Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Generation of azaarene nitrile oxides from methyl azaarenes and *t*-BuONO enabling synthesis of furoxans and 1,2,4-oxadiazoles

Xiang-Jin Zhang,[a,†] Jian-Kang Cao,[a,†] Jun-Jie Ren,[a] Lin Hong,[a] Ru-Jin Liang,[a] Kai-Yan Hao,[a] Kai-Li Wei,[a] Bao-Jing Mi,[a] Yue Liu,[a] Yan-Ping Zhu*[a]

[a] School of Pharmacy, Key Laboratory of Molecular Pharmacology and Drug Evaluation, Ministry of Education, Collaborative Innovation Center of Advanced Drug Delivery System and Biotech Drugs in Universities of Shandong, Yantai University, Shandong, Yantai, 264005, P. R. China.
E-mail: chemzyp@foxmail.com; chemzyp@ytu.edu.cn

† These authors contributed equally to this work.

Table of Contents

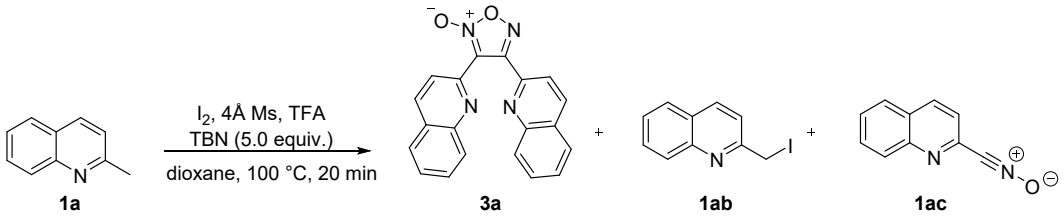
1. General information

Materials and General Experimental: 4Å Ms was purchased from Energy Chemical. *tert*-butyl nitrite (TBN) was purchased from Shanghai Shaoyuan Co. Ltd. 2-Methyl quinoline and trifluoroacetic acid were purchased from Aladdin. Unless otherwise indicated, all solvents and commercially available reagents were obtained from commercial suppliers and used without further purification. Moreover, solvent was freshly distilled prior to use unless otherwise noted. Non-commercial starting materials were prepared as described below or according to literature procedures. Analytical thin layer chromatography (TLC) was performed using pre-coated silica gel HF254 glass plates. For column chromatography, silica gel (200-300 mesh) was employed.

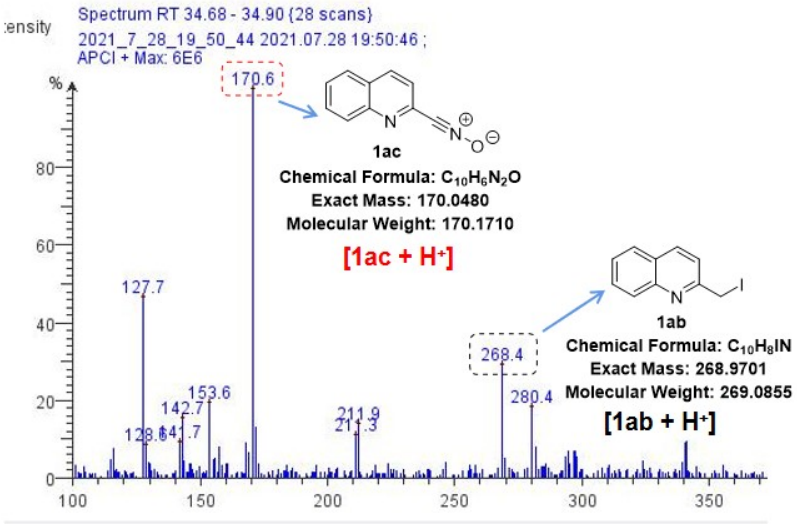
Instrumentation: The ^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker Advance 400 MHz instrument at 400 MHz (^{1}H NMR), 100 MHz (^{13}C NMR). Using the residual solvent peak in $CDCl_3$ as an internal reference: (δ = 7.26 for ^{1}H and δ = 77.0 for $^{13}C\{^{1}H\}$). Chemical shifts (δ) are reported in ppm, relative to the internal standard of tetramethylsilane (TMS). The coupling constants (J) are quoted in Hz (hertz). Resonances are described as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broad) or combinations thereof. High resolution mass spectra (HRMS) were obtained on Thermo Scientific Q-Exactive (ESI mode, Q-Exactive Orbitrap MS system). Melting points were measured with SGW X-4 apparatus. Data collection for crystal structure was performed using Mo Kα radiation on a Bruker Smart APEX CCD area detector diffractometer.

2. Evidence in support of the hypothetic mechanism

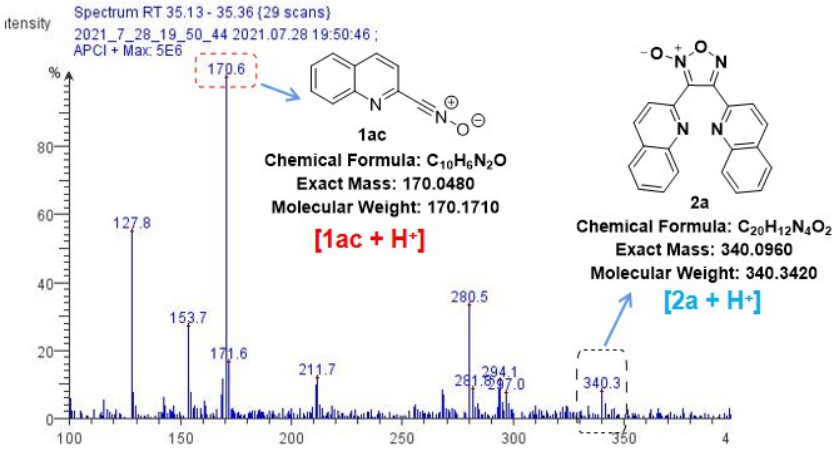
To gain further insight into the reaction mechanism, some control experiments were performed as illustrated in Scheme 7. To address the possible reaction intermediate, 2-methylquinoline (**1a**) was reacted under the standard conditions for 20 mins, 3,4-di(quinolin-2-yl)-furoxan (**2a**), 2-(iodomethyl)quinoline (**1ab**) and nitrile oxides (**1ac**) could be detected by MS (APCI) (Scheme S1-S3).



Scheme S1. Control experiment of **1a** with TBN.



Scheme S2. The MS(APCI) results for the reaction of **1a** was reacted under the standard conditions for 10 mins.



Scheme S3. The MS(APCI) results for the reaction of **1a** was reacted under the standard conditions for 20 mins.

3. X-ray crystal structure and crystallographic data

The purified compound **4p** and **5a** are dissolved in chloroform and petroleum ether, and placed in a dark cabinet to slowly evaporate. After several days, a white bulk crystal

is obtained. The X-ray crystal-structure determinations were obtained on a Bruker Smart APEX CCD area detector diffractometer at 296(2) K.

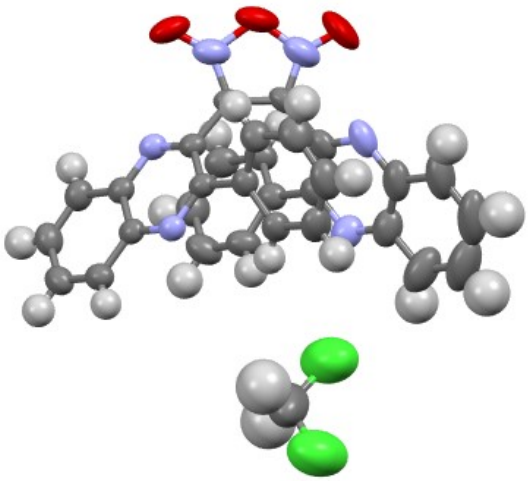


Figure S1. X-ray crystal structure of compound **4p** (displacement ellipsoids are drawn at the 50% probability level).

Table S1. Crystal data and structure refinement for compound **4p**

Identification code	CCDC: 2128033
Empirical formula	$C_{30}H_{18}N_6O_2$
Formula weight	494.15
Temperature/K	296 (2)
Crystal system	monoclinic
Space group	C2/c
a/Å	17.021 (3)
b/Å	36.936 (6)
c/Å	8.7261 (15)
α/°	90
β/°	94.790 (3)
γ/°	90
Volume/Å^3	5466.9 (16)
Z	4
ρ_{calc}g/cm^3	1.305
μ/mm^{-1}	0.179
F(000)	2216.0

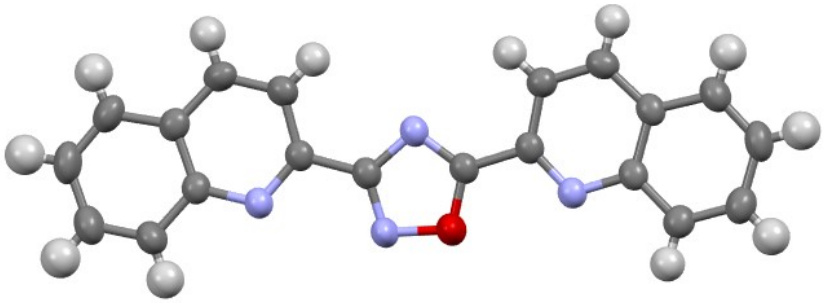


Figure S2. X-ray crystal structure of compound **5a** (displacement ellipsoids are drawn at the 50% probability level).

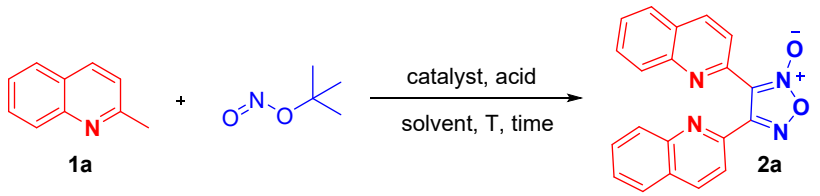
Table S1'. Crystal data and structure refinement for compound **5a**

Identification code	CCDC: 2141316
Empirical formula	$C_{20}H_{12}N_4O$
Formula weight	324.34
Temperature/K	296 K
Crystal system	monoclinic
Space group	P21/n
a/Å	5.866 (2)
b/Å	9.372 (3)
c/Å	28.177 (10)
α/°	90
β/°	91.035 (5)
γ/°	90
Volume/Å^3	1548.8 (9)
Z	4
ρ_{calc}g/cm^3	1.391
μ/mm^{-1}	0.090
F(000)	672.0

4. Experimental Procedures

4.1 Optimization of reaction conditions for the synthesis of furoxans

Table S2. Optimization of the reaction conditions



1a 2a

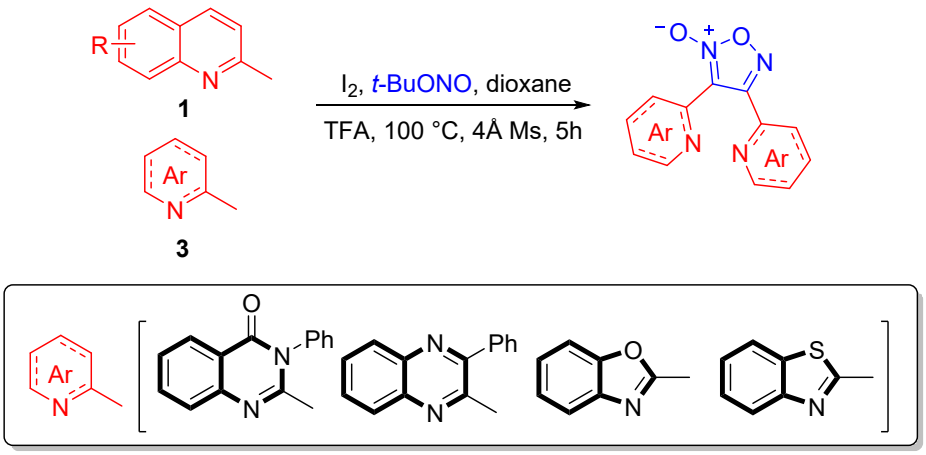
entry	catalyst	acid	solvent	*T* (°C)	Yield[b] (%)
1			dioxane	80	18
2	I_2		dioxane	80	29
3	NH_4I		dioxane	80	25
4	$(NH_4)_2MoO_4$		dioxane	80	17
5	CuI		dioxane	80	0
6[c]	I_2		dioxane	80	52
7[c]	I_2	TFA	dioxane	80	78
8[c]	I_2	HOAc	dioxane	80	27
9[c]	I_2	$TsOH·H_2O$	dioxane	80	35
10[c]	I_2	TFA	Toluene	80	48
11[c]	I_2	TFA	MeCN	80	37
12[c]	I_2	TFA	EtOH	80	0
13[c]	I_2	TFA	DMC	80	68
14[c]	I_2	TFA	THF	80	45
15[c]	I_2	TFA	dioxane	100	85
16[c]	I_2	TFA	dioxane	60	45
17[c,d]	I_2	TFA	dioxane	100	88
18[c,e]	**I_2**	**TFA**	**dioxane**	**100**	**92**
19[c,f]	I_2	TFA	dioxane	100	70

[a] Reaction conditions: **1a** (0.2 mmol), TBN (1.0 mmol), I_2 (0.1 mmol), acid (0.04 mmol) were heated in dioxane (2 mL) at 100 °C for 10 h. [b] Isolated yields. [c] 4Å Ms (100 mg). [d] 7 h. [e] 5 h. [f] 3 h. DMC = dimethyl carbonate.

We initiated our investigation by performing the reaction of 2-methylquinoline **1a** with TBN. To our delight, dioxane as the solvent at 80 °C for 10 h led to a 18% yield (Table S2, entry 1). Subsequently, different catalysts, such as I_2 and NH_4I, were screened for further increasing the reaction conversion, and I_2 was proven to be the most efficient catalyst (compare entries 3-5 with 2), providing 29% yield of **2a** (Table

S2, entry 2). To further improve the reactivity, we examined 4Å Ms as additives, gratifyingly, the isolated yield of the furoxan **2a** was found to be 52% (Table S2, entry 6). Next, several different acids were screened for improving the yield (Table S2, entries 7-9). To our surprise, when the reaction was conducted with the TFA, **2a** could be achieved with 78% yield (Table S2, entry 7). Subsequently, several solvents were examined, nevertheless, no significant enhancement was observed (Table S2, entries 10-14). As a further investigation, we screened the effect of reaction temperature and reaction time for this annulation reaction (Table S2, entries 15-19). Lower reaction time with higher temperature resulted in 92% yield of the product (Table S2, entry 18). After a series of screening, it was found that this reaction is best achieved using 2-methylquinoline (**1a**) (0.2 mmol), TBN (1.0 mmol), I_2 (0.1 mmol), TFA (0.04 mmol), 4Å Ms (100 mg) at 100 °C for 5 h.

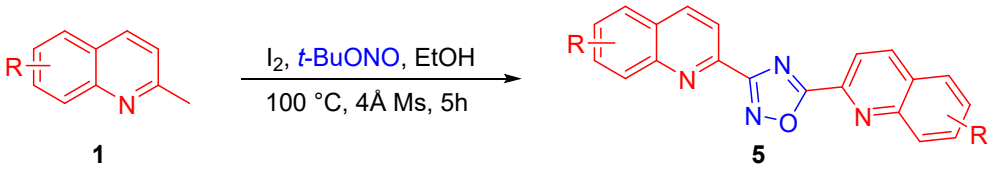
4.2 General Procedure for Synthesis of furoxans



Scheme S4. Synthesis of furoxans.

A sealed tube was charged with methyl azaarene (**1** or **3**) (0.2 mmol), TBN (1.0 mmol), I_2 (0.1 mmol), TFA (0.04 mmol) and 4Å Ms (100 mg) were heated in dioxane (2 mL) at 100 °C for 5 h. After the reaction completed, and added 50 mL water to the mixture, then extracted with EtOAc 3 times (3 × 50 mL). The extract was washed with 10% $Na_2S_2O_3$ solution (w/w), dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude residues were purified by column chromatography using ethyl acetate/petroleum ether mixture to obtain the corresponding products (Scheme S4).

4.3 General Procedure for Synthesis of 1,2,4-oxadiazoles

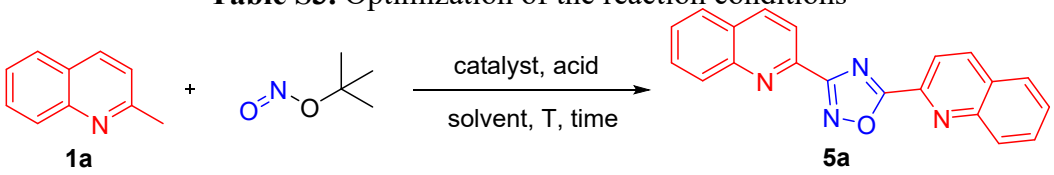


Scheme S5. Synthesis of 1,2,4-oxadiazoles.

A sealed tube was charged with 2-methylquinoline derivatives (**1**) (0.2 mmol), TBN (1.0 mmol), I_2 (0.04 mmol) and 4Å Ms (100 mg) were heated in EtOH (2 mL) at 100 °C for 5 h. After the reaction completed, and added 50 mL water to the mixture, then extracted with EtOAc 3 times (3 × 50 mL). The extract was washed with 10% $Na_2S_2O_3$ solution (w/w), dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude residues were purified by column chromatography using ethyl acetate/petroleum ether mixture to obtain the corresponding products **5** (Scheme S5).

4.4 Optimization of reaction conditions for the synthesis of 1,2,4-oxadiazoles

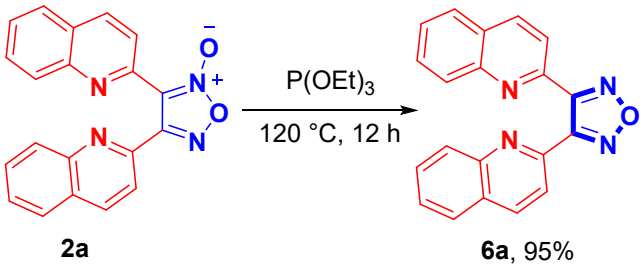
Table S3. Optimization of the reaction conditions



entry	catalyst	acid	solvent	time (h)	*T* (°C)	Yield[b](%)
1	I_2 (0.5 equiv.)	TFA	EtOH	10	80	20
2	I_2 (0.5 equiv.)	TFA	1-Butanol	10	80	12
3	I_2 (0.2 equiv.)	TFA	EtOH	10	80	28
4	I_2 (0.7 equiv.)	TFA	EtOH	10	80	26
5	I_2 (0.2 equiv.)		EtOH	10	80	30
6	I_2 (0.2 equiv.)		EtOH	10	60	13
7	I_2 (0.2 equiv.)		EtOH	10	100	33
8	I_2 (0.2 equiv.)		EtOH	7	100	35
9	**I_2 (0.2 equiv.)**		**EtOH**	**5**	**100**	**37**
10	I_2 (0.2 equiv.)		EtOH	3	100	18

[a] Reaction condition: **1** (0.2 mmol), TBN (1.0 mmol), I_2 (0.04 mmol) and 4Å Ms (100 mg) were heated in EtOH (2 mL) at 100 °C for 5 h. [b] Isolated yields.

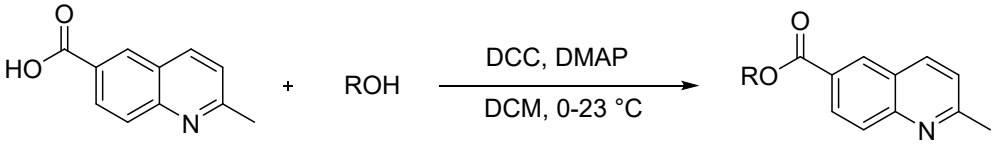
4.5 Chemical transformation of the 3,4-di(quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2a)[1]



Scheme S6. Synthesis of furazan.

A sealed tube was charged with 3,4-di(quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (**2a**) (0.2 mmol) were heated in $P(OEt)_3$ (1 mL) at 120 °C for 12 h. After the reaction completed, and added 50 mL water to the mixture, then extracted with EtOAc 3 times (3 × 50 mL) dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude residues were purified by column chromatography using ethyl acetate/petroleum ether mixture to obtain the corresponding products **6a** (Scheme S6).

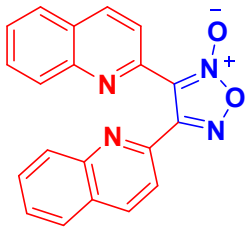
4.6 General procedure for the preparation of 2-methylquinoline-6-carboxylate (adapted from literature) [2]



Scheme S7. Synthesis of 2-methylquinoline-6-carboxylate.

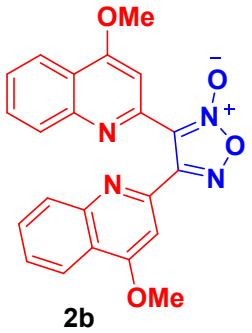
To a solution of ROH (1.0 equiv.) and propiolic acid (5.0 equiv.) in CH_2Cl_2 (0.1 M, based on the ROH)，a solution of DCC (4.5 equiv.) in CH_2Cl_2 (0.5 M) was added dropwise at 0 °C. After 2 h, the ice-water cooling bath was removed and the resulting suspension was stirred vigorously at 23 °C. After full consumption of the starting material, judged by TLC, the mixture was concentrated in vacuo and redissolved in EtOAc (ca. 10 mL per mmol). The mixture was allowed at 0 °C for 1 h. The 1,3-dicyclohexylurea (DCU) was filtered and the filtrate was concentrated in vacuo. Purification by column chromatography on silica gel afforded the desired propiolates (Scheme S7).

5. Characterization of Products



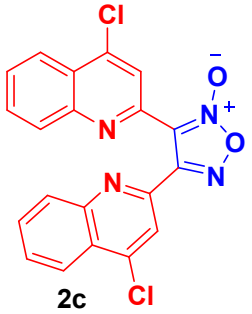
2a

3,4-Di(quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2a), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 31 mg, 92%, white solid, m.p.: 147-148 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.30 (dd, J = 7.6, 6.4 Hz, 2H), 8.07 (d, J = 8.4 Hz, 1H), 8.00 (d, J = 8.8 Hz, 1H), 7.88 (ddd, J = 8.0, 4.4, 1.6 Hz, 2H), 7.75 (m, 2H), 7.69–7.55 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 156.4, 147.7, 147.5, 146.7, 143.9, 136.6, 136.6, 130.1, 129.7, 129.6, 128.2, 127.9, 127.9, 127.6, 127.6, 121.1, 120.6, 114.8. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{13}N_4O_2$: 341.1033; found: 341.1030.



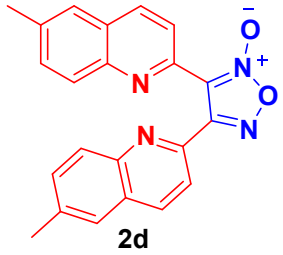
2b

3,4-Bis(4-methoxyquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2b), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 34 mg, 86%, white solid, m.p.: 180-181 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.24–8.21 (m, 2H), 7.71–7.65 (m, 2H), 7.64–7.59 (m, 2H), 7.57–7.51 (m, 2H), 7.48 (s, 1H), 7.42 (s, 1H), 4.09 (s, 3H), 4.08 (s, 3H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 162.7, 162.7, 156.8, 148.5, 148.4, 147.8, 144.9, 130.3, 129.2, 129.0, 126.9, 121.8, 121.3, 121.0, 115.3, 100.6, 100.0, 56.1, 56.1. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_4O_4$: 401.1244; found: 401.1239.



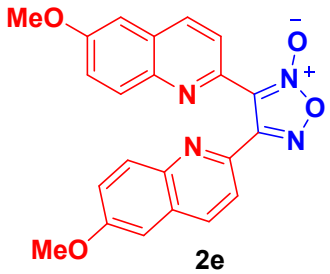
2c

3,4-Bis(4-chloroquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2c), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 24 mg, 60%, white solid, m.p.: 232-233 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.33–8.26 (m, 3H), 8.21 (s, 1H), 7.80–7.69 (m, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 155.4, 148.3, 148.2, 146.4, 143.6, 143.2, 131.1, 130.1, 129.9, 129.1, 126.5, 126.2, 124.1, 121.3, 120.8, 114.0. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{11}Cl_2N_4O_2$: 409.0254; found: 409.0256.



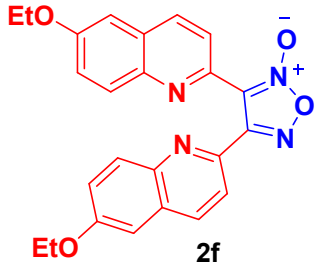
2d

3,4-Bis(6-methylquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2d), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 34 mg, 92%, white solid, m.p.: 188-189 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.20 (t, J = 8.8 Hz, 2H), 8.02 (d, J = 8.4 Hz, 1H), 7.94 (d, J = 8.4 Hz, 1H), 7.69–7.60 (m, 4H), 7.49–7.45 (m, 2H), 2.54 (d, J = 2.0 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 156.5, 146.4, 146.1, 145.8, 143.0, 138.1, 138.1, 135.8, 135.8, 132.4, 132.4, 129.5, 129.3, 128.3, 127.9, 126.4, 126.4, 121.1, 120.7, 114.9, 21.70. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_4O_2$: 369.1346; found: 369.1343.



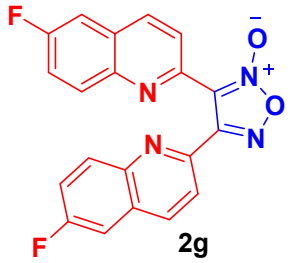
2e

3,4-Bis(6-methoxyquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2e), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 32 mg, 81%, white solid, m.p.: 185-187 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.15 (d, J = 7.6 Hz, 2H), 8.04 (d, J = 9.6 Hz, 2H), 7.64 (d, J = 8.4 Hz, 2H), 7.47 (dd, J = 9.4, 2.6 Hz, 2H), 7.10 (d, J = 2.8 Hz, 2H), 3.97 (s, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 159.9, 144.6, 135.6, 131.5, 130.7, 130.3, 124.6, 123.8, 117.8, 104.6, 55.8. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_4O_4$: 401.1244; found: 401.1241.



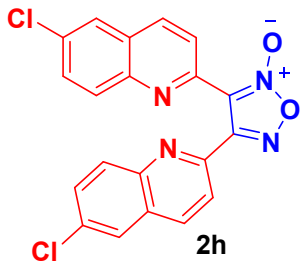
2f

3,4-Bis(6-ethoxyquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2f), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 35 mg, 83%, white solid, m.p.: 179-181 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.15 (t, J = 9.4 Hz, 2H), 8.01 (d, J = 8.8 Hz, 1H), 7.92 (d, J = 8.8 Hz, 1H), 7.65 (dd, J = 17.6, 9.2 Hz, 2H), 7.29 (dt, J = 9.2, 3.0 Hz, 2H), 7.10 (dd, J = 4.0, 2.8 Hz, 2H), 4.17 (qd, J = 7.0, 1.8 Hz, 4H), 1.50 (td, J = 7.2, 1.0 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 158.3, 158.2, 156.5, 144.2, 143.8, 143.6, 141.2, 135.0, 135.0, 131.2, 131.0, 129.6, 129.2, 123.4, 123.3, 121.5, 121.0, 115.0, 105.5, 105.4, 63.9, 14.7. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{24}H_{21}N_4O_4$: 429.1557; found: 429.1559.



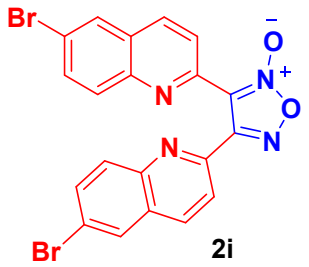
2g

3,4-Bis(6-fluoroquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2g), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 30 mg, 80%, white solid, m.p.: 155-156 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.27 (ddd, J = 8.8, 4.8, 0.8 Hz, 2H), 8.09 (dd, J = 8.8, 0.8 Hz, 1H), 8.03 (dd, J = 8.8, 0.8 Hz, 1H), 7.75–7.68 (m, 2H), 7.51–7.47 (m, 2H), 7.45–7.39 (m, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 162.5, 160.0, 156.0, 146.1 (d, J = 3.2 Hz), 144.7, 144.5, 143.3 (d, J = 3.2 Hz), 136.7 (d, J = 5.9 Hz), 136.0, 135.9, 132.9 (d, J = 9.6 Hz), 132.3 - 132.1 (m), 129.0, 128.9, 128.7, 128.5, 123.9, 121.7, 121.3, 120.7, 120.7, 120.5, 120.4, 114.5, 110.8, 110.8, 110.6, 110.5. ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -107.3, -110.2. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{11}F_2N_4O_2$: 377.0845; found: 377.0841.



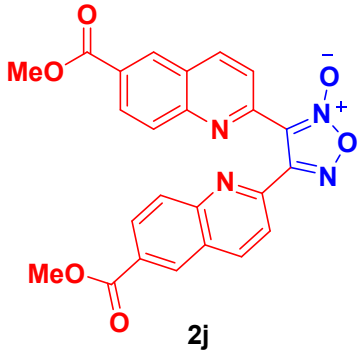
2h

3,4-Bis(6-chloroquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2h), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 32 mg, 78%, white solid, m.p.: 219-220 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.24 (dd, J = 8.6, 4.2 Hz, 2H), 8.10 (d, J = 8.6 Hz, 1H), 8.03 (d, J = 8.6 Hz, 1H), 7.88 (dd, J = 5.6, 2.0 Hz, 2H), 7.69–7.55 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 156.0, 146.9, 146.0, 145.8, 144.2, 135.8, 133.9, 133.9, 131.3, 131.2, 131.1, 128.8, 128.4, 126.4, 126.3, 121.8, 121.5, 114.5. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{11}Cl_2N_4O_2$: 409.0254; found: 409.0251.



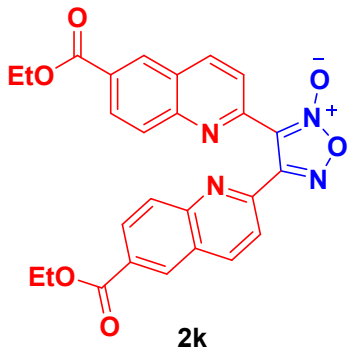
2i

3,4-Bis(6-bromoquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2i), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 36 mg, 73%, white solid, m.p.: 248-249 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.27–8.20 (m, 2H), 8.13–8.00 (m, 4H), 7.72 (ddd, J = 8.8, 5.0, 2.2 Hz, 2H), 7.56 (dd, J = 19.6, 9.0 Hz, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 156.0, 147.1, 146.2, 146.0, 144.3, 135.7, 133.8, 133.4, 131.3, 131.1, 129.7, 129.7, 129.2, 128.9, 122.2, 121.8, 121.5, 114.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{11}Br_2N_4O_2$: 496.9243; found: 496.9245.



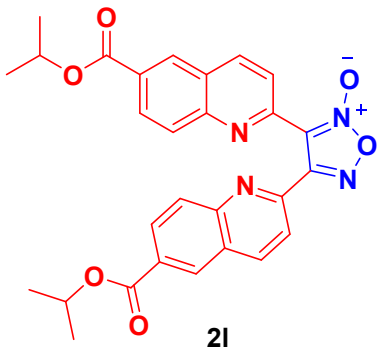
2j

3,4-Bis(6-(methoxycarbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2j), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 38 mg, 85%, white solid, m.p.: 220-221 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.66 (dd, J = 7.4, 1.8 Hz, 2H), 8.44 (dd, J = 8.2, 2.2 Hz, 2H), 8.22 (ddd, J = 9.2, 7.6, 2.0 Hz, 2H), 8.17 (d, J = 8.4 Hz, 1H), 8.10 (d, J = 8.8 Hz, 1H), 7.75 (d, J = 8.8 Hz, 1H), 7.68 (d, J = 8.8 Hz, 1H), 4.00 (d, J = 2.4 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 166.3, 156.1, 148.7, 146.0, 138.1, 138.0, 130.7, 129.9, 129.7, 129.7, 129.4, 127.4, 127.0, 121.6, 121.3, 114.4, 52.58. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{24}H_{17}N_4O_6$: 457.1143; found: 457.1146.



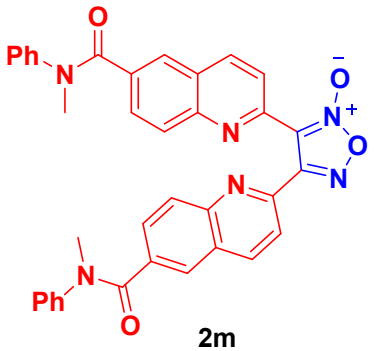
2k

3,4-Bis(6-(ethoxycarbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2k), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 42 mg, 87%, white solid, m.p.: 177-178 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.65 (dd, J = 7.6, 2.0 Hz, 2H), 8.44 (dd, J = 8.6, 2.2 Hz, 2H), 8.22 (td, J = 8.6, 2.0 Hz, 2H), 8.16 (d, J = 8.4 Hz, 1H), 8.08 (d, J = 8.4 Hz, 1H), 7.74 (d, J = 8.8 Hz, 1H), 7.67 (d, J = 9.2 Hz, 1H), 4.46 (qd, J = 7.2, 2.8 Hz, 4H), 1.45 (td, J = 7.2, 2.0 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 165.7, 156.1, 149.3, 149.2, 148.6, 145.9, 138.0, 137.9, 130.6, 129.8, 129.7, 129.7, 129.7, 127.4, 127.0, 121.5, 121.3, 114.5, 61.56, 14.31. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{26}H_{21}N_4O_6$: 485.1456; found: 485.1455.



2l

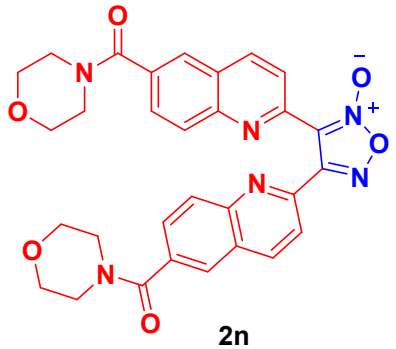
3,4-Bis(6-(isopropoxycarbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2l), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 42 mg, 82%, white solid, m.p.: 175-176 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.63 (dd, J = 8.2, 1.8 Hz, 2H), 8.45 (dd, J = 8.6, 1.8 Hz, 2H), 8.22 (td, J = 8.6, 1.8 Hz, 2H), 8.17 (d, J = 8.8 Hz, 1H), 8.09 (d, J = 8.4 Hz, 1H), 7.74 (d, J = 8.8 Hz, 1H), 7.66 (d, J = 9.2 Hz, 1H), 5.36-5.29 (m, 2H), 1.43 (d, J = 2.4 Hz, 6H), 1.42 (d, J = 2.0 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 165.3, 156.1, 149.3, 149.1, 148.6, 145.8, 138.0, 137.9, 130.5, 130.2, 130.1, 129.8, 129.7, 129.6, 127.4, 127.0, 121.5, 121.3, 114.6, 69.16, 21.94. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{28}H_{25}N_4O_6$: 513.1769; found: 513.1768.



2m

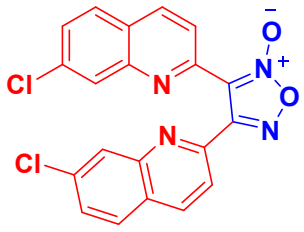
3,4-Bis(6-(methyl(phenyl)carbamoyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2m), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 53 mg, 88%, yellow solid, m.p.: 217-218 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.16 (dd, J = 8.6, 2.6 Hz, 2H), 7.99 (d, J = 8.8 Hz, 1H), 7.94 (d, J = 8.4 Hz, 1H), 7.90 (dd, J = 6.8, 2.0 Hz, 2H), 7.45 (d, J = 8.6 Hz, 2H), 7.38 (dd, J = 8.8, 4.0 Hz, 2H), 7.24–7.16 (m, 4H), 7.15–7.09 (m, 2H), 7.05 (d, J = 7.6 Hz, 4H), 3.56 (s, 6H). ^{13}C-NMR (100

MHz, $CDCl_3$): δ (ppm) 169.4, 155.9, 147.7, 147.4, 147.2, 145.0, 144.3, 137.2, 135.5, 130.2, 129.7, 129.4, 129.4, 128.9, 128.8, 128.7, 128.7, 127.5, 127.3, 126.9, 126.9, 121.5, 120.9, 114.5, 38.44. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{36}H_{27}N_6O_4$: 607.2088; found: 607.2074.



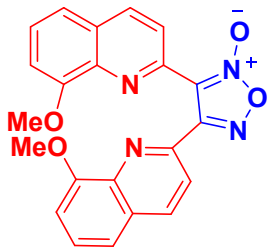
2n

3,4-Bis(6-(morpholine-4-carbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2n), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 51 mg, 90%, yellow solid, m.p.: 208-209 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.36 (dd, J = 8.4, 2.0 Hz, 2H), 8.13 (d, J = 8.4 Hz, 1H), 8.07 (d, J = 8.4 Hz, 1H), 7.98 (dd, J = 7.8, 1.8 Hz, 2H), 7.75 (d, J = 8.4 Hz, 1H), 7.70 (d, J = 8.8 Hz, 1H), 7.64 (ddd, J = 8.8, 5.6, 2.0 Hz, 2H), 3.63 (m, 16H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 169.3, 156.1, 147.9, 147.7, 147.5, 145.2, 137.2, 137.1, 134.8, 130.2, 130.1, 128.5, 127.7, 127.4, 126.8, 126.8, 121.7, 121.4, 114.5, 66.8. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{30}H_{27}N_6O_6$: 567.1987; found: 567.1985.



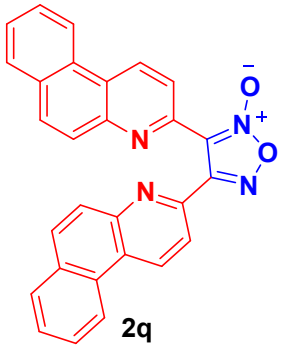
2o

3,4-Bis(7-chloroquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2o), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 31 mg, 76%, white solid, m.p.: 234-235 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.33 (ddd, J = 8.4, 2.8, 0.8 Hz, 2H), 8.08 (d, J = 8.4 Hz, 1H), 8.03 (d, J = 8.4 Hz, 1H), 7.85 (dd, J = 8.8, 5.8 Hz, 2H), 7.75 (d, J = 2.0 Hz, 1H), 7.71 (d, J = 2.4 Hz, 1H), 7.57 (ddd, J = 8.8, 4.0, 2.4 Hz, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 155.9, 147.9, 147.7, 145.0, 136.6, 136.2, 129.1, 128.9, 128.6, 128.4, 126.6, 126.1, 121.2, 120.8. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{11}Cl_2N_4O_2$: 409.0254; found: 409.0252.



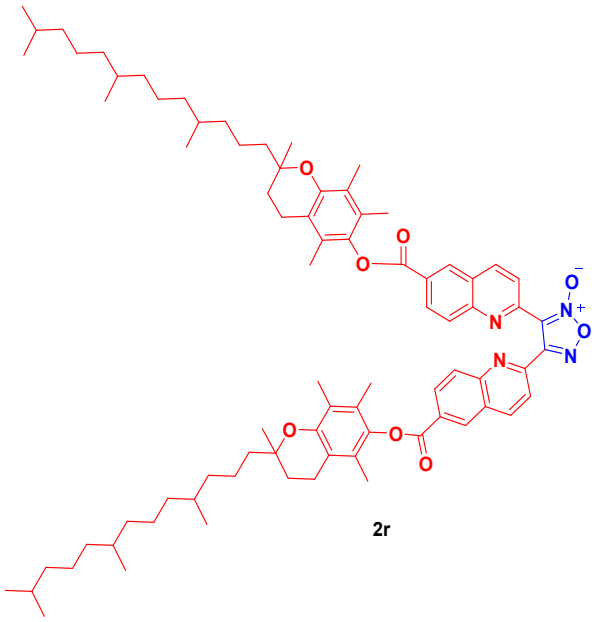
2p

3,4-Bis(8-methoxyquinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2p), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 29 mg, 73%, white solid, m.p.: 169-170 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.25 (dd, J = 8.6, 4.2 Hz, 2H), 8.16 (d, J = 8.8 Hz, 1H), 8.10 (d, J = 8.4 Hz, 1H), 7.50–7.44 (m, 2H), 7.41 (ddd, J = 8.4, 4.2, 1.4 Hz, 2H), 6.92 (ddd, J = 7.6, 4.2, 1.4 Hz, 2H), 3.62 (d, J = 2.0 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 156.8, 155.8, 155.7, 145.4, 142.6, 139.9, 139.7, 136.5, 129.4, 129.1, 128.1, 121.9, 121.4, 119.1, 119.1, 115.3, 108.2, 108.2, 55.6, 55.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_4O_4$: 401.1244; found: 401.1239.



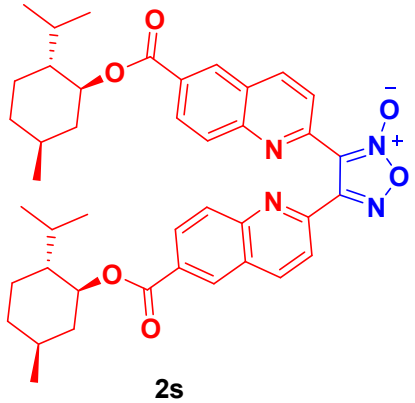
2q

3,4-Bis(benzo[f]quinolin-3-yl)-1,2,5-oxadiazole 2-oxide (2q), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 35 mg, 80%, white solid, m.p.: 226-228 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 9.11 (d, J = 8.4 Hz, 2H), 8.68 (t, J = 8.0 Hz, 2H), 8.32 (d, J = 8.8 Hz, 1H), 8.18 (d, J = 8.8 Hz, 1H), 7.95–7.89 (m, 3H), 7.85 (d, J = 9.2 Hz, 1H), 7.78–7.73 (m, 2H), 7.73–7.69 (m, 2H), 7.64 (d, J = 8.8 Hz, 1H), 7.49 (d, J = 9.6 Hz, 1H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 156.5, 147.8, 147.7, 146.3, 143.2, 132.2, 132.1, 131.7, 131.6, 131.4, 131.3, 129.2, 129.2, 128.8, 128.8, 128.1, 128.0, 127.9, 127.7, 127.5, 127.5, 125.9, 125.6, 123.1, 121.3, 114.9. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{28}H_{17}N_4O_2$: 441.1346; found: 441.1343.



2r

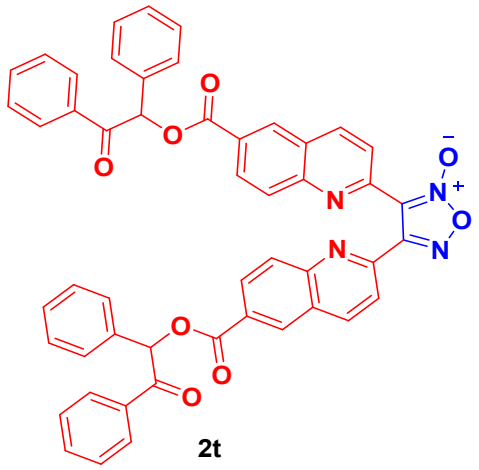
3,4-Bis(6-(((2,5,7,8-tetramethyl-2-(4,8,12-trimethyltridecyl)chroman-6-yl)oxy)carbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2r), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 106 mg, 85%, yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.88 (dd, J = 7.4, 1.8 Hz, 2H), 8.52 (dd, J = 8.4, 2.8 Hz, 2H), 8.43 (td, J = 9.0, 1.8 Hz, 2H), 8.23 (d, J = 8.8 Hz, 1H), 8.15 (d, J = 8.8 Hz, 1H), 7.88 (d, J = 8.8 Hz, 1H), 7.80 (d, J = 8.8 Hz, 1H), 2.64 (t, J = 7.0 Hz, 4H), 2.14 (s, 6H), 2.09 (d, J = 2.8 Hz, 6H), 2.05 (d, J = 3.2 Hz, 6H), 1.90–1.75 (m, 4H), 1.62–1.52 (m, 6H), 1.43–1.38 (m, 4H), 1.32–1.22 (m, 22H), 1.19–1.00 (m, 14H), 0.86 (t, J = 6.2 Hz, 26H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 164.4, 156.1, 149.7, 149.6, 149.5, 148.9, 146.2, 140.5, 138.2, 131.4, 130.3, 130.1, 128.9, 127.5, 127.2, 126.7, 124.9, 123.3, 121.7, 121.5, 117.6, 114.6, 75.2, 39.4, 37.5, 37.5, 37.4, 37.3, 32.8, 27.9, 24.8, 24.4, 24.2, 23.7, 22.7, 22.6, 21.0, 20.6, 19.7, 19.7, 19.6, 19.6, 13.1, 12.3, 11.9. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{80}H_{109}N_4O_8$: 1253.8240; found: 1253.8251.



2s

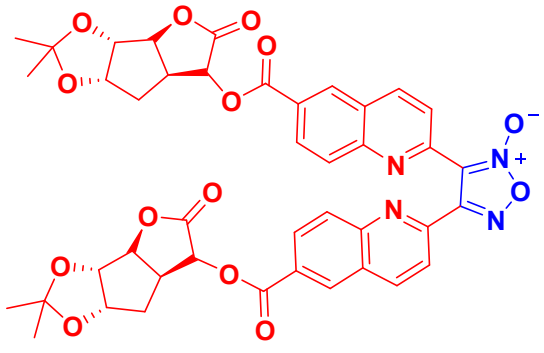
3,4-Bis(6-((((1S,2R,5S)-2-isopropyl-5-methylcyclohexyl)oxy)carbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2s), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 55 mg, 78%, yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.63 (dd, J = 8.6, 1.8 Hz, 2H), 8.45 (dd, J = 8.6, 2.2 Hz, 2H), 8.22 (td, J = 8.8, 1.8 Hz, 2H), 8.16 (d, J = 8.8 Hz, 1H), 8.08 (d, J = 8.8 Hz, 1H), 7.75 (d, J = 8.8

Hz, 1H), 7.67 (d, J = 8.8 Hz, 1H), 5.04–4.97 (m, 2H), 2.20–2.12 (m, 2H), 2.05–1.90 (m, 2H), 1.78–1.72 (m, 4H), 1.64–1.54 (m, 4H), 1.15 (qd, J = 12.2, 2.4 Hz, 4H), 0.98–0.91 (m, 14H), 0.81 (dd, J = 7.2, 2.4 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 165.2, 156.1, 149.2, 149.1, 148.6, 145.8, 138.1, 137.9, 130.5, 130.1, 130.0, 129.8, 129.7, 129.6, 127.4, 127.0, 121.4, 121.2, 114.5, 75.6, 47.2, 40.9, 34.2, 31.4, 26.5, 23.6, 21.9, 20.7, 16.5. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{42}H_{49}N_4O_6$: 705.3647; found: 705.3640.



2t

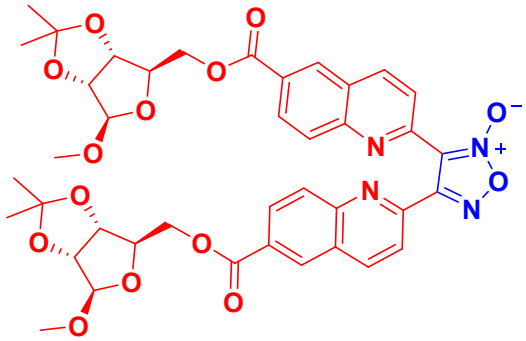
3,4-Bis(6-((2-oxo-1,2-diphenylethoxy)carbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2t), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 72 mg, 89%, white solid, m.p.: 129-130 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.74 (dd, J = 9.0, 1.8 Hz, 2H), 8.44 (dd, J = 8.6, 1.4 Hz, 2H), 8.29 (ddd, J = 9.8, 8.8, 2.0 Hz, 2H), 8.17 (d, J = 8.8 Hz, 1H), 8.08 (d, J = 8.4 Hz, 1H), 8.04–7.97 (m, 4H), 7.75 (d, J = 8.8 Hz, 1H), 7.67 (d, J = 8.8 Hz, 1H), 7.61 (dt, J = 7.8, 2.0 Hz, 4H), 7.58–7.51 (m, 2H), 7.48–7.38 (m, 10H), 7.17 (d, J = 3.6 Hz, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 193.3, 165.2, 156.1, 149.5, 149.4, 148.8, 146.1, 138.2, 138.1, 134.5, 133.6, 133.5, 131.2, 130.1, 129.9, 129.8, 129.6, 129.3, 128.8, 128.7, 128.7, 128.6, 127.3, 126.9, 121.5, 121.4, 114.5, 78.5. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{50}H_{33}N_4O_8$: 817.2293; found: 817.2298.



2u

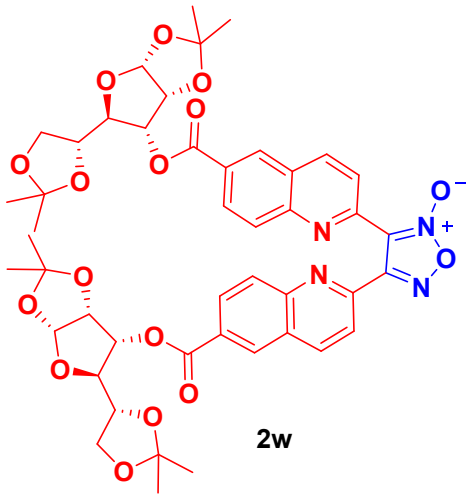
3,4-Bis(6-((((3aS,3bR,6R,6aS,7aS)-2,2-dimethyl-5-oxohexahydro-5H-furo[2',3':3,4]cyclopenta[1,2-d][1,3]dioxol-6-yl)oxy)carbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2u), (silica gel: 200−300 mesh, solvent system: petroleum

ether/ethyl acetate = 10:1-1:1), 66 mg, 81%, white solid, m.p.: 199-201 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.74 (dd, J = 9.2, 2.0 Hz, 2H), 8.46 (dd, J = 8.8, 2.0 Hz, 2H), 8.26 (td, J = 9.4, 1.8 Hz, 2H), 8.18 (d, J = 8.8 Hz, 1H), 8.10 (d, J = 8.4 Hz, 1H), 7.74 (d, J = 8.8 Hz, 1H), 7.66 (d, J = 8.8 Hz, 1H), 6.06 (dd, J = 3.6, 1.6 Hz, 2H), 5.81 (t, J = 4.0 Hz, 2H), 5.30–5.20 (m, 2H), 4.99 (t, J = 2.4 Hz, 2H), 4.89 (dd, J = 3.6, 1.6 Hz, 2H), 1.80–1.60 (m, 4H), 1.52 (s, 6H), 1.35 (s, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 169.5, 164.5, 155.6, 149.6, 149.5, 149.1, 146.4, 138.2, 131.7, 130.2, 129.9, 129.8, 127.4, 127.3, 126.9, 121.6, 121.5, 114.5, 113.6, 107.0, 82.5, 82.3, 70.6, 33.5, 26.8, 26.5. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{42}H_{37}N_4O_{14}$: 821.2301; found: 821.2307.



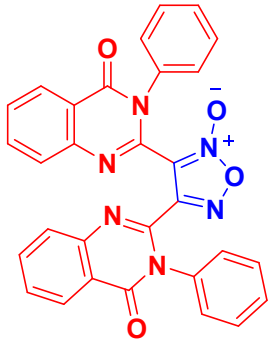
2v

3,4-Bis(6-((((3aR,4R,6R,6aR)-6-methoxy-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)methoxy)carbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2v), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 67 mg, 84%, white solid, m.p.: 124-126 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.68 (dd, J = 8.2, 1.8 Hz, 2H), 8.50–8.40 (m, 2H), 8.24 (td, J = 8.8, 1.6 Hz, 2H), 8.17 (d, J = 8.8 Hz, 1H), 8.09 (d, J = 8.8 Hz, 1H), 7.75 (d, J = 8.8 Hz, 1H), 7.68 (d, J = 8.8 Hz, 1H), 5.04 (d, J = 1.6 Hz, 2H), 4.80 (ddd, J = 5.4, 2.4, 1.2 Hz, 2H), 4.67 (dd, J = 5.8, 1.4 Hz, 2H), 4.58–4.54 (m, 2H), 4.50–4.31 (m, 4H), 3.35 (d, J = 1.6 Hz, 6H), 1.51 (s, 6H), 1.34 (s, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 165.3, 155.9, 149.3, 149.2, 148.8, 146.1, 138.1, 138.0, 130.9, 130.0, 129.8, 129.7, 129.0, 128.9, 127.3, 126.9, 121.6, 121.4, 114.5, 112.7, 109.5, 85.2, 84.3, 81.8, 65.7, 54.9, 26.4, 25.0. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{40}H_{41}N_4O_{14}$: 801.2614; found: 801.2609.



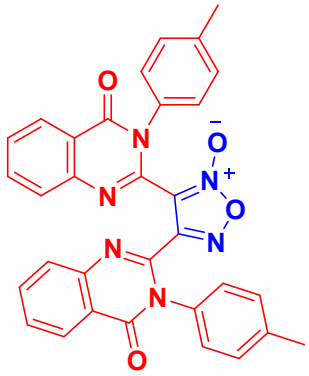
2w

3,4-Bis(6-((((3aR,5R,6R,6aR)-5-((R)-2,2-dimethyl-1,3-dioxolan-4-yl)-2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxol-6-yl)oxy)carbonyl)quinolin-2-yl)-1,2,5-oxadiazole 2-oxide (2w), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 72 mg, 79%, white solid, m.p.: 115-117 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.67 (dd, J = 8.2, 1.8 Hz, 2H), 8.46 (dd, J = 8.6, 2.2 Hz, 2H), 8.26–8.17 (m, 3H), 8.11 (d, J = 8.8 Hz, 1H), 7.77 (d, J = 9.2 Hz, 1H), 7.70 (d, J = 8.8 Hz, 1H), 5.91 (dd, J = 3.6, 1.6 Hz, 2H), 5.18-5.12 (m, 2H), 5.02-4.97 (m, 2H), 4.39–4.34 (m, 4H), 4.13 (ddd, J = 8.2, 6.4, 1.6 Hz, 2H), 4.03–3.98 (m, 2H), 1.56 (s, 6H), 1.41 (d, J = 2.0 Hz, 6H), 1.33 (d, J = 5.2 Hz, 12H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 164.8, 155.9, 149.4, 149.3, 148.9, 146.2, 138.1, 138.1, 131.1, 130.1, 129.9, 129.6, 128.7, 128.7, 127.4, 127.0, 121.6, 121.4, 114.5, 113.3, 110.0, 104.3, 77.8, 77.8, 75.2, 73.8, 65.9, 26.7, 26.4, 24.9. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{46}H_{49}N_4O_{16}$: 913.3138; found: 913.3135.



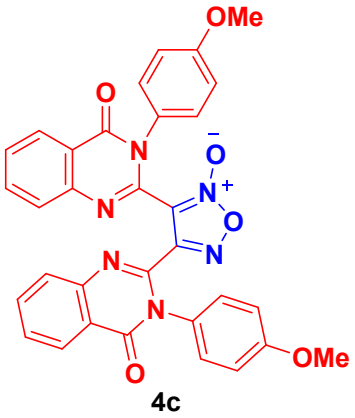
4a

3,4-Bis(4-oxo-3-phenyl-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4a), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 50 mg, 95%, white solid, m.p.: 220-221 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.43 (dd, J = 8.0, 1.6 Hz, 1H), 8.35 (dd, J = 8.0, 1.6 Hz, 1H), 7.85 (ddd, J = 8.4, 7.0, 1.4 Hz, 1H), 7.79–7.69 (m, 2H), 7.65 (ddd, J = 8.2, 7.2, 1.2 Hz, 1H), 7.59 (ddd, J = 8.2, 7.2, 1.2 Hz, 1H), 7.50–7.39 (m, 8H), 7.33 (dd, J = 8.0, 1.2 Hz, 1H), 7.25–7.21 (m, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 161.2, 150.3, 147.0, 145.9, 141.6, 141.3, 135.9, 135.4, 135.3, 135.1, 130.0, 129.7, 129.5, 129.4, 129.3, 128.9, 128.5, 128.2, 127.8, 127.7, 127.6, 127.5, 121.7, 121.6, 111.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{30}H_{19}N_6O_4$: 527.1462; found: 527.1460.



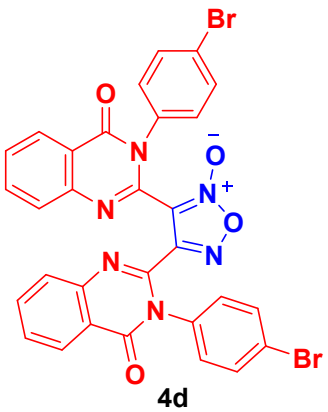
4b

3,4-Bis(4-oxo-3-(p-tolyl)-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4b), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 50 mg, 90%, white solid, m.p.: 214-216 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.43 (dd, J = 8.4, 1.6 Hz, 1H), 8.34 (dd, J = 8.0, 1.2 Hz, 1H), 7.85 (ddd, J = 8.5, 7.0, 1.6 Hz, 1H), 7.77 (dd, J = 8.4, 1.2 Hz, 1H), 7.72 (ddd, J = 8.4, 7.2, 1.4 Hz, 1H), 7.64 (ddd, J = 8.2, 7.0, 1.2 Hz, 1H), 7.58 (ddd, J = 8.2, 7.2, 1.2 Hz, 1H), 7.32–7.20 (m, 7H), 7.08 (d, J = 8.0 Hz, 2H), 2.41 (d, J = 7.6 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 161.3, 150.4, 147.0, 145.9, 141.7, 141.5, 140.2, 139.8, 135.2, 134.9, 133.2, 132.7, 130.1, 130.0, 129.2, 128.8, 128.1, 127.7, 127.5, 127.4, 127.3, 121.6, 121.6, 111.6, 21.3, 21.2. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{32}H_{23}N_6O_4$: 555.1775; found: 555.1772.



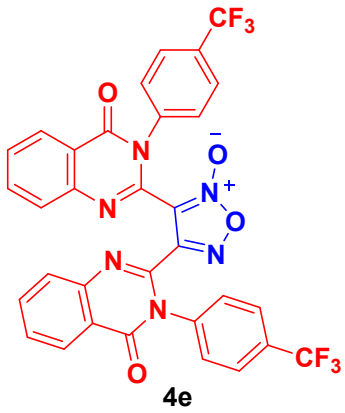
4c

3,4-Bis(3-(4-methoxyphenyl)-4-oxo-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4c), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 52 mg, 89%, white solid, m.p.: 107-108 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.42 (dd, J = 8.0, 1.6 Hz, 1H), 8.34 (dd, J = 8.2, 1.4 Hz, 1H), 7.83 (ddd, J = 8.4, 7.2, 1.6 Hz, 1H), 7.77–7.68 (m, 2H), 7.63 (ddd, J = 8.2, 7.2, 1.2 Hz, 1H), 7.57 (ddd, J = 8.2, 7.2, 1.2 Hz, 1H), 7.38–7.29 (m, 3H), 7.22–7.09 (m, 2H), 7.00–6.92 (m, 2H), 6.92–6.85 (m, 2H), 3.85 (s, 3H), 3.82 (s, 3H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 161.5, 160.5, 160.3, 150.9, 147.1, 145.6, 142.4, 141.6, 135.2, 134.9, 129.5, 129.2, 128.8, 128.4, 128.1, 127.7, 127.6, 127.5, 121.7, 114.7, 114.5, 55.49. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{32}H_{23}N_6O_6$: 587.1674; found: 587.1673.



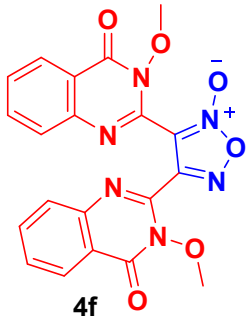
4d

3,4-Bis(3-(4-bromophenyl)-4-oxo-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4d), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 56 mg, 83%, white solid, m.p.: 247-249 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.41 (dd, J = 8.0, 1.2 Hz, 1H), 8.34 (dd, J = 8.0, 1.6 Hz, 1H), 7.85 (ddd, J = 8.6, 7.2, 1.6 Hz, 1H), 7.78–7.70 (m, 2H), 7.66–7.61 (m, 3H), 7.61–7.51 (m, 3H), 7.38–7.32 (m, 3H), 7.20–7.15 (m, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 161.0, 160.9, 150.2, 146.8, 145.7, 141.2, 140.6, 135.5, 135.2, 134.8, 134.2, 132.8, 132.6, 130.1, 129.5, 129.4, 129.1, 128.2, 127.7, 127.7, 127.5, 124.4, 124.1, 121.4, 111.3. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{30}H_{17}Br_2N_6O_4$: 682.9673; found: 682.9670.



4e

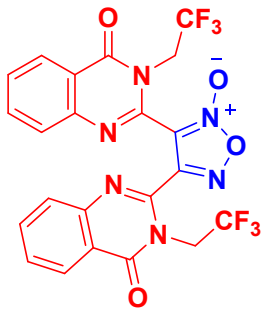
3,4-Bis(4-oxo-3-(4-(trifluoromethyl)phenyl)-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4e), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 57 mg, 86%, white solid, m.p.: 200-201 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.43 (dd, J = 8.0, 1.6 Hz, 1H), 8.36 (dd, J = 8.0, 1.6 Hz, 1H), 7.86 (ddd, J = 8.4, 7.0, 1.4 Hz, 1H), 7.82–7.56 (m, 10H), 7.48 (d, J = 8.0 Hz, 2H), 7.41 (d, J = 8.0 Hz, 1H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 160.9, 160.8, 150.1, 146.7, 145.7, 141.0, 140.2, 139.0, 138.2, 135.6, 135.4, 132.3 – 131.8 (m), 129.7, 129.3, 129.2, 128.6, 128.2, 127.7, 127.7, 127.5, 126.7, 126.7, 126.5, 126.4, 124.8 (d, J = 10.0 Hz), 122.0 (d, J = 6.0 Hz), 121.4, 121.4, 111.2. ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -62.6, -62.7. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{32}H_{17}F_6N_6O_4$: 663.1210; found: 663.1210.



4f

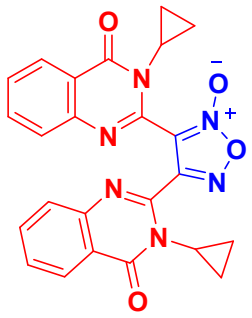
3,4-Bis(3-methoxy-4-oxo-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4f), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 34 mg, 79%, white solid, m.p.: 219-220 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.38 (dd, J = 8.0, 1.6 Hz, 1H), 8.30 (dd, J = 8.0, 1.6 Hz, 1H), 7.82 (ddd, J = 8.6, 7.2,

1.6 Hz, 1H), 7.73 (d, J = 7.2 Hz, 1H), 7.71–7.59 (m, 2H), 7.54 (ddd, J = 8.2, 7.2, 1.2 Hz, 1H), 7.28 (dd, J = 8.2, 1.2 Hz, 1H), 4.22 (s, 3H), 4.11 (s, 3H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 157.2, 157.0, 149.4, 147.0, 145.9, 145.1, 143.9, 140.8, 139.7, 134.9, 134.9, 134.3, 128.9, 128.8, 128.4, 128.2, 127.8, 127.4, 126.9, 126.6, 123.2, 123.1, 108.9, 65.9, 65.7. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{15}N_6O_6$: 435.1048; found: 435.1044.



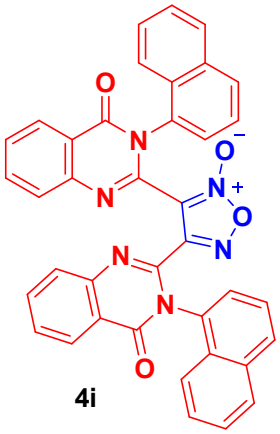
4g

3,4-Bis(4-oxo-3-(2,2,2-trifluoroethyl)-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4g), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 43 mg, 81%, white solid, m.p.: 207-208 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.41 (ddd, J = 8.0, 1.6, 0.8 Hz, 1H), 8.31 (ddd, J = 8.0, 1.6, 0.4 Hz, 1H), 7.81 (ddd, J = 8.4, 7.0, 1.6 Hz, 1H), 7.72–7.61 (m, 3H), 7.57 (ddd, J = 8.2, 7.2, 1.2 Hz, 1H), 7.10 (dd, J = 8.0, 1.2 Hz, 1H), 5.59 (q, J = 8.0 Hz, 2H), 4.88 (q, J = 8.4 Hz, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 161.0, 160.5, 151.3, 146.2, 144.9, 140.6, 140.3, 135.8, 135.5, 130.0, 129.4, 128.3, 127.7, 127.6, 127.5, 124.6, 124.3, 121.8, 121.5, 120.6, 120.5, 110.5, 45.4–44.3 (m), 43.8–42.7 (m). ^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -68.9, -69.0. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{13}F_6N_6O_4$: 539.0897; found: 539.0897.



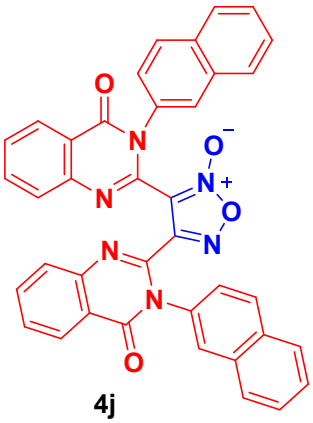
4h

3,4-Bis(3-cyclopropyl-4-oxo-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4h), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 39 mg, 86%, white solid, m.p.: 203-204 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.33–8.25 (m, 2H), 7.69–7.61 (m, 2H), 7.54–7.47 (m, 2H), 7.45 (d, J = 8.0 Hz, 1H), 7.28 (dd, J = 8.2, 1.0 Hz, 1H), 3.51–3.40 (m, 2H), 1.44–0.96 (m, 8H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 162.2, 162.2, 151.5, 146.1, 145.6, 144.3, 142.8, 134.5, 134.4, 128.7, 128.5, 127.7, 127.6, 126.8, 126.8, 121.6, 121.5, 112.4, 29.3, 27.3, 10.6, 7.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{24}H_{19}N_6O_4$: 455.1462; found: 455.1461.



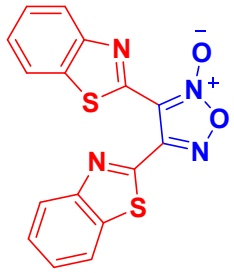
4i

3,4-Bis(3-(naphthalen-1-yl)-4-oxo-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4i), (silica gel: 200−300 mesh, solent system: petroleum ether/ethyl acetate = 10:1-1:1), 50 mg, 80%, white solid, m.p.: 175-177 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.54–8.46 (m, 1H), 8.38–8.31 (m, 1H), 8.04–7.83 (m, 6H), 7.81–7.70 (m, 2H), 7.67–7.60 (m, 1H), 7.57–7.35 (m, 6H), 7.31–7.19 (m, 4H), 7.05–6.68 (m, 1H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 161.1, 160.8, 149.5, 149.1, 147.3, 146.0, 142.4, 142.0, 135.4, 134.1, 133.8, 132.7, 132.2, 132.1, 130.9, 130.8, 130.4, 130.2, 129.3, 129.1, 129.0, 128.5, 128.3, 127.8, 127.6, 127.5, 127.2, 126.9, 126.8, 126.6, 126.4, 125.6, 125.3, 124.8, 122.9, 121.4, 120.4, 111.2. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{38}H_{23}N_6O_4$: 627.1775; found: 627.1776.



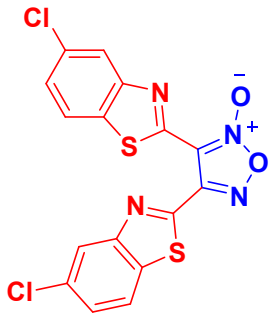
4j

3,4-Bis(3-(naphthalen-2-yl)-4-oxo-3,4-dihydroquinazolin-2-yl)-1,2,5-oxadiazole 2-oxide (4j), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 49 mg, 78%, white solid, m.p.: 150-152 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.47 (dt, J = 8.2, 2.0 Hz, 1H), 8.39 (dd, J = 8.0, 1.6 Hz, 1H), 7.99–7.29 (m, 19H), 7.05 (dd, J = 27.8, 8.2 Hz, 1H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 161.3, 161.3, 150.1, 147.0, 145.9, 145.9, 141.7, 141.6, 141.5, 141.4, 135.4, 135.1, 133.4, 133.2, 133.0, 132.7, 129.5, 129.4, 129.3, 129.2, 128.9, 128.4, 128.3, 128.2, 127.8, 127.8, 127.6, 127.4, 127.2, 126.9, 126.7, 125.6, 125.5, 124.9, 124.6, 121.6, 121.6, 111.4. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{38}H_{23}N_6O_4$: 627.1775; found: 627.1771.



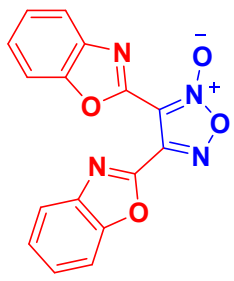
4k

3,4-Bis(benzo[d]thiazol-2-yl)-1,2,5-oxadiazole 2-oxide (4k), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 15 mg, 42%, white solid, m.p.: 165-166 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.26 (dd, J = 7.6, 1.6 Hz, 1H), 8.15 (dd, J = 8.2, 2.0 Hz, 1H), 8.10–8.01 (m, 2H), 7.67–7.49 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 152.9, 152.5, 152.1, 150.3, 149.4, 136.1, 135.0, 127.1, 127.0, 126.9, 124.7, 124.2, 121.7, 121.7. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{16}H_9N_4O_2S_2$: 353.0161; found: 353.0163.



4l

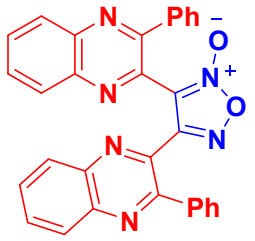
3,4-Bis(5-chlorobenzo[d]thiazol-2-yl)-1,2,5-oxadiazole 2-oxide (4l), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 16 mg, 39%, white solid, m.p.: 190-191 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.24 (dd, J = 2.0, 0.8 Hz, 1H), 8.12 (dd, J = 2.0, 0.8 Hz, 1H), 7.98 (dd, J = 14.8, 8.4 Hz, 2H), 7.57 (dd, J = 8.8, 2.0 Hz, 1H), 7.52 (dd, J = 8.8, 2.0 Hz, 1H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 153.6, 153.2, 151.3, 149.8, 134.4, 133.3, 133.1, 130.2, 127.8, 127.6, 124.3, 123.7, 122.5, 122.5, 111.5. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{16}H_7Cl_2N_4O_2S_2$: 420.9382; found: 420.9380.



4m

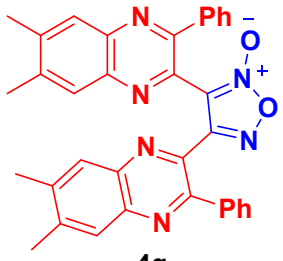
3,4-Bis(benzo[d]oxazol-2-yl)-1,2,5-oxadiazole 2-oxide (4m), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 22 mg, 70%, white

solid, m.p.: 145-147 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 7.95–7.85 (m, 2H), 7.70 (dt, J = 8.4, 0.8 Hz, 1H), 7.66–7.61 (m, 1H), 7.58–7.44 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 150.7, 150.5, 148.1, 145.2, 140.9, 127.7, 127.3, 125.7, 125.7, 121.6, 121.4, 111.4, 111.3. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{16}H_9N_4O_4$: 321.0618; found: 321.0616.



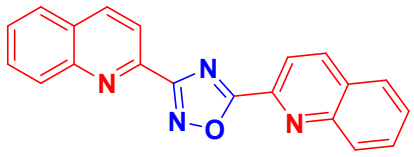
4p

3,4-Bis(3-phenylquinoxalin-2-yl)-1,2,5-oxadiazole 2-oxide (4p), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 40 mg, 82%, white solid, m.p.: 164-166 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.14 (m, 2H), 7.92–7.84 (m, 3H), 7.83–7.72 (m, 3H), 7.22–7.19 (m, 2H), 7.18–7.11 (m, 4H), 7.05–6.96 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 155.3, 152.8, 152.3, 142.0, 141.8, 140.8, 140.5, 139.6, 137.7, 136.29, 131.98, 130.59, 130.49, 129.70, 129.59, 129.56, 129.54, 129.31, 129.27, 128.66, 128.57, 128.52, 127.86, 113.92, 77.32, 77.00, 76.68. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{30}H_{19}N_6O_2$: 495.1564; found: 495.1564.



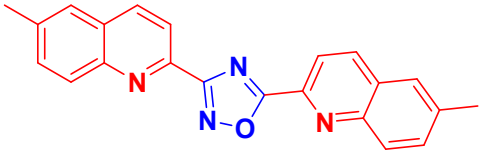
4q

3,4-Bis(6,7-dimethyl-3-phenylquinoxalin-2-yl)-1,2,5-oxadiazole 2-oxide (4q), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 40 mg, 73%, white solid, m.p.: 218-220 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 7.88 (d, J = 4.4 Hz, 2H), 7.63 (s, 1H), 7.53 (s, 1H), 7.25 (t, J = 1.4 Hz, 1H), 7.24–7.19 (m, 3H), 7.19–7.13 (m, 2H), 7.10–7.01 (m, 4H), 2.54 (d, J = 3.2 Hz, 6H), 2.48 (d, J = 6.4 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 155.7, 152.8, 151.7, 143.0, 141.4, 141.3, 141.1, 140.9, 139.9, 139.6, 138.8, 136.8, 129.4, 129.2, 128.6, 128.6, 128.4, 128.3, 128.1, 127.8, 20.6, 20.4, 20.3. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{34}H_{27}N_6O_2$: 551.2190; found: 551.2188.



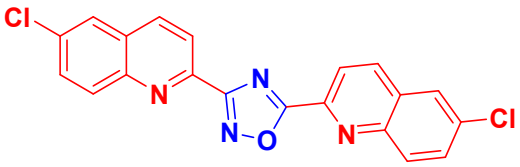
5a

3,5-Di(quinolin-2-yl)-1,2,4-oxadiazole (5a), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 12 mg, 37%, white solid, m.p.: 198-200 °C. ^{1}H-NMR (400 M Hz, $CDCl_3$): δ (ppm) 8.53 (d, J = 8.4 Hz, 1H), 8.45–8.32 (m, 5H), 7.92 (ddd, J = 9.8, 8.0, 1.2 Hz, 2H), 7.88–7.80 (m, 2H), 7.72–7.63 (m, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 175.4, 169.3, 148.1, 148.0, 146.1, 143.2, 137.7, 137.4, 130.8, 130.5, 130.4, 130.2, 129.1, 128.9, 128.8, 128.0, 127.7, 127.6, 120.8, 120.3. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{13}N_4O$: 325.1084; found: 325.1080.



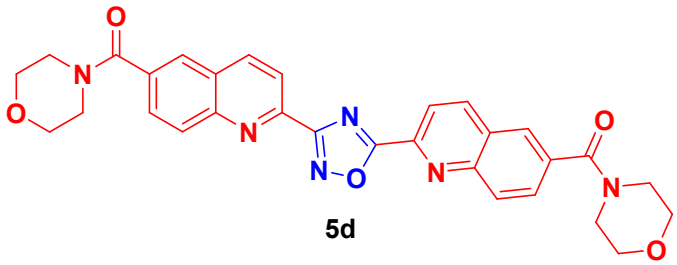
5b

3,5-Bis(6-methylquinolin-2-yl)-1,2,4-oxadiazole (5b), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 11 mg, 31%, white solid, m.p.: 224-226 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.48 (d, J = 8.4 Hz, 1H), 8.35–8.23 (m, 5H), 7.69–7.60 (m, 4H), 2.58 (d, J = 6.0 Hz, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 175.4, 169.3, 146.8, 146.7, 145.2, 142.3, 139.3, 138.2, 136.8, 136.5, 133.1, 132.6, 130.1, 130.1, 129.2, 128.9, 126.5, 126.4, 120.8, 120.3, 21.8, 21.7. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_4O$: 353.1397; found: 353.1393.



5c

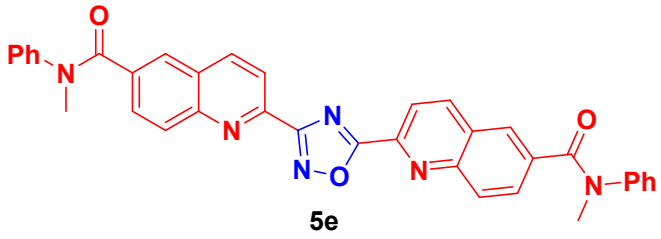
3,5-Bis(6-chloroquinolin-2-yl)-1,2,4-oxadiazole (5c), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 16 mg, 41%, white solid, m.p.: 220-221 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.54 (d, J = 8.4 Hz, 1H), 8.41 (d, J = 8.4 Hz, 1H), 8.34–8.29 (m, 3H), 7.92 (dd, J = 10.6, 2.2 Hz, 2H), 7.77 (ddd, J = 17.2, 9.0, 2.4 Hz, 3H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 175.2, 169.1, 146.5, 146.4, 146.2, 143.2, 136.8, 136.5, 135.1, 134.1, 132.1, 132.0, 131.9, 131.4, 129.7, 129.4, 126.4, 126.3, 121.6, 121.2. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{11}Cl_2N_4O$: 393.0304; found: 393.0300.



5d

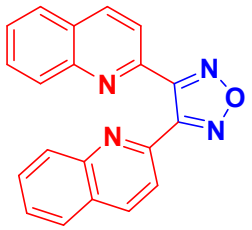
((1,2,4-Oxadiazole-3,5-diyl)bis(quinoline-2,6-diyl))bis(morpholinomethanone) (5d), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-

1:1), 19 mg, 35%, white solid, m.p.: 111-113 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.58 (d, J = 8.4 Hz, 1H), 8.52–8.36 (m, 5H), 8.01 (dd, J = 8.4, 2.0 Hz, 2H), 7.83 (ddd, J = 15.6, 8.6, 1.8 Hz, 2H), 3.95–3.53 (m, 16H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 175.2, 169.3, 169.1, 169.0, 148.2, 148.1, 147.2, 144.1, 138.2, 137.9, 135.7, 134.8, 131.1, 131.0, 129.1, 128.7, 128.3, 126.8, 121.5, 121.1, 66.8. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{30}H_{27}N_6O_5$: 551.2037; found: 551.2035.



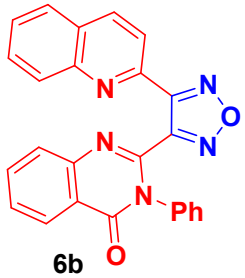
5e

2,2'-(1,2,4-Oxadiazole-3,5-diyl)bis(N-methyl-N-phenylquinoline-6-carboxamide) (5e), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 19 mg, 32%, white solid, m.p.: 266-267 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.43 (d, J = 8.4 Hz, 1H), 8.33–8.18 (m, 3H), 8.07 (dd, J = 8.8, 3.6 Hz, 2H), 7.95 (dd, J = 7.0, 1.8 Hz, 2H), 7.64–7.57 (m, 2H), 7.25–7.17 (m, 5H), 7.16–6.99 (m, 9H), 3.57 (s, 6H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 175.1, 169.5, 169.2, 169.0, 147.9, 147.8, 147.0, 144.2, 144.1, 143.9, 138.3, 138.0, 136.4, 135.5, 130.3, 130.2, 129.8, 129.7, 129.6, 129.4, 129.3, 128.7, 128.2, 127.8, 127.0, 126.9, 126.8, 121.2, 120.7, 38.6, 38.4. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{36}H_{27}N_6O_3$: 591.2139; found: 591.2138.



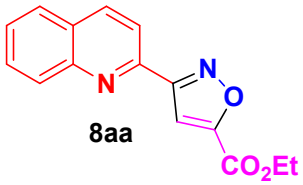
6a

3,4-Di(quinolin-2-yl)-1,2,5-oxadiazole (6a), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 61 mg, 95%, white solid, m.p.: 160-162 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.30 (d, J = 8.4 Hz, 2H), 8.05 (d, J = 8.4 Hz, 2H), 7.89 (dd, J = 8.4, 1.6 Hz, 2H), 7.85 (d, J = 8.0 Hz, 2H), 7.68 (ddd, J = 8.4, 6.8, 1.6 Hz, 2H), 7.60 (ddd, J = 8.2, 6.8, 1.2 Hz, 2H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 153.7, 147.6, 146.4, 136.5, 130.0, 129.8, 128.1, 127.7, 127.6, 121.8. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{20}H_{13}N_4O$: 325.1083; found: 325.1080.



6b

3-Phenyl-2-(4-(quinolin-2-yl)-1,2,5-oxadiazol-3-yl)quinazolin-4(3H)-one (6b), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 81 mg, 97%, white solid, m.p.: 188-189 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.53 (dd, J = 7.8, 1.4 Hz, 1H), 8.25 (d, J = 8.4 Hz, 1H), 7.99 (d, J = 8.4 Hz, 1H), 7.88–7.80 (m, 3H), 7.70–7.53 (m, 4H), 7.23–7.17 (m, 1H), 7.15–7.09 (m, 4H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 161.5, 152.9, 149.3, 147.2, 144.6, 144.5, 137.5, 135.6, 134.9, 130.7, 129.6, 129.3, 128.9, 128.8, 128.3, 128.1, 127.7, 127.4, 121.8, 119.6. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{25}H_{16}N_5O_2$: 418.1298; found: 418.1294.



8aa

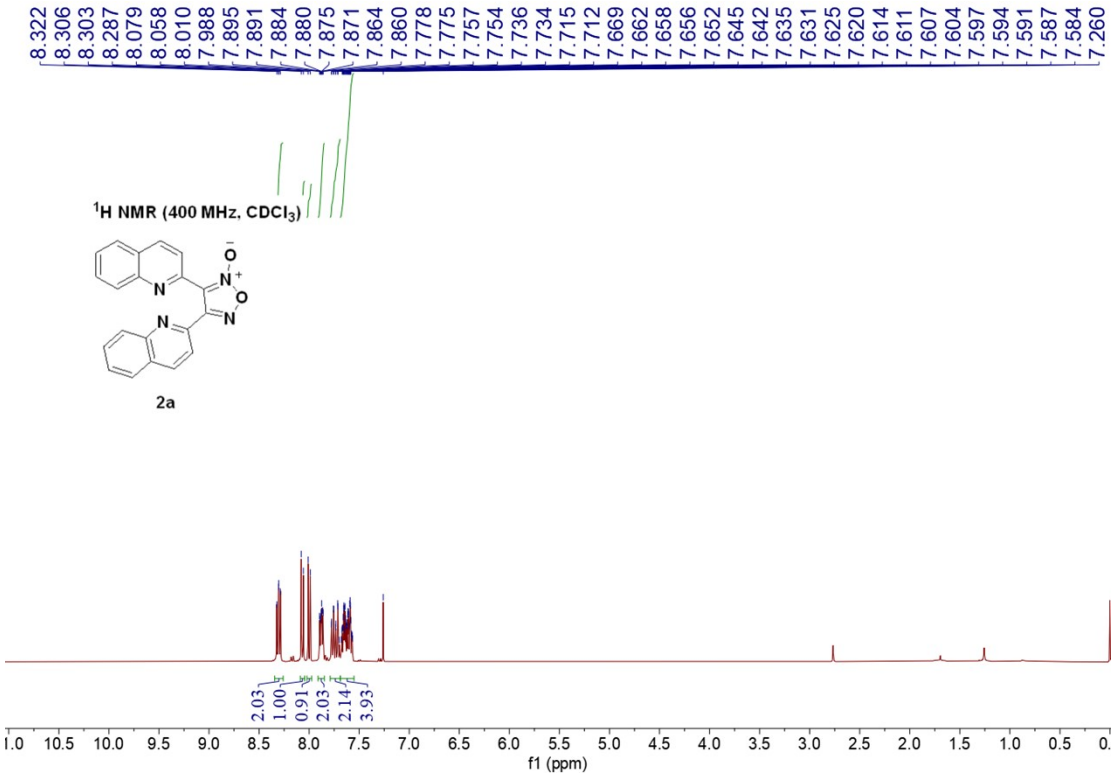
Ethyl 3-(quinolin-2-yl)isoxazole-5-carboxylate (8aa), (silica gel: 200−300 mesh, solvent system: petroleum ether/ethyl acetate = 10:1-1:1), 47 mg, 88%, white solid, m.p.: 89-91 °C. ^{1}H-NMR (400 MHz, $CDCl_3$): δ (ppm) 8.26 (dd, J = 8.8, 0.8 Hz, 1H), 8.20 (d, J = 8.4 Hz, 1H), 8.14 (dd, J = 8.6, 1.0 Hz, 1H), 7.86 (dd, J = 8.2, 1.4 Hz, 1H), 7.80–7.72 (m, 2H), 7.59 (ddd, J = 8.2, 7.0, 1.2 Hz, 1H), 4.48 (q, J = 7.2 Hz, 2H), 1.45 (t, J = 7.2 Hz, 3H). ^{13}C-NMR (100 MHz, $CDCl_3$): δ (ppm) 164.1, 160.9, 156.8, 147.9, 147.4, 137.1, 130.1, 129.8, 128.4, 127.7, 127.5, 118.8, 108.5, 62.3, 14.1. HRMS (ESI): m/z $[M+H]^+$ calcd for $C_{15}H_{13}N_2O_3$: 269.0920; found: 269.0922.

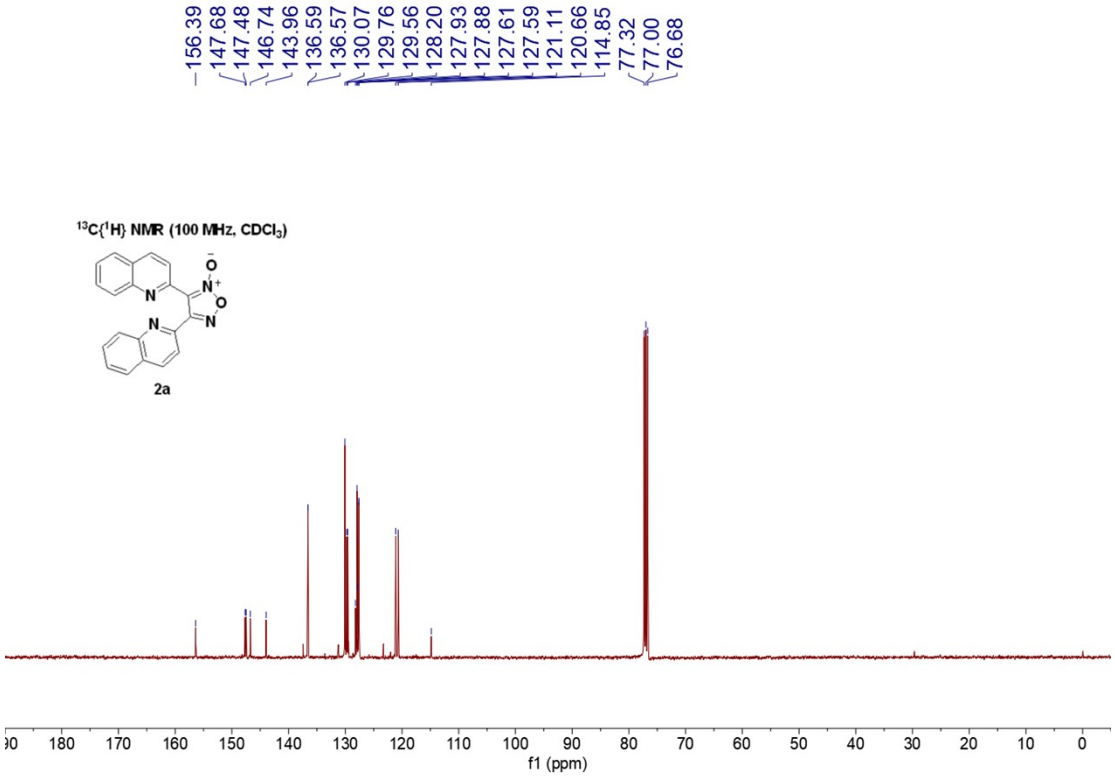
6. References

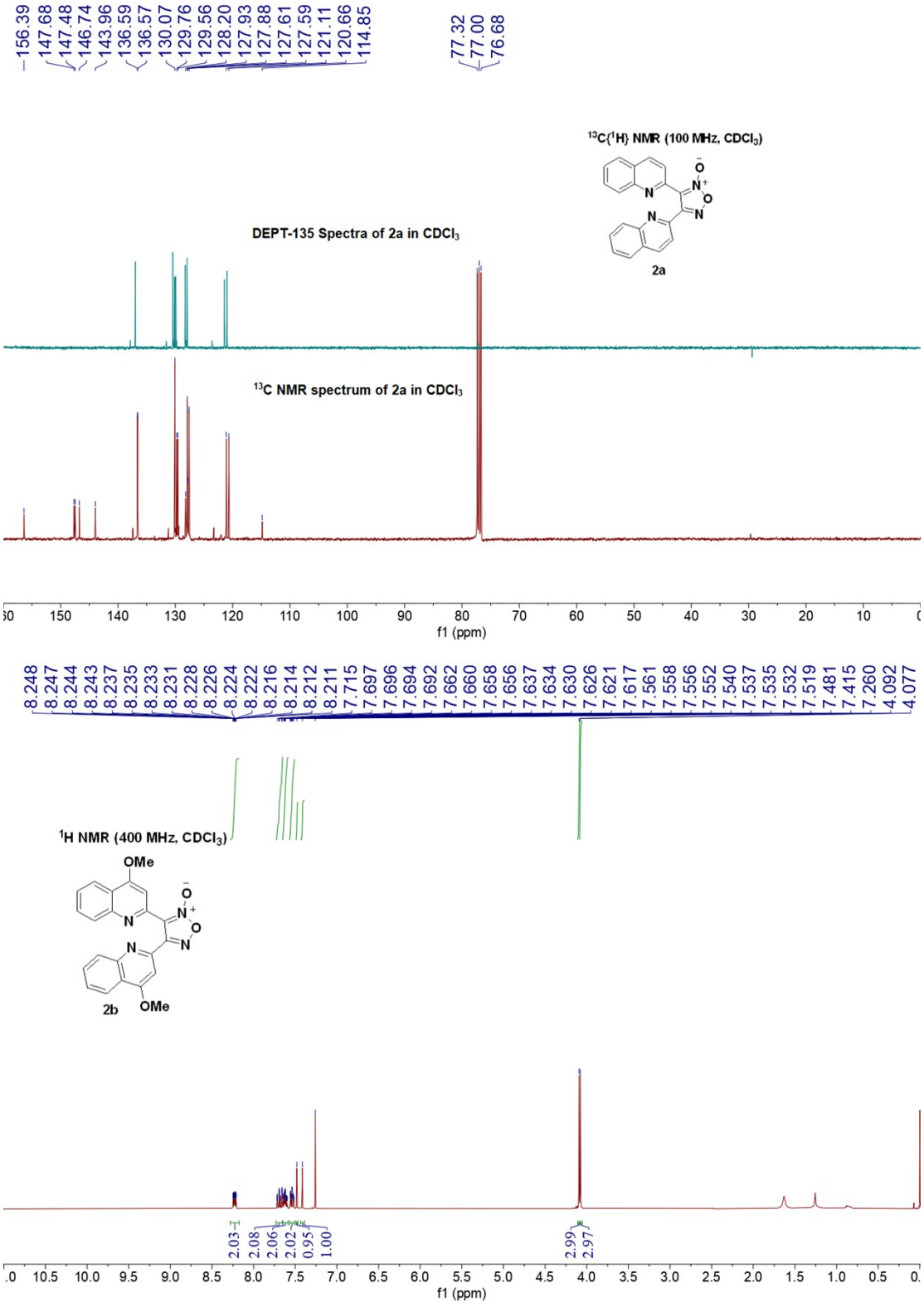
1. Zhao, J.-Q.; Zhou, M.-Q.; Zuo, J.; Xu, X.-Y.; Zhang, X.-M.; Yuan, W.-C. Synthesis of furoxan derivatives: DABCO-mediated cascade sulfonylation/cyclization reaction of α-nitro-ketoximes. *Tetrahedron* **2015**, *71*, 1560-1565.

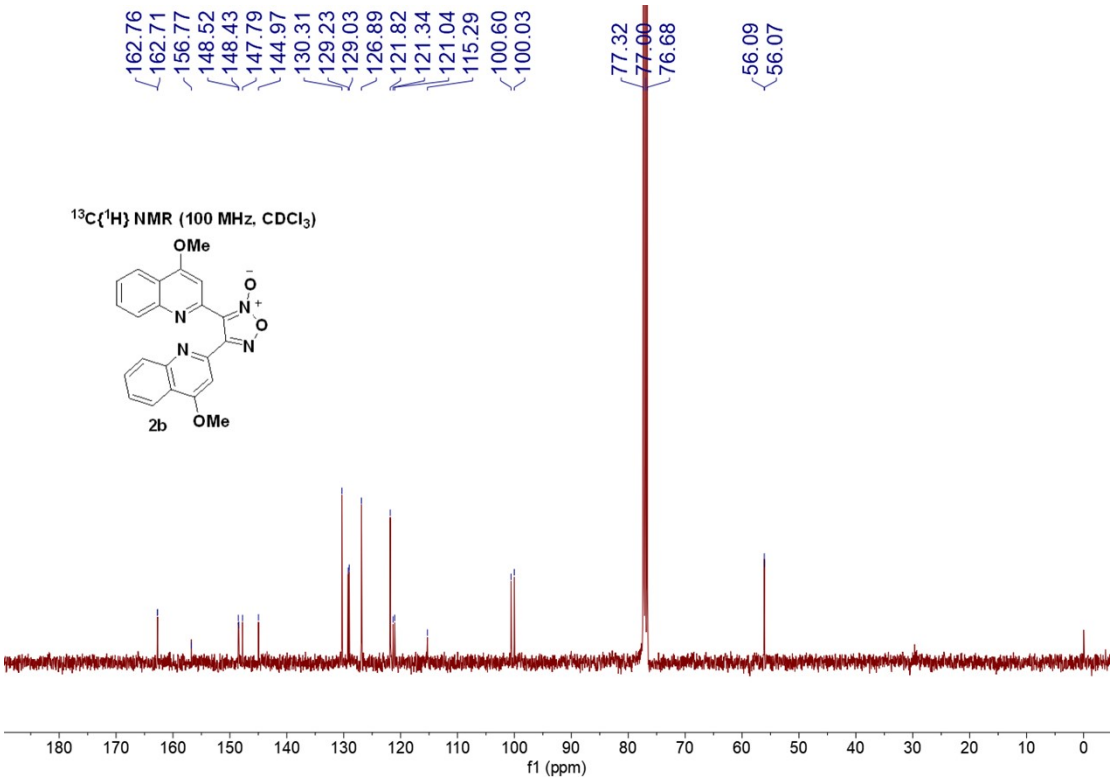
2. Kaplaneris, N.; Kaltenhäuser, F.; Sirvinskaite, G.; Fan, S.; De Oliveira, T.; Conradi, L.-C.; Ackermann, L. Late-stage stitching enabled by manganese-catalyzed C─H activation: Peptide ligation and access to cyclopeptides. *Sci. Adv.* **2021**, *7*, eabe6202.

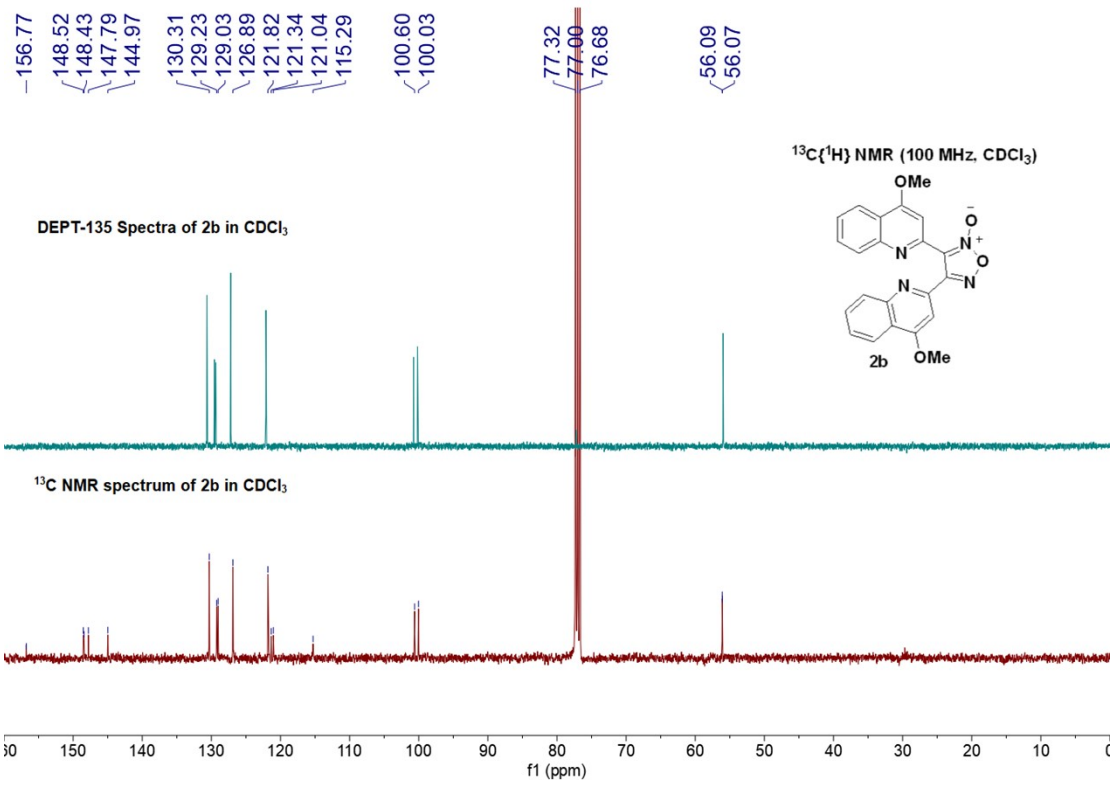
7. Copy of 1H and 13C NMR Spectra of Products

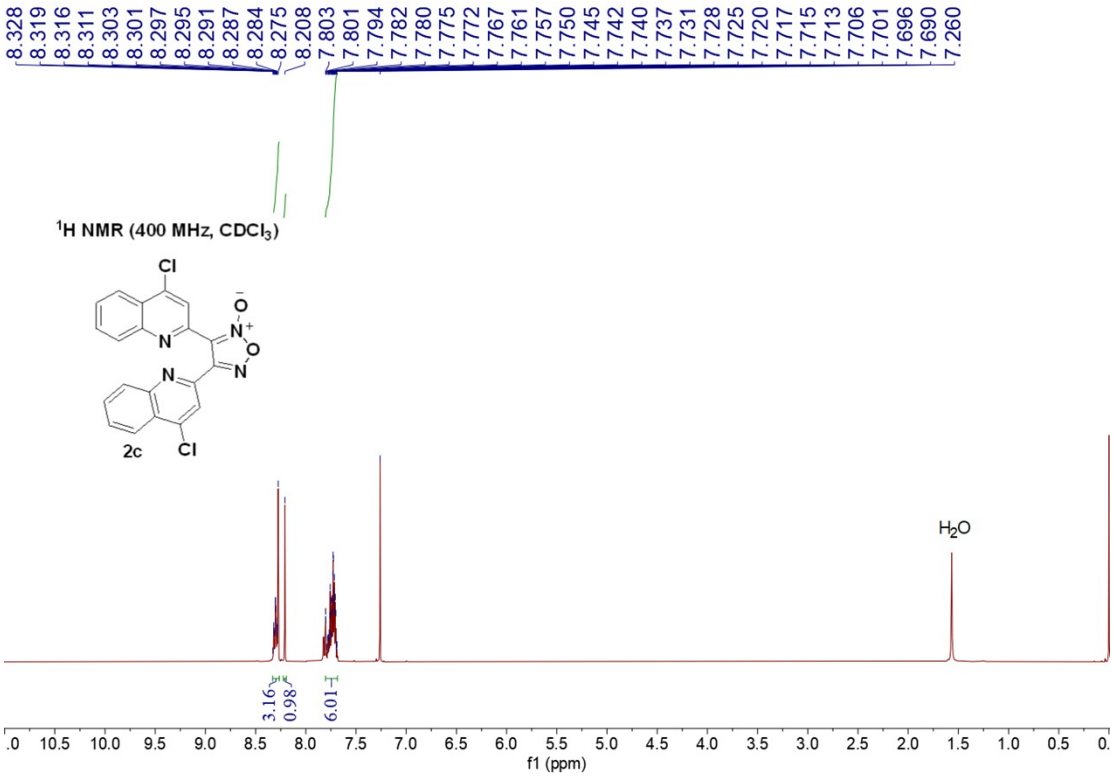

8.322
8.306
8.303
8.287
8.079
8.058
8.010
7.988
7.895
7.891
7.884
7.880
7.875
7.871
7.864
7.860
7.778
7.775
7.757
7.754
7.736
7.734
7.715
7.712
7.669
7.662
7.658
7.656
7.652
7.645
7.642
7.635
7.631
7.625
7.620
7.614
7.611
7.607
7.604
7.597
7.594
7.591
7.587
7.584
7.260
1H NMR (400 MHz, CDCl3)
2a
2.03
1.00
0.91
2.03
2.14
3.93
f1 (ppm)

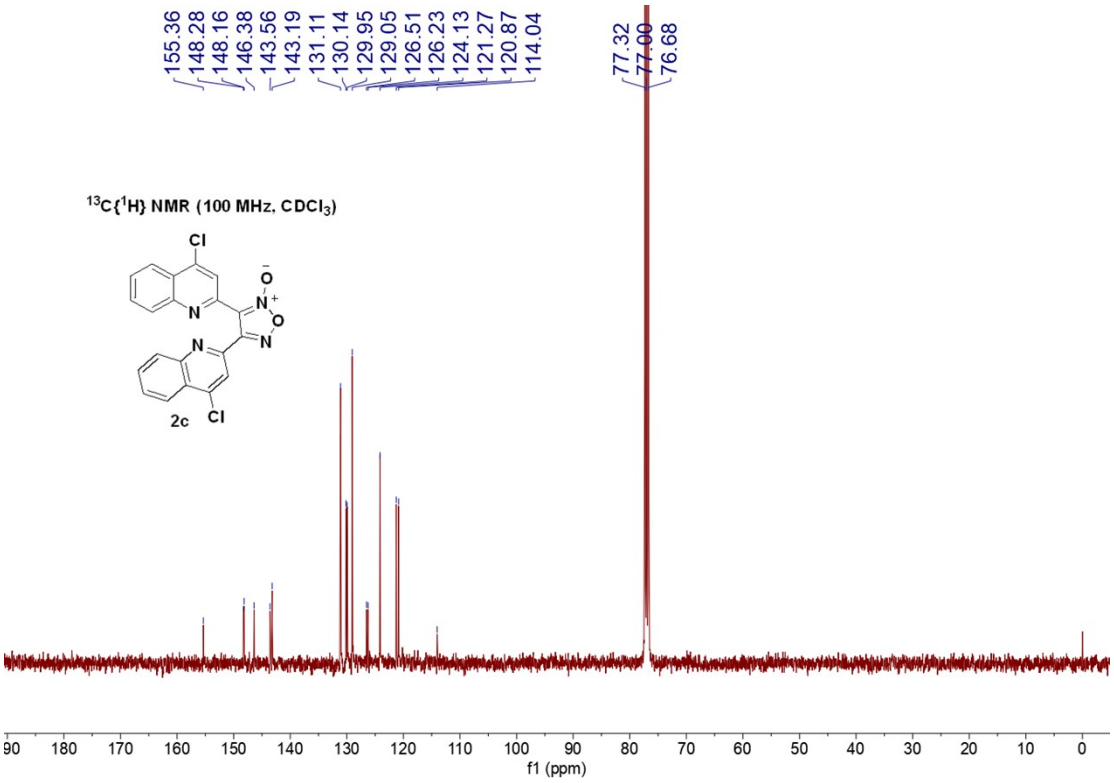

156.39
147.68
147.48
146.74
143.96
136.59
136.57
130.07
129.76
129.56
128.20
127.93
127.88
127.61
127.59
121.11
120.66
114.85
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
2a
f1 (ppm)

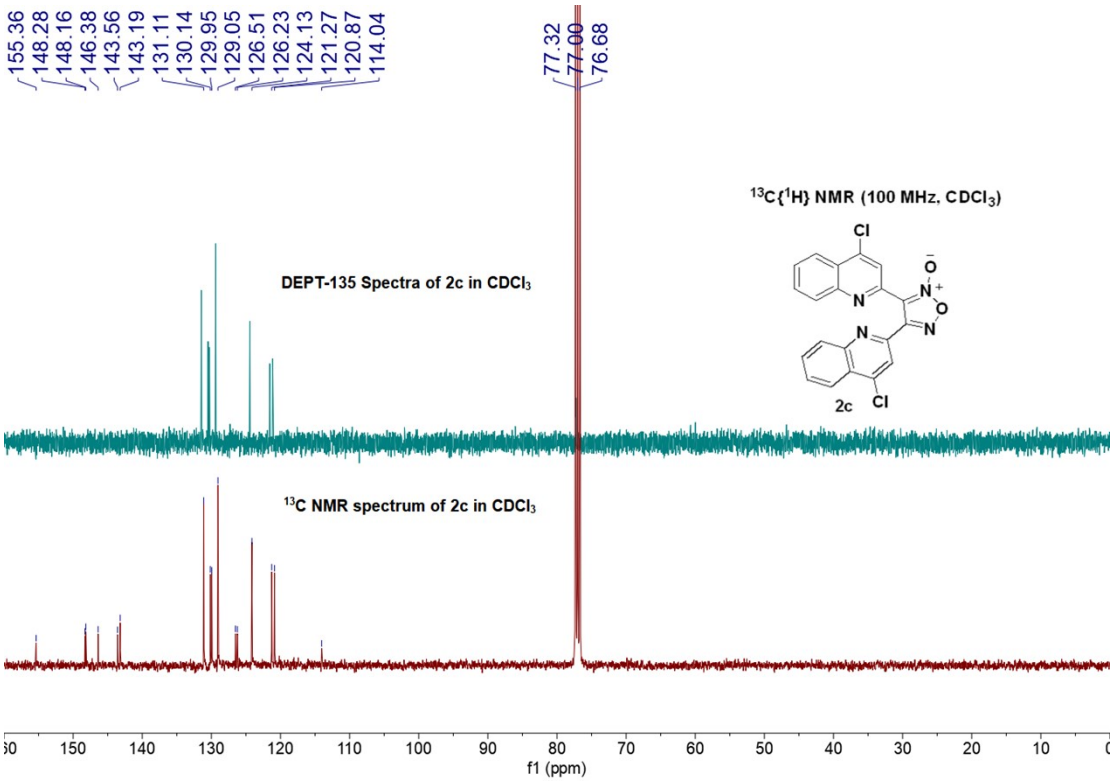

156.39
147.68
147.48
146.74
143.96
136.59
136.57
130.07
129.76
129.56
128.20
127.93
127.88
127.61
127.59
121.11
120.66
114.85
77.32
77.00
76.68
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
DEPT-135 Spectra of 2a in $CDCl_3$
2a
^{13}C NMR spectrum of 2a in $CDCl_3$
f1 (ppm)
8.248
8.247
8.244
8.243
8.237
8.235
8.233
8.231
8.228
8.226
8.224
8.222
8.216
8.214
8.212
8.211
7.715
7.697
7.696
7.694
7.692
7.662
7.660
7.658
7.656
7.637
7.634
7.630
7.626
7.621
7.617
7.561
7.558
7.556
7.552
7.540
7.537
7.535
7.532
7.519
7.481
7.415
7.260
4.092
4.077
^{1}H NMR (400 MHz, $CDCl_3$)
OMe
2b
OMe
2.03
2.08
2.06
2.02
0.95
1.00
2.99
2.97
f1 (ppm)

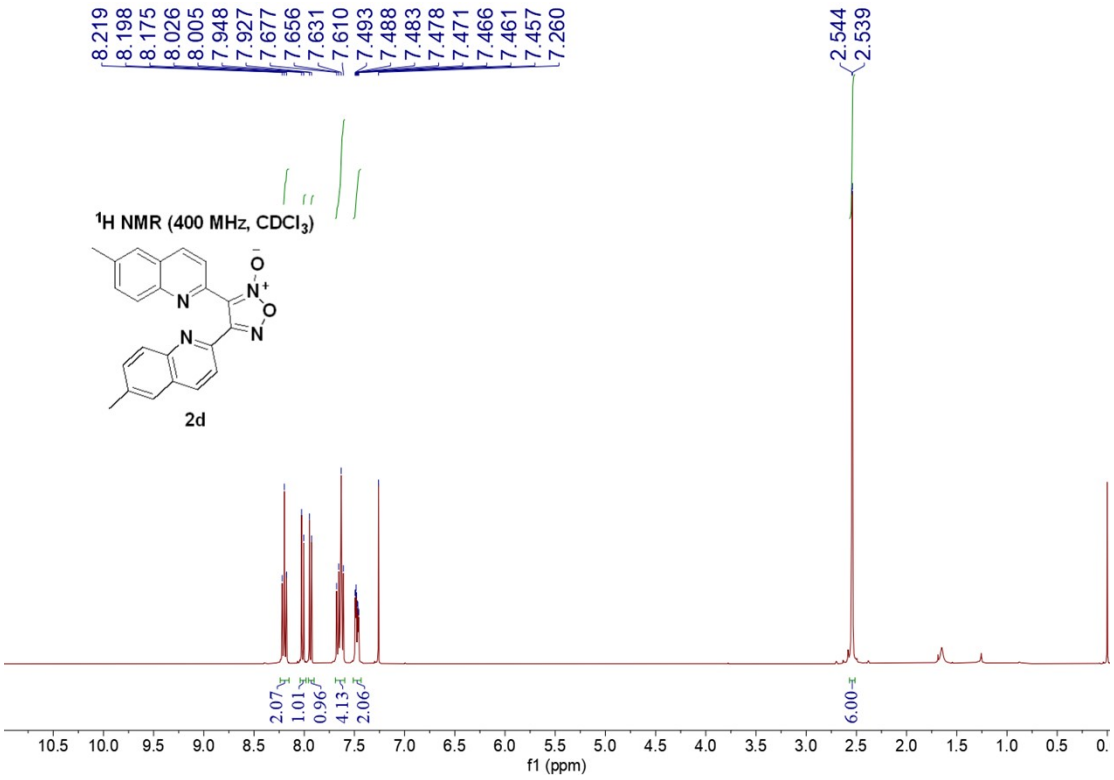

162.76
162.71
156.77
148.52
148.43
147.79
144.97
130.31
129.23
129.03
126.89
121.82
121.34
121.04
115.29
100.60
100.03
77.32
77.00
76.68
56.09
56.07
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
OMe
2b
OMe
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

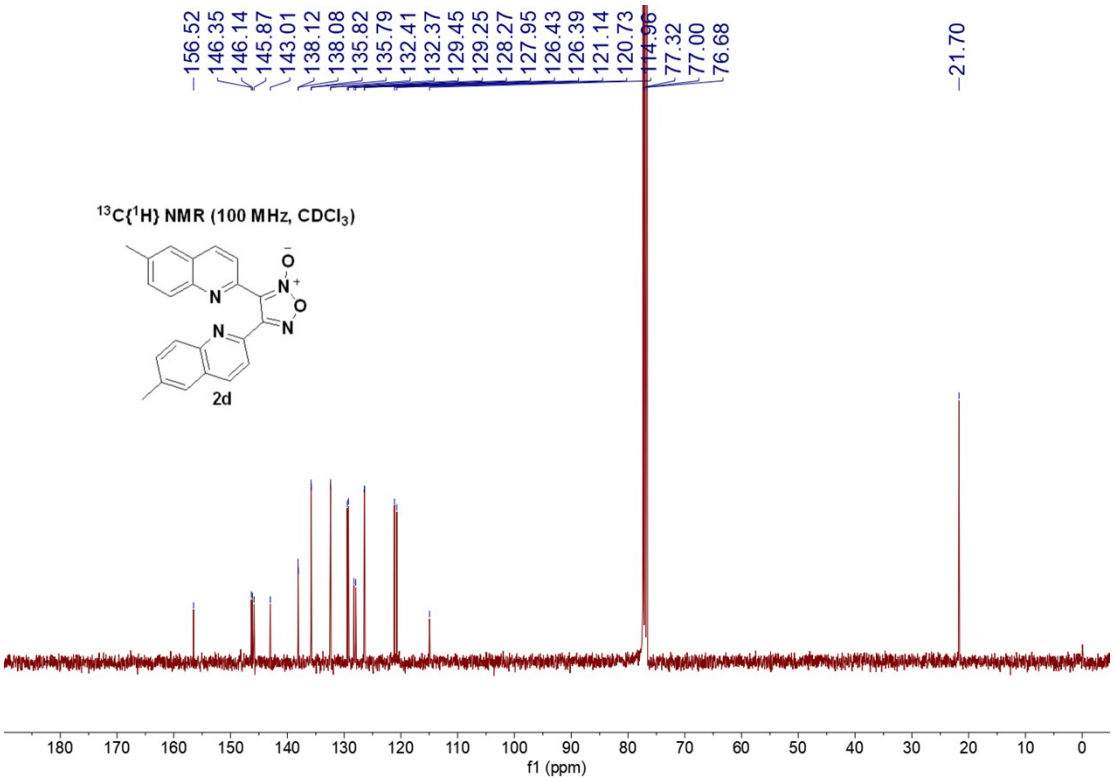

156.77
148.52
148.43
147.79
144.97
130.31
129.23
129.03
126.89
121.82
121.34
121.04
115.29
100.60
100.03
77.32
77.00
76.68
56.09
56.07
DEPT-135 Spectra of 2b in $CDCl_3$
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
OMe
2b
OMe
^{13}C NMR spectrum of 2b in $CDCl_3$
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

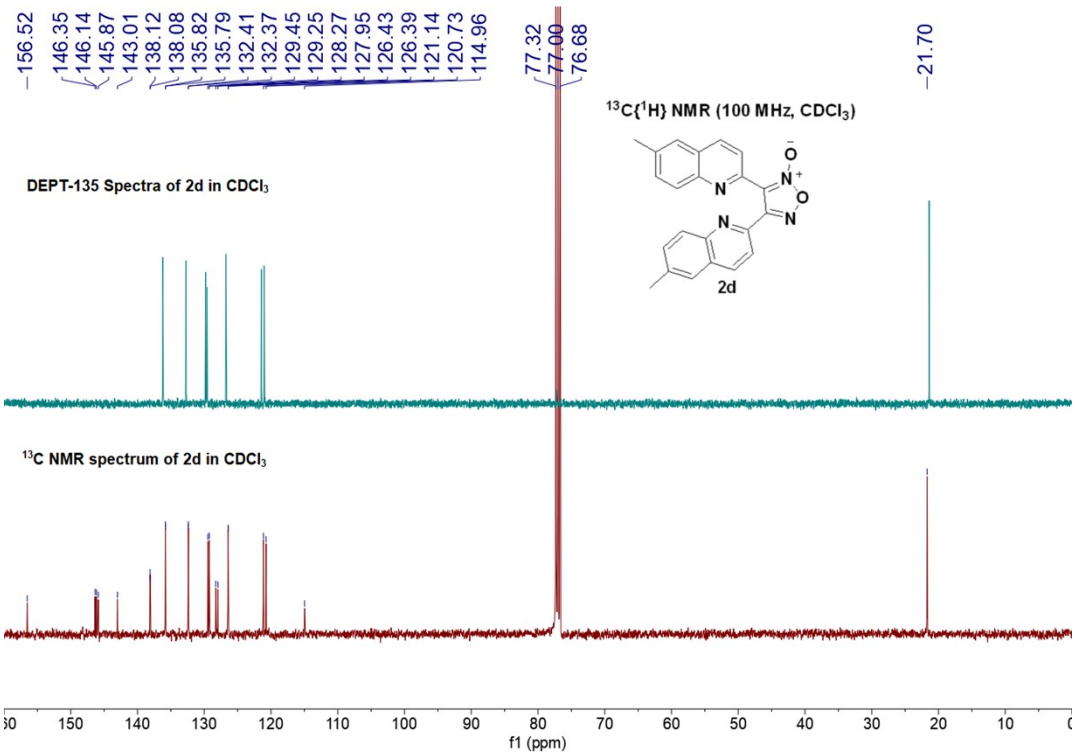

8.328
8.319
8.316
8.311
8.303
8.301
8.297
8.295
8.291
8.287
8.284
8.275
8.208
7.803
7.801
7.794
7.782
7.780
7.775
7.772
7.767
7.761
7.757
7.750
7.745
7.742
7.740
7.737
7.731
7.728
7.725
7.720
7.717
7.715
7.713
7.706
7.701
7.696
7.690
7.260
1H NMR (400 MHz, CDCl3)
Cl
N
O
N+
O
N
N
Cl
2c
H2O
3.16
0.98
6.01
f1 (ppm)

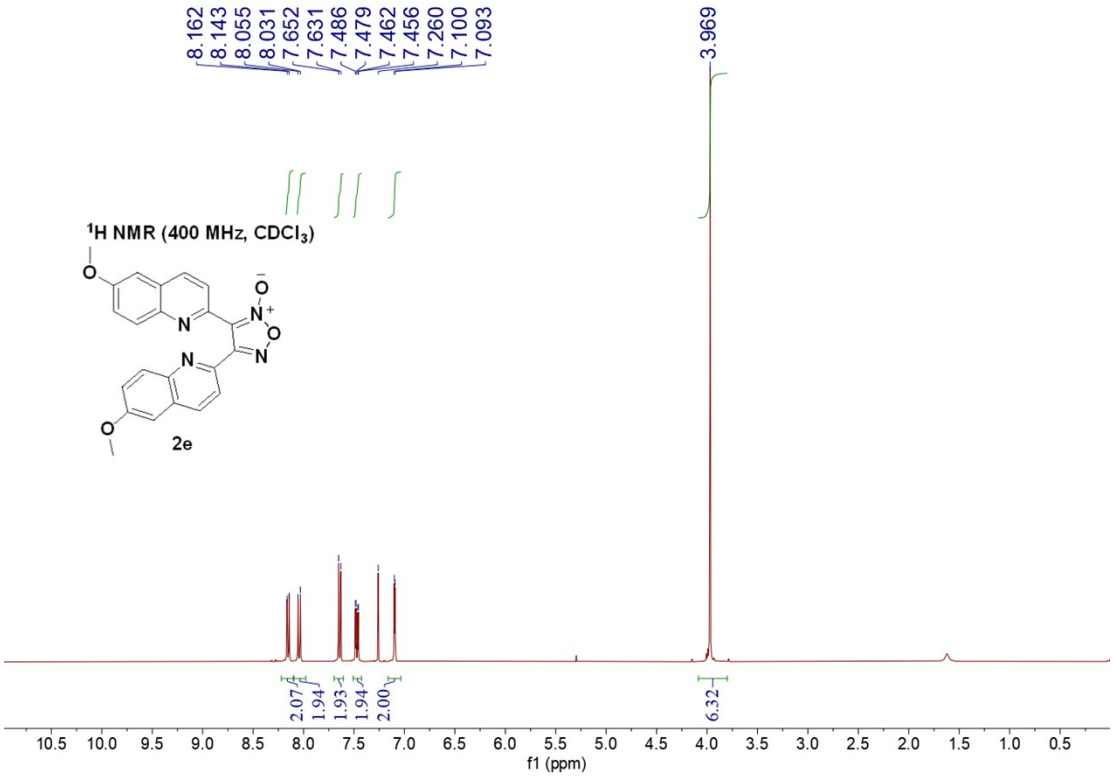

155.36
148.28
148.16
146.38
143.56
143.19
131.11
130.14
129.95
129.05
126.51
126.23
124.13
121.27
120.87
114.04
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Cl
N
O
N+
O
N
N
Cl
2c
f1 (ppm)

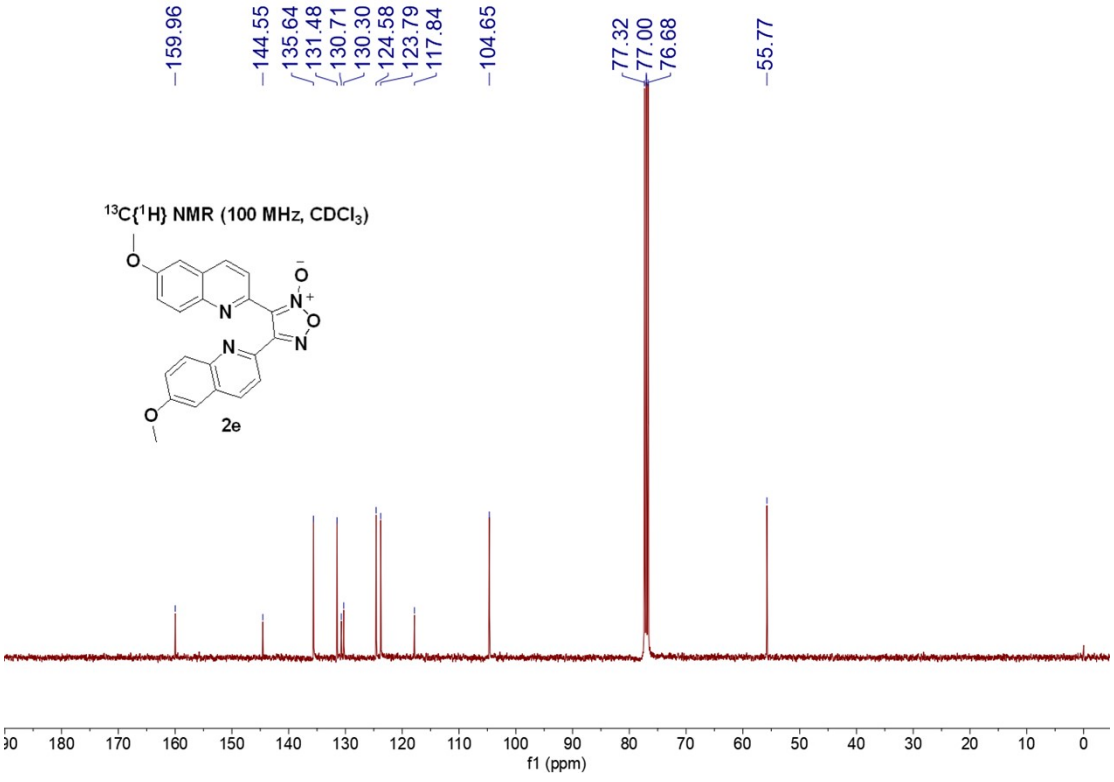

155.36
148.28
148.16
146.38
143.56
143.19
131.11
130.14
129.95
129.05
126.51
126.23
124.13
121.27
120.87
114.04
77.32
77.00
76.68
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
DEPT-135 Spectra of 2c in $CDCl_3$
^{13}C NMR spectrum of 2c in $CDCl_3$
2c
f1 (ppm)

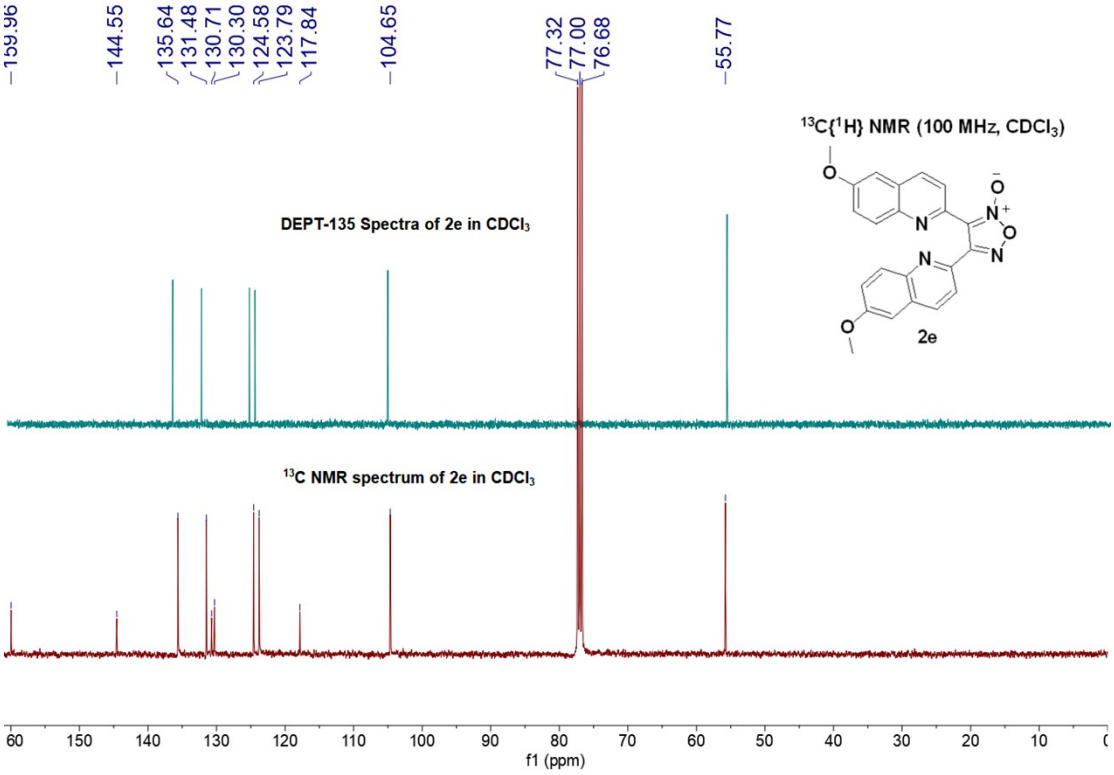

8.219
8.198
8.175
8.026
8.005
7.948
7.927
7.677
7.656
7.631
7.610
7.493
7.488
7.483
7.478
7.471
7.466
7.461
7.457
7.260
2.544
2.539
^{1}H NMR (400 MHz, $CDCl_3$)
2d
2.07
1.01
0.96
4.13
2.06
6.00
f1 (ppm)

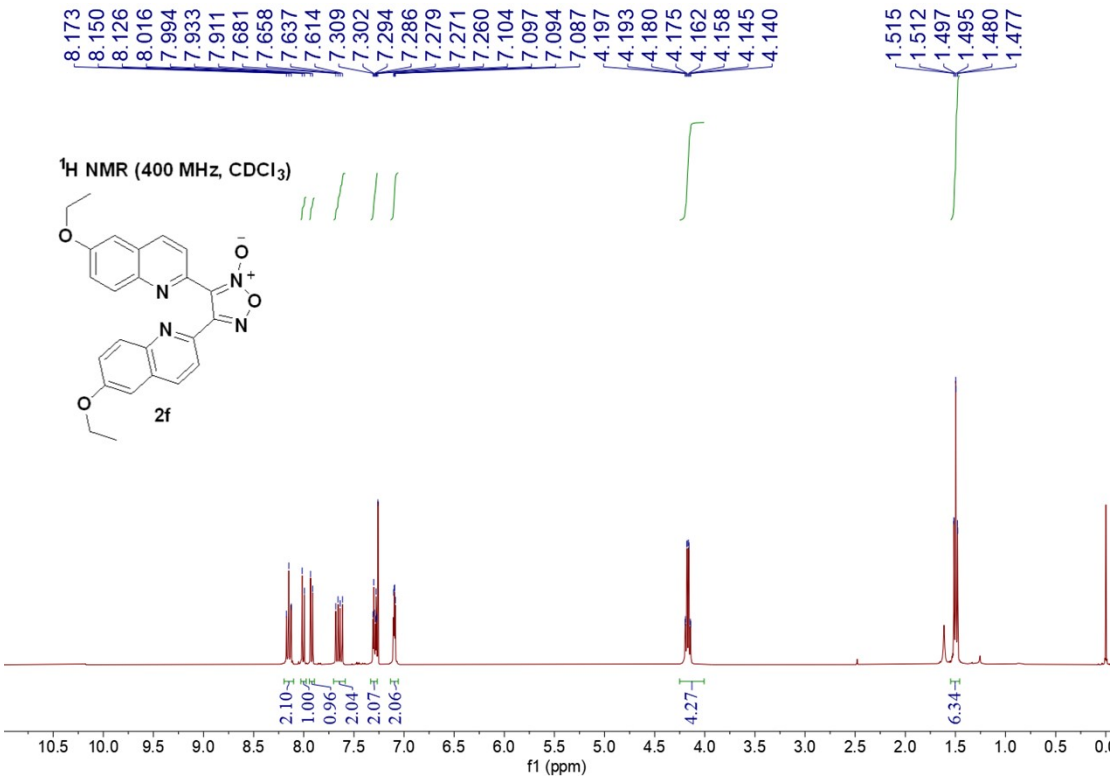

156.52
146.35
146.14
145.87
143.01
138.12
138.08
135.82
135.79
132.41
132.37
129.45
129.25
128.27
127.95
126.43
126.39
121.14
120.73
114.96
77.32
77.00
76.68
21.70
13C{1H} NMR (100 MHz, CDCl3)
2d
f1 (ppm)

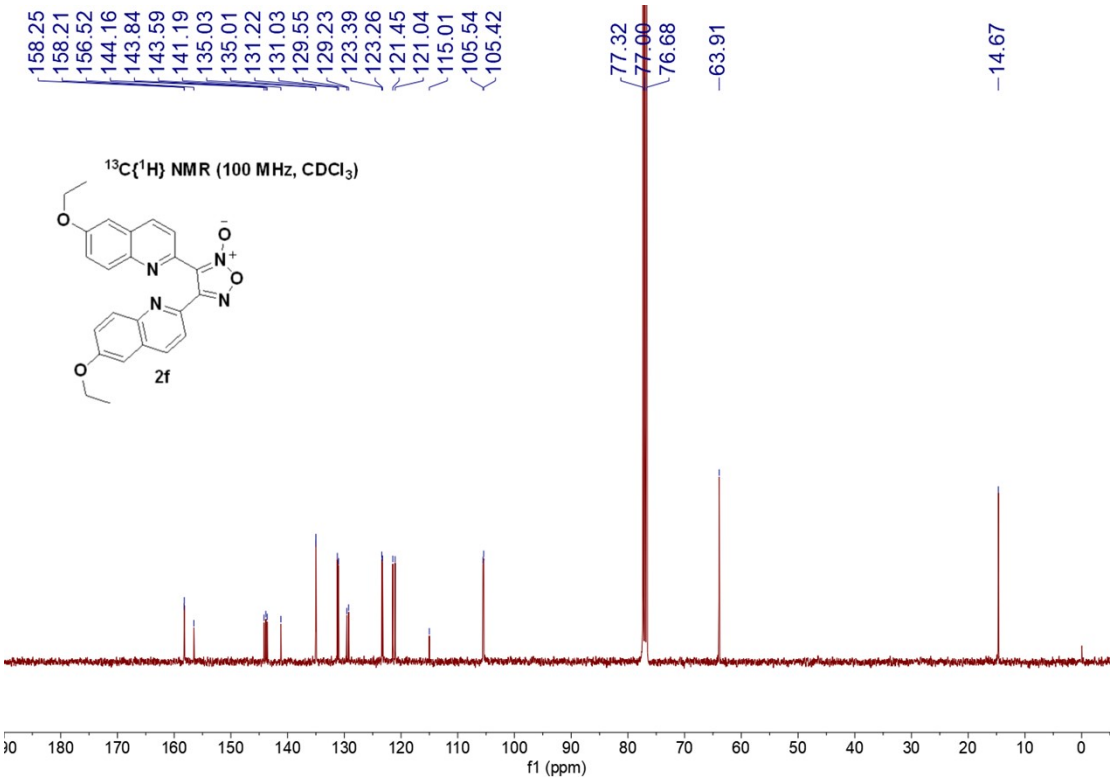

156.52
146.35
146.14
145.87
143.01
138.12
138.08
135.82
135.79
132.41
132.37
129.45
129.25
128.27
127.95
126.43
126.39
121.14
120.73
114.96
77.32
77.00
76.68
21.70
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2d in CDCl3
2d
13C NMR spectrum of 2d in CDCl3
f1 (ppm)

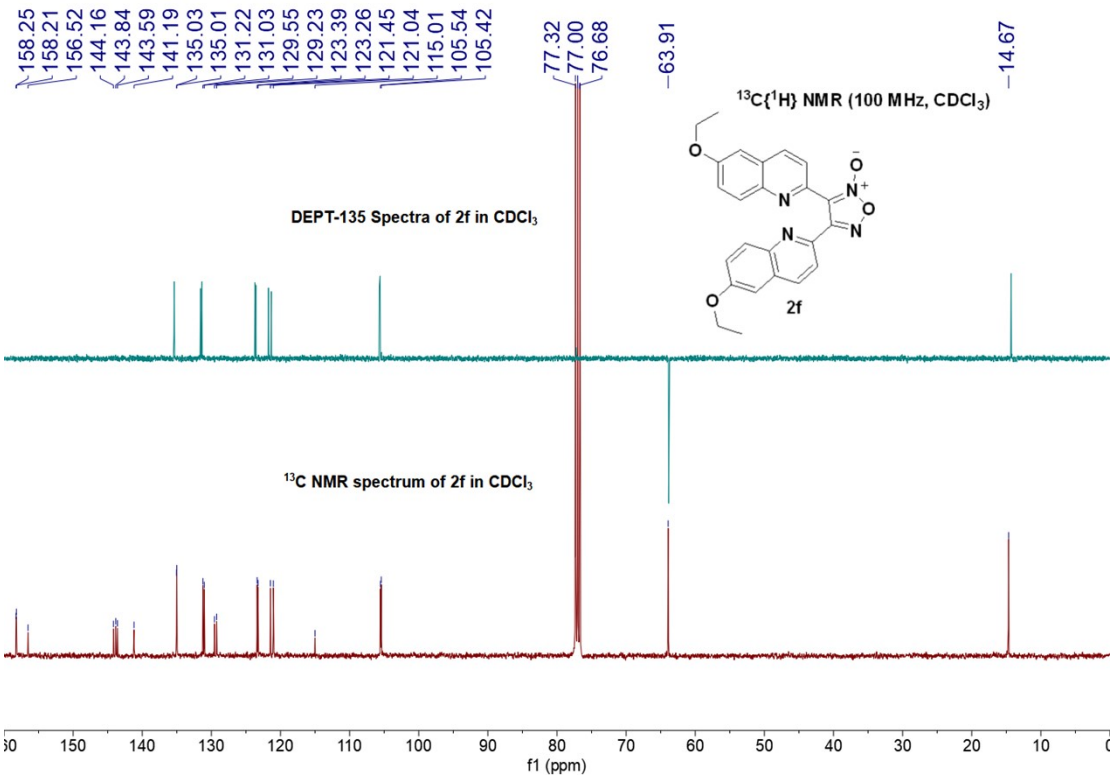

8.162
8.143
8.055
8.031
7.652
7.631
7.486
7.479
7.462
7.456
7.260
7.100
7.093
3.969
¹H NMR (400 MHz, CDCl₃)
2e
2.07
1.94
1.93
1.94
2.00
6.32
f1 (ppm)

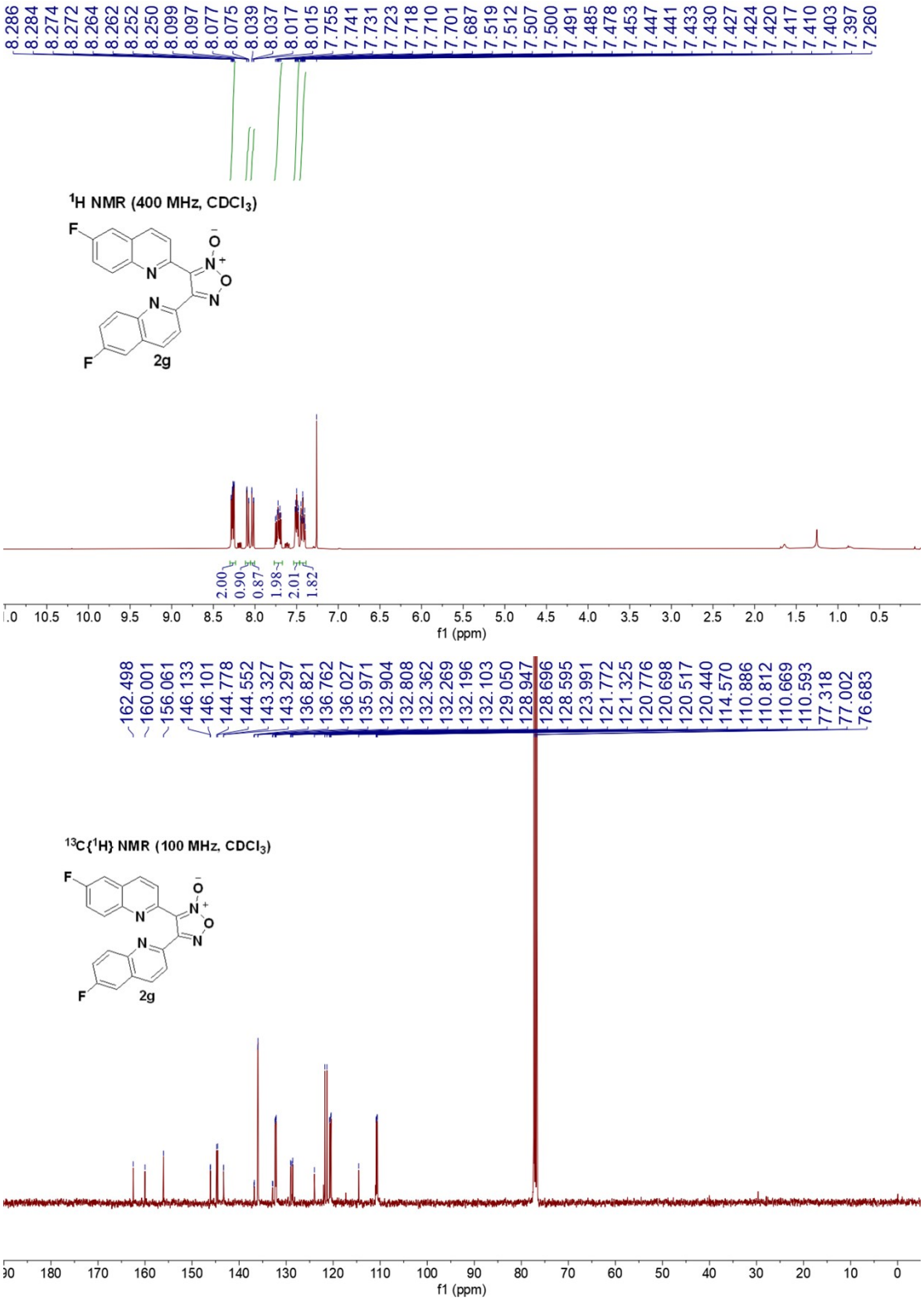

159.96
144.55
135.64
131.48
130.71
130.30
124.58
123.79
117.84
104.65
77.32
77.00
76.68
55.77
¹³C{¹H} NMR (100 MHz, CDCl₃)
2e
f1 (ppm)

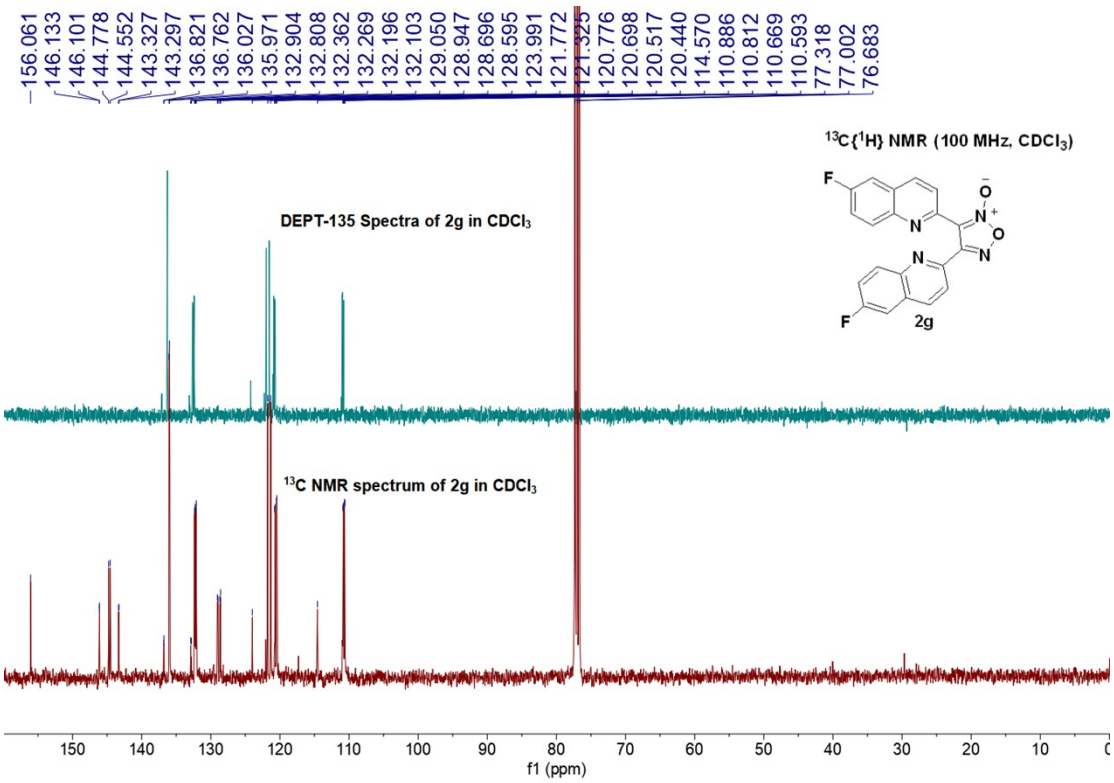

159.96
144.55
135.64
131.48
130.71
130.30
124.58
123.79
117.84
104.65
77.32
77.00
76.68
55.77
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2e in CDCl3
13C NMR spectrum of 2e in CDCl3
2e
f1 (ppm)

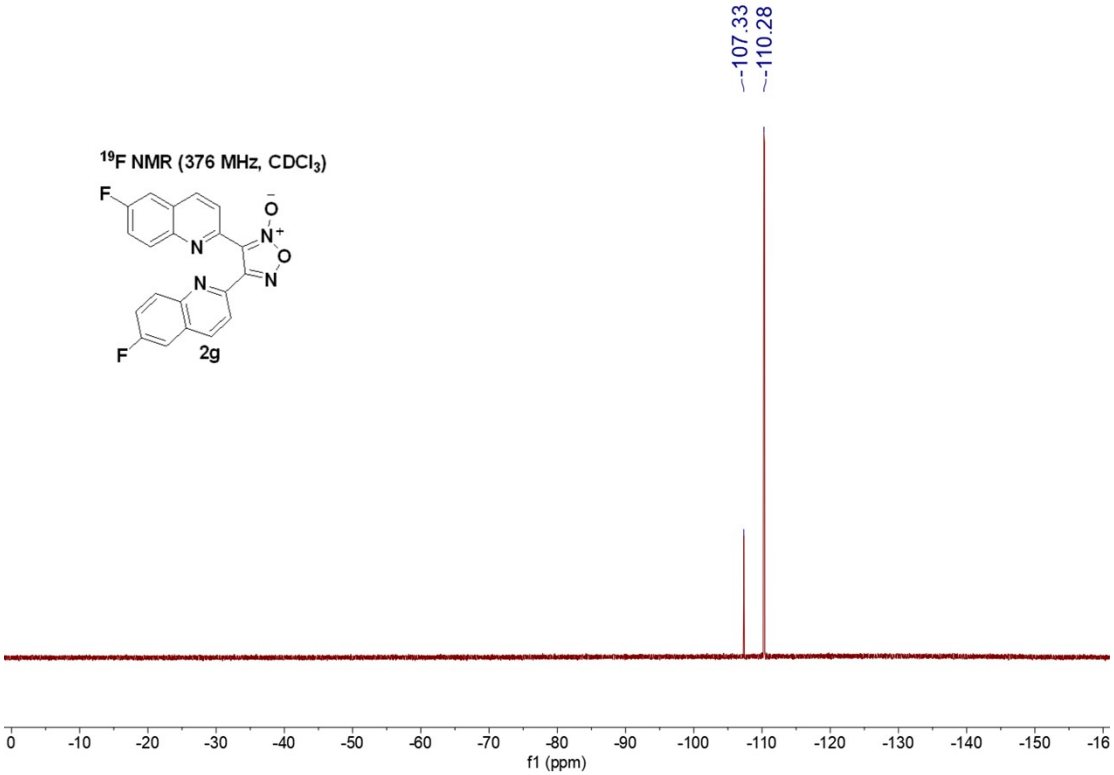

8.173
8.150
8.126
8.016
7.994
7.933
7.911
7.681
7.658
7.637
7.614
7.309
7.302
7.294
7.286
7.279
7.271
7.260
7.104
7.097
7.094
7.087
4.197
4.193
4.180
4.175
4.162
4.158
4.145
4.140
1.515
1.512
1.497
1.495
1.480
1.477
1H NMR (400 MHz, CDCl3)
2f
2.10
1.00
0.96
2.04
2.07
2.06
4.27
6.34
f1 (ppm)

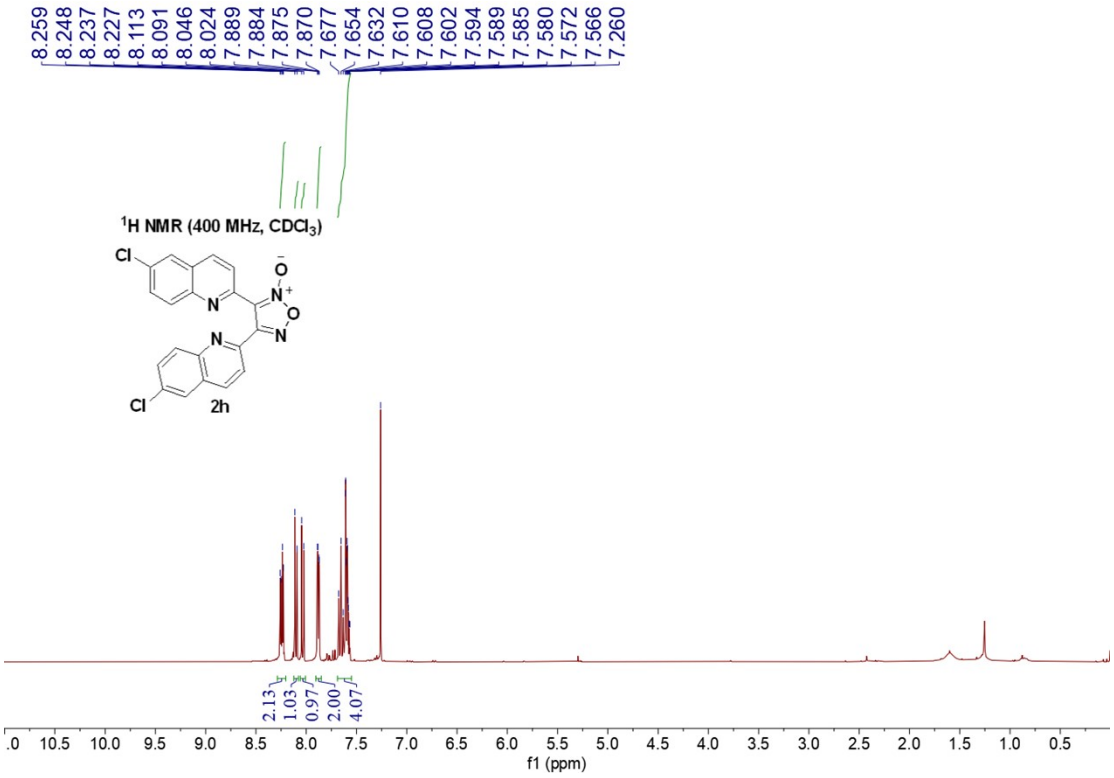

158.25
158.21
156.52
144.16
143.84
143.59
141.19
135.03
135.01
131.22
131.03
129.55
129.23
123.39
123.26
121.45
121.04
115.01
105.54
105.42
77.32
77.00
76.68
63.91
14.67
13C{1H} NMR (100 MHz, CDCl3)
2f
f1 (ppm)

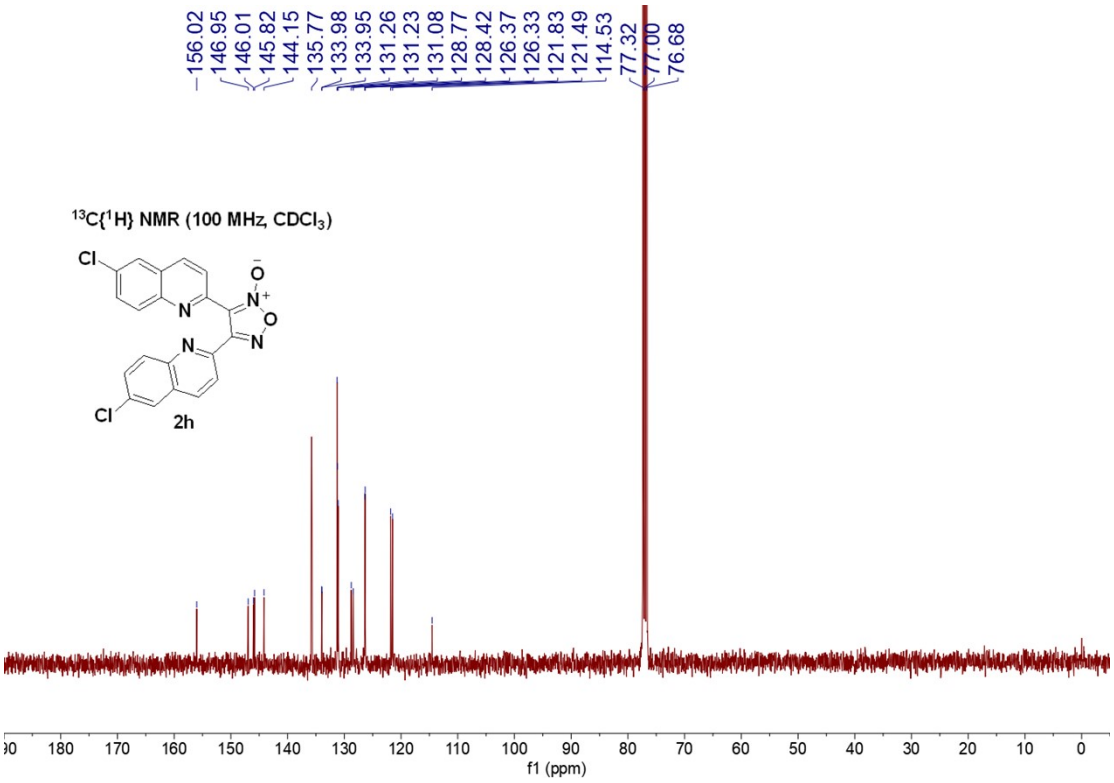

158.25
158.21
156.52
144.16
143.84
143.59
141.19
135.03
135.01
131.22
131.03
129.55
129.23
123.39
123.26
121.45
121.04
115.01
105.54
105.42
77.32
77.00
76.68
63.91
14.67
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2f in CDCl3
2f
13C NMR spectrum of 2f in CDCl3
f1 (ppm)

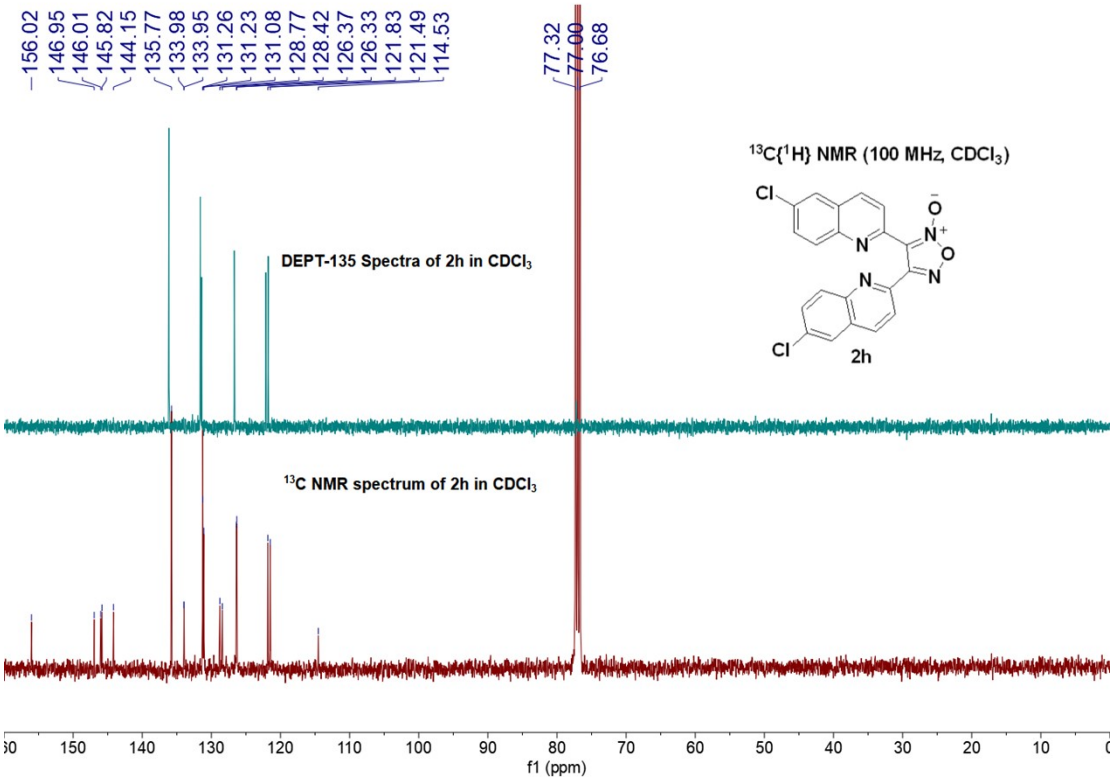

8.286
8.284
8.274
8.272
8.264
8.262
8.252
8.250
8.099
8.097
8.077
8.075
8.039
8.037
8.017
8.015
7.755
7.741
7.731
7.723
7.718
7.710
7.701
7.687
7.519
7.512
7.507
7.500
7.491
7.485
7.478
7.453
7.447
7.441
7.433
7.430
7.427
7.424
7.420
7.417
7.410
7.403
7.397
7.260
1H NMR (400 MHz, CDCl3)
F
N
O
N+
O
N
N
F
2g
2.00
0.90
0.87
1.98
2.01
1.82
f1 (ppm)
162.498
160.001
156.061
146.133
146.101
144.778
144.552
143.327
143.297
136.821
136.762
136.027
135.971
132.904
132.808
132.362
132.269
132.196
132.103
129.050
128.947
128.696
128.595
123.991
121.772
121.325
120.776
120.698
120.517
120.440
114.570
110.886
110.812
110.669
110.593
77.318
77.002
76.683
13C{1H} NMR (100 MHz, CDCl3)
f1 (ppm)

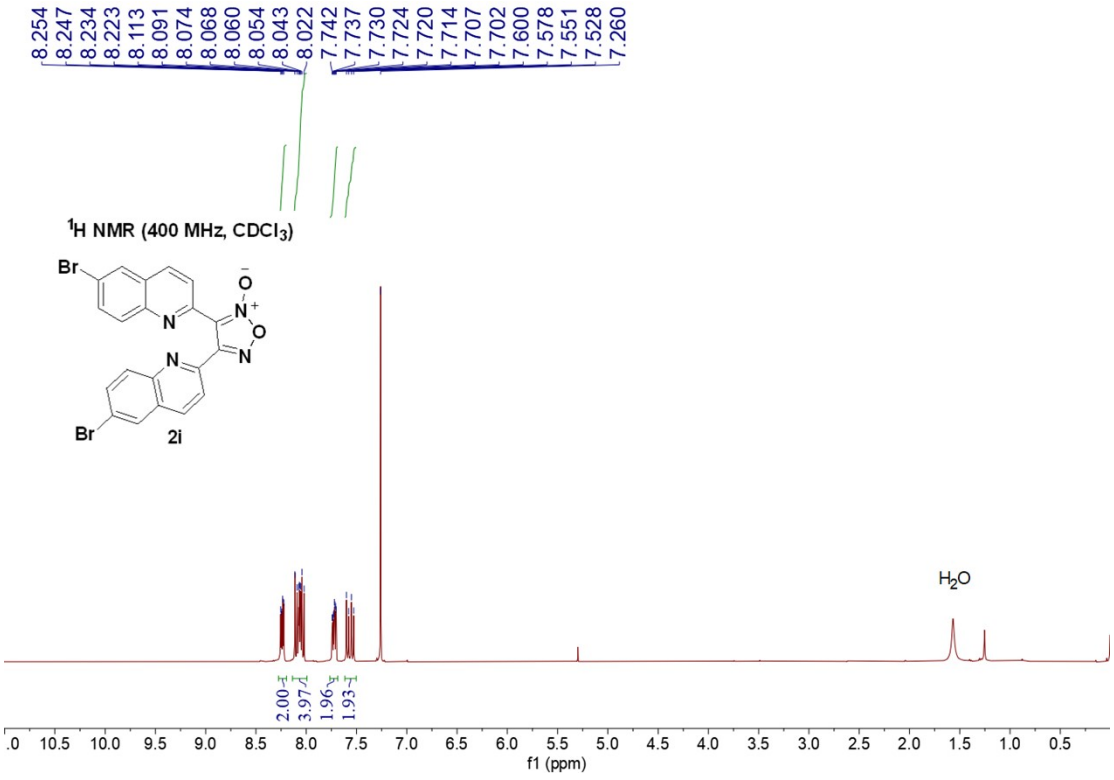

156.061
146.133
146.101
144.778
144.552
143.327
143.297
136.821
136.762
136.027
135.971
132.904
132.808
132.362
132.269
132.196
132.103
129.050
128.947
128.696
128.595
123.991
121.772
121.325
120.776
120.698
120.517
120.440
114.570
110.886
110.812
110.669
110.593
77.318
77.002
76.683
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2g in CDCl3
13C NMR spectrum of 2g in CDCl3
2g
f1 (ppm)

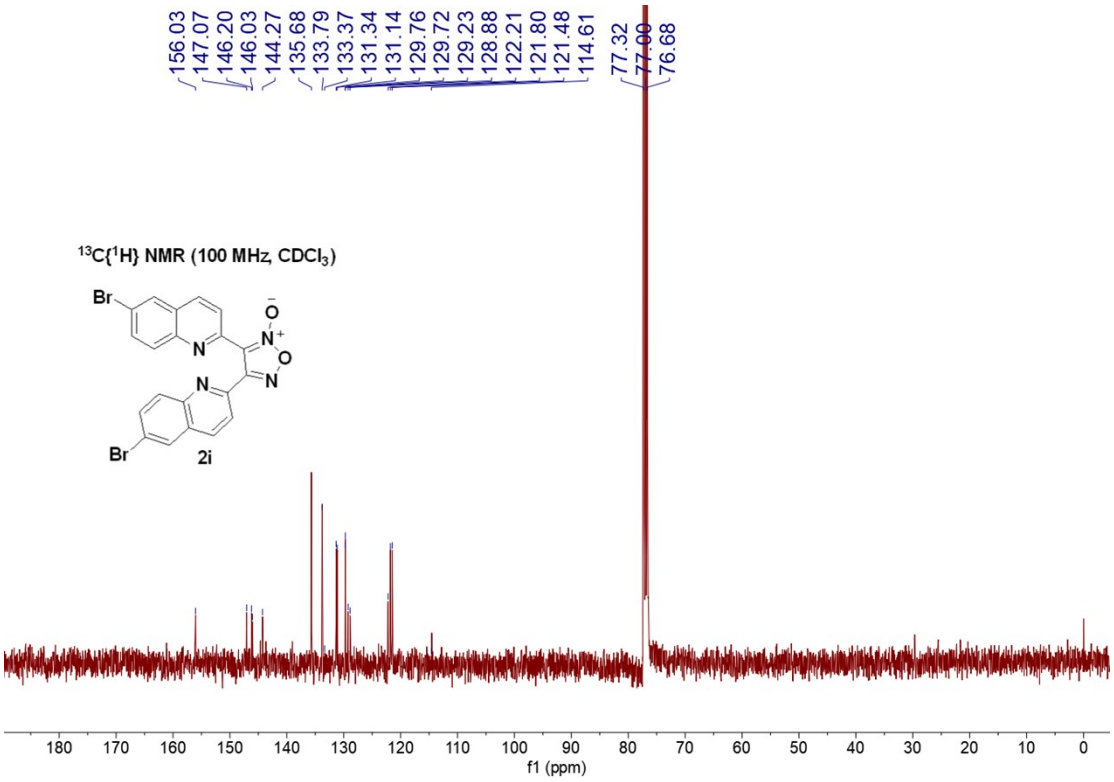

107.33
110.28
19F NMR (376 MHz, CDCl3)
2g
f1 (ppm)

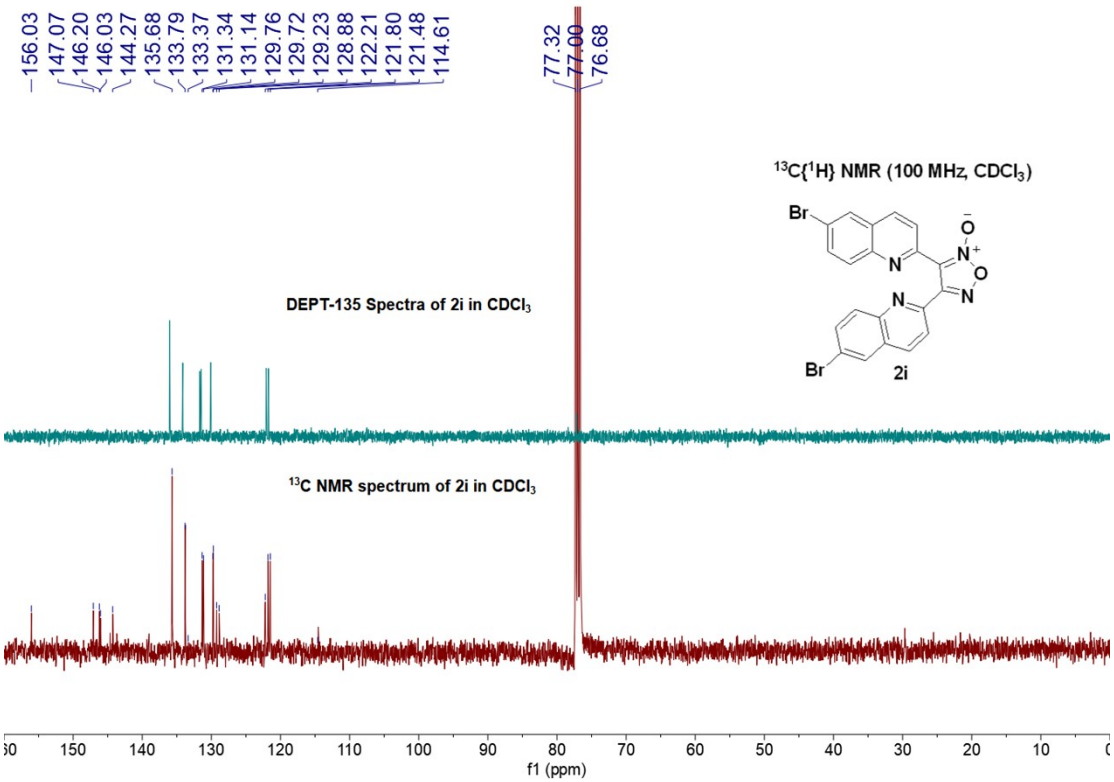

8.259
8.248
8.237
8.227
8.113
8.091
8.046
8.024
7.889
7.884
7.875
7.870
7.677
7.654
7.632
7.610
7.608
7.602
7.594
7.589
7.585
7.580
7.572
7.566
7.260
1H NMR (400 MHz, CDCl3)
Cl
N
O
N+
O
N
N
Cl
2h
2.13
1.03
0.97
2.00
4.07
f1 (ppm)

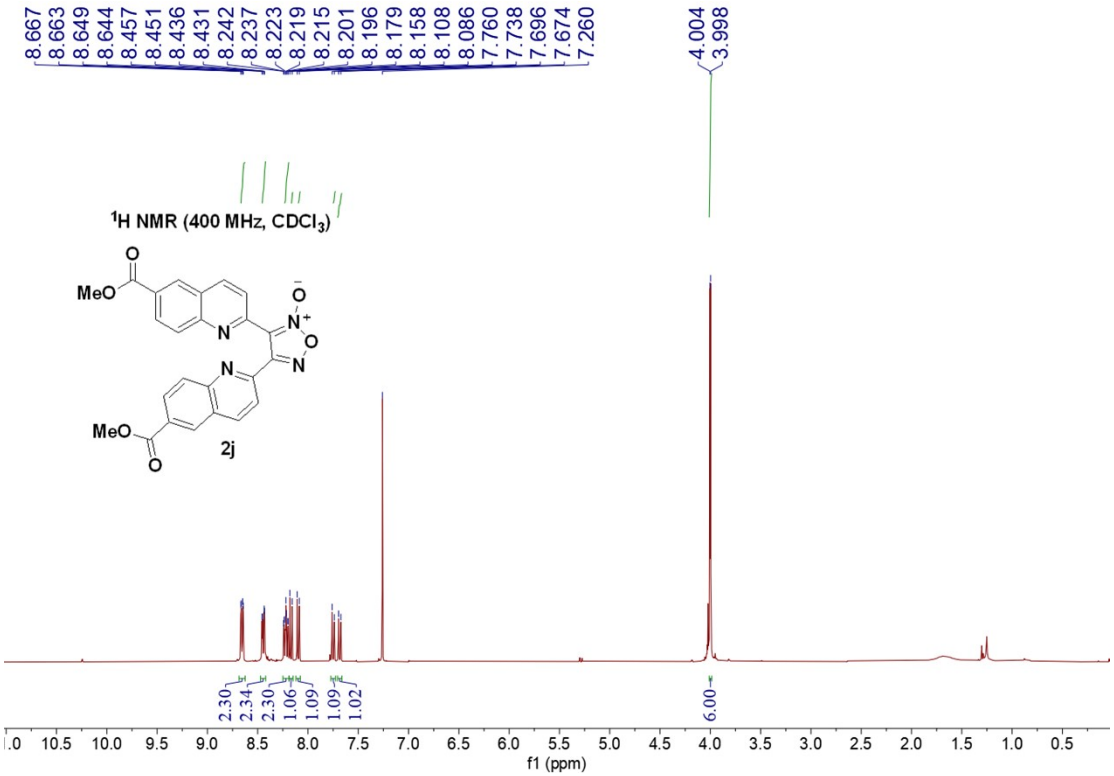

156.02
146.95
146.01
145.82
144.15
135.77
133.98
133.95
131.26
131.23
131.08
128.77
128.42
126.37
126.33
121.83
121.49
114.53
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Cl
N
O
N+
O
N
N
Cl
2h
f1 (ppm)

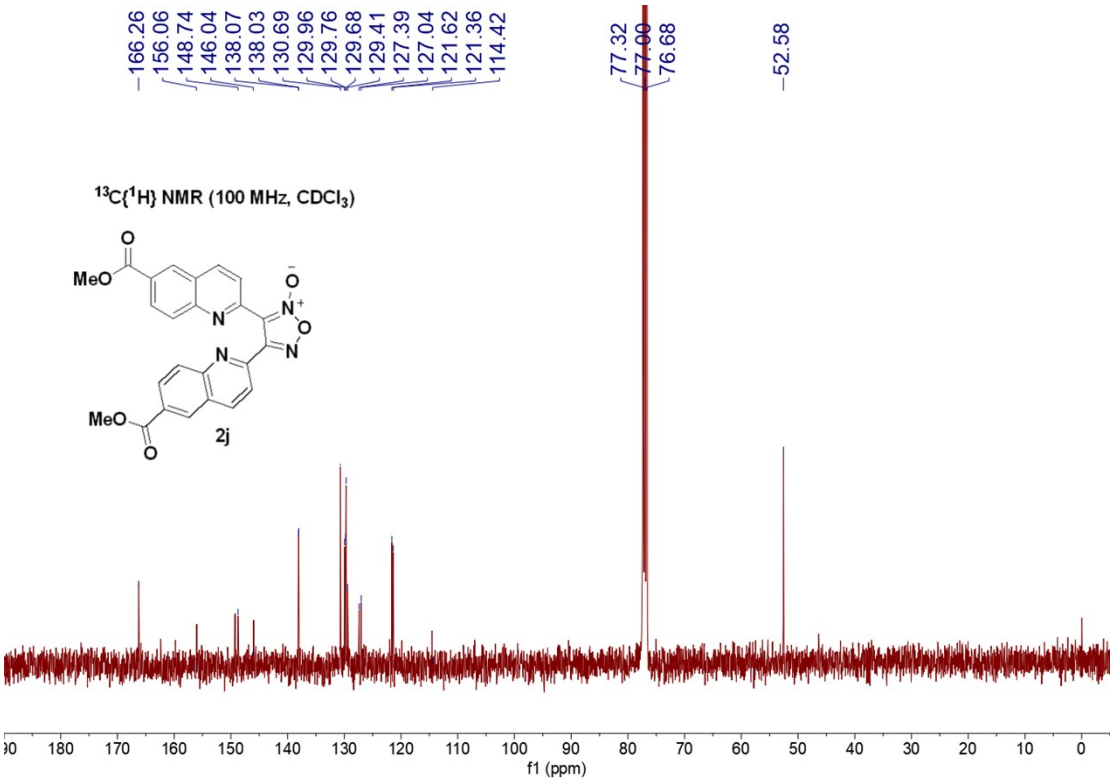

156.02
146.95
146.01
145.82
144.15
135.77
133.98
133.95
131.26
131.23
131.08
128.77
128.42
126.37
126.33
121.83
121.49
114.53
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2h in CDCl3
13C NMR spectrum of 2h in CDCl3
Cl
Cl
2h
f1 (ppm)

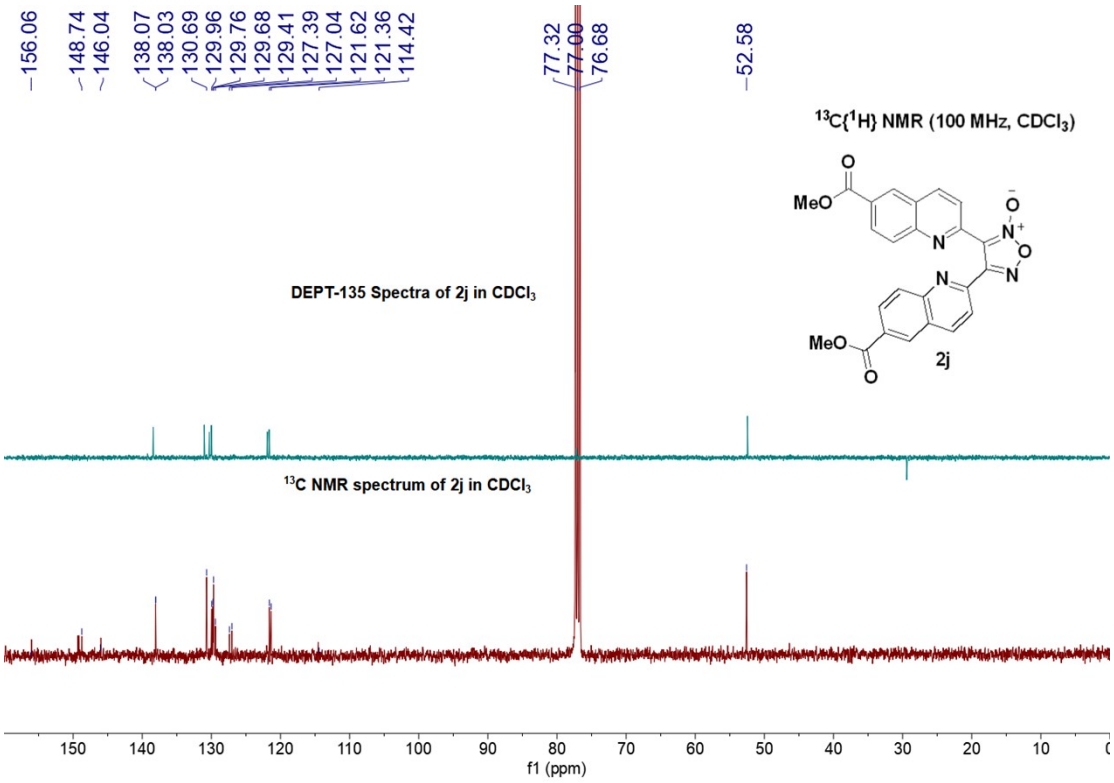

8.254
8.247
8.234
8.223
8.113
8.091
8.074
8.068
8.060
8.054
8.043
8.022
7.742
7.737
7.730
7.724
7.720
7.714
7.707
7.702
7.600
7.578
7.551
7.528
7.260
1H NMR (400 MHz, CDCl3)
Br
Br
2i
H2O
2.00
3.97
1.96
1.93
f1 (ppm)

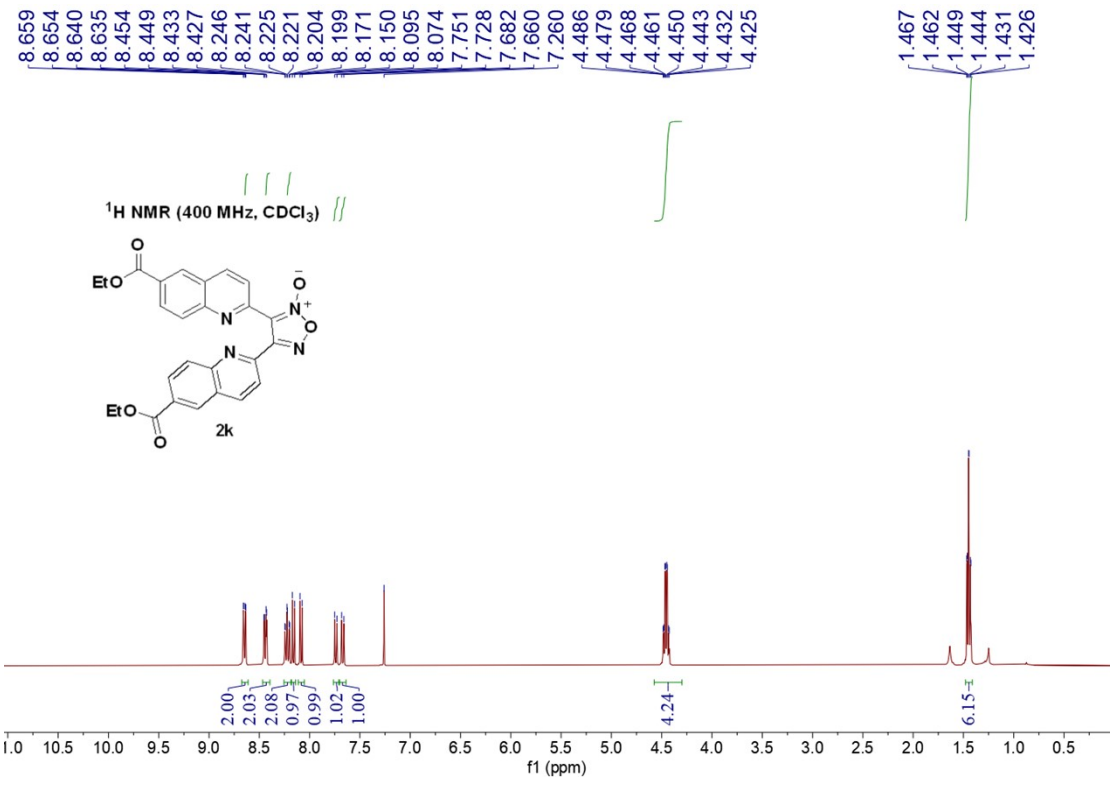

156.03
147.07
146.20
146.03
144.27
135.68
133.79
133.37
131.34
131.14
129.76
129.72
129.23
128.88
122.21
121.80
121.48
114.61
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Br
N
O
N+
O
N
N
Br
2i
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

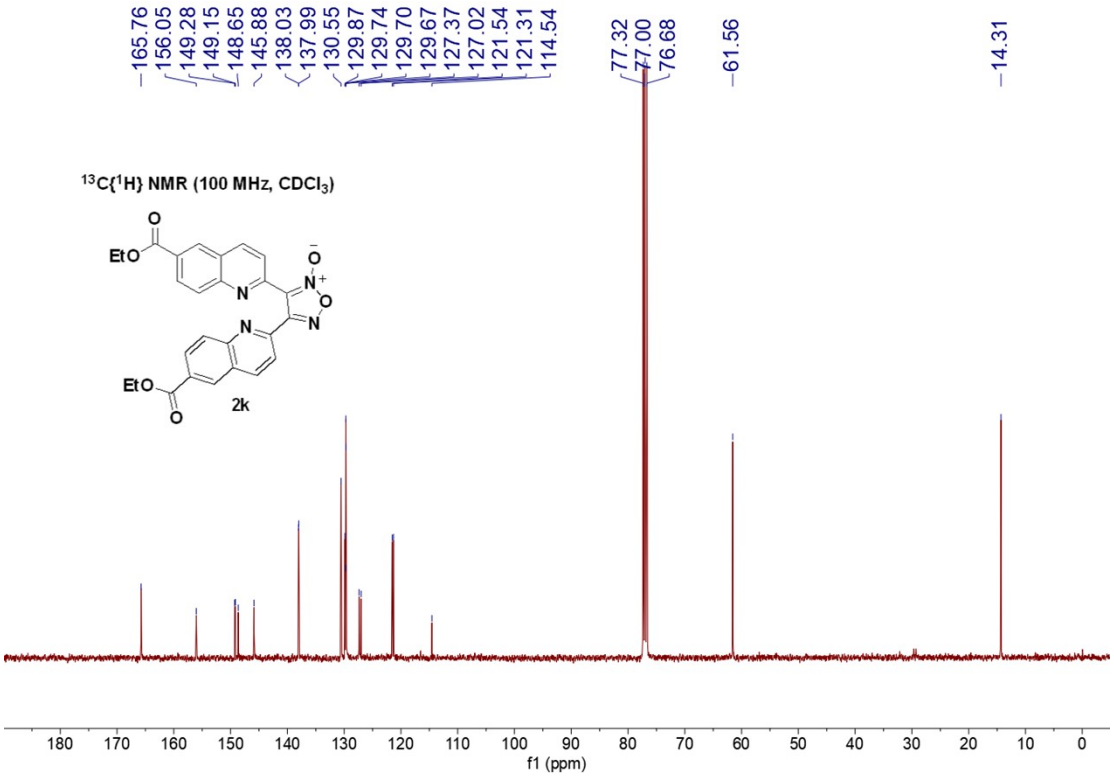

156.03
147.07
146.20
146.03
144.27
135.68
133.79
133.37
131.34
131.14
129.76
129.72
129.23
128.88
122.21
121.80
121.48
114.61
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2i in CDCl3
13C NMR spectrum of 2i in CDCl3
Br
N
O
N+
O
N
N
Br
2i
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

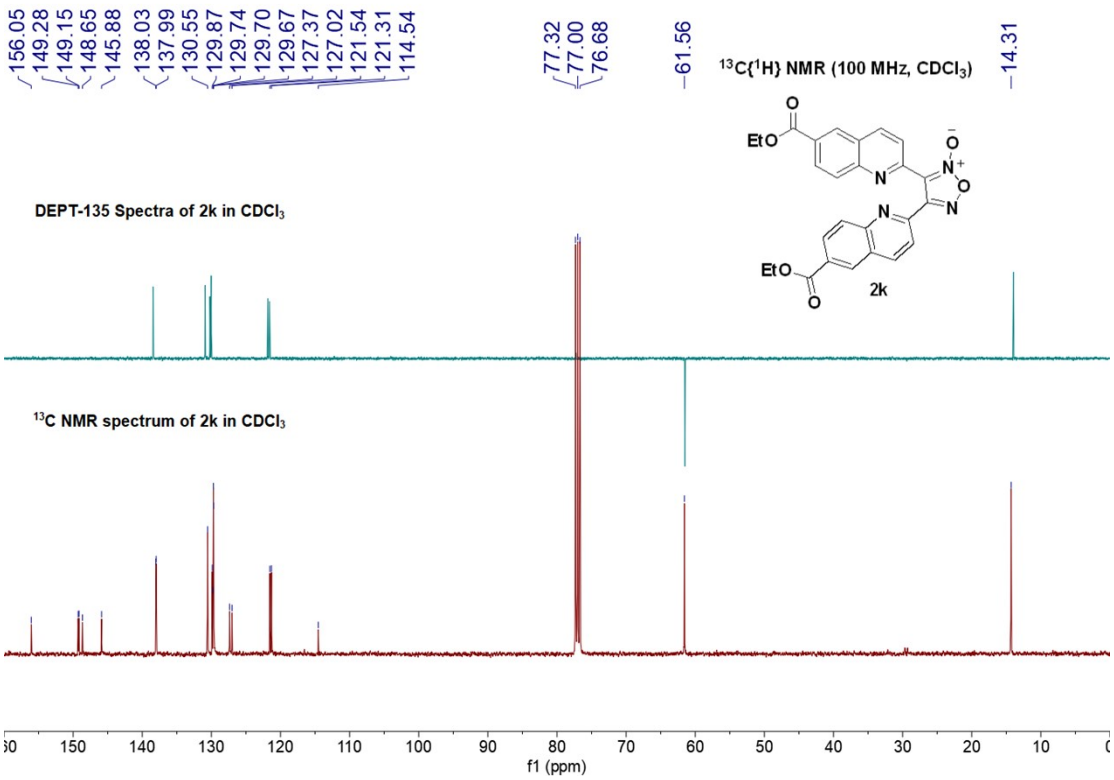

8.667
8.663
8.649
8.644
8.457
8.451
8.436
8.431
8.242
8.237
8.223
8.219
8.215
8.201
8.196
8.179
8.158
8.108
8.086
7.760
7.738
7.696
7.674
7.260
4.004
3.998
1H NMR (400 MHz, CDCl3)
MeO
MeO
2j
2.30
2.34
2.30
1.06
1.09
1.09
1.02
6.00
f1 (ppm)

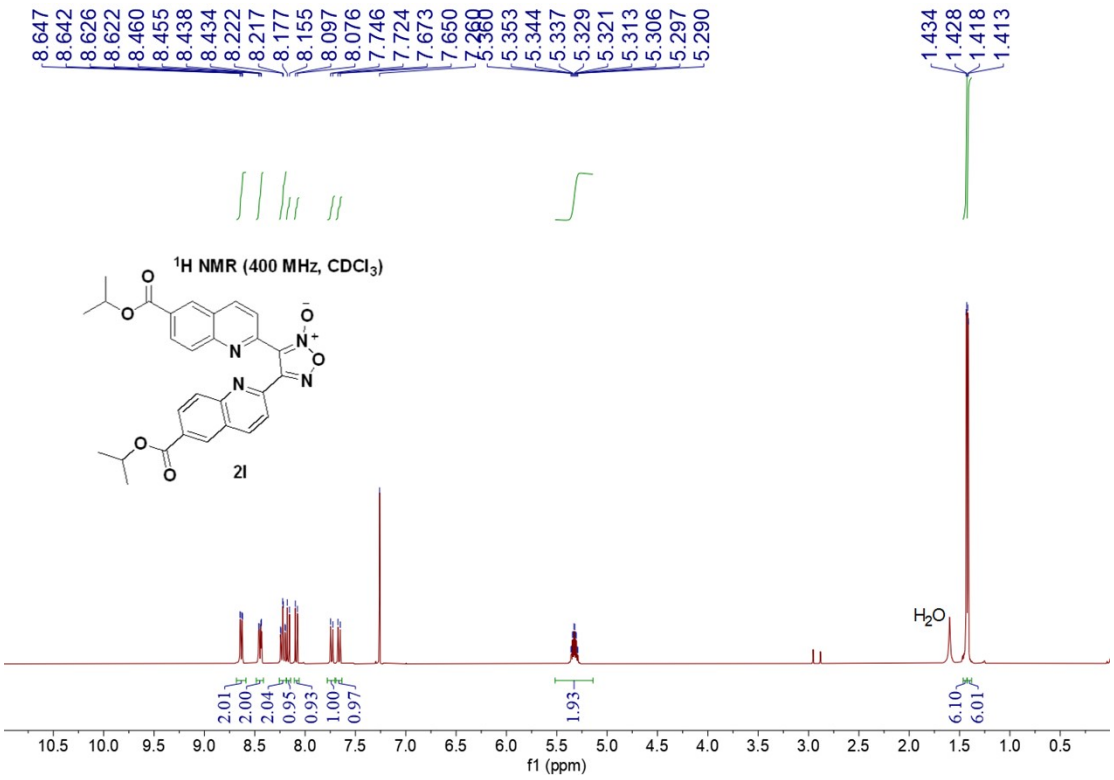

166.26
156.06
148.74
146.04
138.07
138.03
130.69
129.96
129.76
129.68
129.41
127.39
127.04
121.62
121.36
114.42
77.32
77.00
76.68
52.58
13C{1H} NMR (100 MHz, CDCl3)
MeO
MeO
2j
f1 (ppm)

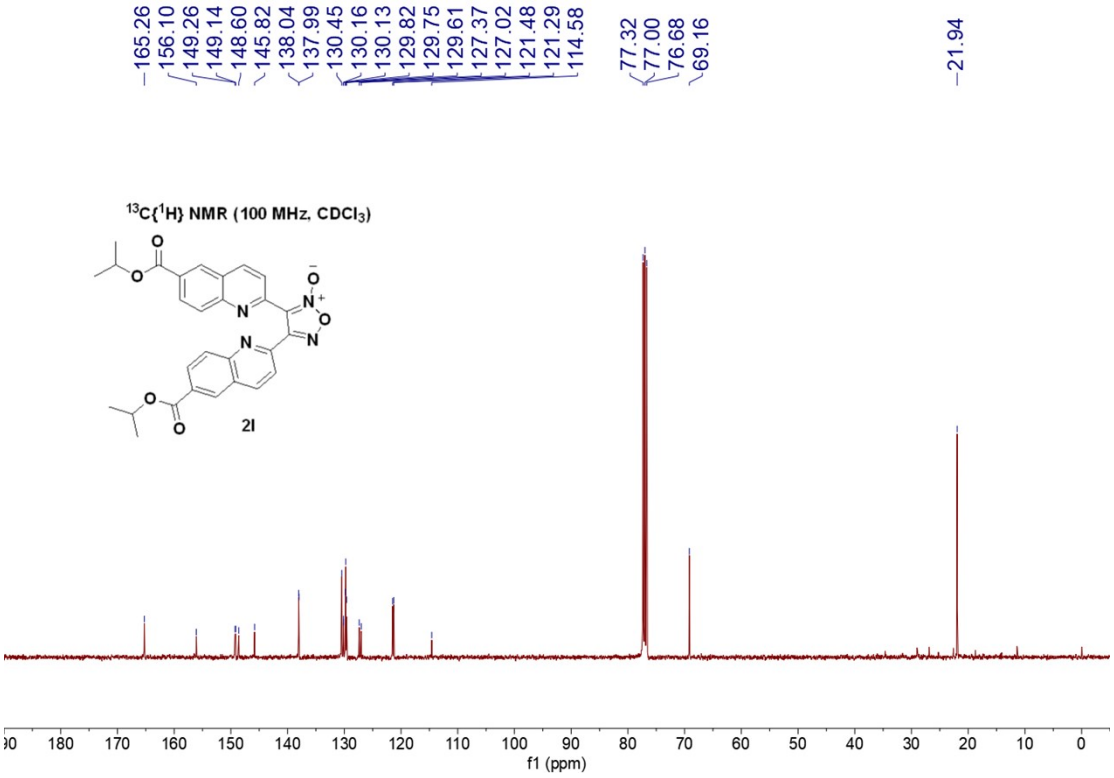

156.06
148.74
146.04
138.07
138.03
130.69
129.96
129.76
129.68
129.41
127.39
127.04
121.62
121.36
114.42
77.32
77.00
76.68
52.58
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2j in CDCl3
13C NMR spectrum of 2j in CDCl3
MeO
MeO
2j
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

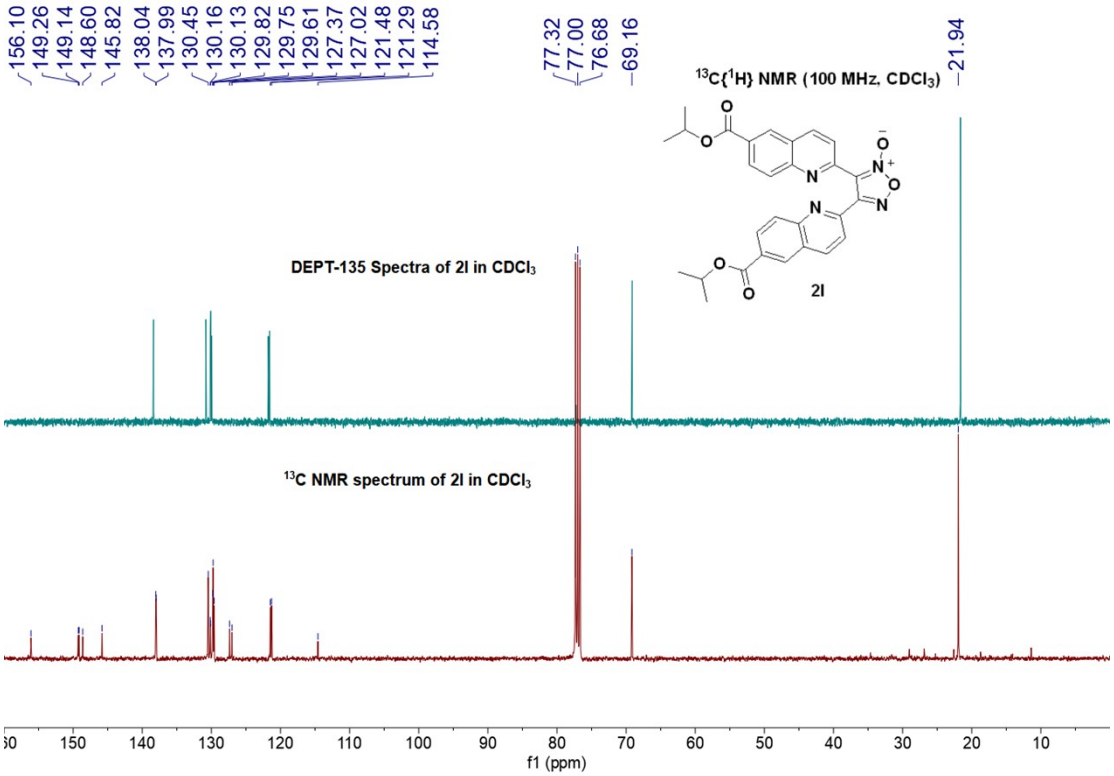

8.659
8.654
8.640
8.635
8.454
8.449
8.433
8.427
8.246
8.241
8.225
8.221
8.204
8.199
8.171
8.150
8.095
8.074
7.751
7.728
7.682
7.660
7.260
4.486
4.479
4.468
4.461
4.450
4.443
4.432
4.425
1.467
1.462
1.449
1.444
1.431
1.426
1H NMR (400 MHz, CDCl3)
EtO
EtO
2k
2.00
2.03
2.08
0.97
0.99
1.02
1.00
4.24
6.15
f1 (ppm)

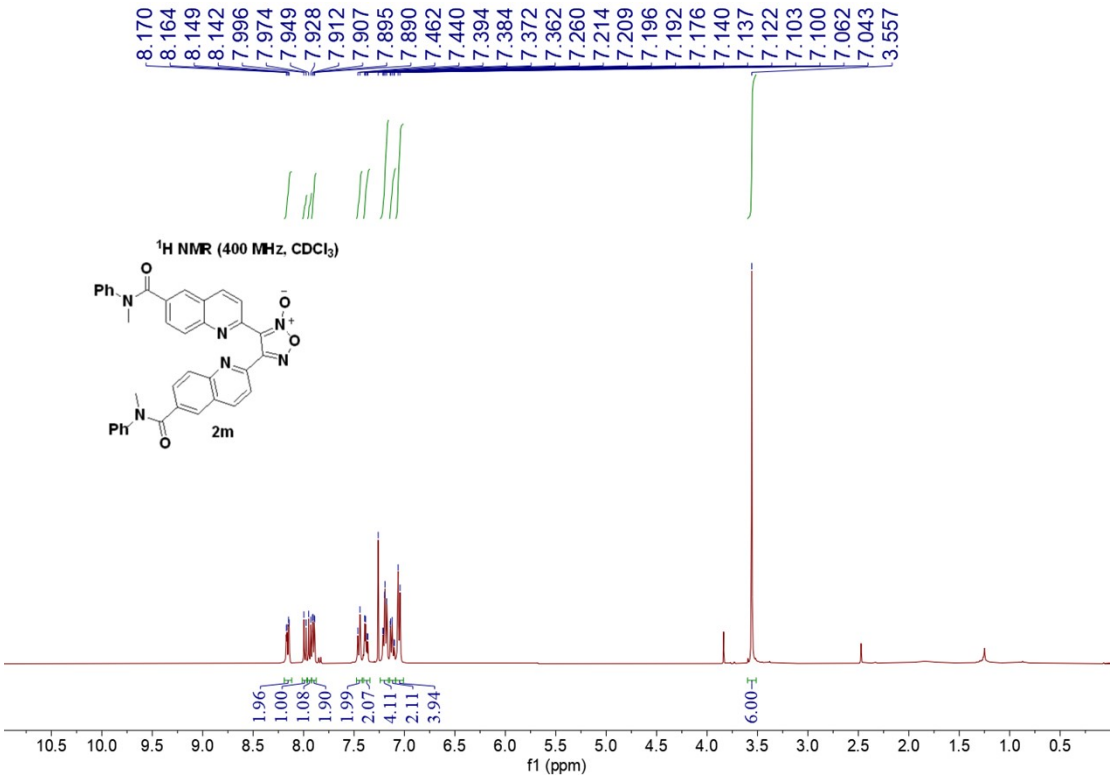

165.76
156.05
149.28
149.15
148.65
145.88
138.03
137.99
130.55
129.87
129.74
129.70
129.67
127.37
127.02
121.54
121.31
114.54
77.32
77.00
76.68
61.56
14.31
13C{1H} NMR (100 MHz, CDCl3)
EtO
O
N
N+
O
N
EtO
O
2k
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

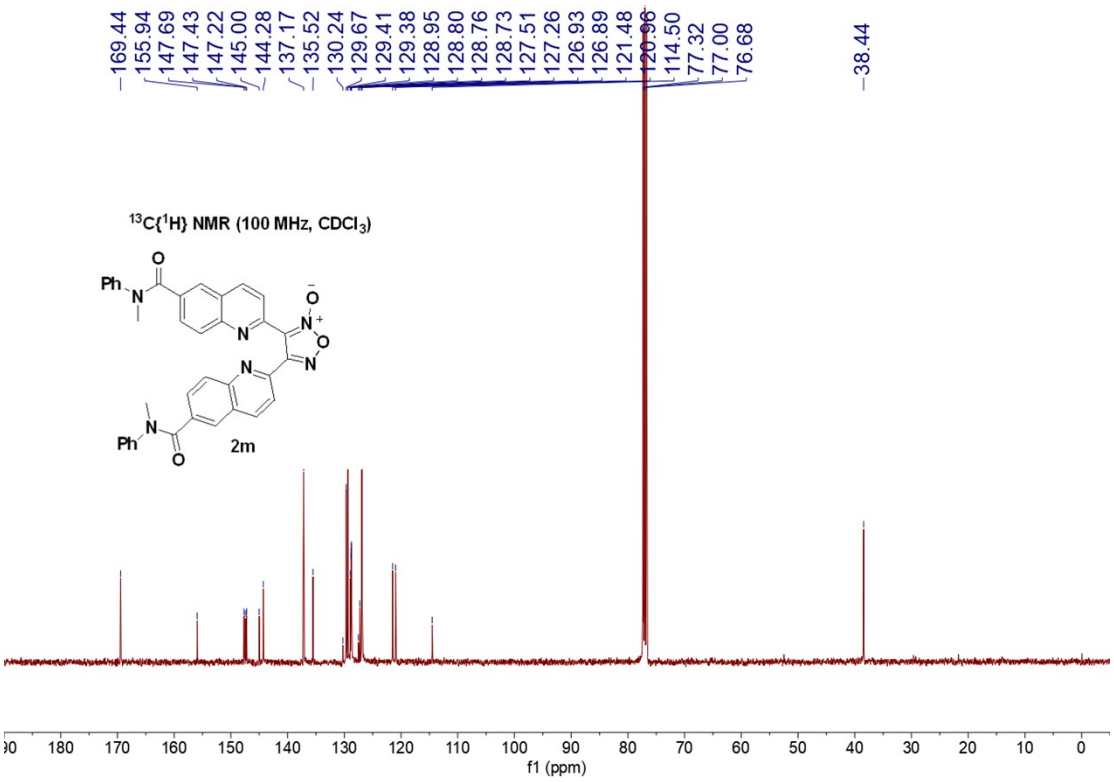

156.05
149.28
149.15
148.65
145.88
138.03
137.99
130.55
129.87
129.74
129.70
129.67
127.37
127.02
121.54
121.31
114.54
77.32
77.00
76.68
61.56
14.31
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2k in CDCl3
13C NMR spectrum of 2k in CDCl3
EtO
O
N
N+
O
N
EtO
O
2k
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

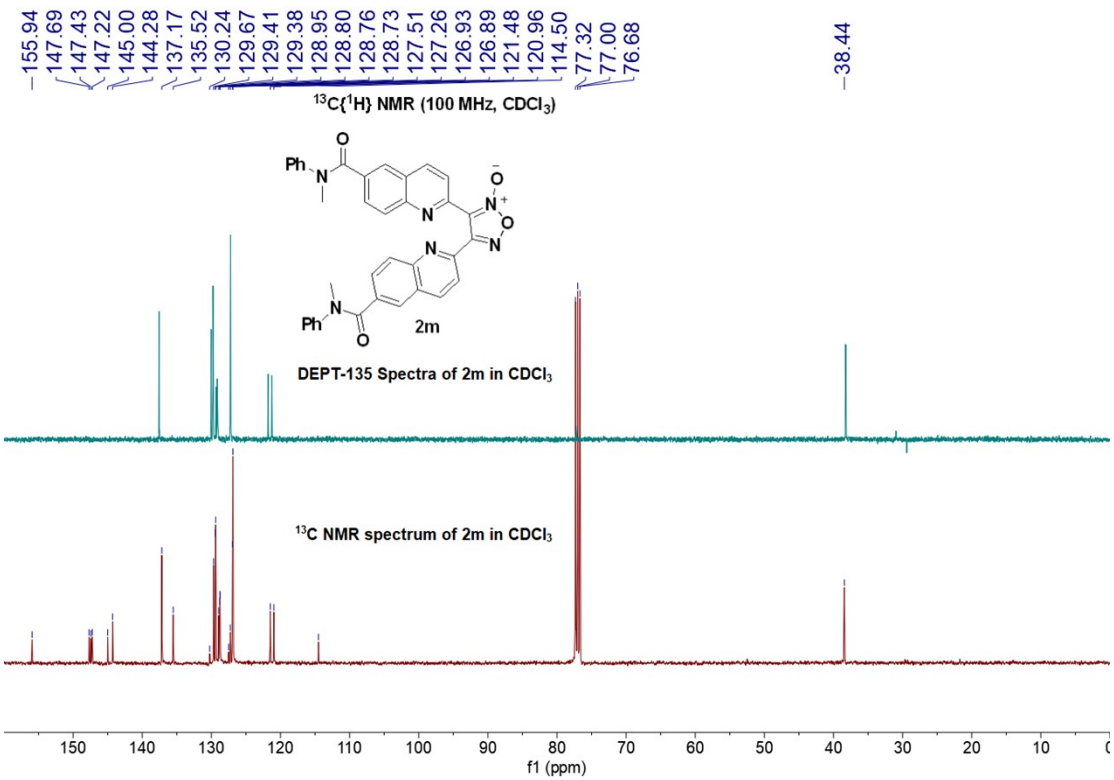

8.647
8.642
8.626
8.622
8.460
8.455
8.438
8.434
8.222
8.217
8.177
8.155
8.097
8.076
7.746
7.724
7.673
7.650
5.360
5.353
5.344
5.337
5.329
5.321
5.313
5.306
5.297
5.290
1.434
1.428
1.418
1.413
^{1}H NMR (400 MHz, CDCl$_3$)
2l
H$_2$O
2.01
2.00
2.04
0.95
0.93
1.00
0.97
1.93
6.10
6.01
f1 (ppm)

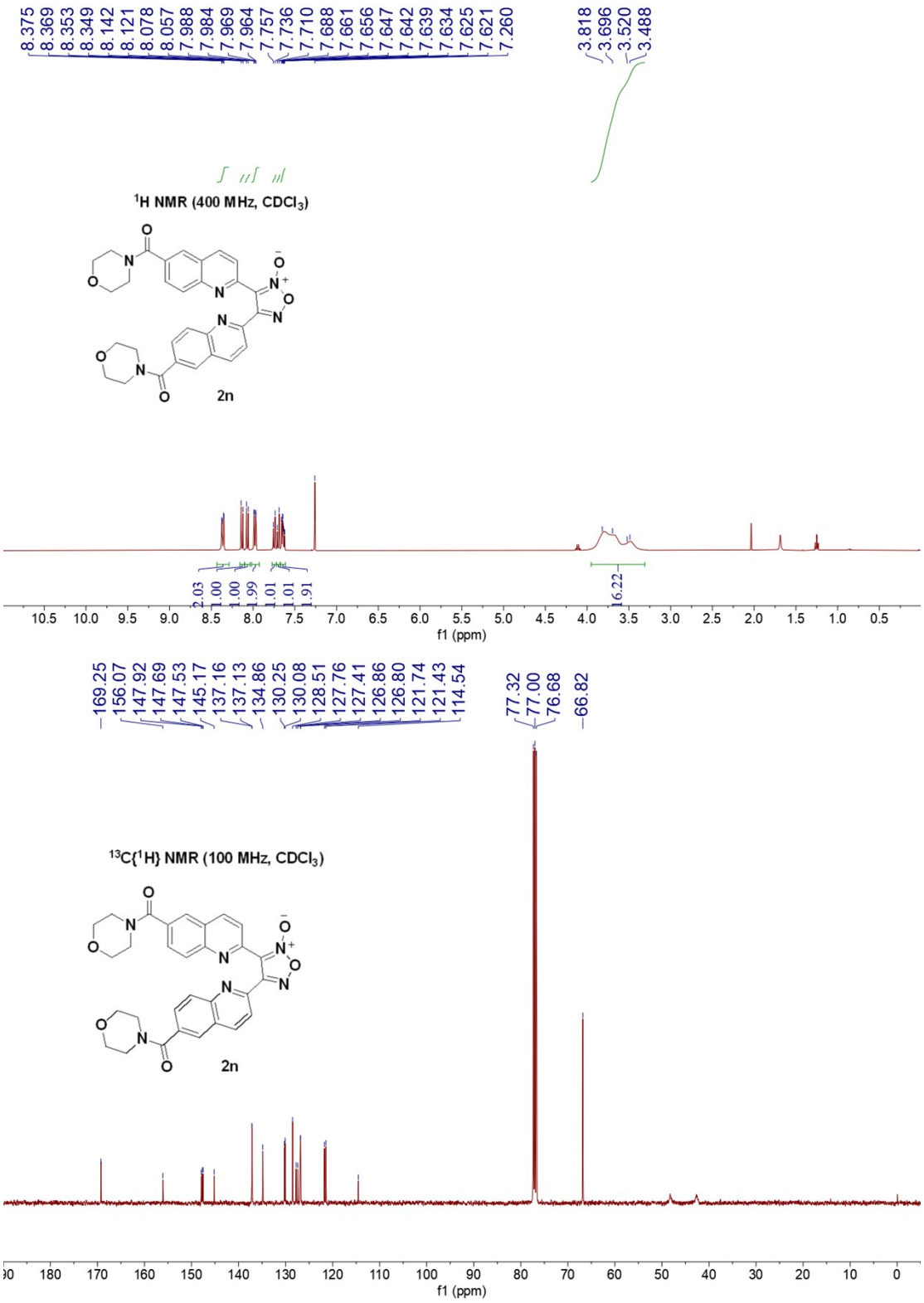

165.26
156.10
149.26
149.14
148.60
145.82
138.04
137.99
130.45
130.16
130.13
129.82
129.75
129.61
127.37
127.02
121.48
121.29
114.58
77.32
77.00
76.68
69.16
21.94
^{13}C{^{1}H} NMR (100 MHz, CDCl$_3$)
2l
f1 (ppm)

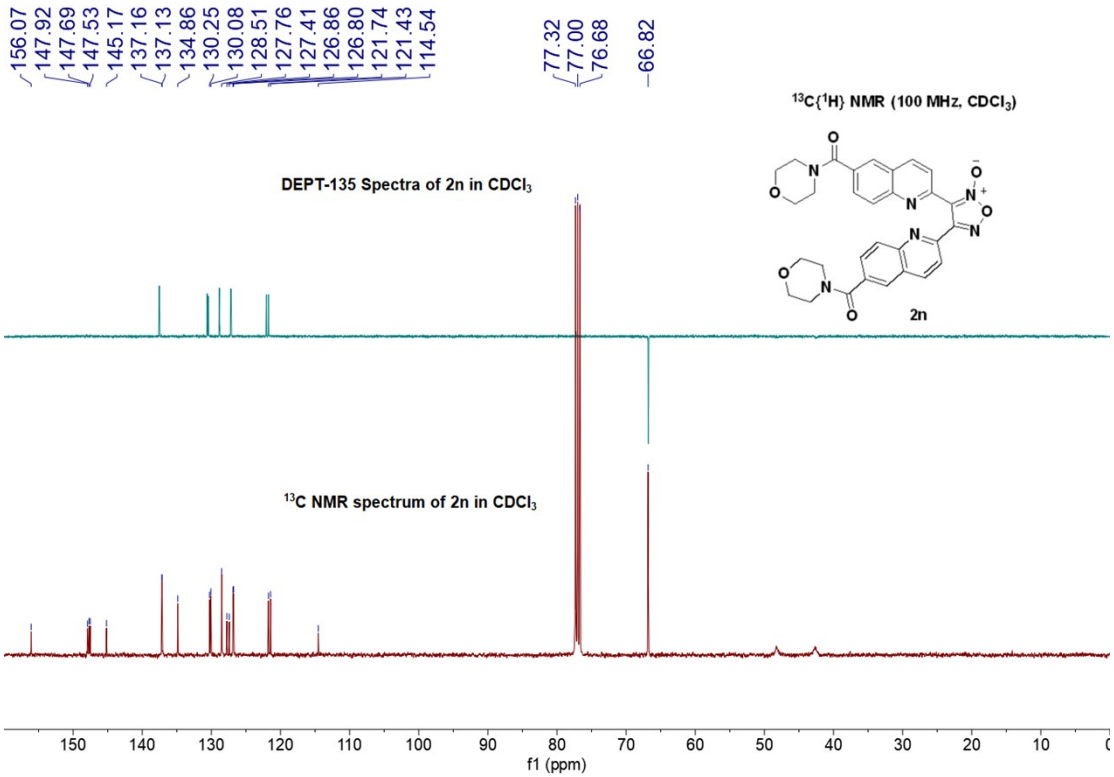

156.10
149.26
149.14
148.60
145.82
138.04
137.99
130.45
130.16
130.13
129.82
129.75
129.61
127.37
127.02
121.48
121.29
114.58
77.32
77.00
76.68
69.16
21.94
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2l in CDCl3
13C NMR spectrum of 2l in CDCl3
2l
f1 (ppm)

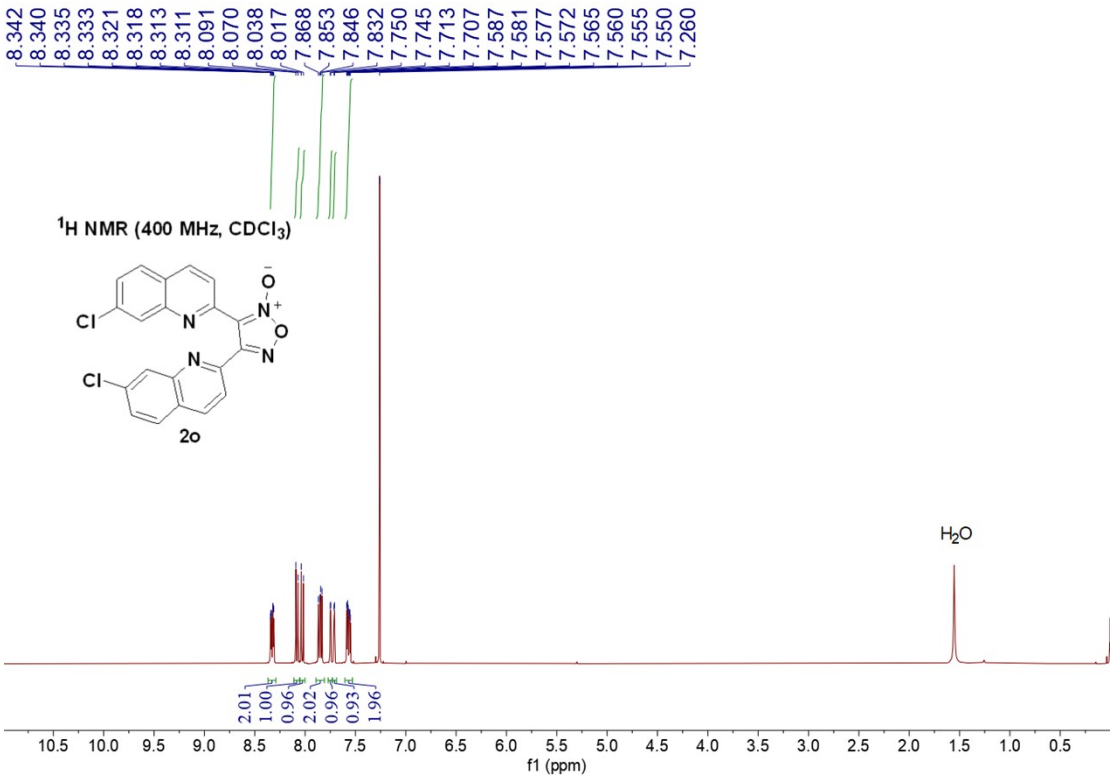

8.170
8.164
8.149
8.142
7.996
7.974
7.949
7.928
7.912
7.907
7.895
7.890
7.462
7.440
7.394
7.384
7.372
7.362
7.260
7.214
7.209
7.196
7.192
7.176
7.140
7.137
7.122
7.103
7.100
7.062
7.043
3.557
1H NMR (400 MHz, CDCl3)
2m
1.96
1.00
1.08
1.90
1.99
2.07
4.11
2.11
3.94
6.00
f1 (ppm)

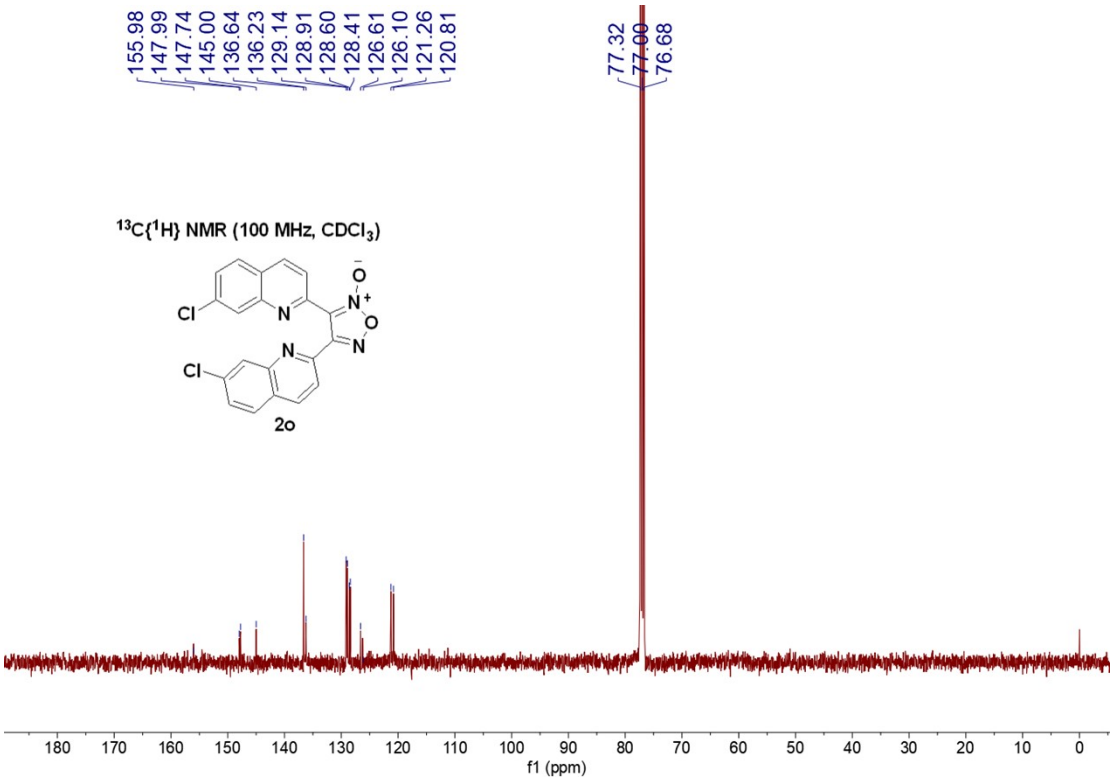

169.44
155.94
147.69
147.43
147.22
145.00
144.28
137.17
135.52
130.24
129.67
129.41
129.38
128.95
128.80
128.76
128.73
127.51
127.26
126.93
126.89
121.48
120.96
114.50
77.32
77.00
76.68
38.44
13C{1H} NMR (100 MHz, CDCl3)
2m
f1 (ppm)

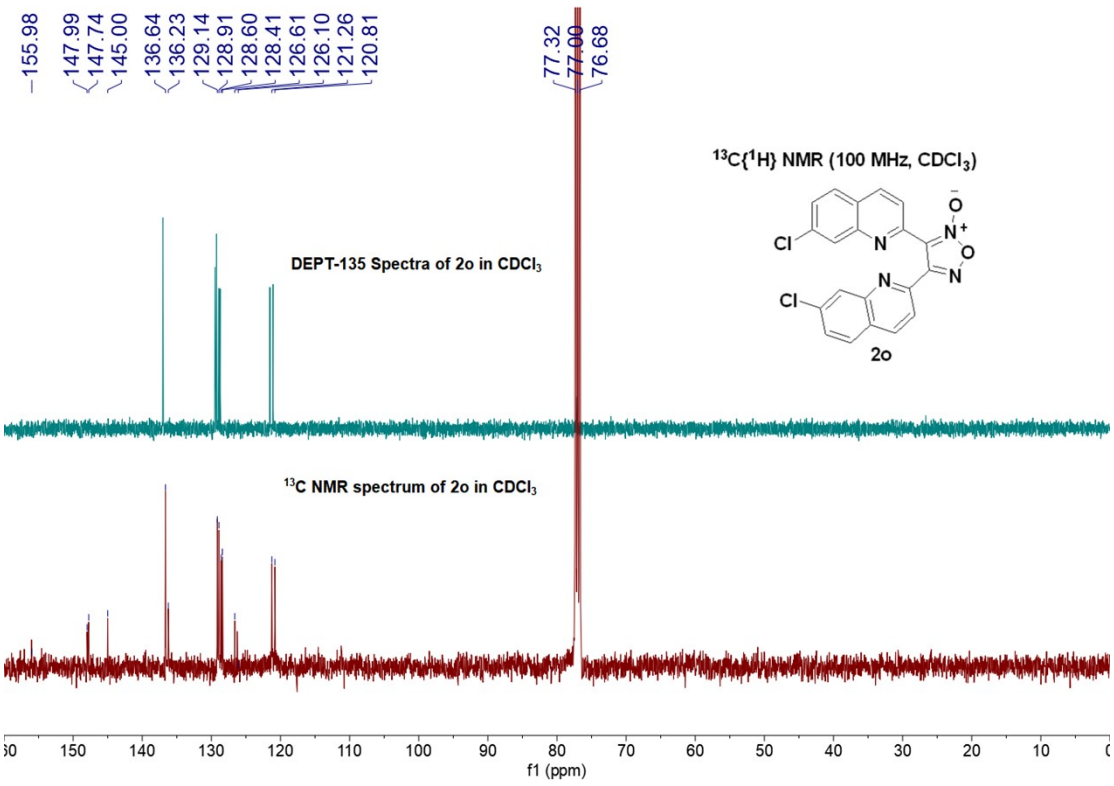

155.94
147.69
147.43
147.22
145.00
144.28
137.17
135.52
130.24
129.67
129.41
129.38
128.95
128.80
128.76
128.73
127.51
127.26
126.93
126.89
121.48
120.96
114.50
77.32
77.00
76.68
38.44
13C{1H} NMR (100 MHz, CDCl3)
2m
DEPT-135 Spectra of 2m in CDCl3
13C NMR spectrum of 2m in CDCl3
f1 (ppm)

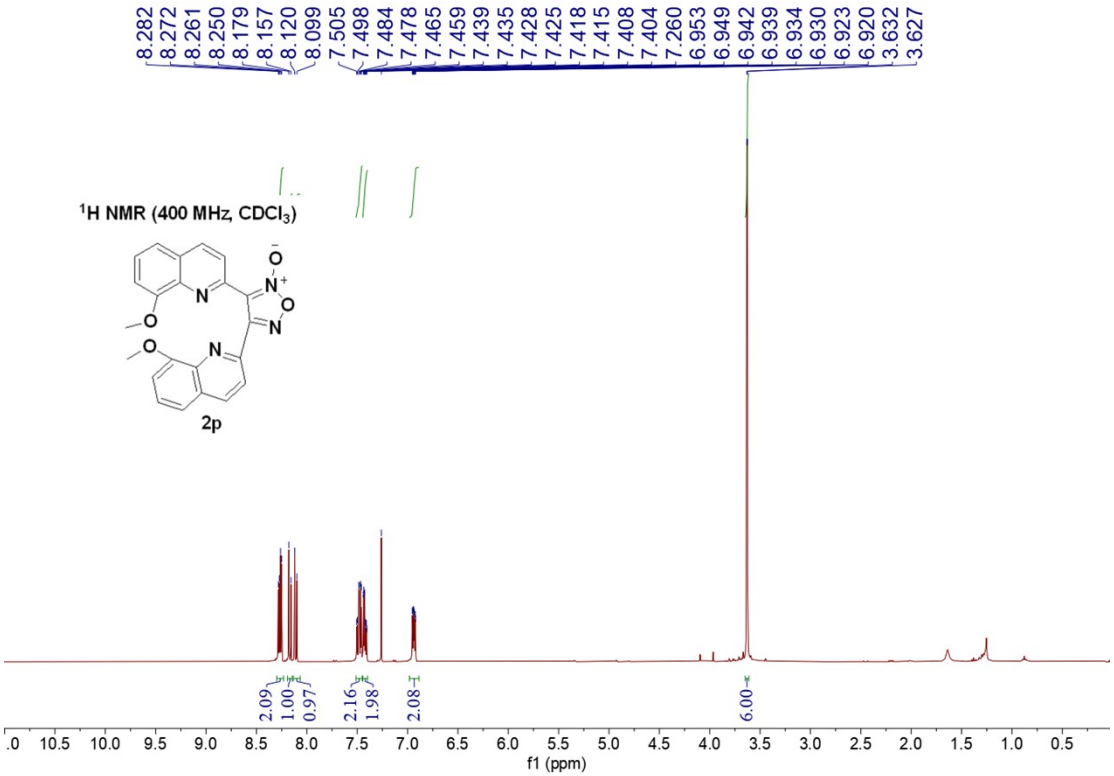

8.375
8.369
8.353
8.349
8.142
8.121
8.078
8.057
7.988
7.984
7.969
7.964
7.757
7.736
7.710
7.688
7.661
7.656
7.647
7.642
7.639
7.634
7.625
7.621
7.260
3.818
3.696
3.520
3.488
1H NMR (400 MHz, CDCl3)
2n
2.03
1.00
1.00
1.99
1.01
1.01
1.91
16.22
f1 (ppm)
169.25
156.07
147.92
147.69
147.53
145.17
137.16
137.13
134.86
130.25
130.08
128.51
127.76
127.41
126.86
126.80
121.74
121.43
114.54
77.32
77.00
76.68
66.82
13C{1H} NMR (100 MHz, CDCl3)
2n
f1 (ppm)

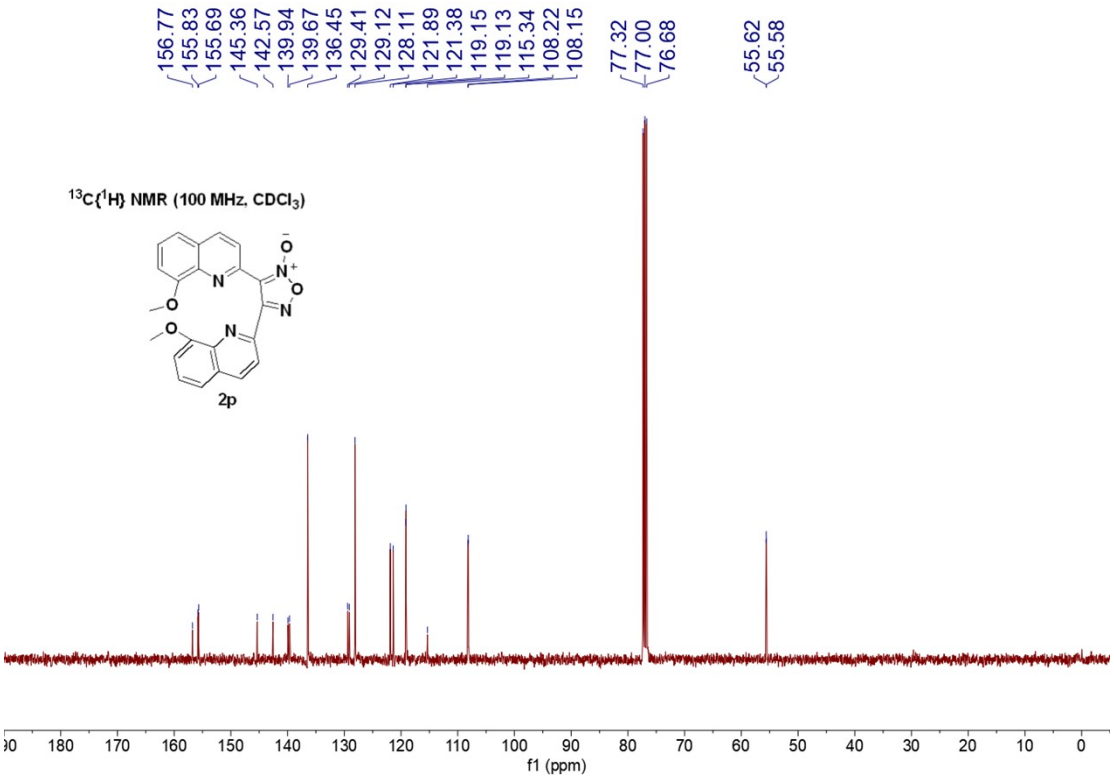

156.07
147.92
147.69
147.53
145.17
137.16
137.13
134.86
130.25
130.08
128.51
127.76
127.41
126.86
126.80
121.74
121.43
114.54
77.32
77.00
76.68
66.82
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
DEPT-135 Spectra of 2n in $CDCl_3$
^{13}C NMR spectrum of 2n in $CDCl_3$
2n
f1 (ppm)

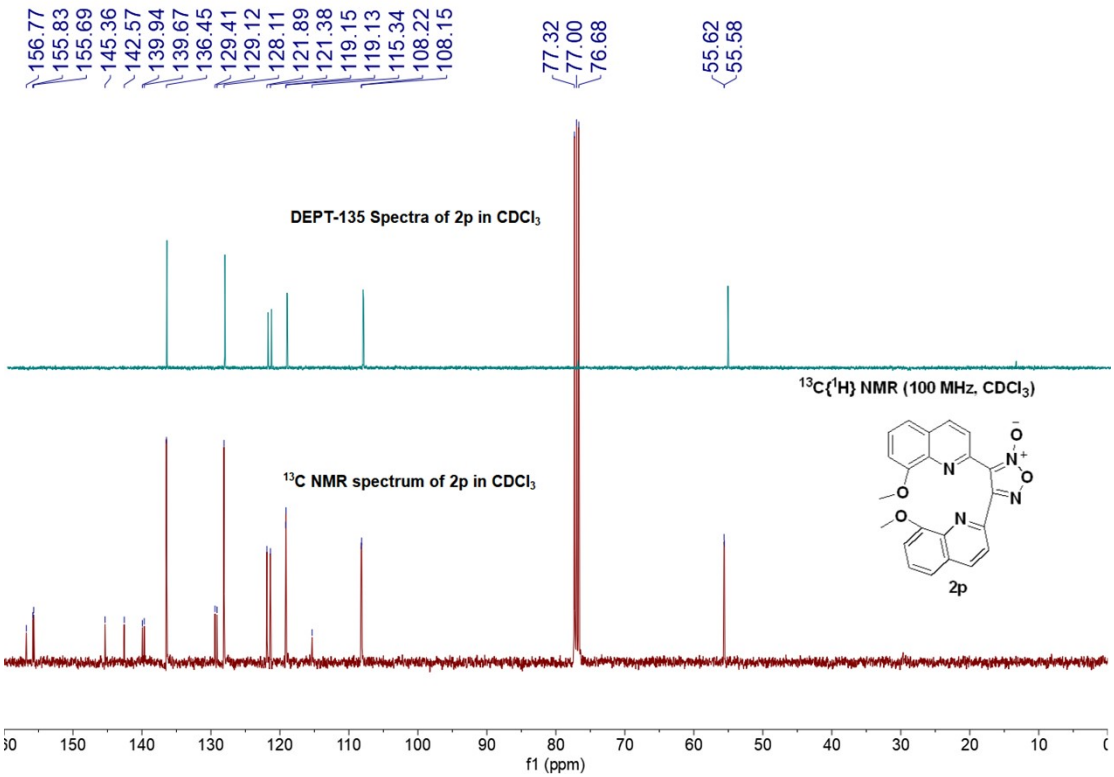

8.342
8.340
8.335
8.333
8.321
8.318
8.313
8.311
8.091
8.070
8.038
8.017
7.868
7.853
7.846
7.832
7.750
7.745
7.713
7.707
7.587
7.581
7.577
7.572
7.565
7.560
7.555
7.550
7.260
^{1}H NMR (400 MHz, $CDCl_3$)
2o
H_2O
2.01
1.00
0.96
2.02
0.96
0.93
1.96
f1 (ppm)

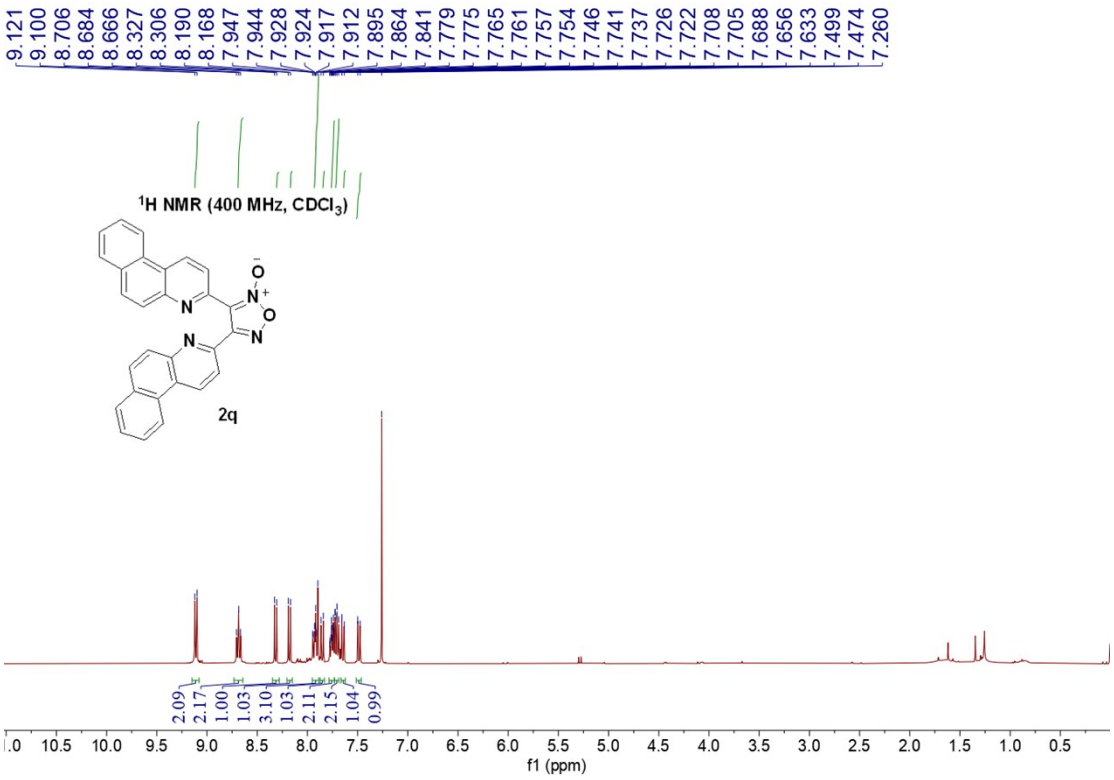

155.98
147.99
147.74
145.00
136.64
136.23
129.14
128.91
128.60
128.41
126.61
126.10
121.26
120.81
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Cl
N
O
N+
O
N
N
Cl
2o
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

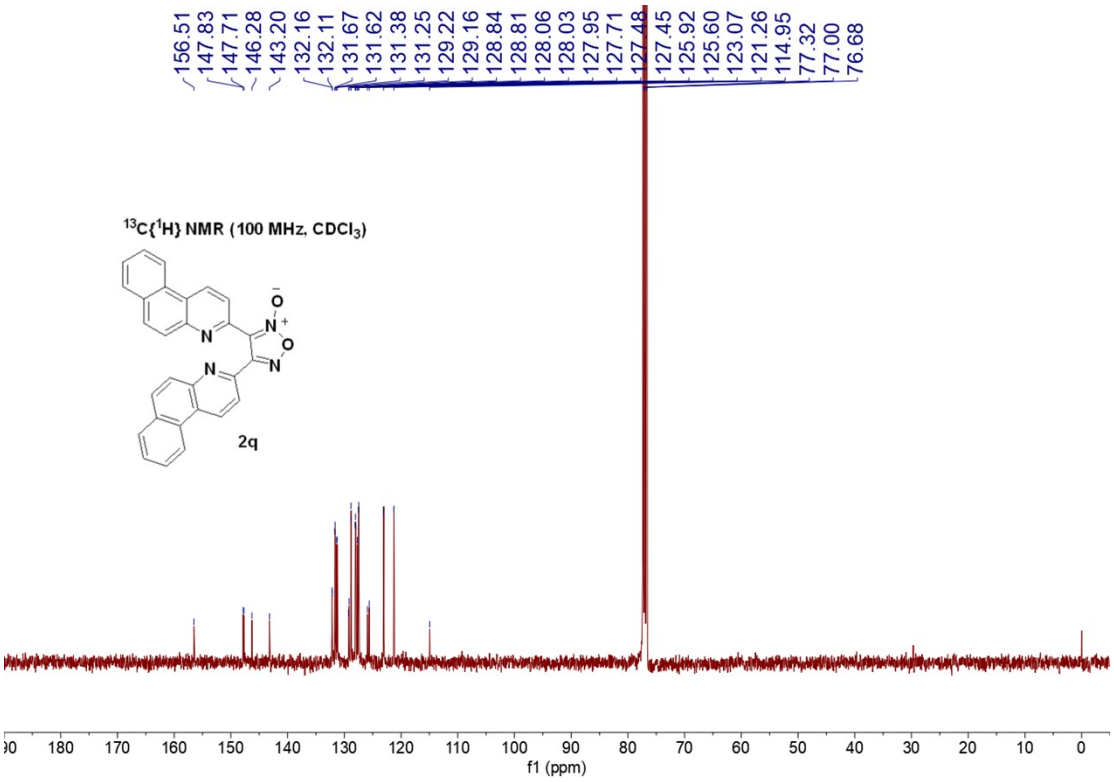

155.98
147.99
147.74
145.00
136.64
136.23
129.14
128.91
128.60
128.41
126.61
126.10
121.26
120.81
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 2o in CDCl3
13C NMR spectrum of 2o in CDCl3
Cl
N
O
N+
O
N
N
Cl
2o
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

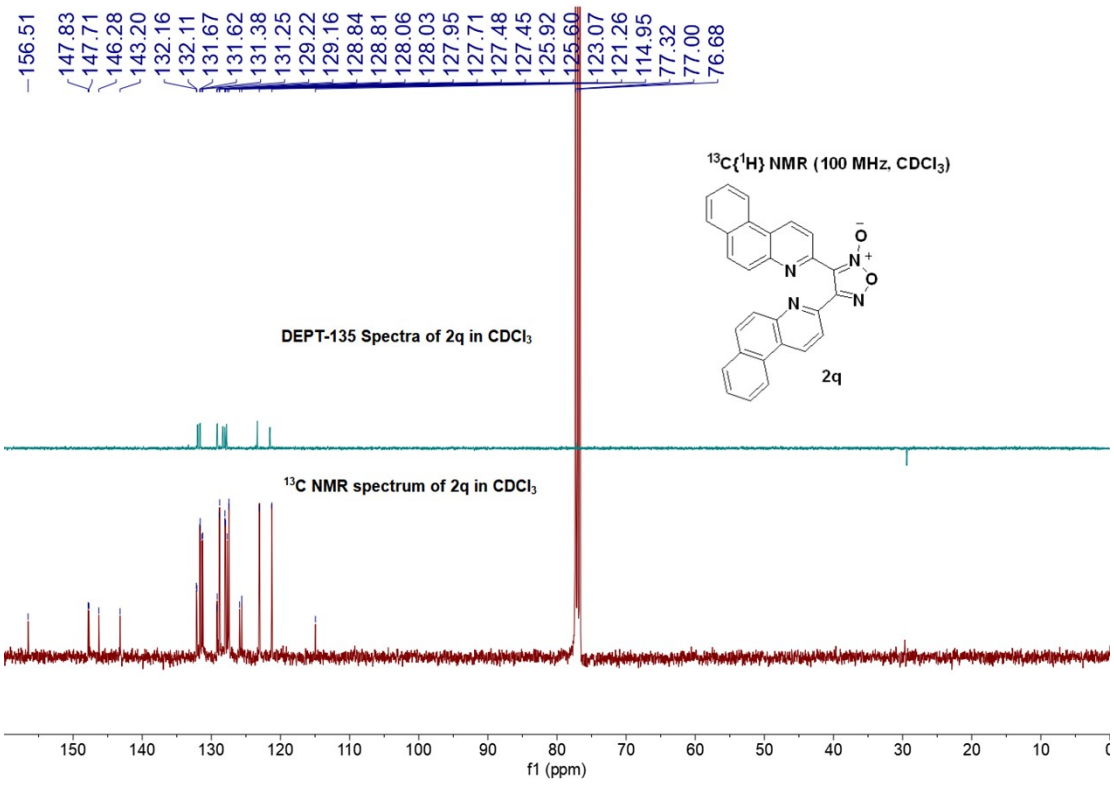

8.282
8.272
8.261
8.250
8.179
8.157
8.120
8.099
7.505
7.498
7.484
7.478
7.465
7.459
7.439
7.435
7.428
7.425
7.418
7.415
7.408
7.404
7.260
6.953
6.949
6.942
6.939
6.934
6.930
6.923
6.920
3.632
3.627
1H NMR (400 MHz, CDCl3)
2p
2.09
1.00
0.97
2.16
1.98
2.08
6.00
f1 (ppm)

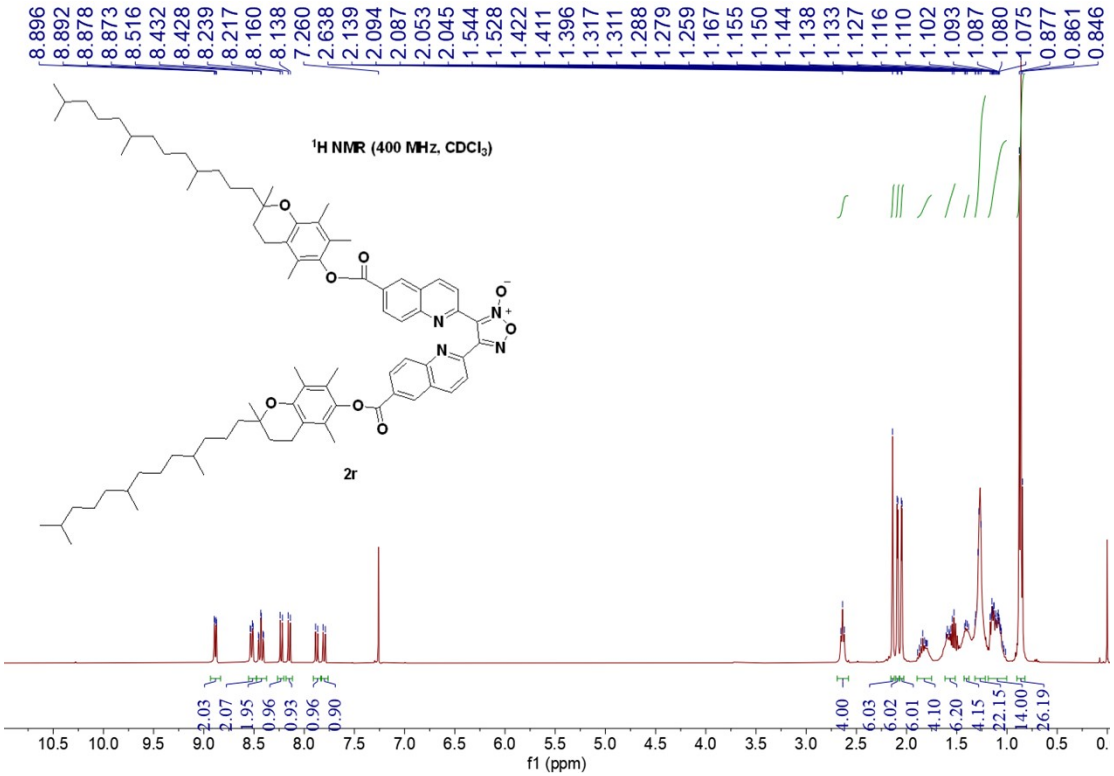

156.77
155.83
155.69
145.36
142.57
139.94
139.67
136.45
129.41
129.12
128.11
121.89
121.38
119.15
119.13
115.34
108.22
108.15
77.32
77.00
76.68
55.62
55.58
13C{1H} NMR (100 MHz, CDCl3)
2p
f1 (ppm)

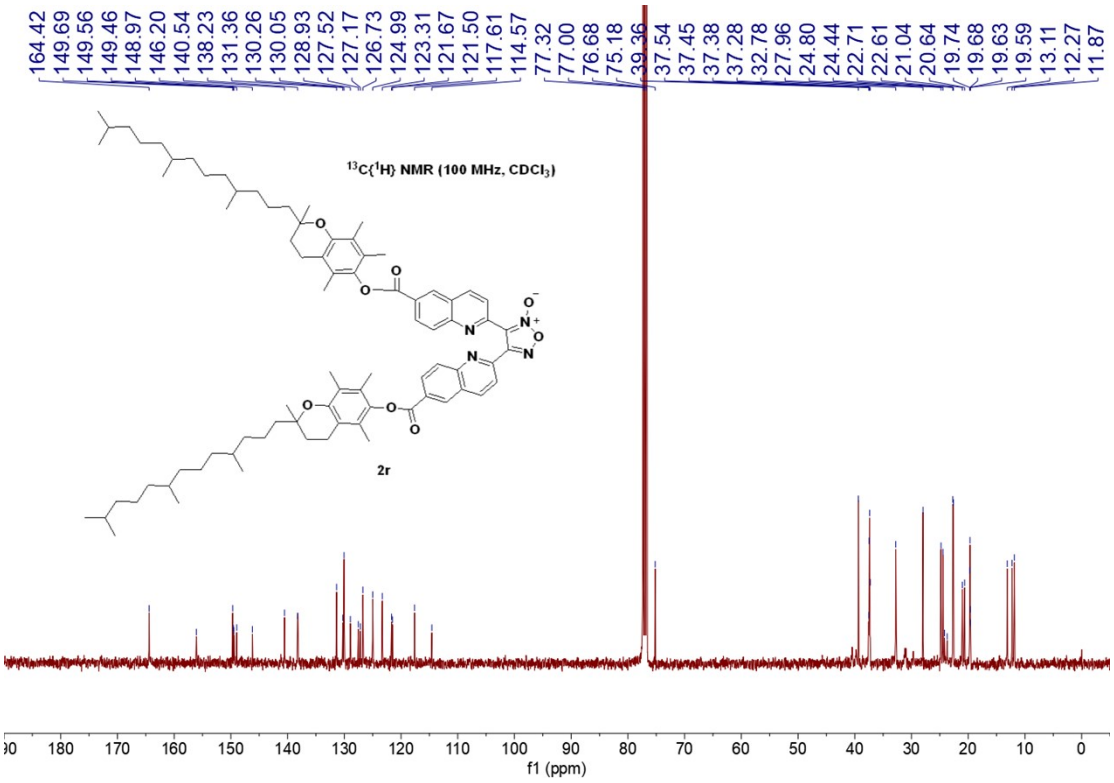

156.77
155.83
155.69
145.36
142.57
139.94
139.67
136.45
129.41
129.12
128.11
121.89
121.38
119.15
119.13
115.34
108.22
108.15
77.32
77.00
76.68
55.62
55.58
DEPT-135 Spectra of 2p in CDCl3
13C{1H} NMR (100 MHz, CDCl3)
13C NMR spectrum of 2p in CDCl3
2p
f1 (ppm)

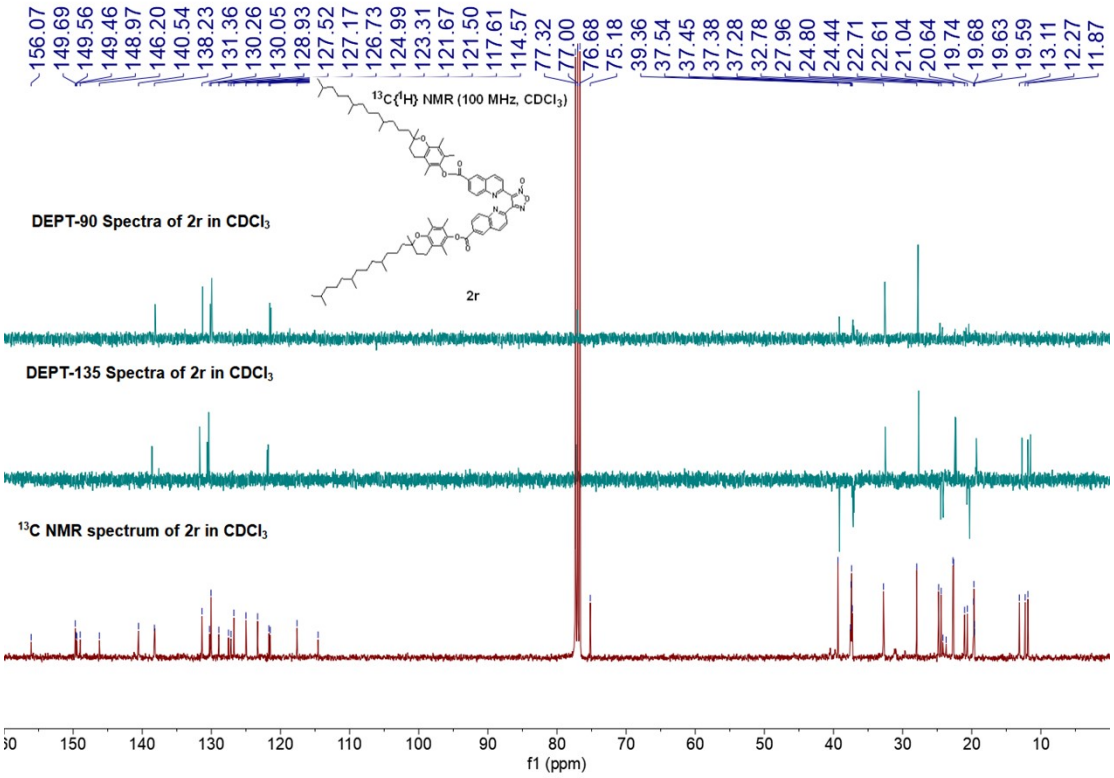

9.121
9.100
8.706
8.684
8.666
8.327
8.306
8.190
8.168
7.947
7.944
7.928
7.924
7.917
7.912
7.895
7.864
7.841
7.779
7.775
7.765
7.761
7.757
7.754
7.746
7.741
7.737
7.726
7.722
7.708
7.705
7.688
7.656
7.633
7.499
7.474
7.260
1H NMR (400 MHz, CDCl3)
2q
2.09
2.17
1.00
1.03
3.10
1.03
2.11
2.15
1.04
0.99
f1 (ppm)

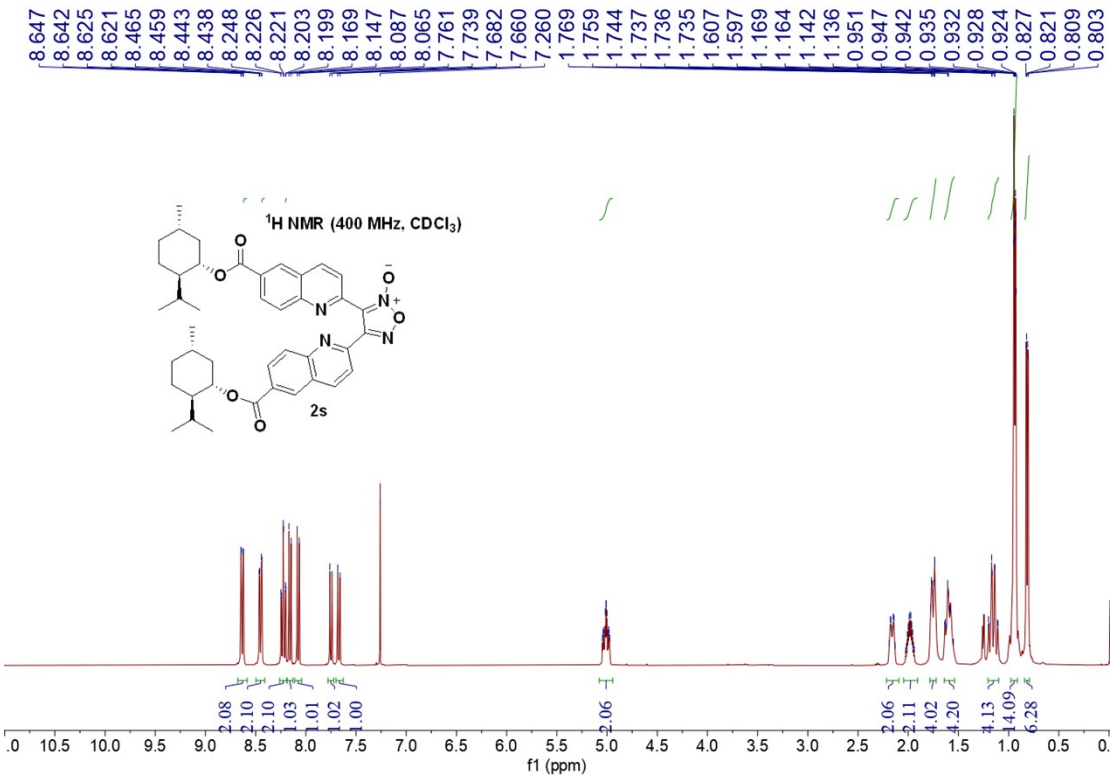

156.51
147.83
147.71
146.28
143.20
132.16
132.11
131.67
131.62
131.38
131.25
129.22
129.16
128.84
128.81
128.06
128.03
127.95
127.71
127.48
127.45
125.92
125.60
123.07
121.26
114.95
77.32
77.00
76.68
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
2q
f1 (ppm)

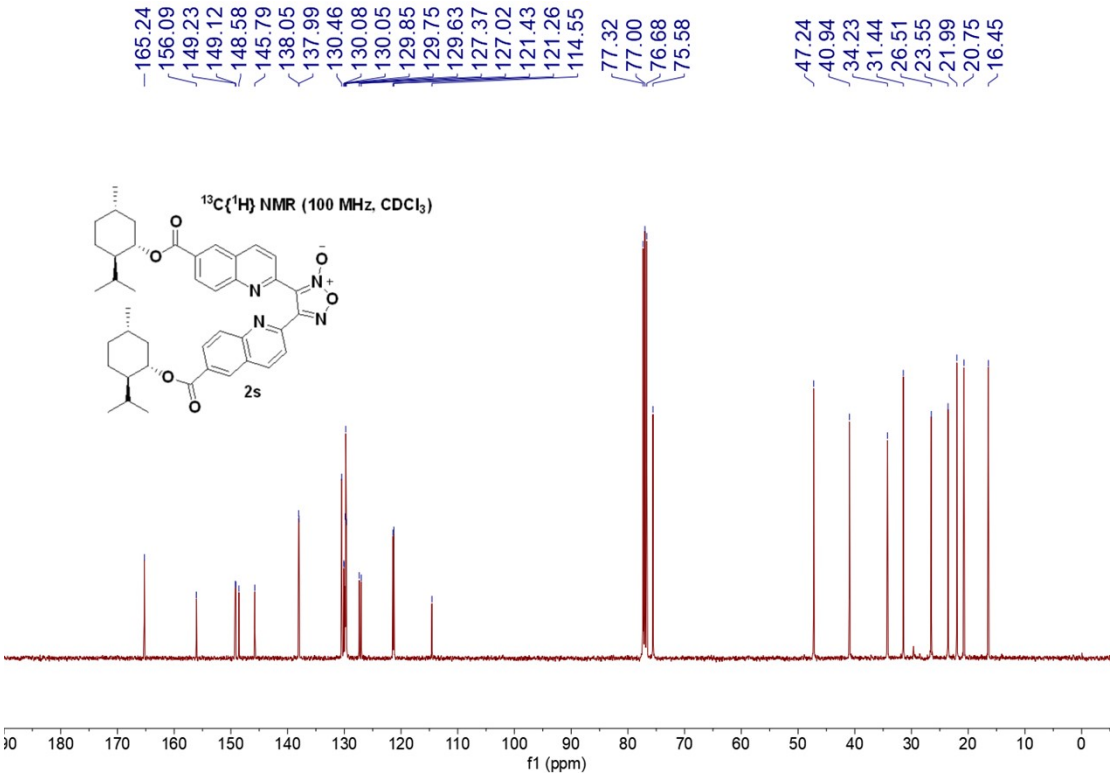

156.51
147.83
147.71
146.28
143.20
132.16
132.11
131.67
131.62
131.38
131.25
129.22
129.16
128.84
128.81
128.06
128.03
127.95
127.71
127.48
127.45
125.92
125.60
123.07
121.26
114.95
77.32
77.00
76.68
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
DEPT-135 Spectra of 2q in $CDCl_3$
2q
^{13}C NMR spectrum of 2q in $CDCl_3$
f1 (ppm)

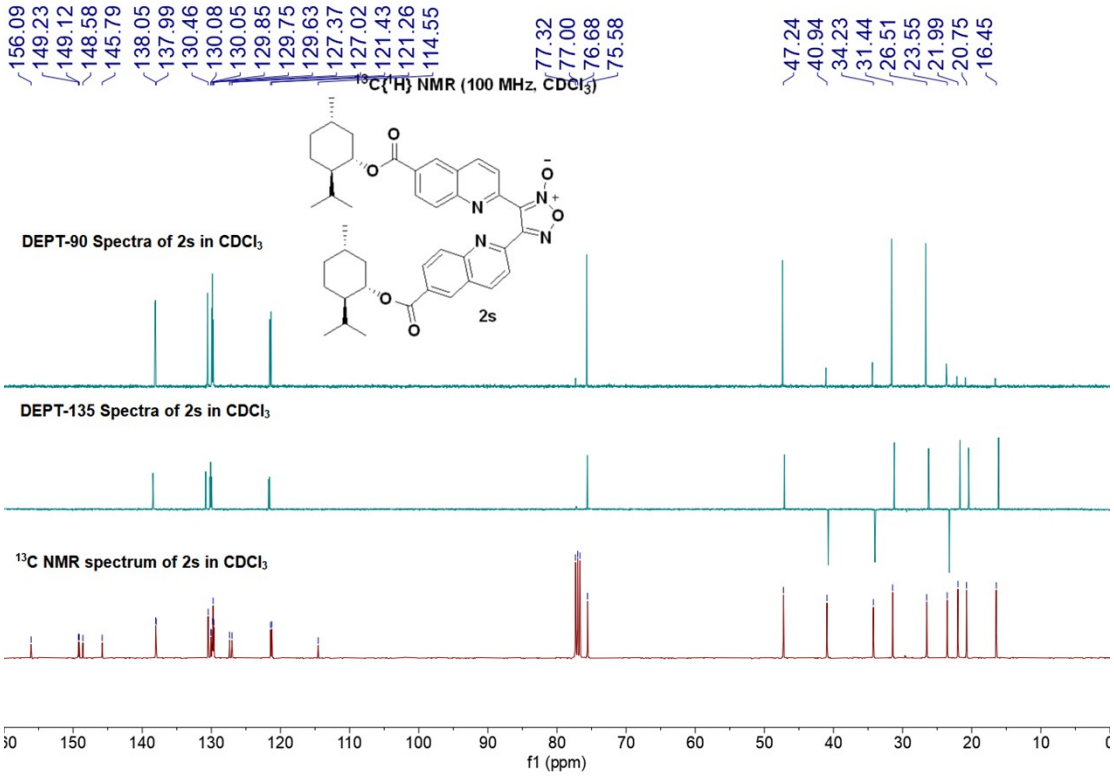

8.896
8.892
8.878
8.873
8.516
8.432
8.428
8.239
8.217
8.160
8.138
7.260
2.638
2.139
2.094
2.087
2.053
2.045
1.544
1.528
1.422
1.411
1.396
1.317
1.311
1.288
1.279
1.259
1.167
1.155
1.150
1.144
1.138
1.133
1.127
1.116
1.110
1.102
1.093
1.087
1.080
1.075
0.877
0.861
0.846
^{1}H NMR (400 MHz, CDCl$_3$)
2r
2.03
2.07
1.95
0.96
0.93
0.96
0.90
4.00
6.03
6.02
6.01
4.10
6.20
4.15
22.15
14.00
26.19
f1 (ppm)

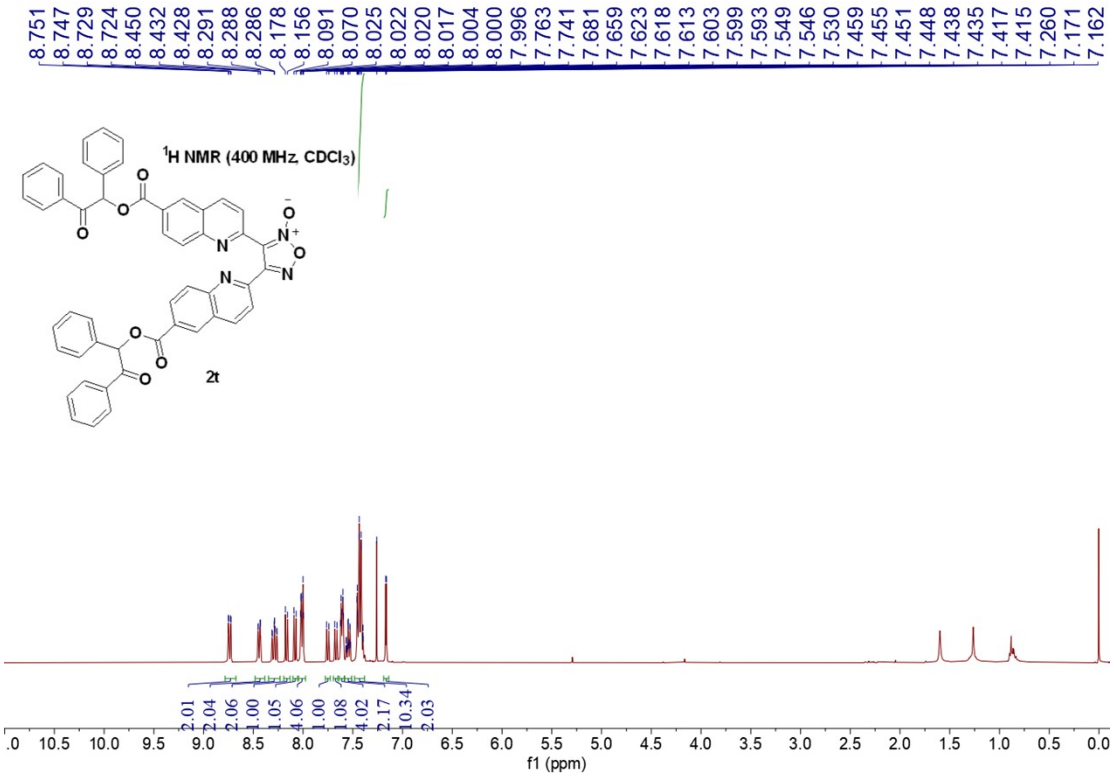

164.42
149.69
149.56
149.46
148.97
146.20
140.54
138.23
131.36
130.26
130.05
128.93
127.52
127.17
126.73
124.99
123.31
121.67
121.50
117.61
114.57
77.32
77.00
76.68
75.18
39.36
37.54
37.45
37.38
37.28
32.78
27.96
24.80
24.44
22.71
22.61
21.04
20.64
19.74
19.68
19.63
19.59
13.11
12.27
11.87
^{13}C{^{1}H} NMR (100 MHz, CDCl$_3$)
2r
f1 (ppm)

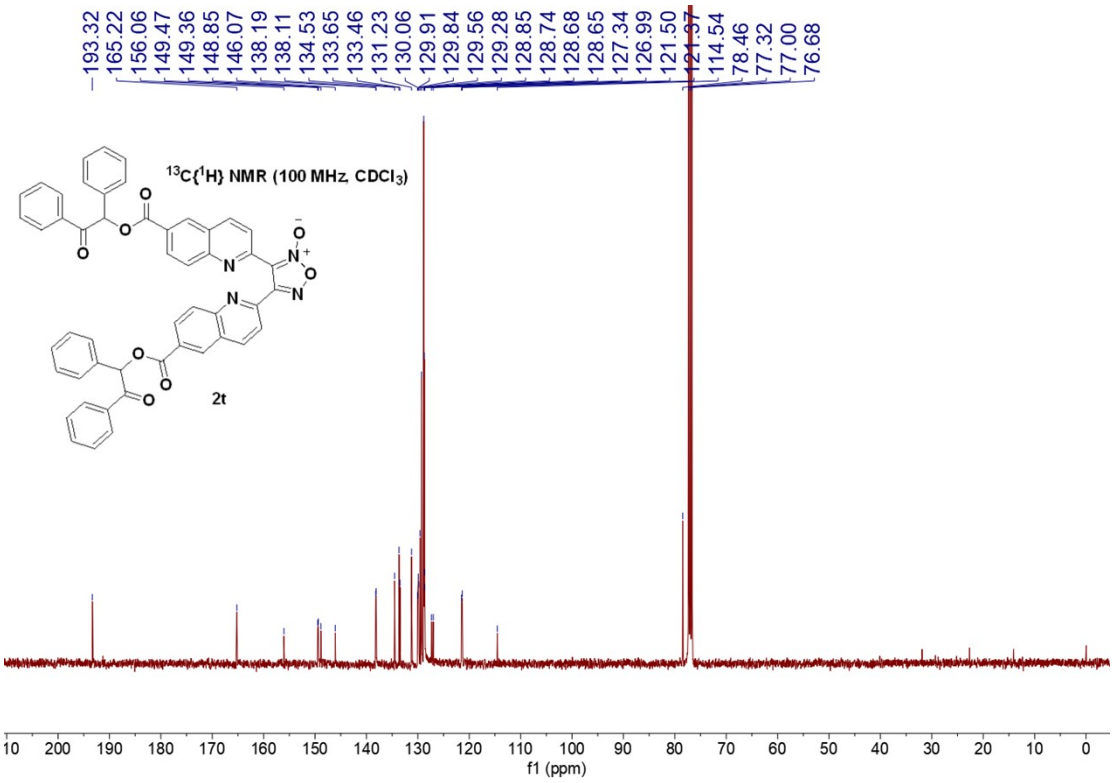

156.07
149.69
149.56
149.46
148.97
146.20
140.54
138.23
131.36
130.26
130.05
128.93
127.52
127.17
126.73
124.99
123.31
121.67
121.50
117.61
114.57
77.32
77.00
76.68
75.18
39.36
37.54
37.45
37.38
37.28
32.78
27.96
24.80
24.44
22.71
22.61
21.04
20.64
19.74
19.68
19.63
19.59
13.11
12.27
11.87
13C{1H} NMR (100 MHz, CDCl3)
DEPT-90 Spectra of 2r in CDCl3
2r
DEPT-135 Spectra of 2r in CDCl3
13C NMR spectrum of 2r in CDCl3
f1 (ppm)

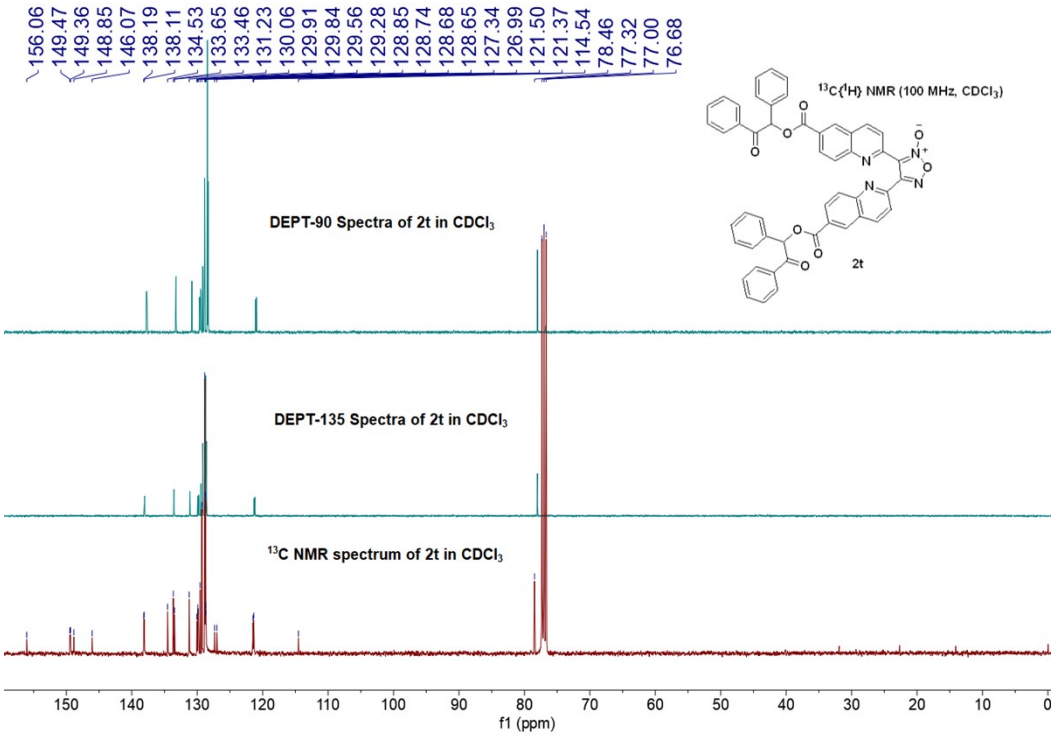

8.647
8.642
8.625
8.621
8.465
8.459
8.443
8.438
8.248
8.226
8.221
8.203
8.199
8.169
8.147
8.087
8.065
7.761
7.739
7.682
7.660
7.260
1.769
1.759
1.744
1.737
1.736
1.735
1.607
1.597
1.169
1.164
1.142
1.136
0.951
0.947
0.942
0.935
0.932
0.928
0.924
0.827
0.821
0.809
0.803
1H NMR (400 MHz, CDCl3)
2s
2.08
2.10
2.10
1.03
1.01
1.02
1.00
2.06
2.06
2.11
4.02
4.20
4.13
14.09
6.28
f1 (ppm)

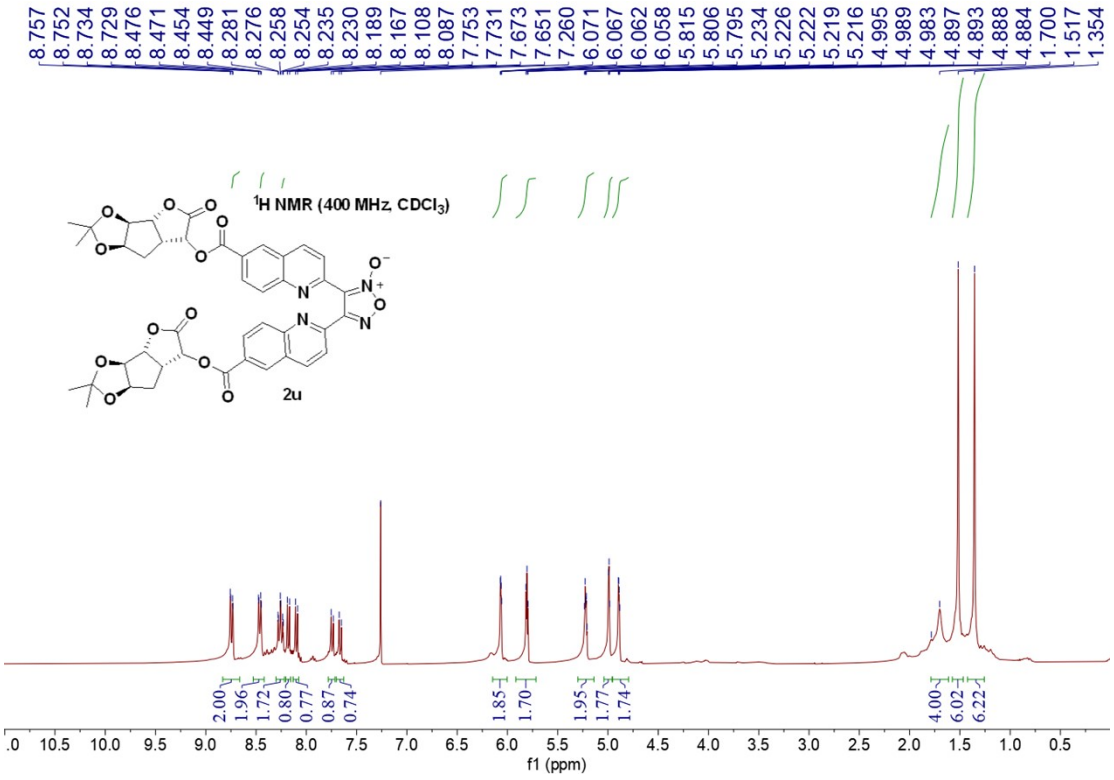

165.24
156.09
149.23
149.12
148.58
145.79
138.05
137.99
130.46
130.08
130.05
129.85
129.75
129.63
127.37
127.02
121.43
121.26
114.55
77.32
77.00
76.68
75.58
47.24
40.94
34.23
31.44
26.51
23.55
21.99
20.75
16.45
13C{1H} NMR (100 MHz, CDCl3)
2s
f1 (ppm)

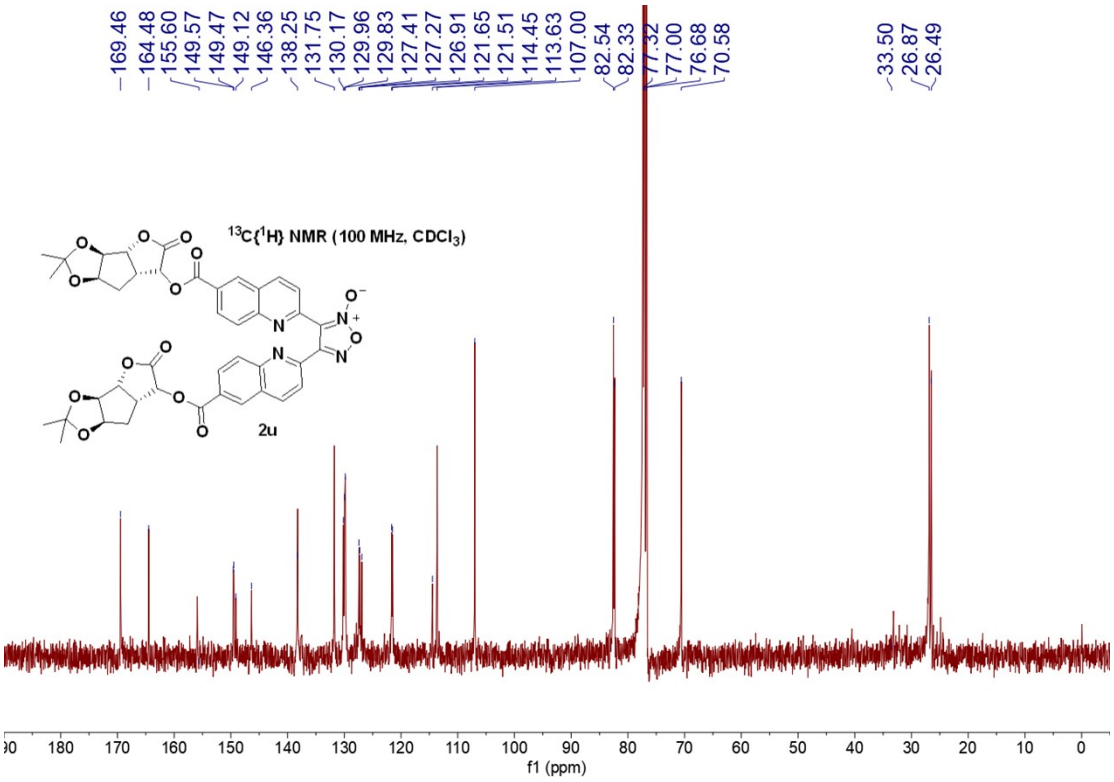

156.09
149.23
149.12
148.58
145.79
138.05
137.99
130.46
130.08
130.05
129.85
129.75
129.63
127.37
127.02
121.43
121.26
114.55
77.32
77.00
76.68
75.58
47.24
40.94
34.23
31.44
26.51
23.55
21.99
20.75
16.45
13C{1H} NMR (100 MHz, CDCl3)
DEPT-90 Spectra of 2s in CDCl3
2s
DEPT-135 Spectra of 2s in CDCl3
13C NMR spectrum of 2s in CDCl3
f1 (ppm)

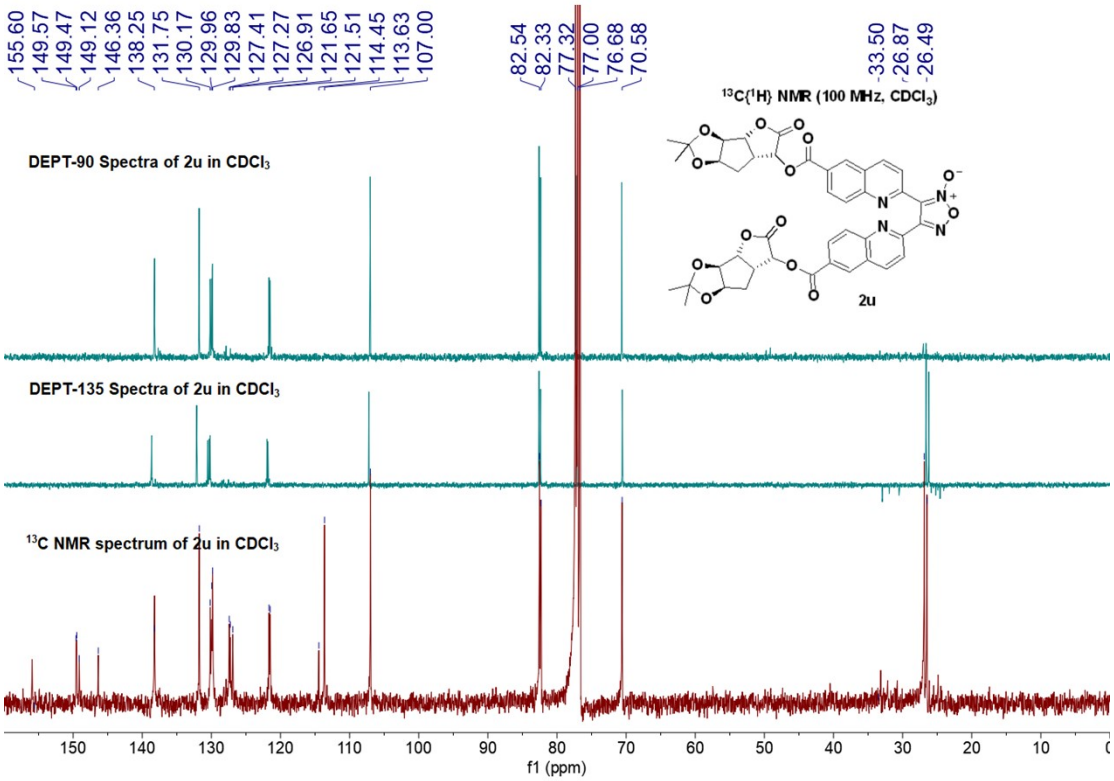

8.751
8.747
8.729
8.724
8.450
8.432
8.428
8.291
8.288
8.286
8.178
8.156
8.091
8.070
8.025
8.022
8.020
8.017
8.004
8.000
7.996
7.763
7.741
7.681
7.659
7.623
7.618
7.613
7.603
7.599
7.593
7.549
7.546
7.530
7.459
7.455
7.451
7.448
7.438
7.435
7.417
7.415
7.260
7.171
7.162
^{1}H NMR (400 MHz, CDCl$_3$)
2t
2.01
2.04
2.06
1.00
1.05
4.06
1.00
1.08
4.02
2.17
10.34
2.03
f1 (ppm)

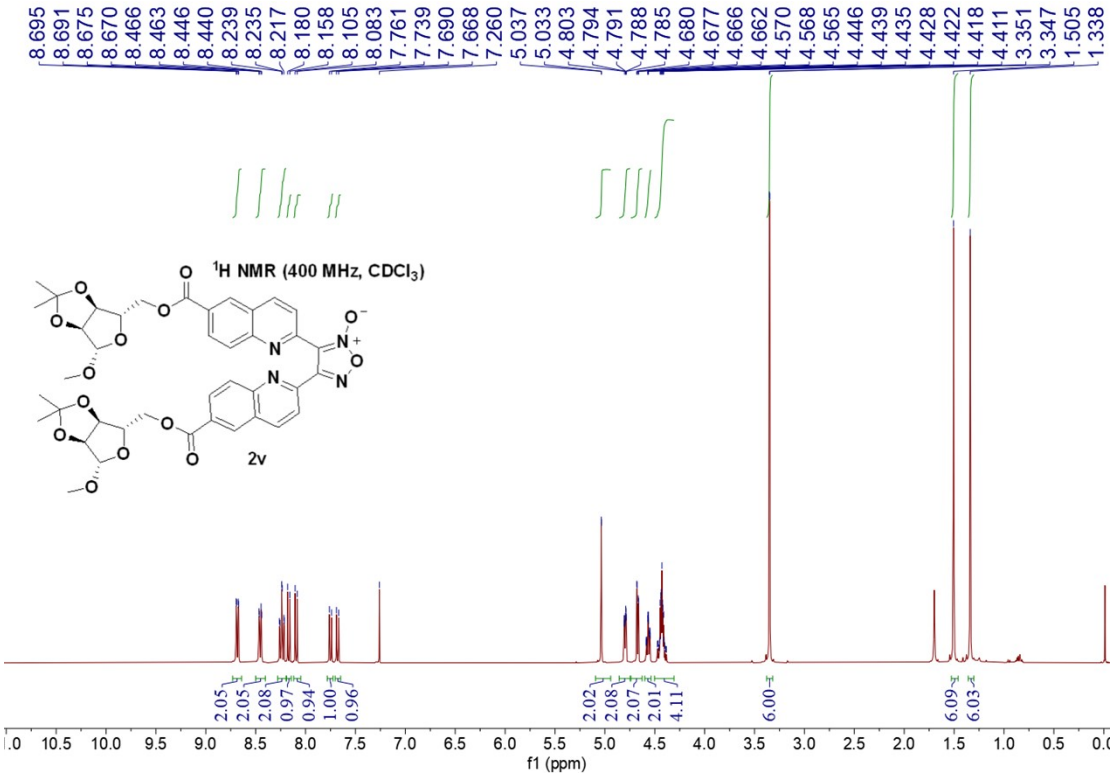

193.32
165.22
156.06
149.47
149.36
148.85
146.07
138.19
138.11
134.53
133.65
133.46
131.23
130.06
129.91
129.84
129.56
129.28
128.85
128.74
128.68
128.65
127.34
126.99
121.50
121.37
114.54
78.46
77.32
77.00
76.68
^{13}C{^{1}H} NMR (100 MHz, CDCl$_3$)
2t
f1 (ppm)

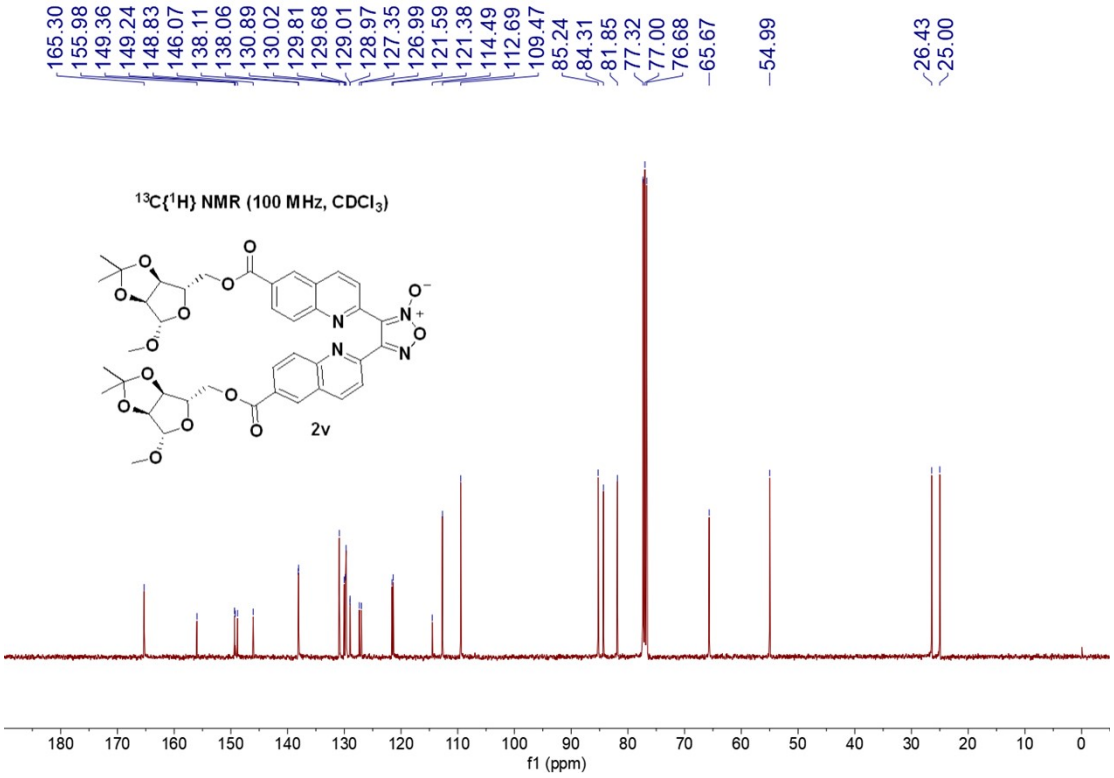

156.06
149.47
149.36
148.85
146.07
138.19
138.11
134.53
133.65
133.46
131.23
130.06
129.91
129.84
129.56
129.28
128.85
128.74
128.68
128.65
127.34
126.99
121.50
121.37
114.54
78.46
77.32
77.00
76.68
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
DEPT-90 Spectra of 2t in $CDCl_3$
DEPT-135 Spectra of 2t in $CDCl_3$
^{13}C NMR spectrum of 2t in $CDCl_3$
2t
f1 (ppm)

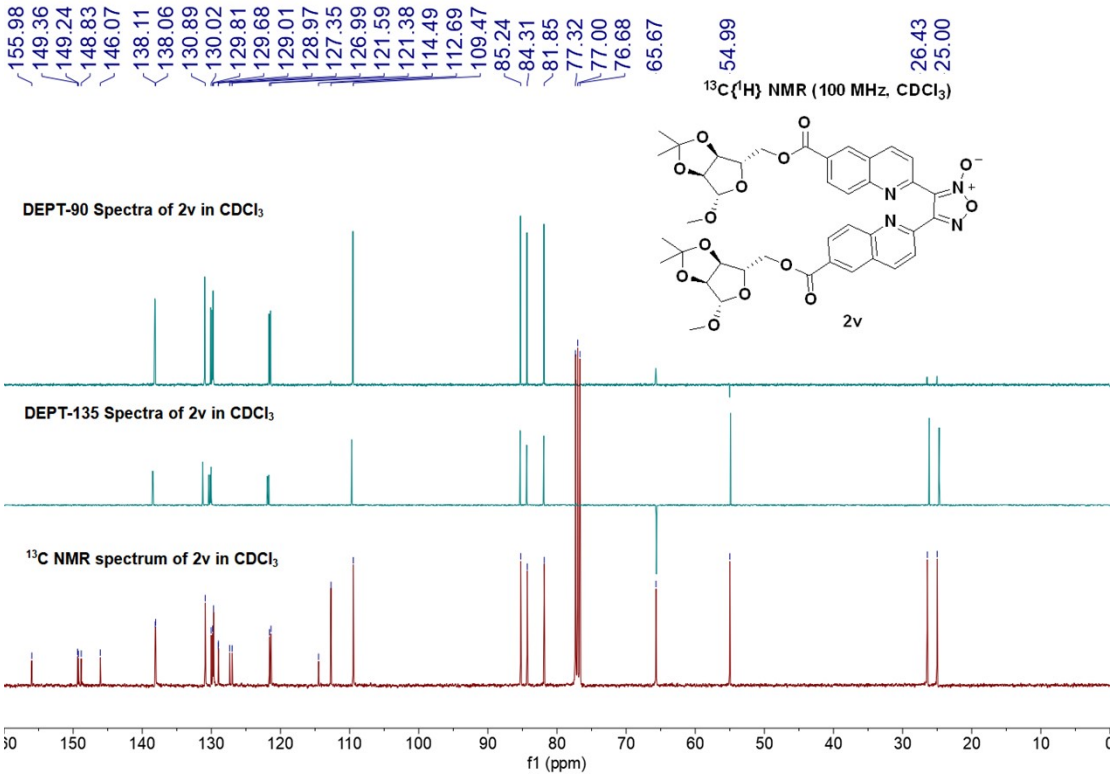

8.757
8.752
8.734
8.729
8.476
8.471
8.454
8.449
8.281
8.276
8.258
8.254
8.235
8.230
8.189
8.167
8.108
8.087
7.753
7.731
7.673
7.651
7.260
6.071
6.067
6.062
6.058
5.815
5.806
5.795
5.234
5.226
5.222
5.219
5.216
4.995
4.989
4.983
4.897
4.893
4.888
4.884
1.700
1.517
1.354
^{1}H NMR (400 MHz, $CDCl_3$)
2u
2.00
1.96
1.72
0.80
0.77
0.87
0.74
1.85
1.70
1.95
1.77
1.74
4.00
6.02
6.22
f1 (ppm)

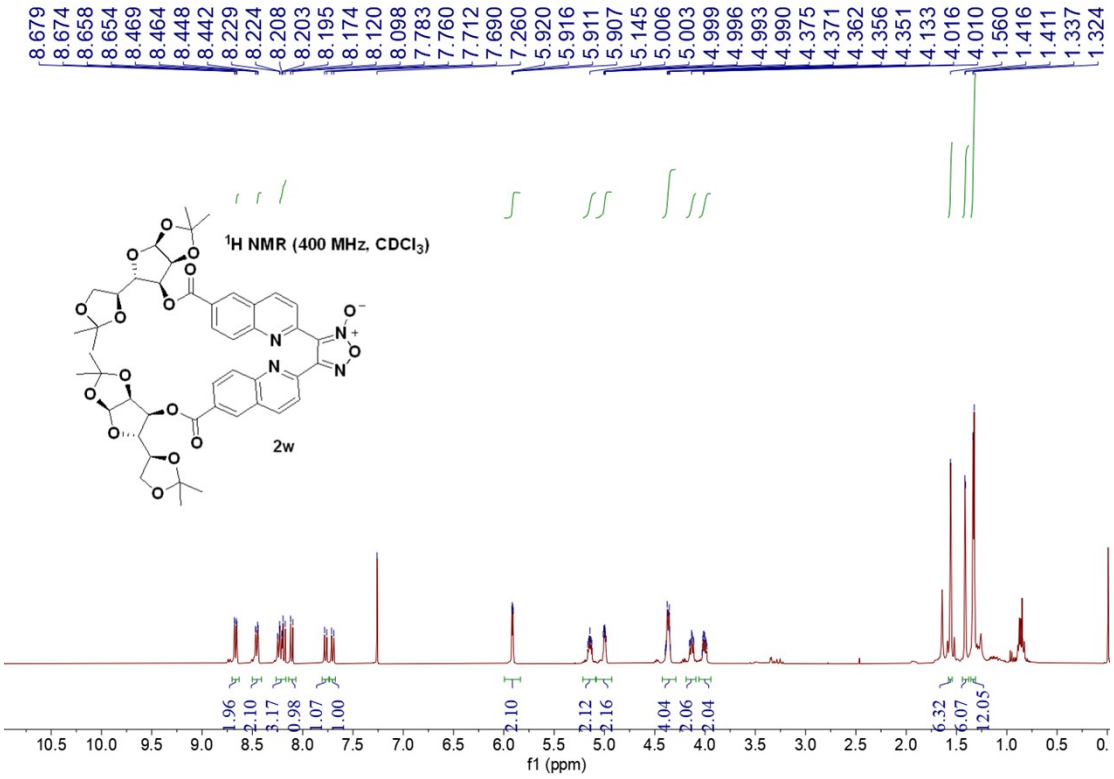

169.46
164.48
155.60
149.57
149.47
149.12
146.36
138.25
131.75
130.17
129.96
129.83
127.41
127.27
126.91
121.65
121.51
114.45
113.63
107.00
82.54
82.33
77.32
77.00
76.68
70.58
33.50
26.87
26.49
13C{1H} NMR (100 MHz, CDCl3)
2u
f1 (ppm)

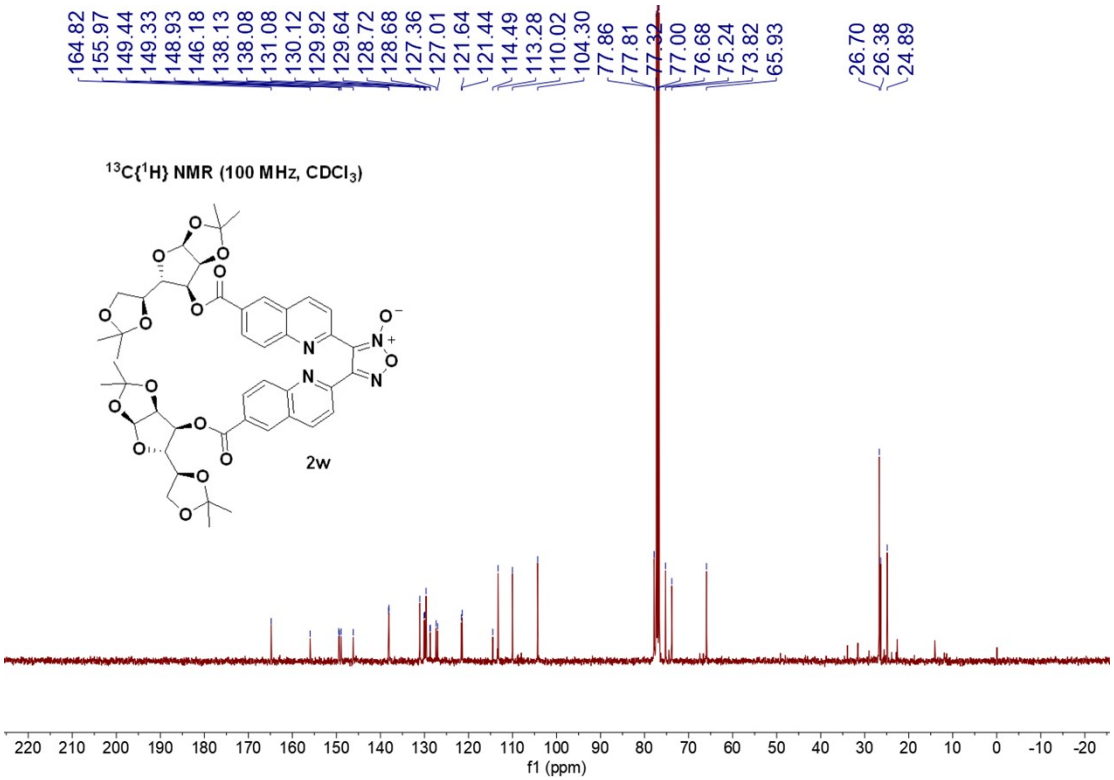

155.60
149.57
149.47
149.12
146.36
138.25
131.75
130.17
129.96
129.83
127.41
127.27
126.91
121.65
121.51
114.45
113.63
107.00
82.54
82.33
77.32
77.00
76.68
70.58
33.50
26.87
26.49
13C{1H} NMR (100 MHz, CDCl3)
DEPT-90 Spectra of 2u in CDCl3
DEPT-135 Spectra of 2u in CDCl3
13C NMR spectrum of 2u in CDCl3
2u
f1 (ppm)

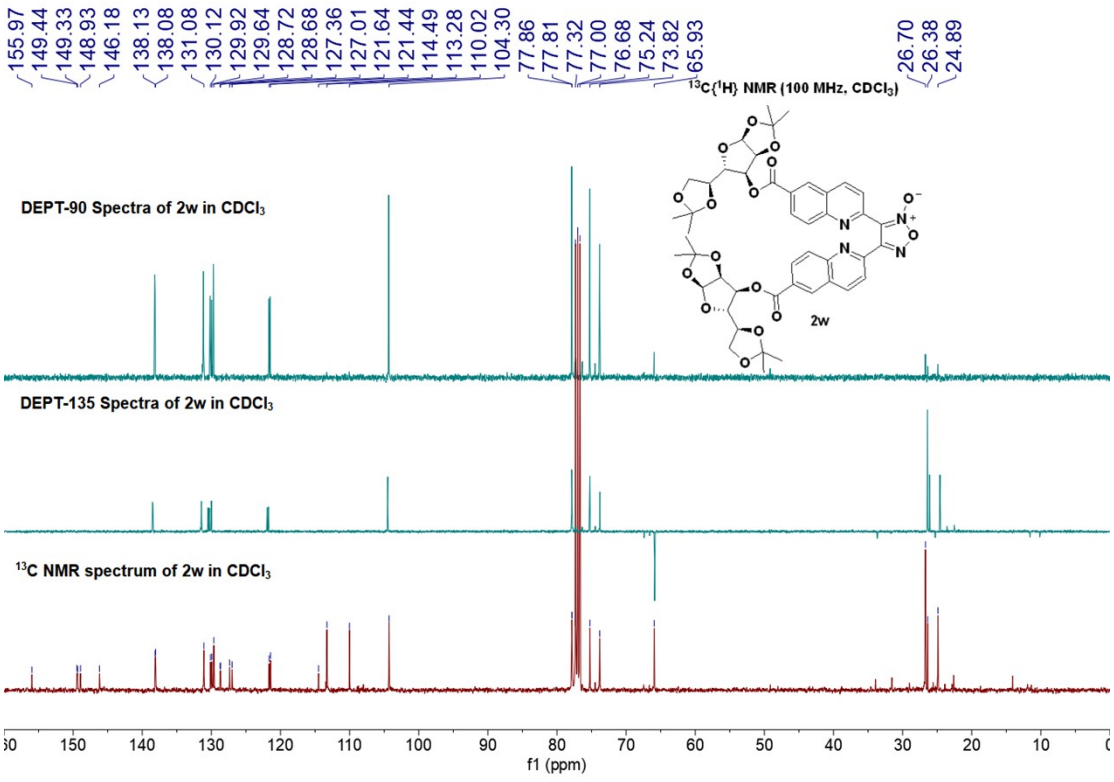

8.695
8.691
8.675
8.670
8.466
8.463
8.446
8.440
8.239
8.235
8.217
8.180
8.158
8.105
8.083
7.761
7.739
7.690
7.668
7.260
5.037
5.033
4.803
4.794
4.791
4.788
4.785
4.680
4.677
4.666
4.662
4.570
4.568
4.565
4.446
4.439
4.435
4.428
4.422
4.418
4.411
3.351
3.347
1.505
1.338
^{1}H NMR (400 MHz, CDCl$_3$)
2v
2.05
2.05
2.08
0.97
0.94
1.00
0.96
2.02
2.08
2.07
2.01
4.11
6.00
6.09
6.03
f1 (ppm)

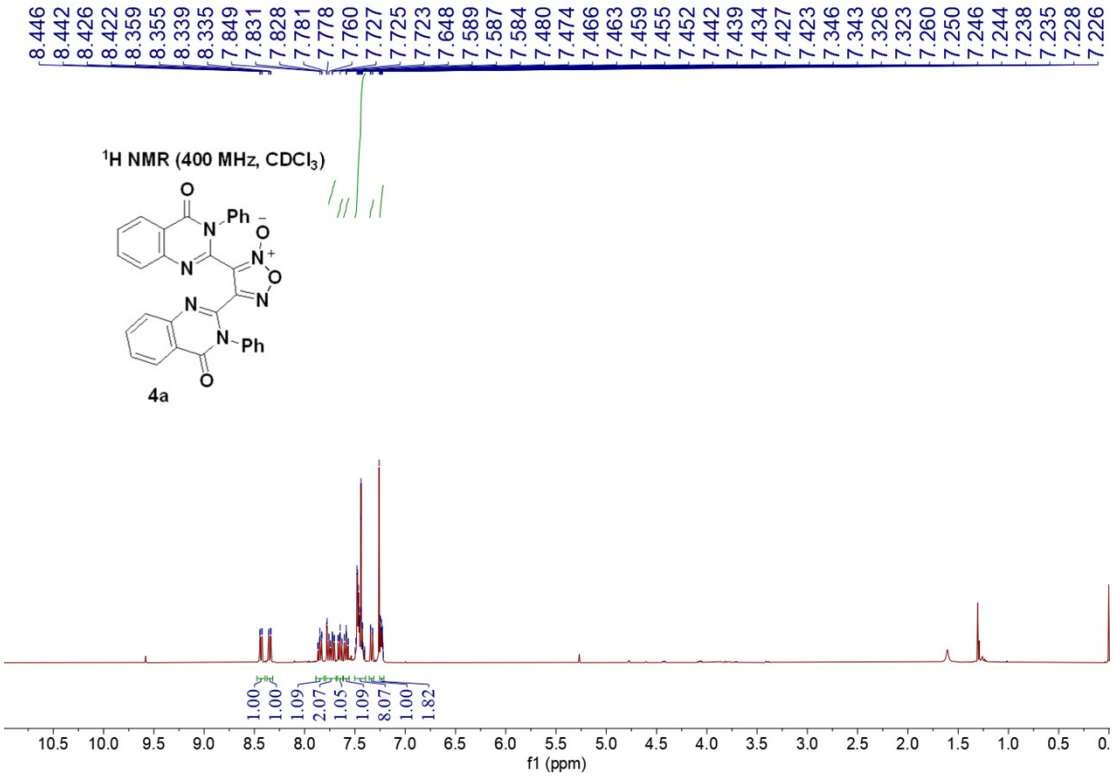

165.30
155.98
149.36
149.24
148.83
146.07
138.11
138.06
130.89
130.02
129.81
129.68
129.01
128.97
127.35
126.99
121.59
121.38
114.49
112.69
109.47
85.24
84.31
81.85
77.32
77.00
76.68
65.67
54.99
26.43
25.00
^{13}C{^{1}H} NMR (100 MHz, CDCl$_3$)
2v
f1 (ppm)

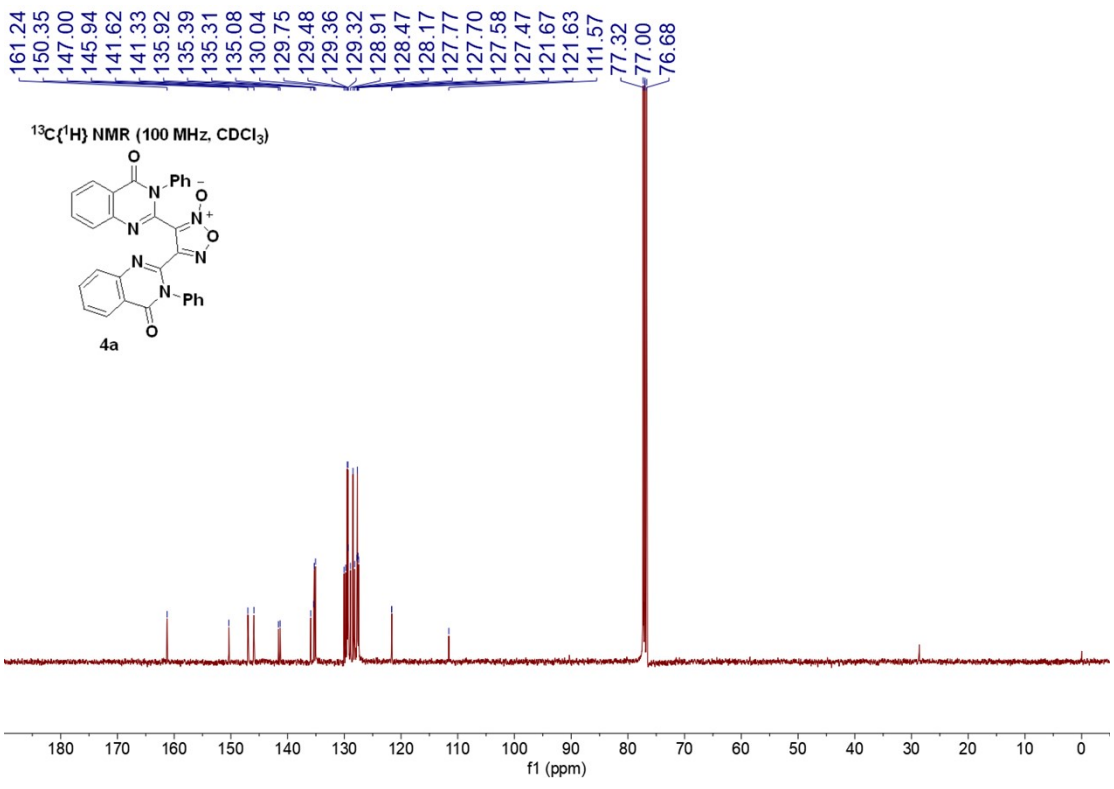

155.98
149.36
149.24
148.83
146.07
138.11
138.06
130.89
130.02
129.81
129.68
129.01
128.97
127.35
126.99
121.59
121.38
114.49
112.69
109.47
85.24
84.31
81.85
77.32
77.00
76.68
65.67
54.99
26.43
25.00
13C{1H} NMR (100 MHz, CDCl3)
DEPT-90 Spectra of 2v in CDCl3
2v
DEPT-135 Spectra of 2v in CDCl3
13C NMR spectrum of 2v in CDCl3
f1 (ppm)

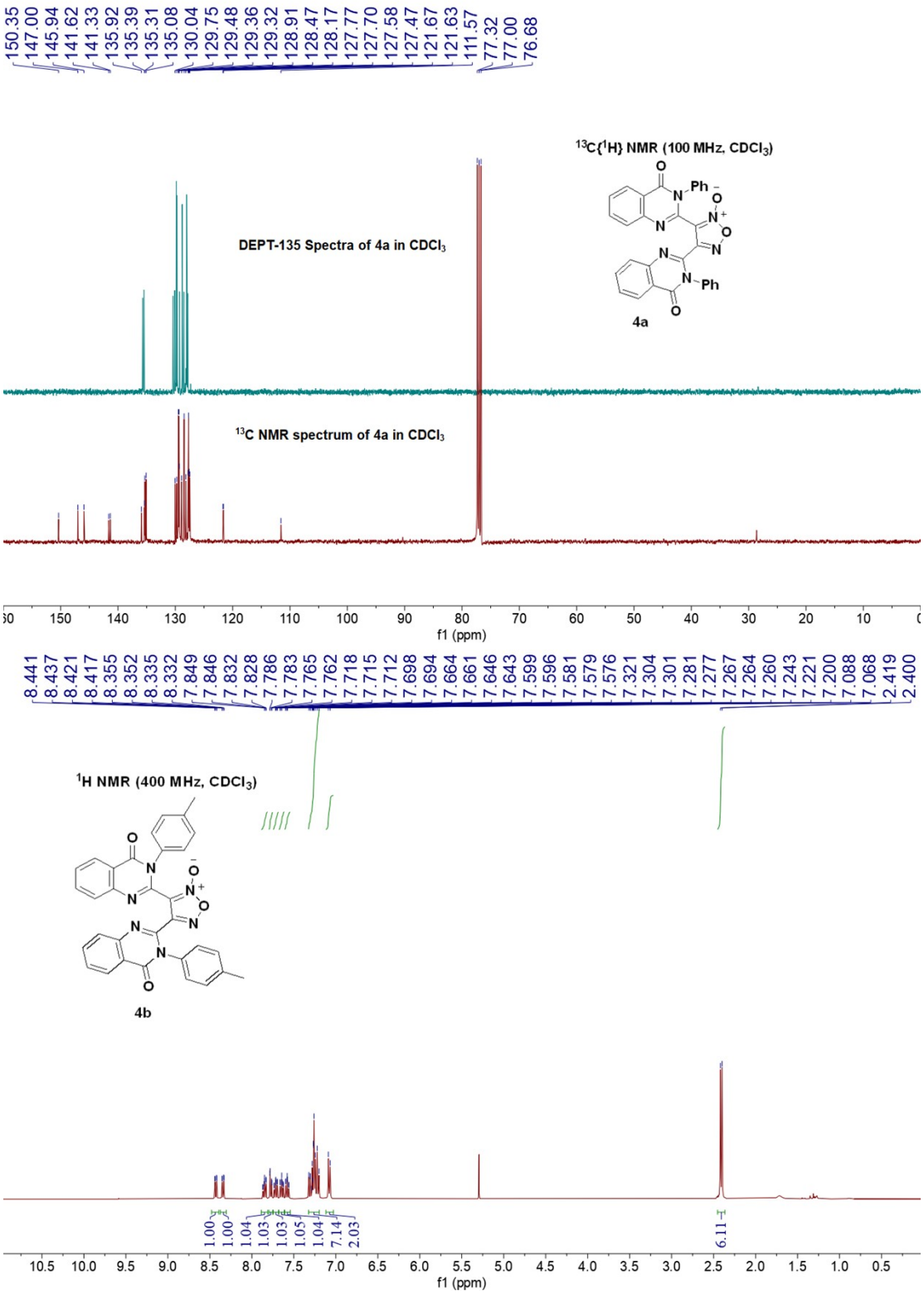

8.679
8.674
8.658
8.654
8.469
8.464
8.448
8.442
8.229
8.224
8.208
8.203
8.195
8.174
8.120
8.098
7.783
7.760
7.712
7.690
7.260
5.920
5.916
5.911
5.907
5.145
5.006
5.003
4.999
4.996
4.993
4.990
4.375
4.371
4.362
4.356
4.351
4.133
4.016
4.010
1.560
1.416
1.411
1.337
1.324
1H NMR (400 MHz, CDCl3)
2w
1.96
2.10
3.17
0.98
1.07
1.00
2.10
2.12
2.16
4.04
2.06
2.04
6.32
6.07
12.05
f1 (ppm)

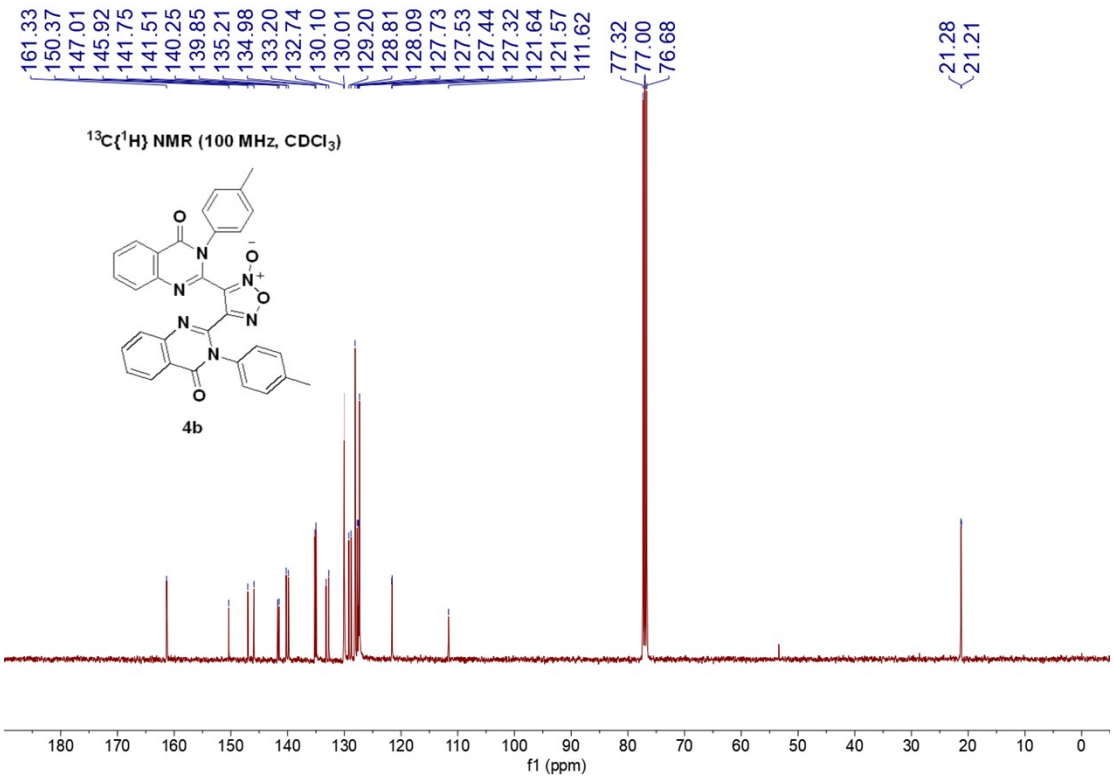

164.82
155.97
149.44
149.33
148.93
146.18
138.13
138.08
131.08
130.12
129.92
129.64
128.72
128.68
127.36
127.01
121.64
121.44
114.49
113.28
110.02
104.30
77.86
77.81
77.32
77.00
76.68
75.24
73.82
65.93
26.70
26.38
24.89
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
2w
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)

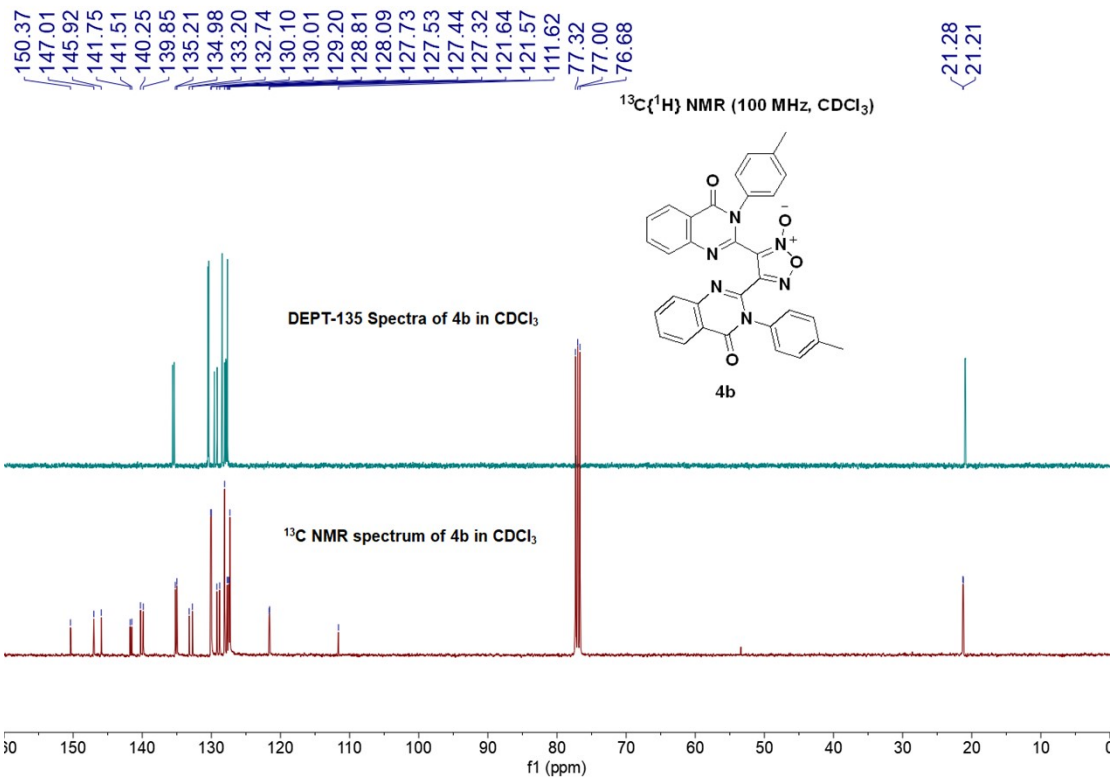

155.97
149.44
149.33
148.93
146.18
138.13
138.08
131.08
130.12
129.92
129.64
128.72
128.68
127.36
127.01
121.64
121.44
114.49
113.28
110.02
104.30
77.86
77.81
77.32
77.00
76.68
75.24
73.82
65.93
26.70
26.38
24.89
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
2w
DEPT-90 Spectra of 2w in $CDCl_3$
DEPT-135 Spectra of 2w in $CDCl_3$
^{13}C NMR spectrum of 2w in $CDCl_3$
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

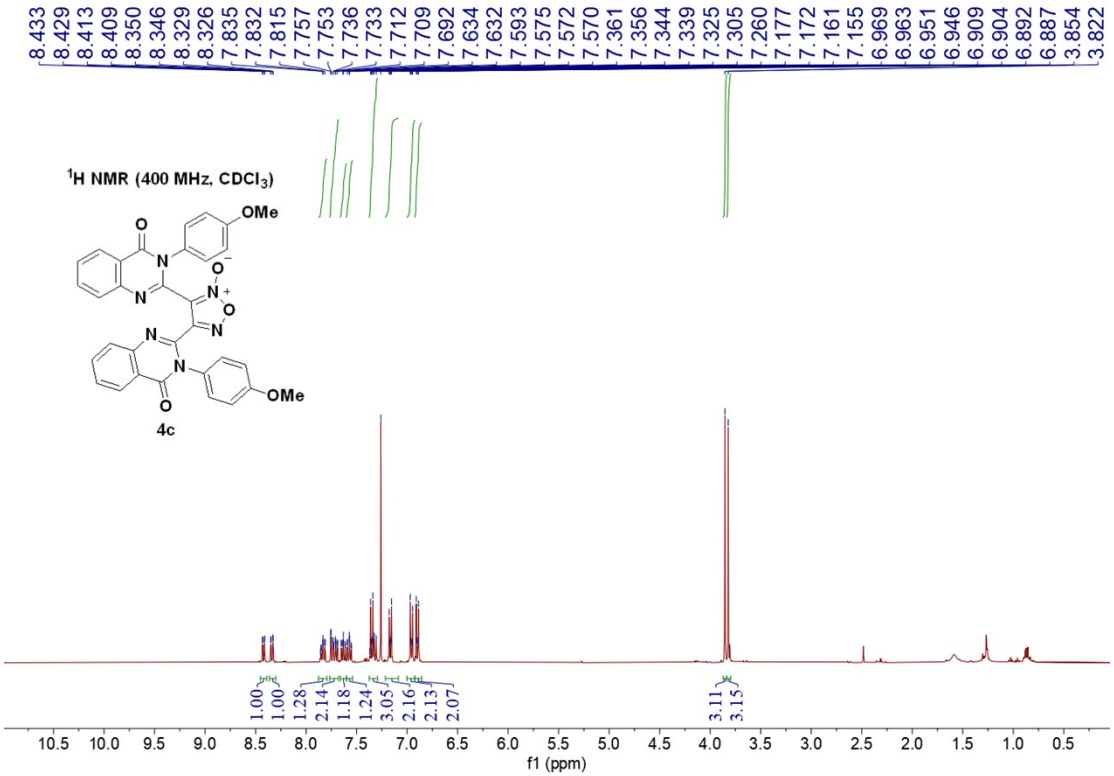

8.446
8.442
8.426
8.422
8.359
8.355
8.339
8.335
7.849
7.831
7.828
7.781
7.778
7.760
7.727
7.725
7.723
7.648
7.589
7.587
7.584
7.480
7.474
7.466
7.463
7.459
7.455
7.452
7.442
7.439
7.434
7.427
7.423
7.346
7.343
7.326
7.323
7.260
7.250
7.246
7.244
7.238
7.235
7.228
7.226
1H NMR (400 MHz, CDCl3)
Ph
Ph
4a
1.00
1.00
1.09
2.07
1.05
1.09
8.07
1.00
1.82
f1 (ppm)

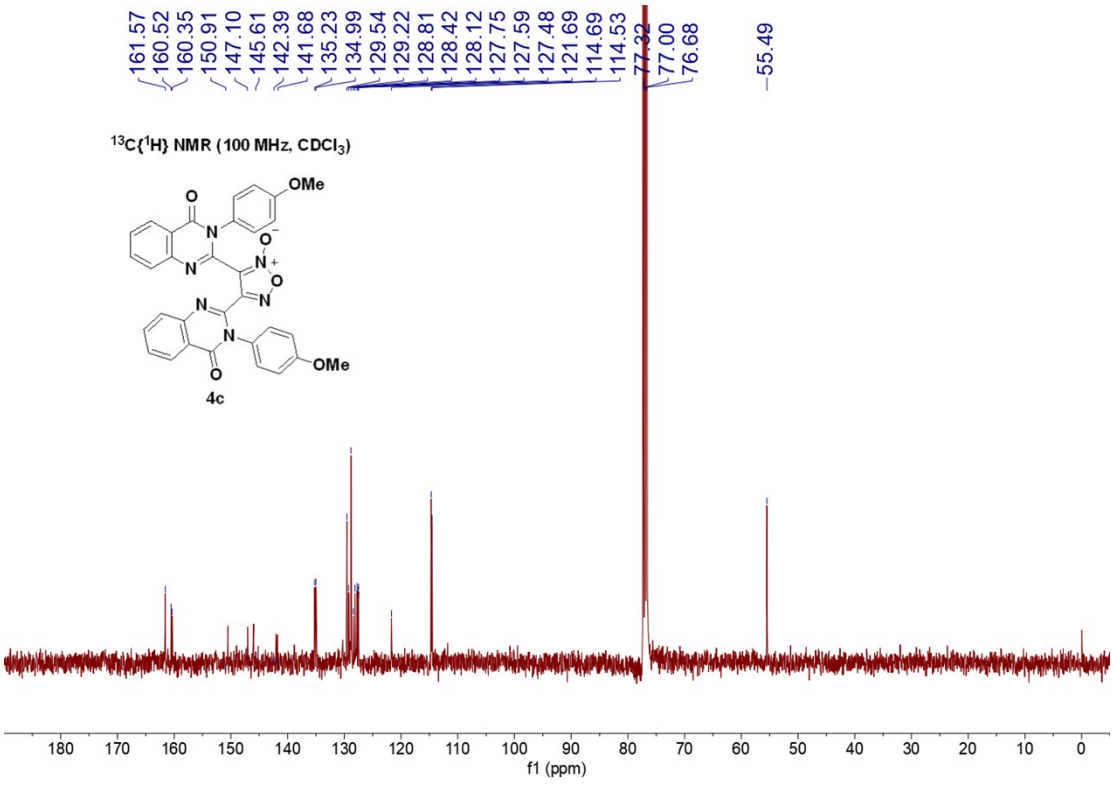

161.24
150.35
147.00
145.94
141.62
141.33
135.92
135.39
135.31
135.08
130.04
129.75
129.48
129.36
129.32
128.91
128.47
128.17
127.77
127.70
127.58
127.47
121.67
121.63
111.57
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Ph
Ph
4a
f1 (ppm)

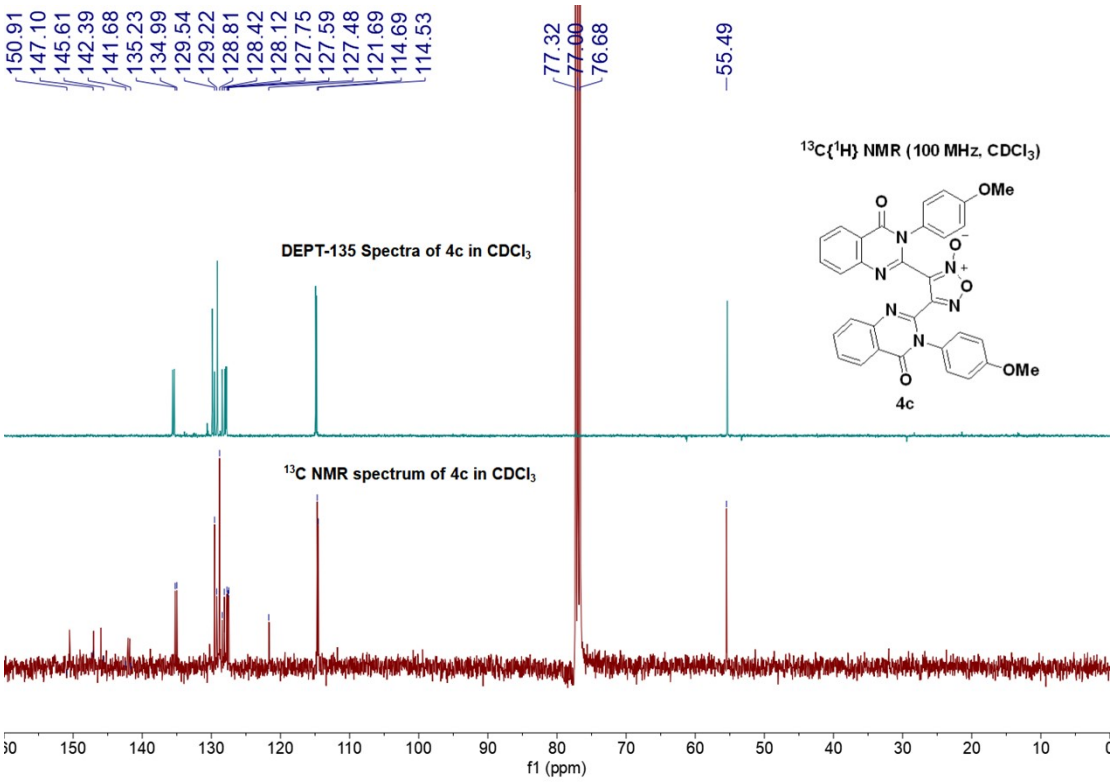

150.35
147.00
145.94
141.62
141.33
135.92
135.39
135.31
135.08
130.04
129.75
129.48
129.36
129.32
128.91
128.47
128.17
127.77
127.70
127.58
127.47
121.67
121.63
111.57
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 4a in CDCl3
13C NMR spectrum of 4a in CDCl3
4a
f1 (ppm)
8.441
8.437
8.421
8.417
8.355
8.352
8.335
8.332
7.849
7.846
7.832
7.828
7.786
7.783
7.765
7.762
7.718
7.715
7.712
7.698
7.694
7.664
7.661
7.646
7.643
7.599
7.596
7.581
7.579
7.576
7.321
7.304
7.301
7.281
7.277
7.267
7.264
7.260
7.243
7.221
7.200
7.088
7.068
2.419
2.400
1H NMR (400 MHz, CDCl3)
4b
1.00
1.00
1.04
1.03
1.03
1.05
1.04
7.14
2.03
6.11
f1 (ppm)

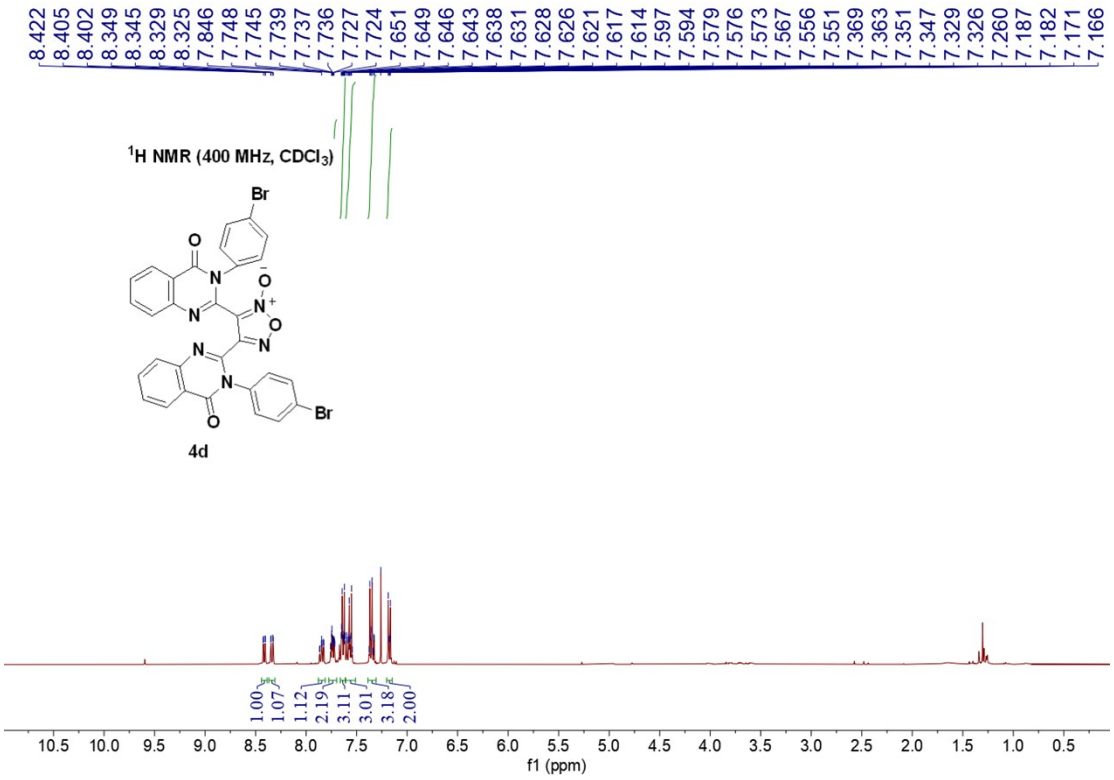

161.33
150.37
147.01
145.92
141.75
141.51
140.25
139.85
135.21
134.98
133.20
132.74
130.10
130.01
129.20
128.81
128.09
127.73
127.53
127.44
127.32
121.64
121.57
111.62
77.32
77.00
76.68
21.28
21.21
13C{1H} NMR (100 MHz, CDCl3)
4b
f1 (ppm)

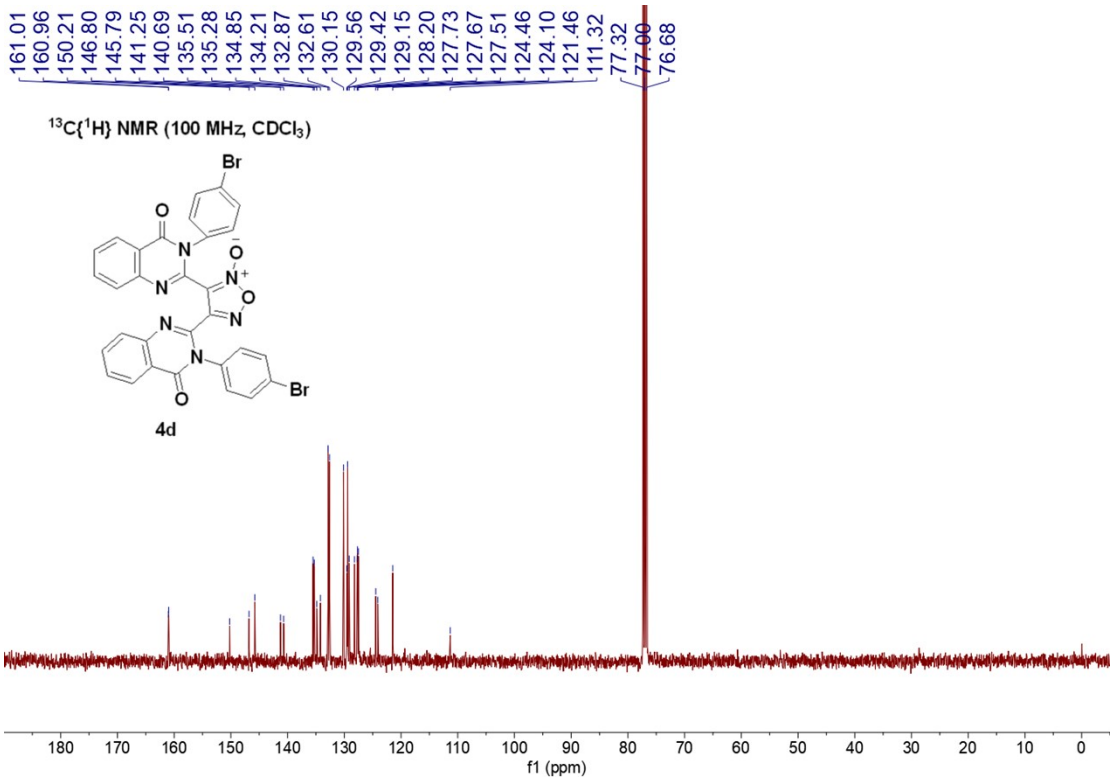

150.37
147.01
145.92
141.75
141.51
140.25
139.85
135.21
134.98
133.20
132.74
130.10
130.01
129.20
128.81
128.09
127.73
127.53
127.44
127.32
121.64
121.57
111.62
77.32
77.00
76.68
21.28
21.21
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 4b in CDCl3
13C NMR spectrum of 4b in CDCl3
4b
f1 (ppm)

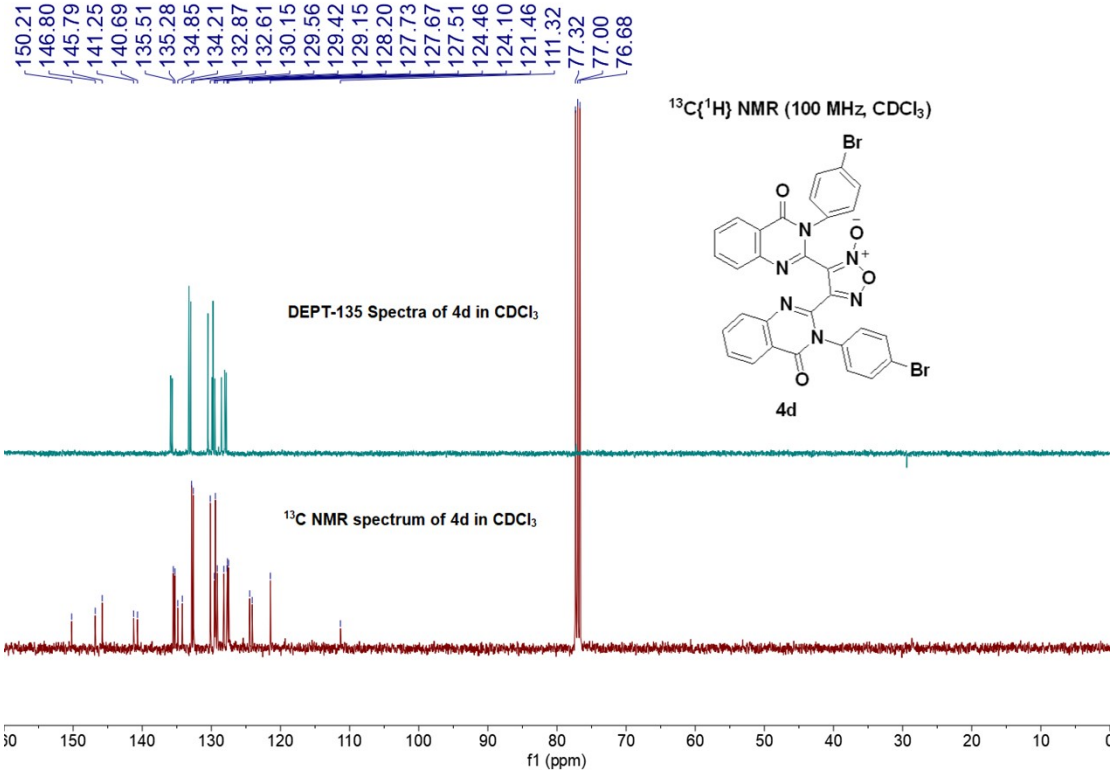

8.433
8.429
8.413
8.409
8.350
8.346
8.329
8.326
7.835
7.832
7.815
7.757
7.753
7.736
7.733
7.712
7.709
7.692
7.634
7.632
7.593
7.575
7.572
7.570
7.361
7.356
7.344
7.339
7.325
7.305
7.260
7.177
7.172
7.161
7.155
6.969
6.963
6.951
6.946
6.909
6.904
6.892
6.887
3.854
3.822
1H NMR (400 MHz, CDCl3)
OMe
OMe
4c
1.00
1.00
1.28
2.14
1.18
1.24
3.05
2.16
2.13
2.07
3.11
3.15
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

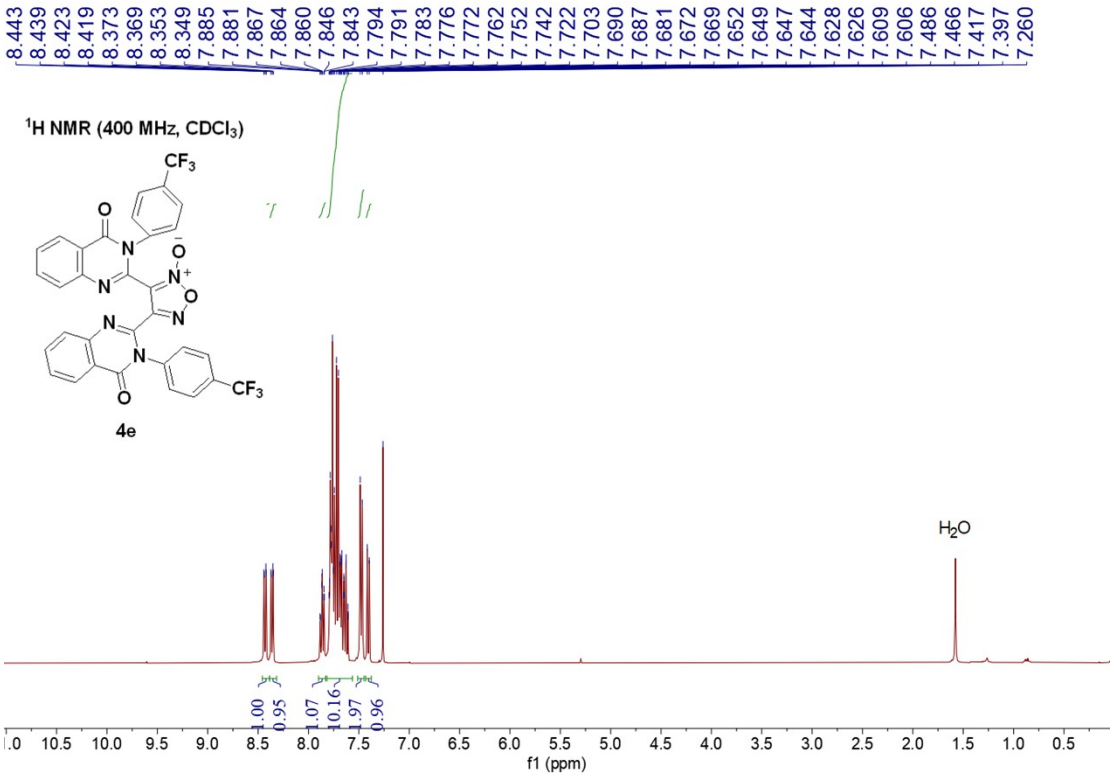

161.57
160.52
160.35
150.91
147.10
145.61
142.39
141.68
135.23
134.99
129.54
129.22
128.81
128.42
128.12
127.75
127.59
127.48
121.69
114.69
114.53
77.32
77.00
76.68
55.49
13C{1H} NMR (100 MHz, CDCl3)
OMe
OMe
4c
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

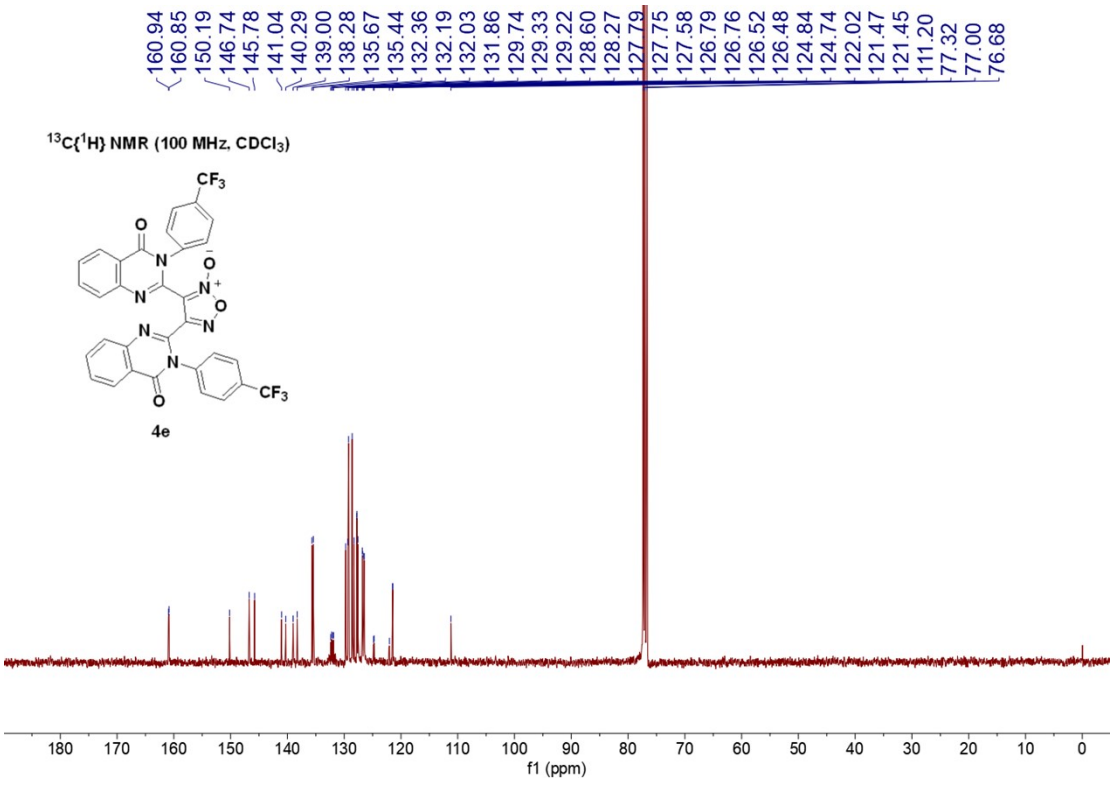

150.91
147.10
145.61
142.39
141.68
135.23
134.99
129.54
129.22
128.81
128.42
128.12
127.75
127.59
127.48
121.69
114.69
114.53
77.32
77.00
76.68
55.49
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 4c in CDCl3
13C NMR spectrum of 4c in CDCl3
OMe
OMe
4c
f1 (ppm)

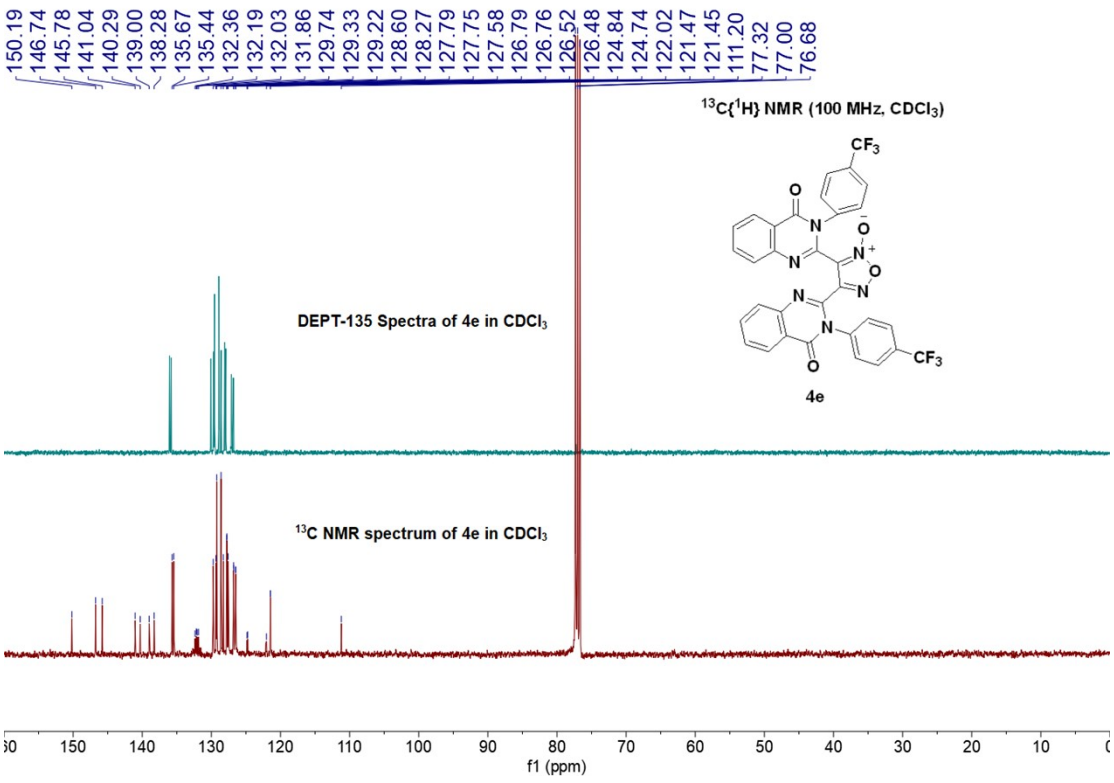

8.422
8.405
8.402
8.349
8.345
8.329
8.325
7.846
7.748
7.745
7.739
7.737
7.736
7.727
7.724
7.651
7.649
7.646
7.643
7.638
7.631
7.628
7.626
7.621
7.617
7.614
7.597
7.594
7.579
7.576
7.573
7.567
7.556
7.551
7.369
7.363
7.351
7.347
7.329
7.326
7.260
7.187
7.182
7.171
7.166
1H NMR (400 MHz, CDCl3)
Br
Br
4d
1.00
1.07
1.12
2.19
3.11
3.01
3.18
2.00
f1 (ppm)

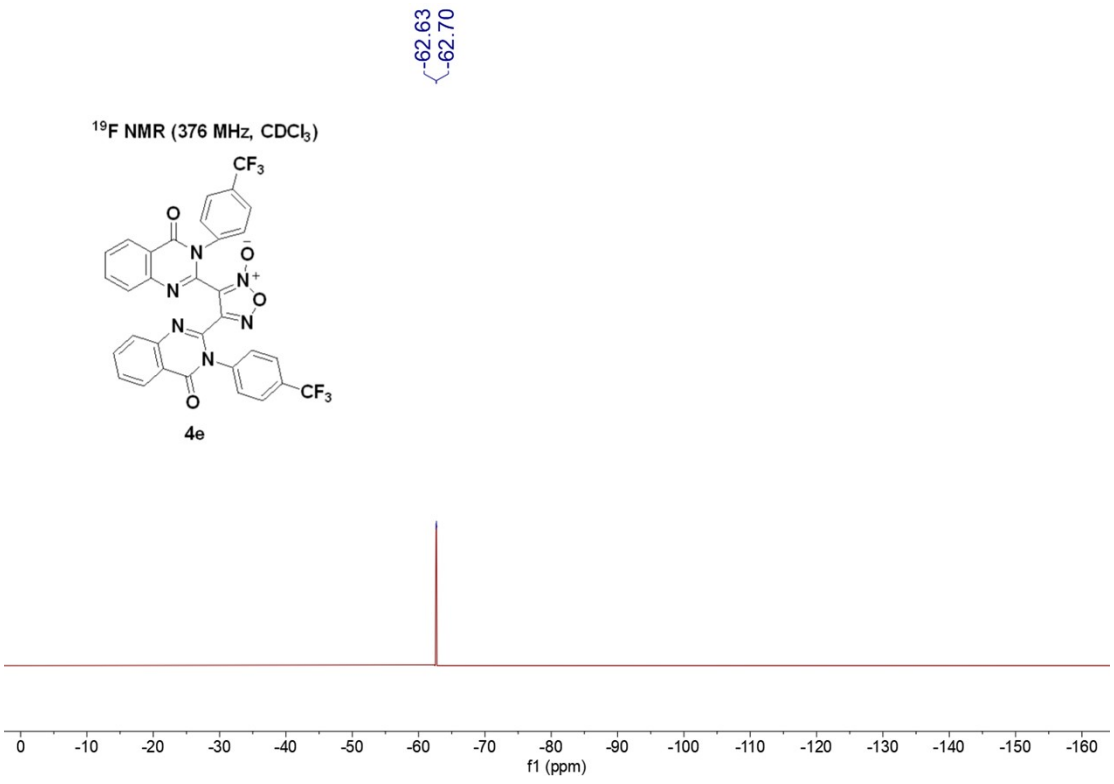

161.01
160.96
150.21
146.80
145.79
141.25
140.69
135.51
135.28
134.85
134.21
132.87
132.61
130.15
129.56
129.42
129.15
128.20
127.73
127.67
127.51
124.46
124.10
121.46
111.32
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Br
O
N
O
N+
O
N
N
N
O
Br
4d
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

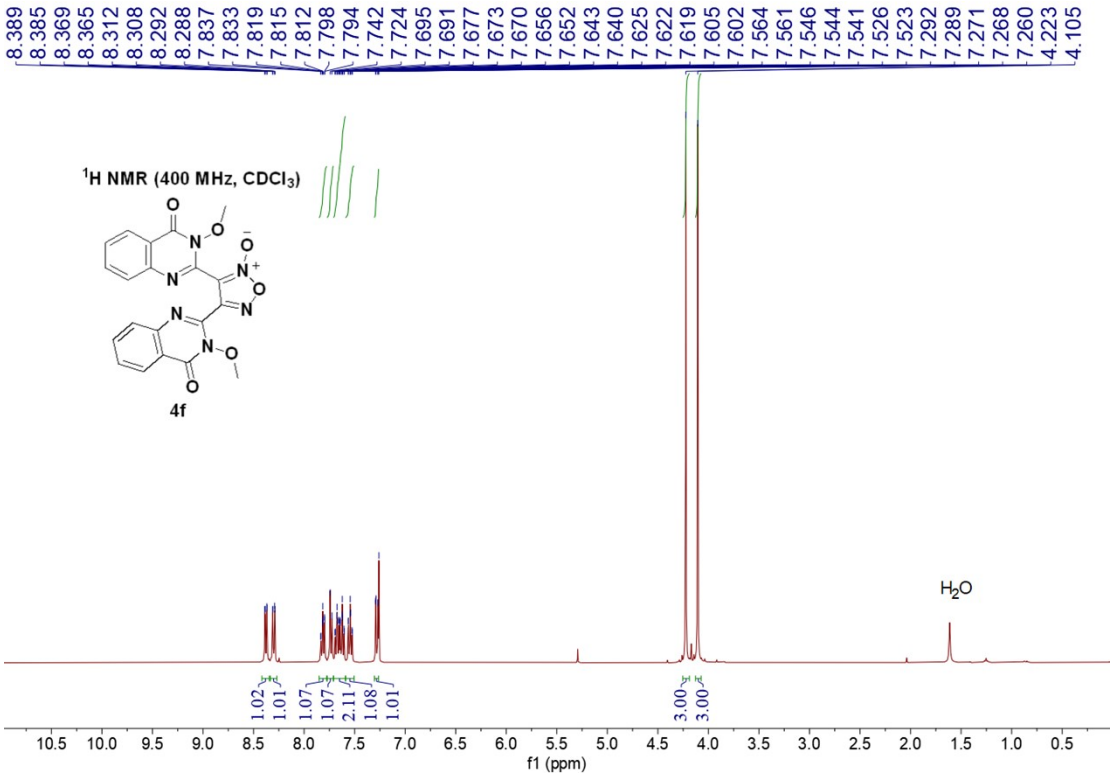

150.21
146.80
145.79
141.25
140.69
135.51
135.28
134.85
134.21
132.87
132.61
130.15
129.56
129.42
129.15
128.20
127.73
127.67
127.51
124.46
124.10
121.46
111.32
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Br
O
N
O
N+
O
N
N
N
O
Br
4d
DEPT-135 Spectra of 4d in CDCl3
13C NMR spectrum of 4d in CDCl3
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

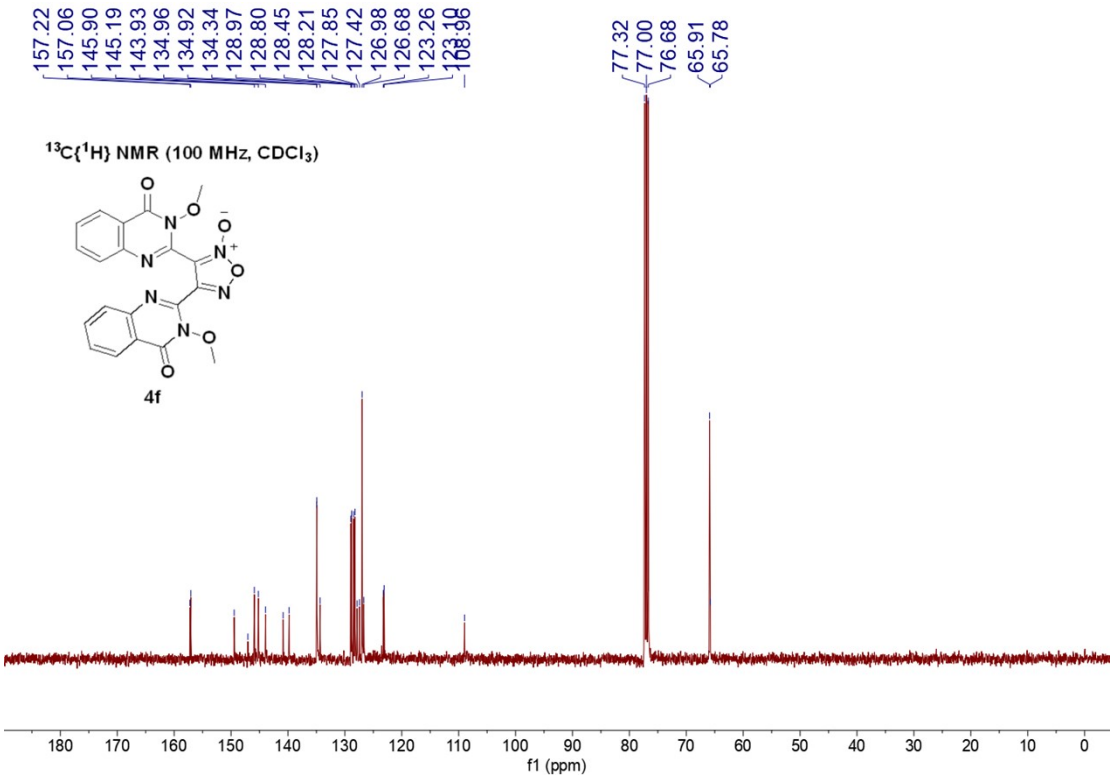

8.443
8.439
8.423
8.419
8.373
8.369
8.353
8.349
7.885
7.881
7.867
7.864
7.860
7.846
7.843
7.794
7.791
7.783
7.776
7.772
7.762
7.752
7.742
7.722
7.703
7.690
7.687
7.681
7.672
7.669
7.652
7.649
7.647
7.644
7.628
7.626
7.609
7.606
7.486
7.466
7.417
7.397
7.260
^{1}H NMR (400 MHz, CDCl$_3$)
CF$_3$
CF$_3$
4e
H$_2$O
1.00
0.95
1.07
10.16
1.97
0.96
f1 (ppm)

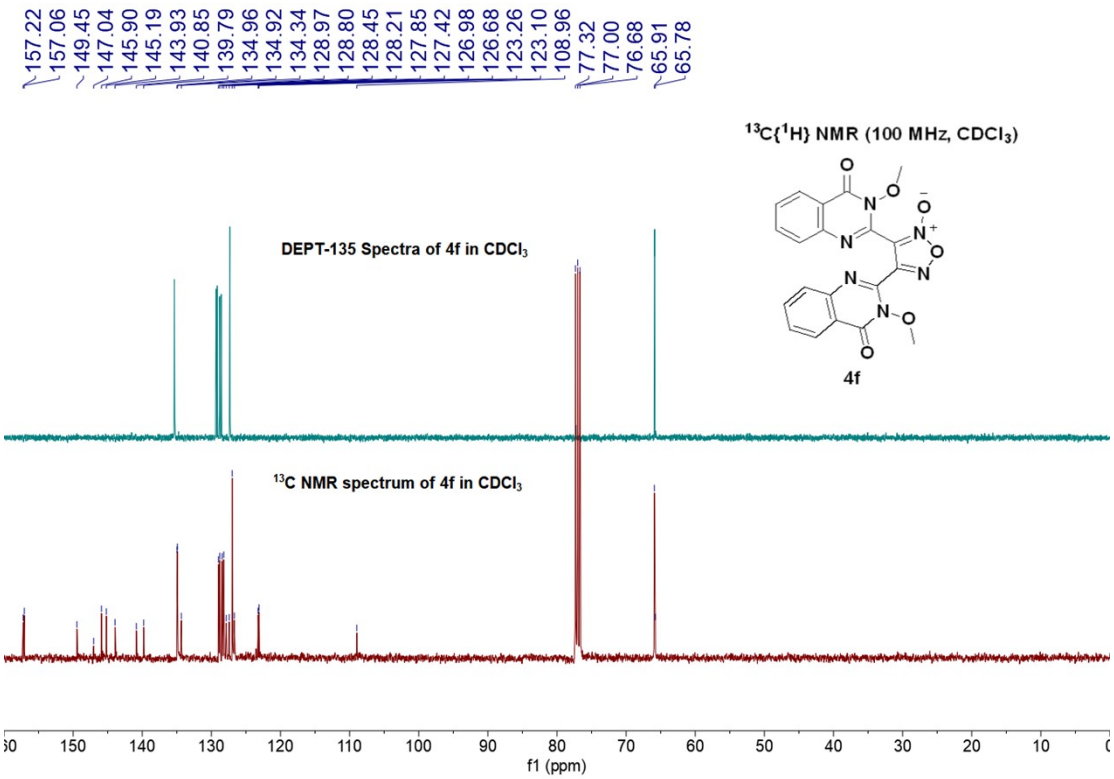

160.94
160.85
150.19
146.74
145.78
141.04
140.29
139.00
138.28
135.67
135.44
132.36
132.19
132.03
131.86
129.74
129.33
129.22
128.60
128.27
127.79
127.75
127.58
126.79
126.76
126.52
126.48
124.84
124.74
122.02
121.47
121.45
111.20
77.32
77.00
76.68
^{13}C{^{1}H} NMR (100 MHz, CDCl$_3$)
CF$_3$
CF$_3$
4e
f1 (ppm)

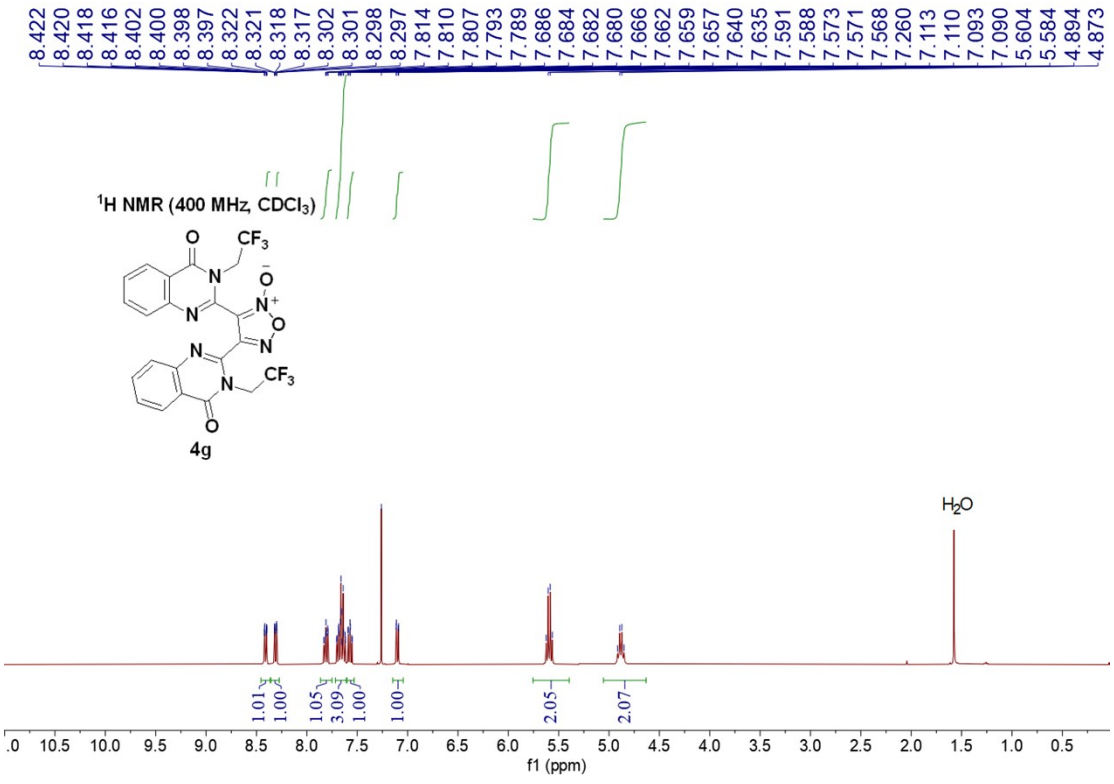

150.19
146.74
145.78
141.04
140.29
139.00
138.28
135.67
135.44
132.36
132.19
132.03
131.86
129.74
129.33
129.22
128.60
128.27
127.79
127.75
127.58
126.79
126.76
126.52
126.48
124.84
124.74
122.02
121.47
121.45
111.20
77.32
77.00
76.68
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
DEPT-135 Spectra of 4e in $CDCl_3$
^{13}C NMR spectrum of 4e in $CDCl_3$
f1 (ppm)

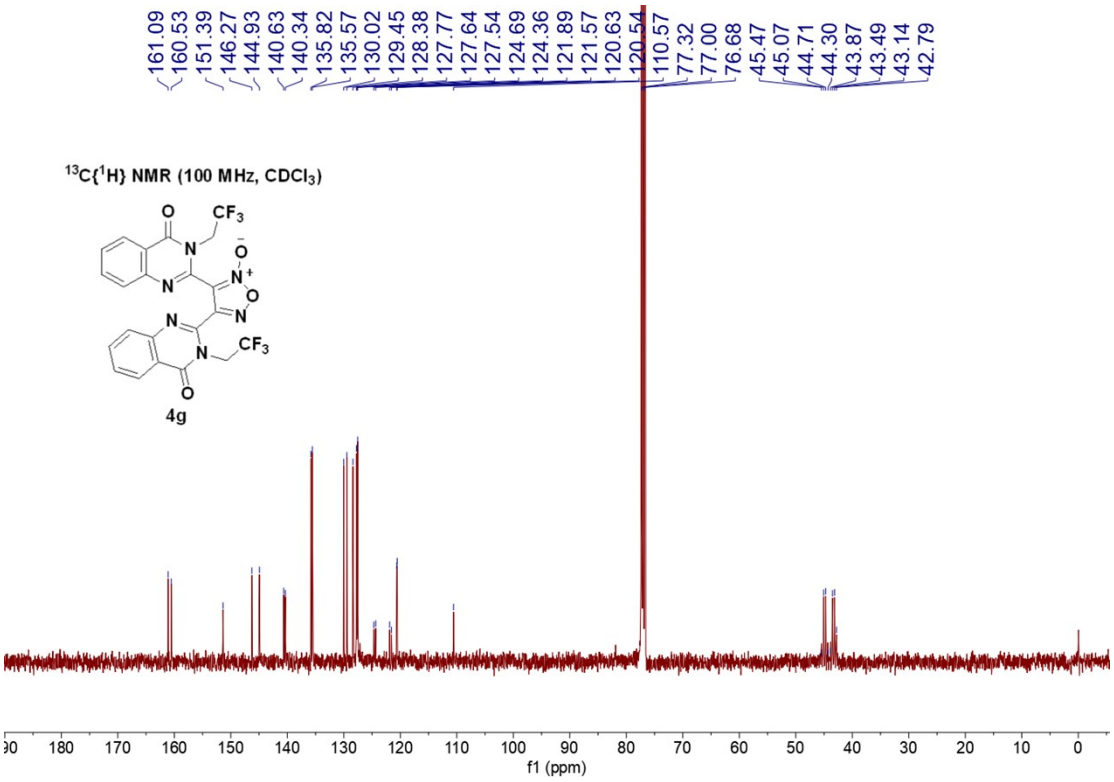

-62.63
-62.70
^{19}F NMR (376 MHz, $CDCl_3$)
4e
f1 (ppm)

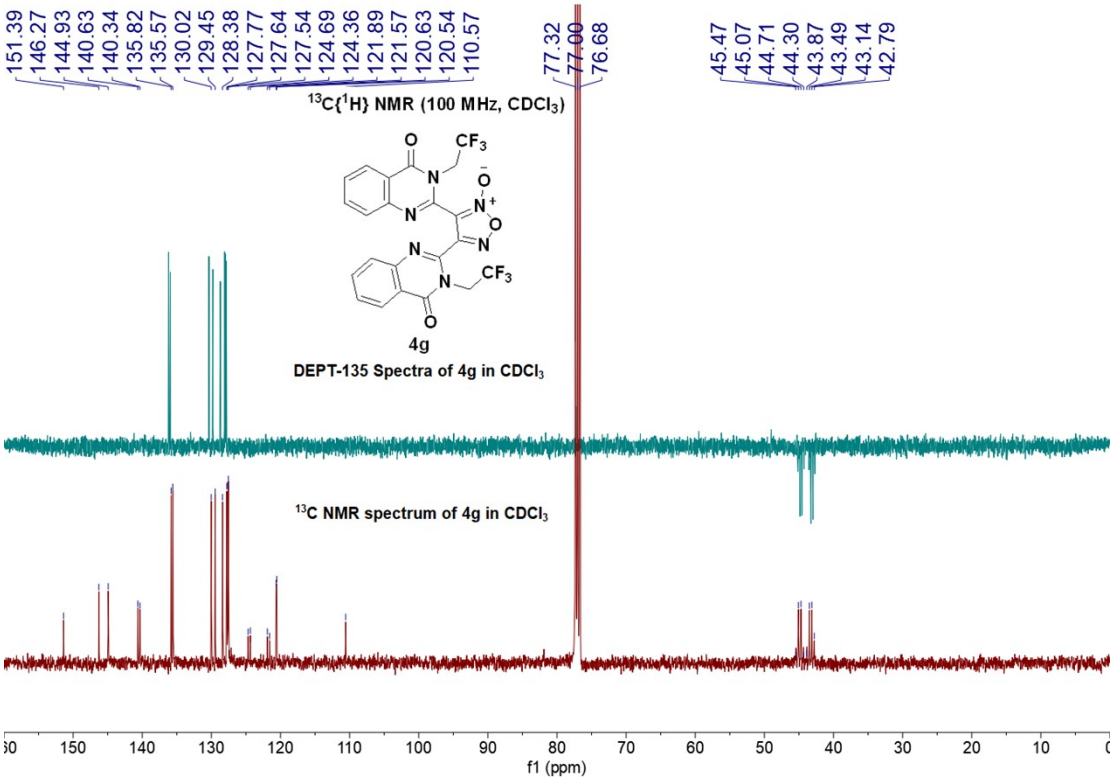

8.389
8.385
8.369
8.365
8.312
8.308
8.292
8.288
7.837
7.833
7.819
7.815
7.812
7.798
7.794
7.742
7.724
7.695
7.691
7.677
7.673
7.670
7.656
7.652
7.643
7.640
7.625
7.622
7.619
7.605
7.602
7.564
7.561
7.546
7.544
7.541
7.526
7.523
7.292
7.289
7.271
7.268
7.260
4.223
4.105
1H NMR (400 MHz, CDCl3)
4f
H2O
1.02
1.01
1.07
1.07
2.11
1.08
1.01
3.00
3.00
f1 (ppm)

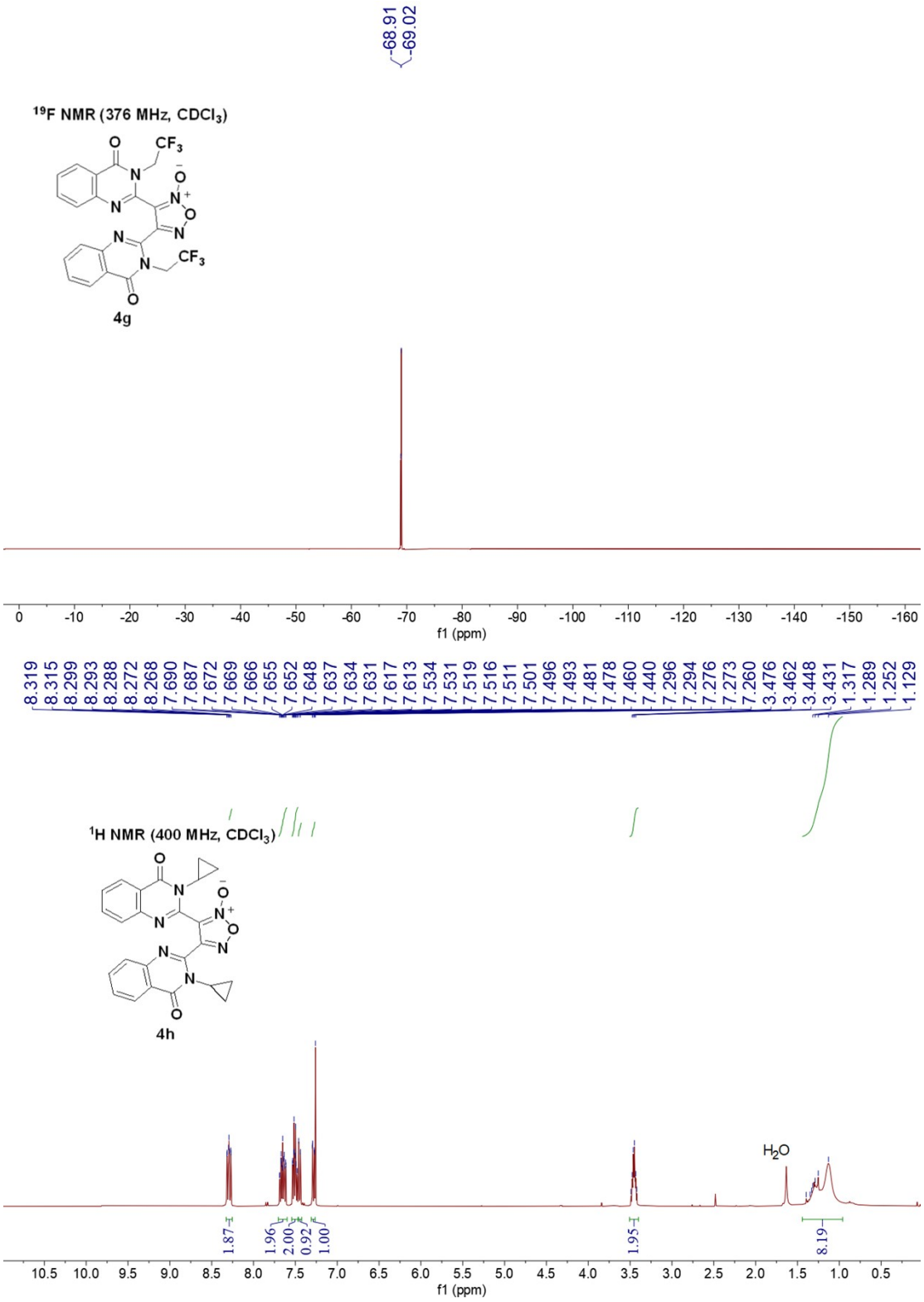

157.22
157.06
145.90
145.19
143.93
134.96
134.92
134.34
128.97
128.80
128.45
128.21
127.85
127.42
126.98
126.68
123.26
77.32
77.00
76.68
65.91
65.78
13C{1H} NMR (100 MHz, CDCl3)
4f
f1 (ppm)

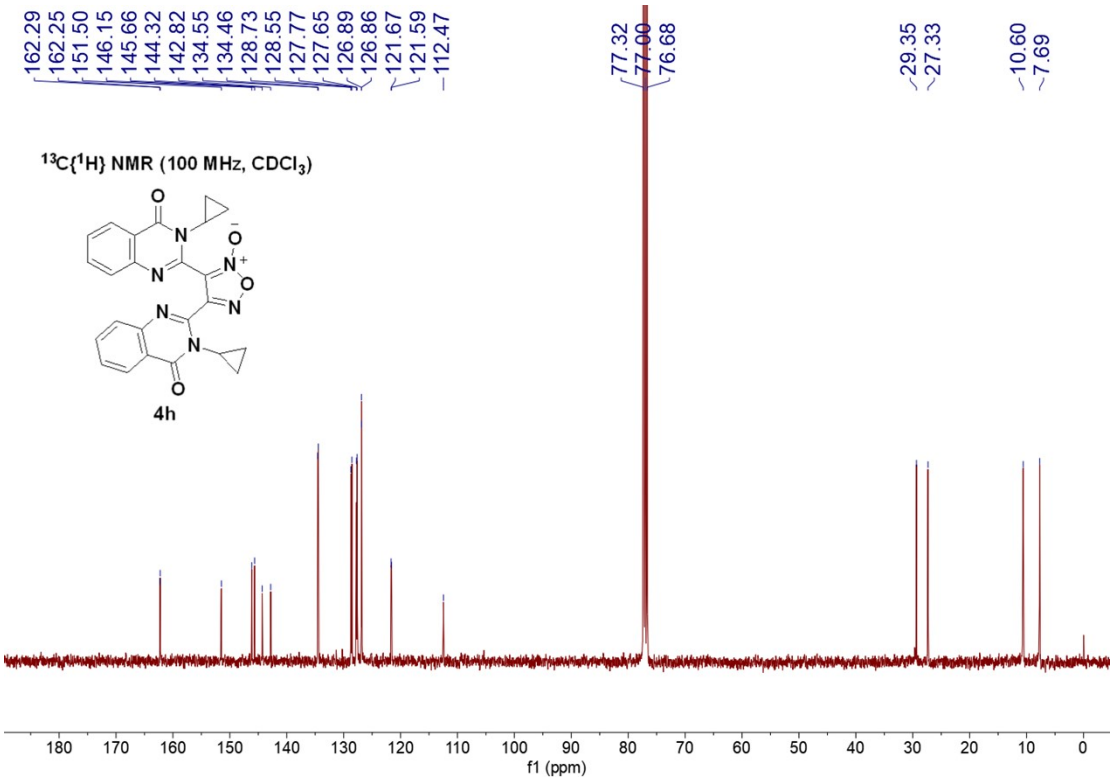

157.22
157.06
149.45
147.04
145.90
145.19
143.93
140.85
139.79
134.96
134.92
134.34
128.97
128.80
128.45
128.21
127.85
127.42
126.98
126.68
123.26
123.10
108.96
77.32
77.00
76.68
65.91
65.78
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 4f in CDCl3
13C NMR spectrum of 4f in CDCl3
4f
f1 (ppm)

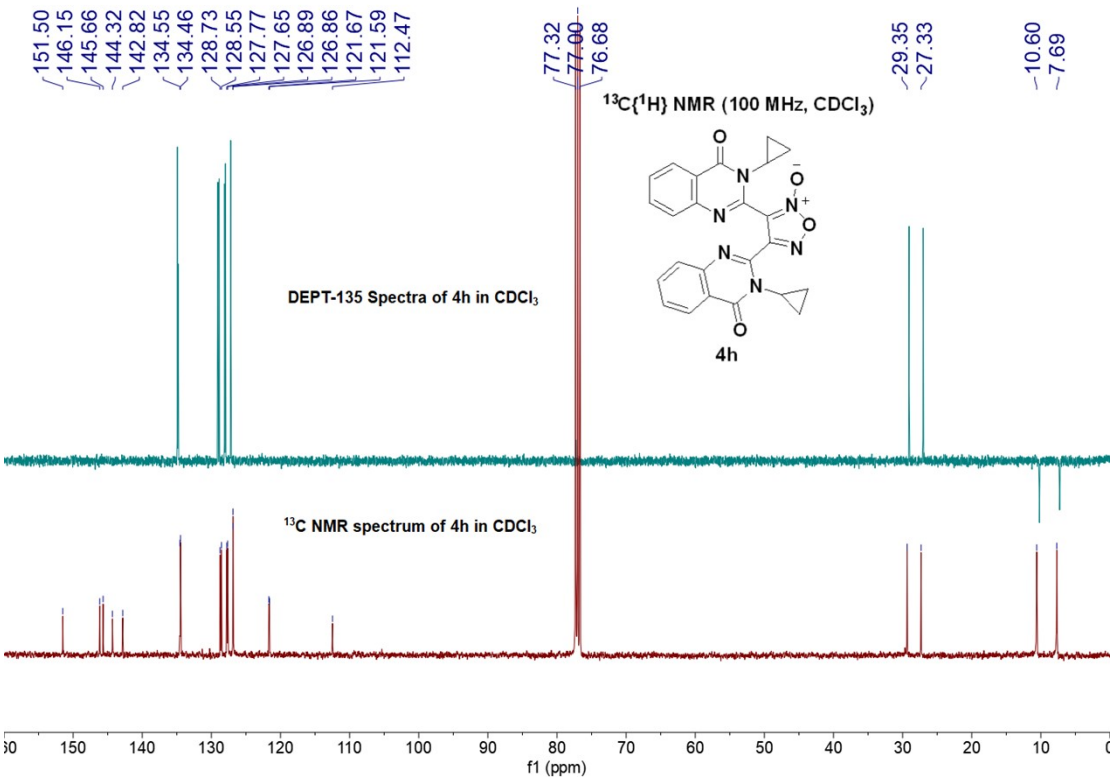

8.422
8.420
8.418
8.416
8.402
8.400
8.398
8.397
8.322
8.321
8.318
8.317
8.302
8.301
8.298
8.297
7.814
7.810
7.807
7.793
7.789
7.686
7.684
7.682
7.680
7.666
7.662
7.659
7.657
7.640
7.635
7.591
7.588
7.573
7.571
7.568
7.260
7.113
7.110
7.093
7.090
5.604
5.584
4.894
4.873
1H NMR (400 MHz, CDCl3)
4g
H2O
1.01
1.00
1.05
3.09
1.00
1.00
2.05
2.07
f1 (ppm)

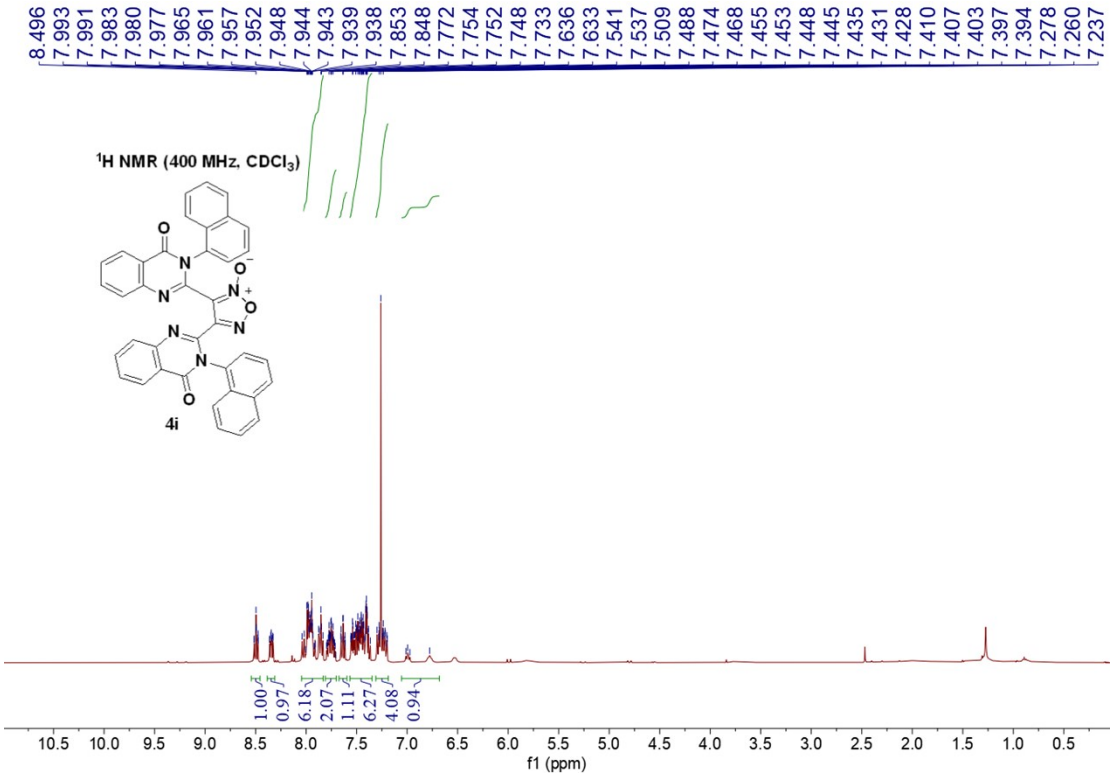

161.09
160.53
151.39
146.27
144.93
140.63
140.34
135.82
135.57
130.02
129.45
128.38
127.77
127.64
127.54
124.69
124.36
121.89
121.57
120.63
120.54
110.57
77.32
77.00
76.68
45.47
45.07
44.71
44.30
43.87
43.49
43.14
42.79
13C{1H} NMR (100 MHz, CDCl3)
4g
f1 (ppm)

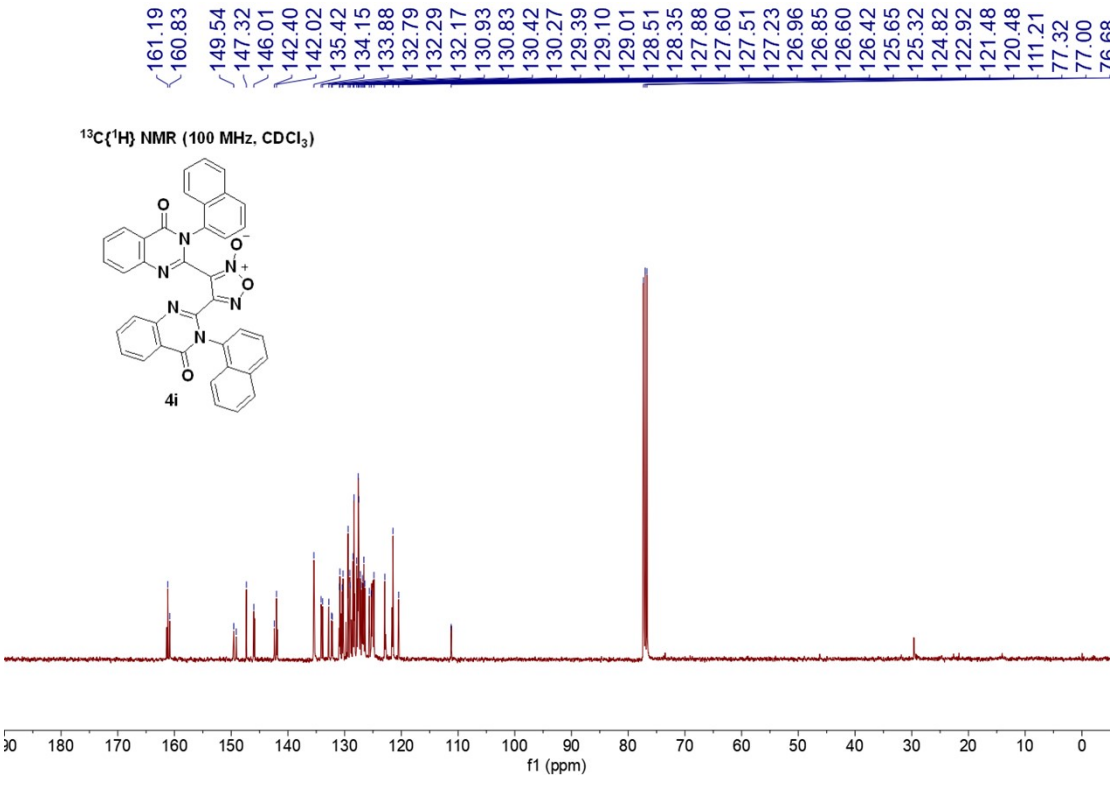

151.39
146.27
144.93
140.63
140.34
135.82
135.57
130.02
129.45
128.38
127.77
127.64
127.54
124.69
124.36
121.89
121.57
120.63
120.54
110.57
77.32
77.00
76.68
45.47
45.07
44.71
44.30
43.87
43.49
43.14
42.79
13C{1H} NMR (100 MHz, CDCl3)
4g
DEPT-135 Spectra of 4g in CDCl3
13C NMR spectrum of 4g in CDCl3
f1 (ppm)

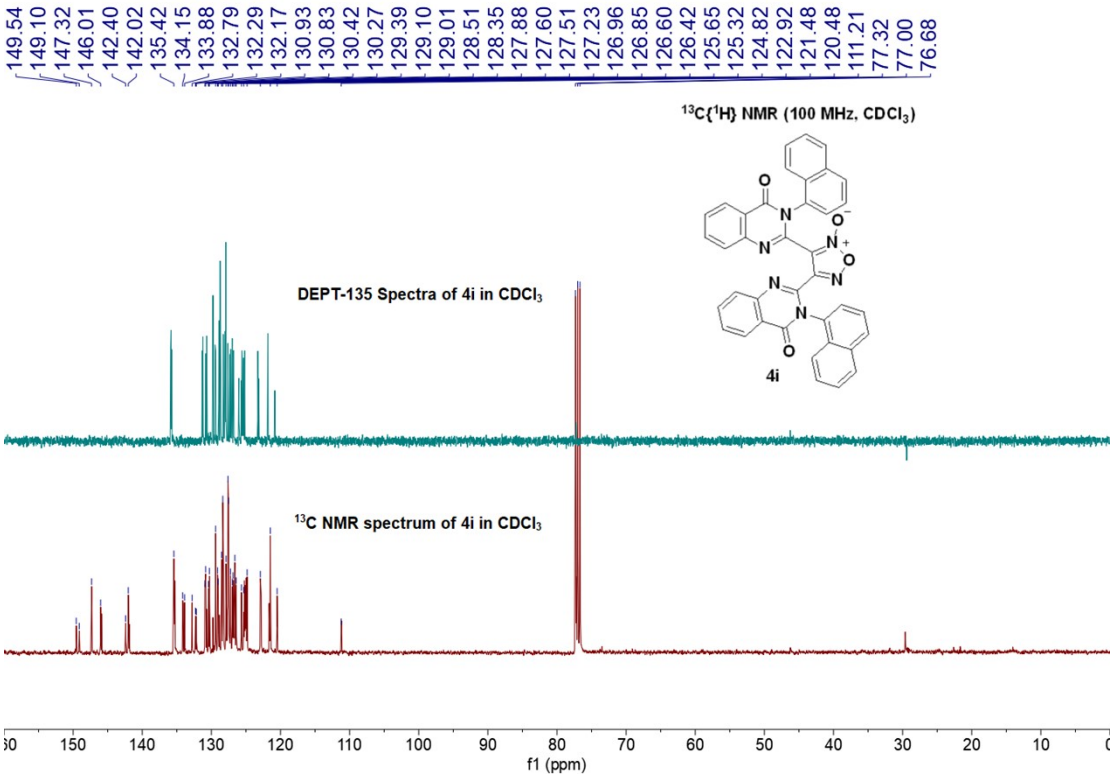

-68.91
-69.02
19F NMR (376 MHz, CDCl3)
4g
f1 (ppm)
8.319
8.315
8.299
8.293
8.288
8.272
8.268
7.690
7.687
7.672
7.669
7.666
7.655
7.652
7.648
7.637
7.634
7.631
7.617
7.613
7.534
7.531
7.519
7.516
7.511
7.501
7.496
7.493
7.481
7.478
7.460
7.440
7.296
7.294
7.276
7.273
7.260
3.476
3.462
3.448
3.431
1.317
1.289
1.252
1.129
1H NMR (400 MHz, CDCl3)
4h
H2O
1.87
1.96
2.00
0.92
1.00
1.95
8.19
f1 (ppm)

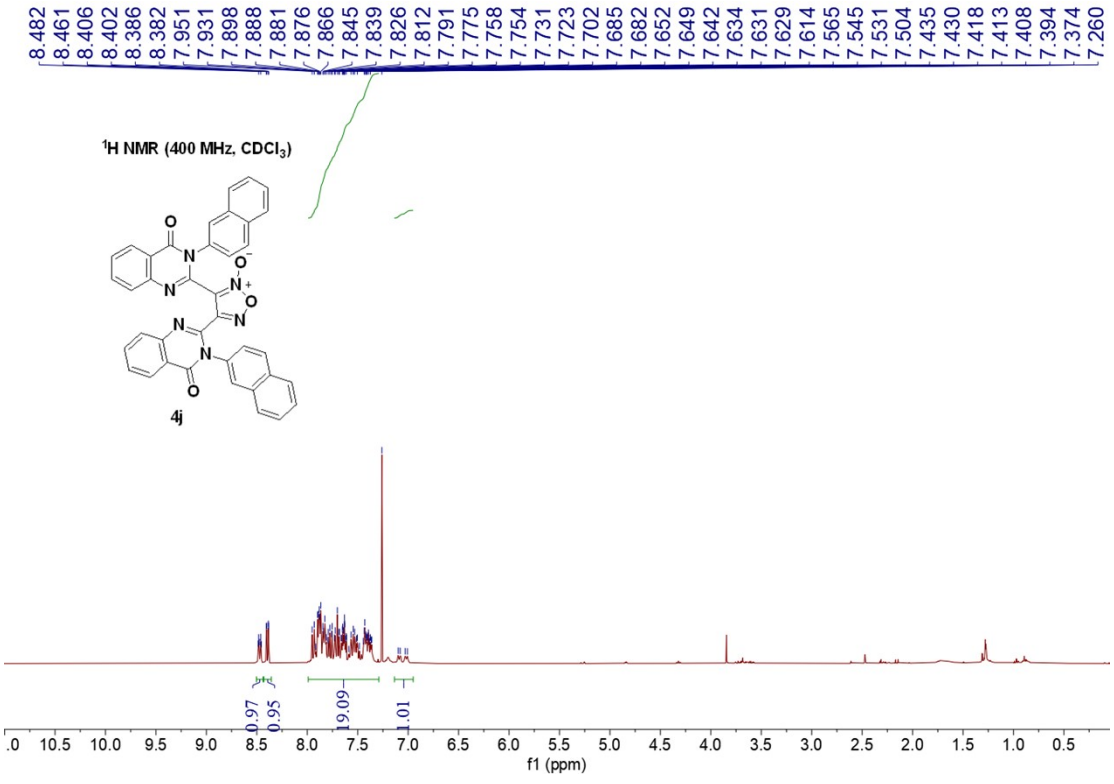

162.29
162.25
151.50
146.15
145.66
144.32
142.82
134.55
134.46
128.73
128.55
127.77
127.65
126.89
126.86
121.67
121.59
112.47
77.32
77.00
76.68
29.35
27.33
10.60
7.69
13C{1H} NMR (100 MHz, CDCl3)
4h
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

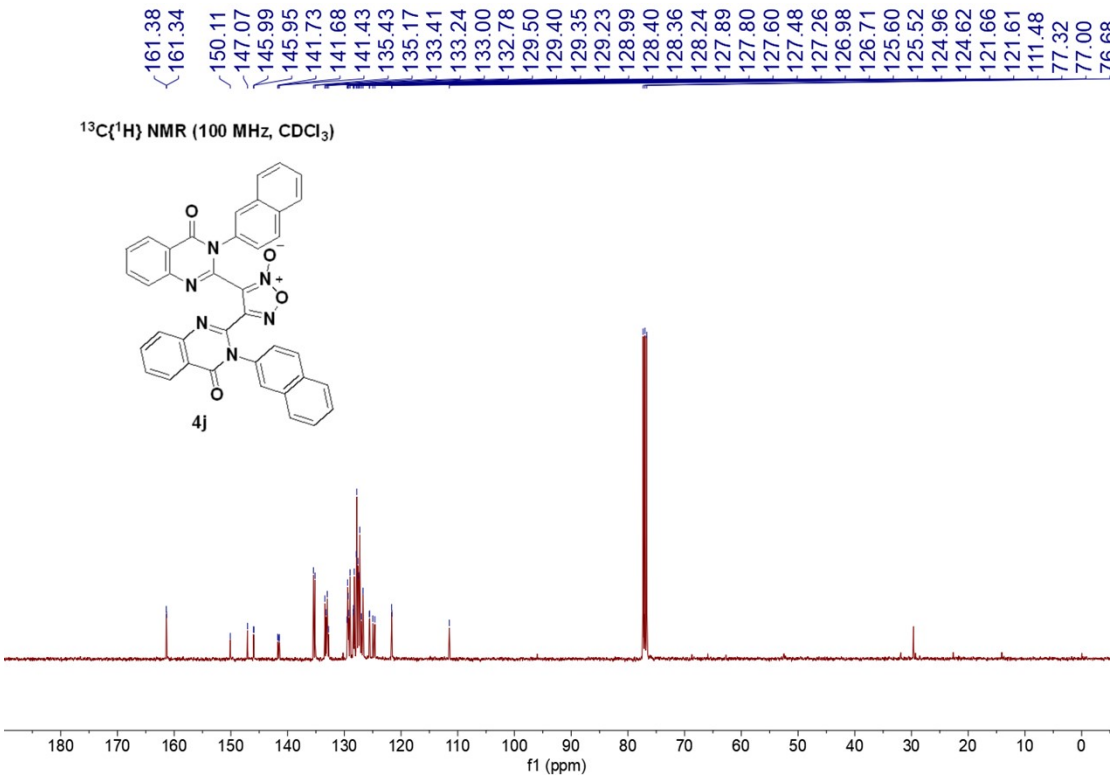

151.50
146.15
145.66
144.32
142.82
134.55
134.46
128.73
128.55
127.77
127.65
126.89
126.86
121.67
121.59
112.47
77.32
77.00
76.68
29.35
27.33
10.60
7.69
13C{1H} NMR (100 MHz, CDCl3)
4h
DEPT-135 Spectra of 4h in CDCl3
13C NMR spectrum of 4h in CDCl3
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

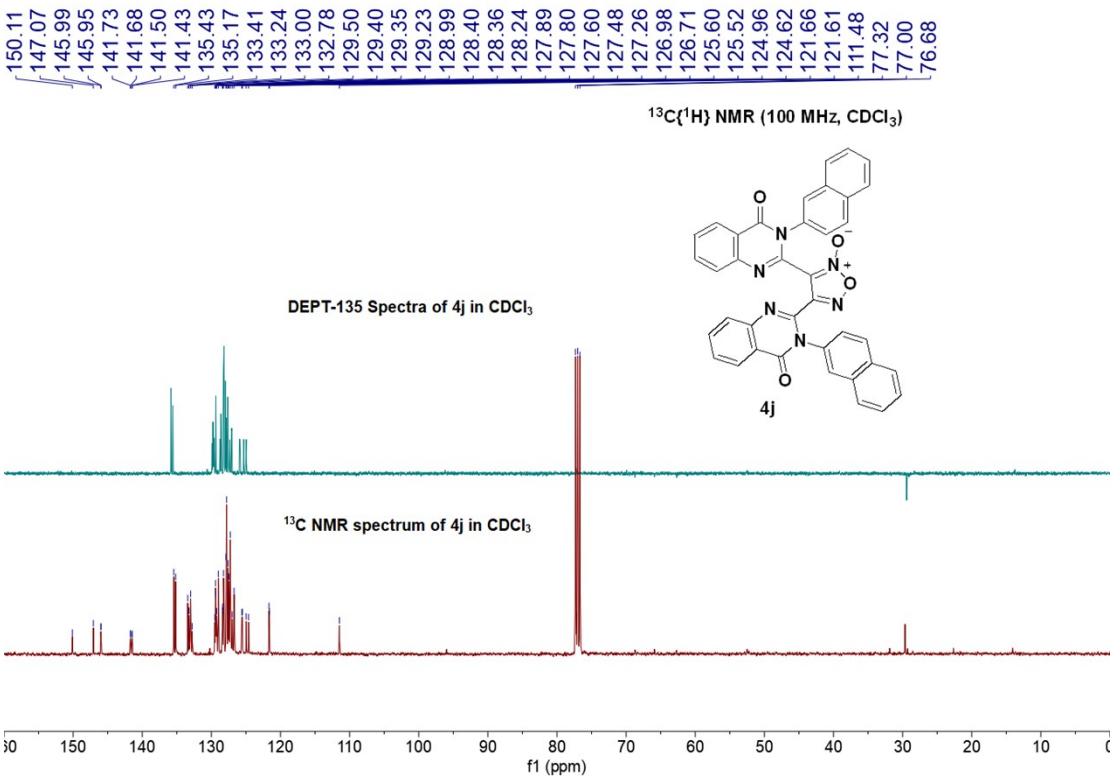

8.496
7.993
7.991
7.983
7.980
7.977
7.965
7.961
7.957
7.952
7.948
7.944
7.943
7.939
7.938
7.853
7.848
7.772
7.754
7.752
7.748
7.733
7.636
7.633
7.541
7.537
7.509
7.488
7.474
7.468
7.455
7.453
7.448
7.445
7.435
7.431
7.428
7.410
7.407
7.403
7.397
7.394
7.278
7.260
7.237
1H NMR (400 MHz, CDCl3)
4i
1.00
0.97
6.18
2.07
1.11
6.27
4.08
0.94
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

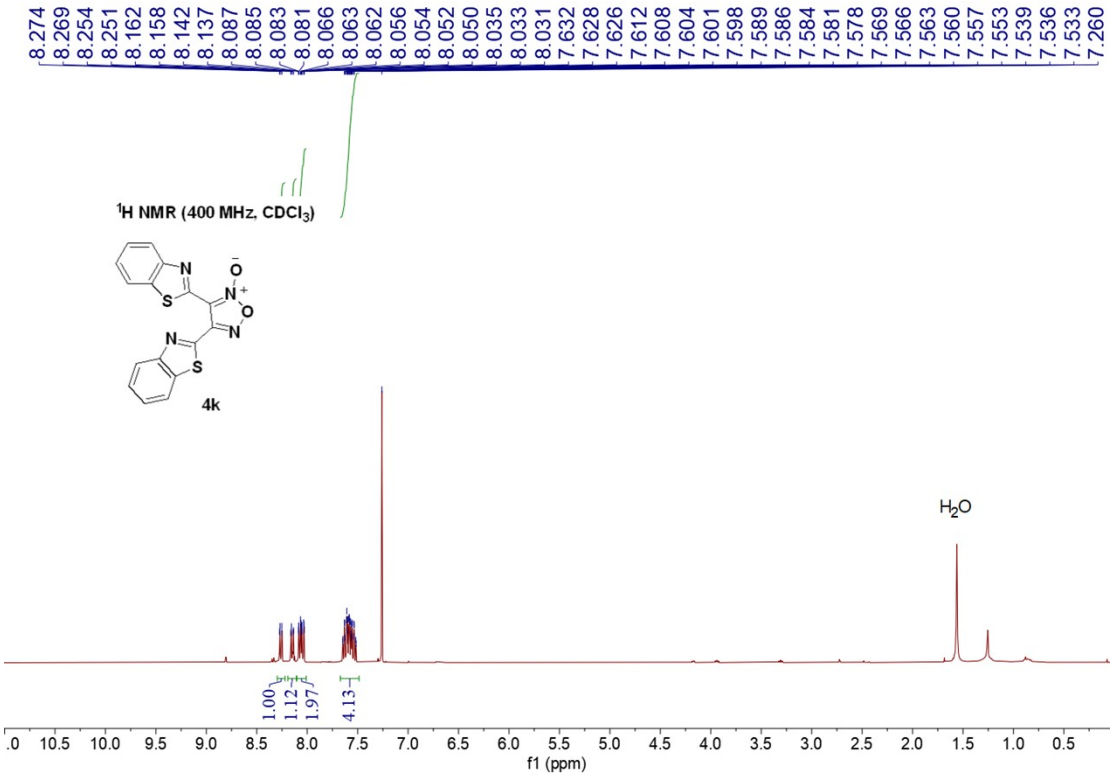

161.19
160.83
149.54
147.32
146.01
142.40
142.02
135.42
134.15
133.88
132.79
132.29
132.17
130.93
130.83
130.42
130.27
129.39
129.10
129.01
128.51
128.35
127.88
127.60
127.51
127.23
126.96
126.85
126.60
126.42
125.65
125.32
124.82
122.92
121.48
120.48
111.21
77.32
77.00
13C{1H} NMR (100 MHz, CDCl3)
4i
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

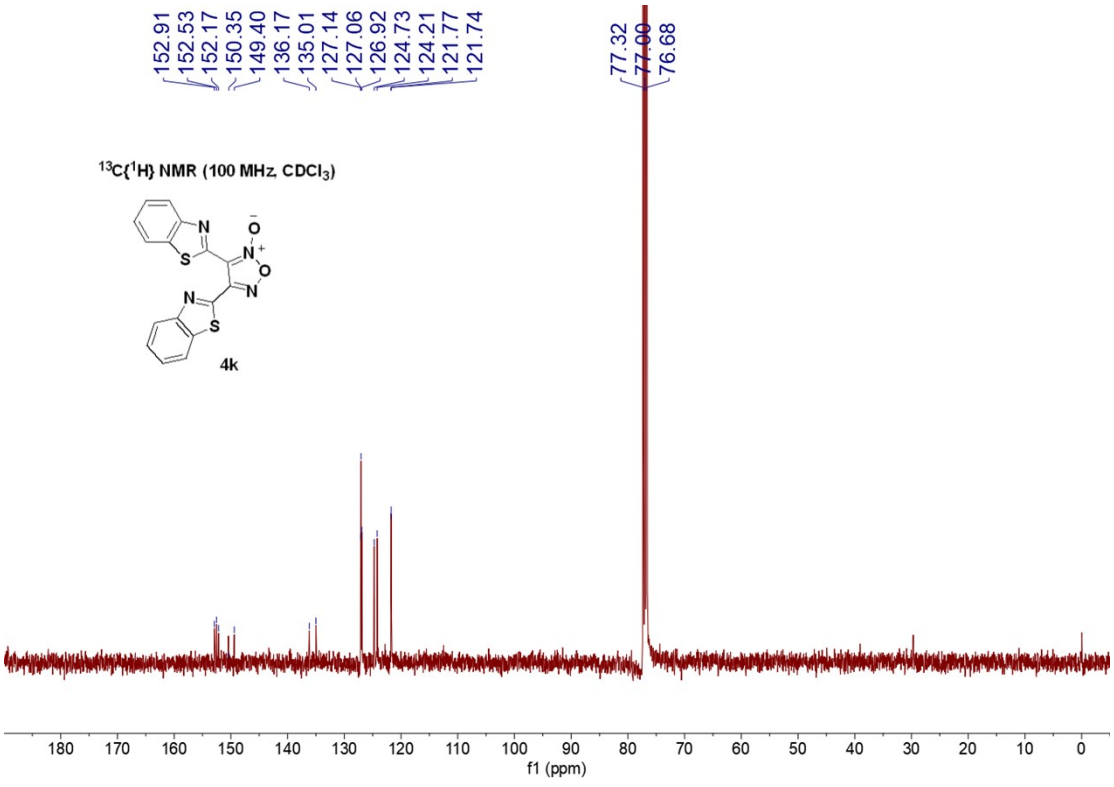

149.54
149.10
147.32
146.01
142.40
142.02
135.42
134.15
133.88
132.79
132.29
132.17
130.93
130.83
130.42
130.27
129.39
129.10
129.01
128.51
128.35
127.88
127.60
127.51
127.23
126.96
126.85
126.60
126.42
125.65
125.32
124.82
122.92
121.48
120.48
111.21
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
4i
DEPT-135 Spectra of 4i in CDCl3
13C NMR spectrum of 4i in CDCl3
f1 (ppm)

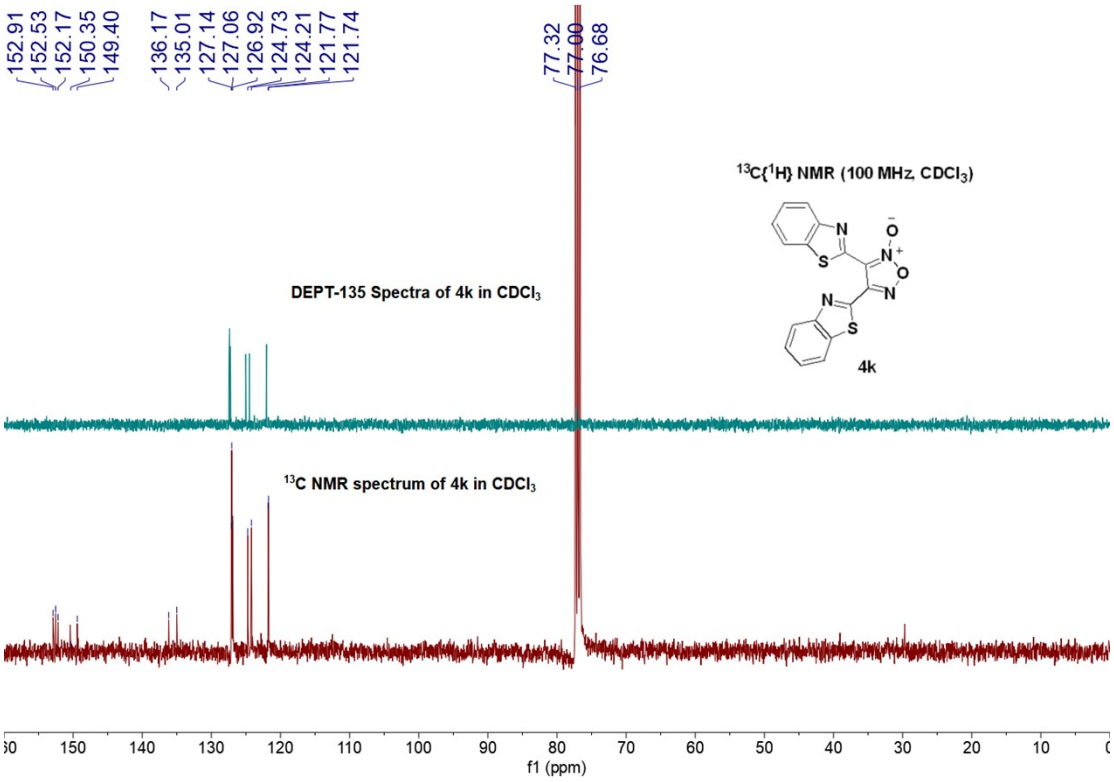

8.482
8.461
8.406
8.402
8.386
8.382
7.951
7.931
7.898
7.888
7.881
7.876
7.866
7.845
7.839
7.826
7.812
7.791
7.775
7.758
7.754
7.731
7.723
7.702
7.685
7.682
7.652
7.649
7.642
7.634
7.631
7.629
7.614
7.565
7.545
7.531
7.504
7.435
7.430
7.418
7.413
7.408
7.394
7.374
7.260
1H NMR (400 MHz, CDCl3)
4j
0.97
0.95
19.09
1.01
f1 (ppm)

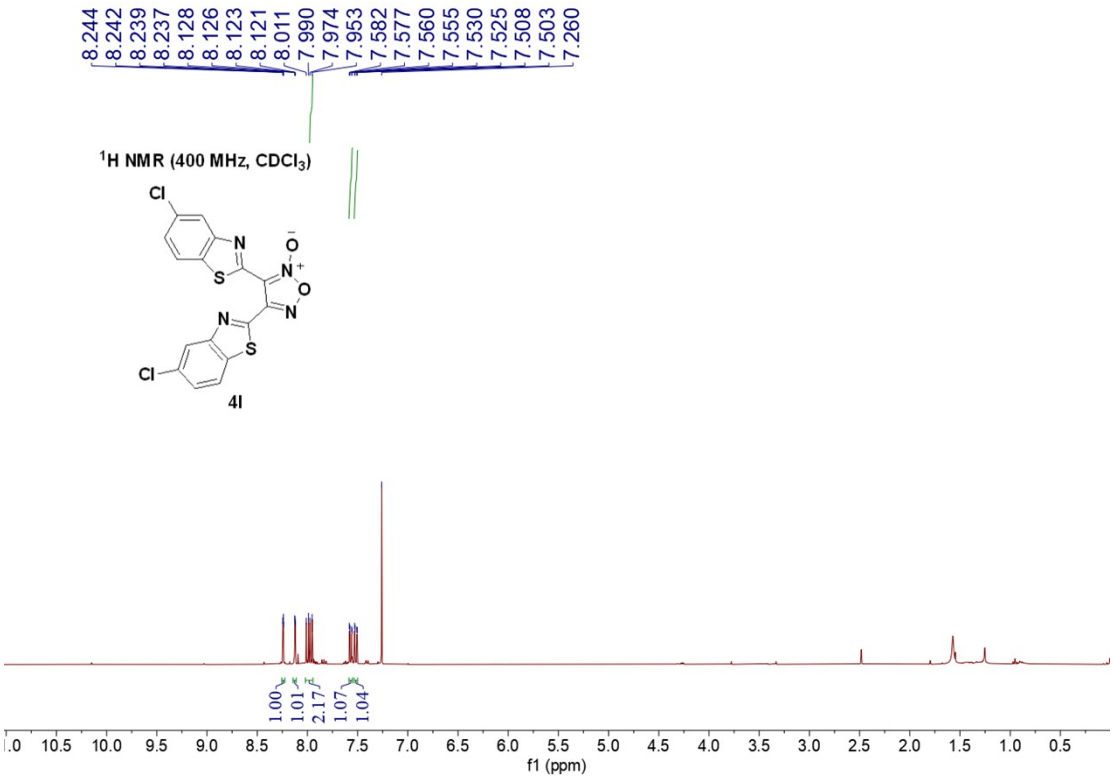

161.38
161.34
150.11
147.07
145.99
145.95
141.73
141.68
141.43
135.43
135.17
133.41
133.24
133.00
132.78
129.50
129.40
129.35
129.23
128.99
128.40
128.36
128.24
127.89
127.80
127.60
127.48
127.26
126.98
126.71
125.60
125.52
124.96
124.62
121.66
121.61
111.48
77.32
77.00
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
4j
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

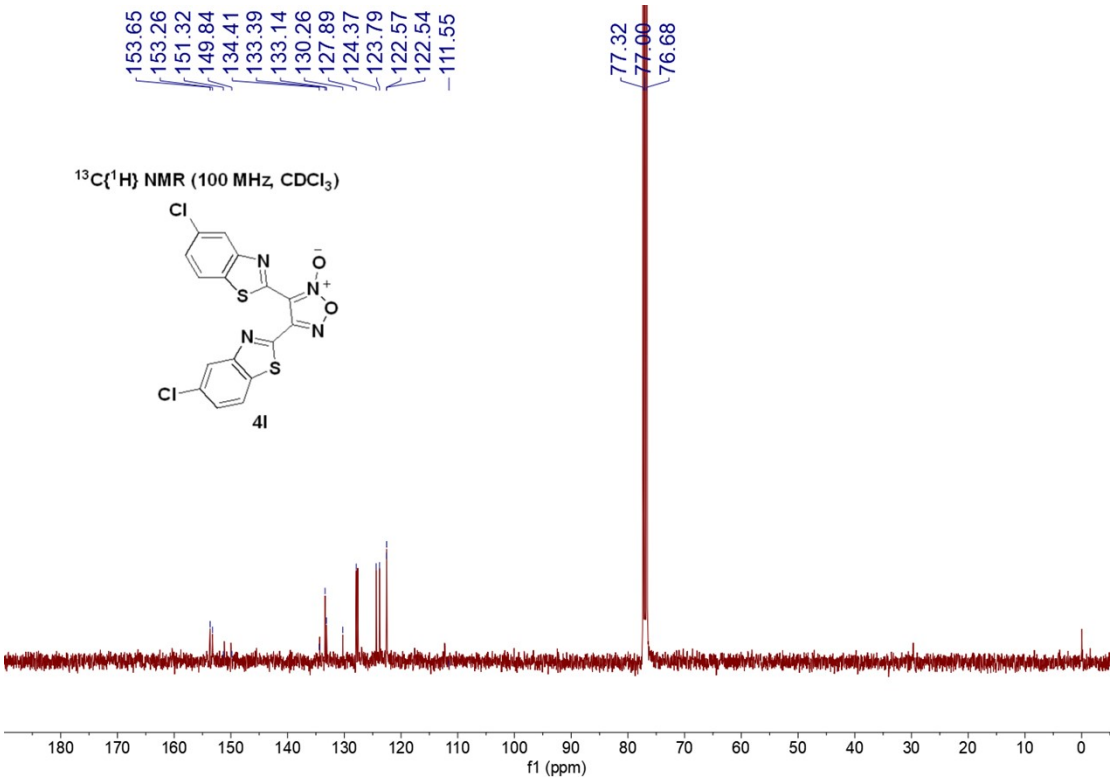

150.11
147.07
145.99
145.95
141.73
141.68
141.50
141.43
135.43
135.17
133.41
133.24
133.00
132.78
129.50
129.40
129.35
129.23
128.99
128.40
128.36
128.24
127.89
127.80
127.60
127.48
127.26
126.98
126.71
125.60
125.52
124.96
124.62
121.66
121.61
111.48
77.32
77.00
76.68
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
DEPT-135 Spectra of 4j in $CDCl_3$
^{13}C NMR spectrum of 4j in $CDCl_3$
4j
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

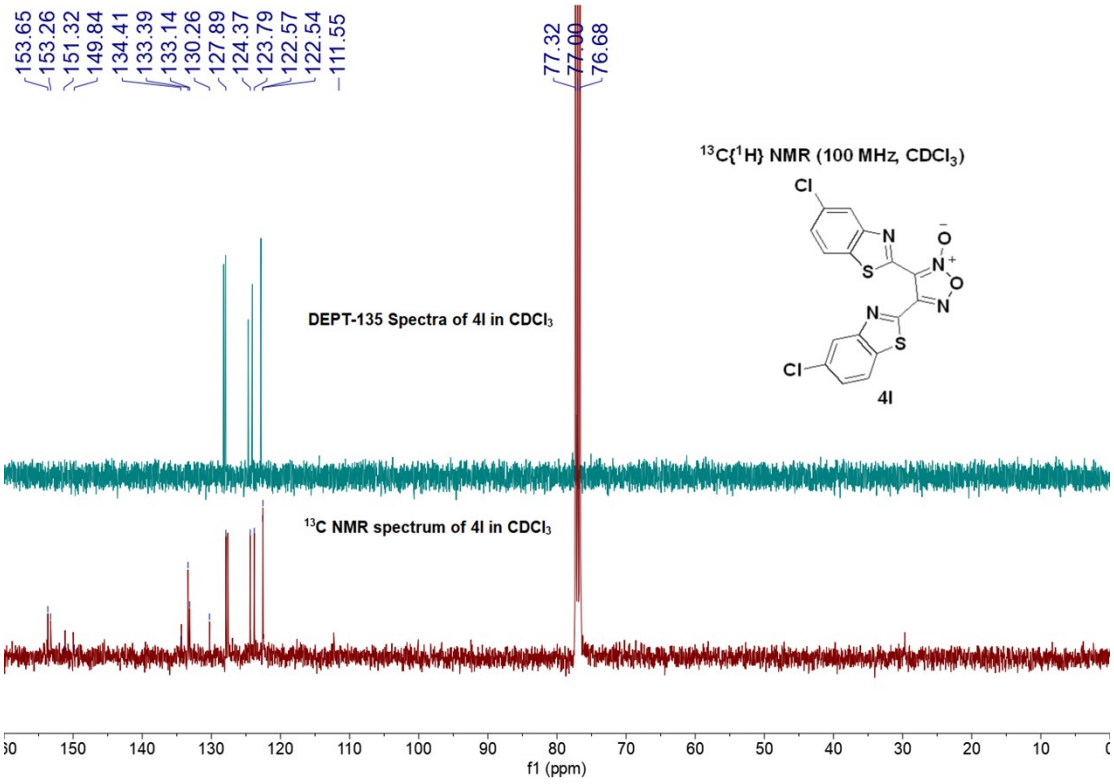

8.274
8.269
8.254
8.251
8.162
8.158
8.142
8.137
8.087
8.085
8.083
8.081
8.066
8.063
8.062
8.056
8.054
8.052
8.050
8.035
8.033
8.031
7.632
7.628
7.626
7.612
7.608
7.604
7.601
7.598
7.589
7.586
7.584
7.581
7.578
7.569
7.566
7.563
7.560
7.557
7.553
7.539
7.536
7.533
7.260
1H NMR (400 MHz, CDCl3)
4k
H2O
1.00
1.12
1.97
4.13
f1 (ppm)

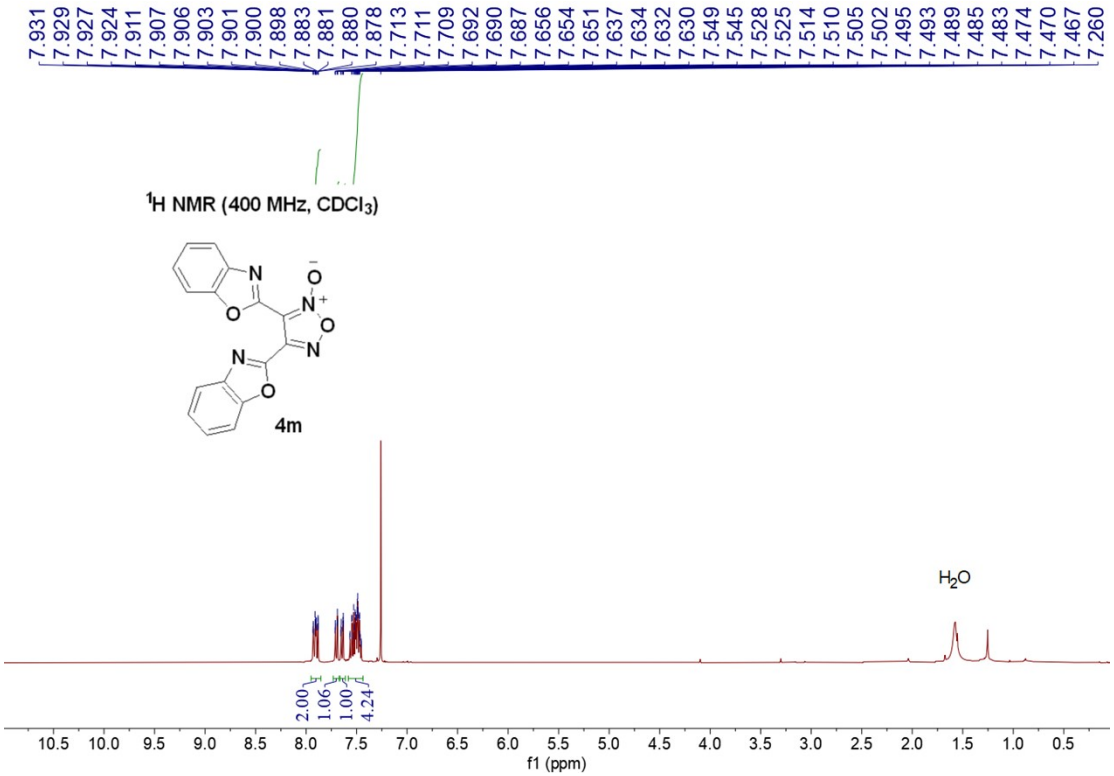

152.91
152.53
152.17
150.35
149.40
136.17
135.01
127.14
127.06
126.92
124.73
124.21
121.77
121.74
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
4k
f1 (ppm)

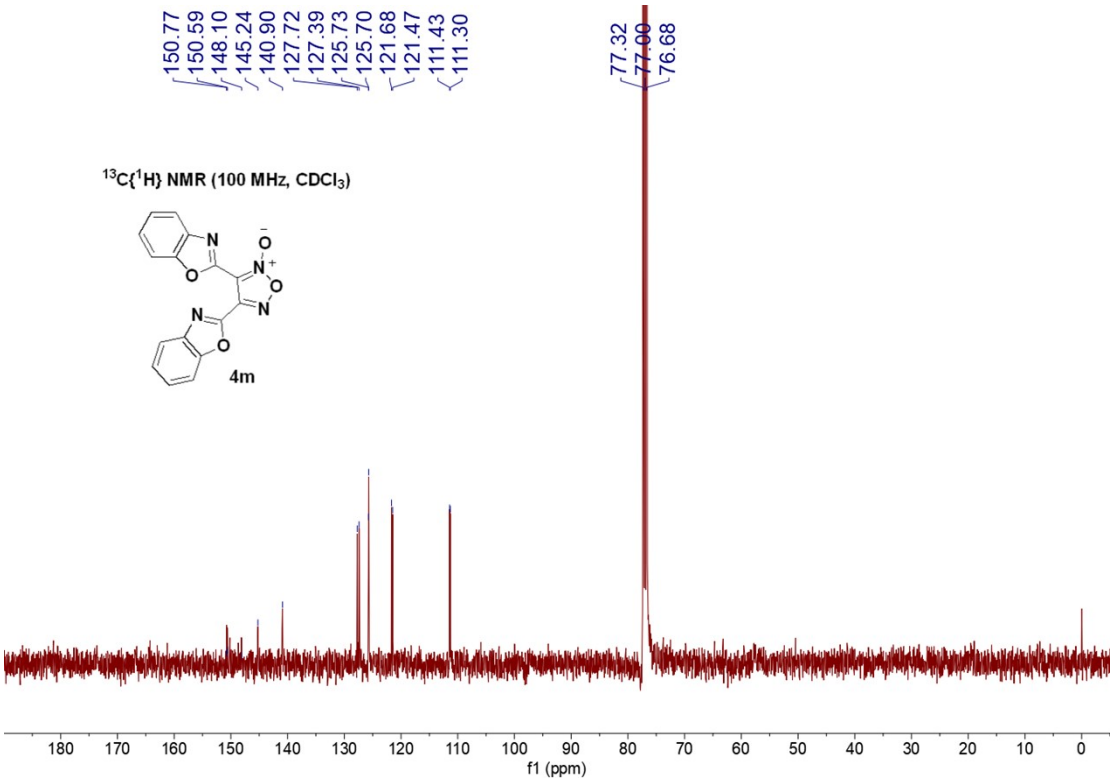

152.91
152.53
152.17
150.35
149.40
136.17
135.01
127.14
127.06
126.92
124.73
124.21
121.77
121.74
77.32
77.00
76.68
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)
DEPT-135 Spectra of 4k in $CDCl_3$
4k
^{13}C NMR spectrum of 4k in $CDCl_3$
f1 (ppm)

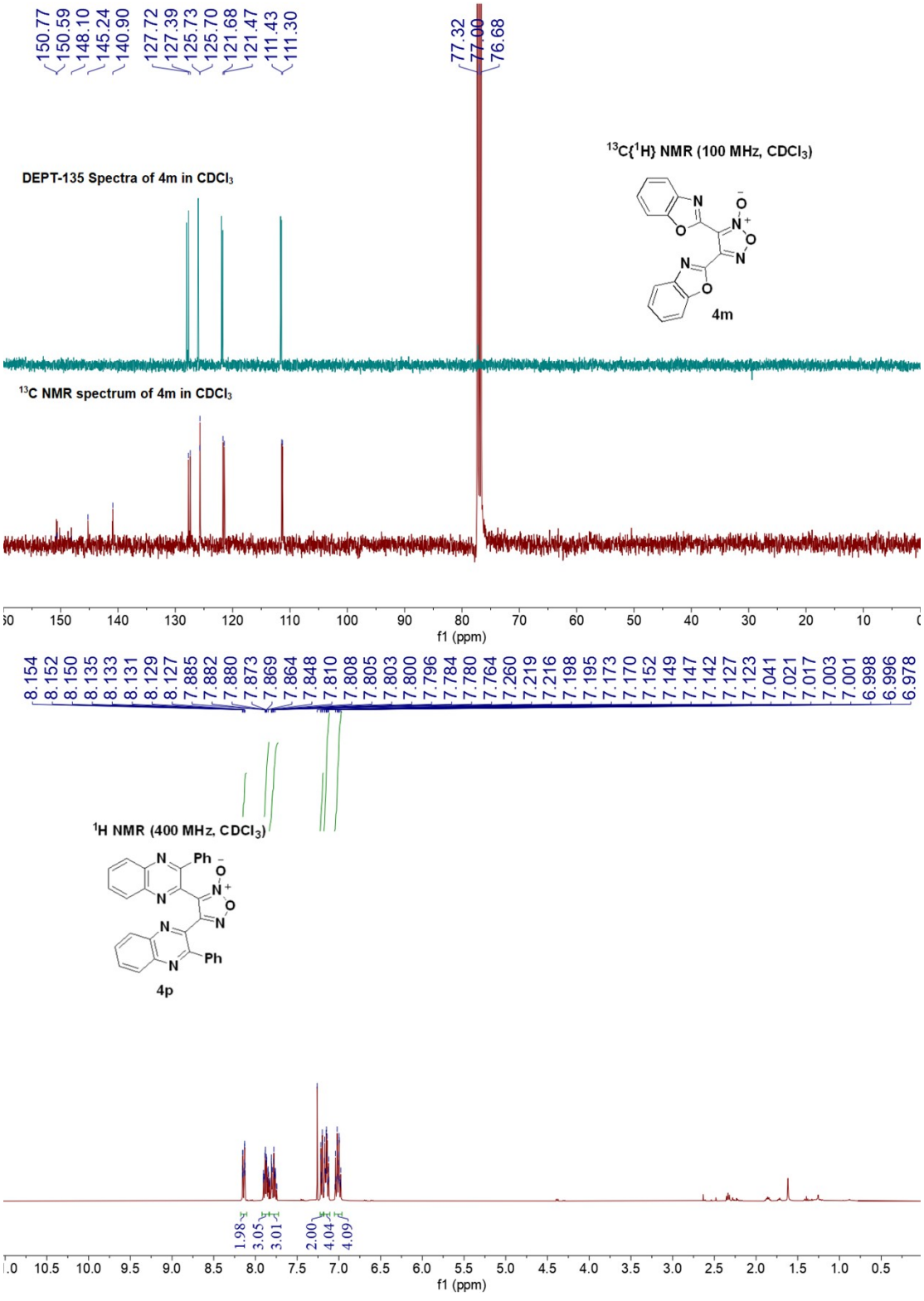

8.244
8.242
8.239
8.237
8.128
8.126
8.123
8.121
8.011
7.990
7.974
7.953
7.582
7.577
7.560
7.555
7.530
7.525
7.508
7.503
7.260
^{1}H NMR (400 MHz, $CDCl_3$)
4l
1.00
1.01
2.17
1.07
1.04
f1 (ppm)

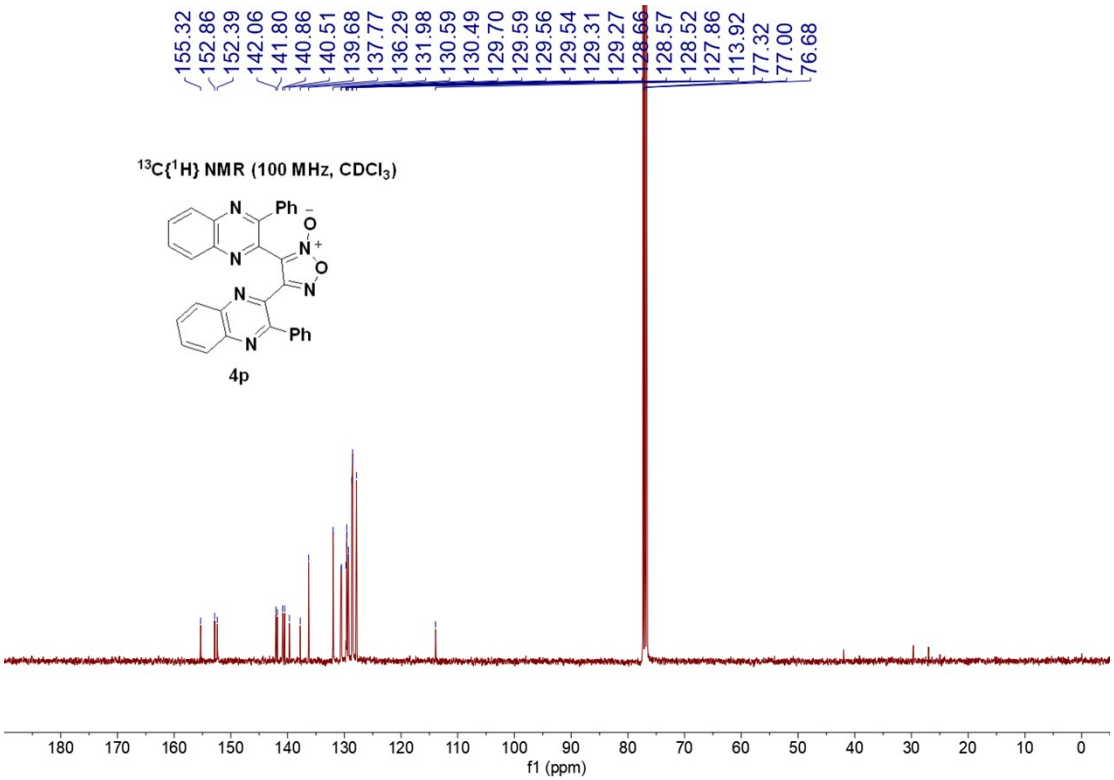

153.65
153.26
151.32
149.84
134.41
133.39
133.14
130.26
127.89
124.37
123.79
122.57
122.54
111.55
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Cl
N
S
O
N+
O
N
N
S
Cl
4l
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

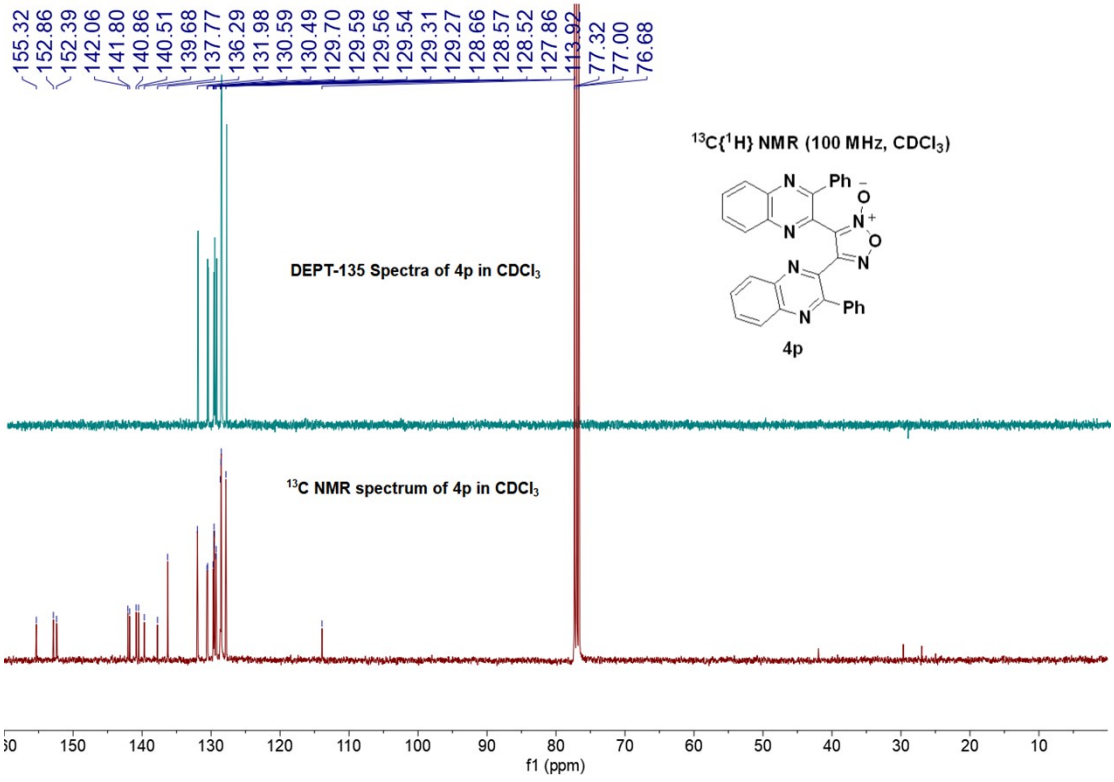

153.65
153.26
151.32
149.84
134.41
133.39
133.14
130.26
127.89
124.37
123.79
122.57
122.54
111.55
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Cl
N
S
O
N+
O
N
N
S
Cl
4l
DEPT-135 Spectra of 4l in CDCl3
13C NMR spectrum of 4l in CDCl3
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

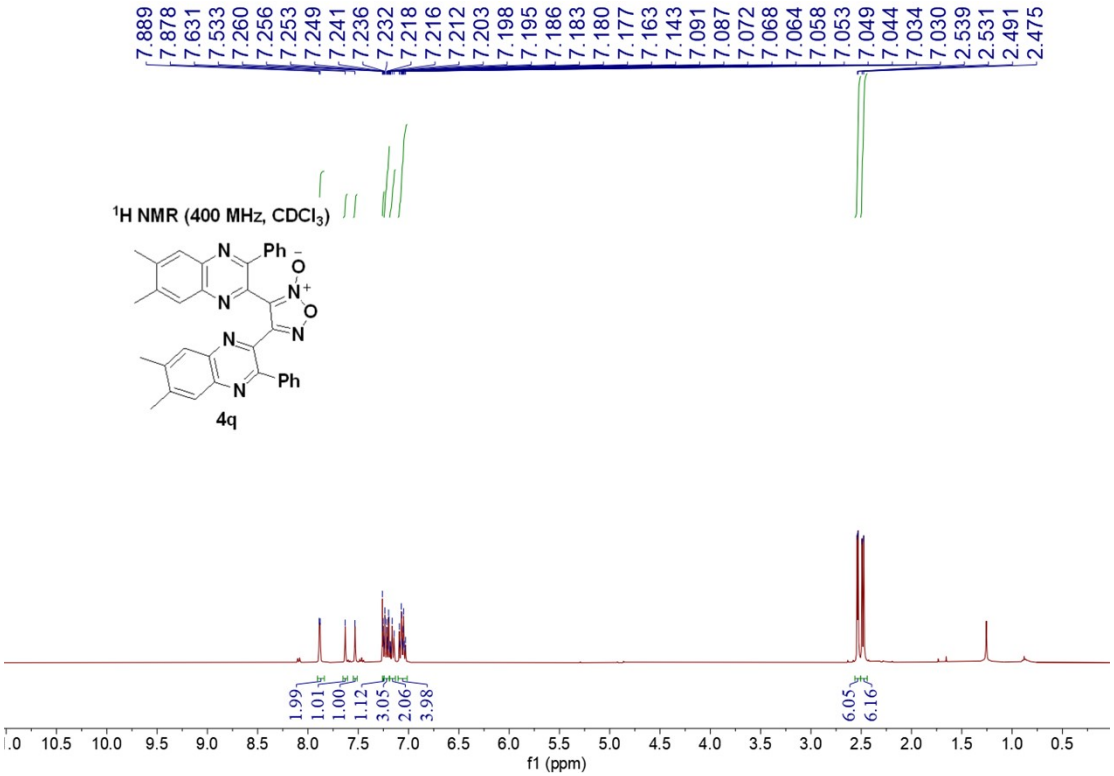

7.931
7.929
7.927
7.924
7.911
7.907
7.906
7.903
7.901
7.900
7.898
7.883
7.881
7.880
7.878
7.713
7.711
7.709
7.692
7.690
7.687
7.656
7.654
7.651
7.637
7.634
7.632
7.630
7.549
7.545
7.528
7.525
7.514
7.510
7.505
7.502
7.495
7.493
7.489
7.485
7.483
7.474
7.470
7.467
7.260
^{1}H NMR (400 MHz, CDCl$_3$)
4m
H$_2$O
2.00
1.06
1.00
4.24
f1 (ppm)

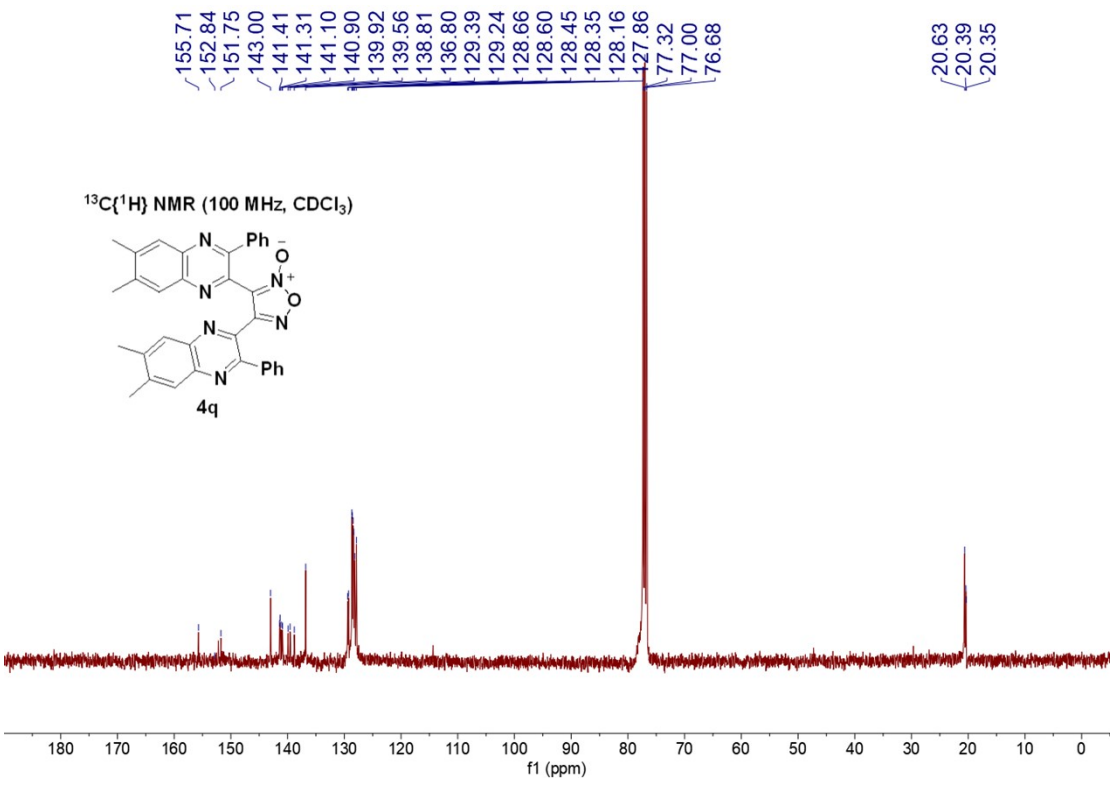

150.77
150.59
148.10
145.24
140.90
127.72
127.39
125.73
125.70
121.68
121.47
111.43
111.30
77.32
77.00
76.68
^{13}C{^{1}H} NMR (100 MHz, CDCl$_3$)
4m
f1 (ppm)

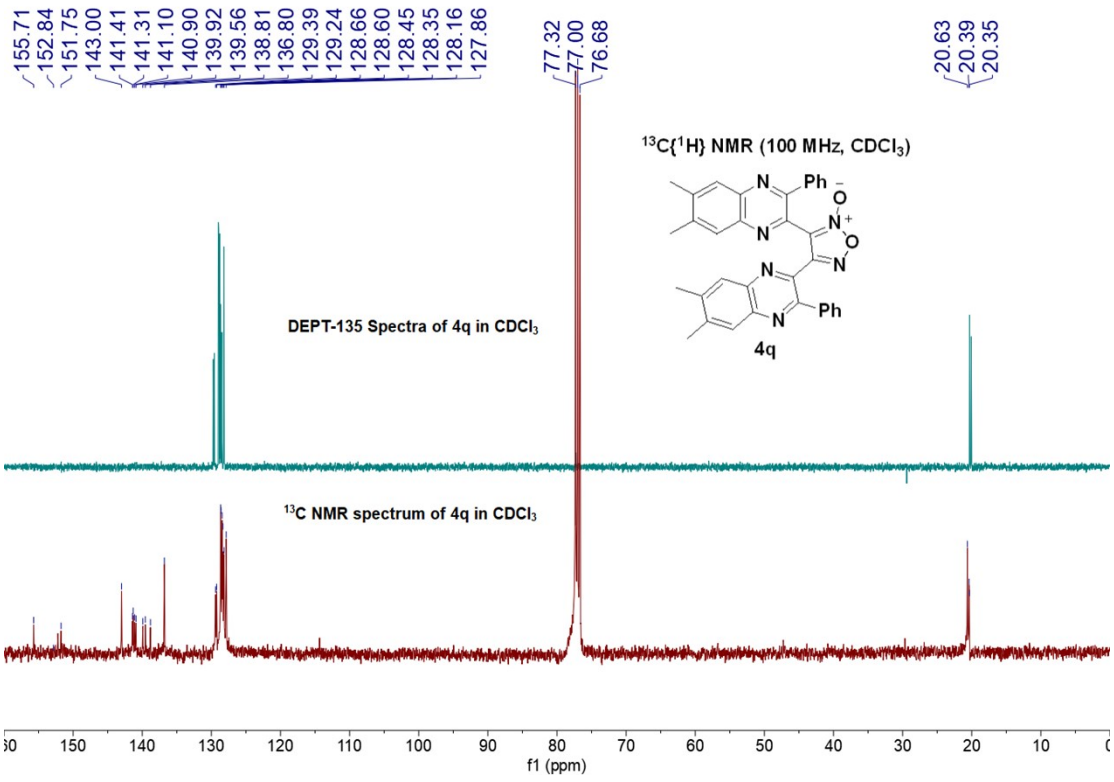

150.77
150.59
148.10
145.24
140.90
127.72
127.39
125.73
125.70
121.68
121.47
111.43
111.30
77.32
77.00
76.68
DEPT-135 Spectra of 4m in CDCl3
13C{1H} NMR (100 MHz, CDCl3)
4m
13C NMR spectrum of 4m in CDCl3
f1 (ppm)
8.154
8.152
8.150
8.135
8.133
8.131
8.129
8.127
7.885
7.882
7.880
7.873
7.869
7.864
7.848
7.810
7.808
7.805
7.803
7.800
7.796
7.784
7.780
7.764
7.260
7.219
7.216
7.198
7.195
7.173
7.170
7.152
7.149
7.147
7.142
7.127
7.123
7.041
7.021
7.017
7.003
7.001
6.998
6.996
6.978
1H NMR (400 MHz, CDCl3)
4p
1.98
3.05
3.01
2.00
4.04
4.09
f1 (ppm)

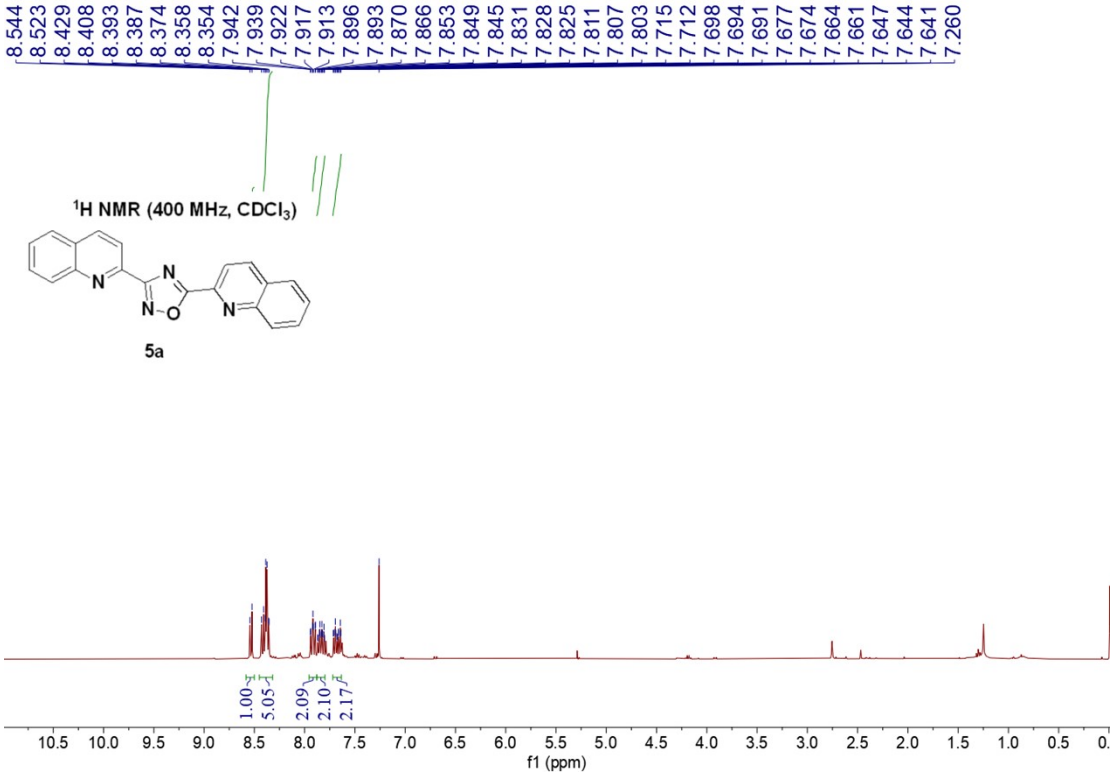

155.32
152.86
152.39
142.06
141.80
140.86
140.51
139.68
137.77
136.29
131.98
130.59
130.49
129.70
129.59
129.56
129.54
129.31
129.27
128.66
128.57
128.52
127.86
113.92
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Ph
Ph
4p
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

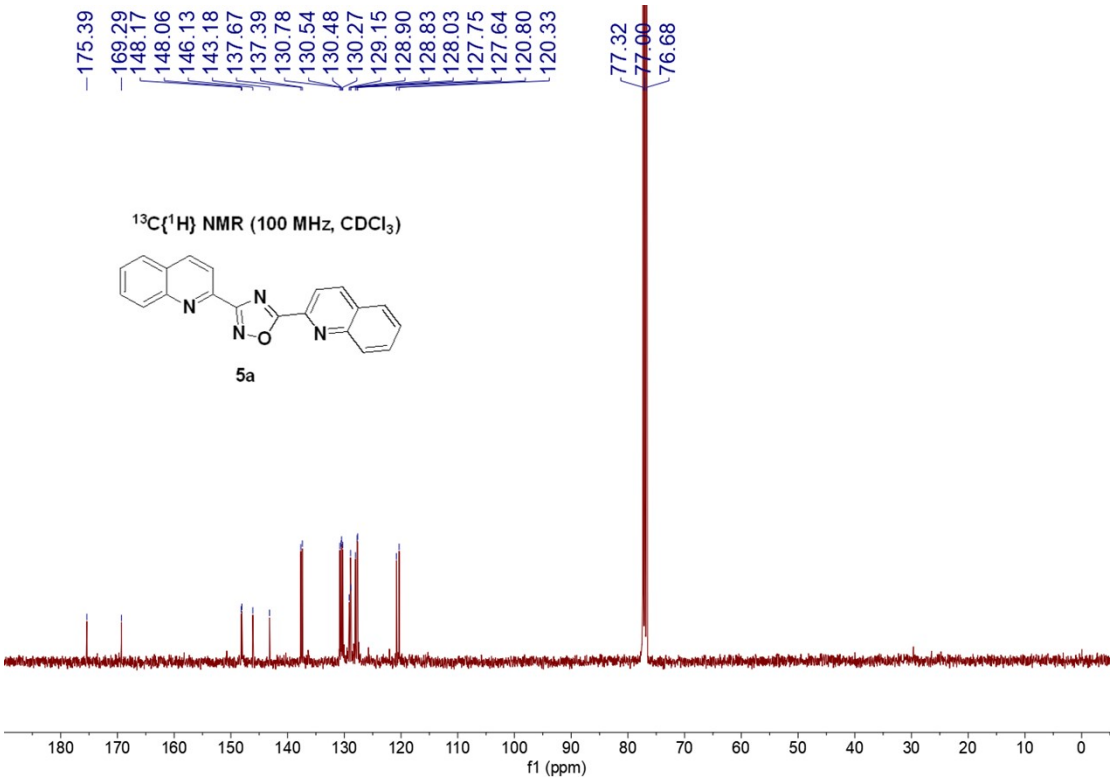

155.32
152.86
152.39
142.06
141.80
140.86
140.51
139.68
137.77
136.29
131.98
130.59
130.49
129.70
129.59
129.56
129.54
129.31
129.27
128.66
128.57
128.52
127.86
113.92
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Ph
Ph
4p
DEPT-135 Spectra of 4p in CDCl3
13C NMR spectrum of 4p in CDCl3
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


7.889
7.878
7.631
7.533
7.260
7.256
7.253
7.249
7.241
7.236
7.232
7.218
7.216
7.212
7.203
7.198
7.195
7.186
7.183
7.180
7.177
7.163
7.143
7.091
7.087
7.072
7.068
7.064
7.058
7.053
7.049
7.044
7.034
7.030
2.539
2.531
2.491
2.475
^{1}H NMR (400 MHz, CDCl$_3$)
Ph
O
N+
O
N
N
N
Ph
4q
1.99
1.01
1.00
1.12
3.05
2.06
3.98
6.05
6.16
f1 (ppm)


155.71
152.84
151.75
143.00
141.41
141.31
141.10
140.90
139.92
139.56
138.81
136.80
129.39
129.24
128.66
128.60
128.45
128.35
128.16
127.86
77.32
77.00
76.68
20.63
20.39
20.35
^{13}C{^{1}H} NMR (100 MHz, CDCl$_3$)
Ph
O
N+
O
N
N
N
Ph
4q
f1 (ppm)

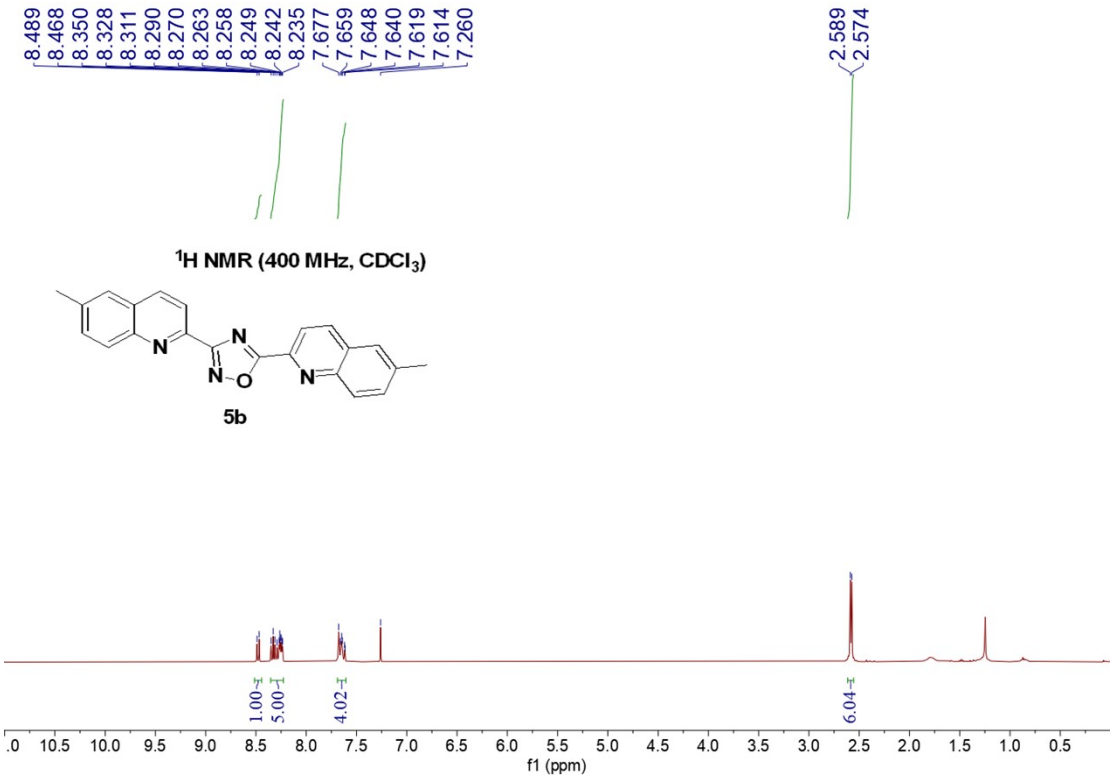

155.71
152.84
151.75
143.00
141.41
141.31
141.10
140.90
139.92
139.56
138.81
136.80
129.39
129.24
128.66
128.60
128.45
128.35
128.16
127.86
77.32
77.00
76.68
20.63
20.39
20.35
13C{1H} NMR (100 MHz, CDCl3)
DEPT-135 Spectra of 4q in CDCl3
13C NMR spectrum of 4q in CDCl3
4q
f1 (ppm)


8.544
8.523
8.429
8.408
8.393
8.387
8.374
8.358
8.354
7.942
7.939
7.922
7.917
7.913
7.896
7.893
7.870
7.866
7.853
7.849
7.845
7.831
7.828
7.825
7.811
7.807
7.803
7.715
7.712
7.698
7.694
7.691
7.677
7.674
7.664
7.661
7.647
7.644
7.641
7.260
1H NMR (400 MHz, CDCl3)
5a
1.00
5.05
2.09
2.10
2.17
f1 (ppm)



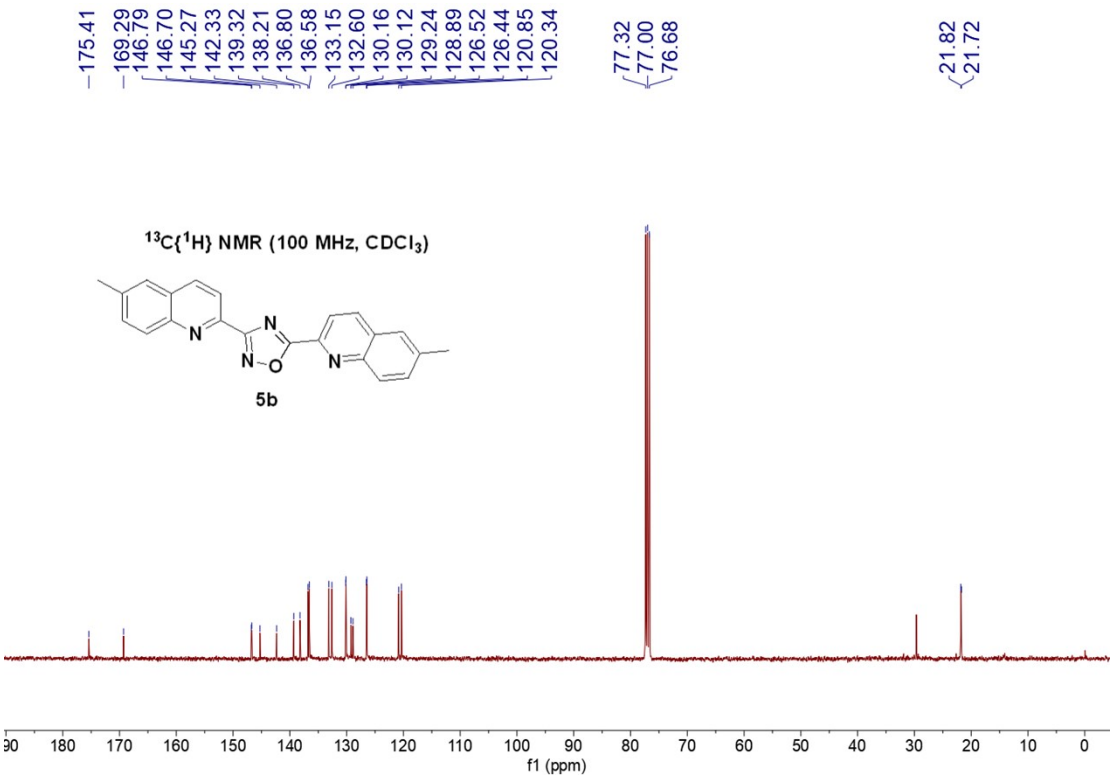
$^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$)

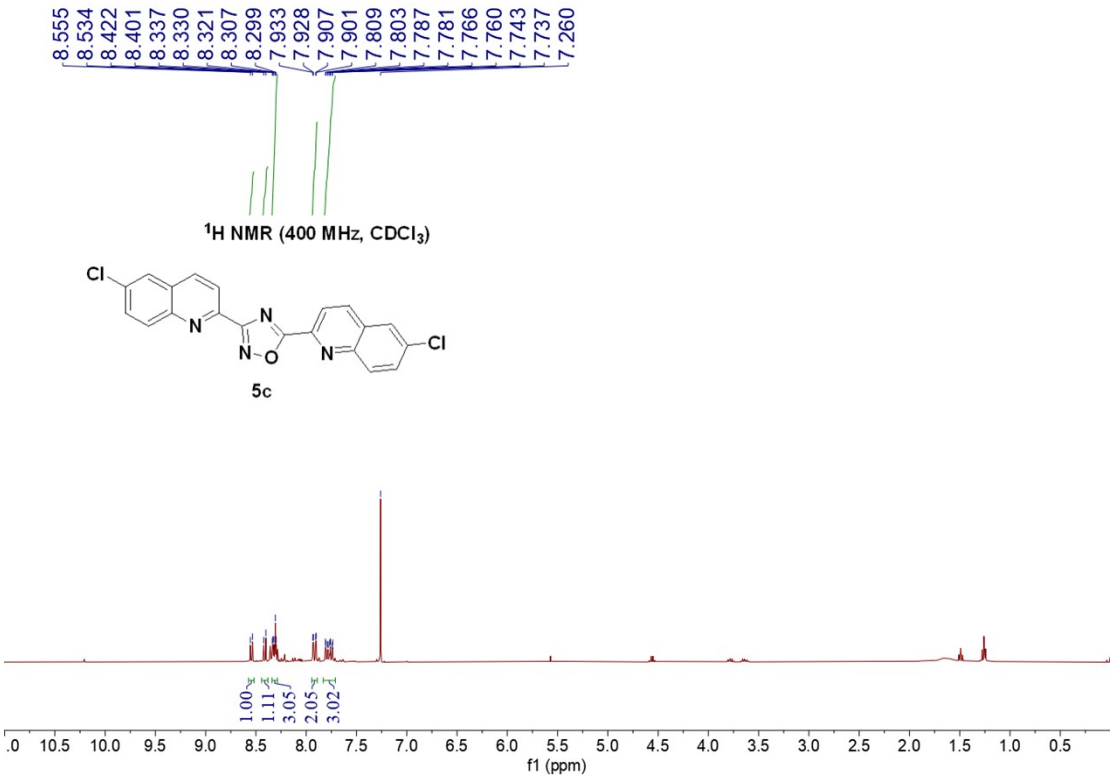
5a

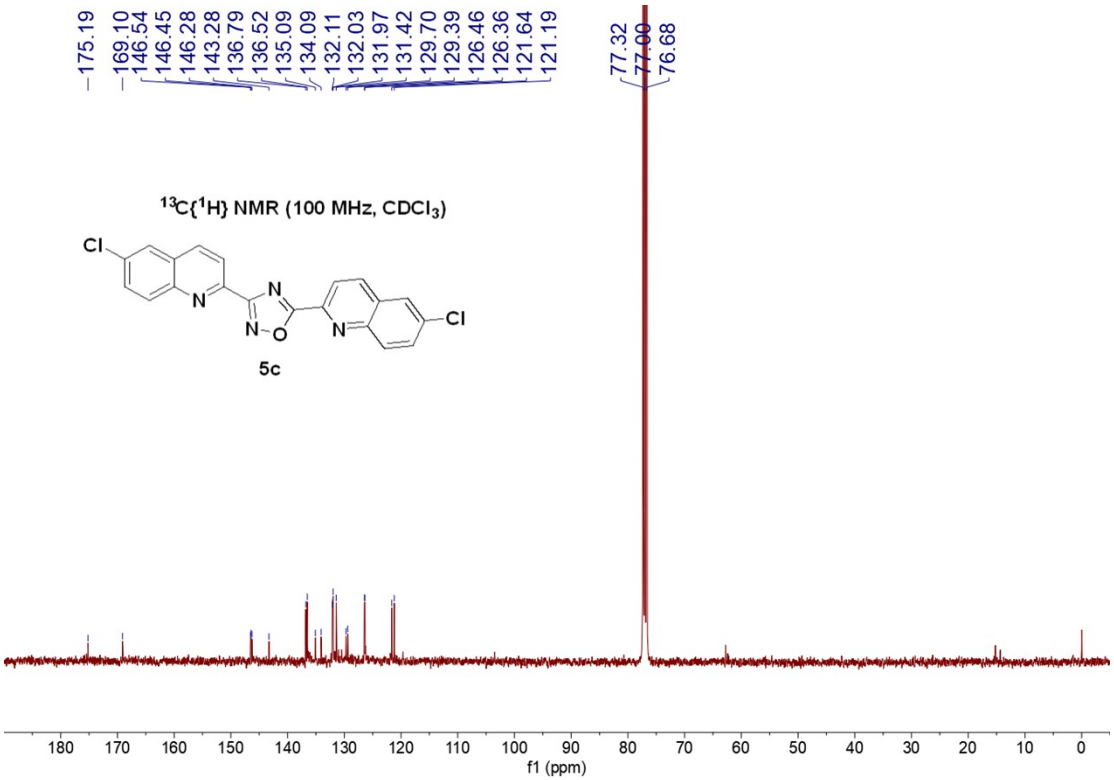


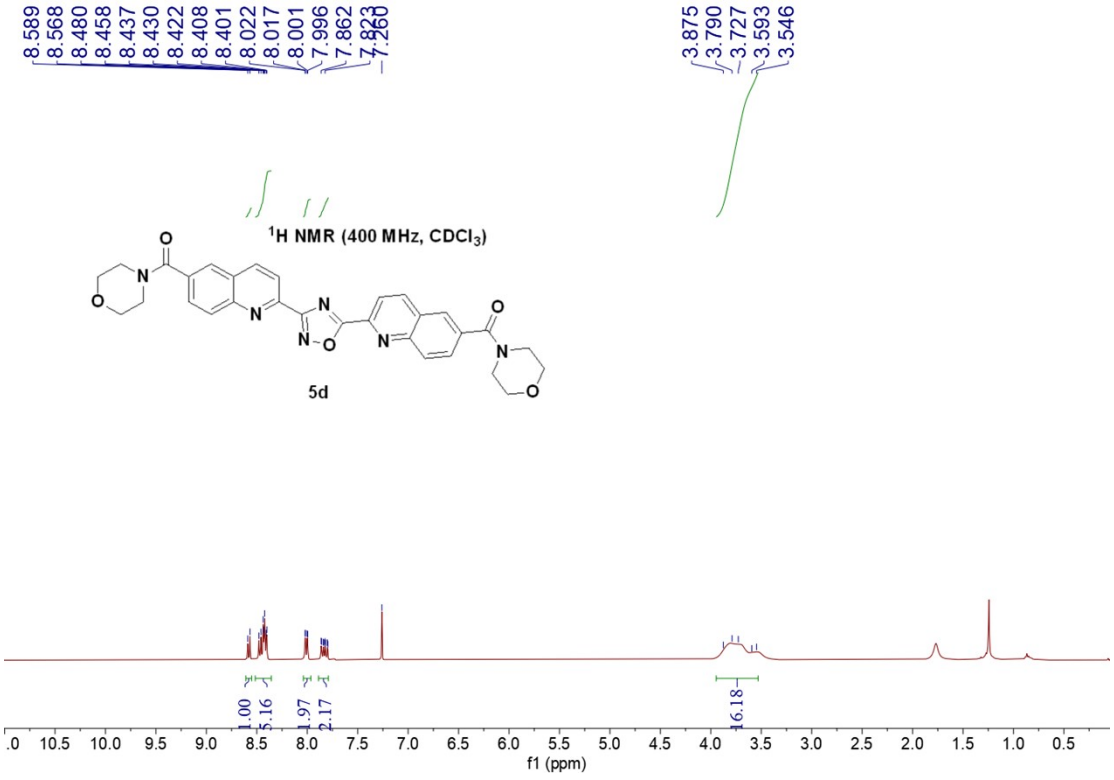
^{1}H NMR (400 MHz, $CDCl_3$)

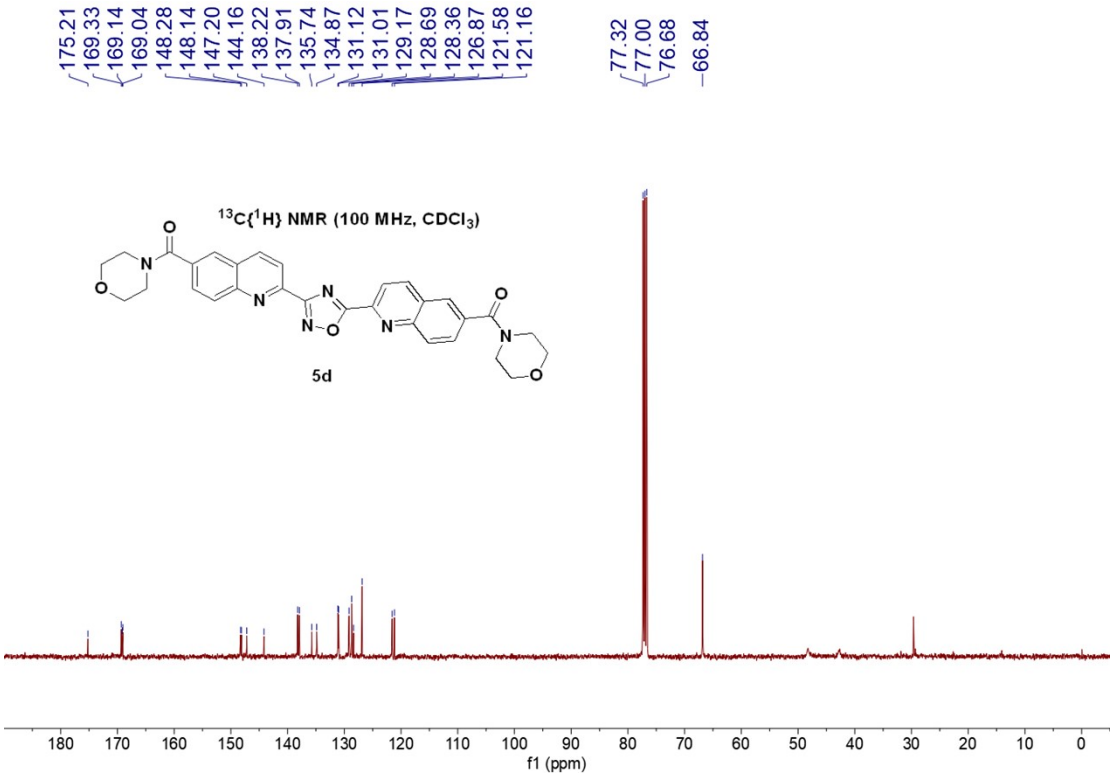
5b

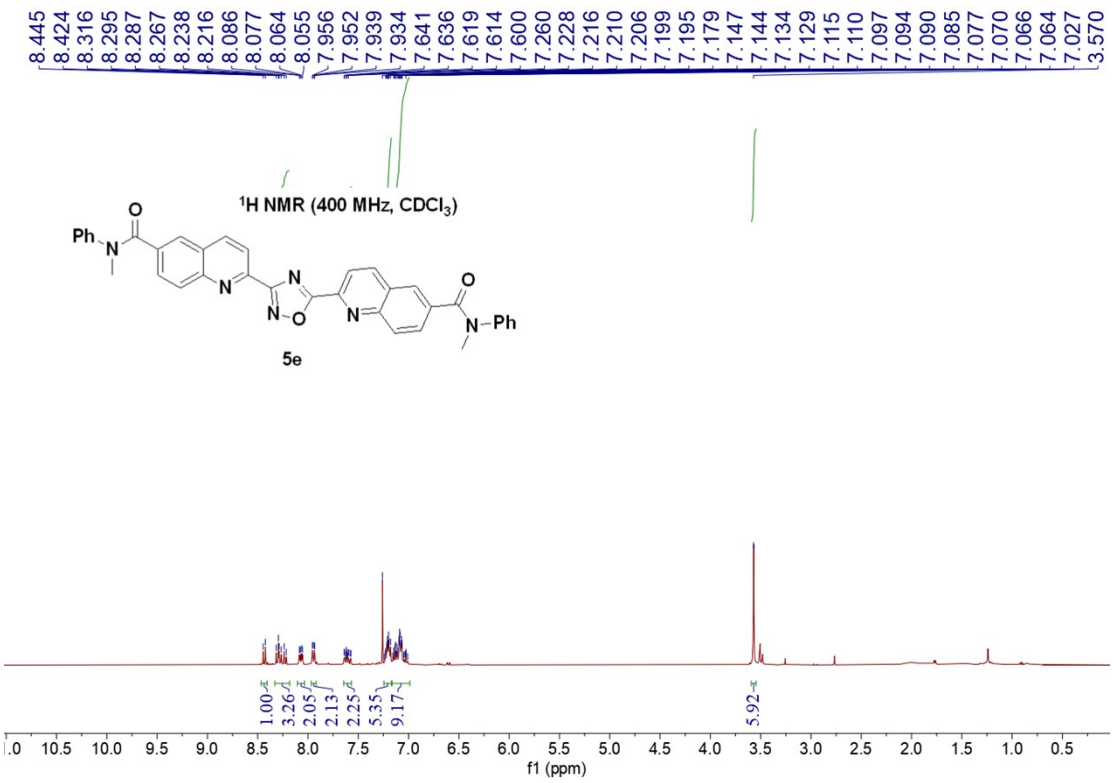

175.41
169.29
146.79
146.70
145.27
142.33
139.32
138.21
136.80
136.58
133.15
132.60
130.16
130.12
129.24
128.89
126.52
126.44
120.85
120.34
77.32
77.00
76.68
21.82
21.72
13C{1H} NMR (100 MHz, CDCl3)
5b
f1 (ppm)

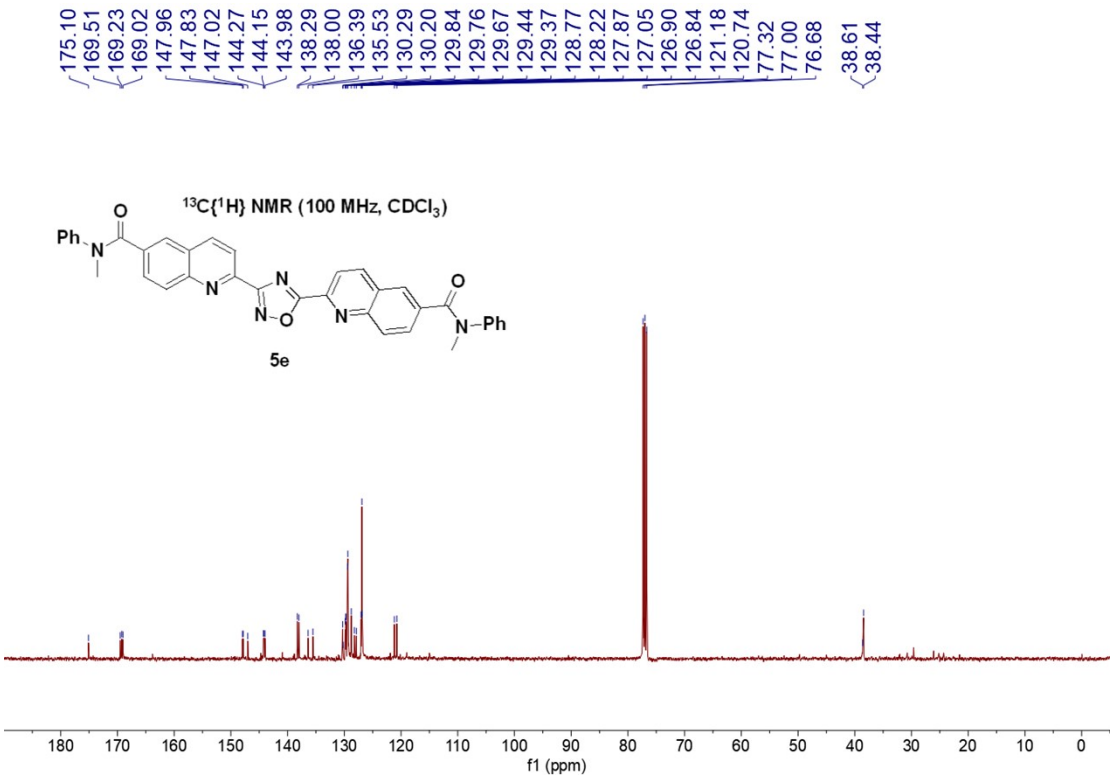

8.555
8.534
8.422
8.401
8.337
8.330
8.321
8.307
8.299
7.933
7.928
7.907
7.901
7.809
7.803
7.787
7.781
7.766
7.760
7.743
7.737
7.260
1H NMR (400 MHz, CDCl3)
Cl
Cl
5c
1.00
1.11
3.05
2.05
3.02
f1 (ppm)

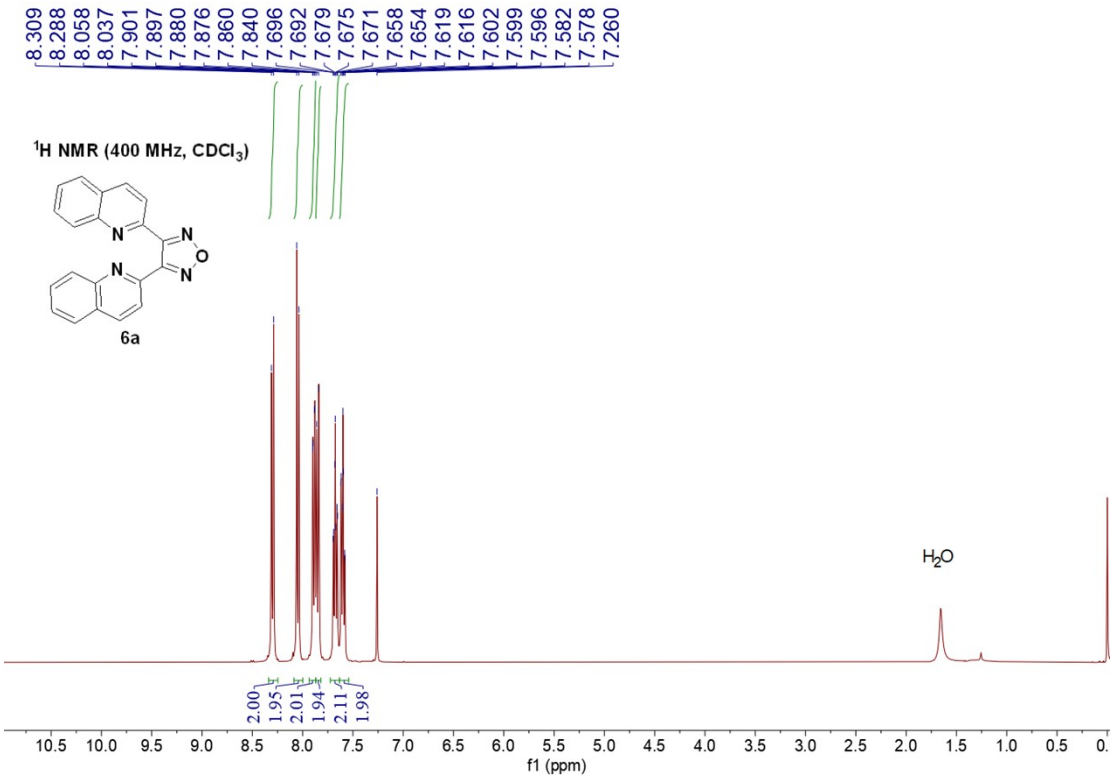

175.19
169.10
146.54
146.45
146.28
143.28
136.79
136.52
135.09
134.09
132.11
132.03
131.97
131.42
129.70
129.39
126.46
126.36
121.64
121.19
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
Cl
N
N
N
O
N
Cl
5c
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

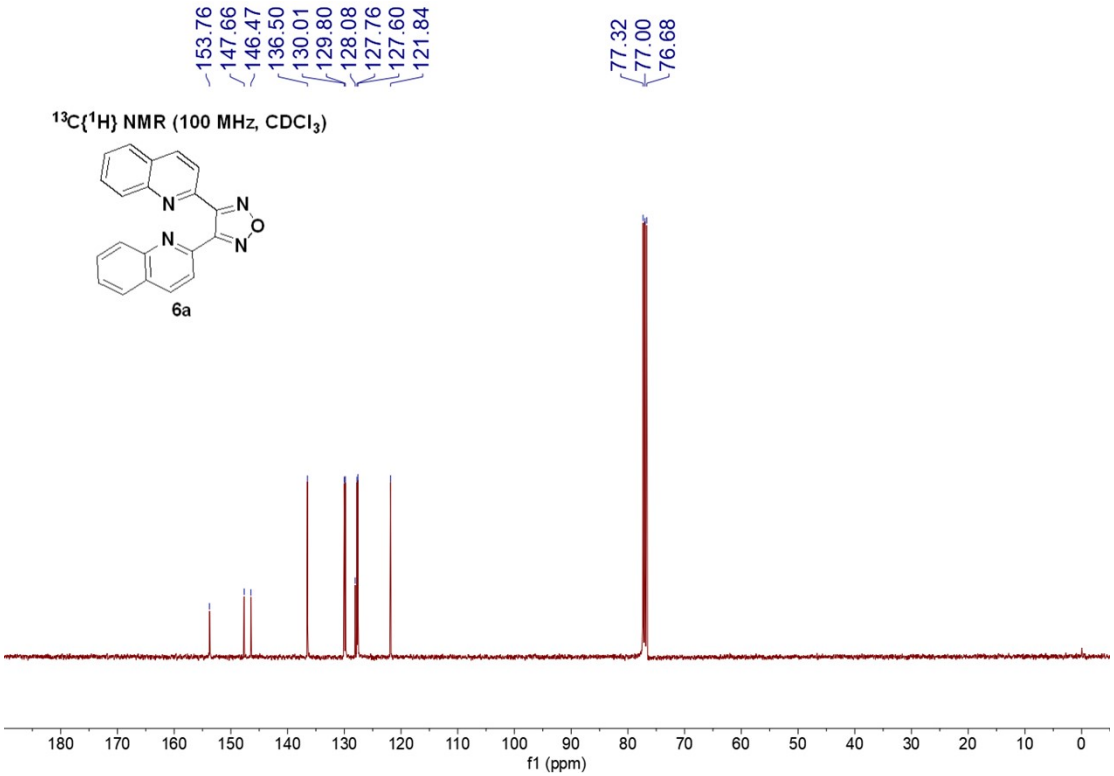

8.589
8.568
8.480
8.458
8.437
8.430
8.422
8.408
8.401
8.022
8.017
8.001
7.996
7.862
7.260
3.875
3.790
3.727
3.593
3.546
1H NMR (400 MHz, CDCl3)
O
N
O
N
N
N
O
N
O
5d
1.00
5.16
1.97
2.17
16.18
.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

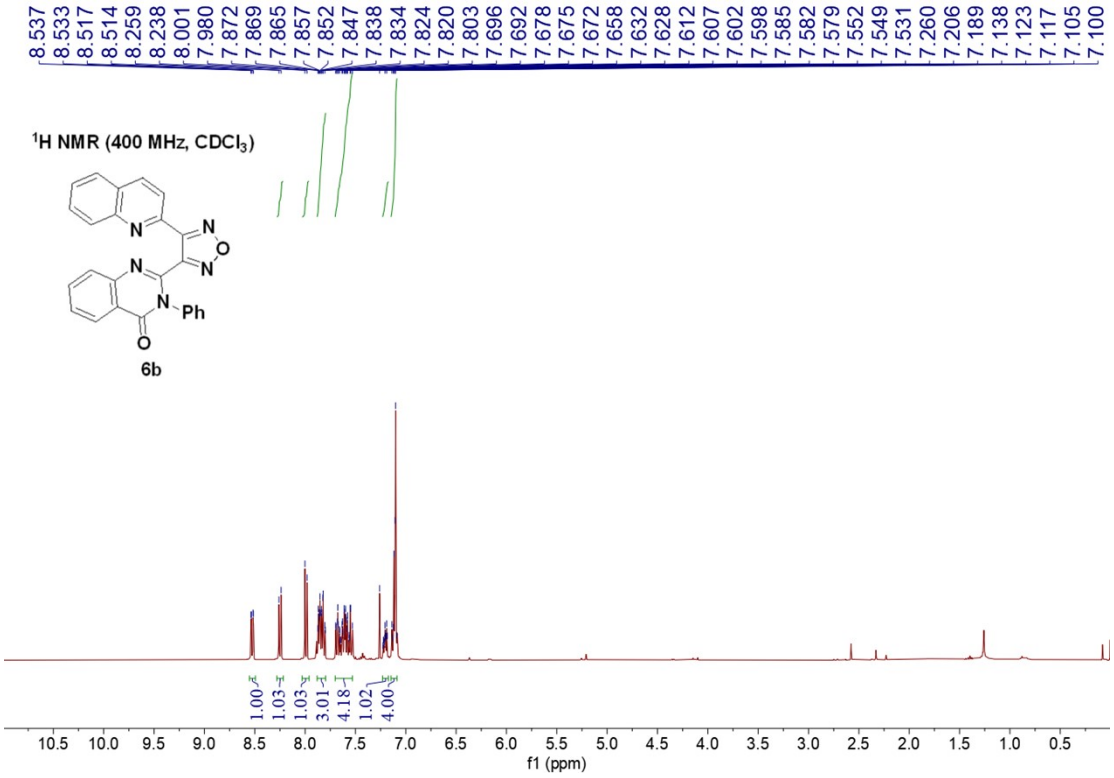

175.21
169.33
169.14
169.04
148.28
148.14
147.20
144.16
138.22
137.91
135.74
134.87
131.12
131.01
129.17
128.69
128.36
126.87
121.58
121.16
77.32
77.00
76.68
66.84
13C{1H} NMR (100 MHz, CDCl3)
5d
f1 (ppm)

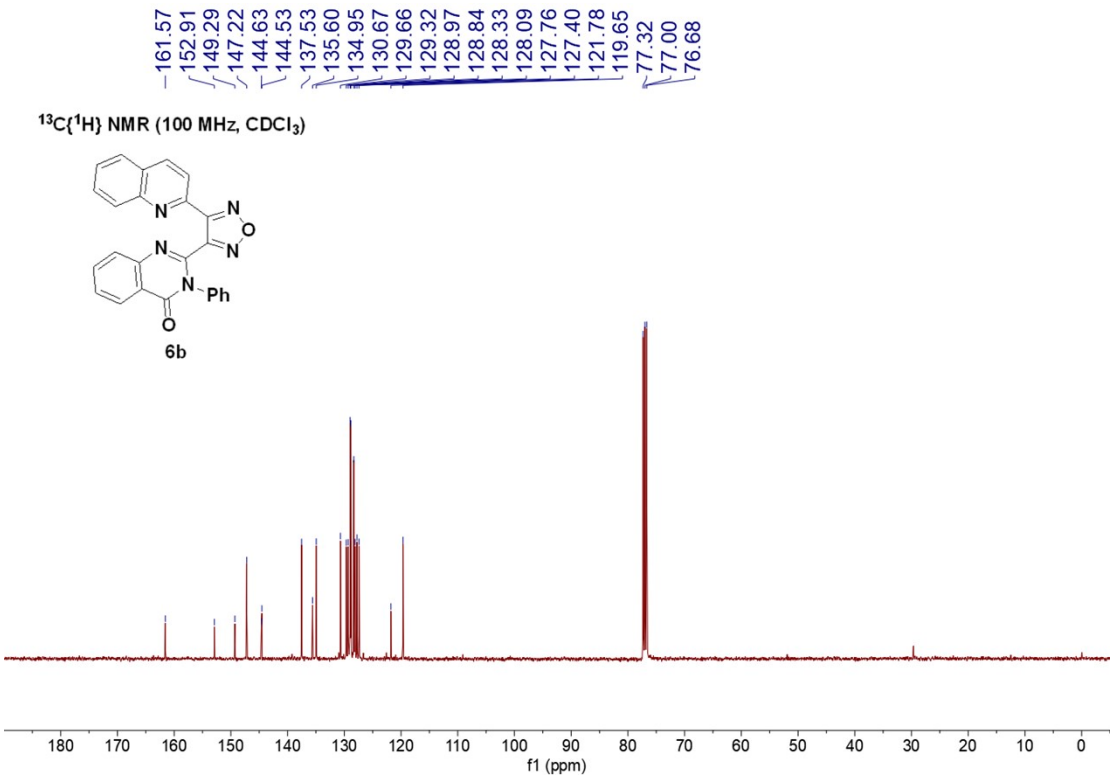

8.445
8.424
8.316
8.295
8.287
8.267
8.238
8.216
8.086
8.077
8.064
8.055
7.956
7.952
7.939
7.934
7.641
7.636
7.619
7.614
7.600
7.260
7.228
7.216
7.210
7.206
7.199
7.195
7.179
7.147
7.144
7.134
7.129
7.115
7.110
7.097
7.094
7.090
7.085
7.077
7.070
7.066
7.064
7.027
3.570
1H NMR (400 MHz, CDCl3)
5e
1.00
3.26
2.05
2.13
2.25
5.35
9.17
5.92
f1 (ppm)

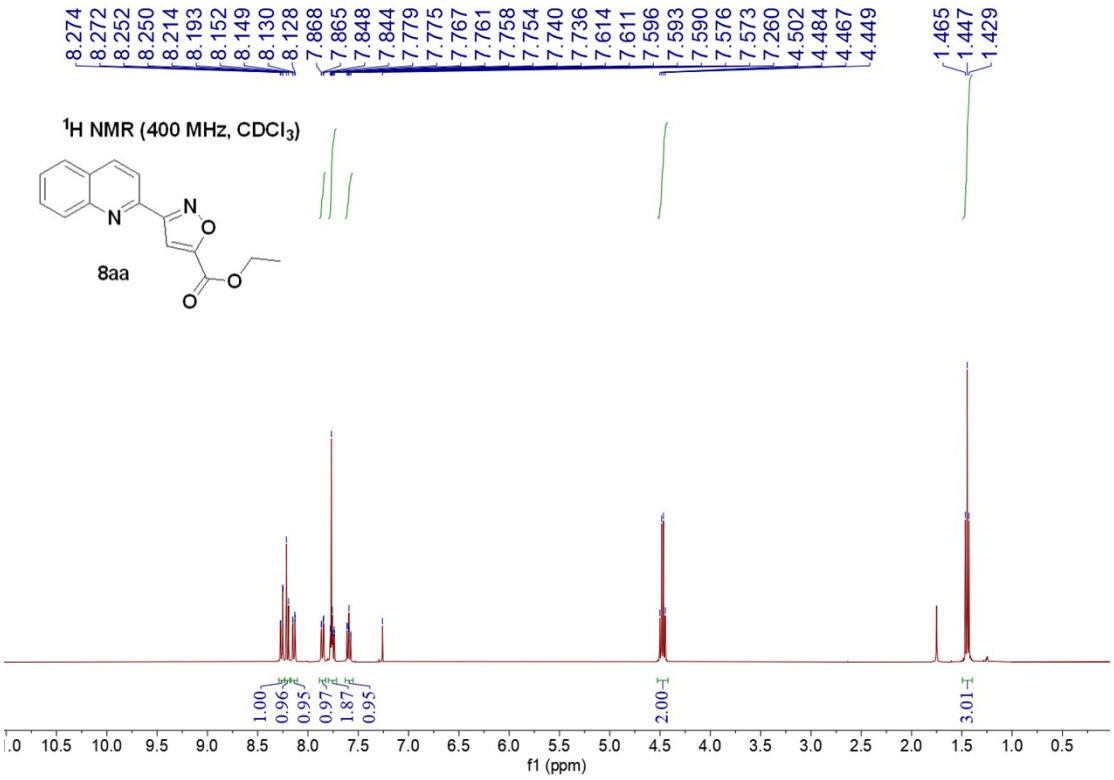

175.10
169.51
169.23
169.02
147.96
147.83
147.02
144.27
144.15
143.98
138.29
138.00
136.39
135.53
130.29
130.20
129.84
129.76
129.67
129.44
129.37
128.77
128.22
127.87
127.05
126.90
126.84
121.18
120.74
77.32
77.00
76.68
38.61
38.44
13C{1H} NMR (100 MHz, CDCl3)
Ph
N
O
N
N
N
O
N
O
N–Ph
5e
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

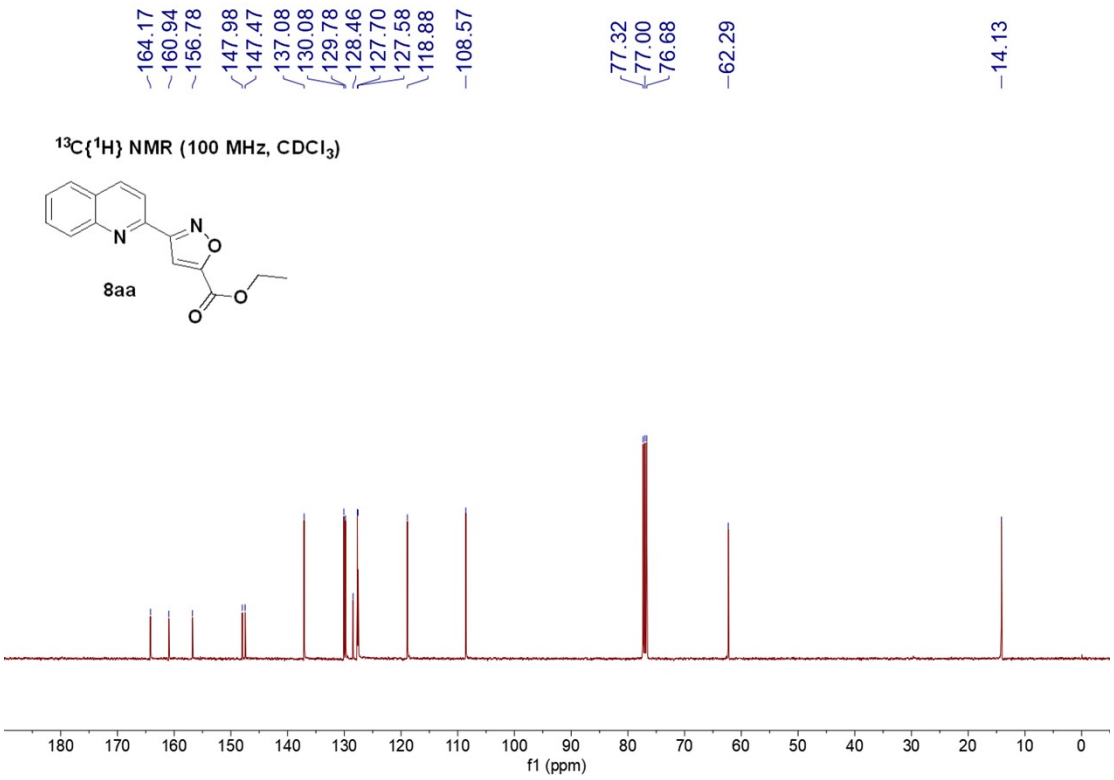

8.309
8.288
8.058
8.037
7.901
7.897
7.880
7.876
7.860
7.840
7.696
7.692
7.679
7.675
7.671
7.658
7.654
7.619
7.616
7.602
7.599
7.596
7.582
7.578
7.260
1H NMR (400 MHz, CDCl3)
N
N
O
N
N
6a
H2O
2.00
1.95
2.01
1.94
2.11
1.98
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.
f1 (ppm)


153.76
147.66
146.47
136.50
130.01
129.80
128.08
127.76
127.60
121.84
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
6a
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.537
8.533
8.517
8.514
8.259
8.238
8.001
7.980
7.872
7.869
7.865
7.857
7.852
7.847
7.838
7.834
7.824
7.820
7.803
7.696
7.692
7.678
7.675
7.672
7.658
7.632
7.628
7.612
7.607
7.602
7.598
7.585
7.582
7.579
7.552
7.549
7.531
7.260
7.206
7.189
7.138
7.123
7.117
7.105
7.100
1H NMR (400 MHz, CDCl3)
Ph
6b
1.00
1.03
1.03
3.01
4.18
1.02
4.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


161.57
152.91
149.29
147.22
144.63
144.53
137.53
135.60
134.95
130.67
129.66
129.32
128.97
128.84
128.33
128.09
127.76
127.40
121.78
119.65
77.32
77.00
76.68
13C{1H} NMR (100 MHz, CDCl3)
N
N
O
N
N
N
Ph
O
6b
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.274
8.272
8.252
8.250
8.214
8.193
8.152
8.149
8.130
8.128
7.868
7.865
7.848
7.844
7.779
7.775
7.767
7.761
7.758
7.754
7.740
7.736
7.614
7.611
7.596
7.593
7.590
7.576
7.573
7.260
4.502
4.484
4.467
4.449
1.465
1.447
1.429
1H NMR (400 MHz, CDCl3)
N
N
O
O
O
8aa
1.00
0.96
0.95
0.97
1.87
0.95
2.00
3.01
.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


164.17
160.94
156.78
147.98
147.47
137.08
130.08
129.78
128.46
127.70
127.58
118.88
108.57
77.32
77.00
76.68
62.29
14.13
13C{1H} NMR (100 MHz, CDCl3)
8aa
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)