832115	-0.048727	H	1	3.357916	-3.641233	-0.68306
C	6	-0.962134	0.45063	-0.010254	H	1	4.913988	-4.05372	0.047848
H	1	-1.378571	2.601692	-0.097861	H	1	6.145985	-1.253135	1.139731
C	6	-2.39016	0.024277	0.005672	H	1	6.492622	-2.658688	0.112895
C	6	-3.417547	0.878737	0.442508	H	1	3.556297	-3.555684	1.083925
C	6	-2.732308	-1.273047	-0.416944	H	1	6.318134	-1.066242	-0.624405
C	6	-4.745074	0.459779	0.451375	C	6	-6.441343	-1.270511	0.018974
H	1	-3.18583	1.875212	0.805117	N	7	-7.550413	-1.624823	0.020677

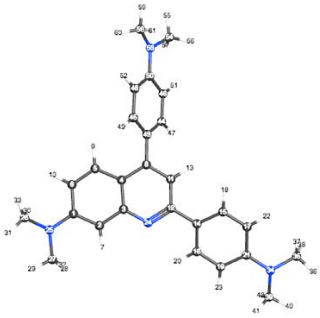


4i

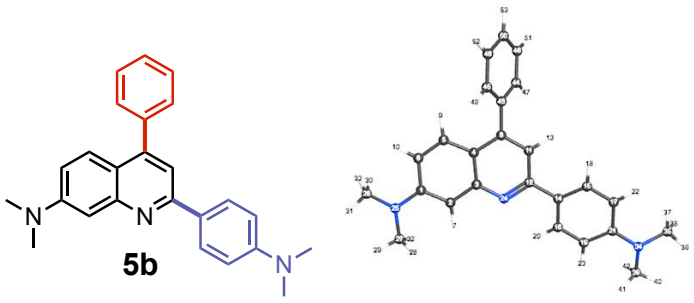
4i (4OMe)	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	-3.681395	-1.07285	-0.03229	C	6	4.983155	-0.515882	0.086238
C	6	-2.29638	-1.255409	-0.000801	H	1	5.346129	1.482258	0.785758
C	6	-1.398639	-0.162083	-0.014128	H	1	4.288671	-2.450168	-0.612793
C	6	-1.91638	1.176697	-0.048281	Cl	17	-1.462361	3.89424	-0.137602
C	6	-3.322238	1.351178	-0.062139	N	7	-0.063502	-0.43625	0.016113
C	6	-4.175946	0.273737	-0.051122	N	7	-4.561533	-2.144212	-0.055663
H	1	-1.846969	-2.239309	0.03727	C	6	-4.037134	-3.489224	0.124707
C	6	-0.949985	2.211689	-0.066768	C	6	-5.9808	-1.927028	0.189071
H	1	-3.731381	2.356137	-0.079819	H	1	-6.416892	-1.262346	-0.56544
H	1	-5.242918	0.460743	-0.058354	H	1	-6.501273	-2.884141	0.118781
C	6	0.393811	1.929434	-0.043243	H	1	-3.56596	-3.630195	1.111273
C	6	0.807209	0.564126	0.008962	H	1	-4.853227	-4.207596	0.024646
H	1	1.117055	2.733724	-0.090795	H	1	-6.180554	-1.499455	1.184932
C	6	2.251022	0.212251	0.039835	H	1	-3.292426	-3.721099	-0.645283
C	6	3.243254	1.128873	0.4399	O	8	6.324196	-0.767903	0.14061
C	6	2.666592	-1.07628	-0.327135	C	6	6.789715	-2.062667	-0.218541
C	6	4.586449	0.775156	0.466059	H	1	7.873499	-2.032253	-0.093974
H	1	2.969593	2.129096	0.762381	H	1	6.367686	-2.834521	0.43822
C	6	4.012378	-1.445422	-0.312337	H	1	6.548636	-2.297742	-1.26348
H	1	1.914016	-1.796523	-0.630033					



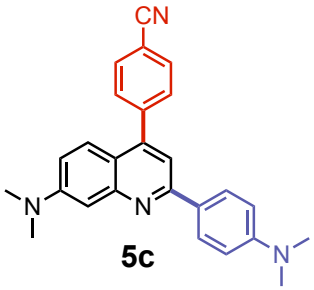
5a



5a	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	-1.1271	4.224993	-0.03093	H	1	-2.212443	7.395379	0.176594
C	6	0.073589	3.515419	-0.077921	H	1	0.608983	6.216918	0.929479
C	6	0.107793	2.099012	-0.056625	H	1	-3.229925	6.035855	-0.290024
C	6	-1.115732	1.35526	0.006787	N	7	6.703698	-2.048508	-0.170614
C	6	-2.324244	2.092739	0.103365	C	6	6.877962	-3.491761	-0.209819
C	6	-2.338222	3.469092	0.089158	H	1	7.944554	-3.720692	-0.262919
H	1	1.034162	4.012341	-0.1265	H	1	6.458126	-3.995853	0.677101
C	6	-1.024232	-0.072444	0.021363	H	1	6.405301	-3.920016	-1.101268
H	1	-3.264101	1.560356	0.210818	C	6	7.816157	-1.249148	0.318561
H	1	-3.291767	3.976112	0.177116	H	1	8.74502	-1.804826	0.172172
C	6	0.238555	-0.637651	0.007899	H	1	7.901239	-0.312241	-0.243434
C	6	1.406683	0.176375	-0.049333	H	1	7.72506	-1.000501	1.389437
H	1	0.327232	-1.718053	0.024179	C	6	-2.224124	-0.950172	0.051405
C	6	2.764741	-0.425376	-0.075355	C	6	-2.358684	-1.964279	1.012713
C	6	2.996342	-1.783908	-0.34785	C	6	-3.241725	-0.84961	-0.911164
C	6	3.897301	0.369233	0.176769	C	6	-3.453623	-2.82524	1.029084
C	6	4.278812	-2.325364	-0.369895	H	1	-1.593013	-2.076995	1.776763
H	1	2.16711	-2.449822	-0.567739	C	6	-4.338156	-1.707702	-0.916129
C	6	5.183581	-0.155354	0.165391	H	1	-3.162243	-0.102343	-1.696712
H	1	3.750119	1.422409	0.391743	C	6	-4.486182	-2.713495	0.068466
C	6	5.416561	-1.522668	-0.121639	H	1	-3.500552	-3.582921	1.80264
H	1	4.386697	-3.380715	-0.591611	H	1	-5.077601	-1.590094	-1.699667
H	1	6.01203	0.508752	0.383485	N	7	-5.602208	-3.54566	0.097161
N	7	1.333231	1.502104	-0.086744	C	6	-5.583487	-4.723805	0.950444
N	7	-1.165762	5.616267	-0.103698	H	1	-6.540178	-5.242958	0.860628
C	6	-2.366417	6.3234	0.319276	H	1	-4.778446	-5.430299	0.685958
C	6	0.088326	6.349646	-0.034414	H	1	-5.459833	-4.443122	2.002603
H	1	0.765292	6.028995	-0.833462	C	6	-6.500072	-3.562563	-1.047083
H	1	-0.112437	7.414018	-0.176895	H	1	-7.328124	-4.243753	-0.839428
H	1	-2.616967	6.148199	1.379219	H	1	-6.928662	-2.569293	-1.222423
					H	1	-6.003766	-3.892036	-1.975737



5b	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	3.363567	-2.456653	-0.05412	H	1	2.508232	-4.94102	-0.824757
C	6	1.970119	-2.37845	-0.089244	H	1	3.928686	-5.755712	-0.162479
C	6	1.290085	-1.136081	-0.071092	H	1	5.613807	-3.451315	1.310484
C	6	2.036727	0.086411	-0.01947	H	1	5.78905	-4.769697	0.129484
C	6	3.450177	-0.011275	0.058257	H	1	2.742517	-5.009568	0.93838
C	6	4.094015	-1.227623	0.045062	H	1	6.055179	-3.10486	-0.380748
H	1	1.345037	-3.261511	-0.126662	N	7	-6.473408	-0.475349	-0.126938
C	6	1.29726	1.309079	0.001763	C	6	-7.293193	0.725598	-0.159384
H	1	4.042406	0.89414	0.14722	H	1	-8.345847	0.437683	-0.19942
H	1	5.175073	-1.24026	0.116105	H	1	-7.141843	1.367056	0.72488
C	6	-0.082682	1.23688	-0.0036	H	1	-7.080836	1.321995	-1.054426
C	6	-0.748155	-0.023619	-0.057453	C	6	-7.091677	-1.706183	0.340534
H	1	-0.655646	2.156895	0.02368	H	1	-8.172812	-1.635843	0.203395
C	6	-2.230085	-0.111976	-0.0728	H	1	-6.741056	-2.565906	-0.241882
C	6	-3.061519	0.991655	-0.327245	H	1	-6.889145	-1.90743	1.405889
C	6	-2.869199	-1.340188	0.174662	C	6	1.96201	2.643178	0.035294
C	6	-4.449314	0.88498	-0.335642	C	6	1.669597	3.555882	1.062501
H	1	-2.632182	1.965765	-0.542333	C	6	2.856675	3.036169	-0.975181
C	6	-4.252455	-1.463933	0.176275	C	6	2.258003	4.822944	1.083247
H	1	-2.253124	-2.210255	0.375975	H	1	0.986131	3.261365	1.854905
C	6	-5.089633	-0.352723	-0.091724	C	6	3.440004	4.304887	-0.95855
H	1	-5.031423	1.775335	-0.542661	H	1	3.079132	2.349203	-1.787573
H	1	-4.682153	-2.435958	0.389333	C	6	3.145153	5.202204	0.072336
N	7	-0.072856	-1.166378	-0.09351	H	1	2.024187	5.512143	1.891038
N	7	4.035117	-3.673878	-0.11915	H	1	4.121811	4.593954	-1.75469
C	6	5.439067	-3.743625	0.261494	H	1	3.601742	6.188662	0.086269
C	6	3.26064	-4.901812	-0.029623					



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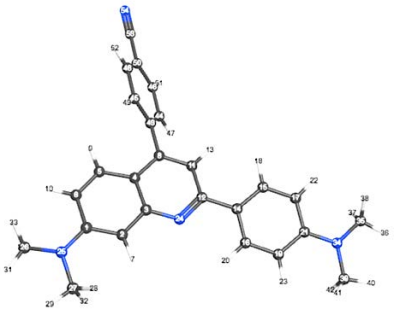
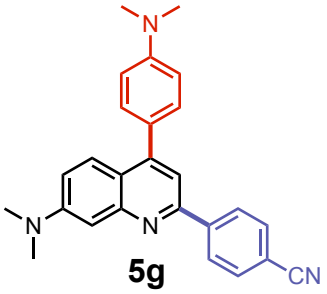
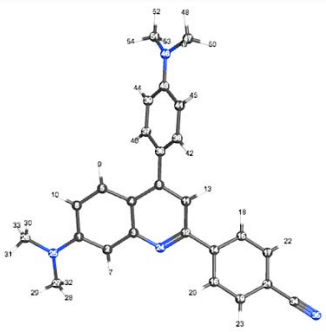


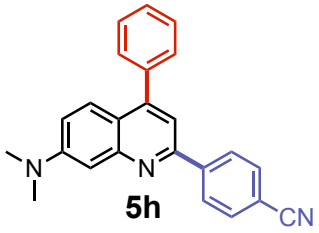
5c	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	-2.322261	3.556397	-0.043768	H	1	-0.879282	5.751488	-0.816862
C	6	-0.991657	3.13306	-0.077477	H	1	-2.051835	6.891616	-0.149318
C	6	-0.643066	1.761017	-0.064722	H	1	-4.276155	5.070456	1.301964
C	6	-1.671287	0.762621	-0.019862	H	1	-4.096726	6.398831	0.134121
C	6	-3.016117	1.208836	0.056701	H	1	-1.081924	5.876377	0.947206
C	6	-3.336136	2.547186	0.048126	H	1	-4.762915	4.857952	-0.399099
H	1	-0.166396	3.832819	-0.108766	N	7	6.713775	-0.800817	-0.118757
C	6	-1.254752	-0.603601	-0.003267	C	6	7.214408	-2.166211	-0.149117
H	1	-3.818508	0.482317	0.141768	H	1	8.305066	-2.145313	-0.196084
H	1	-4.380204	2.827941	0.118178	H	1	6.916629	-2.746659	0.739747
C	6	0.098983	-0.879589	-0.006659	H	1	6.856214	-2.696532	-1.03939
C	6	1.057822	0.176552	-0.054352	C	6	7.62118	0.250776	0.313984
H	1	0.425008	-1.91328	0.012608	H	1	8.650015	-0.092513	0.187829
C	6	2.51432	-0.104959	-0.067657	H	1	7.497015	1.152287	-0.297136
C	6	3.047211	-1.385151	-0.296281	H	1	7.475603	0.528914	1.370882
C	6	3.437798	0.932888	0.155178	C	6	-2.226412	-1.732365	0.018979
C	6	4.417901	-1.624238	-0.304438	C	6	-2.159138	-2.705691	1.031077
H	1	2.391868	-2.229157	-0.490249	C	6	-3.198953	-1.877859	-0.986462
C	6	4.808327	0.711875	0.156569	C	6	-3.034426	-3.788689	1.046968
H	1	3.056402	1.932104	0.336717	H	1	-1.420105	-2.601944	1.820607
C	6	5.344806	-0.577448	-0.08571	C	6	-4.07594	-2.95881	-0.985227
H	1	4.762402	-2.634698	-0.490322	H	1	-3.252775	-1.146419	-1.787594
H	1	5.465564	1.552021	0.348947	C	6	-4.001377	-3.922444	0.036084
N	7	0.684242	1.450263	-0.085681	H	1	-2.977295	-4.529771	1.838464
N	7	-2.668781	4.900419	-0.101448	H	1	-4.815553	-3.066141	-1.772902
C	6	-4.017003	5.316986	0.259053	C	6	-4.906347	-5.03566	0.044955
C	6	-1.614555	5.899489	-0.018275	N	7	-5.640962	-5.938795	0.051925

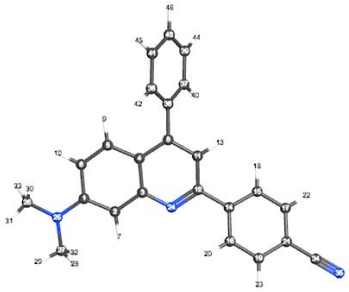


5g

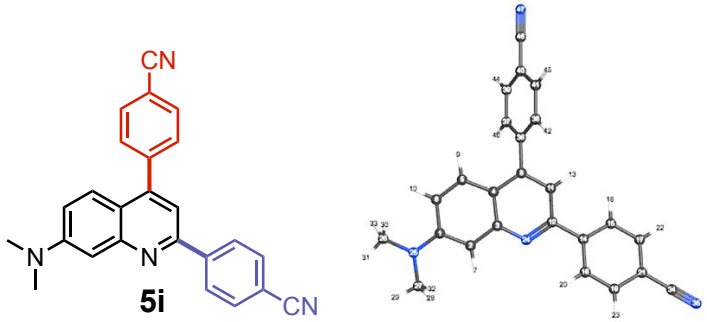


5g	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	-0.172688	4.150071	0.111772	H	1	-2.474287	5.539933	0.670358
C	6	-1.196696	3.20439	0.032328	H	1	-1.825286	7.060245	0.047667
C	6	-0.928913	1.814207	0.023564	H	1	1.132361	6.350277	-1.042757
C	6	0.42476	1.339568	0.058633	H	1	0.249592	7.477046	0.010817
C	6	1.452608	2.315214	0.153942	H	1	-2.166714	5.718867	-1.073599
C	6	1.174125	3.661812	0.176459	H	1	1.423241	6.367859	0.715222
H	1	-2.240077	3.488816	-0.016813	C	6	-6.488319	-3.634502	-0.113923
C	6	0.64003	-0.073436	0.040764	N	7	-7.444331	-4.299261	-0.12931
H	1	2.486087	1.992708	0.226342	H	6	1.995294	-0.682153	0.054057
H	1	2.000741	4.357758	0.256884	H	6	2.976614	-0.343846	-0.892464
C	6	-0.478256	-0.893309	0.019883	H	6	2.32839	-1.677843	0.986821
C	6	-1.783842	-0.336254	-0.013403	C	6	4.226261	-0.956876	-0.907019
H	1	-0.342179	-1.969098	0.019732	H	1	2.749668	0.392941	-1.658824
C	6	-2.991993	-1.20976	-0.048784	C	6	3.57704	-2.292946	0.994541
C	6	-2.939455	-2.53958	-0.503134	H	1	1.597826	-1.96956	1.737668
C	6	-4.232808	-0.697675	0.373339	C	6	4.57187	-1.940065	0.05155
C	6	-4.080473	-3.336717	-0.529467	H	1	4.93147	-0.669133	-1.67771
H	1	-2.005913	-2.957827	-0.865634	H	1	3.774492	-3.048117	1.745999
C	6	-5.377676	-1.485353	0.357795	N	7	5.832153	-2.524393	0.071954
H	1	-4.278964	0.331219	0.712619	C	6	6.060519	-3.694064	0.906942
C	6	-5.310823	-2.816246	-0.094159	H	1	7.105633	-3.997081	0.816578
H	1	-4.026471	-4.358924	-0.891552	H	1	5.875033	-3.464621	1.962596
H	1	-6.327357	-1.080064	0.694023	H	1	5.425326	-4.549737	0.623495
N	7	-2.000967	0.972019	-0.014802	C	6	6.738477	-2.301077	-1.044048
N	7	-0.430691	5.513122	0.153926	H	1	7.685728	-2.804111	-0.839208
C	6	0.651876	6.464325	-0.057384	H	1	6.341613	-2.684608	-1.998876
C	6	-1.792188	5.975105	-0.06878	H	1	6.952869	-1.233132	-1.16635





5h	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	-2.987572	-2.380169	-0.020852	N	7	0.491989	-1.214268	0.027824
C	6	-1.591336	-2.354204	0.013957	N	7	-3.701982	-3.567564	0.017698
C	6	-0.869552	-1.13712	0.01594	C	6	-5.120987	-3.576485	-0.311486
C	6	-1.568494	0.115561	-0.012581	C	6	-2.97719	-4.826478	-0.066306
C	6	-2.985939	0.070755	-0.08962	H	1	-2.241354	-4.902777	0.742156
C	6	-3.671323	-1.121106	-0.097646	H	1	-3.681805	-5.652857	0.046016
H	1	-0.999801	-3.260638	0.028887	H	1	-5.321021	-3.238369	-1.341083
C	6	-0.790244	1.311407	0.003283	H	1	-5.500384	-4.594812	-0.207341
H	1	-3.544464	0.998595	-0.160496	H	1	-2.447303	-4.946513	-1.025484
H	1	-4.752049	-1.094195	-0.169753	H	1	-5.692124	-2.943524	0.377109
C	6	0.589221	1.191121	-0.001247	C	6	6.90792	-0.748185	0.049358
C	6	1.199134	-0.09336	0.002197	N	7	8.064109	-0.885821	0.063157
H	1	1.196958	2.087637	0.050302	C	6	-1.409301	2.666733	0.035877
C	6	2.683015	-0.241875	0.00692	C	6	-1.094369	3.612979	-0.953524
C	6	3.538461	0.79605	-0.403482	C	6	-2.282587	3.042528	1.071161
C	6	3.259762	-1.456539	0.421848	C	6	-1.642166	4.897509	-0.913995
C	6	4.921259	0.635919	-0.393596	H	1	-0.428617	3.331728	-1.765632
H	1	3.129168	1.736815	-0.757105	C	6	-2.823399	4.329152	1.115433
C	6	4.638754	-1.627222	0.440304	H	1	-2.520958	2.32849	1.855178
H	1	2.602732	-2.262628	0.728667	C	6	-2.507768	5.260126	0.121337
C	6	5.483989	-0.578673	0.032804	H	1	-1.393311	5.613391	-1.693354
H	1	5.56872	1.444056	-0.719937	H	1	-3.48819	4.605479	1.930042
H	1	5.070886	-2.567317	0.769836	H	1	-2.93162	6.260464	0.154735



5i

5i	Atomic Number	X	Y	Z		Atomic Number	X	Y	Z
C	6	1.49281	3.676634	0.065924	N	7	-1.274702	1.267472	-0.015687
C	6	0.212805	3.11733	0.012277	N	7	1.695075	5.043648	0.089667
C	6	0.012845	1.71764	0.009239	C	6	3.036534	5.592307	-0.05533
C	6	1.138667	0.827162	0.033351	C	6	0.554542	5.931624	-0.077835
C	6	2.431577	1.411376	0.101892	H	1	-0.192738	5.760847	0.706606
C	6	2.607959	2.774622	0.114403	H	1	0.891131	6.966682	0.002041
H	1	-0.680291	3.72808	-0.022875	H	1	3.506854	5.307936	-1.00946
C	6	0.871871	-0.574118	0.028456	H	1	2.978895	6.681406	-0.017053
H	1	3.306212	0.771177	0.15859	H	1	0.06271	5.799494	-1.054459
H	1	3.617547	3.16393	0.170298	H	1	3.692299	5.269392	0.762544
C	6	-0.447694	-0.992204	0.02124	C	6	-7.024141	-1.619816	-0.060717
C	6	-1.501778	-0.03783	-0.010316	N	7	-8.14483	-1.935423	-0.065217
H	1	-0.668436	-2.053767	0.033965	C	6	1.958216	-1.593719	0.033682
C	6	-2.928749	-0.468771	-0.032887	C	6	2.929584	-1.625931	-0.982596
C	6	-3.31455	-1.749274	-0.467142	C	6	2.004097	-2.575513	1.038233
C	6	-3.931566	0.426813	0.38152	C	6	3.91743	-2.606516	-0.998109
C	6	-4.653333	-2.130786	-0.481318	H	1	2.896768	-0.887301	-1.77828
H	1	-2.57144	-2.455206	-0.824171	C	6	2.991307	-3.55794	1.037166
C	6	-5.27079	0.055541	0.377372	H	1	1.265659	-2.558106	1.834919
H	1	-3.638712	1.419111	0.706127	C	6	3.956696	-3.57922	0.01634
C	6	-5.643712	-1.230719	-0.054009	H	1	4.656496	-2.628527	-1.793138
H	1	-4.937522	-3.119732	-0.827581	H	1	3.021807	-4.306579	1.822851
H	1	-6.034608	0.753228	0.707221	C	6	4.976731	-4.588384	0.008103
					N	7	5.804916	-5.406254	0.000982

Reference

1) Nasr, M.; Drach, J. C.; Smith, S. H.; Shipman, C. Jr.; Burckhaltert, J. H. *Eur. J. Med. Chem.* **1988**, 31, 1351-1355.

2) Eisenhart, T. T; Howland, W. C.; Dempsey, J.L. *J. Phys. Chem. B.* **2016**, 120, 7896−7905.

3) Naik, M.; Humnabadkar, V.; Tantry, S.; Panda, M.; Narayan, A.; Guptha, S.; Panduga, V.; Manjrekar, P.; Jena, L.; Koushik, K.; Shanbhag, G.; Jatheendranath, S.; Manjunatha, M.; Gorai, G.; Bathula, C.; Rudrapatna, S.; Achar, V.; Sharma, S.; Ambady, A.; Hegde, N.; Mahadevaswamy, J.; Kaur, P.; Sambandamurthy, V.; Awasthy, D.; Narayan, C.; Ravishankar, S.; Madhavapeddi, P.; Reddy, J.; Prabhakar, KR.; Saralaya, R.; Chatterji, M.; Whiteaker, J.; McLaughlin, B.; Chiarelli, L.; Riccardi, G.; Pasca, M.; Binda, C.; Neres, J.; Dhar, N.; Signorino-Gelo, F.; McKinney, J.; Ramachandran, V.; Shandil, R.; Tommasi, R.; Iyer, P.; Narayanan, S.; Hosagrahara, V.; Kavanagh, S.; Dinesh, N.; Ghorpade. S., *J. Med. Chem.* **2014**, 57, 5419-5434.

4) Gaussian 09, Revision D.01, M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G. A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H. P. Hratchian, A. F. Izmaylov, J. Bloino, G. Zheng, J. L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J. A. Montgomery, Jr., J. E. Peralta, F. Ogliaro, M. Bearpark, J. J. Heyd, E. Brothers, K. N. Kudin, V. N. Staroverov, T. Keith, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J. M. Millam, M. Klene, J. E. Knox, J. B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R. E. Stratmann, O. Yazyev, A. J. Austin, R. Cammi, C. Pomelli, J. W. Ochterski, R. L. Martin, K. Morokuma, V. G. Zakrzewski, G. A. Voth, P. Salvador, J. J. Dannenberg, S. Dapprich, A. D. Daniels, O. Farkas, J. B. Foresman, J. V. Ortiz, J. Cioslowski, and D. J. Fox, Gaussian, Inc., Wallingford CT, **2013**.

5) Patalinghug, W. C.; Chang, M.; Solis, *J. J. Chem. Educ*. **2007**, *84*, 1945–1947.

6) (a)Zollinger,H. Color Chemistry; VCH:Weinheim,Germany, 1991; (b) Bauernschmitt, R.; Ahlrichs, R.; Hennrich, F. H.; Kappes, M. M. *J. Am. Chem. Soc*. **1998**, 120, 5052–5059.

7) Kim, E.; Koh, M.; Lim, B.J.; Park, S.B. *J. Am. Chem. Soc*. **2011**, *133*, 6642–6649.