

Photocatalytic Dehydrogenative Lactonization of 2-Arylbenzoic Acids

Nieves P. Ramirez,[†] Irene Bosque,[†] Jose C. Gonzalez-Gomez*

Departamento de Química Orgánica, Facultad de Ciencias and Instituto de Síntesis Orgánica (ISO),
Universidad de Alicante, Apdo. 99, 03080 Alicante, Spain.

Supporting Information

	Page
1. General Remarks	S2
2. Set up of the Reaction	S3
3. Kinetic Isotopic Effect (KIE) Experiments	S4
3.1. Calibration Curve	S4
3.2. Measurement of the Kinetic Isotopic Effect (KIE) from Individual Experiments	S5
3.3. Measurement of the Kinetic Isotopic Effect (KIE) from Competition Experiments in an Equimolar Mixture of 1a and 1a-D₅	S7
4. Alternative pathway for 3'-methoxy-2-arylbenzoic acid 1i	S8
5. Reaction Performed Under Solar-Light Irradiation	S9
6. Syntheses of 2-Arylbenzoic Acids 1b – 1u	S10
<i>Procedure for the synthesis of PdCl₂(PPh₃)₂ catalyst</i>	S10
6.1. Synthesis of compounds 1b-1l.	S10
<i>General procedure for the synthesis of biaryl 2-carboxylic acids 1b - 1l using Suzuki Cross-coupling reaction</i>	S10
6.2. Procedure for the synthesis of acid 1m	S15
6.3. Procedure for the synthesis of acid 1n and 1o	S16
6.4. Procedure for the synthesis of acid 1p	S17
6.5. Procedure for synthesis of acids 1q-1s	S18
<i>General procedure for the synthesis of biaryl 2-carboxylic acids 1q – 1s</i>	S18
6.6. Procedure for synthesis of acid 1t	S20
6.7. Procedure for synthesis of acid 1u	S20
7. Synthesis of benzocoumarins 2a-2s	S21
<i>General procedure for the synthesis of benzocoumarins 2a – 2s by visible-light photoredox catalysis</i>	S21
8. Synthesis of Deuterated Phenylboronic Acid 1a-D₅ and Benzo-3,4-coumarin 2a-D₄	S30
9. ¹H NMR and ¹³C NMR Spectra of 2-Biarylcarboxylic Acids 1b – 1u	S32
10. ¹H NMR and ¹³C NMR Spectra of Benzo-3,4-coumarins 2a - 2s	S72
11. ¹H NMR and ¹³C NMR Spectra of Deuterated Acid 1a-D₅ and Deuterated Benzo-3,4-coumarin 2a-D₄	S110

1. General Remarks

TLC was performed on silica gel 60 F₂₅₄, using aluminium plates and visualized by exposure to ultraviolet light. Flash chromatography was carried out on handpacked columns of silica gel 60 (230 – 400 mesh). Melting points are uncorrected. Infrared (IR) analysis was performed with a JASCO FT/IR 4100 spectrophotometer equipped with an ATR component; wavenumbers are given in cm⁻¹. LRMS were performed in an AGILENT 6890N mass spectrometer coupled with a gas chromatographer (GC); the mobile phase was helium (2 mL/min); HP-1 column of 12 m was used; temperature program starts at 60 °C for 3 min, then up to 270 °C with a rate of 15 °C/min, and 10 min at 270 °C. HRMS analyses were carried out in an AGILENT 7200 using the Electron Impact (EI) mode at 70 eV by Q-TOF. ¹H NMR spectra were recorded at 300, 400 or 500 MHz for ¹H NMR and 75, 101 or 126 MHz for ¹³C NMR, using CDCl₃ as the solvent and TMS as an internal Standard (0.00 ppm). The data is being reported as (s = singlet, d = doublet, t = triplet, m = multiplet or unresolved, br s = broad signal, coupling constant(s) in Hz, integration). ¹³C NMR spectra were recorded with ¹H-decoupling at 100 MHz and referenced to CDCl₃ at 77.16 ppm. DEPT-135 experiments were performed to assign CH, CH₂ and CH₃.

2. Set up of the Reaction



Photoreactor was made with flexible 2 m strip lights (30 microchips/m; 4.8 W/m) of multicolor LEDs (5122161 model), set up as an spiral of 12 cm of diameter as shown.

Reactions were performed in Pyrex tubes of 25 mL and 1.6 cm of diameter located 1-2 cm from LED chips.

Blue light was selected to perform the reactions.

A thermometer was placed in a parallel Pyrex tube containing the solvent of the reaction. The measured temperature in all reactions varied from 30 to 35 °C.

3. Kinetic Isotopic Effect (KIE) Experiments

3.1. Calibration Curve.

For this calibration, benzophenone was selected as internal standard (**IS**). In a vial, a known quantity of **IS** and coumarin **2a** were weight and dissolved in 2 mL of EtOAc. This procedure was repeated 4 times obtaining different molar **IS:2a** ratios. 1 μ L of each sample was injected into a GC and the areas of **IS** and **2a** were measured.

	IS (mg)	2a (mg)	IS (mmol)	2a (mmol)	Area IS	Area 2a	mmol 2a /mmol IS	Area 2a /Area IS
CAL 1	4,261	4,126	0,0234	0,0210	3983,6	3106,7	0,899	0,779
CAL 2	3,416	2,002	0,0187	0,0102	3402,5	1596,4	0,544	0,469
CAL 3	5,616	0,766	0,0308	0,0039	6297,2	705,2	0,126	0,112
CAL 4	4,066	1,020	0,0223	0,0052	4318	872,2	0,232	0,202
CAL 5	3,165	1,270	0,0173	0,0064	3651,2	1168,1	0,372	0,319

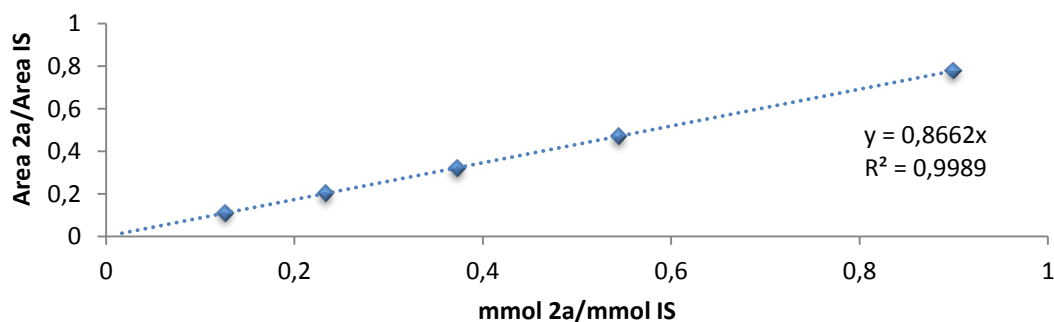


Figure S1: Calibration curve for coumarin **2a** in GC

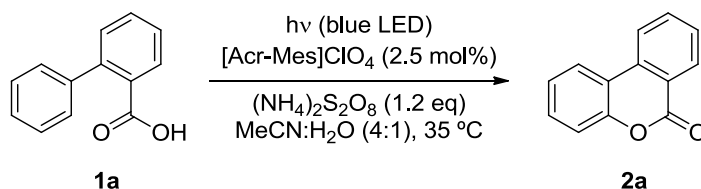
Therefore, the following relationship was obtained:

$$\frac{\text{Area } \mathbf{2a}}{\text{Area } \mathbf{IS}} = 0.8662 \times \frac{\text{mmol } \mathbf{2a}}{\text{mmol } \mathbf{IS}} \quad \text{Eq S1}$$

3.2. Measurement of the Kinetic Isotopic Effect (KIE) from Individual Experiments.

A reaction for the synthesis of benzocoumarin **2a** was performed. Into a 25 mL pyrex tube (1.5 cm of diameter) acid **1a** (39.6 mg, 0.2 mmol), photocatalyst [Acr-Mes]ClO₄ (2.1 mg, 2.5 mol%) and ammonium persulfate (55 mg, 1.2 eq) were added and dissolved with a 4:1 mixture of MeCN:H₂O (2 mL). The reaction mixture was stirred while irradiating with blue LEDs at 35 °C.

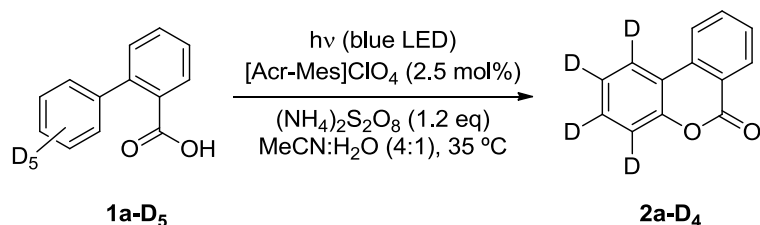
At the indicated time, 100 µL of the reaction mixture was extracted and added to a vial with known quantity of **IS** and EtOAc (0.9 mL). This solution was dried over MgSO₄, carefully filtered through cotton and introduced into a light-protected vial. 1 µL of this solution was then injected into a GC and the areas of the **IS** and coumarin **2a** were measured (**Table S1**). By using **Eq S1**, the concentration of coumarin **2a** in the reaction vessel was calculated and represented vs the reaction time (**Figure S2**, blue line).



t (min)	IS (mg)	Area IS	Area 2a	area 2a /area IS	2a produced (mg)	Yield 2a (%)	[2a] (M)
0	-	-	-	-	0	0	0
10	2,03	4010,2	30,1	0,008	0,378	0,96	0,9664
17	1,99	3951,4	53,6	0,013	0,671	1,71	0,0017
33	2,02	3998,2	140,0	0,035	1,758	4,48	4,4864
54	2,05	3984,6	237,1	0,059	3,035	7,66	0,0077
68	2,10	4085,6	328,5	0,080	4,198	10,60	10,7097
82	2,13	4280,8	430,9	0,100	5,340	13,48	0,0136

Table S1: Use of GC and **Eq 1** to calculate the concentration of **2a** at initial stages of the reaction.

The same procedure described above was followed in order to synthesize benzocoumarin [**D₄**]-**2a** from acid [**D₅**]-**1a** (40.2 mg, 0.2 mmol). As before, by using the calibration curve, the concentration of benzocoumarin [**D₄**]-**2a** (**Table S2**) in the reaction mixture was represented vs the reaction time (**Figure S2**, orange line).



t (min)	IS (mg)	Area IS	Area 2a-D₄	area 2a-D₄ /area IS	2a-D₄ produced (mg)	Yield 2a-D₄ (%)	[2a-D₄] (M)
0	-	-	-	-	0	0	0
11	2,31	4511,1	31,2	0,0069	0,407	1,04	1,0133
19	2,36	4544,9	58,8	0,0129	0,778	1,98	0,0019
28	2,20	4270	85,7	0,0201	1,126	2,86	2,8006
45	2,21	4251,5	140,5	0,0330	1,862	4,73	0,0046
57	2,30	4500,2	190,1	0,0422	2,477	6,30	6,1625
74	2,36	5045,2	335,6	0,0665	4,003	10,18	0,0099

Table S2: Use of GC and **Eq 1** to calculate the concentration of **2a-D₄** at initial stages of the reaction. GC response was proved to be the same for both, benzocoumarins **2a** and **2a-D₄**.

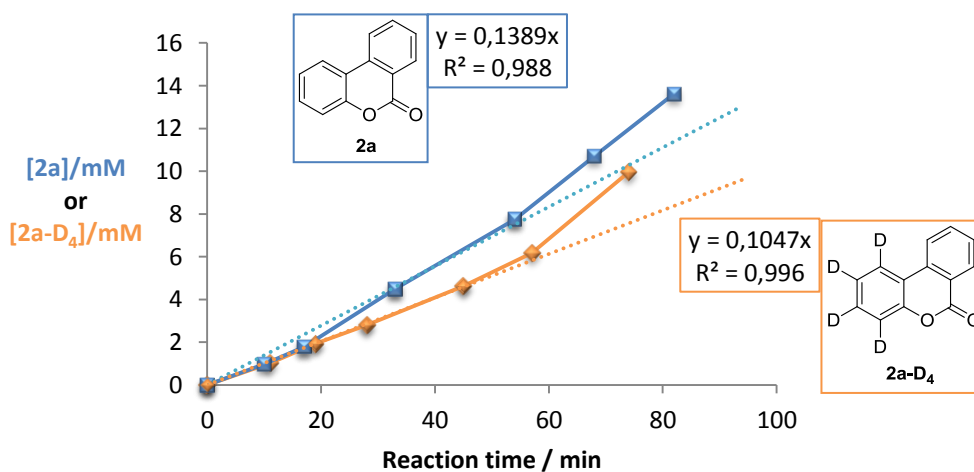
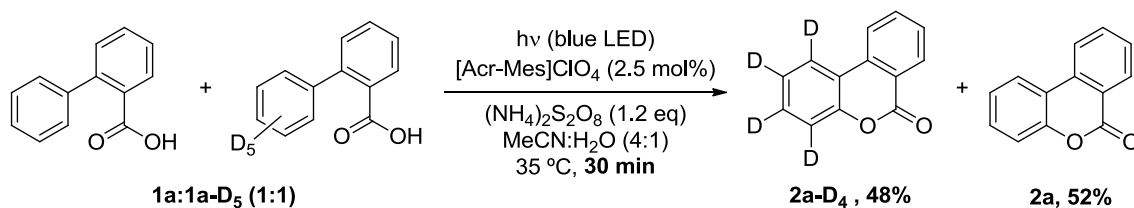


Figure S2. Initial rate of formation of **2a** or **2a-D₄**.

For benzocoumarin **2a**: $k_H = 0.1389 \text{ mM} \cdot \text{min}^{-1}$
 For benzocoumarin **2a-D₄**: $k_D = 0.1047 \text{ mM} \cdot \text{min}^{-1}$

$$KIE = \frac{k_H}{k_D} = \frac{0.1389}{0.1047} = 1.3 \quad \text{Eq 2}$$

3.3. Measurement of the Kinetic Isotopic Effect (KIE) from Competition Experiments in an Equimolar Mixture of **1a** and **1a-D₅**.



Into a pyrex tube of 25 mL acid **1a** (29.7 mg, 0.15 mmol), acid **1a-D₅** (30.5 mg, 0.15 mmol) and photocatalyst [Acr-Mes]ClO₄ (1.6 mg, 2.5 mol%) were dissolved in MeCN (1.2 mL). Then a solution of (NH₄)₂S₂O₈ (41.1 mg, 1.2 eq.) in H₂O (0.3 mL) was added and the reaction mixture was irradiated with blue LEDs lights and stirred at 35 °C. After 30 min, the reaction mixture was concentrated under reduced pressure to afford a yellow residue which was purified by column chromatography (95:5, Hexane/EtOAc). A mixture of benzocoumarins **2a** and **2a-D₄** were isolated as a white solid (3 mg, ~ 5 % yield). ¹H-NMR, represented in **Figure S3**, showed quasi-equimolar mixture of benzocoumarins.

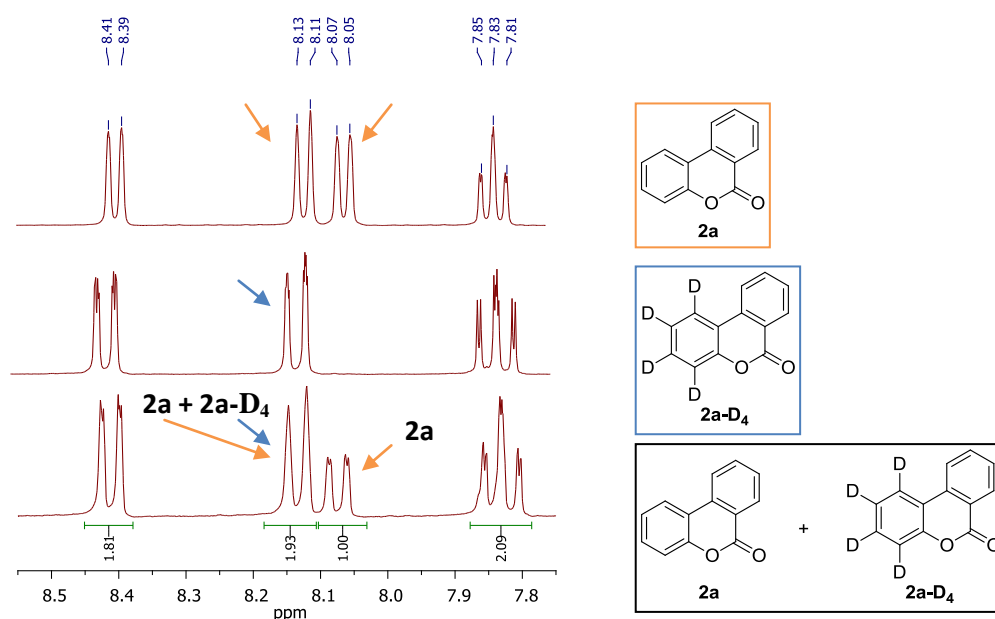


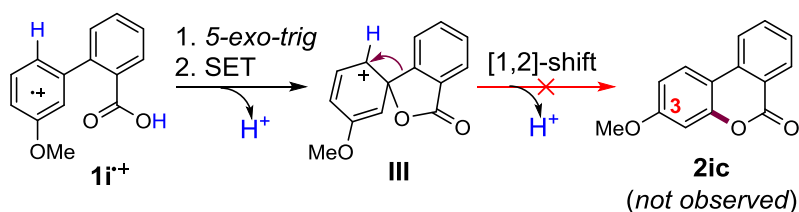
Figure S3. Part of the ¹H-NMR (300 MHz, CDCl₃) obtained for pure benzocoumarins **2a**, **2a-D₄**, and for the mixture obtained after purification from the reaction described above.

$$KIE = \frac{1.00}{1.93-1.00} = 1.1$$

Eq 3

4. Alternative pathway for 3'-methoxy-2-arylbenzoic acid **1i**

For methoxy-substituted substrates an initial formation of the corresponding radical cation would be possible by SET [E^{red} (methoxybenzene) = 1.76 V vs SCE)¹. In this case, the 5-*exo-trig* cyclization would also be possible, followed by a SET oxidation and a [1,2]-shift to obtain the 3-methoxy isomer **2ic**. Remarkably, we did not observe the formation of this isomer, which was the main product observed in some cases by Martin`s when iodine (III) catalysts were used.¹

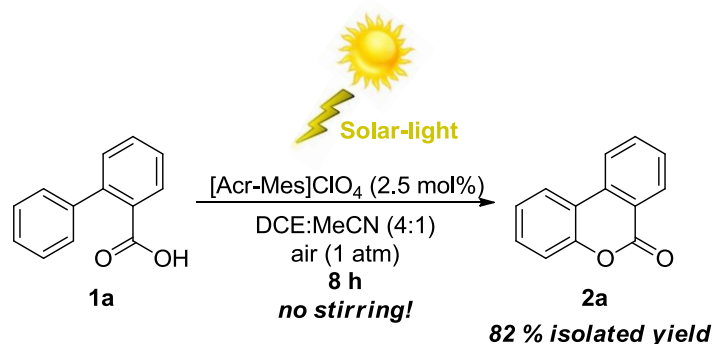


¹ Ohkubo, K.; Mizushima, K.; Iwata, R.; Fukuzumi, S. *Chem. Sci.* **2011**, 2, 715.

5. Reaction Performed Under Solar-Light Irradiation



Into a pyrex tube of 25 mL (1.5 cm of diameter) acid **1a** (39.6 mg, 0.2 mmol), and photocatalyst [Acr-Mes]ClO₄ (2.1 mg, 2.5 mol%) were dissolved in a 1:1 mixture of DCE:MeCN (2 mL). The tube was capped with a septa wearing a needle (air was allowed to enter the tube) and placed at the windowsill without stirring. After 8 h under solar-light irradiation,² the reaction mixture was concentrated under reduced pressure to afford a yellow residue which was purified by column chromatography (95:5 Hexane/EtOAc). The corresponding benzocoumarin **2a** was obtained as a white solid (32.2 mg, 82%). Characterization is described below.



Scheme S3: Formation of **2a** under solar-light irradiation and using air as terminal oxidant.

² The reaction was performed in Alicante on May 07, 2015. The reaction temperature was measured by introducing a thermometer into the reaction tube and varied from 25 to 35 °C.

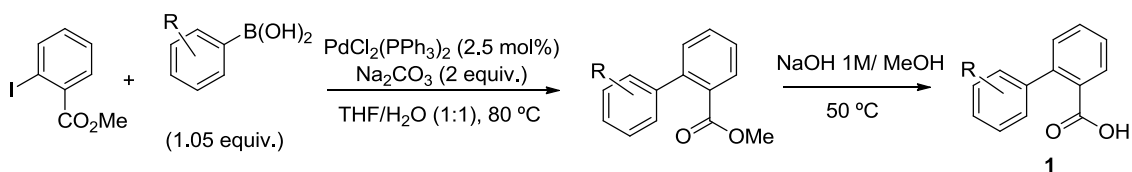
6. Syntheses of 2-Arylbenzoic Acids **1b** – **1u**

- *Procedure for the synthesis of $\text{PdCl}_2(\text{PPh}_3)_2$ catalyst*³

Into an oven-dried *Schlenck* a suspension of PdCl_2 (53 mg, 0.3 mmol) in dry THF (3 mL) was prepared under Ar atmosphere. Then, LiCl (26 mg, 0.6 mmol) was added and the reaction mixture was stirred under Ar atmosphere for 5 minutes at room temperature. After this time, PPh_3 (157 mg, 0.60 mmol) was added to the resulted grey suspension. The reaction mixture was stirred under Ar atmosphere for at least 2 h at room temperature. The formed pale yellow suspension remained under Ar atmosphere and was directly used for the Suzuki Cross-coupling reactions.

6.1. Synthesis of compounds **1b-1l**.

- *General procedure for the synthesis of biaryl 2-carboxylic acids **1b** - **1l** using Suzuki Cross-coupling reaction.*⁴



To a solution of the desired arylboronic acid (2.1 mmol, 1.05 equiv.) in dry THF (4.5 mL) was added the prepared suspension of $\text{PdCl}_2(\text{PPh}_3)_2$ in dry THF (0.5 mL, 0.1 M). The suspension was stirred and a Na_2CO_3 aqueous solution (5 mL, 0.8 M) was added. The reaction mixture was stirred under Ar atmosphere for 2 minutes at room temperature. Finally, methyl 2-iodobenzoate (294 μL , 2 mmol) was added and the reaction mixture was heated at 80 °C for 12 h under Ar atmosphere. The resultant mixture was extracted with EtOAc (3 \times 10 mL). The combined layers were washed with brine (1 \times 5 mL), dried over anhydrous MgSO_4 , filtered and concentrated under reduced pressure. The residue was purified by column chromatography (95:5 Hexane/EtOAc) to provide the corresponding methyl esters as pale yellow oils.

A NaOH aqueous solution (7 mL, 1 M) was added to a stirring mixture of the desired ester (1.8 mmol) in MeOH (7 mL) under Ar atmosphere. The reaction mixture was heated to 50 °C, observing complete hydrolysis by TLC after 12 h. The reaction mixture was concentrated under reduced pressure. The residue was quenched with 6 M HCl until

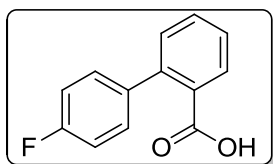
³ Molander, G.A. Handbook of Reagents for Organic Synthesis. Catalyst Components for Coupling Reactions. Wiley **2008**, pp 332-343.

⁴ Wang, Y.; Gulevich, A.V.; Gevorgyan, V. *Chem. Eur. J.* **2013**, *19*, 15836.

pH < 3 and was extracted with EtOAc (3 × 10 mL). The combined layers were washed with brine (1 × 5 mL), dried over anhydrous MgSO₄, filtered and concentrated under reduced pressure to afford the desired pure biaryl 2-carboxylic acids.

4'-fluoro-[1,1'-biphenyl]-2-carboxylic acid (**1b**)⁵:

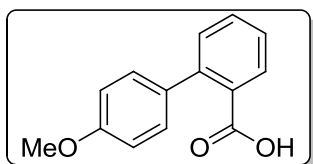
Compound **1b** was prepared from 4-fluorophenylboronic acid following the general procedure described above.



Compound **1b** was obtained as a white solid (361 mg, 1.67 mmol, 91% over two steps): *R*_f 0.37 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH⁶); ¹H NMR (300 MHz, CDCl₃) δ 7.96 (dd, *J* = 7.8, 1.1 Hz, 1H), 7.57 (td, *J* = 7.6, 1.4 Hz, 1H), 7.43 (td, *J* = 7.6, 1.4 Hz, 1H), 7.33 (dd, *J* = 7.8, 1.1 Hz, 1H), 7.31 - 7.25 (m, 2H), 7.13 - 7.01 (m, 2H); ¹³C NMR (75 MHz, CDCl₃) δ 173.4 (C), 162.5 (d, *J* = 244.5 Hz, C), 142.6 (C), 137.2 (d, *J* = 3.0 Hz, C), 132.4 (CH), 131.4 (CH), 131.0 (CH), 130.2 (d, *J* = 7.5 Hz, 2 × CH), 129.2 (C), 127.5 (CH), 115.2 (d, *J* = 21.8 Hz, 2 × CH).

4'-methoxy-[1,1'-biphenyl]-2-carboxylic acid (**1c**)⁷:

Compound **1c** was prepared from 4-methoxyphenylboronic acid following the general procedure described above, but in a larger scale, using 5 mmol of methyl 2-iodobenzoate.



Compound **1c** was obtained as a white solid (959 mg, 4.2 mmol, 85% over two steps): *R*_f 0.34 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ¹H NMR (300 MHz, CDCl₃) δ 7.92 (dd, *J* = 7.8, 0.9 Hz, 1H), 7.54 (td, *J* = 7.5, 1.5 Hz, 1H), 7.40 (dd, *J* = 7.6, 1.4 Hz, 1H), 7.35 (dd, *J* = 7.7, 1.2 Hz, 1H), 7.29 - 7.24 (m, 2H), 6.96 - 6.89 (m, 2H), 3.84 (s, 3H); ¹³C NMR (75 MHz, CDCl₃) δ 173.8 (C), 159.2 (C), 143.0 (C), 133.4 (C), 132.2 (CH), 131.3 (CH), 130.8 (CH), 129.8 (2 × CH), 129.4 (C), 127.0 (CH), 113.7 (2 × CH), 55.4 (CH₃).

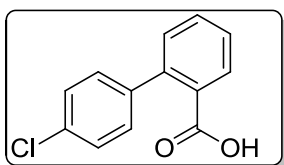
⁵ Li, Y.; Ding, Y.-J.; Wang, J.-Y.; Su, Y.-M.; Wang, X.-S. *Org. Lett.* **2013**, *15*, 2574.

⁶ Taygerly, J. P.; Miller, L. M.; Yee, A.; Peterson, E. A. *Green Chem.* **2012**, *14*, 3020.

⁷ Wang, Y.; Gulevich, A.V.; Gevorgyan, V. *Chem. Eur. J.* **2013**, *19*, 15836.

4'-chloro-[1,1'-biphenyl]-2-carboxylic acid (**1d**)⁵:

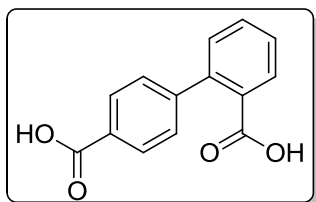
Compound **1d** was prepared from 4-chlorophenylboronic acid following the general procedure described above, but in a larger scale, using 5 mmol of methyl 2-iodobenzoate.



Compound **1d** was obtained as a white solid (977 mg, 4.2 mmol, 84% over two steps): R_f 0.53 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 7.97 (d, J = 7.7 Hz, 1H), 7.57 (t, J = 7.5 Hz, 1H), 7.44 (t, J = 7.6 Hz, 1H), 7.34 (t, J = 8.5 Hz, 3H), 7.29 – 7.23 (m, 2H); ^{13}C NMR (75 MHz, CDCl_3) δ 173.0 (C), 142.5 (C), 139.7 (C), 133.6 (C), 132.5 (CH), 131.3 (CH), 130.0 (2 \times CH), 129.1 (C), 128.4 (2 \times CH), 127.7 (CH), 77.6 (CH).

[1,1'-biphenyl]-2,4'-dicarboxylic acid (**1e**):

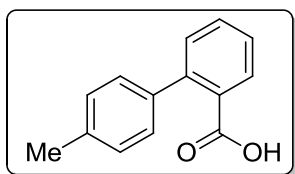
Compound **1e** was prepared from (4-(ethoxycarbonyl)phenyl)boronic acid following the general procedure described above.



Compound **1e** was obtained as a white solid (193.8 mg, 0.8 mmol, 40% over two steps): R_f 0.16 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 12.92 (br s, 2H), 7.97 (d, J = 8.4 Hz, 2H), 7.80 (dd, J = 7.7, 1.2 Hz, 1H), 7.10 (td, J = 7.5, 1.4 Hz, 1H), 7.50 (td, J = 7.6, 1.2 Hz, 1H), 7.44 (d, J = 8.4 Hz, 2H), 7.41 (dd, J = 7.6, 0.9 Hz, 1H); ^{13}C NMR (75 MHz, $\text{DMSO}-d_6$) δ 169.2 (C), 167.3 (C), 145.5 (C), 140.4 (C), 132.0 (C), 131.2 (CH), 130.5 (CH), 129.5 (C + CH), 129.1 (2 \times CH), 128.6 (2 \times CH), 127.8 (CH).

4'-methyl-[1,1'-biphenyl]-2-carboxylic acid (**1f**)⁷:

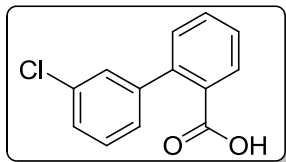
Compound **1f** was prepared from 4-methylphenylboronic acid following the general procedure described above.



Compound **1f** was obtained as a white solid (350 mg, 1.65 mmol, 87% over two steps): R_f 0.56 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 7.92 (dd, J = 7.8, 1.1 Hz, 1H), 7.53 (td, J = 7.6, 1.4 Hz, 1H), 7.39 (td, J = 7.6, 1.4 Hz, 1H), 7.35 (dd, J = 7.7, 0.9 Hz, 1H), 7.26 - 7.14 (m, 4H), 2.38, (s, 3H); ^{13}C NMR (75 MHz, CDCl_3) δ 174.0 (C), 143.4 (C), 138.2 (C), 137.2 (C), 132.2 (CH), 131.4 (CH), 130.8 (CH), 129.5 (C), 129.0 (2 \times CH), 128.5 (2 \times CH), 127.1 (CH), 21.4 (CH_3).

3'-chloro-[1,1'-biphenyl]-2-carboxylic acid (**1g**)⁵:

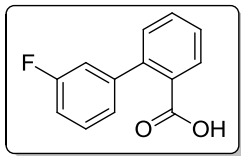
Compound **1g** was prepared from 3-chlorophenylboronic acid following the general procedure described above, using a 1.82 mmol scale of methyl 2-iodobenzoate.



Compound **1g** was obtained as a white solid (123.1 mg, 0.53 mmol, 29% over two steps): R_f 0.38 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 7.99 (ddd, $J = 7.9, 1.5, 0.5$ Hz, 1H), 7.58 (td, $J = 7.6, 1.5$ Hz, 1H), 7.46 (td, $J = 7.6, 1.4$ Hz, 1H), 7.37 – 7.30 (m, 4H), 7.23 – 7.17 (m, 1H); ^{13}C NMR (75 MHz, CDCl_3) δ 171.9 (C), 142.9 (C), 142.1 (C), 133.8 (C), 132.3 (CH), 131.3 (CH), 130.9 (CH), 129.2 (CH), 128.9 (C), 128.5 (CH), 127.8 (CH), 127.4 (CH), 126.8 (CH).

3'-fluoro-[1,1'-biphenyl]-2-carboxylic acid (**1h**)⁵:

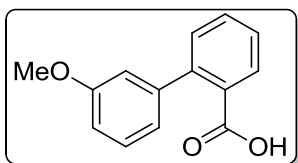
Compound **1h** was prepared from 3-fluorophenylboronic acid following the general procedure described above.



Compound **1h** was obtained as a white solid (318 mg, 1.47 mmol, 77% over two steps): R_f 0.53 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (400 MHz, CDCl_3) δ 7.97 (dd, $J = 7.8, 1.1$ Hz, 1H), 7.57 (td, $J = 7.6, 1.4$ Hz, 1H), 7.44 (td, $J = 7.6, 1.3$ Hz, 1H), 7.34 (ddd, $J = 7.7, 3.3, 1.4$ Hz, 2H), 7.06 (dd, $J = 20.4, 8.6$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 173.2 (C), 162.6 (d, $J = 246.4$ Hz, C), 143.4 (d, $J = 8.1$ Hz, C), 142.4 (C), 142.3 (C), 132.4 (CH), 131.2 (CH), 131.0 (CH), 129.6 (d, $J = 4.0$ Hz, CH), 127.8 (CH), 124.4 (d, $J = 3.0$ Hz, CH), 115.7 (d, $J = 22.2$ Hz, CH), 114.4 (d, $J = 21.2$ Hz, CH).

3'-methoxy-[1,1'-biphenyl]-2-carboxylic acid (**1i**)⁵:

Compound **1i** was prepared from 3-methoxyphenylboronic acid following the general procedure described above.

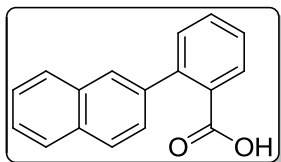


Compound **1i** was obtained as a white solid (367 mg, 1.61 mmol, 85% over two steps): R_f 0.28 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (400 MHz, CDCl_3) δ 7.92 (dd, $J = 7.8, 1.1$ Hz, 1H), 7.54 (td, $J = 7.6, 1.4$ Hz, 1H), 7.41 (td, $J = 7.6, 1.3$ Hz, 1H), 7.37 (dd, $J = 7.7, 0.9$ Hz, 1H), 7.31 – 7.23 (m, 1H), 6.94 - 6.86 (m, 3H), 3.80 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 173.8 (C), 159.4 (C), 143.2 (C),

142.5 (C), 132.2 (CH), 131.2 (CH), 130.7 (CH), 129.6 (C), 129.2 (CH), 127.4 (CH), 121.2 (CH), 114.3 (CH), 113.1 (CH), 55.4 (CH₃).

2-(naphthalen-2-yl)benzoic acid (**1j**)⁵:

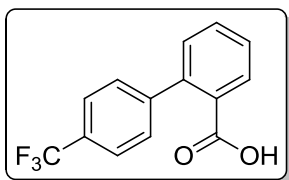
Compound **1j** was prepared from 2-naphthylboronic acid following the general procedure described above, using a 1.3 mmol scale of methyl 2-iodobenzoate.



Compound **1j** was obtained as a white solid (187 mg, 0.75 mmol, 58% over two steps): *R_f* 0.43 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ¹H NMR (300 MHz, CDCl₃) δ 7.98 (dd, *J* = 8.1, 1.4 Hz, 1H), 7.88 - 7.81 (m, 3H), 7.79 (s, 1H), 7.59 (td, *J* = 7.7, 1.4 Hz, 1H), 7.52 - 7.42 (m, 5H); ¹³C NMR (101 MHz, CDCl₃) δ 172.4 (C), 143.5 (C), 138.9 (C), 133.4 (C), 132.7 (C), 132.3 (CH), 131.7 (CH), 131.0 (CH), 129.4 (C), 128.3 (CH), 127.9 (CH), 127.6 (CH), 127.3 (CH), 127.1 (CH), 126.3 (CH), 126.2 (CH), 126.0 (CH).

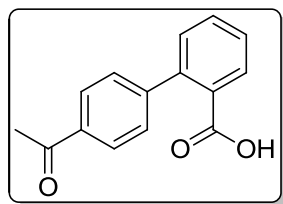
4'-(trifluoromethyl)-[1,1'-biphenyl]-2-carboxylic acid (**1k**)⁸:

Compound **1k** was prepared from 4-(trifluoromethyl)phenylboronic acid following the general procedure described above, using a 1.3 mmol scale of methyl 2-iodobenzoate.



Compound **1k** was obtained as a white solid (72 mg, 0.27 mmol, 44% over two steps): *R_f* 0.57 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ¹H NMR (300 MHz, CDCl₃) δ 8.03 (dd, *J* = 7.8, 1.1 Hz, 1H), 7.64 (d, *J* = 7.9 Hz, 2H), 7.59 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.48 (td, *J* = 7.6, 1.3 Hz, 1H), 7.43 (d, *J* = 8.0 Hz, 2H), 7.33 (dd, *J* = 7.6, 1.0 Hz, 1H); ¹³C NMR (75 MHz, CDCl₃) δ 171.7 (C), 145.0 (C), 142.5 (C), 132.6, 131.2 (2 × CH), 129.7 (q, *J* = 32.7 Hz, C), 129.0 (2 × CH), 128.1 (2 × CH), 128.0 (C), 125.1 (q, *J* = 3.5 Hz, 2 × CH), 124.2 (q, *J* = 272.0 Hz, C).

4'-acetyl-[1,1'-biphenyl]-2-carboxylic acid (**1l**)⁸:

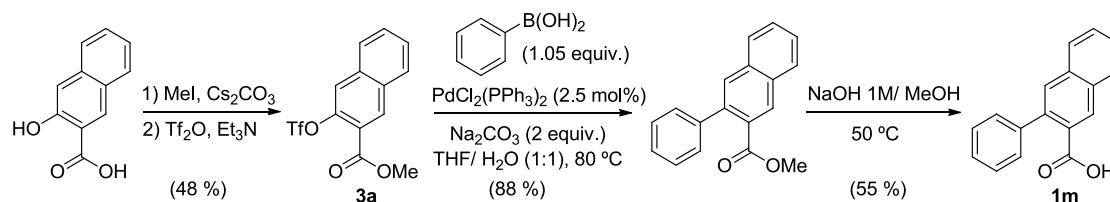


Compound **1l** was prepared from 4-(acetyl)phenylboronic acid following the general procedure described above, using a 1.3 mmol scale of methyl 2-iodobenzoate. Compound **1l** was obtained as a brown pale solid (210 mg, 0.92 mmol, 71% over two steps): *R_f* 0.39 (7:3 Hexane/(3:1:0.08)

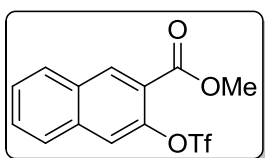
⁸ Day, J.-J.; Xu, W.-T.; Wu, Y.-D.; Zhang, W.-M.; Gong, Y.; He, X.-P.; Zhang, X.-Q.; Xu, H. J. *J. Org. Chem.* **2015**, *2*, 911.

EtOAc/EtOH/AcOH); ^1H NMR (400 MHz, CDCl_3) δ 7.99 (dd, $J = 11.3, 8.2$ Hz, 3H), 7.60 (td, $J = 7.60, 1.4$ Hz, 1H), 7.47 (td, $J = 7.7, 1.3$ Hz, 1H), 7.44 (dd, $J = 13.8, 4.9$ Hz, 2H), 7.35 (dd, $J = 7.6, 1.0$ Hz, 1H), 2.64 (s, 3H); ^{13}C NMR (75 MHz, CDCl_3) δ 198.2 (C), 172.6 (C), 146.4 (C), 142.6 (C), 136.0 (C), 132.5 (CH), 131.1 (2 x CH), 129.2 (CH), 128.9 (C), 128.3 (2 x CH), 128.1 (2 x CH), 26.8 (CH_3).

6.2. Procedure for the synthesis of acid 1m.



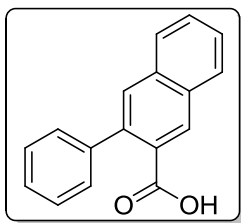
Methyl 3-(((trifluoromethyl)sulfonyl)oxy)-2-naphthoate (3a)⁵:



To a solution of 3-hydroxy-2-naphthoic acid (564 mg, 3 mmol) in dry DMF (30 mL) was added Cs_2CO_3 (489 mg, 1.5 mmol) under Ar atmosphere, followed by MeI (196 μL , 3.15 mmol). The mixture reaction was stirred for 90 minutes under Ar atmosphere at room temperature. At this time, the reaction was distributed between phases using a EtOAc/ H_2O mixture (30 mL:30 mL). The aqueous layer was extracted with EtOAc (4 \times 20 mL). The combined layers were washed with H_2O (2 \times 10 mL), NaHCO_3 (aq. sat.) (2 \times 10 mL) and brine (1 \times 5 mL), dried over anhydrous MgSO_4 , filtered and concentrated under reduced pressure to afford the desired hydroxiester intermediate.

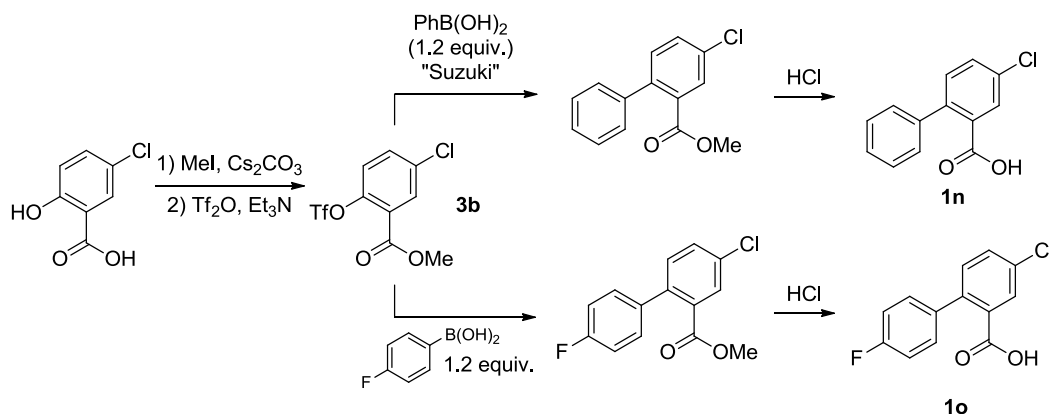
The hydroxiester afforded in the previously step was dissolved in dry CH_2Cl_2 (30 mL). This reaction mixture was cooled to -78°C under Ar atmosphere and Et_3N (6.6 mmol, 921 μL) followed by Tf_2O (4.5 mmol, 760 μL) were both added dropwise. After complete addition, the reaction mixture was stirred for 30 minutes at -78°C , and allowed to reach room temperature for 12 hours under Ar atmosphere. The reaction mixture was extracted with diethyl ether (4 \times 25 mL). The combined layers was washed with HCl 1M (4 \times 25 mL) and brine (1 \times 5 mL). The organic layer was dried over anhydrous MgSO_4 , filtered and concentrated under reduced pressure affording the reaction crude. This residue was purified by column chromatography (95:5 hexane/EtOAc) to provide the desired ester **3a** as a pale yellow solid (480 mg, 1.45 mmol, 48 %): CG: R_T 15.06 min; LRMS (EI): m/z (%) = 334 (M^+ , 100), 303 (20), 201 (67), 173 (32), 143 (84), 114 (38), 69 (14).

3-phenyl-2-naphthoic acid (**1m**)⁵:

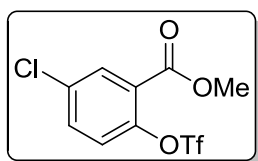


The desired biaryl 2-carboxylic acid **1m** was obtained following the general procedure described for the synthesis of acids **1b** - **1l**, from 1.27 mmol of ester **3a** instead of using methyl 2-iodobenzoate. Compound **1m** was obtained as a white solid (132 mg, 0.53 mmol, 52% over two steps): R_f 0.28 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 8.54 (s, 1H), 7.95 (d, J = 8.3 Hz, 1H), 7.87 (d, J = 8.3 Hz, 1H), 7.81 (s, 1H), 7.67 – 7.49 (m, 2H), 7.49 – 7.32 (m, 5H); ^{13}C NMR (75 MHz, CDCl_3) δ 172.6 (C), 141.4 (C), 139.3 (C) 134.9 (CH), 132.4 (C), 131.7 (CH), 130.3 (2 \times C), 130.0 (CH), 128.9 (CH), 128.8 (2 \times CH), 128.2 (2 \times CH), 127.9 (CH), 127.3 (CH), 126.9 (CH).

6.3. Procedure for the synthesis of acid **1n** and **1o**.

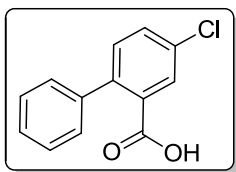


Methyl 5-chloro-2-((trifluoromethyl)sulfonyl)benzoate (**3b**)⁵



Methylester **3b** was prepared from 5-chloro-2-hydroxybenzoic acid (704.33 mg, 4 mmol) following the same procedure described for the synthesis of compound **3a**, obtaining product **3b** after column chromatography (95:5 Hexane/EtOAc) as a colorless liquid (815 mg, 2.56 mmol, 64 %): GC: R_T 15.67 min; LRMS (EI): m/z (%) = 318/320 (54/21, M^+), 287/289 (35/12), 223/225 (100/35), 185/187 (52/18), 169/171 (18/6), 154/156 (42/30), 129/131 (36/12), 63 (40).

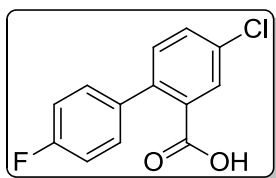
4-chloro-[1, 1'-biphenyl]-2-carboxylic acid (**1n**):⁵



Compound **1n** was prepared from 1.25 mmol of methylester **3b** instead of using methyl 2-iodobenzoate, following the general procedure for the synthesis of biaryl 2-carboxylic acids **1b** - **1l**.

Compound **1n** was obtained as a white solid (242 mg, 1.04 mmol, 84% over two steps): R_f 0.53 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 7.92 (d, J = 2.3 Hz, 1H), 7.53 (dd, J = 8.3, 2.3 Hz, 1H), 7.41 – 7.35 (m, 3H), 7.34 – 7.27 (m, 3H); ^{13}C NMR (75 MHz, CDCl_3) δ 172.4 (C), 141.9 (C), 139.9 (C), 133.5 (C), 132.7 (CH), 132.2 (CH), 130.8 (C), 130.7 (CH) 128.5 (2 \times CH), 128.3 (2 \times CH), 127.8 (CH).

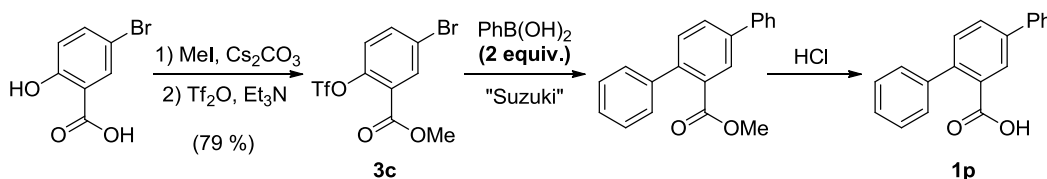
4-chloro-4'-fluoro-[1,1'-biphenyl]-2-carboxylic acid (**1o**):



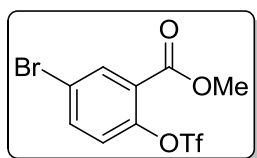
Compound **1o** was prepared from 1.25 mmol of methylester **3b** and 1.5 mmol of 4-fluorophenylboronic acid, following the typical procedure for the synthesis of biaryl 2-carboxylic acids **1b** - **1l**. Compound **1o** was obtained as a white solid (122 mg,

0.49 mmol, 45% over two steps): R_f 0.31 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 7.94 (d, J = 2.3 Hz, 1H), 7.53 (dd, J = 8.3, 2.3 Hz, 1H), 7.31 - 7.18 (m, 3H), 7.14 - 7.00 (m, 2H); ^{13}C NMR (75 MHz, CDCl_3) δ 171.6 (C), 162.7 (d, J = 246 Hz, C), 141.1 (C), 136.0 (d, J = 3.8 Hz, C), 133.7 (C), 132.7 (CH), 132.4 (CH) 130.9 (CH), 130.5 (C), 130.2 (d, J = 8.3 Hz, 2 \times CH), 115.3 (d, J = 21 Hz, 2 \times CH).

6.4. Procedure for the synthesis of acid **1p**.



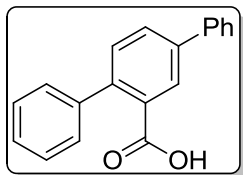
Methyl 5-bromo-2-(((trifluoromethyl)sulfonyl)oxy) benzoate (**3c**):⁵



Methylester **3c** was prepared from 5-chloro-2-hydroxybenzoic acid (836 mg, 2.3 mmol) following the same procedure described for the synthesis of methylester **3a**, obtaining product **3c** as pale yellow oil (856 mg, 2.36 mmol, 79 %) after column

chromatography (97:3, Hexane/EtOAc): GC: R_T 12.51 min; LRMS (EI): m/z (%) = 364/363 (84/80, M^+), 333/332 (32/31), 269/268 (100/96).

[1, 1':4', 1'':terphenyl]-2'-carboxylic acid (**1p**):⁸

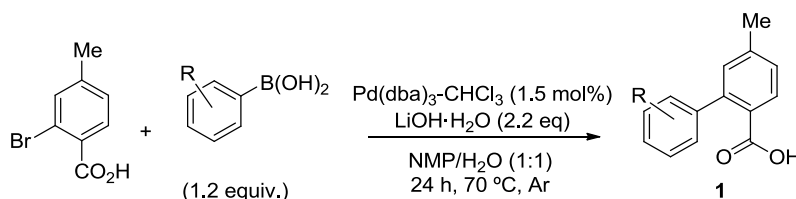


Compound **1p** was prepared from 2.3 mmol of methylester **3c** and 3.8 mmol (2 eq) of phenylboronic acid, following the general procedure for the synthesis of biaryl 2-carboxylic acids **1b** - **1l**.

Compound **1p** was obtained as a white solid (466.3 mg, 1.7 mmol, 74%): R_f : 0.31 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 8.19 (d, J = 1.9 Hz, 1H), 7.79 (dd, J = 8.0, 2.0 Hz, 1H), 7.65 (dd, J = 8.3, 1.3 Hz, 2H), 7.54 – 7.34 (m, 9H); ^{13}C NMR (75 MHz, CDCl_3) δ 173.3 (C), 142.3 (C), 140.8 (C), 140.4 (C), 139.7 (C), 131.9 (CH), 130.7 (CH), 129.8 (C), 129.5 (CH), 129.1 (2 \times CH), 128.7 (2 \times CH), 128.3 (2 \times CH), 128.0 (CH), 127.6 (CH), 127.2 (2 \times CH).

6.5. Procedure for synthesis of acids **1q**-**1s**:^{5,9}

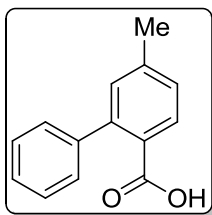
- General procedure for the synthesis of biaryl 2-carboxylic acids **1q** - **1s**



Into an oven dried pyrex tube, 2-bromo-4-methylbenzoic acid (329 mg, 1.5 mmol), the desired phenylboronic acid (1.8 mmol) and $\text{LiOH}\cdot\text{H}_2\text{O}$ (141 mg, 3.3 mmol) were added under Ar atmosphere. Then, a NMP: H_2O (4.5 mL:4.5 mL) degassed mixture was added, followed by $\text{Pd}_2(\text{dba})_3\text{-CHCl}_3$ (21 mg, 1.5 mol%) The reaction mixture was stirred for 24 hours under Ar atmosphere at 70 °C until conversion into a major product was observed (monitored by GC). At this time, the reaction mixture was quenched with HCl 2 M until pH < 3. The aqueous layer was extracted with EtOAc (3 \times 10 mL). The organic extracts were combined, washed with brine (1 \times 5 mL), dried over anhydrous MgSO_4 , filtered and concentrated under reduced pressure allowing a yellow viscous solid as the crude reaction. This residue was purified by column chromatography (8:2, Hexane/[EtOAc/EtOH/AcOH (3:1:0.08)]).

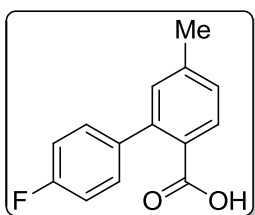
⁹ Houpis, I. N.; Huang, C.; Nettekove, U.; Chen, J. G.; Liu, R.; Canters, M. *Org. Lett.* **2008**, *10*, 5601.

5-methyl-[1,1'-biphenyl]-2-carboxylic acid (**1q**)⁵:



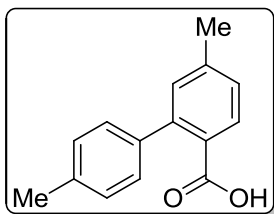
Compound **1q** was obtained following the general procedure for the synthesis of biaryl 2-carboxylic acids **1q** - **1s**, from 1.8 mmol (252 mg) of phenylboronic acid. Compound **1q** was obtained as a yellow solid (213 mg, 1 mmol, 67%¹⁰); R_f 0.34 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 7.88 (dd, J = 8.0, 4.3 Hz, 1H), 7.43 - 7.07 (m, 7H), 2.42 (s, 3H); ^{13}C NMR (75 MHz, CDCl_3) δ 173.0 (C), 143.8 (C), 142.9 (C), 141.4 (C), 132.2 (CH), 131.2 (CH), 128.6 (2 \times CH), 128.1 (2 \times CH), 128.0 (CH), 127.4 (CH), 126.4 (C), 21.6 (CH_3).

4'-fluoro-5-methyl-[1,1'-biphenyl]-2-carboxylic acid (**1r**):



Compound **1r** was obtained following the typical procedure for the synthesis of biaryl 2-carboxylic acids **1q** - **1s**, from 0.90 mmol (126 mg) of 4-fluorophenylboronic acid and 0.75 mmol (165 mg) of 2-bromo-4-methylbenzoic acid. Compound **1r** was obtained as a yellow solid (103.4 mg, 0.45 mmol 60 %¹⁰); R_f 0.33 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (400 MHz, CDCl_3) δ 7.90 (d, J = 8.3 Hz, 1H), 7.31 - 6.98 (m, 6 H), 2.42 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 173.2 (C), 162.4 (d, J = 246.4 Hz, C), 144.9 (C), 143.2 (CH), 137.4 (d, J = 3.0 Hz, C), 135.6 (CH), 132.8 (CH), 131.4 (C), 130.2 (d, J = 7.1 Hz, 2 \times CH), 122.8 (C), 115.0 (d, J = 21.2 Hz, 2 \times CH), 21.6 (CH_3).

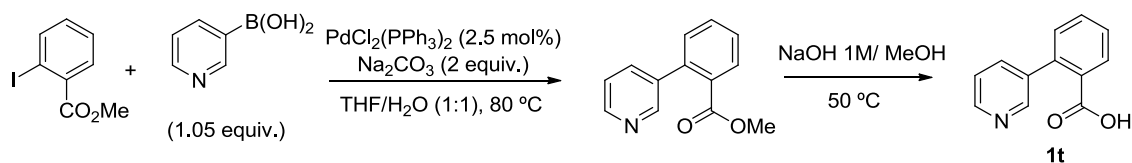
4'-5-dimethyl-[1, 1'-biphenyl]-2-carboxylic acid (**1s**):



Compound **1s** was obtained following the typical procedure for the synthesis of biaryl 2-carboxylic acids **1q** - **1s**, from 0.54 mmol (122 mg) of 3-methylboronic acid acid and 0.75 mmol (165 mg) of 2-bromo-4-methylbenzoic acid. Compound **1s** was obtained as a yellow solid (116 mg, 0.51 mmol 68 %¹⁰); R_f 0.37 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (400 MHz, CDCl_3) δ 7.90 (d, J = 8.3 Hz, 1H), 7.31 - 6.98 (m, 6H), 2.41 (s, 3H), 2.39 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 173.4 (C), 143.8 (C), 142.9 (C), 138.5 (C), 137.1 (C), 132.3 (CH), 131.2 (CH), 128.9 (2 \times CH), 128.5 (2 \times CH), 127.9 (CH), 126.4 (C), 21.7 (CH_3), 21.4 (CH_3).

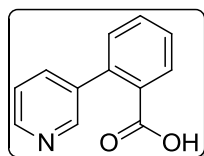
¹⁰ According to ^1H NMR spectrum, biaryl 2-carboxylic acids **1q**, **1r** and **1s** were contaminated with 2-bromo-4-methylbenzoic acid. These results were corrected according to the integration of the methyl signals at ^1H NMR spectrum.

6.6. Procedure for synthesis of acid **1t**:



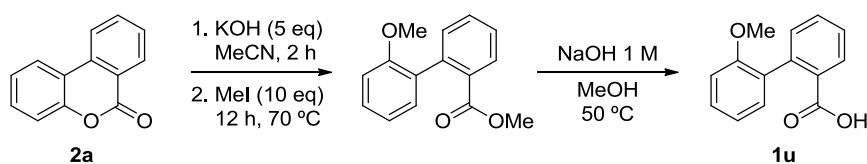
Compound **1t** was prepared from 3-pyridinylboronic acid following the general procedure described for the synthesis of acids **1b-1l**. After hydrolysis, the aqueous phase was basified and washed once with EtOAc (10 mL). The aqueous phase was acidified to pH 6 and the product was extracted with CH₂Cl₂ (4 x 10 mL). Organic phases were collected, dried over MgSO₄, filtered and concentrated.

2-(3'-Pyridinyl)benzoic acid (**1t**):



Compound **1t** was obtained as a white solid (95.5 mg, 0.48 mmol, 24 %): *R*_f: 0.07 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ¹H NMR (400 MHz, DMSO-*d*₆ + D₂O) δ 8.50 – 8.40 (m, 1H), 8.40 (s, 1H), 7.80 (d, *J* = 7.7 Hz, 1H), 7.74 (d, *J* = 7.9 Hz, 1H), 7.60 (t, *J* = 7.5 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 1H), 7.45 (dd, *J* = 7.9, 4.9 Hz, 1H), 7.36 (d, *J* = 7.6 Hz, 1H); ¹³C NMR (101 MHz, DMSO-*d*₆ + D₂O) δ 169.9 (C), 148.2 (CH), 148.0 (CH), 138.0 (C), 137.5 (C), 136.9 (CH), 132.1 (CH), 132.0 (C), 131.2 (CH), 130.2 (CH), 128.8 (CH), 124.1 (CH).

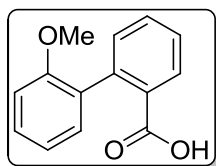
6.7. Procedure for synthesis of acid **1u** ^{5,7}:



To a KOH suspension (280 mg, 5 mmol) in dry MeCN (10 mL) was added **2a** (196 mg, 1 mmol) under Ar atmosphere. The suspension was stirred for 2 hours under Ar atmosphere at room temperature. After this time, MeI (6.2 mL, 10 mmol) was added dropwise and the reaction mixture was stirred overnight under Ar atmosphere at reflux. The solvent was evaporated, affording a white wax. An EtOAc/H₂O mixture was added (10 mL/10 mL) and the aqueous layer was extracted with EtOAc (4 × 10 mL). The organic extracts were combined, washed with brine (1 × 5 mL), dried over anhydrous MgSO₄, filtered and concentrated under reduced pressure giving a yellow oil (241 mg, 99 %).

The desired biaryl 2-carboxylic acid **1u** was obtained following the general procedure described for the synthesis of acids **1b-1l**.

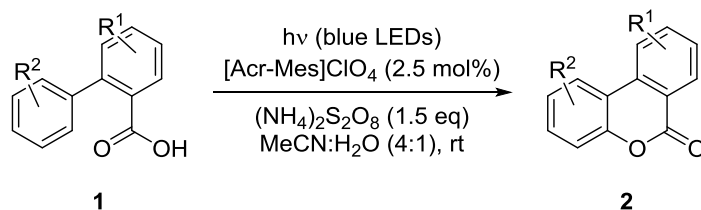
2'-methoxy-[1, 1'-biphenyl]-2-carboxylic acid (**1u**):



Compound **1u** was obtained as a white solid (84 mg, 0.84 mmol, 84 %): R_f : 0.47 (7:3 Hexane/(3:1:0.08) EtOAc/EtOH/AcOH); ^1H NMR (300 MHz, CDCl_3) δ 7.92 (dd, $J = 7.7, 1.4$ Hz, 1H), 7.57 (td, $J = 7.5, 1.4$ Hz, 1H), 7.39 (td, $J = 7.6, 1.3$ Hz, 1H), 7.33 (d, $J = 7.3$ Hz, 2H), 7.28 (dd, $J = 8.8, 1.7$ Hz, 1H), 7.03 (td, $J = 7.4, 0.9$ Hz, 1H), 6.86 (d, $J = 8.8$ Hz, 1H), 3.69 (s, 3H); ^{13}C NMR (75 MHz, CDCl_3) δ 173.5 (C), 156.3 (C), 139.2 (C), 132.4 (CH), 131.7 (C), 130.8 (C), 130.3 (CH), 130.0 (2 x CH), 129.2 (CH), 127.3 (CH), 121.0 (CH), 110.7 (CH), 55.2 (CH_3).

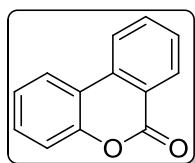
7. Synthesis of benzocoumarins **2a-2s**.

- General procedure for the synthesis of benzocoumarins **2a – 2s** by visible-light photoredox catalysis



Into a 25 mL pyrex tube, a solution of the desired acid **1** (0.20 mmol) in MeCN (1.6 mL) was added, followed by $[\text{Acr-Mes}]\text{ClO}_4$ (2.1 mg, 2.5 mol%). Then, a solution of $(\text{NH}_4)_2\text{S}_2\text{O}_8$ (69 mg, 0.30 mmol) in H_2O (0.4 mL) was added. The reaction mixture was irradiated with blue LED's and stirred at room temperature¹¹ until complete conversion of starting material (monitored by TLC). The reaction mixture was concentrated under reduced pressure to afford a yellow residue which was purified by column chromatography (a gradient from 95:5 to 80:20, Hexane/EtOAc was used).

6H-benzo[c]chromen-6-one (**2a**)⁸:



Compound **2a** was prepared following the general procedure and was obtained after 8 h as a white solid (34 mg, 0.17 mmol, 87%): R_f 0.14 (95:5 Hexane/EtOAc); GC: R_T 15.7 min; IR: ν 3075, 3026, 1725,

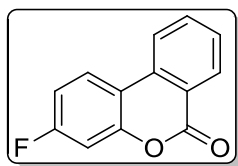
¹¹ Upon irradiation the internal temperature increased to 30-35 °C.

1606, 1077, 744, 718, 681 cm^{-1} ; LRMS (EI): m/z (%) = 196 (M^+ , 100), 168 (40), 139 (40); ^1H NMR (400 MHz, CDCl_3) δ 8.38 (d, J = 7.9 Hz, 1H), 8.10 (d, J = 8.1 Hz, 1H), 8.04 (d, J = 7.8 Hz, 1H), 7.81 (td, J = 7.8, 10 Hz, 1H), 7.57 (t, J = 7.6 Hz, 1H), 7.49 - 7.44 (m, 1H), 7.39 - 7.29 (m, 2H); ^{13}C NMR (75 MHz, CDCl_3) δ 116.3 (C), 151.4 (C), 134.9 (CH), 134.8 (C), 130.6 (CH), 130.5 (CH), 128.9 (CH), 124.6 (CH), 122.6 (CH), 121.8 (CH), 121.3 (C), 118.1 (C), 117.9 (CH).

Scaled-up to 2 mmol:

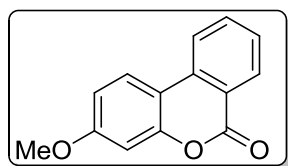
Into a 25 mL pyrex tube, a solution of the desired acid **1** (2 mmol) in MeCN:DCE (10 mL: 10 mL) was added, followed by [Acr-Mes] ClO_4 (2.1 mg, 2.5 mol%). The reaction mixture was irradiated with blue LED's and stirred at room temperature for 22 h (complete conversion of starting material by TLC). The reaction mixture was concentrated under reduced pressure to afford a yellow residue which was purified by column chromatography (95:5, Hexane/EtOAc), giving the corresponding product **2a** as a white solid (230 mg, 60 %).

3-Fluoro-6H-benzo[c]chromen-6-one (**2b**)⁵:



Compound **2b** was prepared following the general procedure and was obtained after 9 h as a white solid (30 mg 0.14 mmol, 70%): R_f 0.20 (95:5 Hexane/EtOAc); GC: R_T 15.5 min; IR: ν 1746, 1607, 1456, 1273, 1154, 1052, 875, 764 cm^{-1} ; LRMS (EI): m/z (%) = 214 (M^+ , 100), 186 (44), 157 (35); ^1H NMR (300 MHz, CDCl_3) δ 8.38 (ddd, J = 8.0, 1.4, 0.6 Hz, 1H), 8.07 - 8.00 (m, 2H), 7.83 (ddd, J = 8.1, 7.3, 1.4 Hz, 1H), 7.58 (ddd, J = 8.3, 7.3, 1.1 Hz, 1H), 7.11 - 7.05 (m, 2H); ^{13}C NMR (75 MHz, CDCl_3) δ 163.6 (d, J = 249.8 Hz, C), 160.9 (C), 152.3 (d, J = 12 Hz, C), 135.2 (CH), 134.4 (C), 130.8 (CH), 128.9 (CH), 124.5 (d, J = 9.8 Hz, CH), 121.6 (CH), 120.6 (C), 114.7 (d, J = 3 Hz, C), 112.6 (d, J = 21.8 Hz, CH), 105.2 (d, J = 24.8 Hz, CH).

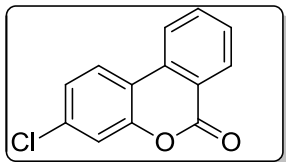
3-methoxy-6H-benzo[c]chromen-6-one (**2c**)⁷:



Compound **2c** was prepared following the general procedure, but employing 3 equiv. of $(\text{NH}_4)_2\text{S}_2\text{O}_8$. Compound **2c** was obtained after 65 h as a white solid (33 mg 0.15 mmol, 73%): R_f 0.10 (95:5 Hexane/EtOAc); GC: R_T 17.9 min; IR: ν 1732, 1619, 1609, 1277, 1265, 1034, 760 cm^{-1} ; LRMS (EI): m/z (%) = 226 (M^+ 100), 183 (37), 127 (24); ^1H NMR (400 MHz, CDCl_3) δ 8.36 (dd, J = 8.0, 0.9 Hz, 1H), 8.00 (d, J = 8.1

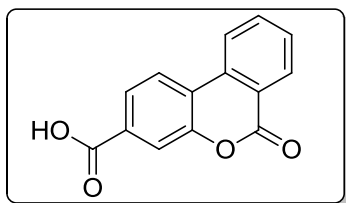
Hz, 1H), 7.95 (d, $J = 8.8$ Hz, 1H), 7.82 - 7.75 (m, 1H), 7.54 - 7.48 (m, 1H), 6.92 (dd, $J = 8.8, 2.6$ Hz, 1H), 6.87 (d, $J = 2.5$ Hz, 1H), 3.86 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 161.6 (2 x C), 152.8 (C), 135.3 (C), 135.0 (CH), 130.7 (CH), 127.9 (CH), 123.9 (CH), 121.2 (CH), 120.1 (C), 112.6 (CH), 111.3 (C), 101.8 (CH), 55.8 (CH_3).

3-chloro-6H-benzo[c]chromen-6-one (2d)⁵:



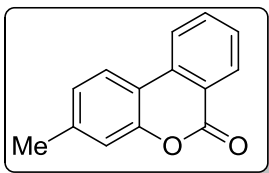
Compound **2d** was prepared following the general procedure and was obtained after 7 h as a white solid (32 mg 0.14 mmol, 70%): R_f 0.17 (95:5 Hexane/EtOAc); GC: R_T 17.2 min; IR: ν 1754, 1605, 1262, 1067, 761, 709 cm^{-1} ; LRMS (EI): m/z (%) = 232/230 (M^+ , 32/100), 204/202 (11/34), 139 (45); ^1H NMR (300 MHz, CDCl_3) δ 8.41 (ddd, $J = 7.9, 1.4, 0.5$ Hz, 1H), 8.08 (d, $J = 8.5$ Hz, 1H), 8.00 (d, $J = 8.6$ Hz, 1H), 7.91 - 7.79 (m, 1H), 7.62 (ddd, $J = 8.4, 7.3, 1.1$ Hz, 1H), 7.40 (d, $J = 2.0$, 1H), 7.33 (dd, $J = 8.5, 2.1$ Hz, 1H); ^{13}C NMR (75 MHz, CDCl_3) δ 160.7 (C), 151.7 (C), 136.1 (C), 135.2 (CH), 134.1 (C), 130.9 (CH), 129.3 (CH), 125.2 (C), 123.9 (CH), 121.8 (C), 121.1 (CH), 118.1 (CH), 116.9 (CH).

6-oxo-6H-benzo[c]chromene-3-carboxylic acid (2e):



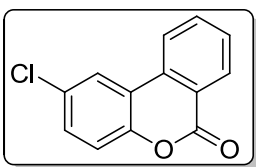
For the synthesis of compound **2e** a different procedure was followed: Into a pyrex tube, a solution of **1e** (47.7 mg, 0.25 mmol) in a 1:1:1 mixture of DCE/MeOH/MeCH (3 mL) was added, followed by [Acr-Mes] ClO_4 (2.625 mg 2.5 mol%). The reaction mixture was irradiated with blue LED's lights and stirred at room temperature for 24 hours after which time, a precipitate appeared into the reaction vessel. At this time, the precipitate was filtered under vacuum, affording the desired pure product **2e** after 24 h as a white solid (24 mg 0.1 mmol, 53 %): R_f 0.23 [7:3 Hexane: (3:1:0.08, EtOAc/EtOH/AcOH)]; IR: ν 1756, 1673, 1424, 1072, 752 cm^{-1} ; LRMS (EI) m/z (%) = 240 (M^+ , 100), 223 (28), 195 (13), 167 (12), 139 (23), 44 (21); HRMS: *Calcd.* for $\text{C}_{14}\text{H}_8\text{O}_4$ 240.0423, *found* 240.0427; ^1H NMR (300 MHz, $\text{DMSO}-d_6$) δ 13.42 (s, 1H), 8.50 (d, $J = 5.0$ Hz, 2H), 8.28 (d, $J = 7.3$ Hz, 1H), 8.19 - 7.52 (m, 4H); ^{13}C NMR (75 MHz, $\text{DMSO}-d_6$) δ 166.2 (C), 159.9 (C), 150.5 (C), 135.4 (CH), 133.3 (C), 132.5 (C), 130.3 (CH), 129.8 (CH), 125.0 (CH), 124.1 (CH), 123.3 (CH), 121.5 (C), 121.2 (C), 117.8 (CH).

3-methyl-6H-benzo[c]chromen-6-one (**2f**)⁷:



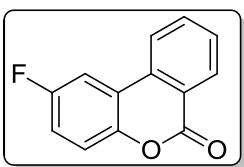
Compound **2f** was prepared following the general procedure, but employing a DCE/H₂O mixture (1.6 mL, 0.4 mL) as solvent. Compound **2f** was obtained after 14 h as a white solid (32 mg 0.16 mmol, 76%): *R_f* 0.17 (95:5 Hexane/EtOAc); GC: *R_T* 16.8 min; IR: ν 1727, 1606, 1458, 1254, 1081, 1046, 760 cm⁻¹; LRMS (IE): *m/z* (%) = 210 (M⁺, 100), 212 (16), 208 (12), 182 (11), 181 (42), 154 (13), 152 (25), 76 (10); ¹H NMR (300 MHz, CDCl₃) δ 8.39 (dd, *J* = 7.9 Hz, 1H), 8.09 (d, *J* = 8.1 Hz, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.81 (td, *J* = 8.3, 7.9, 1.4 Hz, 1H), 7.55 (td, *J* = 8.1, 0.9, 1H), 7.16 (d, *J* = 9.1 Hz, 2H), 2.46 (s, 3H); ¹³C NMR (75 MHz, CDCl₃) δ 161.6 (C), 151.5 (C), 141.5 (C), 135.2 (C), 134.9 (CH), 130.7 (CH), 128.5 (CH), 125.8 (CH), 122.7 (CH), 121.6 (CH), 121.1 (C), 118.1 (CH), 115.6 (C), 21.6 (CH₃).

2-chloro-6H-benzo[c]chromen-6-one (**2g**)⁵:



Compound **2g** was prepared following the general procedure and was obtained after 48 h as a mixture of regioisomers as a white solid (36 mg, 0.16 mmol, 80%, 90:10 rr¹² according to ¹H NMR): For major regioisomer: *R_f* 0.36 (9:1 Hexane/EtOAc); GC: *R_T* 17.1 min; IR: ν 2973, 2926, 2884, 1604, 1047, 1038 cm⁻¹; LRMS (IE): *m/z* (%) = 232/230 (M⁺, 32/100), 204/202 (10/34), 139 (48); HRMS: *Calcd.* for C₁₃H₇ClO₂ 230.0135, found 230.0133; ¹H NMR (300 MHz, CDCl₃) δ 8.42 (dd, *J* = 8.0, 0.9 Hz, 1H), 8.08 (d, *J* = 8.1 Hz, 1H), 8.03 (d, *J* = 2.4 Hz, 1H), 7.93 - 7.81 (m, 1H), 7.73 - 7.60 (m, 1H), 7.44 (dd, *J* = 8.8, 2.4 Hz, 1H), 7.33 (d, *J* = 8.8 Hz, 1H); ¹³C NMR (75 MHz, CDCl₃) δ 160.7 (C), 149.8 (C), 135.2 (CH), 133.7 (C), 130.9 (CH), 130.5 (CH), 130.0 (C), 129.7 (CH), 122.7 (CH), 121.9 (CH), 121.4 (C), 119.5 (C), 119.3 (CH).

2-fluoro-6H-benzo[c]chromen-6-one (**2h**)⁵:

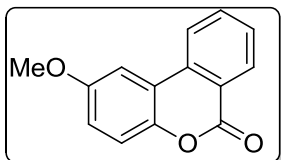


Compound **2h** was prepared following the general procedure and was obtained as a mixture of regioisomers after 48 h as a white solid (35 mg 82%, 96:4 rr¹² according to ¹H NMR): For major regioisomer: *R_f* 0.14 (95:5 Hexane/EtOAc); GC: *R_T* 15.6 min; IR: ν 1717, 1496, 1185, 1076, 871, 763, 684 cm⁻¹; LRMS (IE): *m/z* (%) = 214 (M⁺, 100), 186 (50), 157 (43); ¹H NMR (300 MHz, CDCl₃) δ 8.43 (ddd, *J* = 7.9, 1.4, 0.6 Hz, 1H),

¹² Regioselectivity was calculated according to ¹H NMR spectra of a regioisomers mixture, which was purified by column chromatography.

8.05 (d, $J = 8.1$ Hz, 1H), 7.90 - 7.83 (m, 1H), 7.73 (dd, $J = 9.1, 2.9$ Hz, 1H), 7.68 - 7.60 (m, 1H), 7.37 (dd, $J = 9.0, 4.7$ Hz, 1H), 7.20 (ddd, $J = 9.1, 7.7, 2.9$ Hz, 1H); ^{13}C NMR (101 MHz, CDCl_3) δ 160.9 (C), 159.4 (d, $J = 244.4$ Hz, C), 147.5 (C), 135.1 (CH), 134.1 (d, $J = 3.0$ Hz, C), 130.9 (CH), 129.7 (CH), 122.0 (CH), 121.4 (C), 119.5 (d, $J = 8.0$ Hz, C), 119.4 (d, $J = 8.0$ Hz, CH), 117.8 (d, $J = 24.2$ Hz, CH), 108.9 (d, $J = 25.3$ Hz, CH).

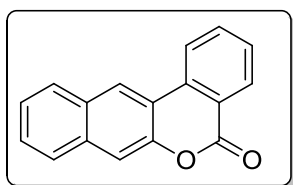
2-methoxy-6H-benzo[c]chromen-6-one (**2i**)⁵:



Compound **2i** was prepared following the general procedure and was obtained as a mixture of regioisomers after 48 h as a white solid (32.5 mg 72%, 92:8 rr¹² according to ^1H NMR):

For the major regioisomer: R_f 0.08 (95:5 Hexane/EtOAc); GC: R_T 17.8 min; IR: ν 1710, 1091, 1048, 879, 681 cm^{-1} ; LRMS (IE): m/z (%) = 226 (M^+ , 100), 211 (46), 183 (32), 155 (11), 127 (26), 101 (11); ^1H NMR (300 MHz, CDCl_3) δ 8.41 (d, $J = 0.7$ Hz, 1H), 8.06 (d, $J = 8.1$ Hz, 1H), 7.82 (td, $J = 8.1, 1.3$ Hz, 1H), 7.62 - 7.56 (m, 1H), 7.49 (d, $J = 2.9$ Hz, 1H), 7.30 (d, $J = 9.0$ Hz, 1H), 7.05 (dd, $J = 9.0, 2.9$ Hz, 1H), 3.91 (s, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 161.4 (C), 156.5 (C), 145.7 (C), 134.9 (CH), 134.8 (C), 130.8 (CH), 129.1 (CH), 121.8 (CH), 121.5 (C), 118.8 (CH), 118.7 (C), 117.2 (CH), 106.5 (CH), 56.0 (CH_3).

6H-dibenzo[c,h]chromen-6-one (**2j**)¹³:

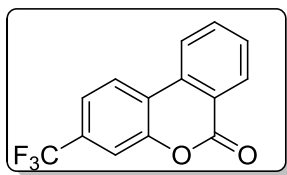


Compound **2j** was prepared following the general procedure, but adding a DCE/ H_2O mixture (1.6 mL:0.4 mL) as solvent and AcOH (100 μL) in order to improve the solubility.

Product **2j** was obtained after 24 h as a white solid (39.9 mg, 0.15 mmol, 75%): R_f 0.26 (95:5 Hexane/EtOAc); GC: R_T 21.15 min; IR: ν 1717, 1610, 1270, 1064, 784 cm^{-1} ; LRMS (IE): m/z (%) = 246 (M^+ , 100), 218 (20), 189 (35), 95 (11); ^1H NMR (400 MHz, CDCl_3) δ 8.53 (d, $J = 7.6$ Hz, 1H), 8.42 (d, $J = 7.9$ Hz, 1H), 8.12 (d, $J = 8.1$ Hz, 1H), 7.98 (d, $J = 8.8$ Hz, 1H), 7.82 (t, $J = 7.3$ Hz, 2H), 7.70 (d, $J = 8.8$ Hz, 1H), 7.62 - 7.54 (m, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 161.3 (C), 147.3 (C), 135.4 (C), 135.0 (CH), 134.3 (C), 130.7 (CH), 128.7 (CH), 128.0 (CH), 127.7 (CH), 127.2 (CH), 124.6 (CH), 123.9 (C), 122.4 (CH), 122.1 (CH), 121.2 (C), 119.2 (CH), 113.1 (C).

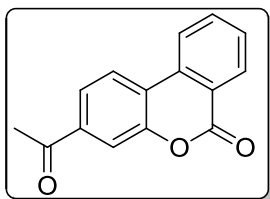
¹³ Gallardo – Donaire, J.; Martin, R. *J. Am. Chem. Soc.* **2013**, *135*, 9350.

3-(trifluoromethyl)-6H-benzo[c]chromen-6-one (2k)⁸:



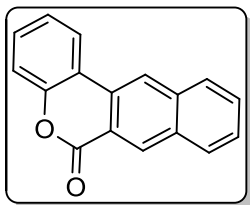
Compound **2k** was prepared following the general procedure, but employing 3 equiv. of (NH₄)₂S₂O₈ and was obtained after 57 h as a white solid (18 mg, 0.07 mmol, 70%): *R_f* 0.30 (95:5 Hexane/EtOAc); GC: *R_T* 15.33 min; IR: ν 1728, 1407, 1336, 1045, 722 cm⁻¹; LRMS (IE): *m/z* (%) = 264 (M⁺, 100), 236 (33), 217 (11), 186 (11), 139 (14); ¹H NMR (300 MHz, CDCl₃) δ 8.46 (ddd, *J* = 7.9, 1.4, 0.5 Hz, 1H), 8.23-8.16 (m, 2H), 7.94-7.87 (m, 1H), 7.73-7.66 (m, 1H), 7.66-7.58 (m, 2H); ¹³C NMR (126 MHz, CDCl₃) δ 160.4 (C), 151.2 (C), 135.5 (CH), 133.6 (C), 132.5 (q, *J* = 33.5 Hz, C), 131.1 (CH), 130.3 (CH), 123.8 (CH), 123.5 (q, *J* = 273.0, C), 122.4 (CH), 121.9 (C), 121.3 (C), 121.2 (q, *J* = 3.4 Hz, CH), 115.4 (q, *J* = 4.0 Hz, CH).

3-acetyl-6H-benzo[c]chromen-6-one (2l)⁸:



Compound **2l** was prepared following the general procedure and was obtained after 39 h as a white solid (24 mg, 0.1 mmol, 50%): *R_f* 0.06 (95:5 Hexane/EtOAc); GC: *R_T* 19.16 min; IR: ν 1736, 1686, 1476, 1262, 1217, 1032, 767, 716 cm⁻¹; LRMS (IE): *m/z* (%) = 238 (M⁺, 47), 223 (100), 167 (25), 139 (33); ¹H NMR (300 MHz, CDCl₃) δ 8.44 (dd, *J* = 7.9, 1.0 Hz, 1H), 8.17 (t, *J* = 7.4 Hz, 2H), 7.97 - 7.85 (m, 3H), 7.72 - 7.63 (m, 1H), 2.67 (s, 3H); ¹³C NMR (75 MHz, CDCl₃) δ 196.5 (C), 160.6 (C), 151.1 (C), 138.4 (C), 135.1 (CH), 133.6 (C), 130.8 (CH), 130.1 (CH), 123.7 (CH), 123.2 (CH), 122.4 (CH), 122.0 (C), 121.8 (C), 117.9 (CH), 26.7 (CH₃).

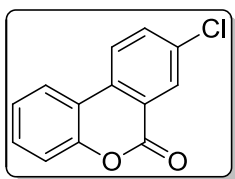
6H-naphtho[2,3-c]chromen-6-one (2m)⁵:



Compound **2m** was prepared from **1m** (0.17 mmol, 41.5 mg) following the general procedure, but using a DCE/H₂O mixture (1.6 mL:0.4 mL) as solvent. Compound **2m** was obtained after 14 h as a white solid (30 mg 0.12 mmol, 72%): *R_f* 0.14 (95:5 Hexane/EtOAc); GC: *R_T* 21.6 min; IR: ν 1728, 1173, 752 cm⁻¹. LRMS (IE): *m/z* (%) = 246 (M⁺, 100), 218 (34), 189 (40), 95 (14); ¹H NMR (300 MHz, CDCl₃) δ 9.04 (s, 1H), 8.55 (s, 1H), 8.35 - 8.19 (m, 1H), 8.12 - 7.99 (m, 2H), 7.70 (ddd, *J* = 8.3, 6.8, 1.4 Hz, 1H), 7.60 (ddd, *J* = 8.1, 6.8, 1.3 Hz, 1H), 7.53 - 7.45 (m, 1H), 7.43 - 7.33 (m, 2H); ¹³C NMR (101 MHz, CDCl₃) δ 161.6 (C), 150.9 (C), 136.3 (C), 132.9

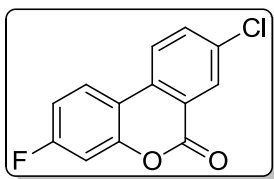
(CH), 132.5 (C), 130.3 (CH), 129.7 (C), 129.6 (2 x CH), 128.2 (CH), 127.3 (CH), 124.7 (CH), 123.0 (CH), 120.8 (CH), 119.3 (C), 118.4 (C), 118.0 (CH).

8-chloro-6H-benzo[c]chromen-6-one (2n)⁵:



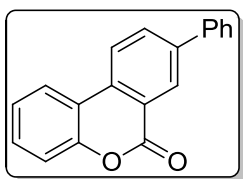
Compound **2n** was prepared following the general procedure, and was obtained after 15 h as a white solid (37 mg 0.16 mmol, 80%): R_f 0.30 (95:5 Hexane/EtOAc); GC: R_T 17.1 min; IR: ν 1718, 1604, 1307, 1089, 827 cm^{-1} ; LRMS (IE): m/z (%) = 232/230 (M^+ , 32/100), 204/202 (11/32), 139 (46); ^1H NMR (300 MHz, CDCl_3) δ 8.38 (d, J = 2.2 Hz, 1H), 8.08 (d, J = 8.6 Hz, 1H), 8.03 (dd, J = 7.9, 1.5 Hz, 1H), 7.78 (dd, J = 8.6, 2.3 Hz, 1H), 7.58 - 7.47 (m, 1H), 7.44 - 7.33 (m, 2H); ^{13}C NMR (101 MHz, CDCl_3) δ 160.2 (C), 151.3 (C), 135.3 (CH), 135.1 (C), 133.4 (C), 131.0 (CH), 130.2 (CH), 125.0 (CH), 123.6 (CH), 122.9 (CH), 122.7 (C), 118.0 (CH), 117.4 (C).

8-chloro-3-fluoro-6H-benzo[c]chromen-6-one (2o):



Compound **2o** was prepared following the general procedure using a DCE/ H_2O mixture (1.6 mL:0.4 mL) as solvent. Compound **2o** was obtained after 22 h as a white solid (40 mg 0.16 mmol, 79%): R_f 0.27 (95:5 Hexane/EtOAc); CG: R_T 16.8 min; IR: ν 1742, 1608, 1475, 1275, 1151, 1116, 805, 786, 772 cm^{-1} ; LRMS (IE): m/z (%) = 250/248 (M^+ , 33/100), 222/220 (13/36), 157 (43); HRMS: *Calcd.* for $\text{C}_{13}\text{H}_6\text{ClFO}_2$ 248.0040, found 248.0042; ^1H NMR (400 MHz, CDCl_3) δ 8.32 (d, J = 2.3 Hz, 1H), 7.98 (t, J = 8.1 Hz, 2H), 7.77 (dd, J = 8.6, 2.3 Hz, 1H), 7.09 (t, J = 8.2 Hz, 2H); ^{13}C NMR (101 MHz, CDCl_3) δ 163.6 (d, J = 253.5 Hz, C), 159.6 (C), 152.0 (d, J = 12.1 Hz, C), 135.4 (CH), 134.9 (C), 132.7 (C), 130.3 (CH), 124.5 (d, J = 10.1 Hz, CH), 123.4 (CH), 121.8 (C), 114.0 (d, J = 3.0 Hz, C), 112.9 (d, J = 23.0 Hz, CH), 105.4 (d, J = 25.3 Hz, CH).

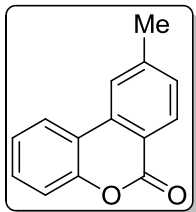
8-phenyl-6H-benzo[c]chromen-6-one (2p)⁸:



Compound **2p** was prepared following the general procedure and was obtained as a white solid after 11 h (35 mg 0.13 mmol, 65%): R_f 0.15 (95:5 Hexane/EtOAc); R_T 24.7 min; IR: ν 1727, 1442, 1235, 840, 743 cm^{-1} ; LRMS (IE): m/z (%) = 272 (M^+ , 100), 244 (12), 215 (20), 189 (9); ^1H NMR (300 MHz, CDCl_3) δ 8.65 (s, 1H), 8.21 (d, J = 8.4 Hz, 1H), 8.14 - 8.06 (m, 2H), 7.72 (dd, J = 8.3, 1.3 Hz, 2H), 7.56 - 7.32 (m, 6H); ^{13}C NMR

(75 MHz, CDCl₃) δ 161.3 (C), 151.2 (C), 141.8 (C), 139.0 (C), 133.5 (CH), 133.5 (C), 130.4 (CH), 129.1 (2 x CH), 128.6 (CH), 128.3 (CH), 127.1 (2 x CH), 124.6 (CH), 122.8 (CH), 122.4 (CH), 121.7 (C), 117.9 (C), 117.8 (CH).

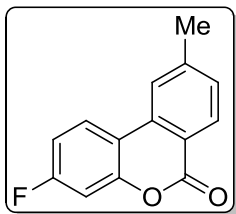
9-methyl-6H-benzo[c]chromen-6-one (**2q**)⁵:



Compound **2q** was prepared from **1q** (0.17 mmol, 39.1 mg), following the general procedure, but adding 1.2 equiv. of (NH₄)₂S₂O₈, and using a DCE/H₂O mixture (1.6 mL:0.4 mL) as a solvent. Compound **2q** was obtained after 20 h as a white solid (25 mg 0.12 mmol, 71%): *R*_f 0.14 (95:5 Hexane/EtOAc); GC: *R*_T 16.8 min; IR: ν

1722, 1613, 1268, 743 cm⁻¹; LRMS (IE): *m/z* (%) = 272 (M⁺, 100), 244 (12), 215 (20), 189 (9); ¹H NMR (400 MHz, CDCl₃) δ 8.27 (d, *J* = 8.1 Hz, 1H), 8.04 (d, *J* = 8.0 Hz, 1H), 7.89 (s, 1H), 7.51 - 7.43 (m, 1H), 7.41 - 7.28 (m, 3H), 2.55 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 161.4 (C), 151.6 (C), 146.0 (C), 134.8 (C), 130.7 (CH), 130.4 (CH), 130.3 (CH), 124.5 (CH), 122.8 (CH), 122.0 (CH), 118.9 (C), 118.2 (C), 117.9 (CH), 22.4 (CH₃).

3-fluoro-9-methyl-6H-benzo[c]chromen-6-one (**2r**)¹⁴:

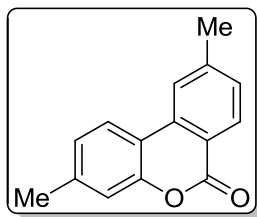


Benzocoumarin **2r** was prepared from **1r** (0.17 mmol, 39.1 mg), following the general procedure, but using a DCE/H₂O mixture (1.6 mL:0.4 mL) as a solvent. Compound **2r** was obtained after 24 h as a white solid; (22 mg, 0.1 mmol, 59%): *R*_f 0.20 (95:5 Hexane/EtOAc); GC: *R*_T 16.4 min; IR: ν 1717, 1599, 1266, 1106,

769 cm⁻¹; LRMS (IE): *m/z* (%) = 228 (M⁺, 100), 213 (11), 199 (45), 170 (16); ¹H NMR (400 MHz, CDCl₃) δ 8.26 (d, *J* = 8.1 Hz, 1H), 8.05 - 7.99 (m, 1H), 7.82 (s, 1H), 7.38 (d, *J* = 8.1 Hz, 1H), 7.06 (m, 2H), 2.56 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 163.5 (d, *J* = 251.5 Hz, C), 161.0 (C), 152.5 (d, *J* = 12.1 Hz, C), 146.4 (C), 134.4 (C), 130.8 (CH), 130.2 (CH), 124.4 (d, *J* = 10.1 Hz, CH), 121.8 (CH), 118.2 (C), 114.8 (d, *J* = 2.0 Hz, C), 112.4 (d, *J* = 22.2 Hz, CH), 106.2 (d, *J* = 25.3 Hz, CH), 22.4 (CH₃).

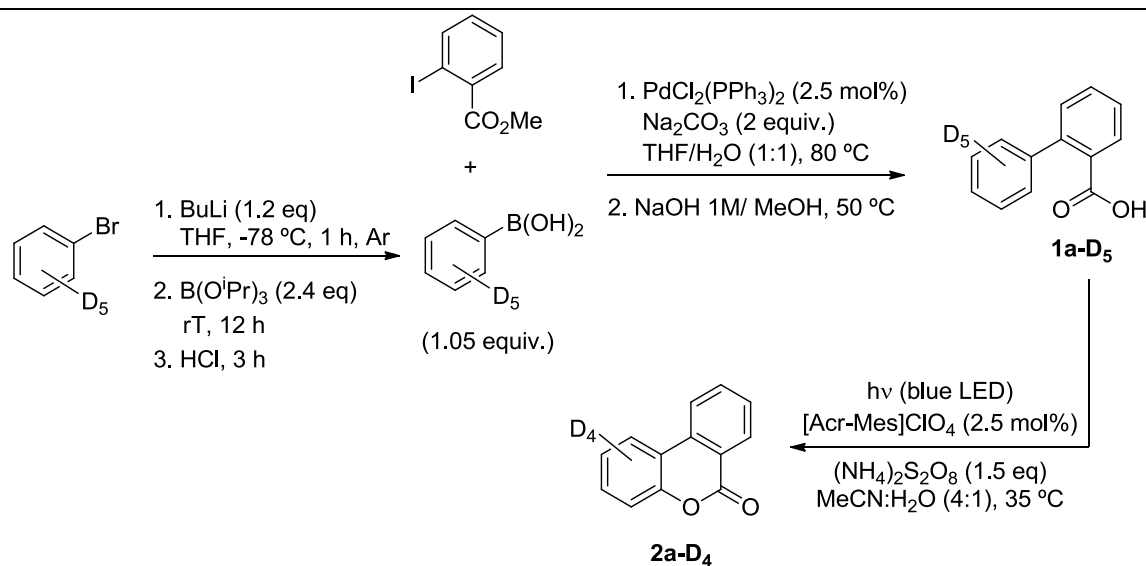
¹⁴ Lee, T. – H.; Jayakumar, J.; Cheng, C. – H.; Chuang, S. – S. *Chem. Comm.* **2013**, 40, 11797.

3, 9-dimethyl-6*H*-benzo[*c*]chromen-6-one (2s):



Benzocoumarin **2s** was prepared from **1s** (0.17 mmol, 38.4 mg), following the general procedure, but using a DCE/H₂O mixture (1.6 mL:0.4 mL) as a solvent. Compound **2s** was obtained after 18 h as a white solid (29 mg, 0.13 mmol, 77%): *R*_f 0.29 (95:5 Hexane/EtOAc); GC: *R*_T 17.7 min; IR: ν 1717, 1087, 1039, 890 cm⁻¹; LRMS (IE): *m/z* (%) = 224 (M⁺, 100), 195 (24), 181 (10), 152 (15); HRMS *Calcd.* for C₁₅H₁₁O₂ 223.0759, found 223.0767; ¹H NMR (400 MHz, CDCl₃) δ 8.26 (d, *J* = 8.1 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.86 (s, 1H), 7.35 (d, *J* = 8.1 Hz, 1H), 7.18 - 7.11 (m, 2H), 2.55 (s, 3H), 2.45 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 161.7 (C), 151.6 (C), 146.0 (C), 141.2 (C), 135.1 (C), 130.7 (CH), 129.8 (CH), 125.7 (CH), 122.6 (CH), 121.7 (CH), 118.6 (C), 118.0 (CH), 115.6 (C), 22.4 (CH₃), 21.6 (CH₃).

8. Synthesis of Deuterated Phenylboronic Acid¹⁵ 1a-D₅ and Benzo-3,4-coumarin 2a-D₄.¹⁶

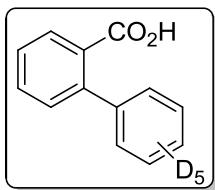


Into an oven-dried one-necked 100 mL flask a solution of polideuterated bromobenzene (10 mmol, 2.03 mL) in dry THF under Ar atmosphere was prepared. The solution was cooled at -78 °C and BuLi (3.8 mL of a solution 3.2 M, 12 mmol) was carefully charged dropwise over the stirred solution *ca.* 15 minutes. The reaction mixture was stirred under Ar atmosphere at -78 °C for 1 h. Then, B(OⁱPr)₃ (26 mmol, 6.12 mL) was added dropwise and the reaction mixture was allowed to reach room temperature and stirred overnight. After this time, complete conversion was observed (monitored by TLC) and the reaction mixture was quenched with HCl (10 %, 30 mL) until pH<1 and stirred for 3 h. The reaction mixture was concentrated and H₂O (10 mL) was added. The aqueous layer was extracted with EtOAc (4 × 10 mL). The combined organic layers were washed with brine (1 × 5 mL), dried over anhydrous MgSO₄ and filtered under reduced pressure affording a viscous yellow oil. The oil was crystallized with hexane (18 mL) forming a white solid which was used without further purification at the Suzuki Cross-Coupling reaction. The desired deuterated phenyl 2-carboxylic acid **1a-D₅** was obtained following the typical procedure described for the synthesis of acids **1b-1l** by using 0.86 mmol of methyl 2-iodobenzoate.

¹⁵ (a) Gandeepan P.; Cheng, C. – H. *Org. Lett.* **2013**, *15*, 2084; (b) Zhou, B.; Chen, H.; Wang, C. *J. Am. Chem. Soc.* **2013**, *135*, 1264.

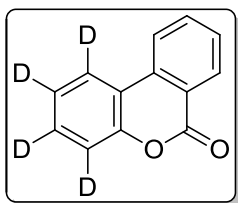
¹⁶ Wang, C.; Rakshit, S.; Glorius, F. *J. Am. Chem. Soc.* **2010**, *132*, 14006

(1,1'-Biphenyl-2',3',4',5',6'-d₅)-2-carboxylic acid (1a-D₅):



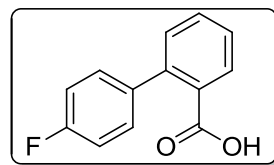
Compound **1a-D₅** was obtained as a white solid (116 mg, 0.54 mmol, 63%): R_f 0.4 (95:5 Hexane/EtOAc); GC: R_T 14.26 min. LRMS (IE): m/z (%) = 203 (M^+ , 100), 185 (37), 157 (40), 78 (11); 1H NMR (300 MHz, $CDCl_3$) δ 7.95 (dd, J = 7.8, 1.1 Hz, 1H), 7.56 (td, J = 7.5, 1.4 Hz, 1H), 7.47-7.35 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 173.4 (C), 143.5 (C), 141.0 (C), 132.2 (CH), 131.3 (CH), 130.8 (CH), 129.5 (C), 127.3 (CH).

6H-Benzo[c]chromen-6-one-1,2,3,4-d₄ (2a-D₄):



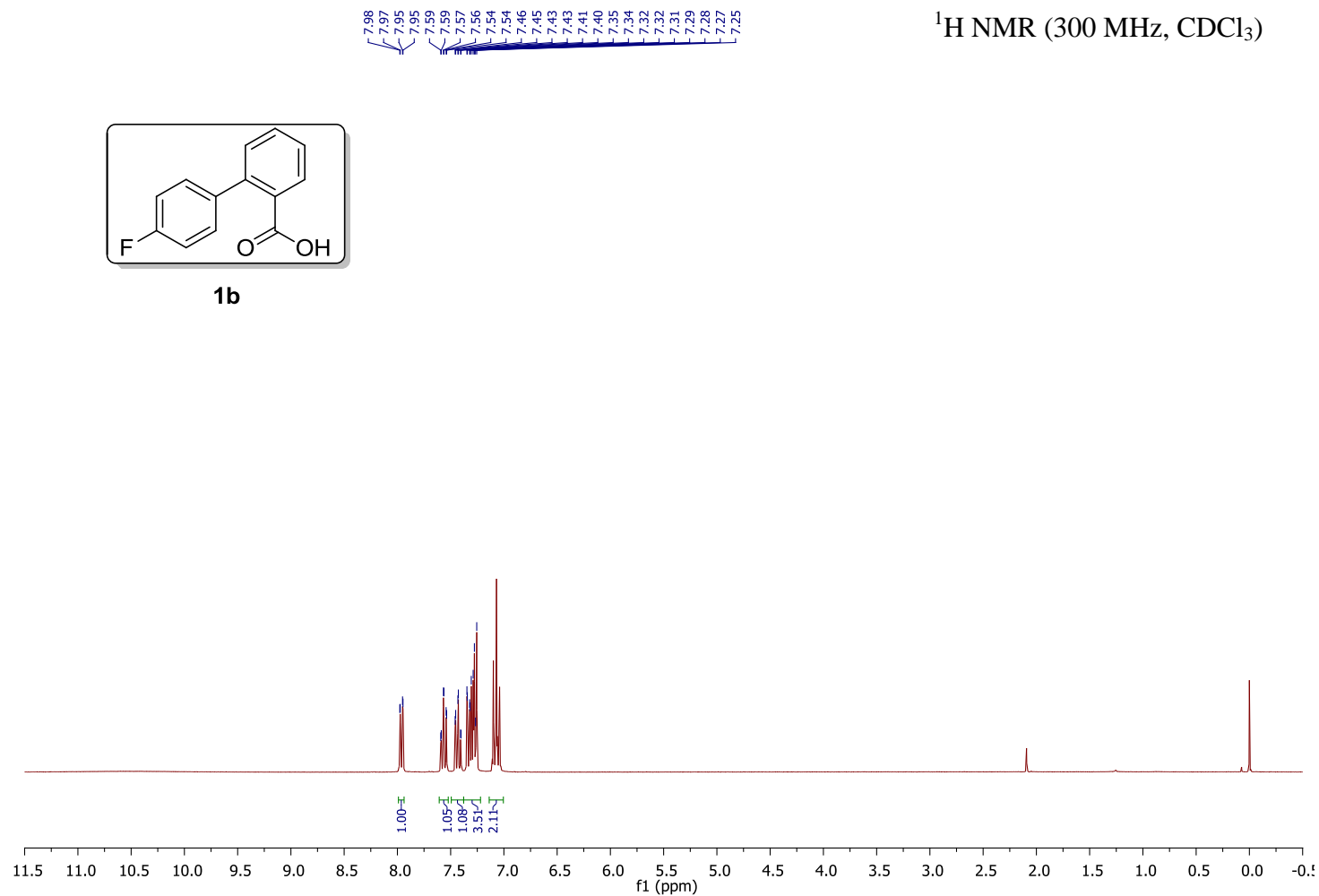
Compound **2a-D₄** was prepared following the general procedure, and was obtained as a white solid (20 mg, 0.1 mmol, 50 %): R_f 0.23 (95:5 Hexane/EtOAc); GC: R_T 15.85 min; IR: ν 1721, 1604, 1582, 1257, 1114, 679 cm^{-1} ; LRMS (IE): m/z (%) = 200 (M^+ , 100), 172 (41), 143 (25); HRMS *Calcd.* for $C_{13}H_4D_4O_2$ 200.0775, found 200.0777 1H NMR (300 MHz, $CDCl_3$) δ 8.41 (ddd, J = 7.9, 1.4, 0.6 Hz, 1 H), 8.13 (ddd, J = 8.1, 1.1, 0.6 Hz, 1H), 7.83 (ddd, J = 8.1, 7.3, 1.4 Hz, 1H), 7.59 (ddd, J = 8.0, 7.3, 1.1 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.3 (C), 151.4 (C), 135.0 (CH), 134.9 (C), 130.7 (CH), 129.0 (CH), 121.8 (CH), 121.4 (C), 118.1 (C).

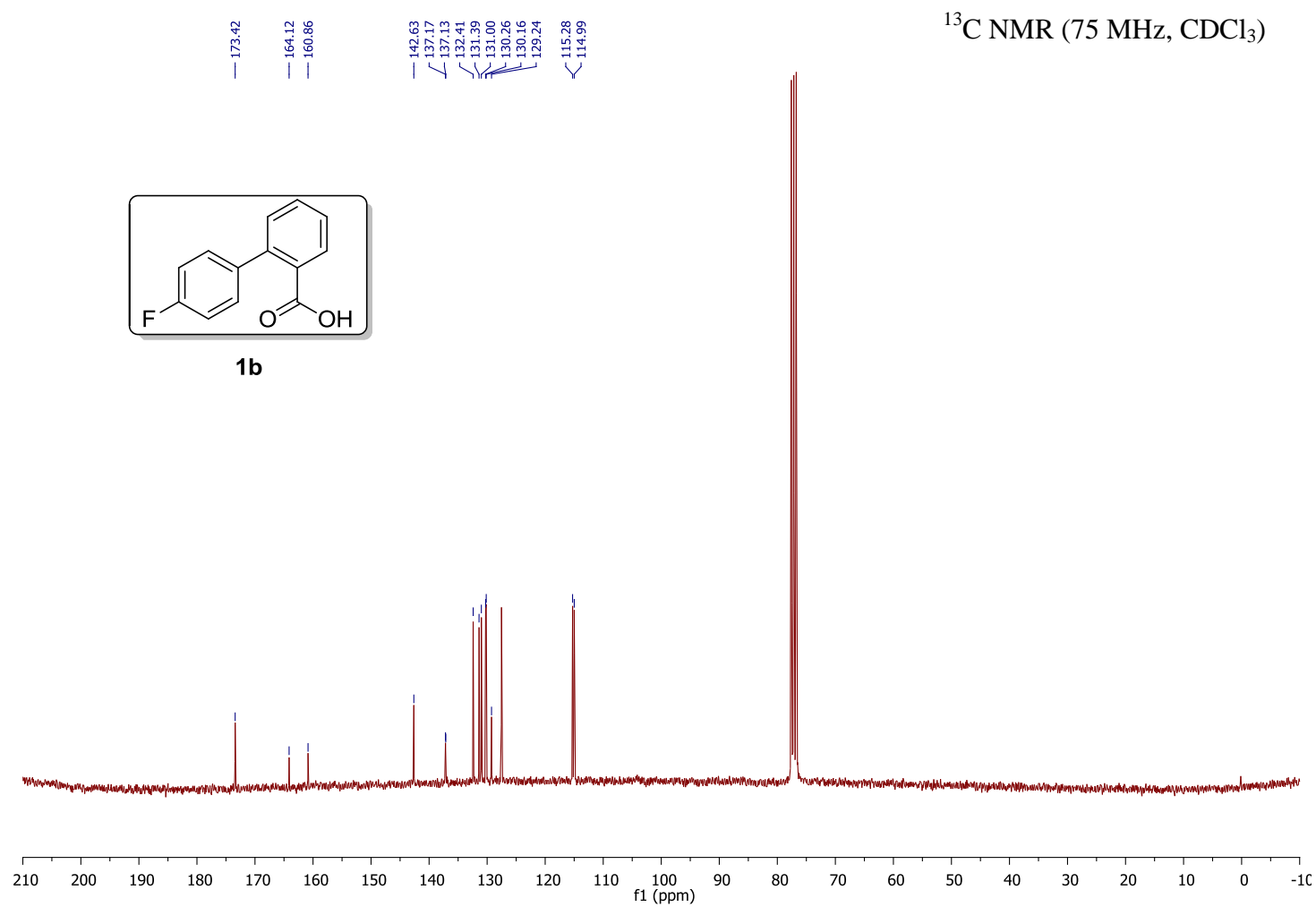
9. ^1H NMR and ^{13}C NMR Spectra of 2-Biarylcarboxylic Acids 1b - 1t

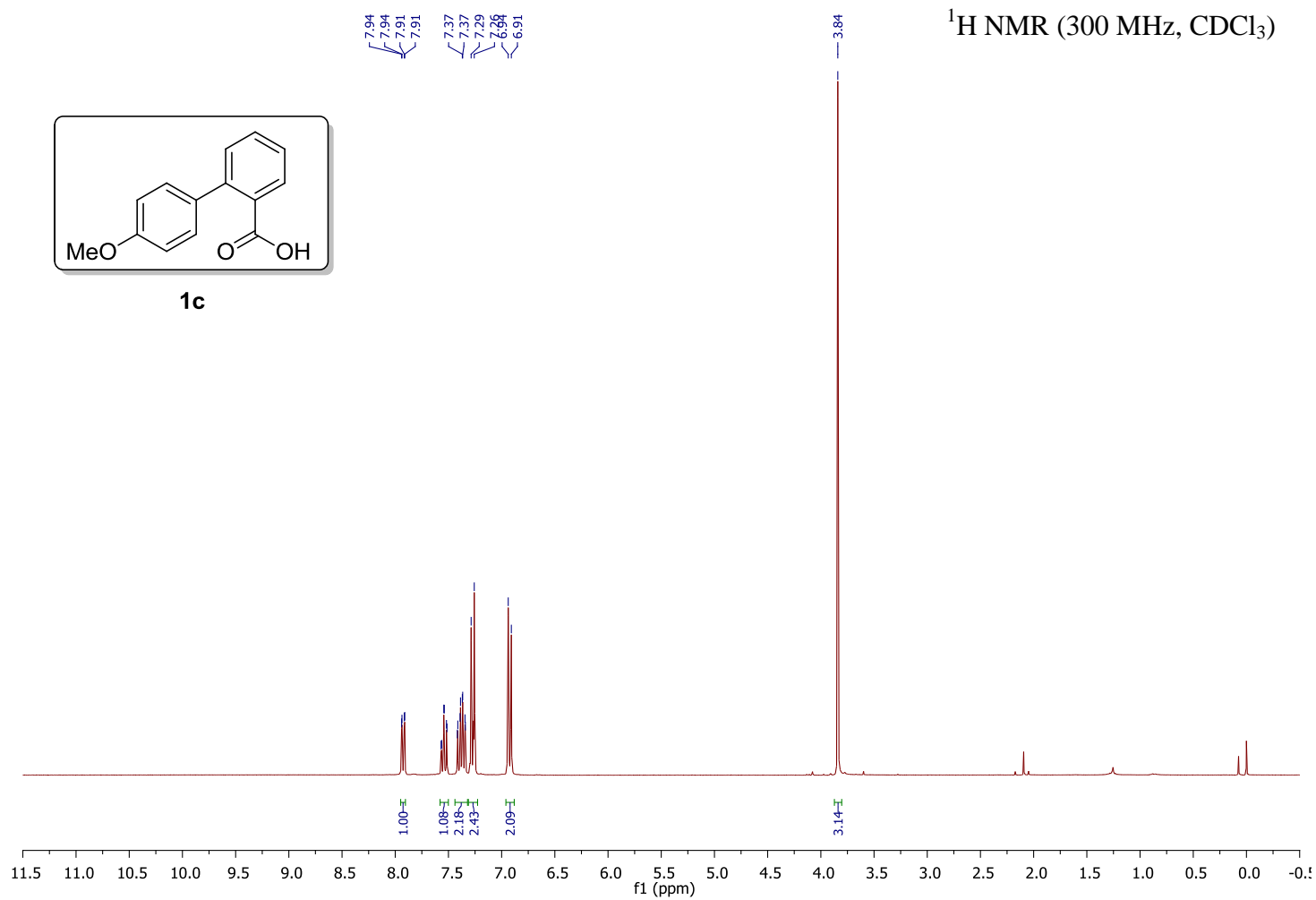


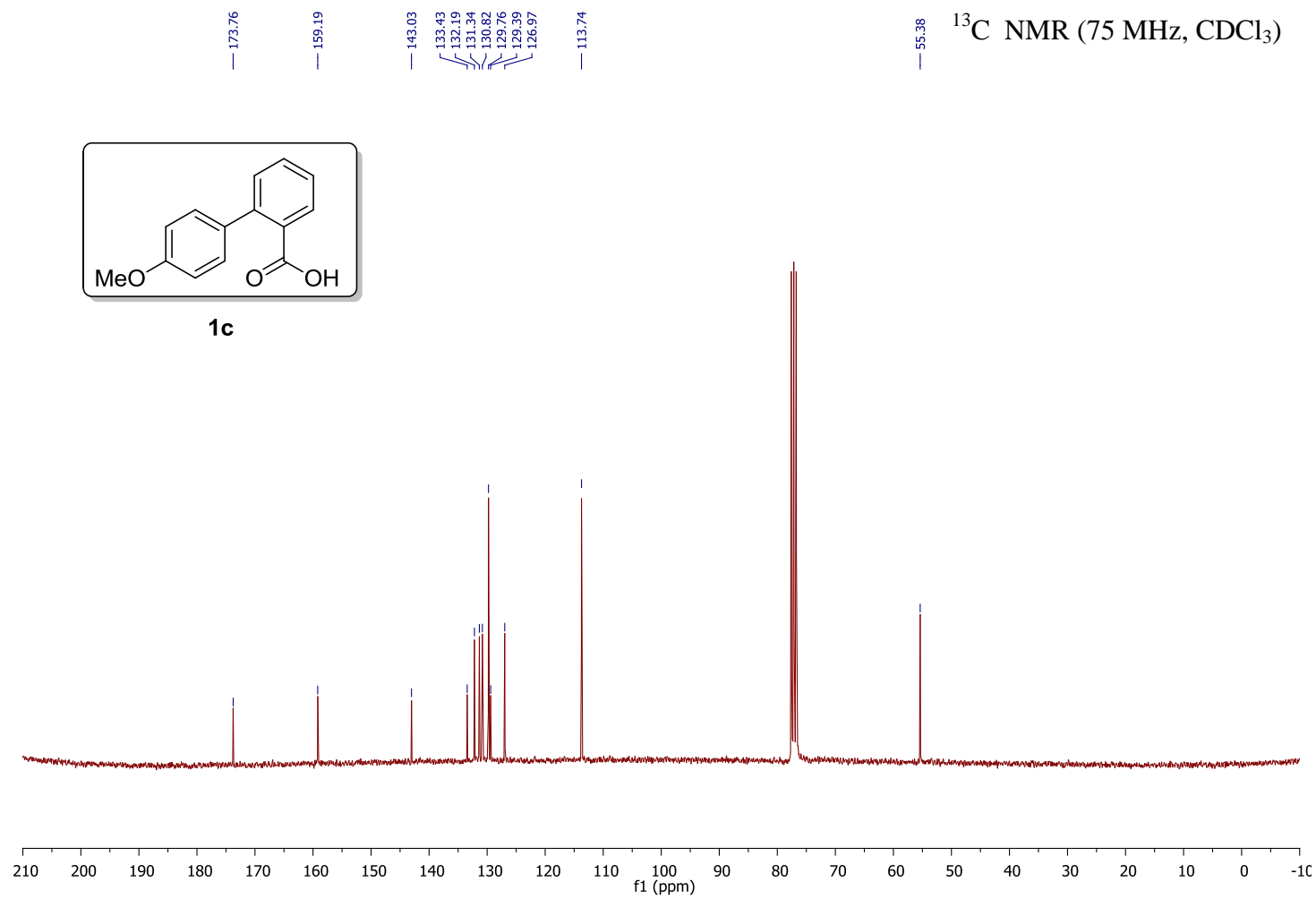
1b

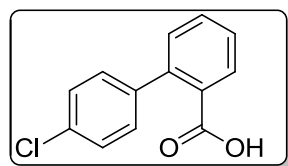
^1H NMR (300 MHz, CDCl_3)





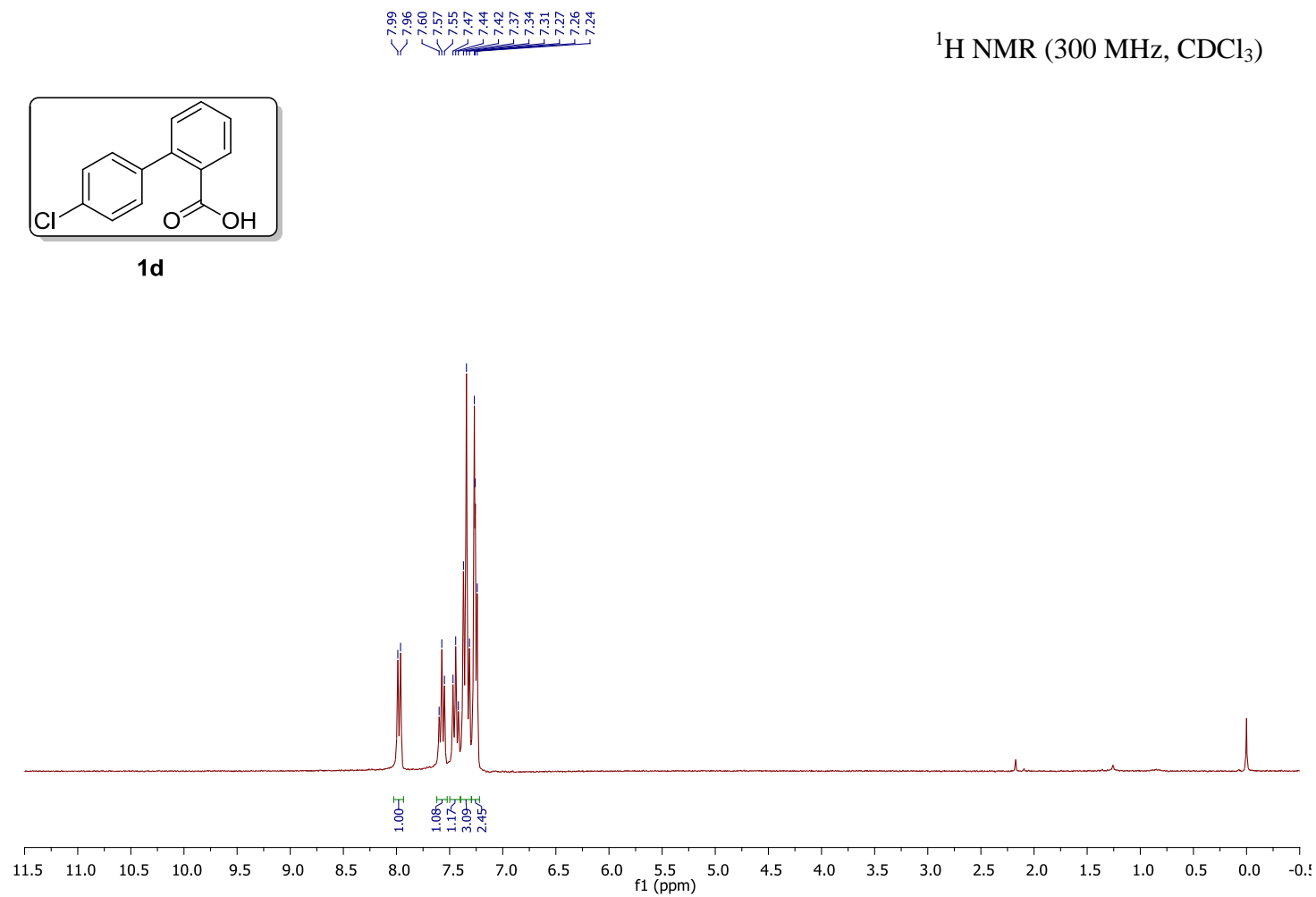


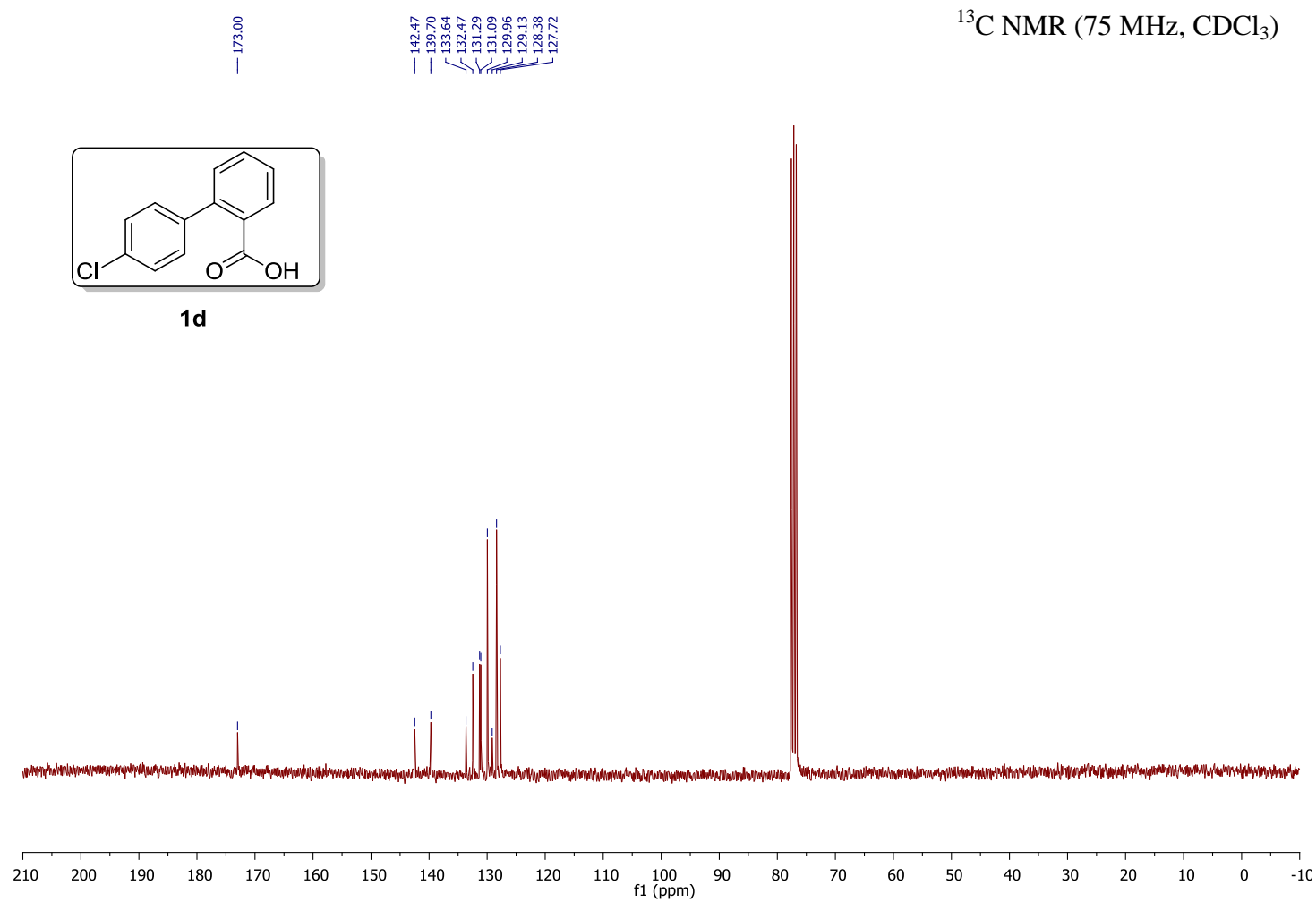


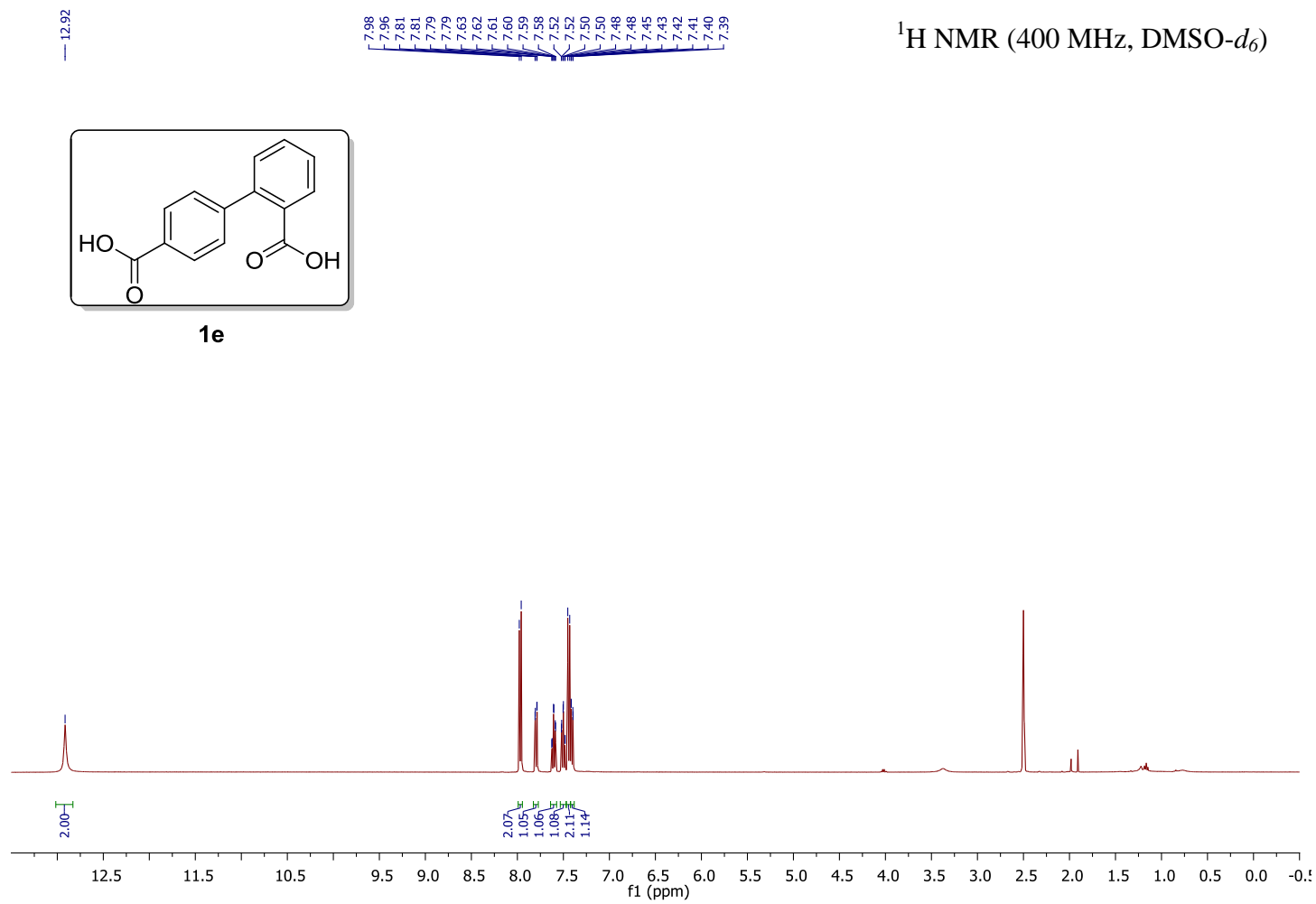


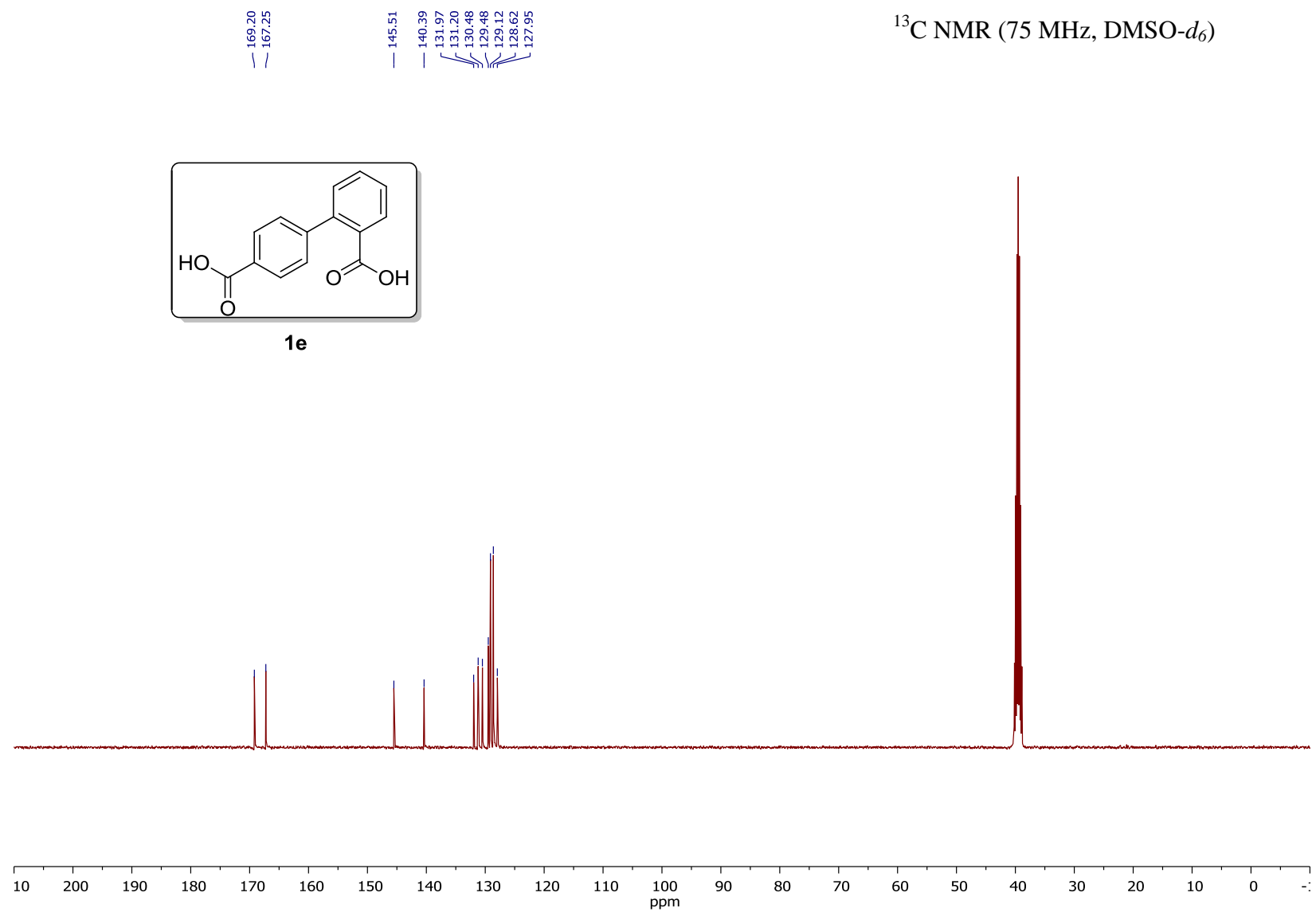
1d

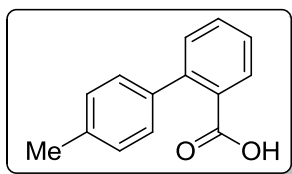
^1H NMR (300 MHz, CDCl_3)



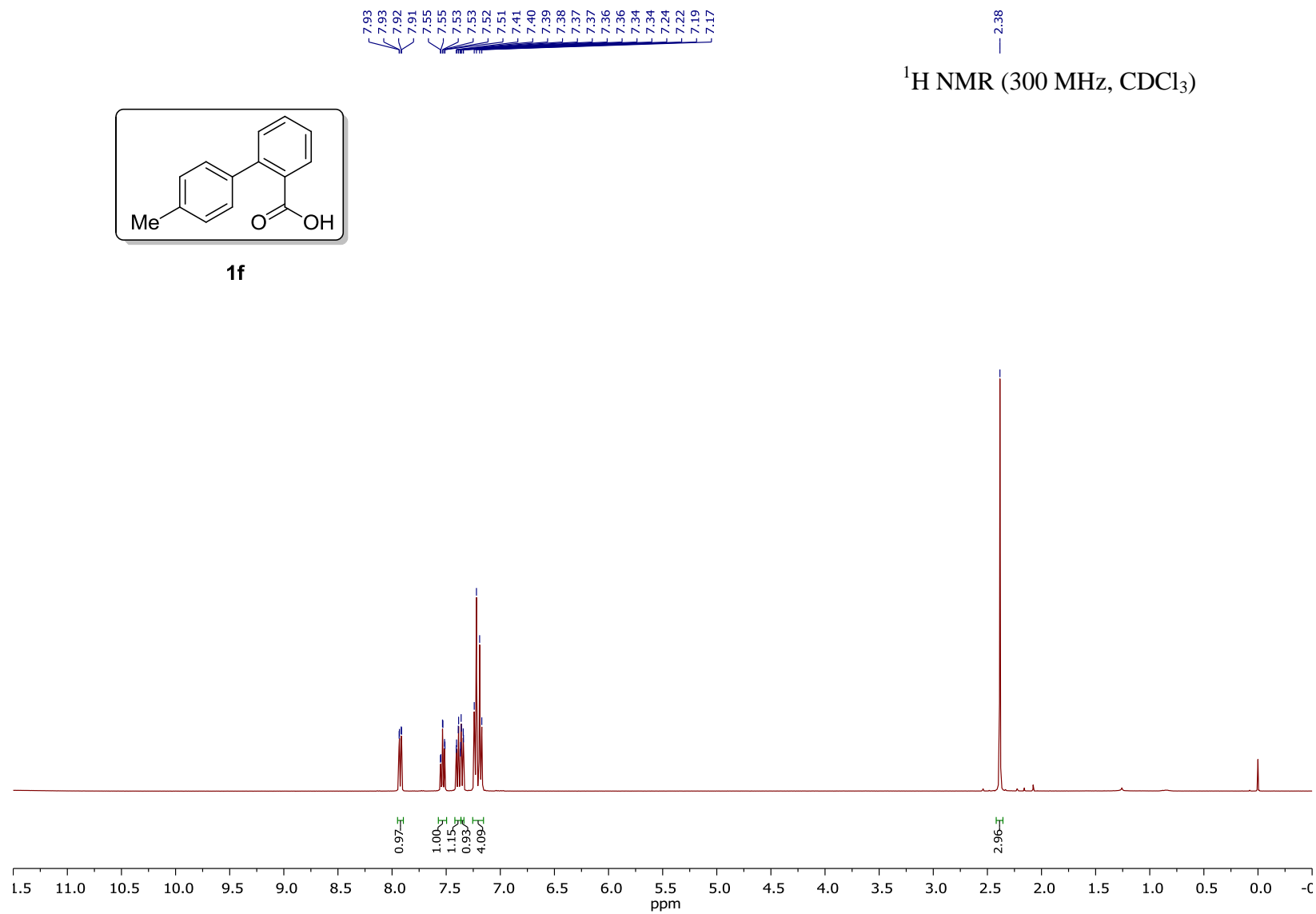


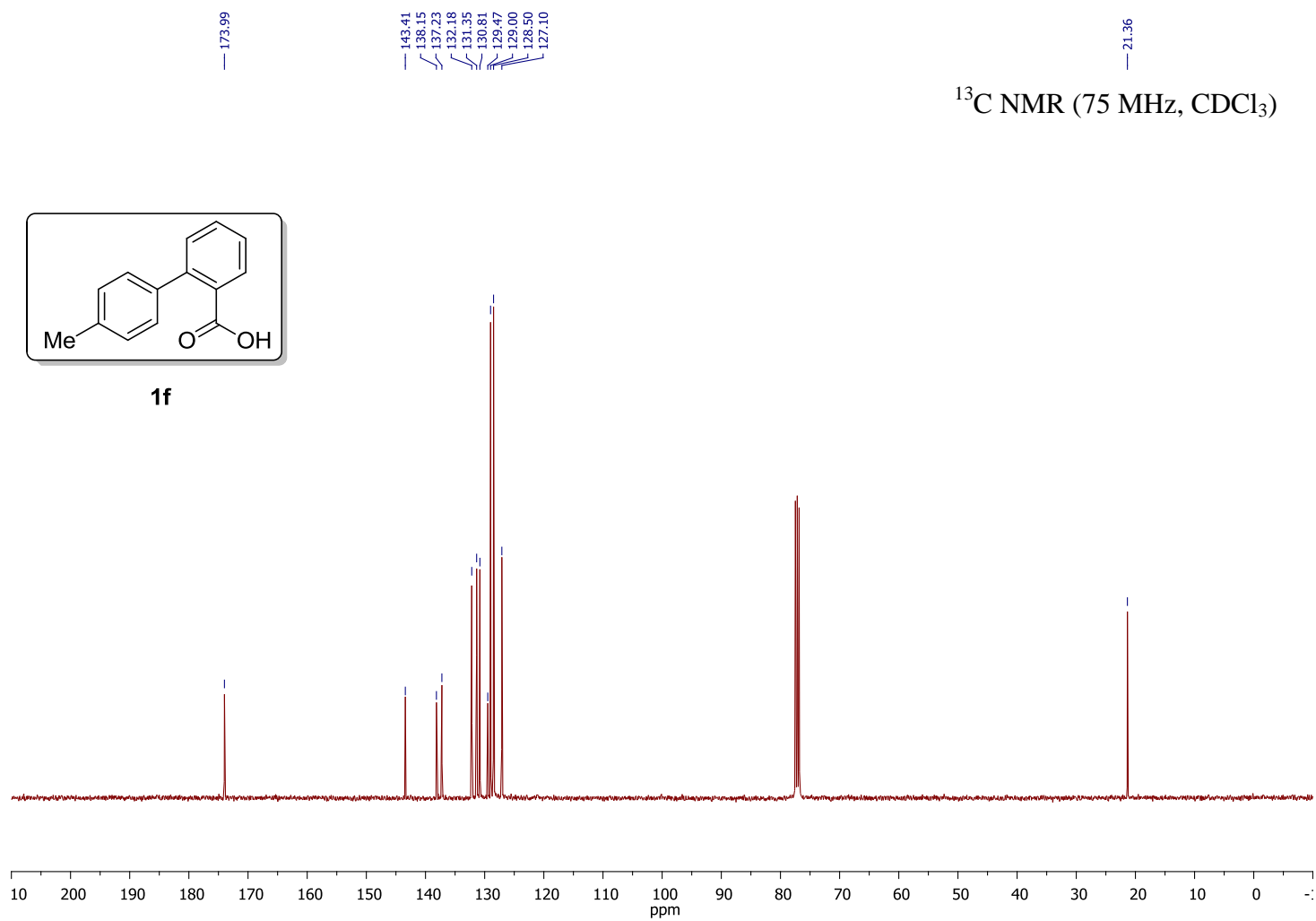


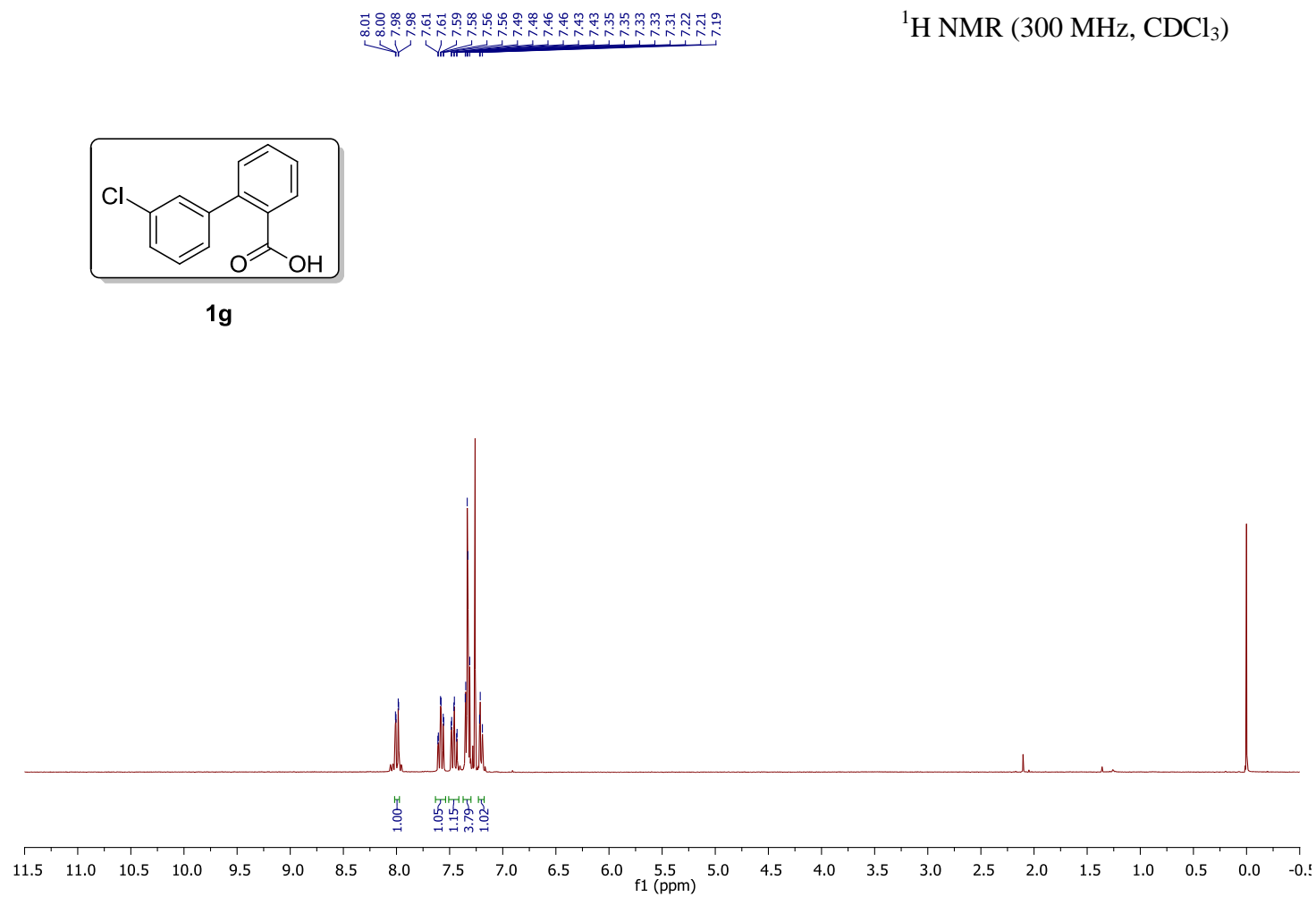


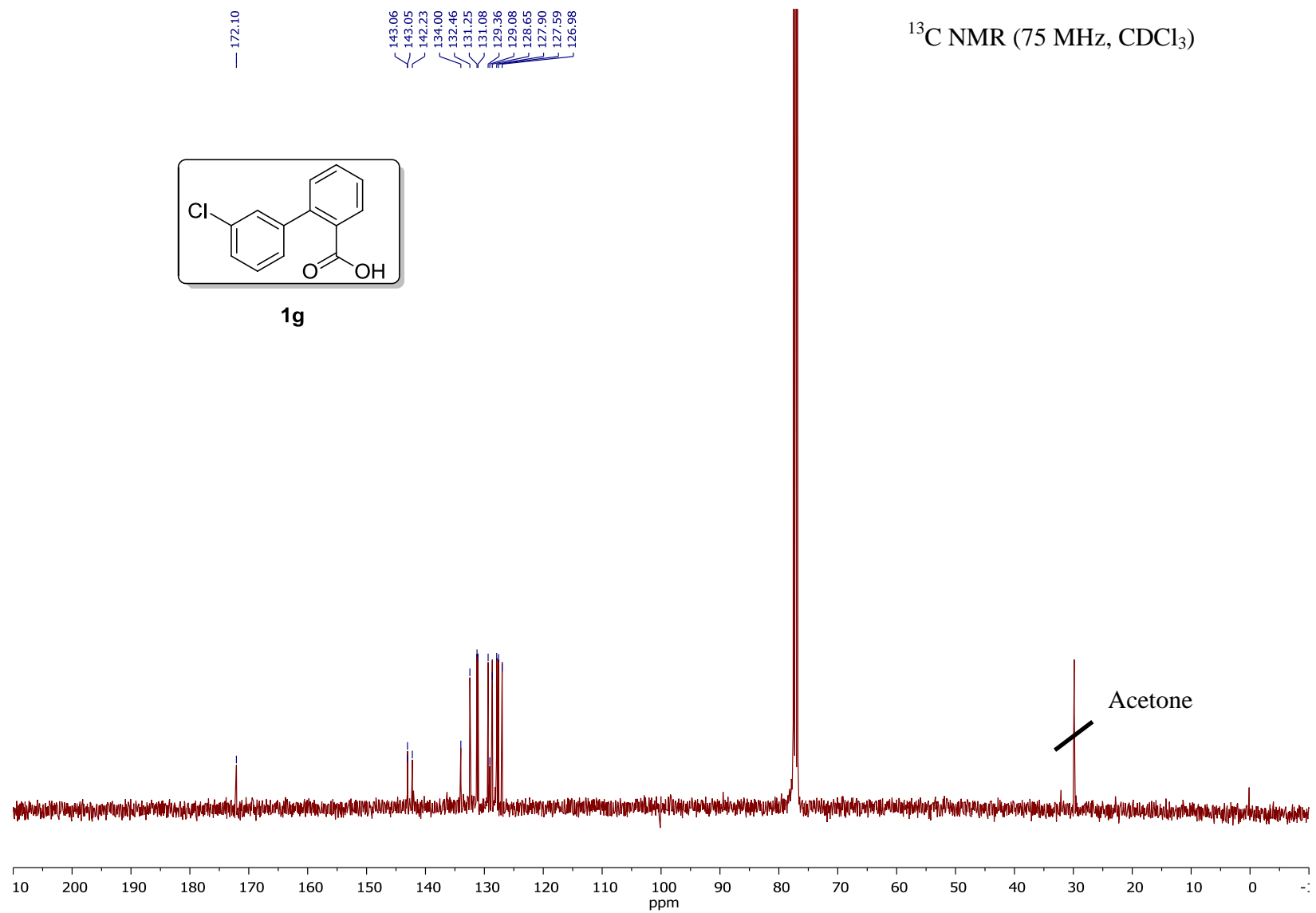


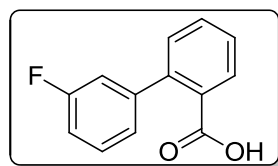
1f







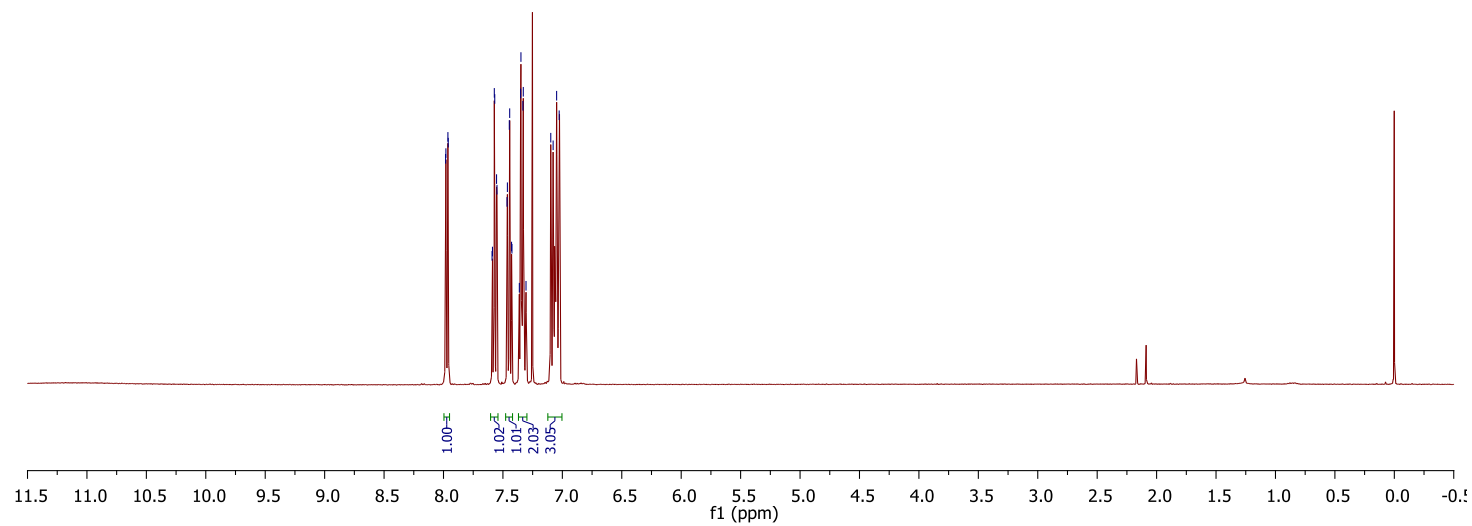


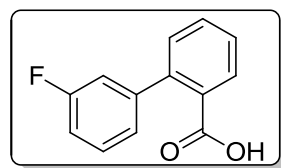


1h

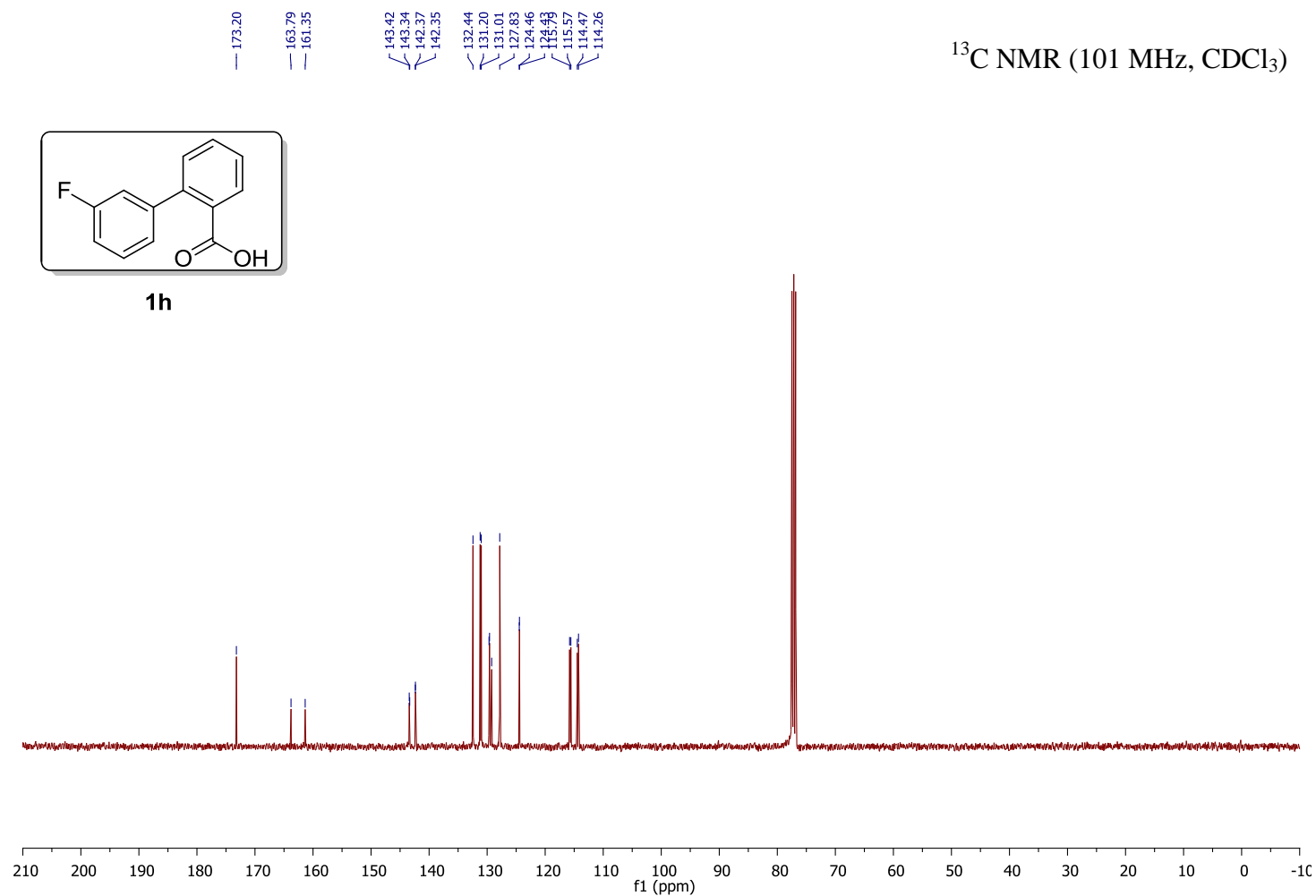
7.98
7.98
7.96
7.96
7.99
7.97
7.57
7.55
7.55
7.47
7.46
7.45
7.44
7.43
7.42
7.36
7.35
7.35
7.33
7.33
7.31
7.10
7.08
7.05
7.03

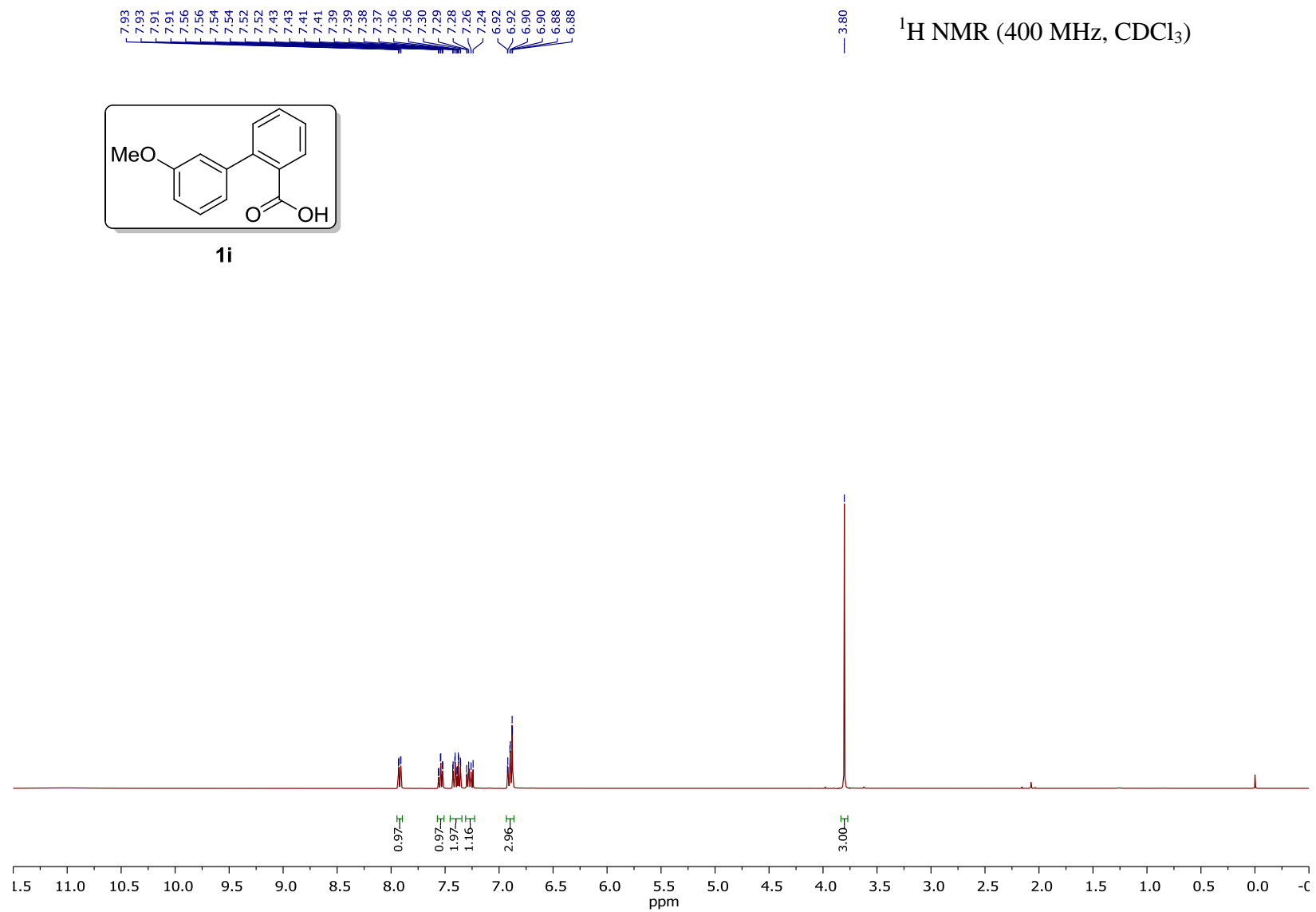
^1H NMR (400 MHz, CDCl_3)

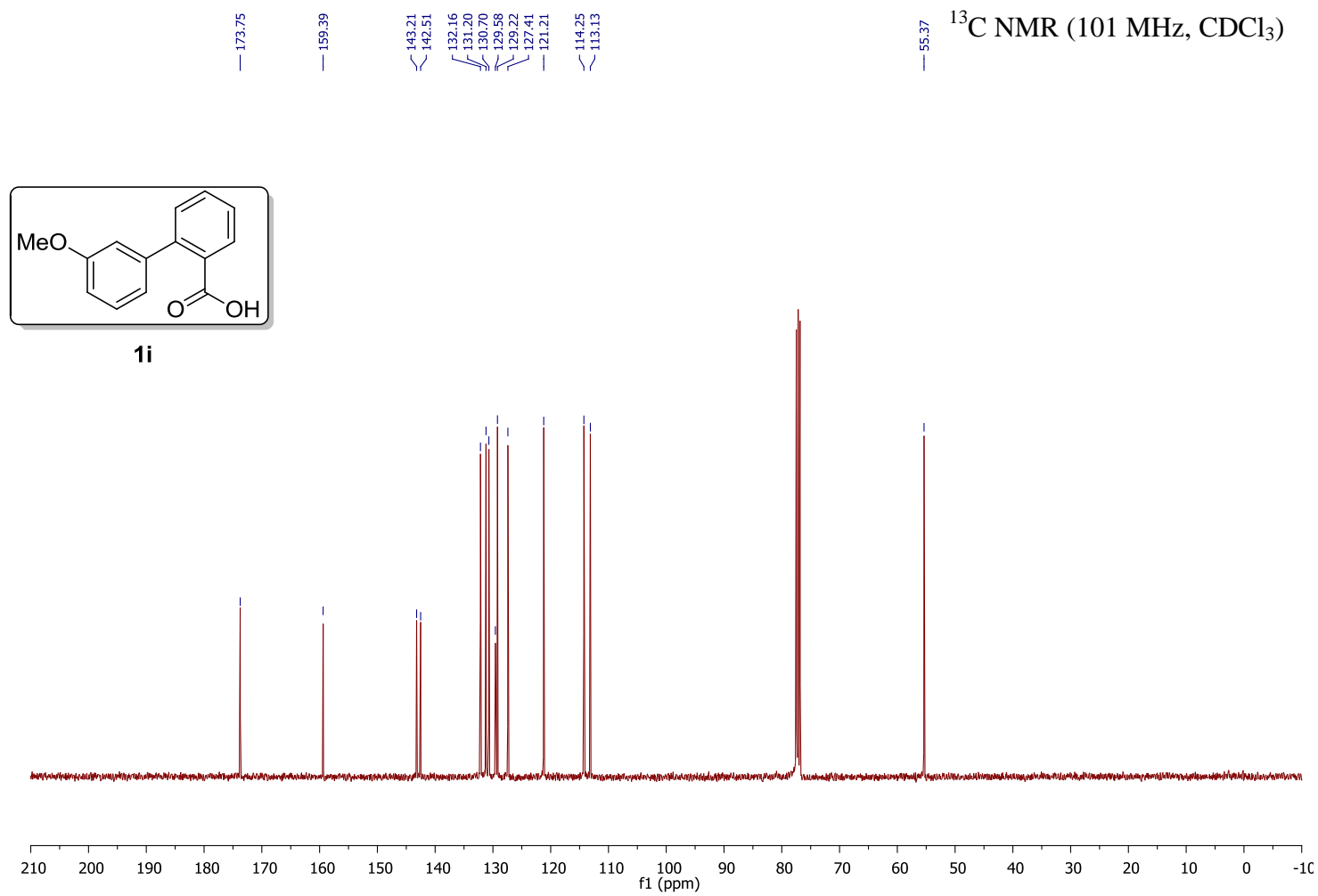


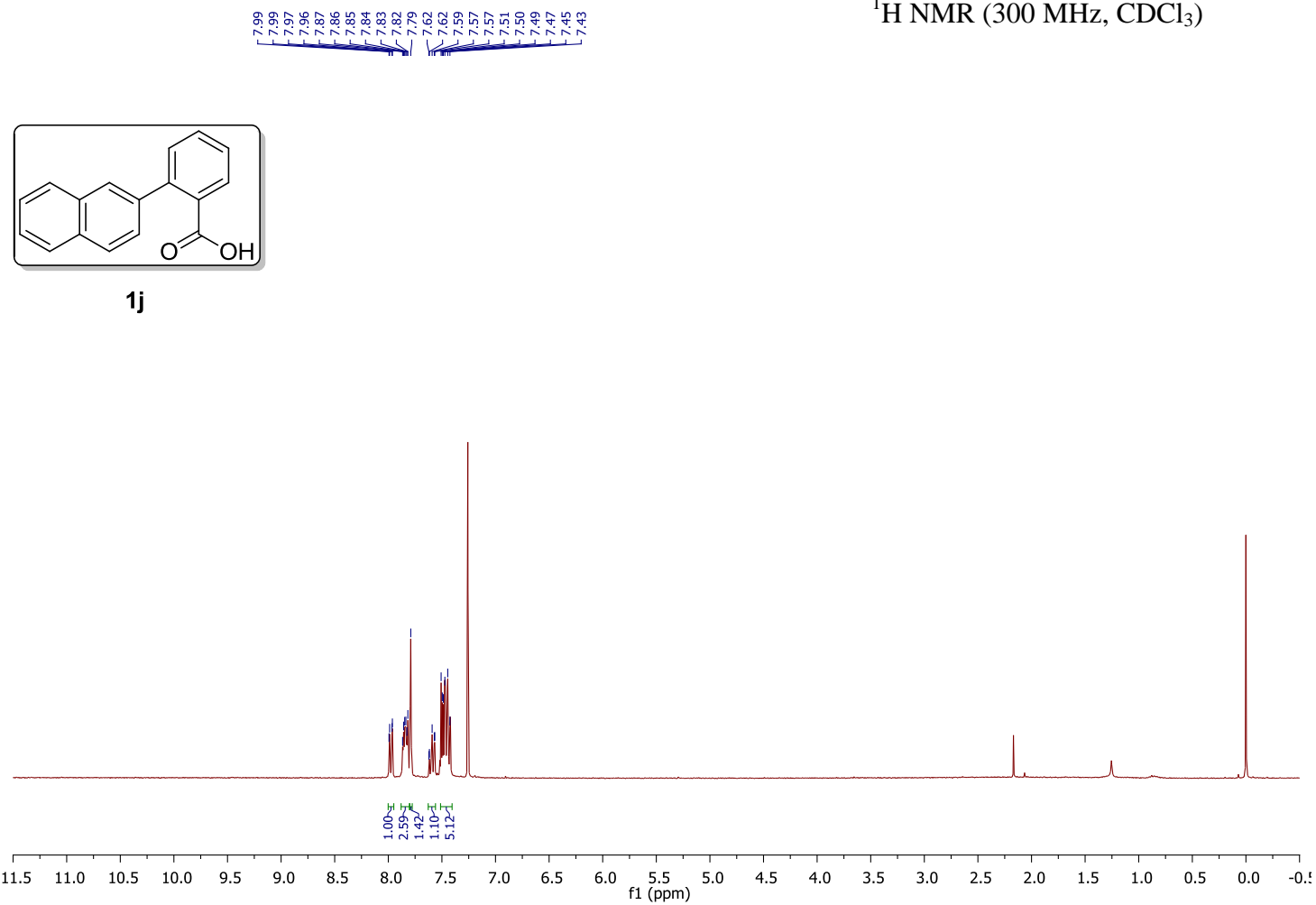


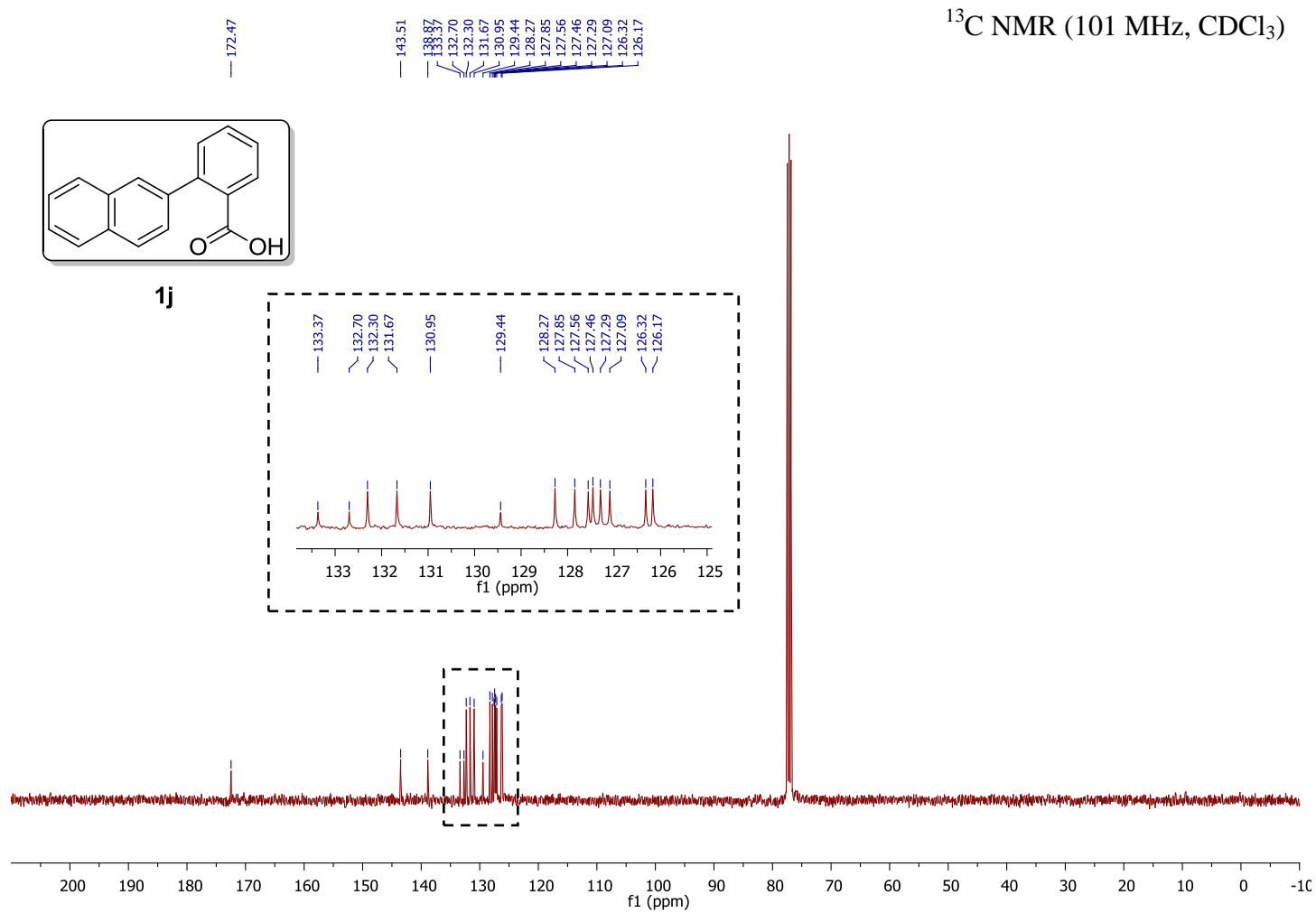
1h

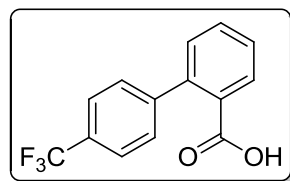




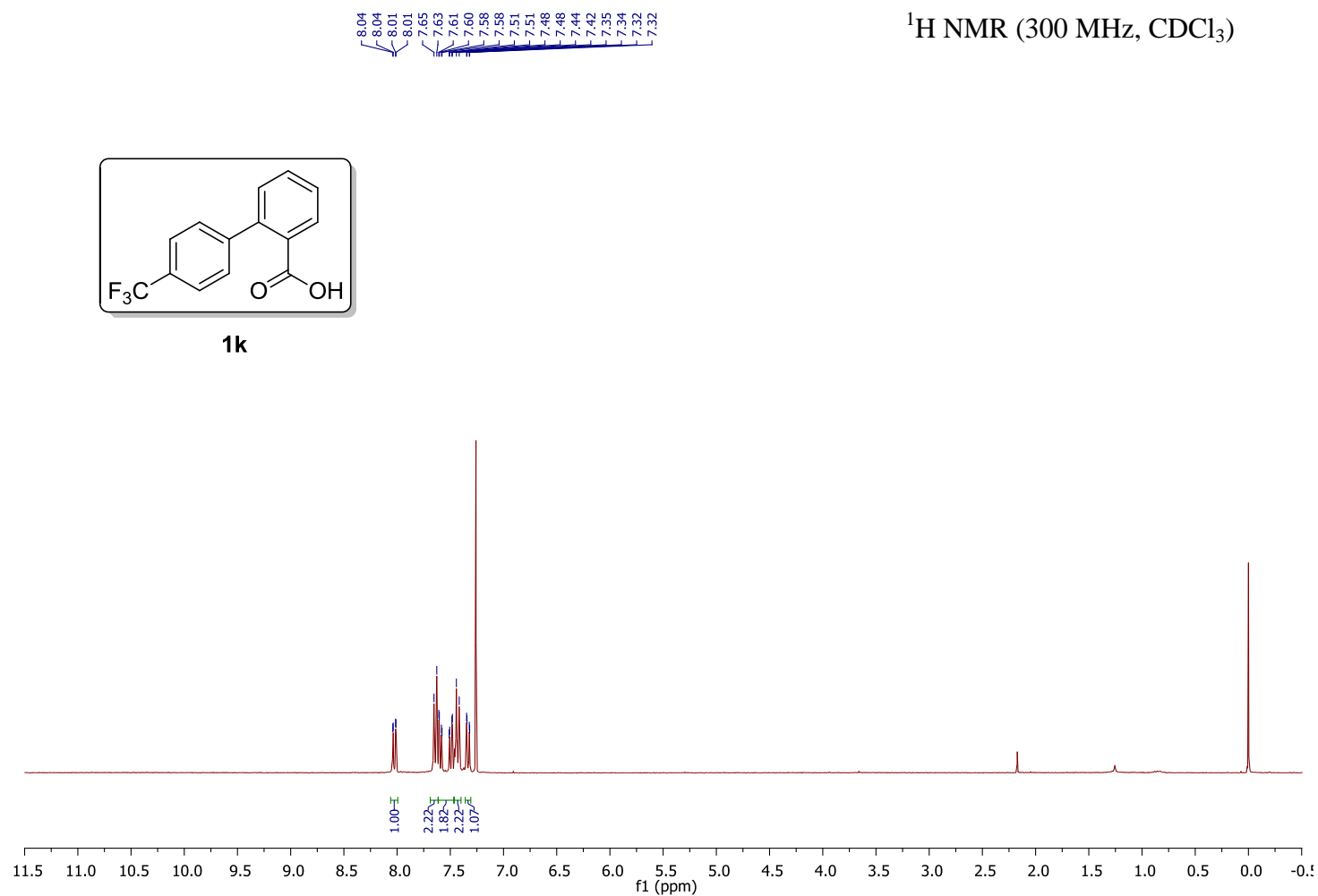


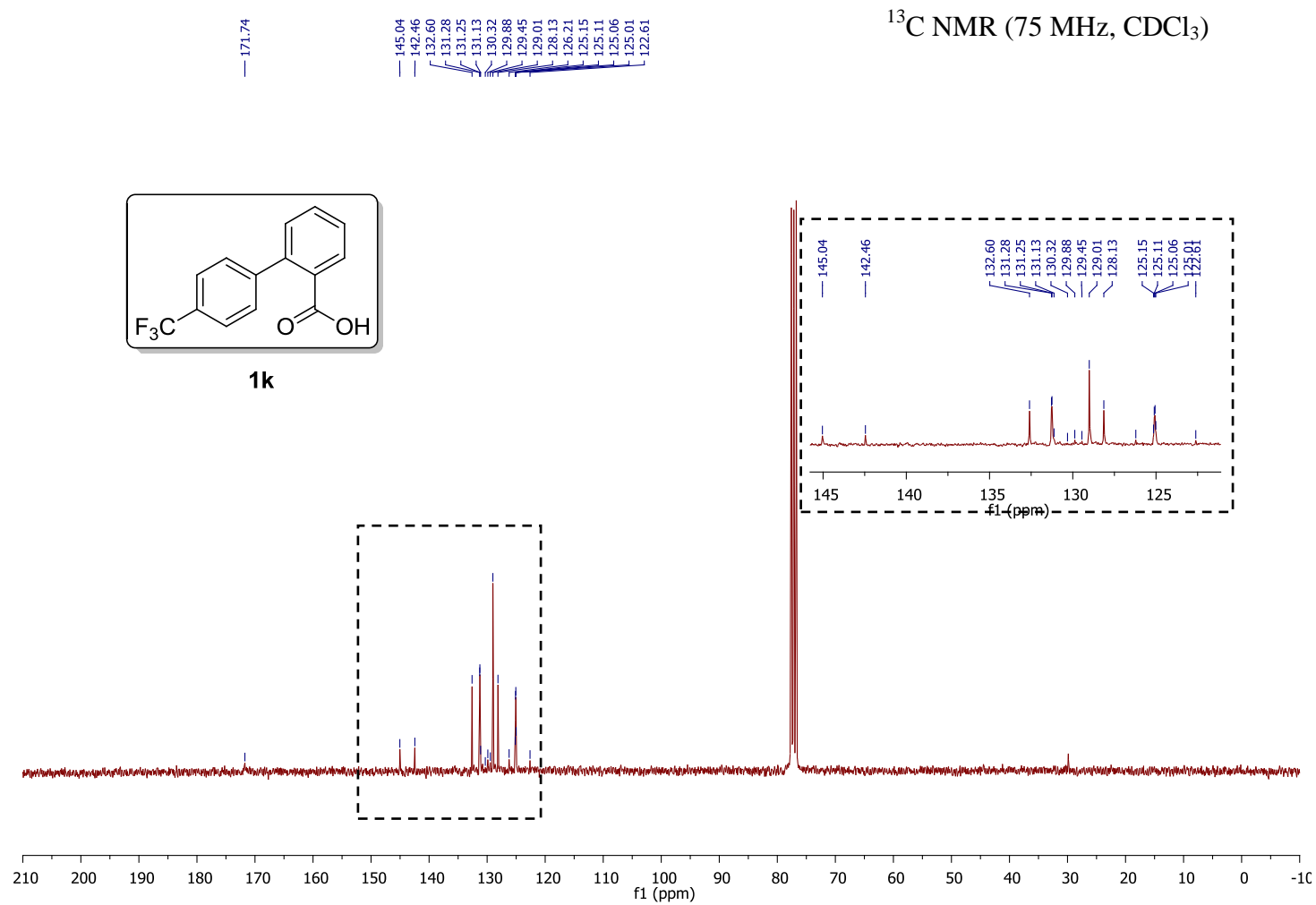


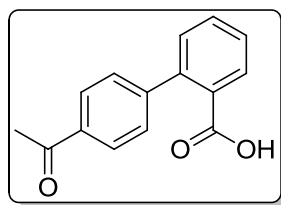




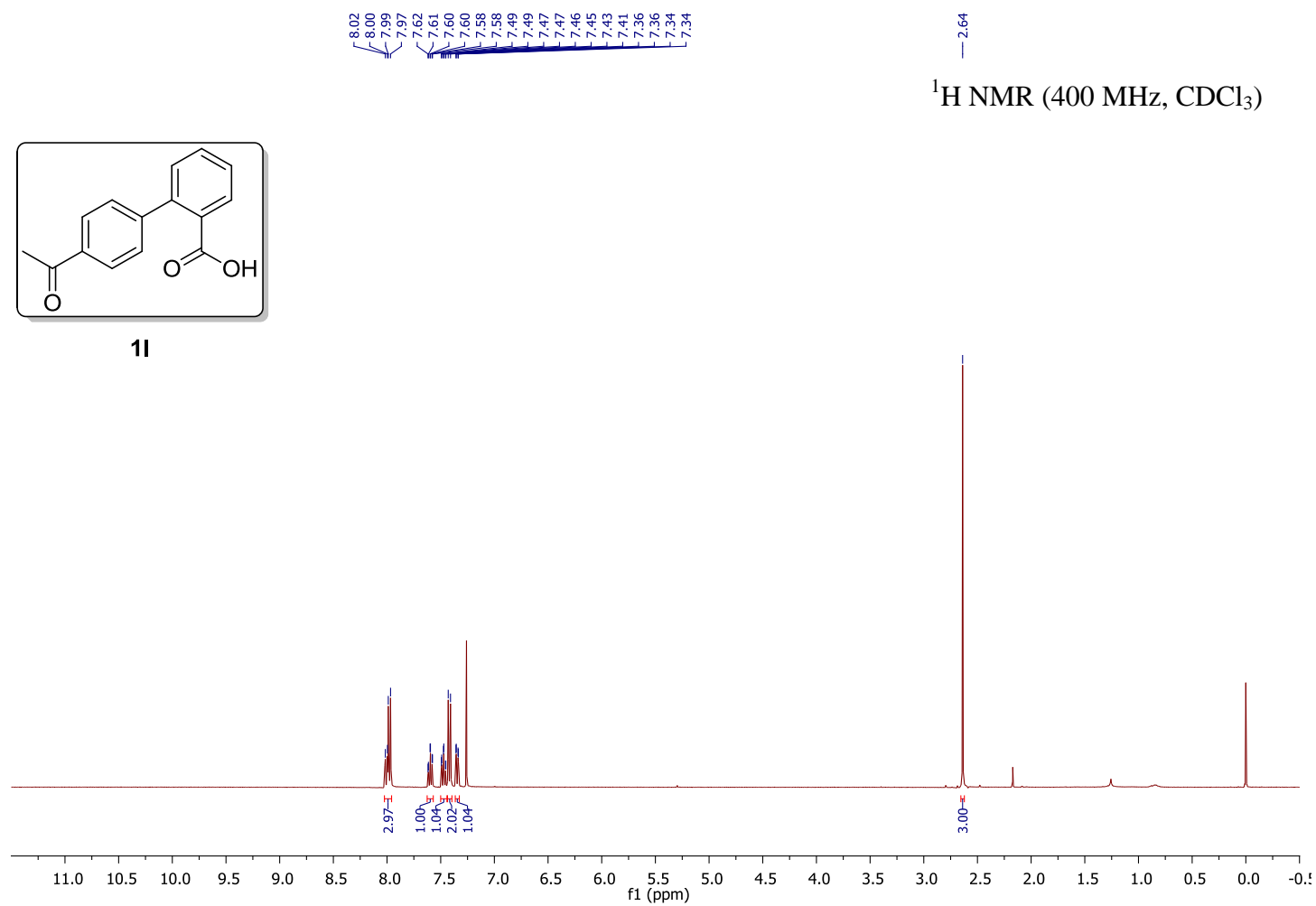
1k

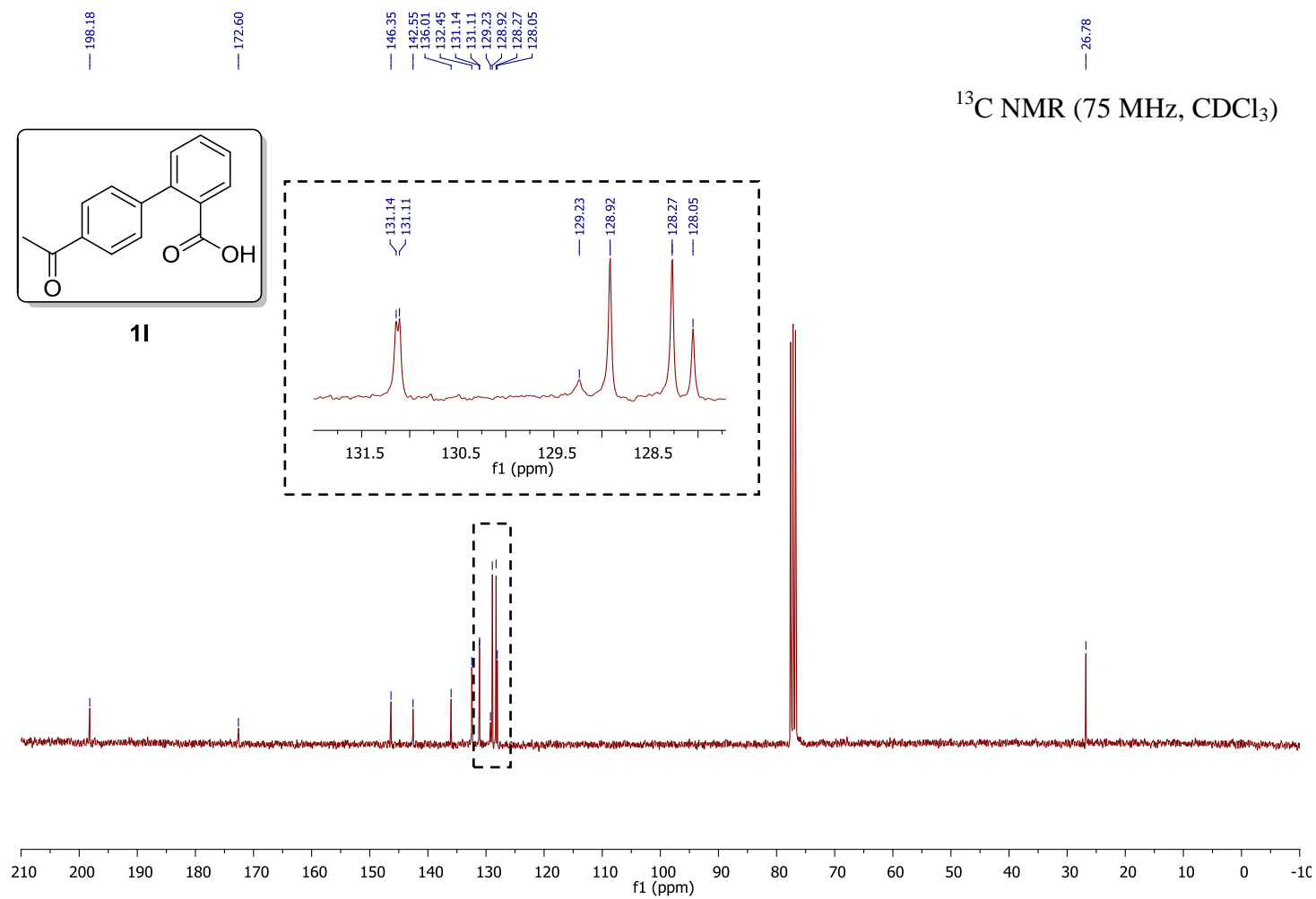


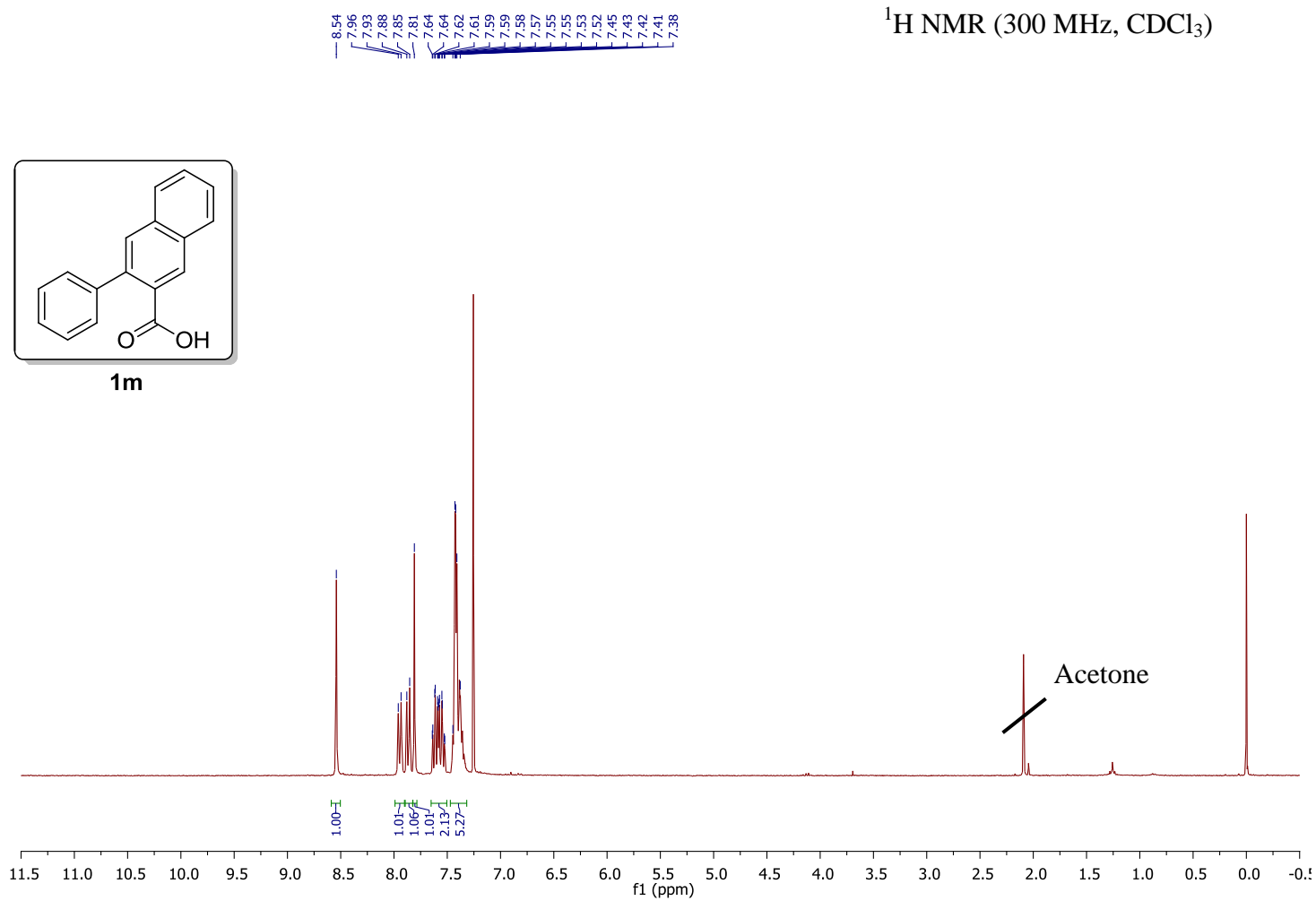


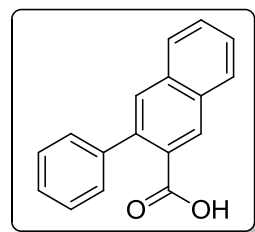


11

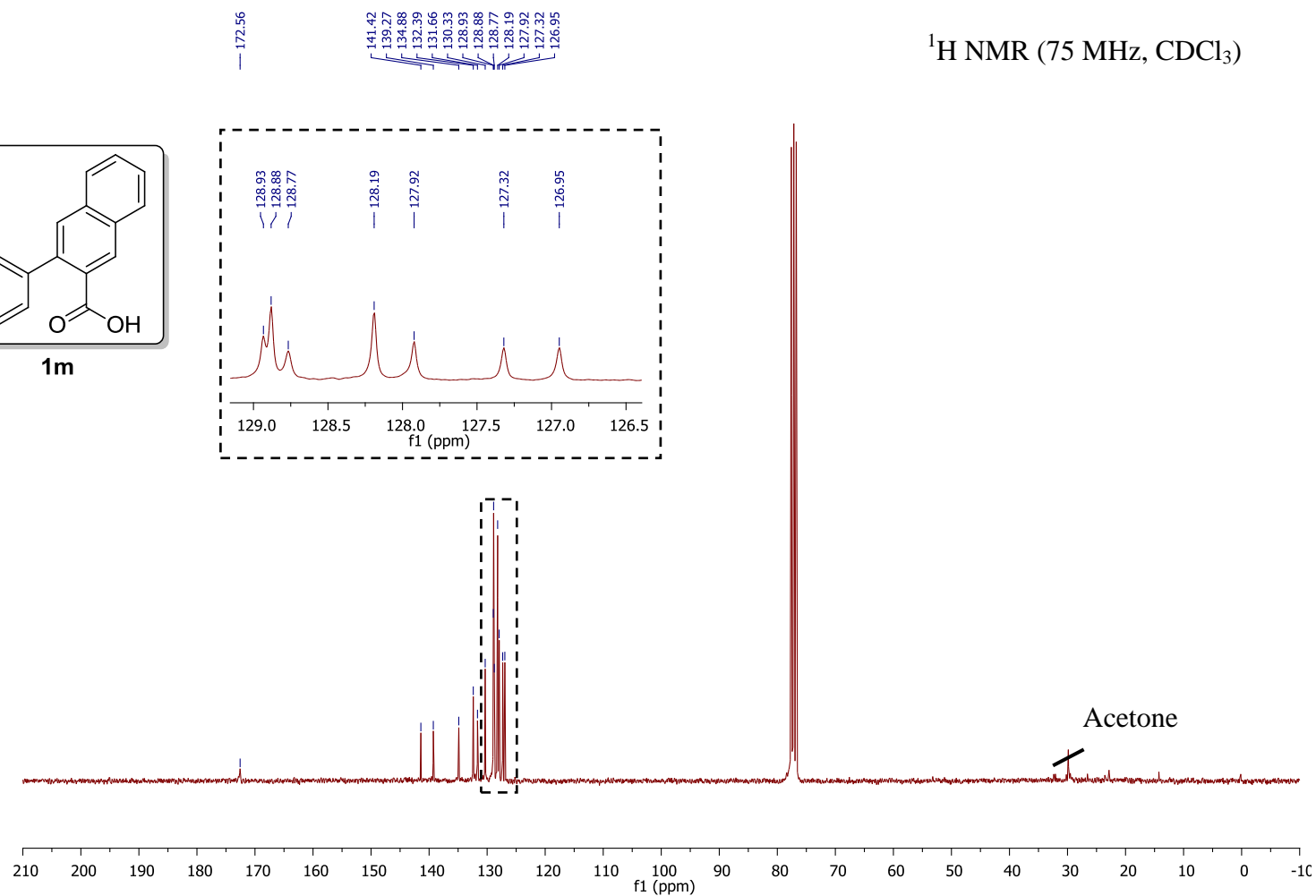


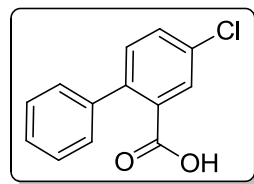






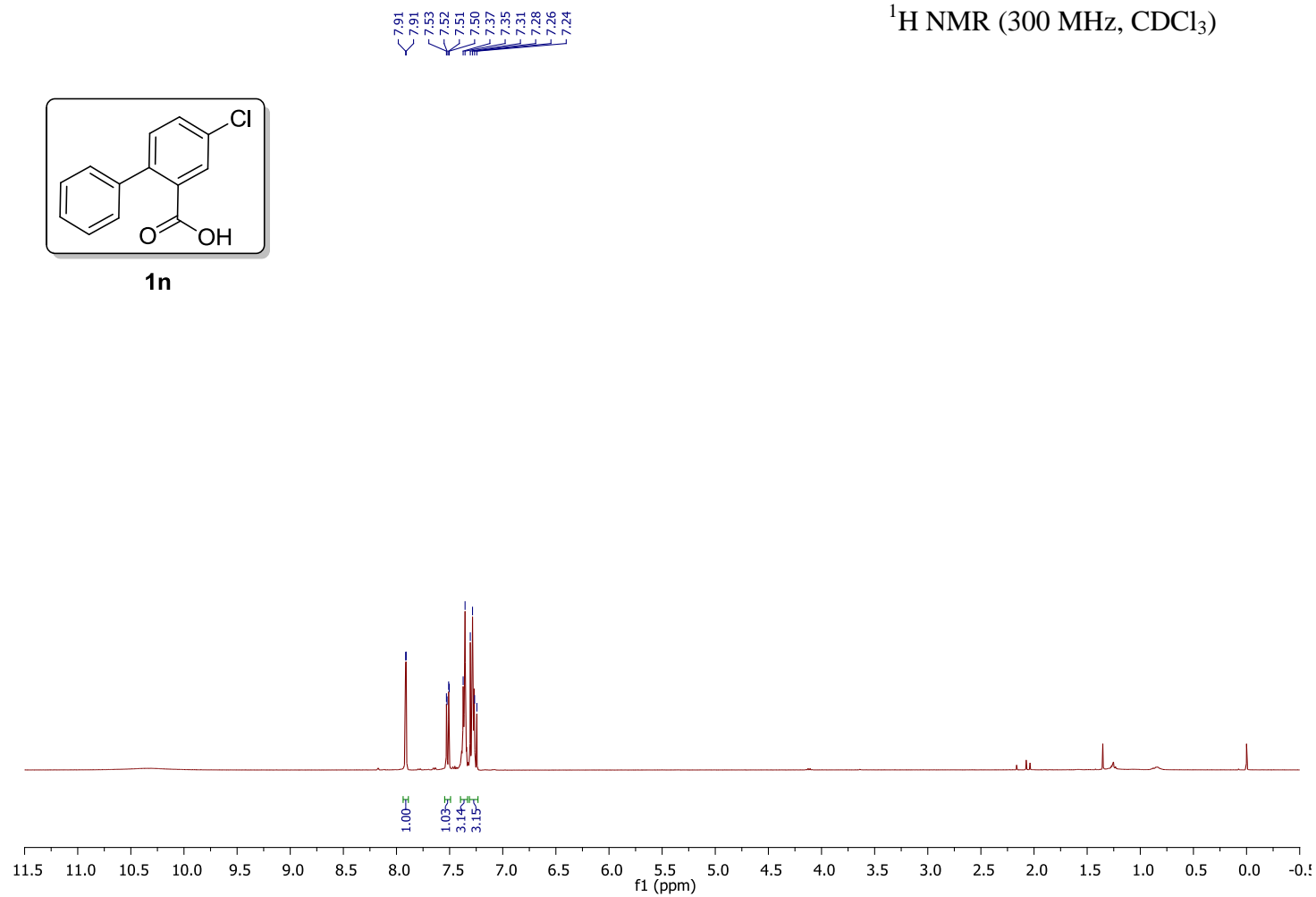
1m

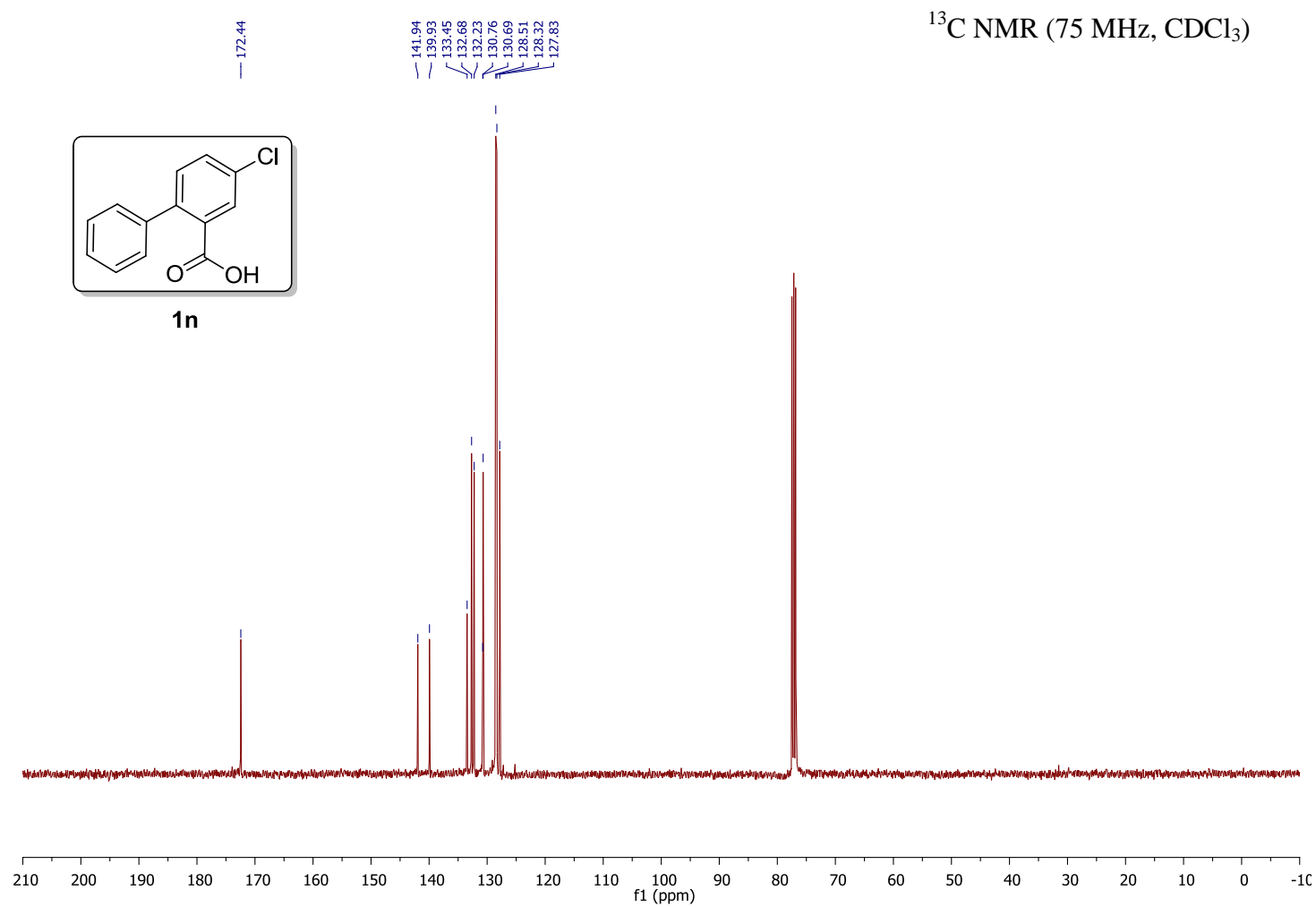


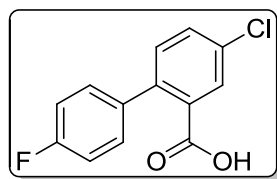


1n

^1H NMR (300 MHz, CDCl_3)

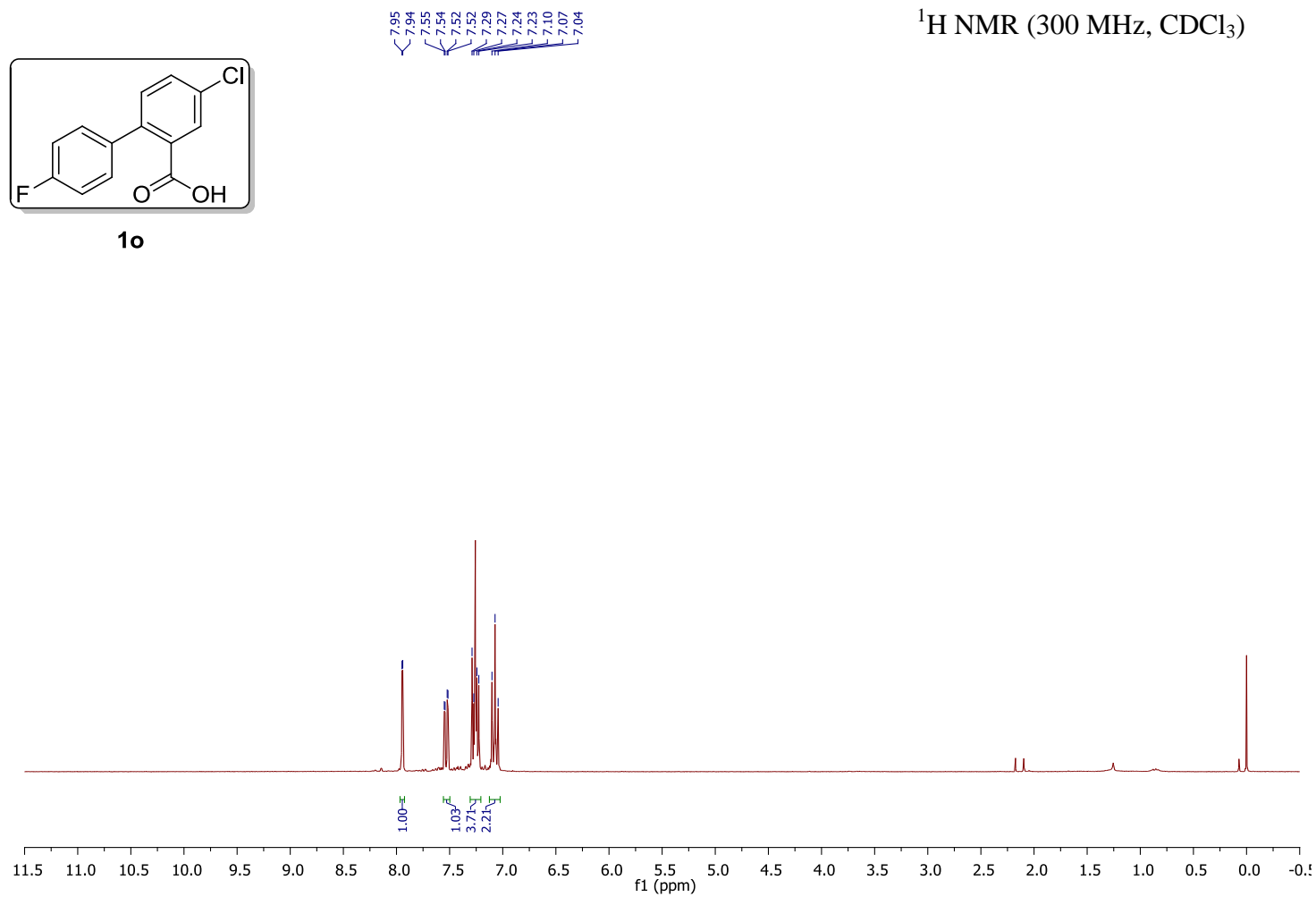


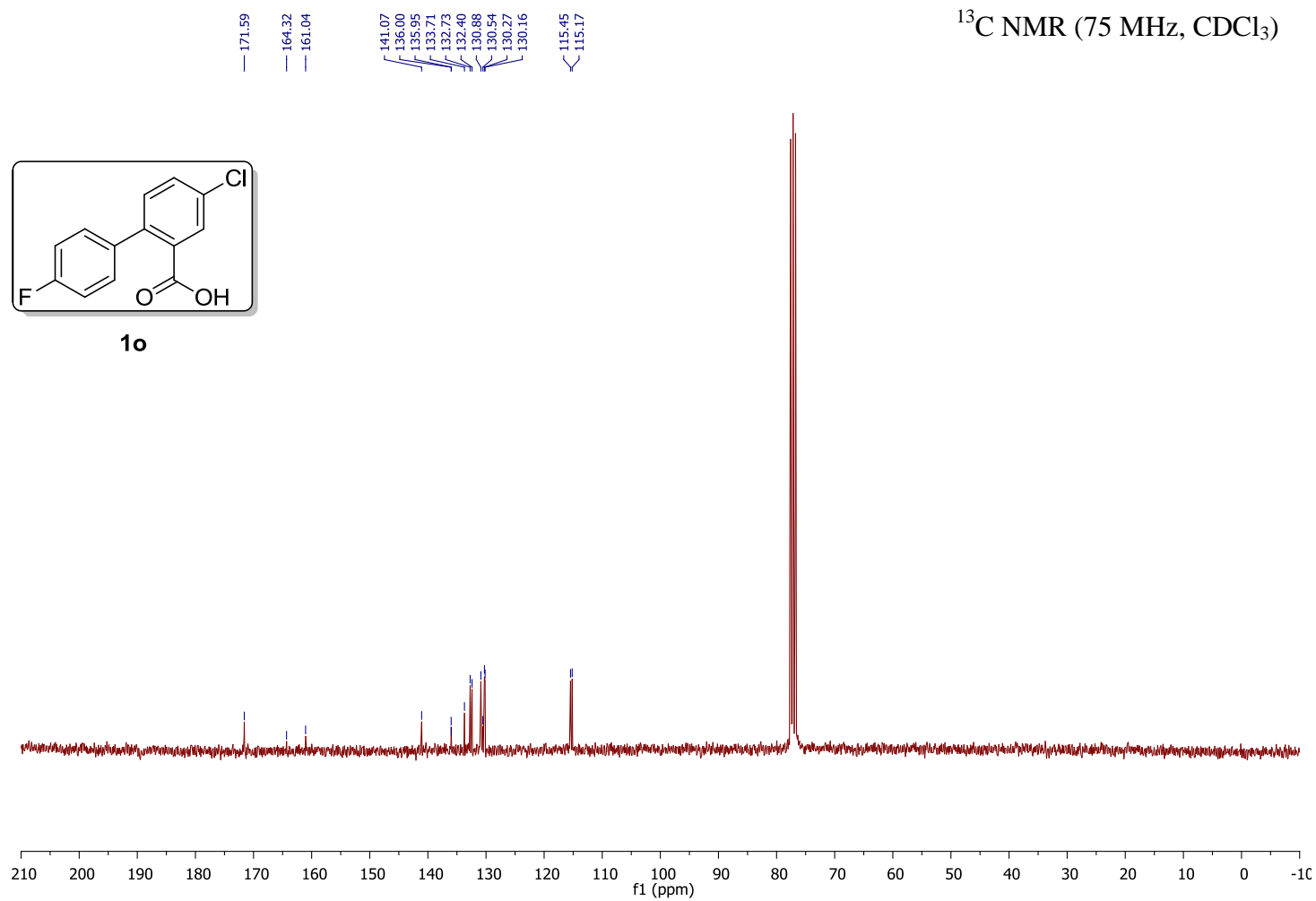


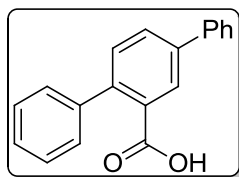


1o

^1H NMR (300 MHz, CDCl_3)



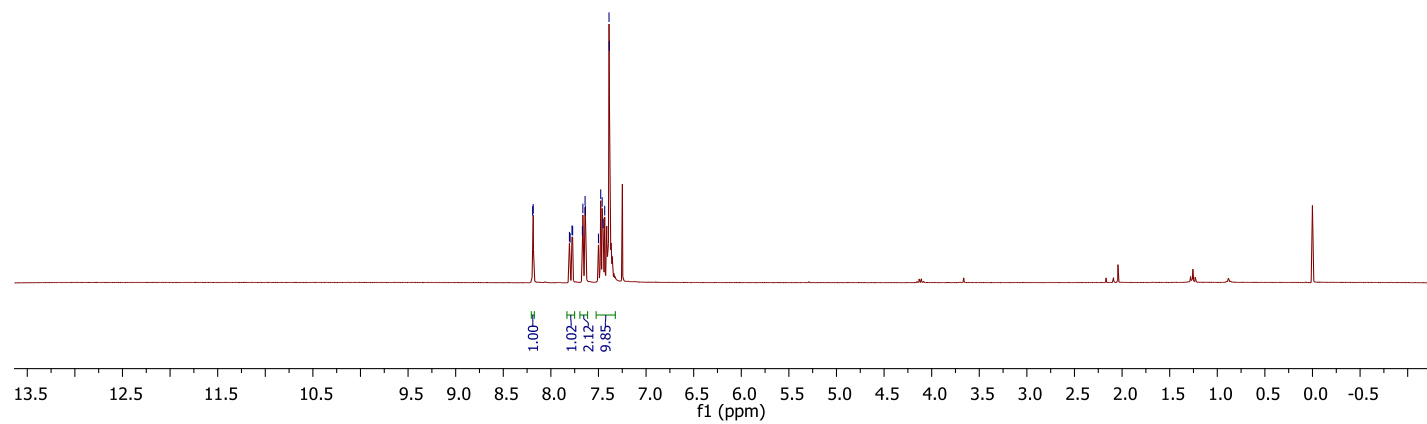


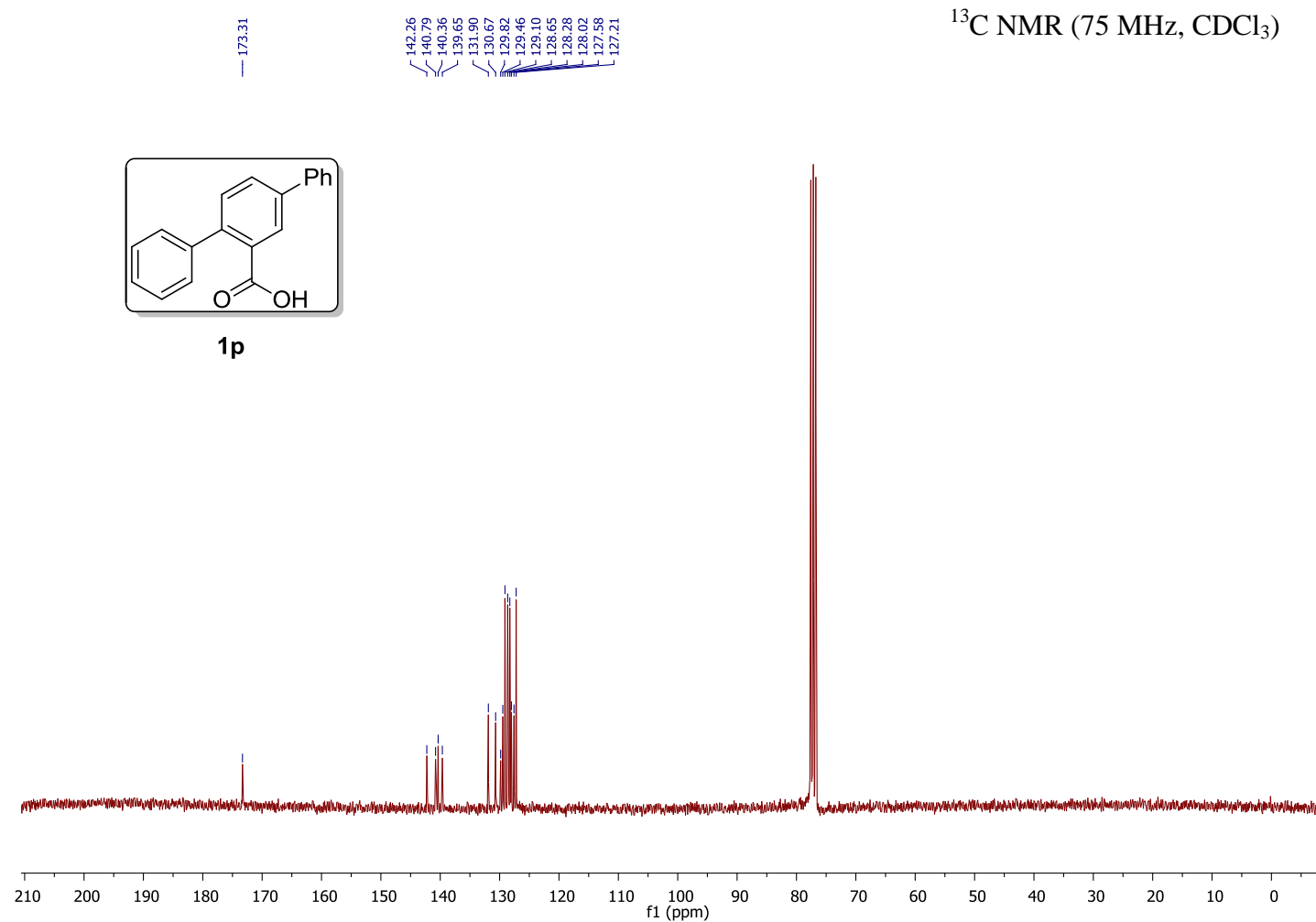


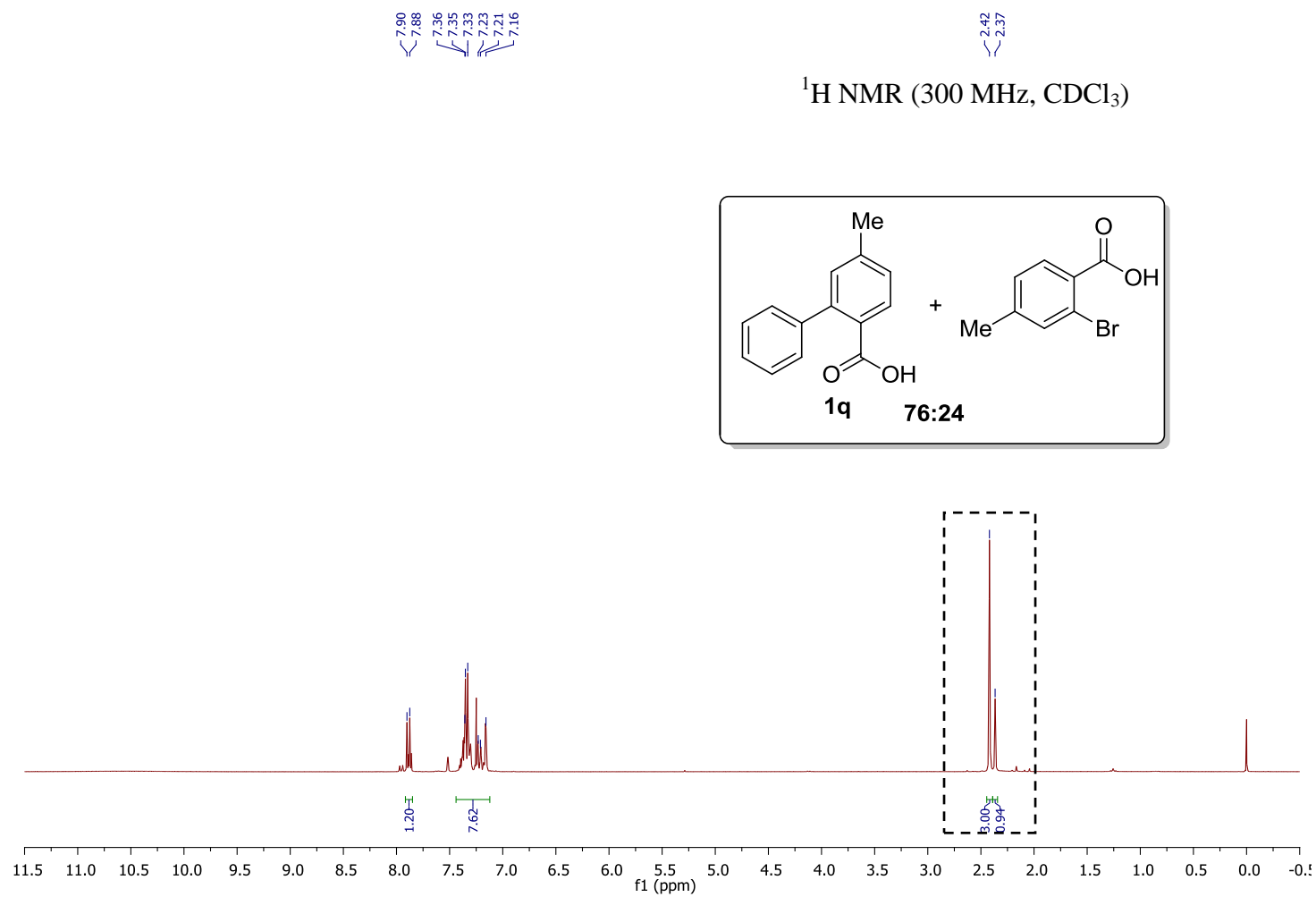
1p

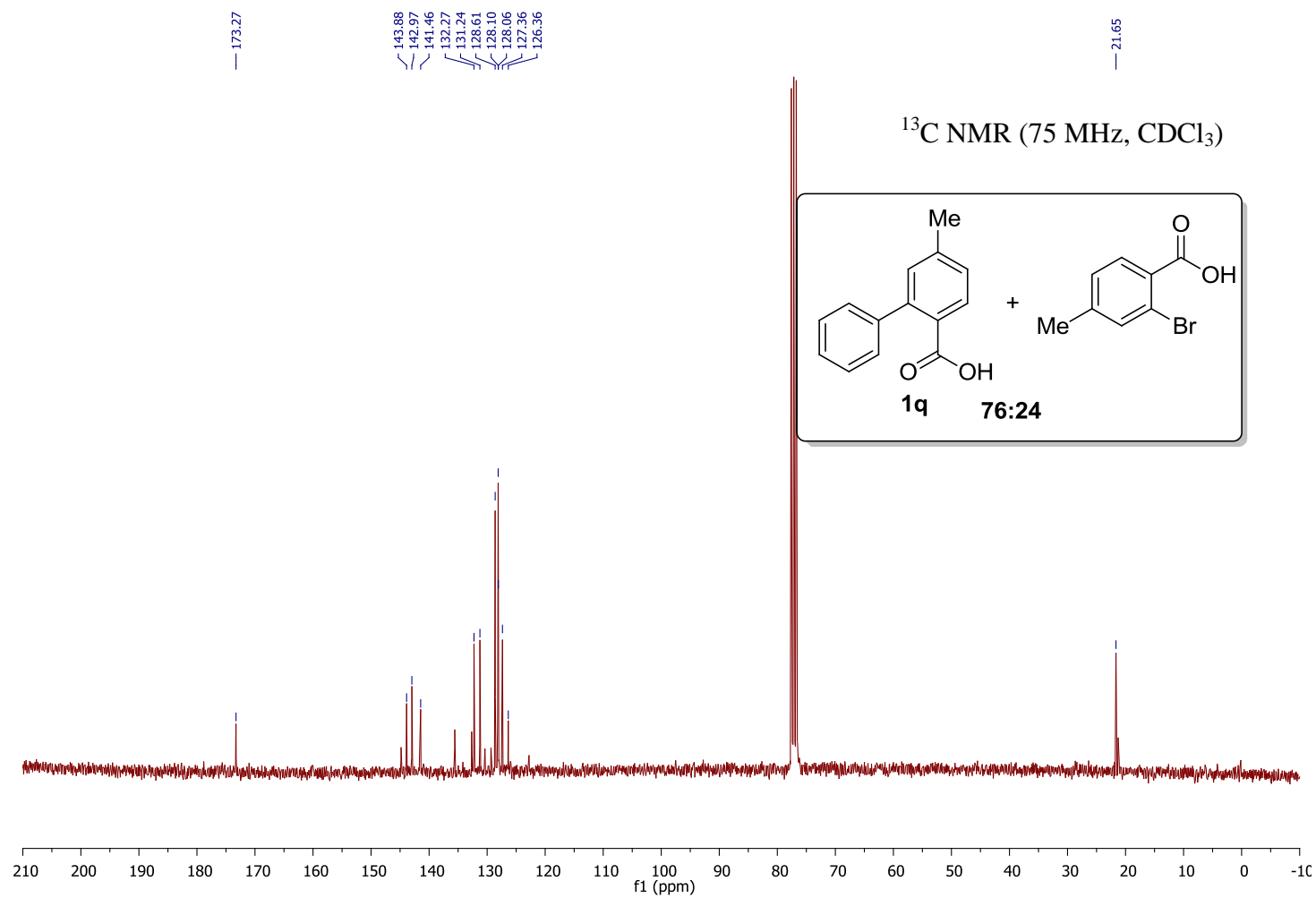
8.19
8.19
7.80
7.78
7.77
7.67
7.66
7.64
7.50
7.48
7.46
7.45
7.43
7.39

^1H NMR (300 MHz, CDCl_3)





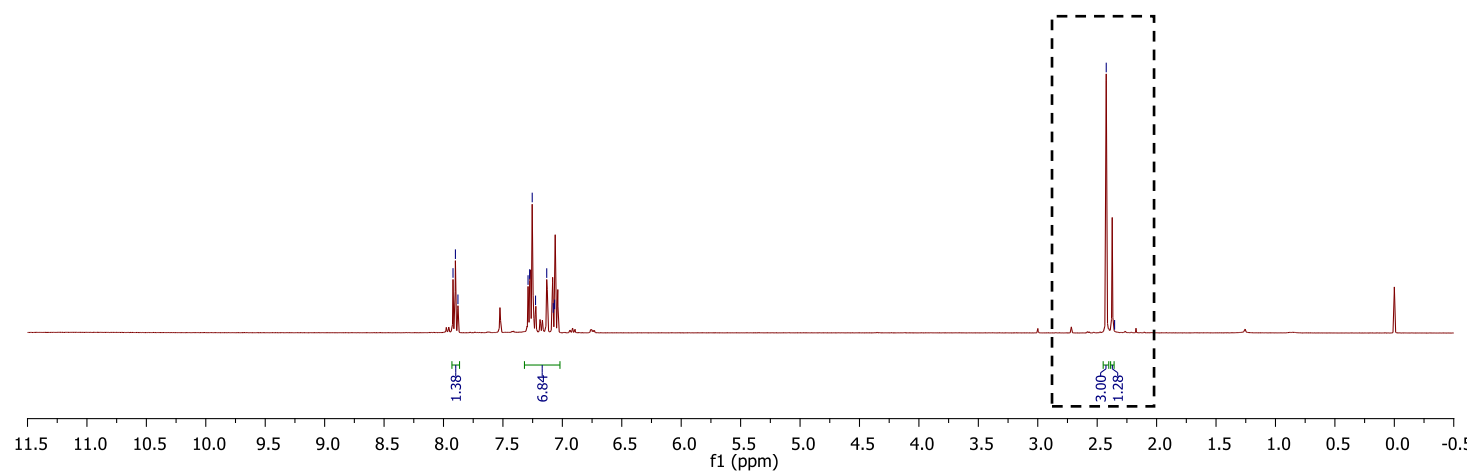
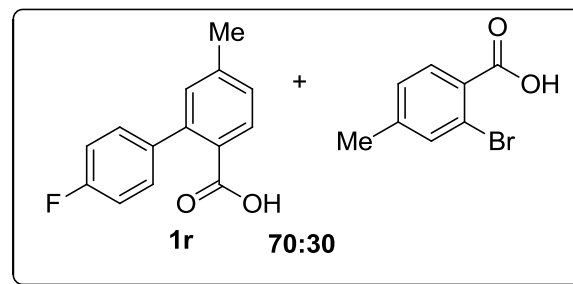


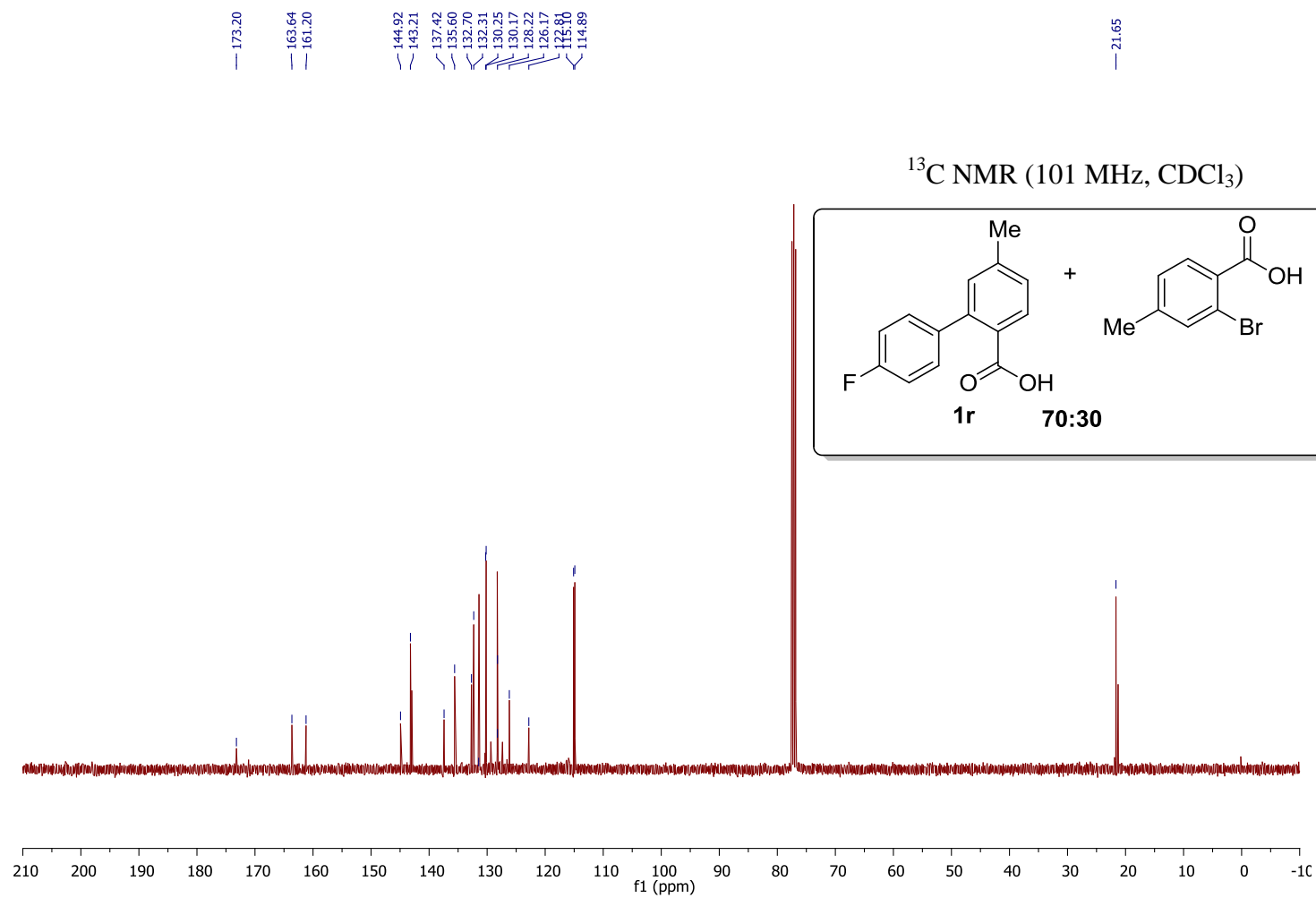


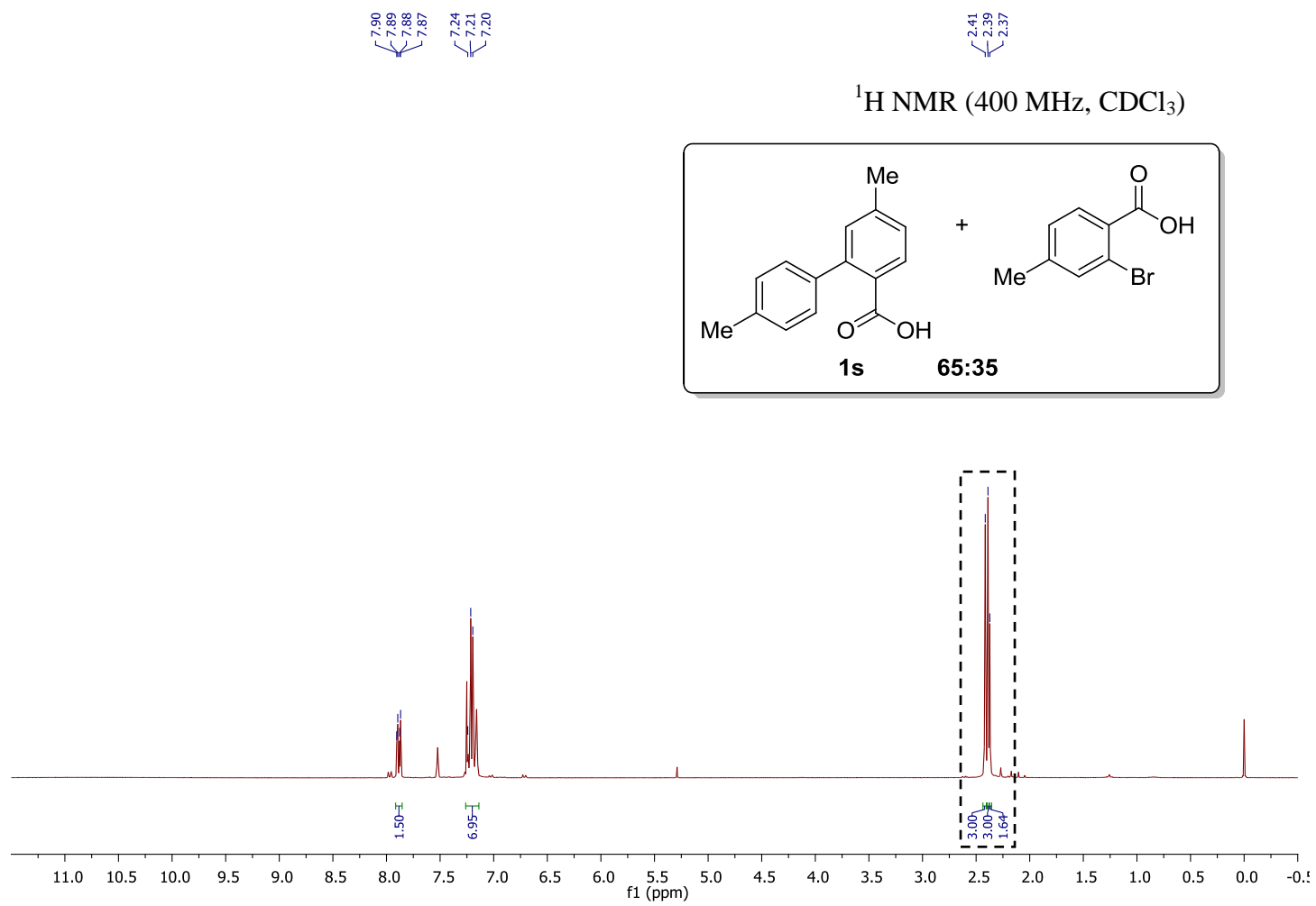
7.92
7.90
7.88
7.29
7.28
7.25
7.23
7.13
7.08
7.07

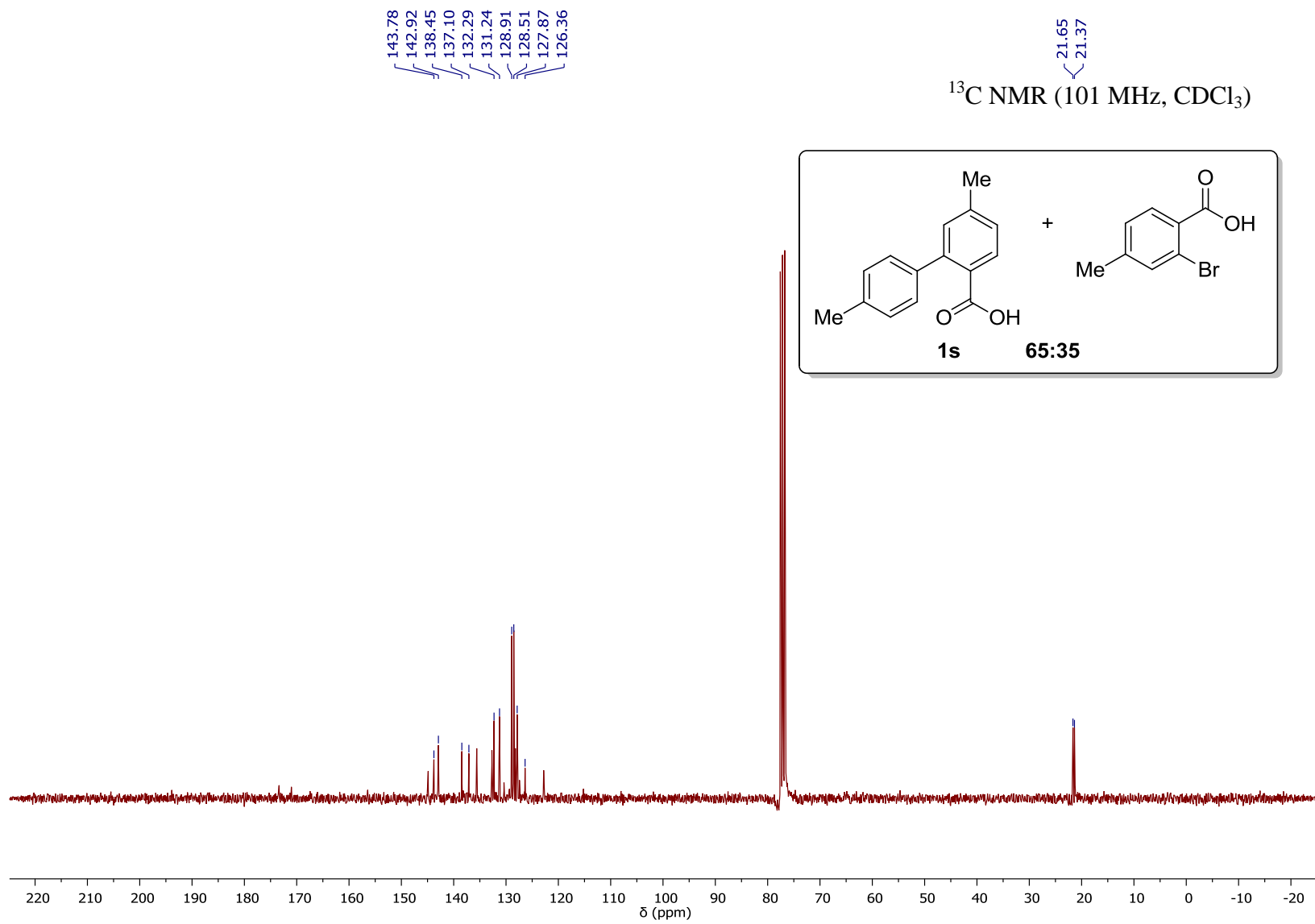
2.42
2.35

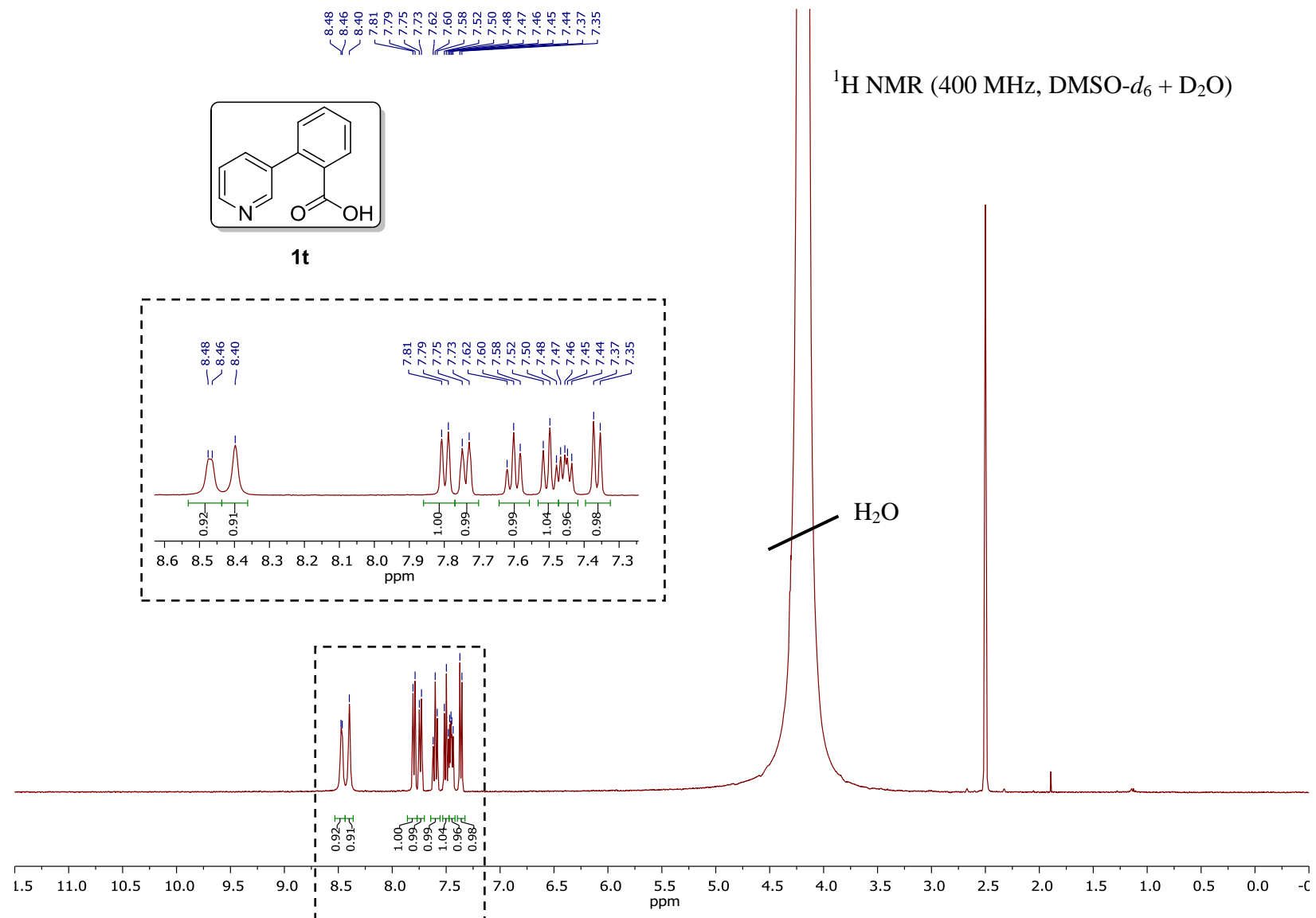
^1H NMR (400 MHz, CDCl_3)

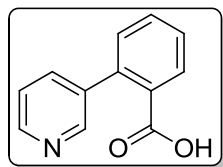






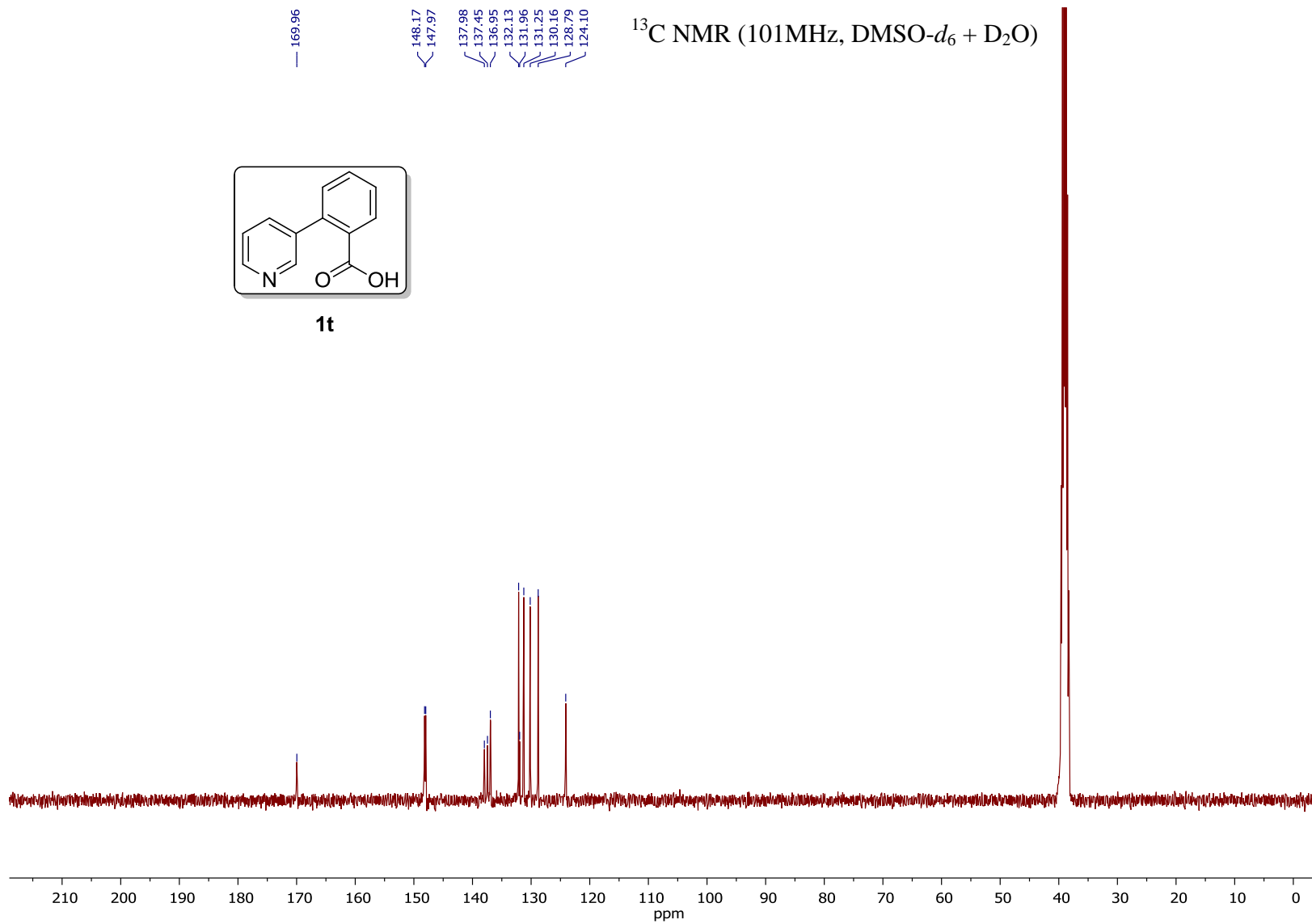


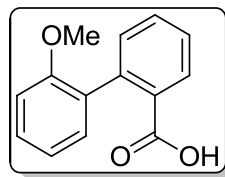




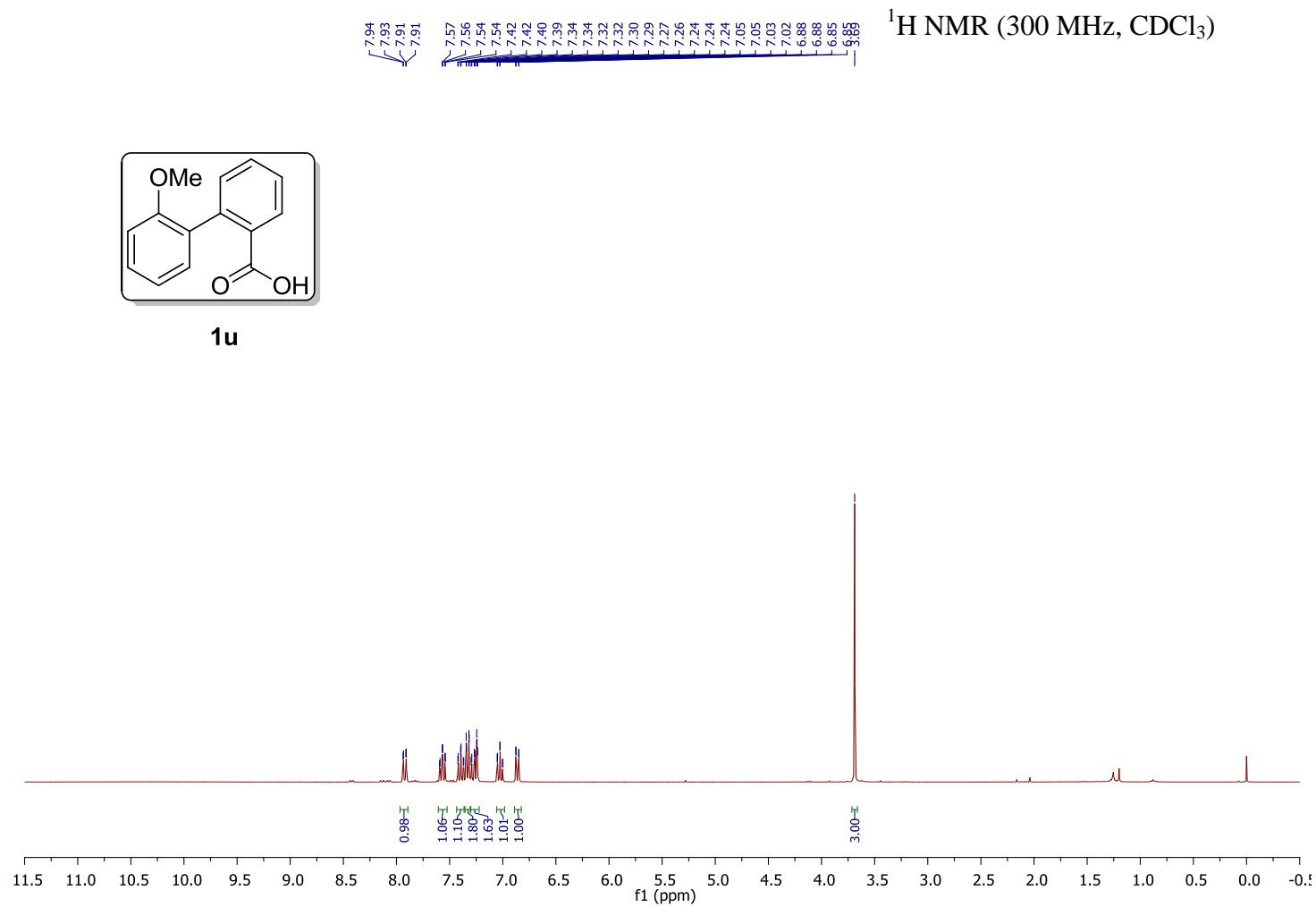
1t

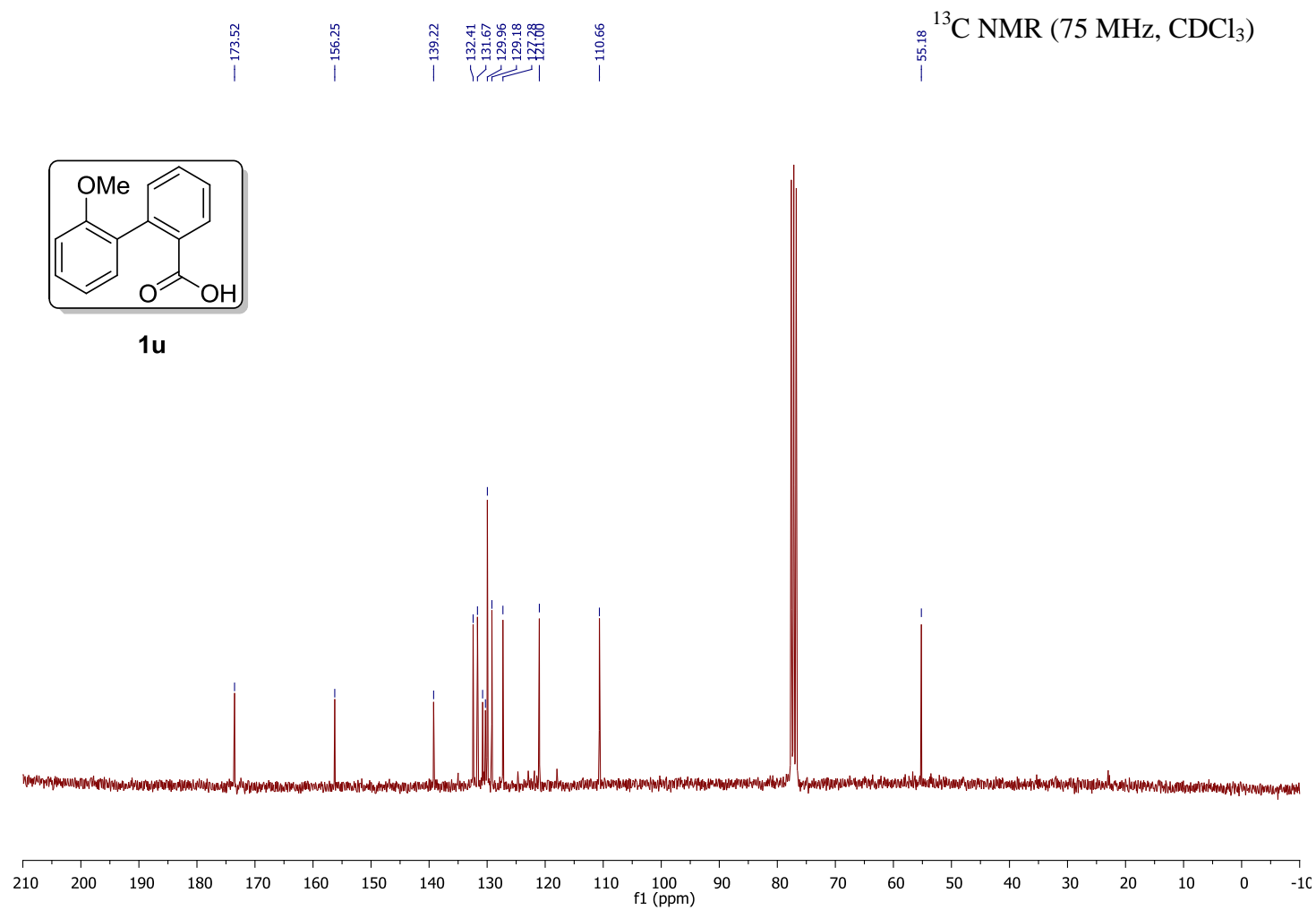
^{13}C NMR (101MHz, $\text{DMSO}-d_6 + \text{D}_2\text{O}$)



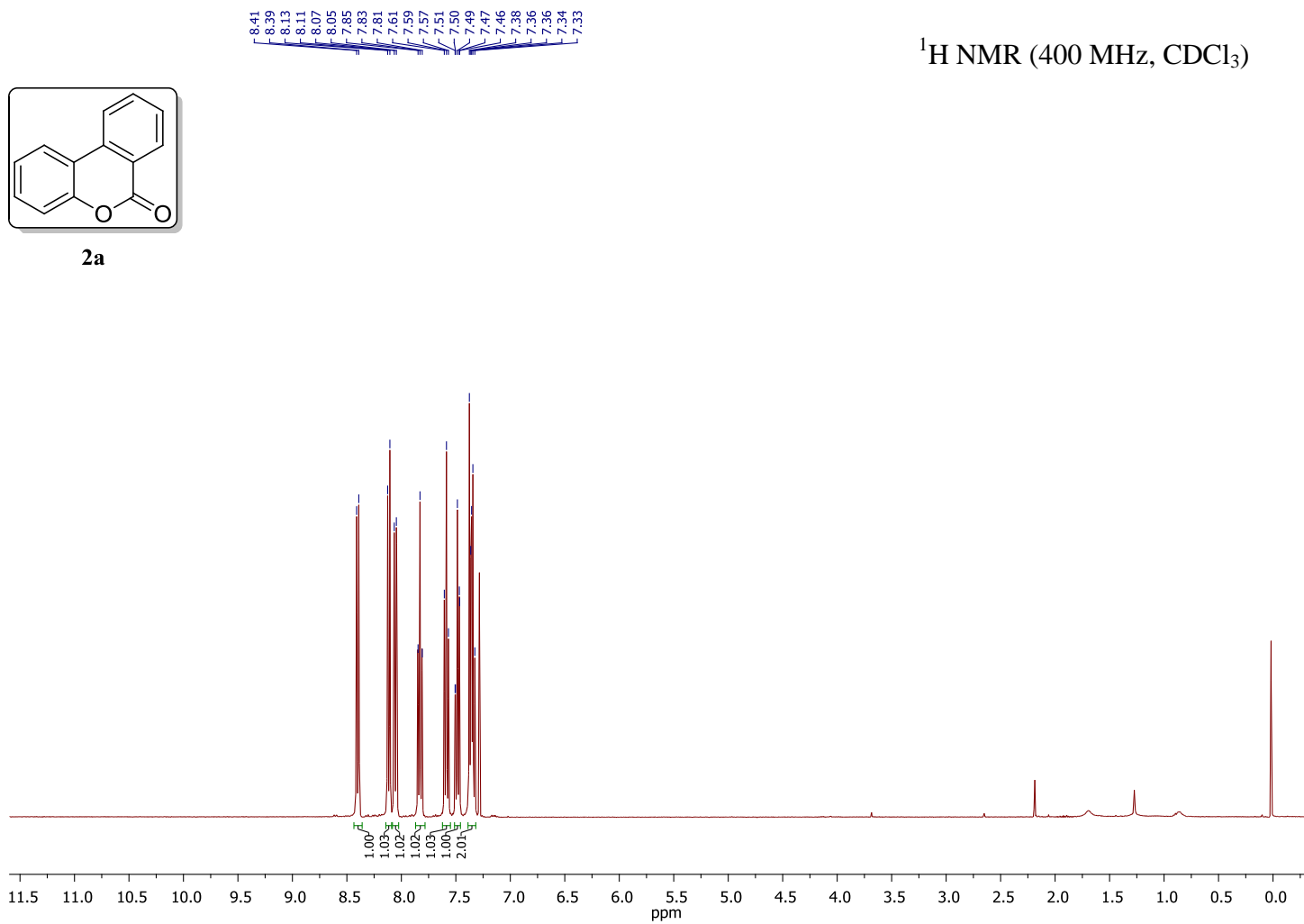


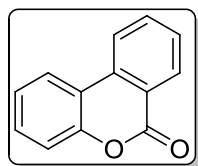
1u



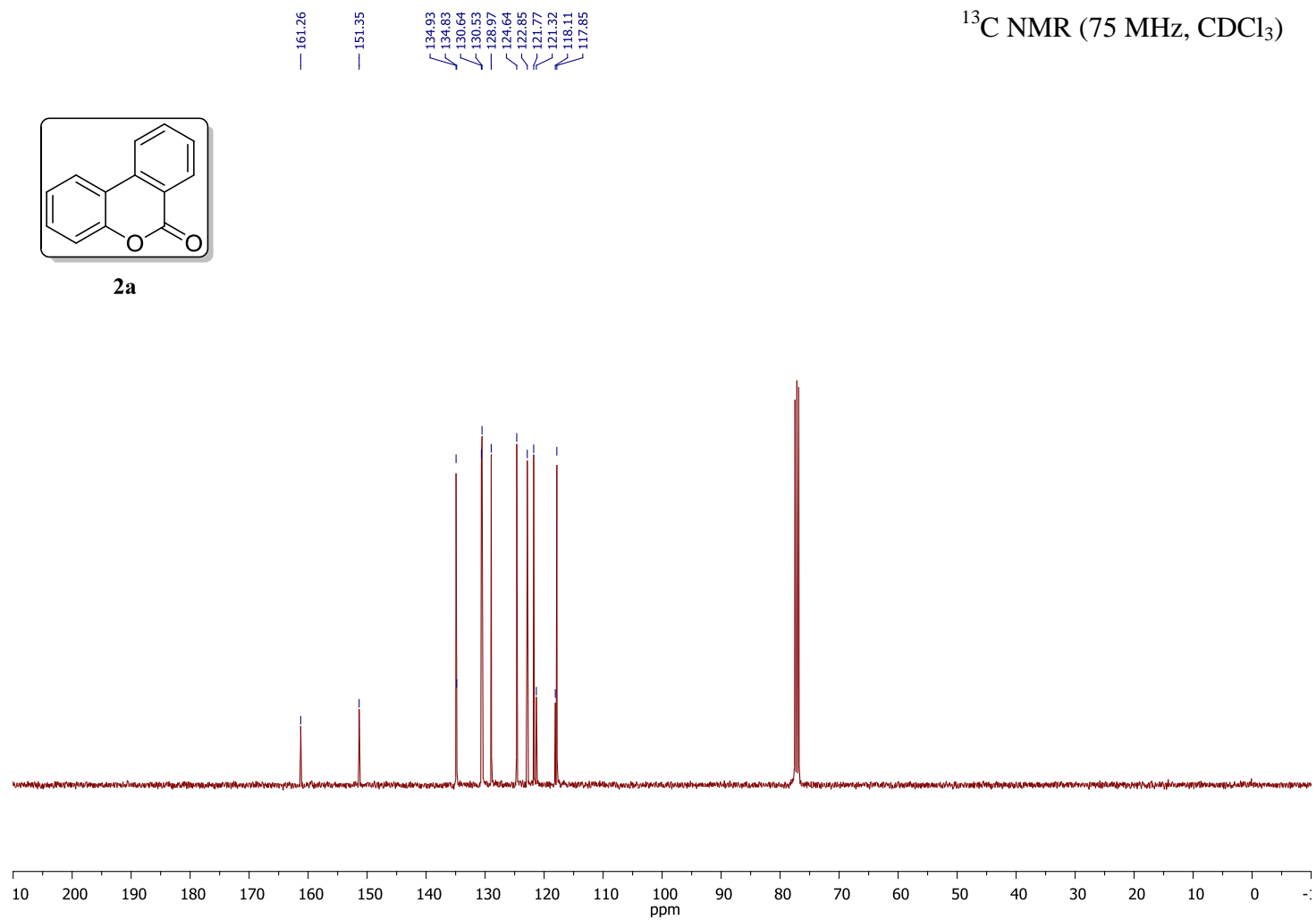


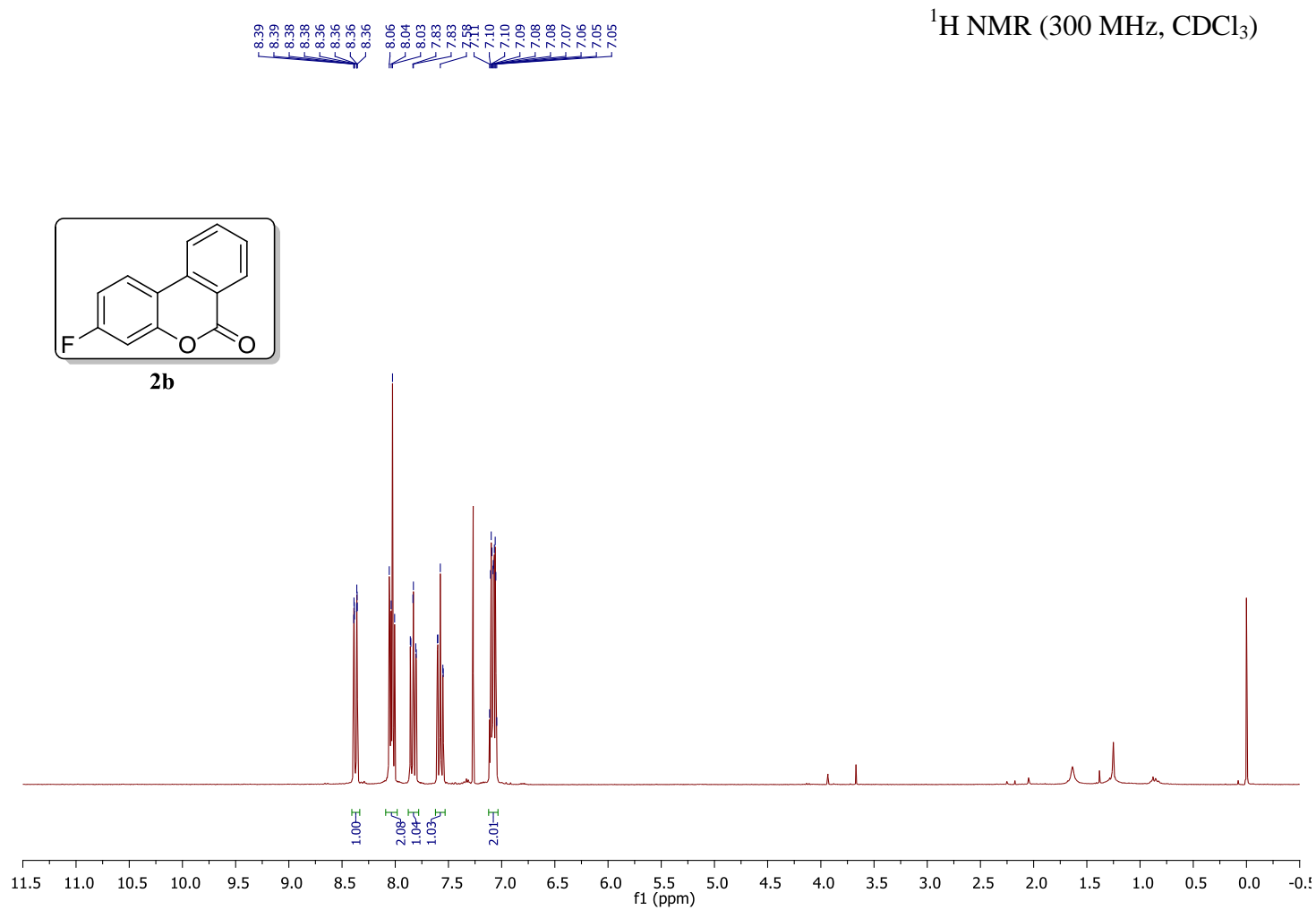
10. ¹H NMR and ¹³C NMR Spectra of Benzo-3,4-coumarins 2a - 2s

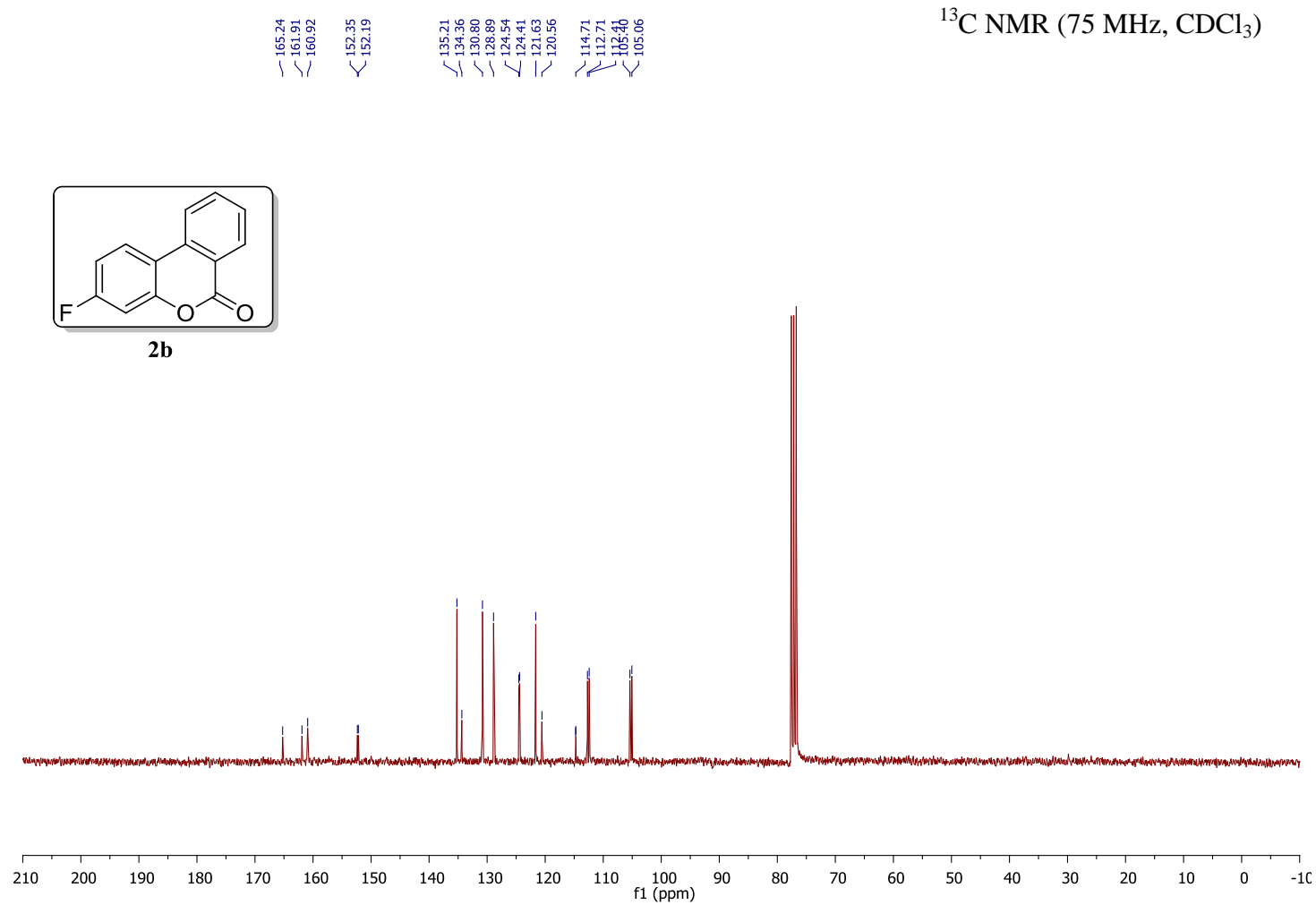


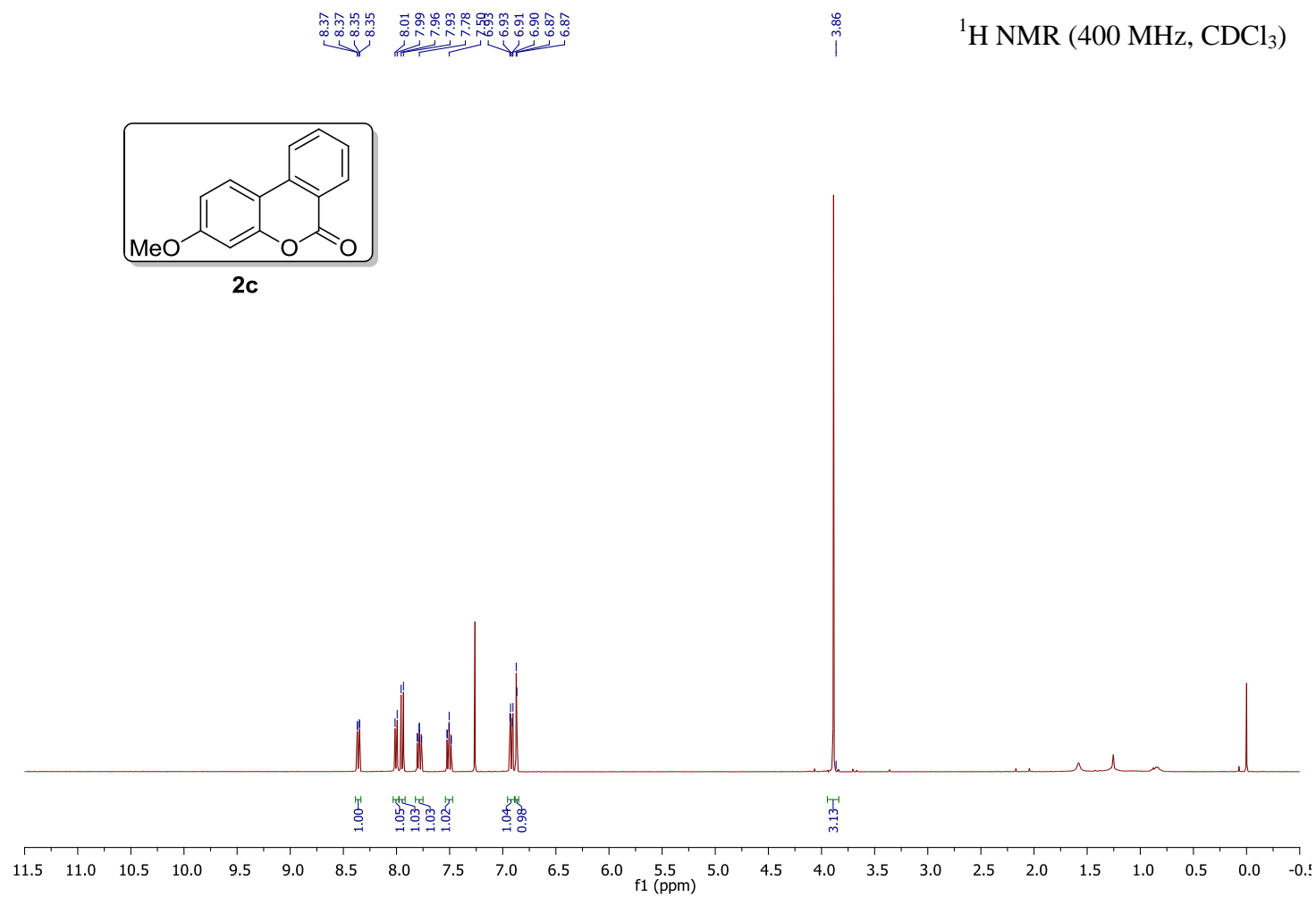


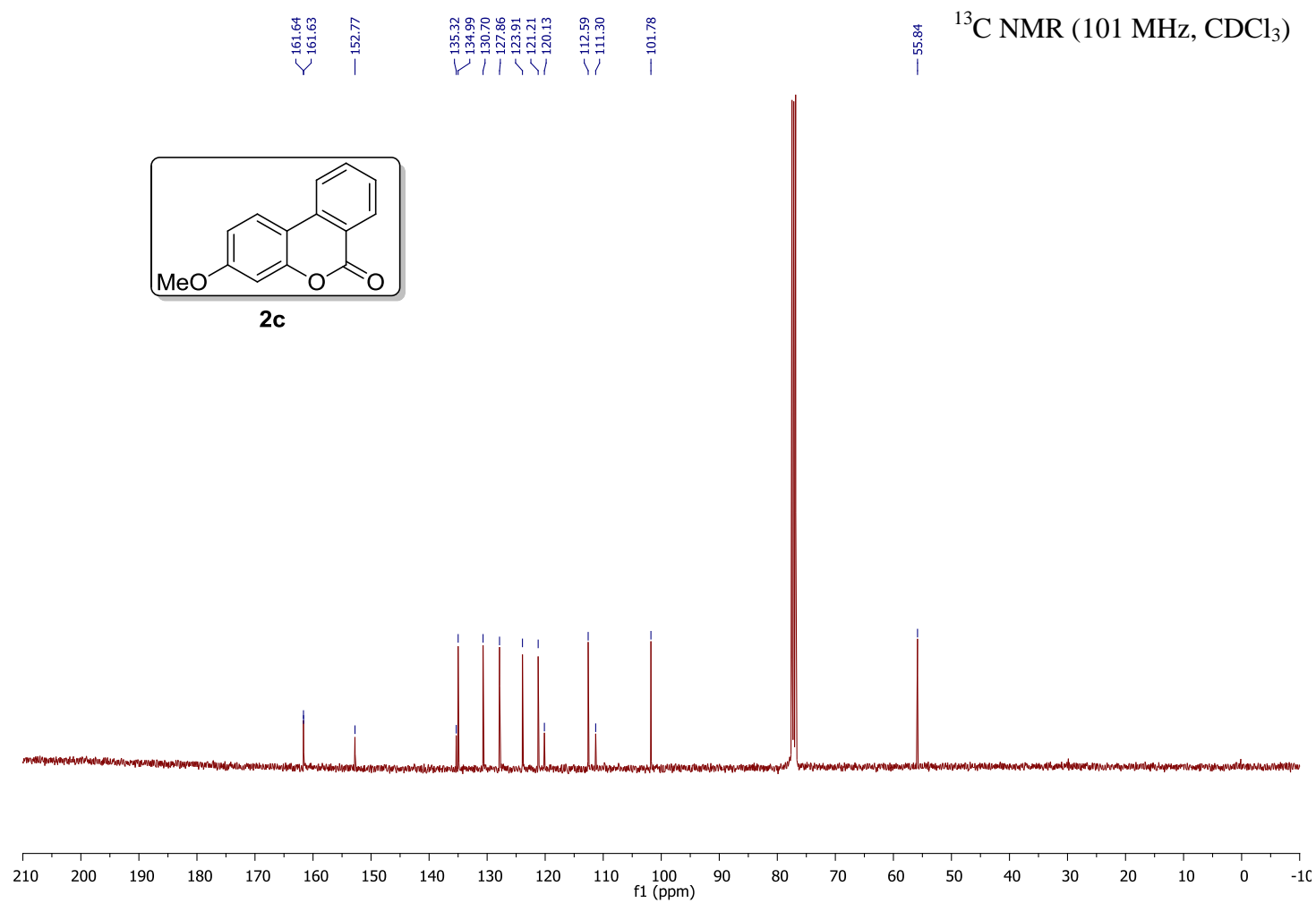
2a

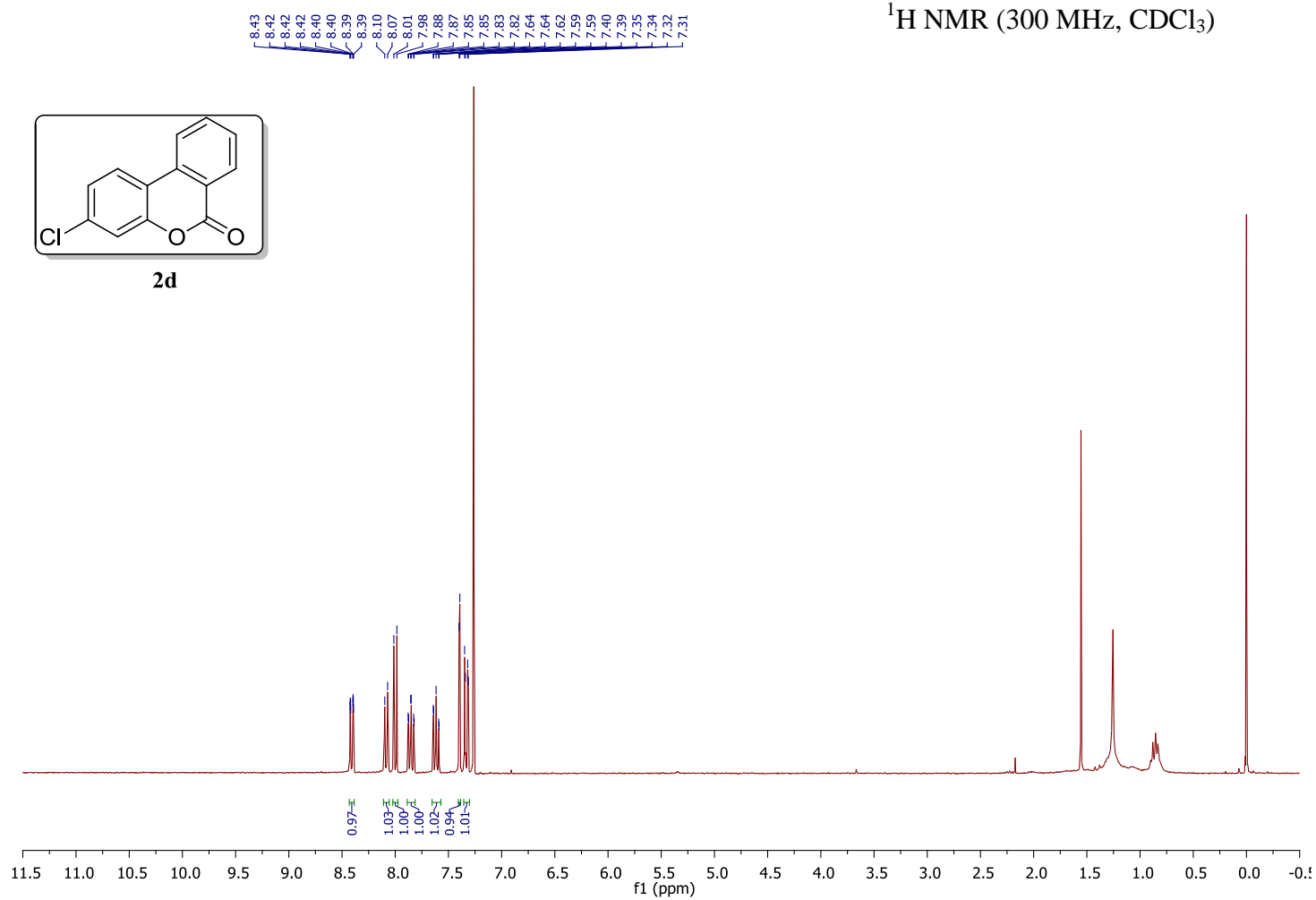


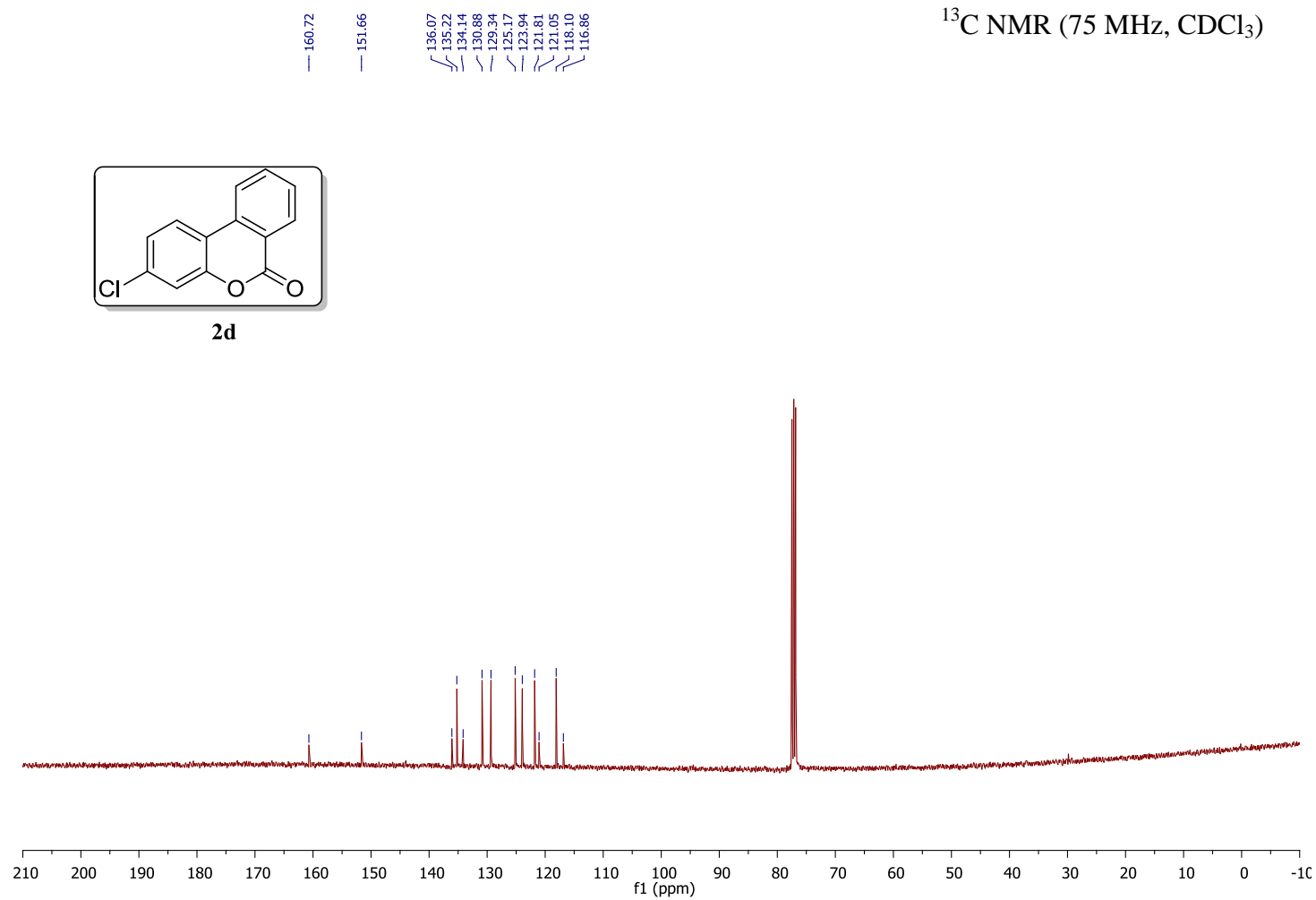


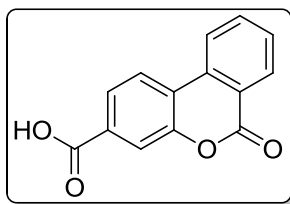




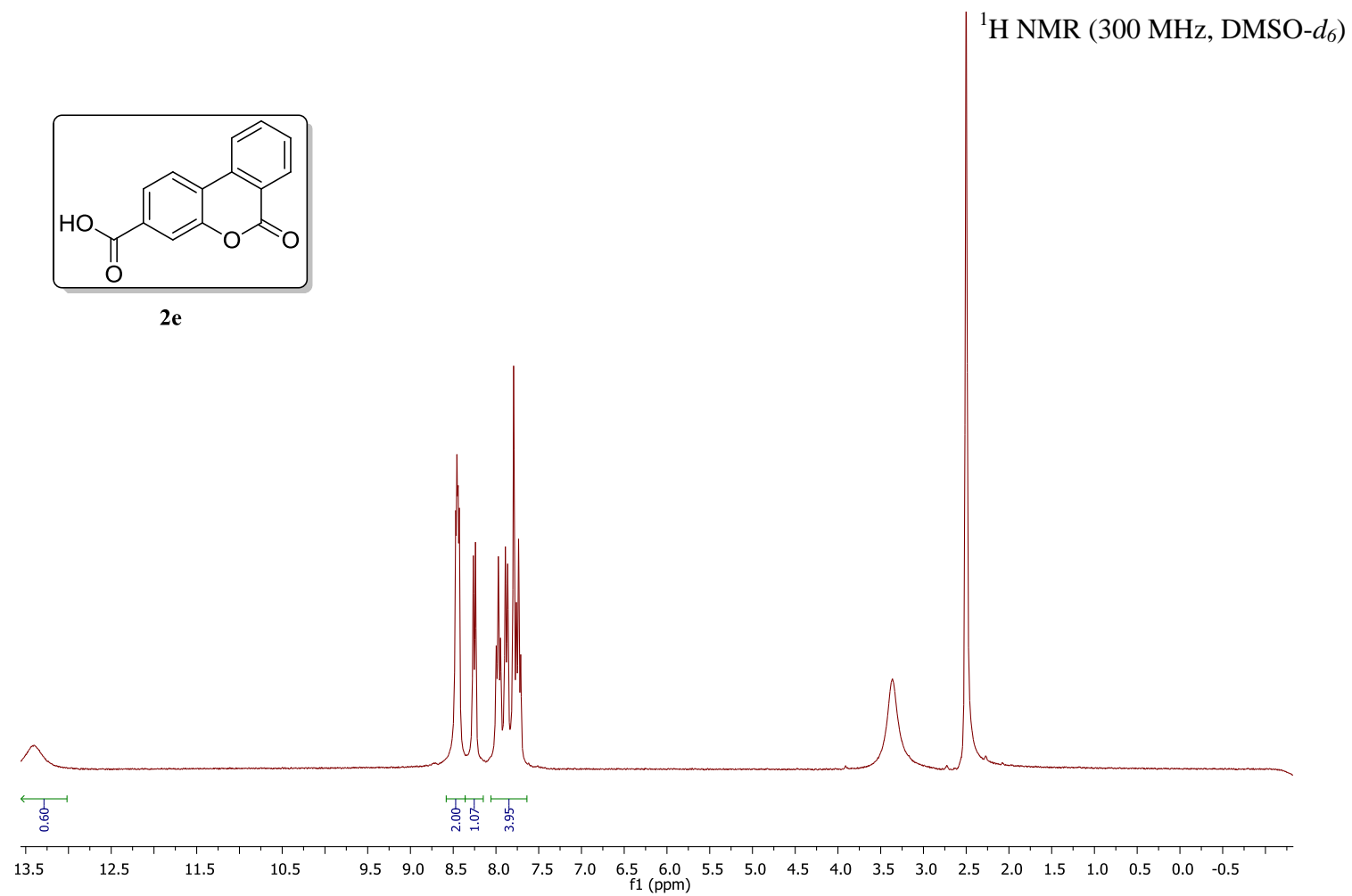


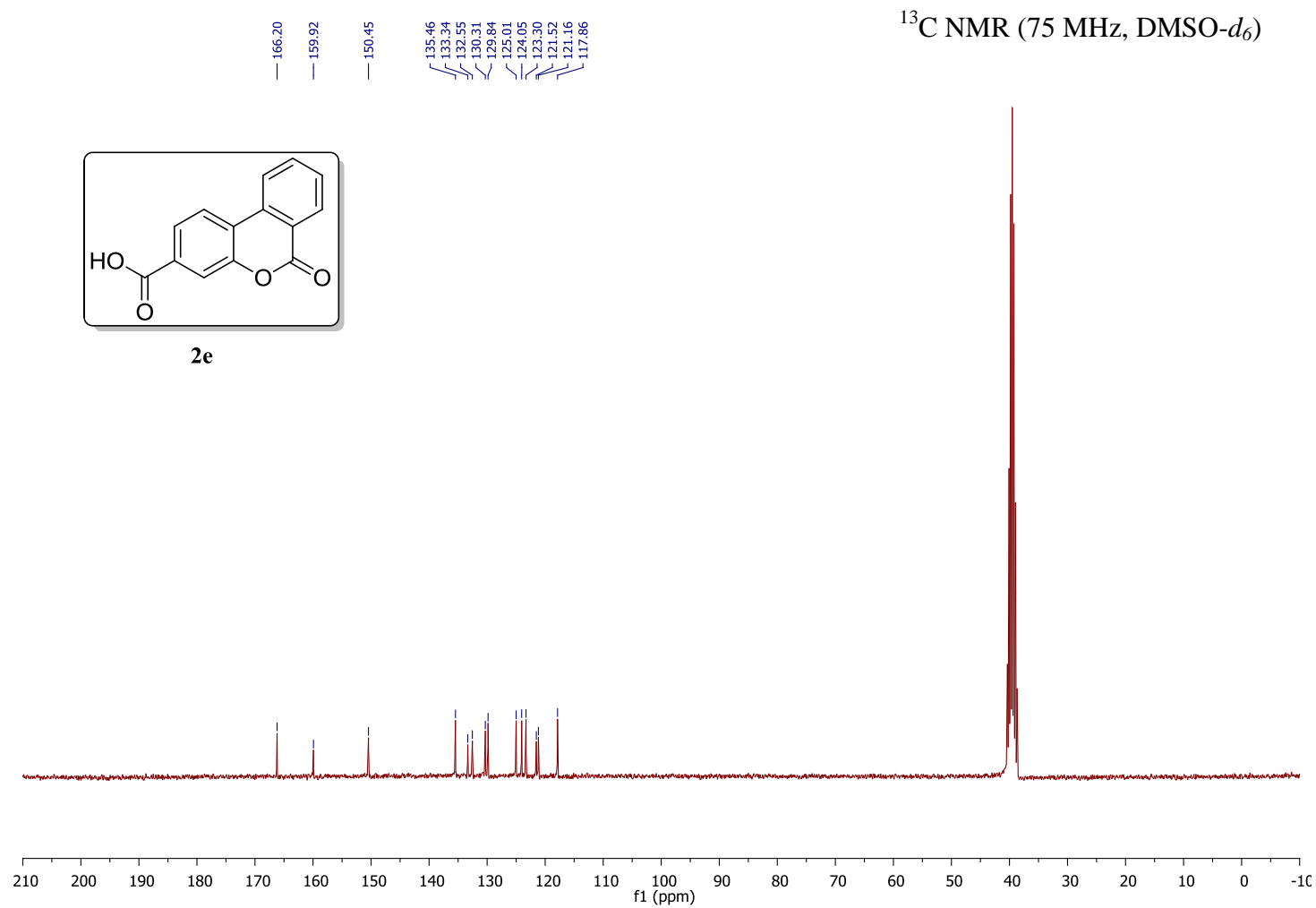


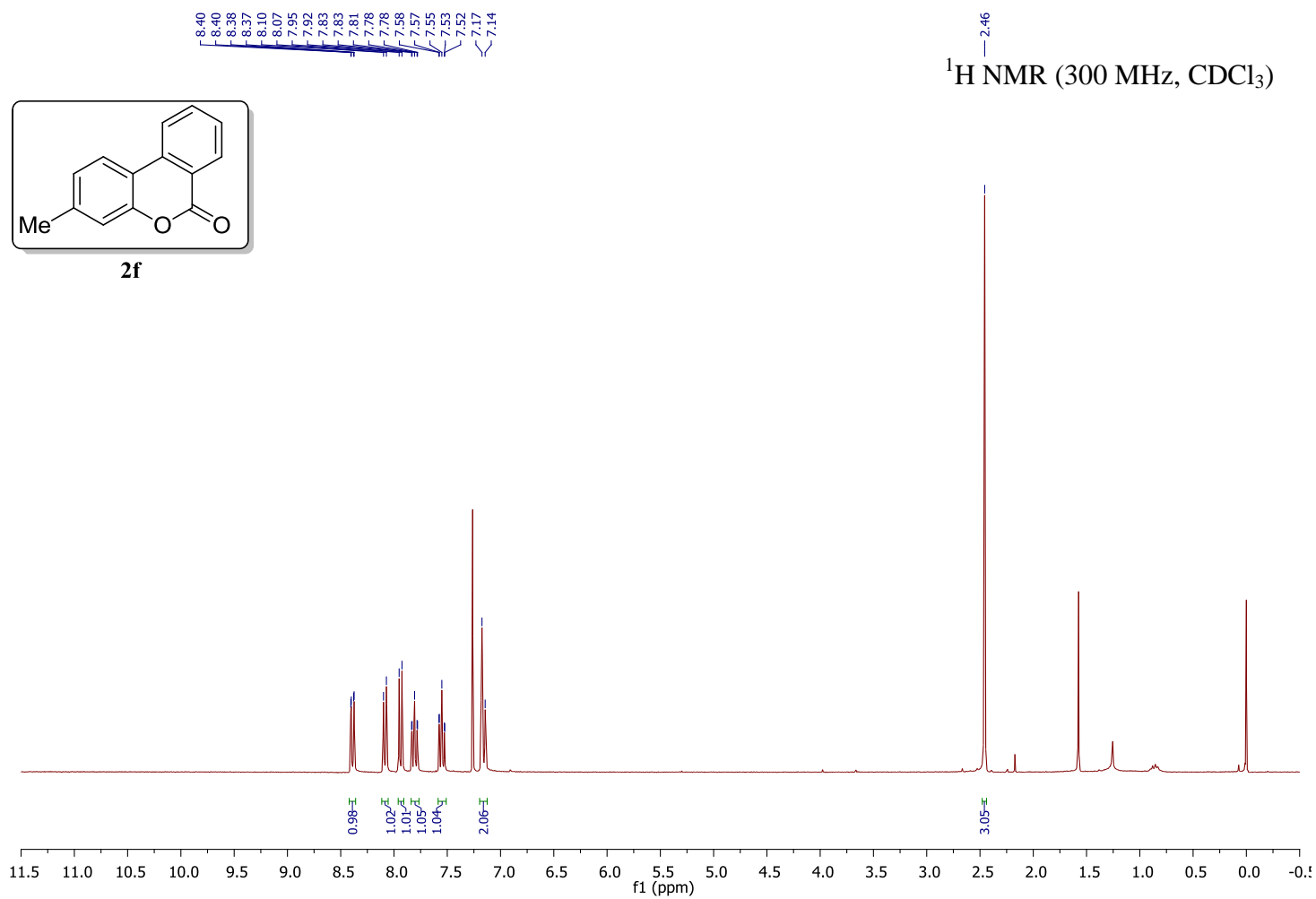


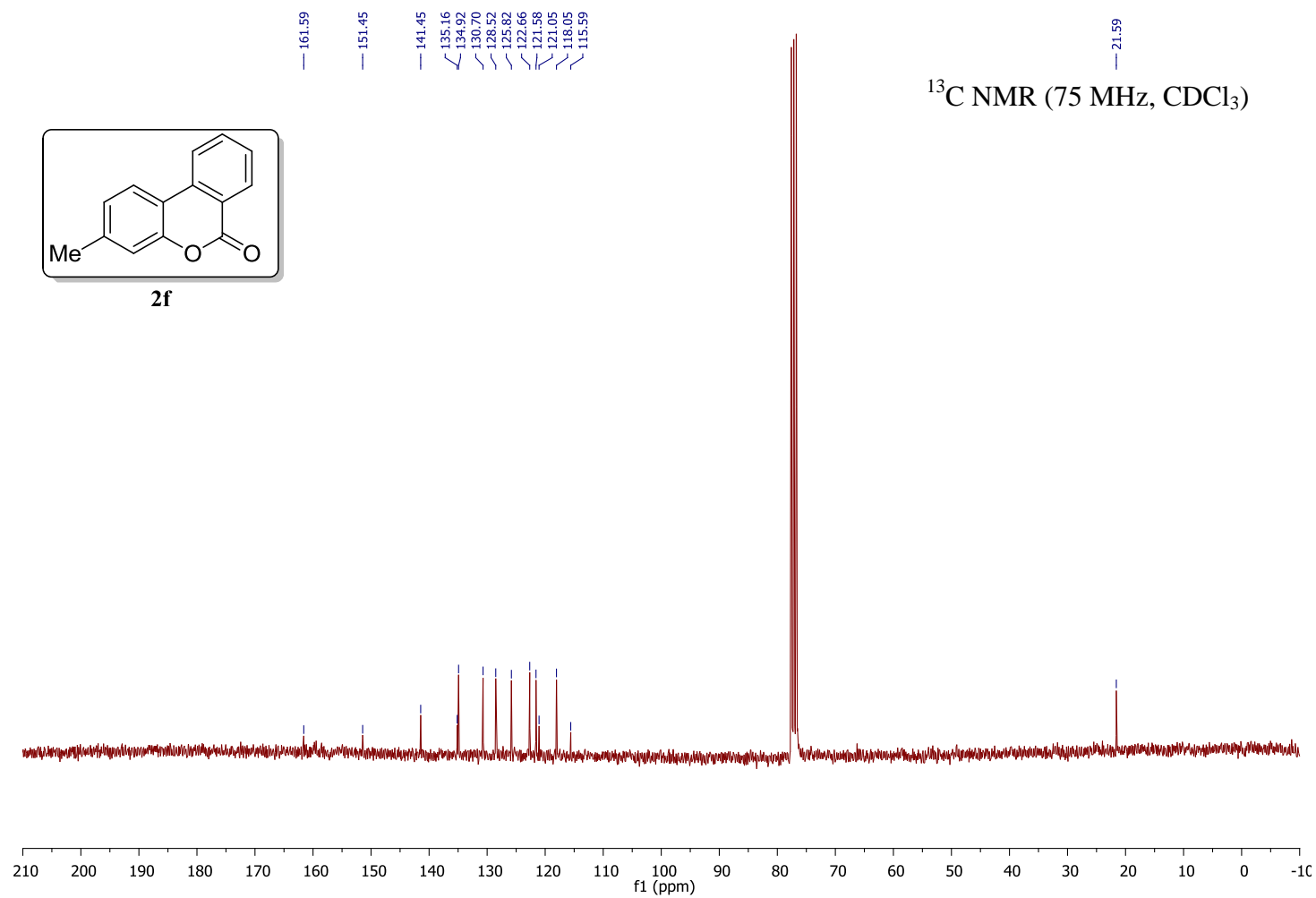


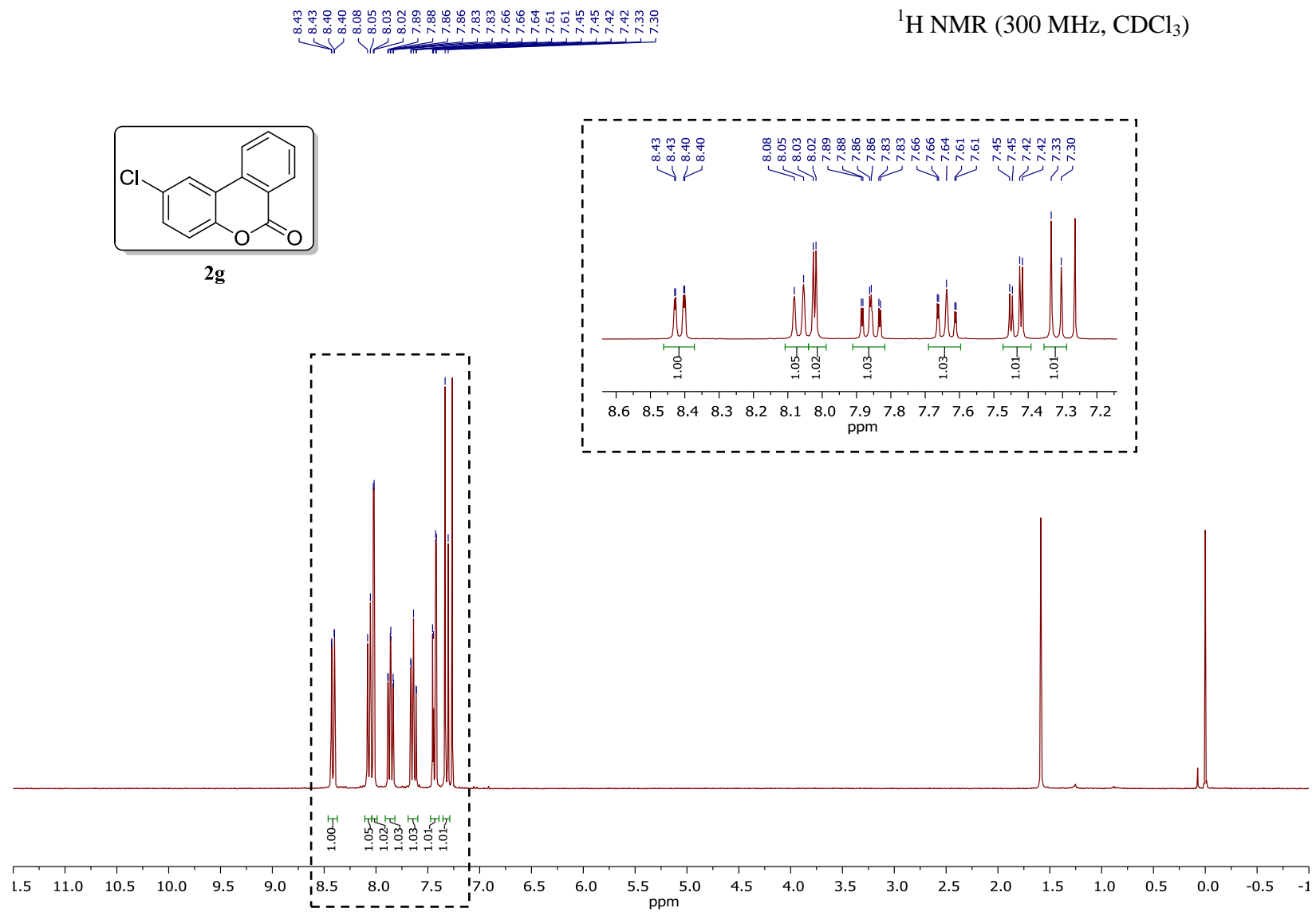
2e

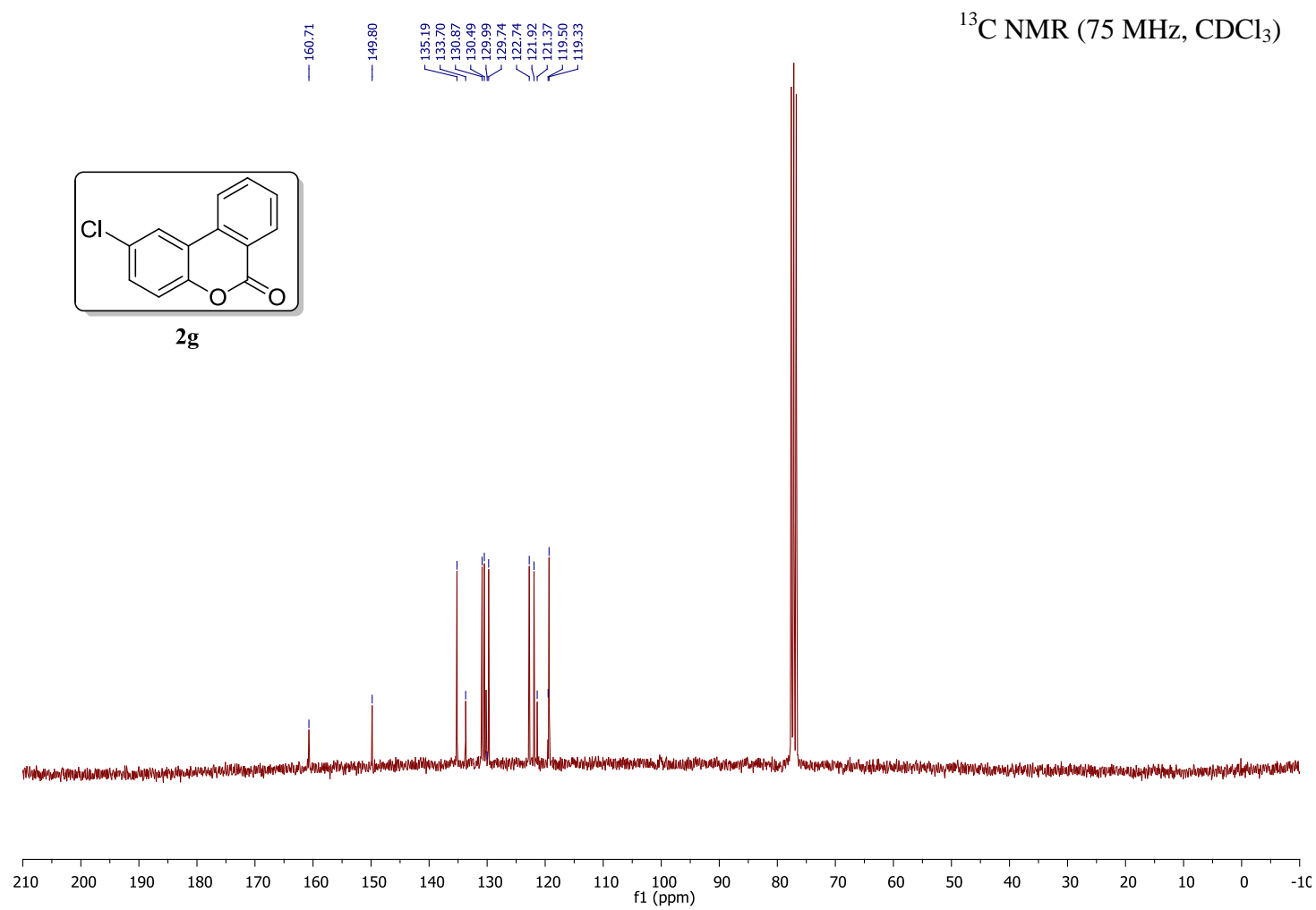


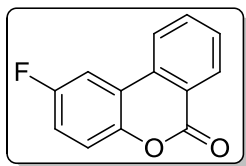




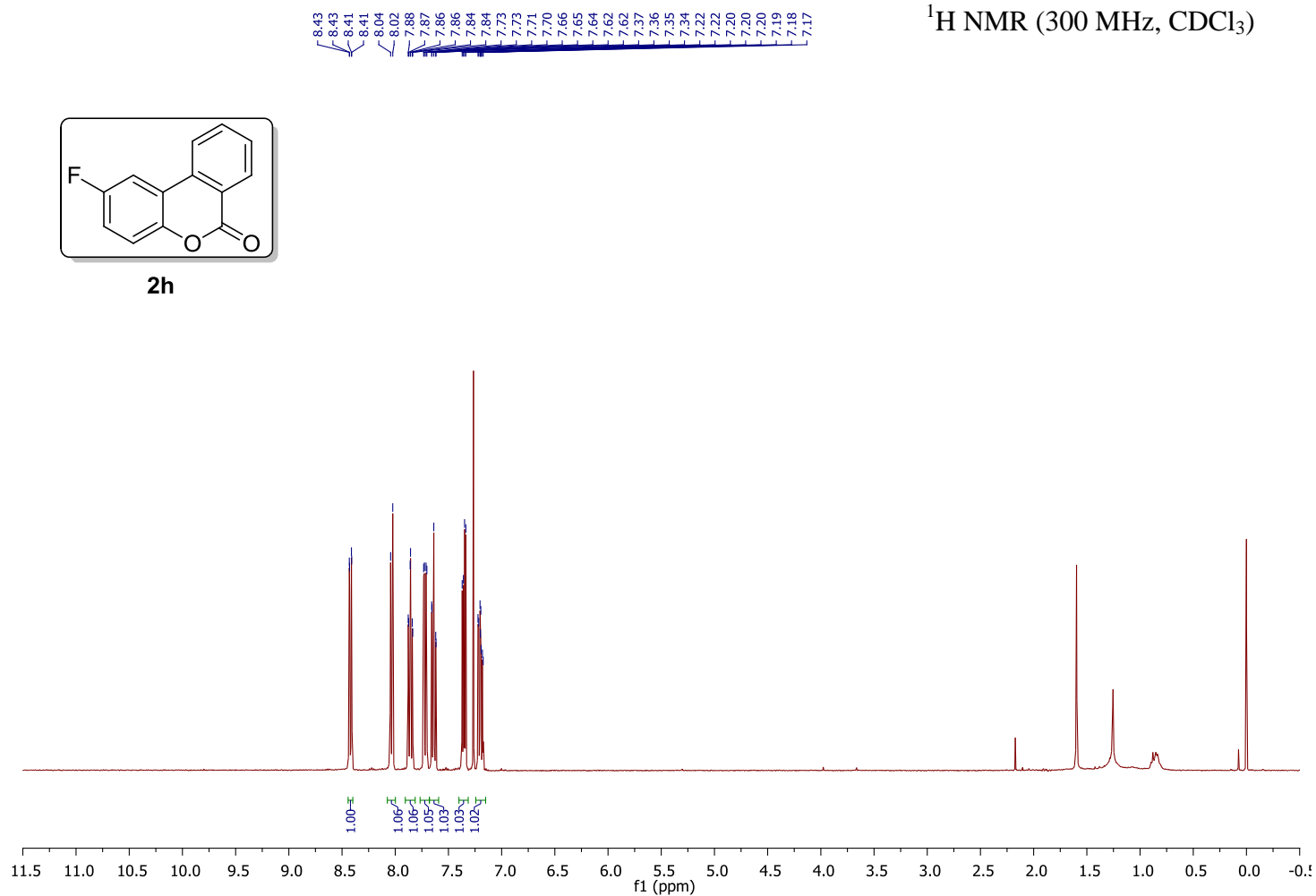




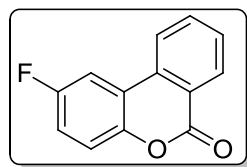




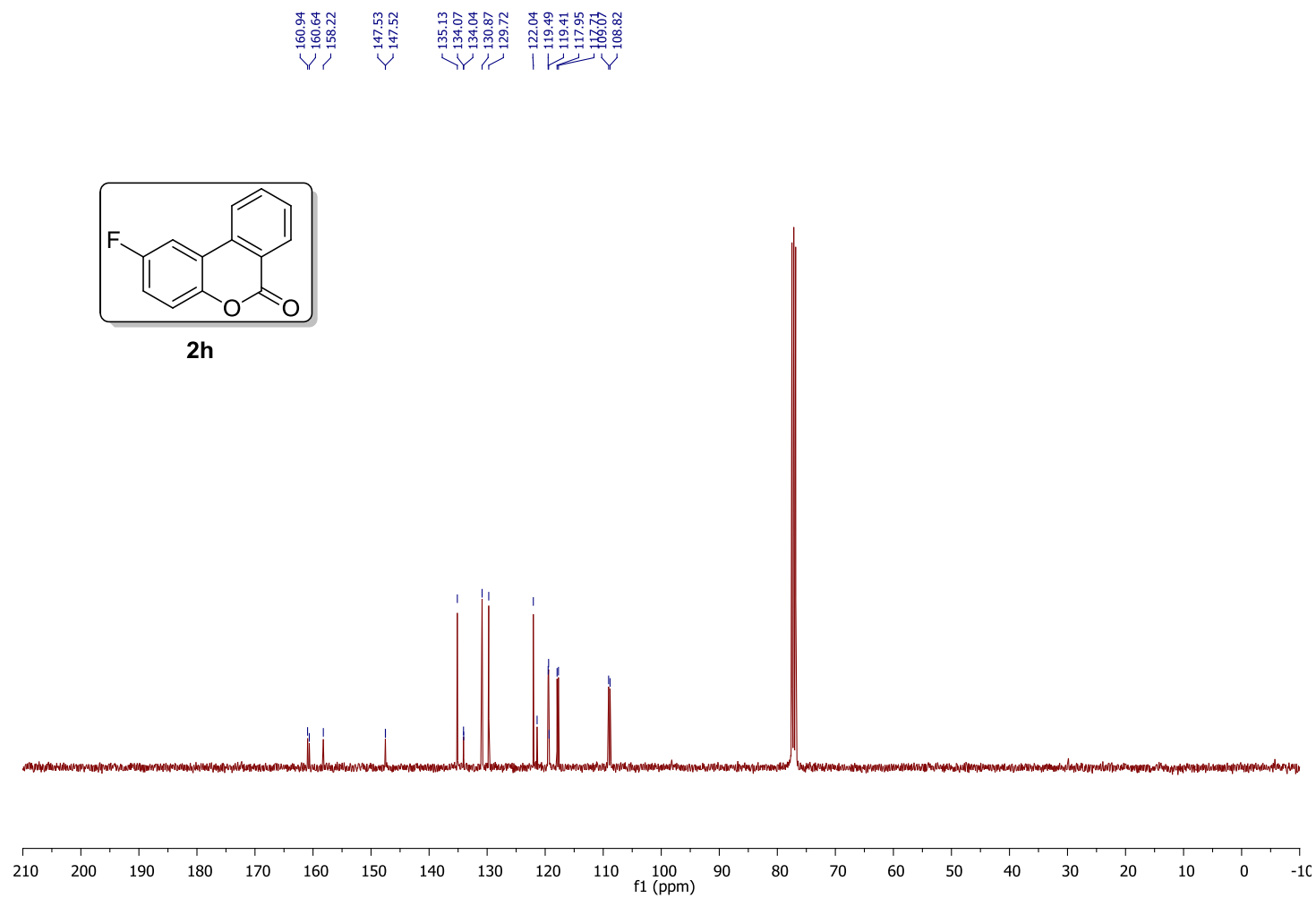
2h

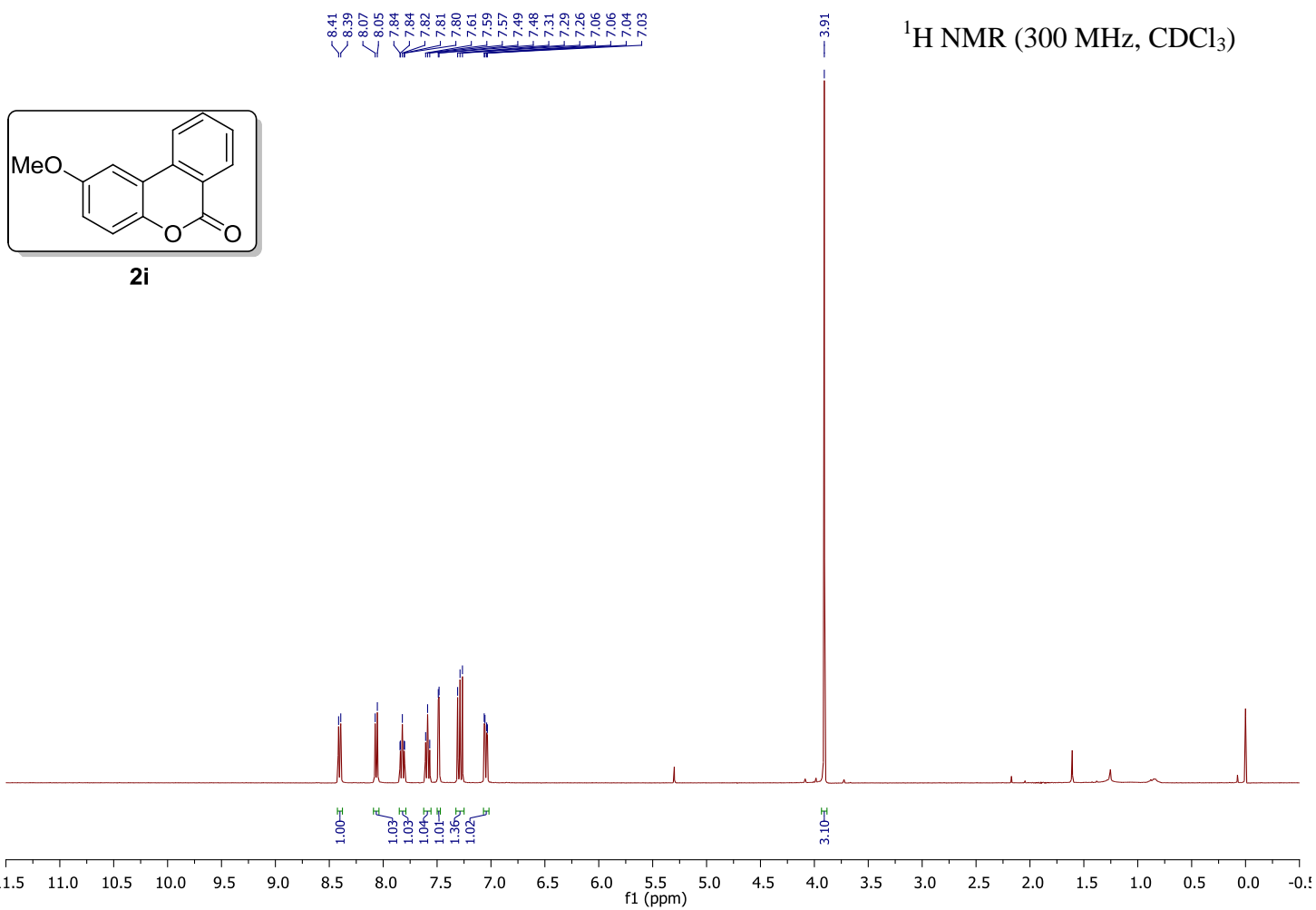


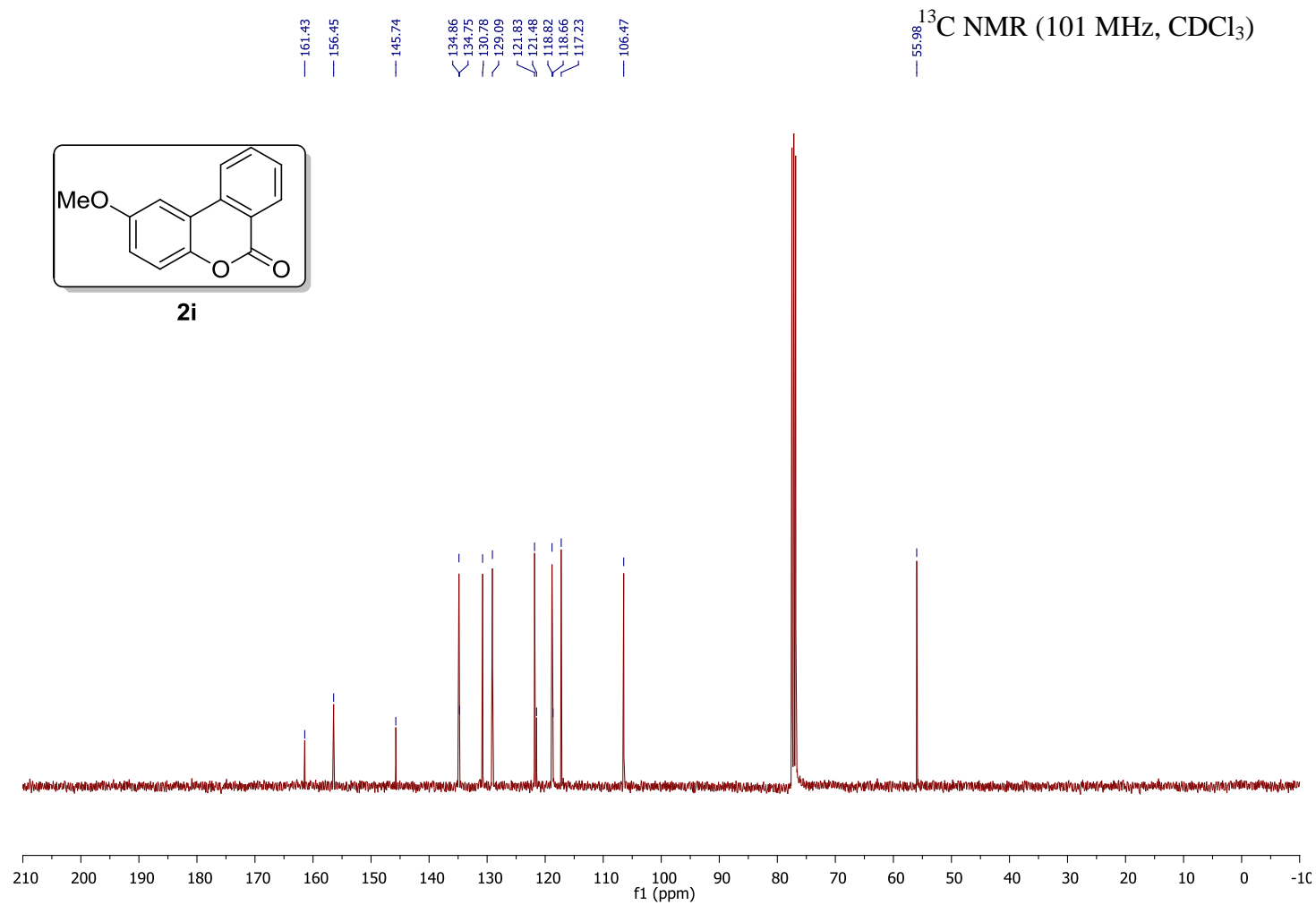
¹³C NMR (101 MHz, CDCl₃)

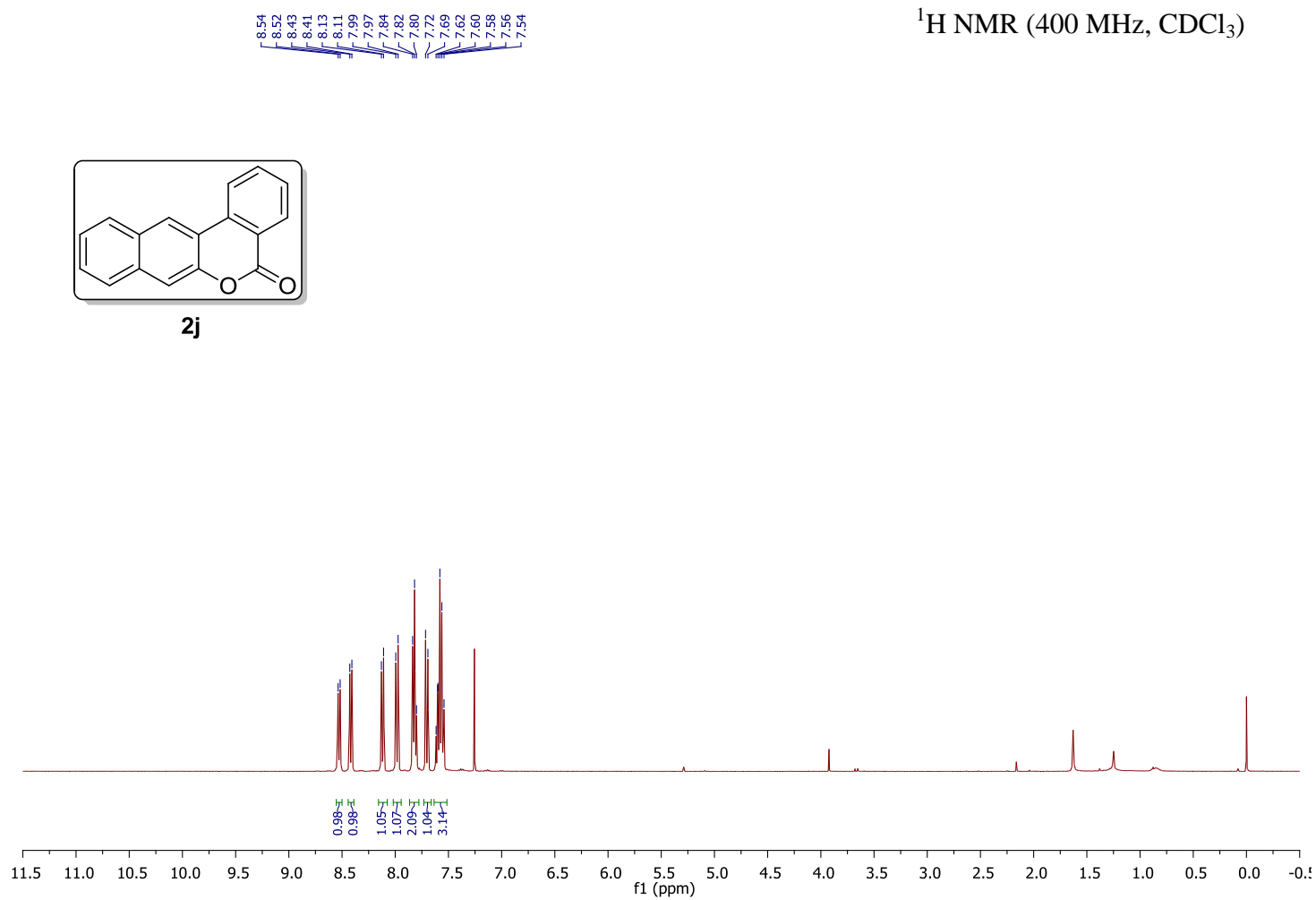


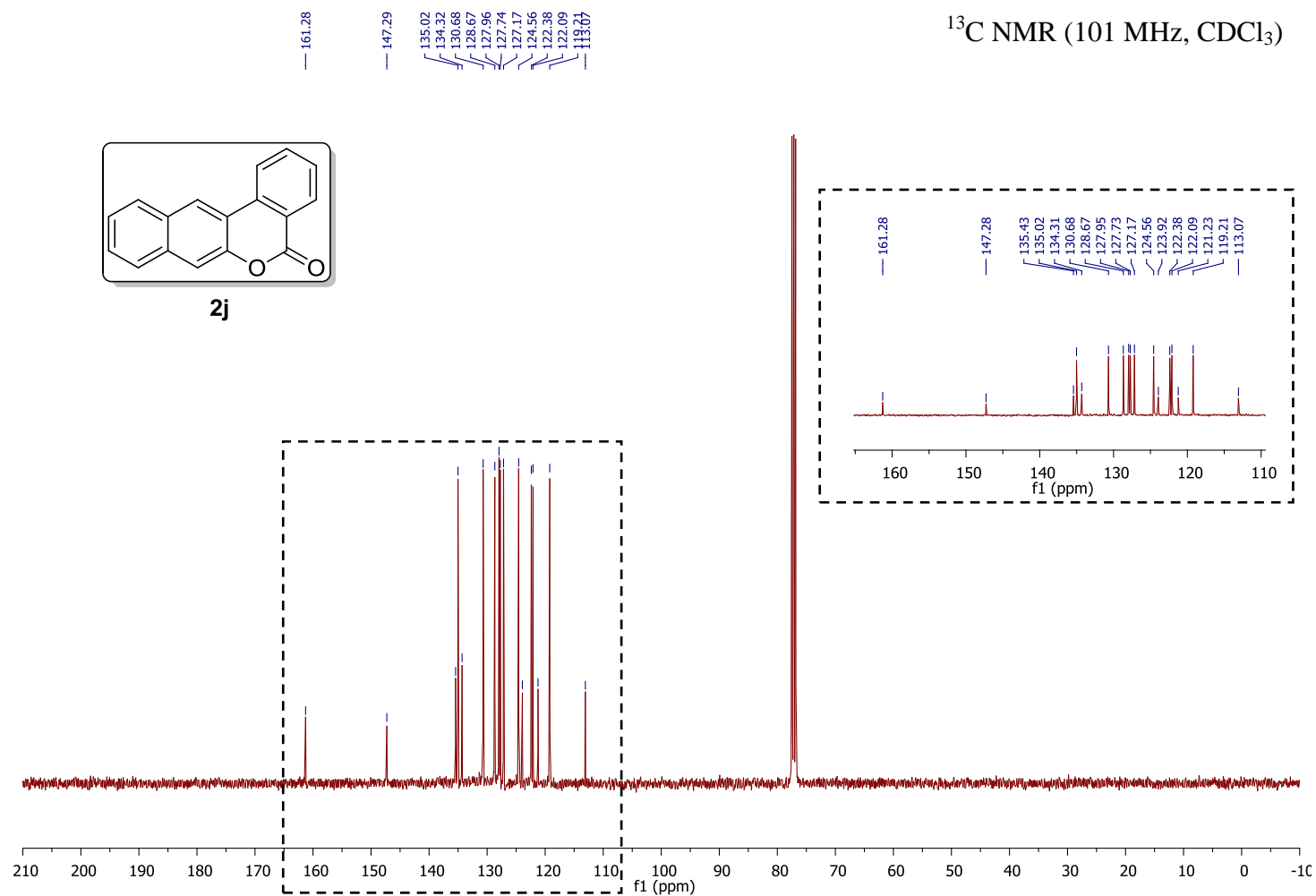
2h

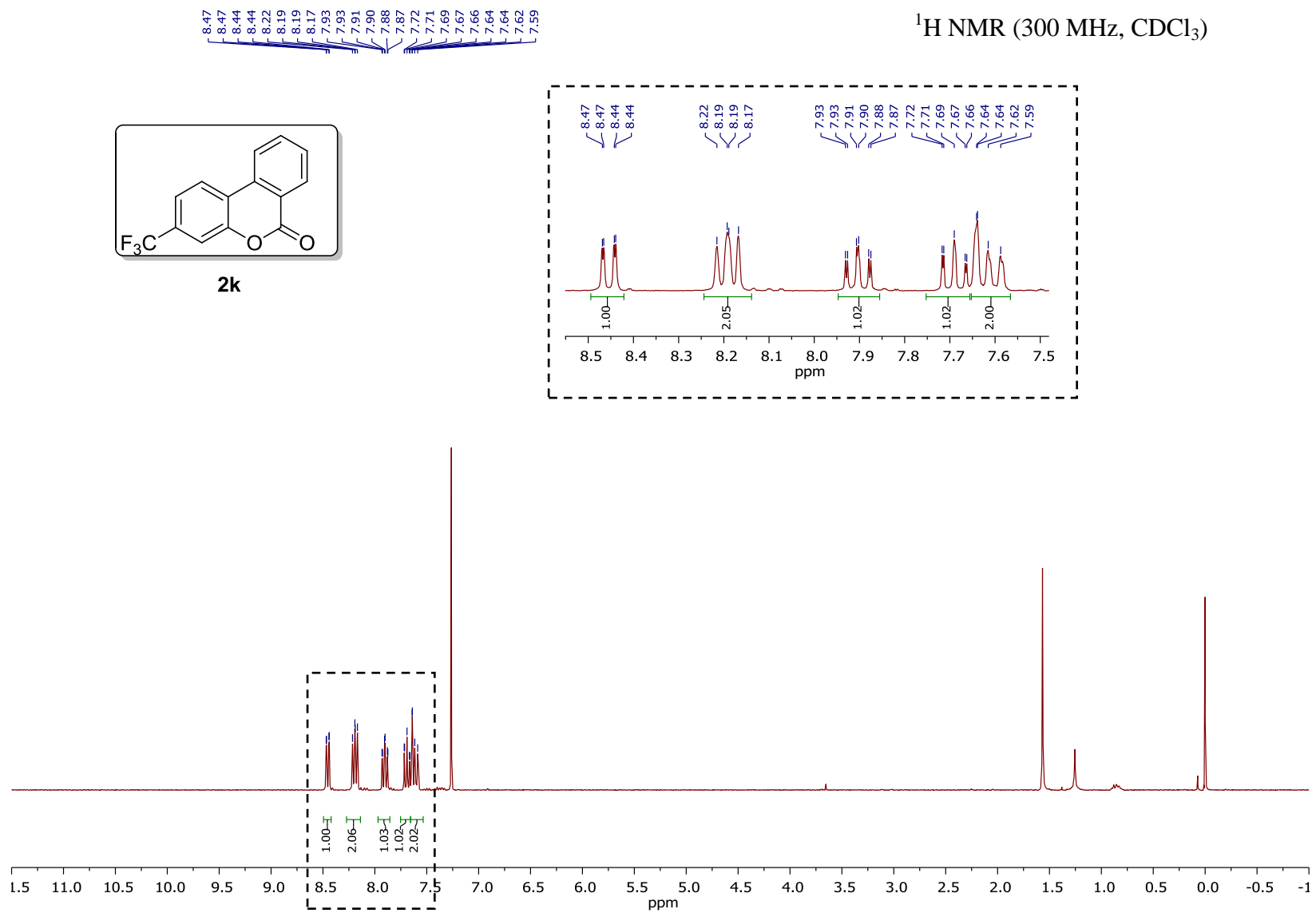


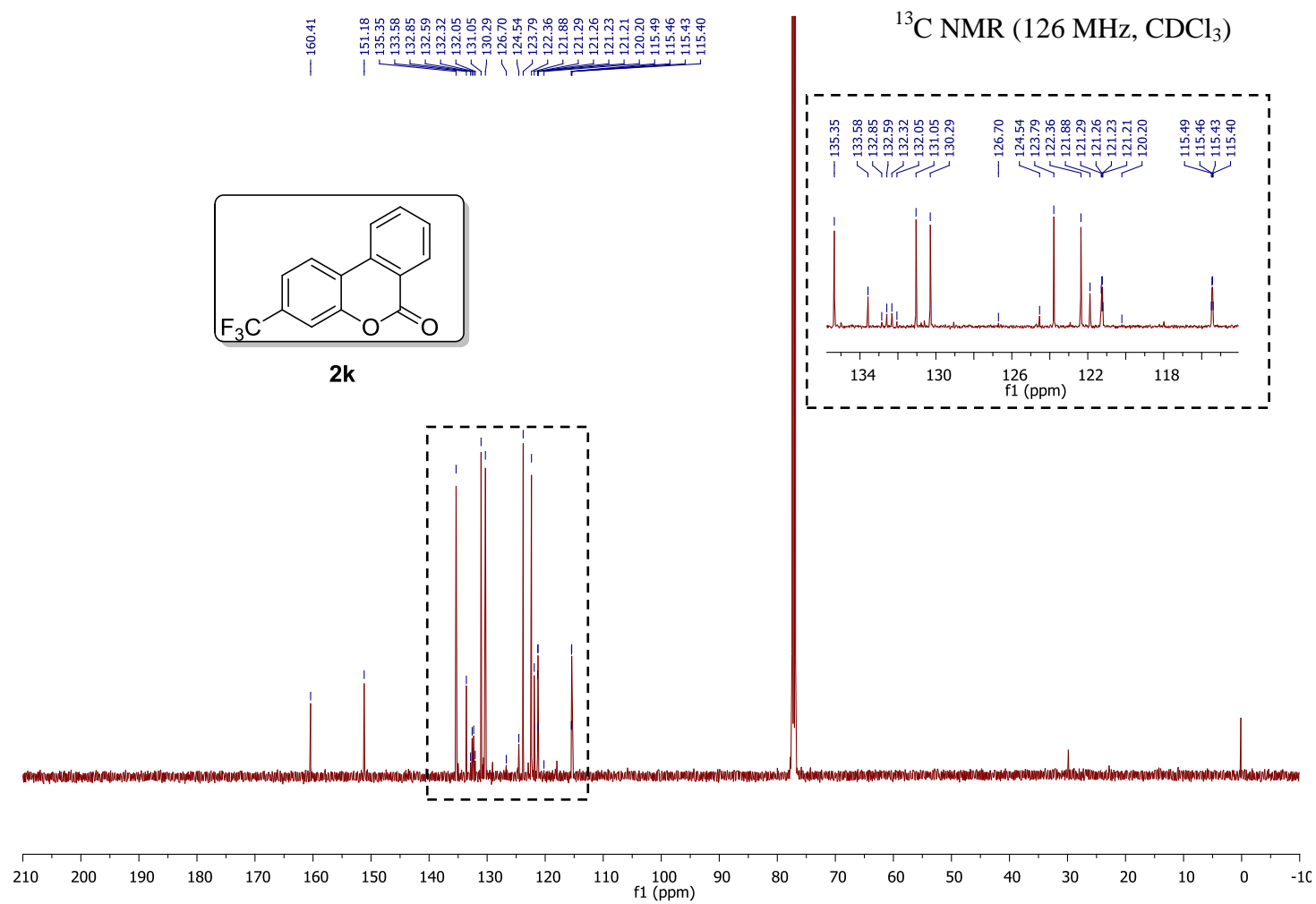


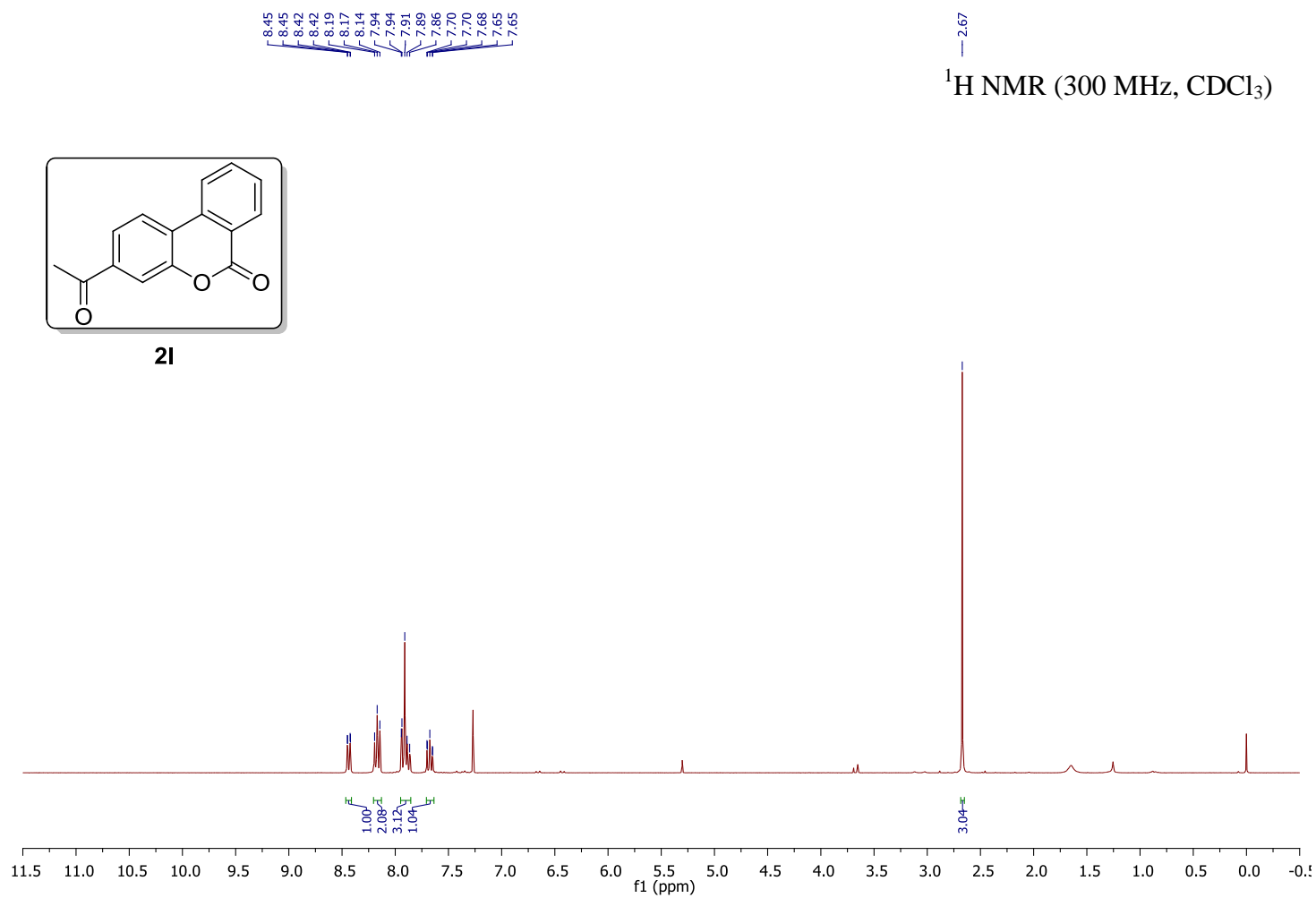


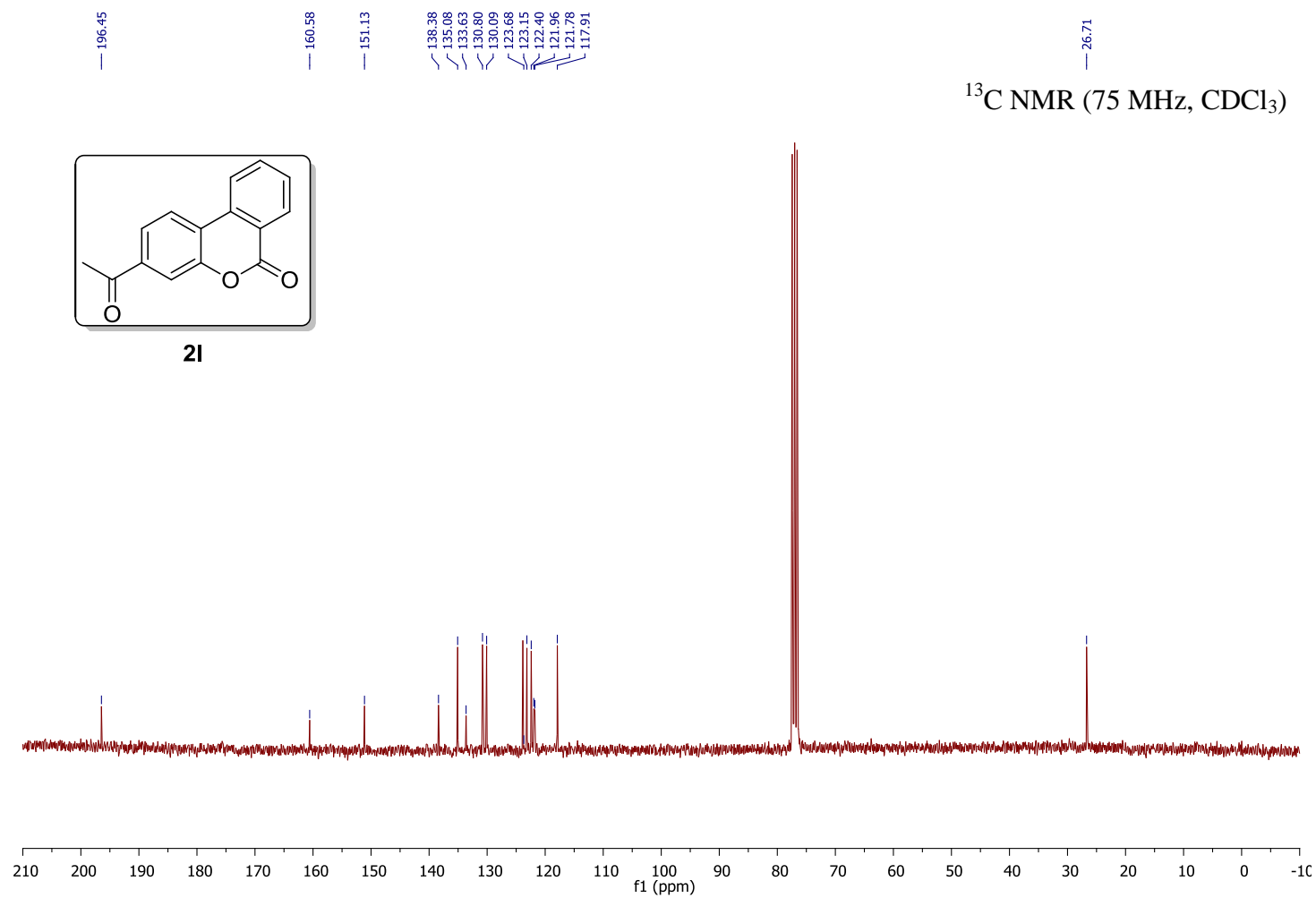


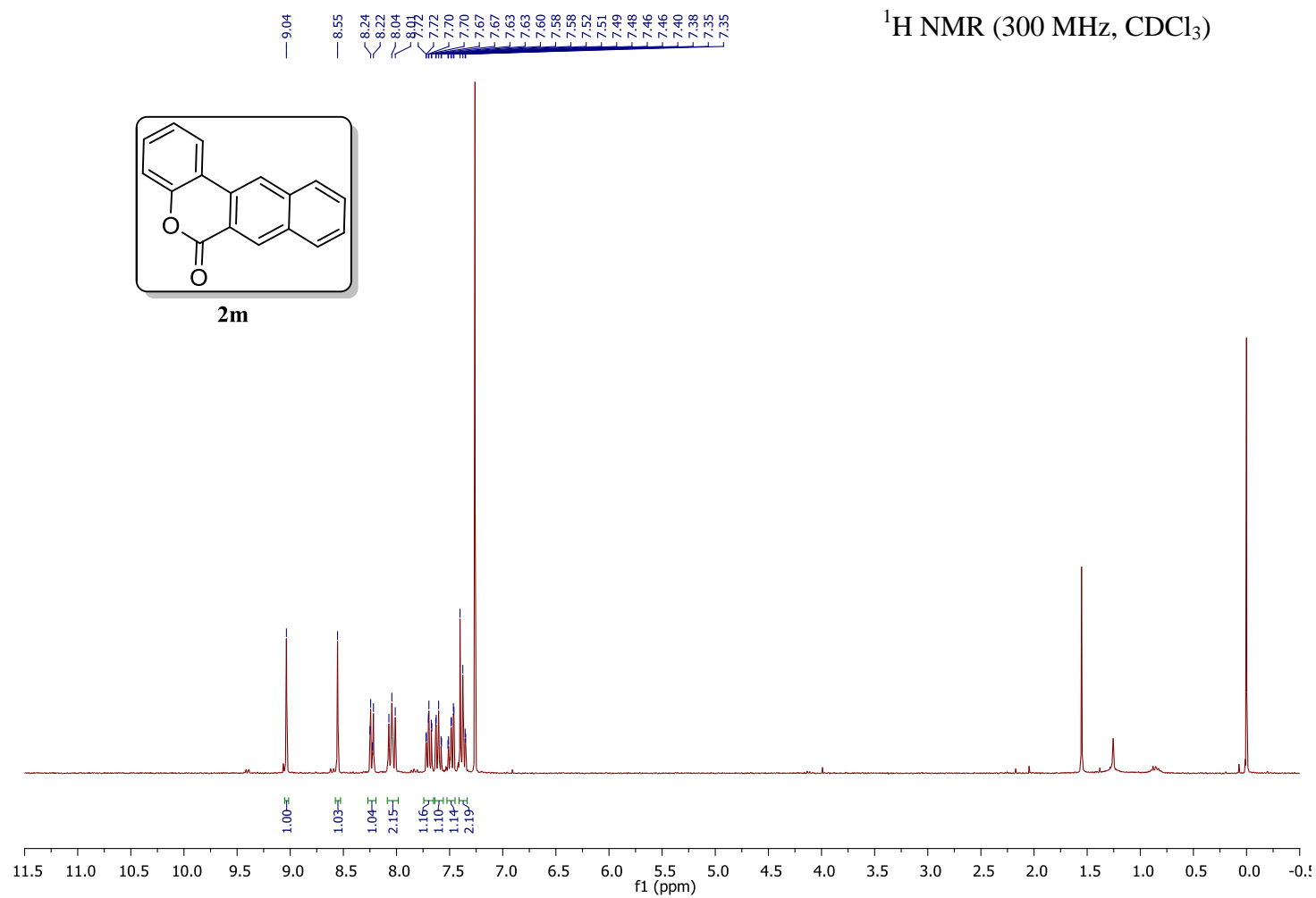


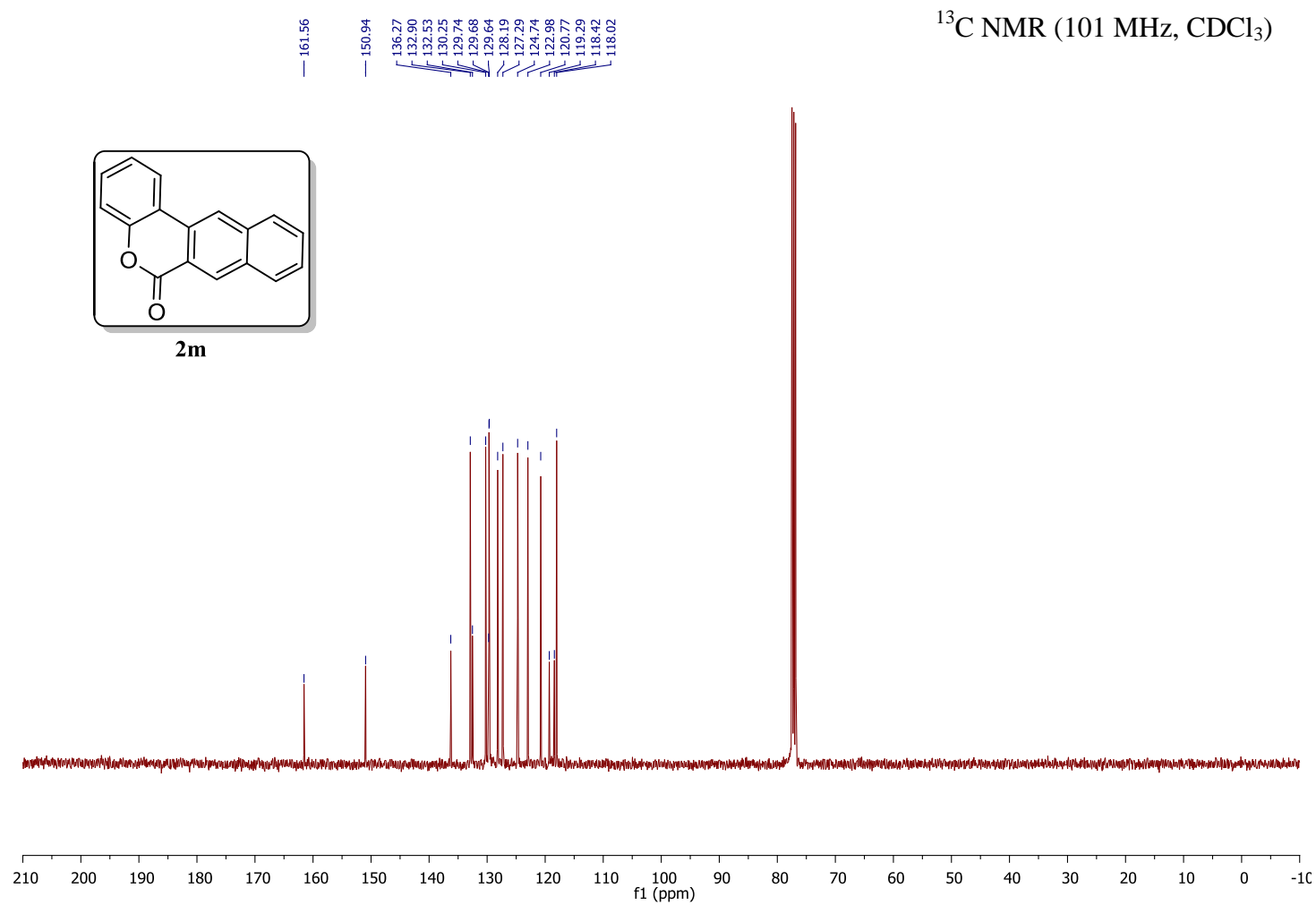


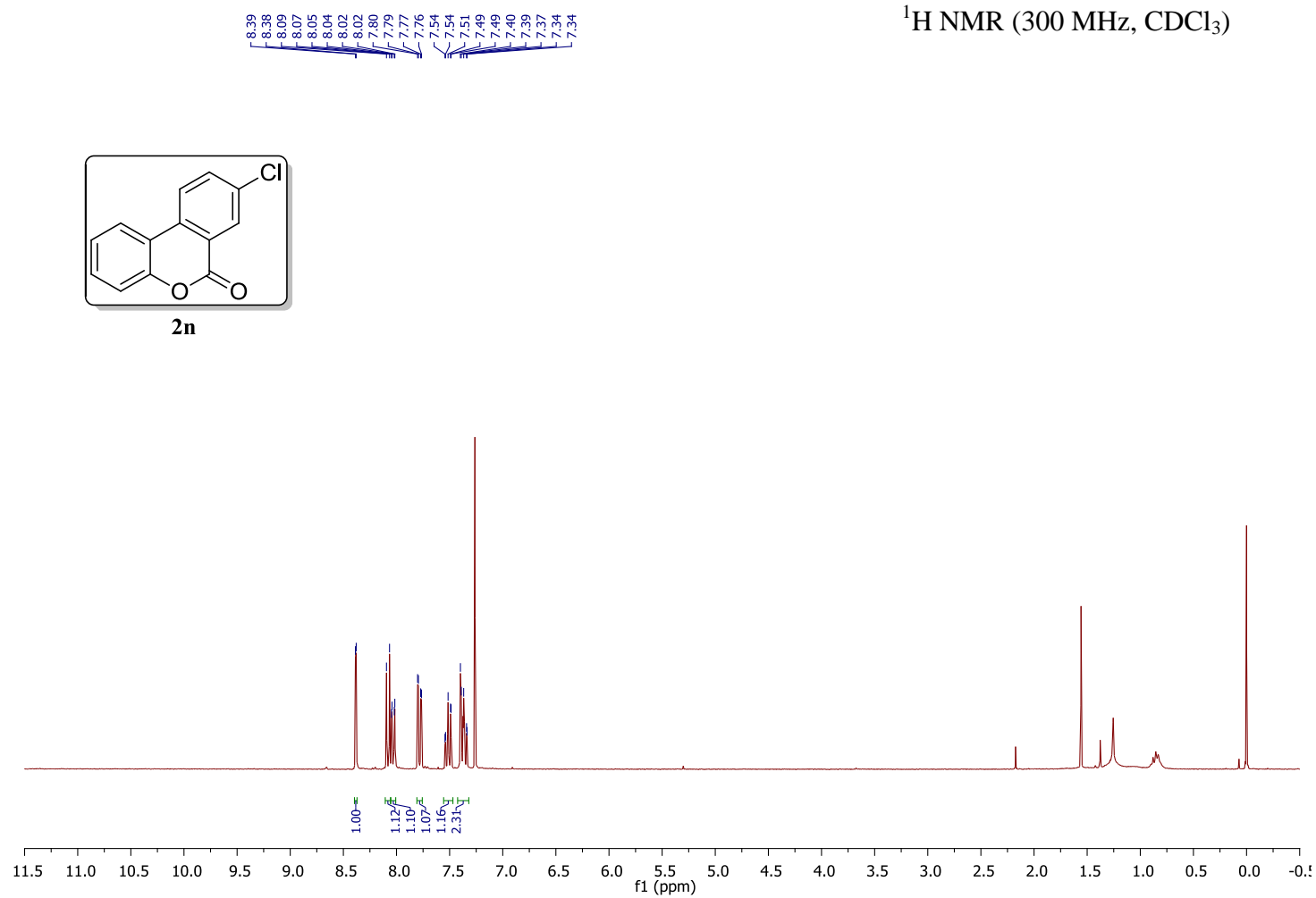


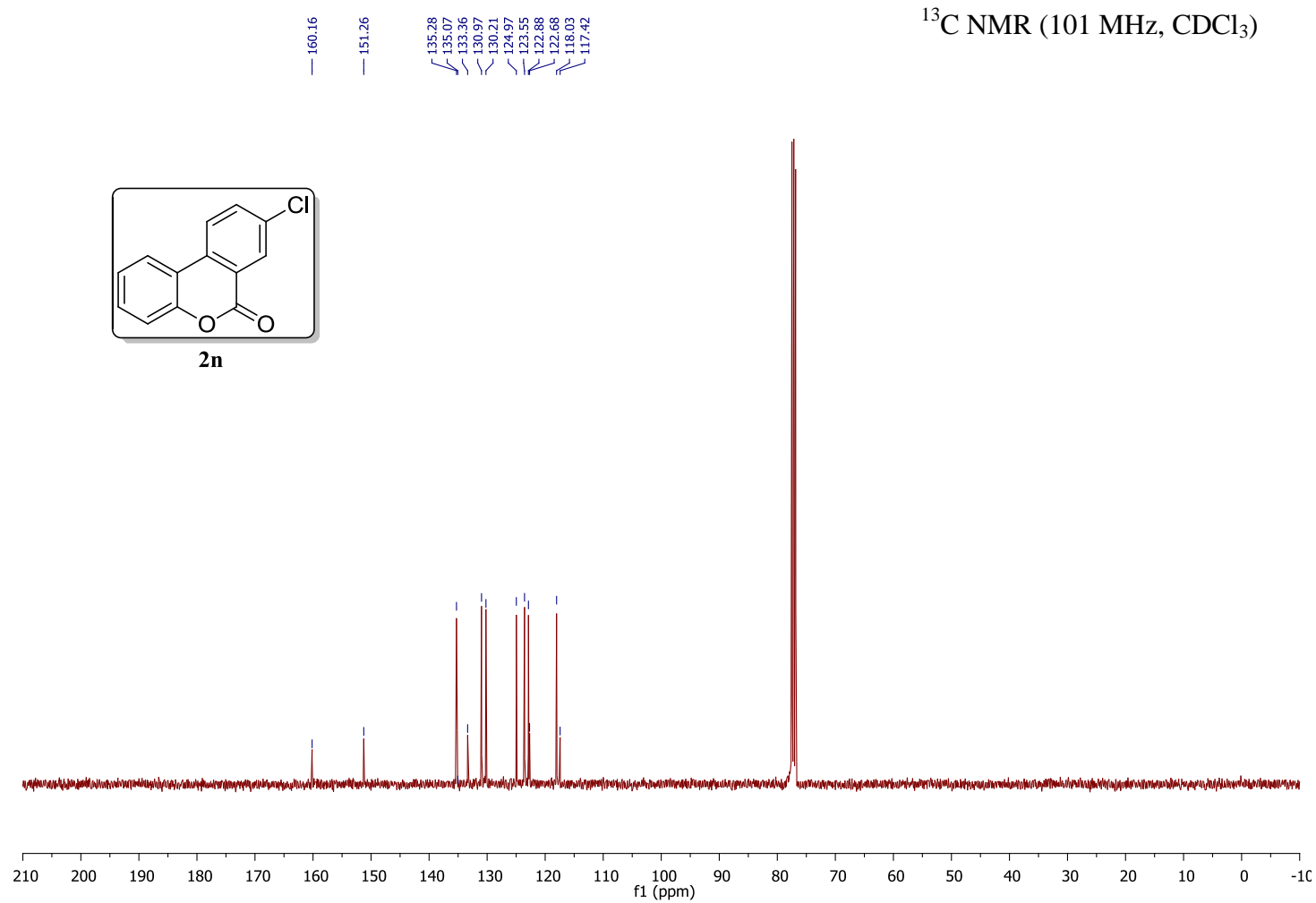


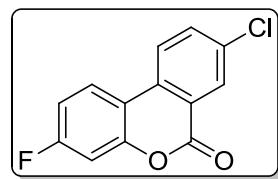








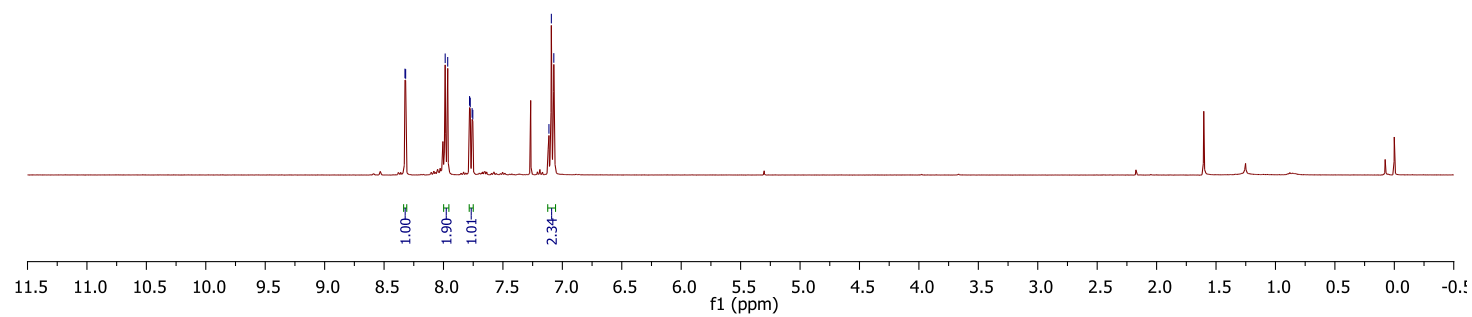


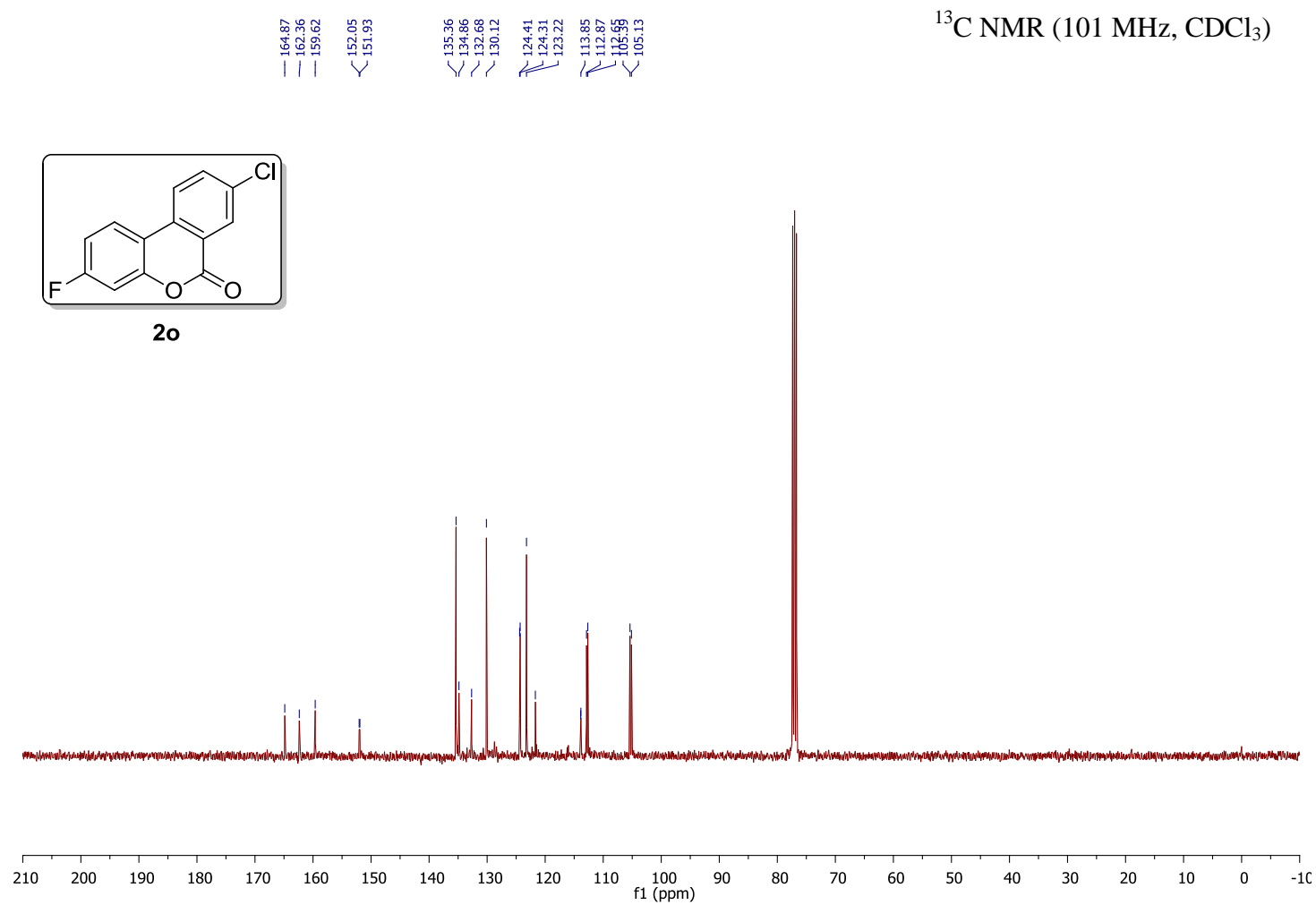


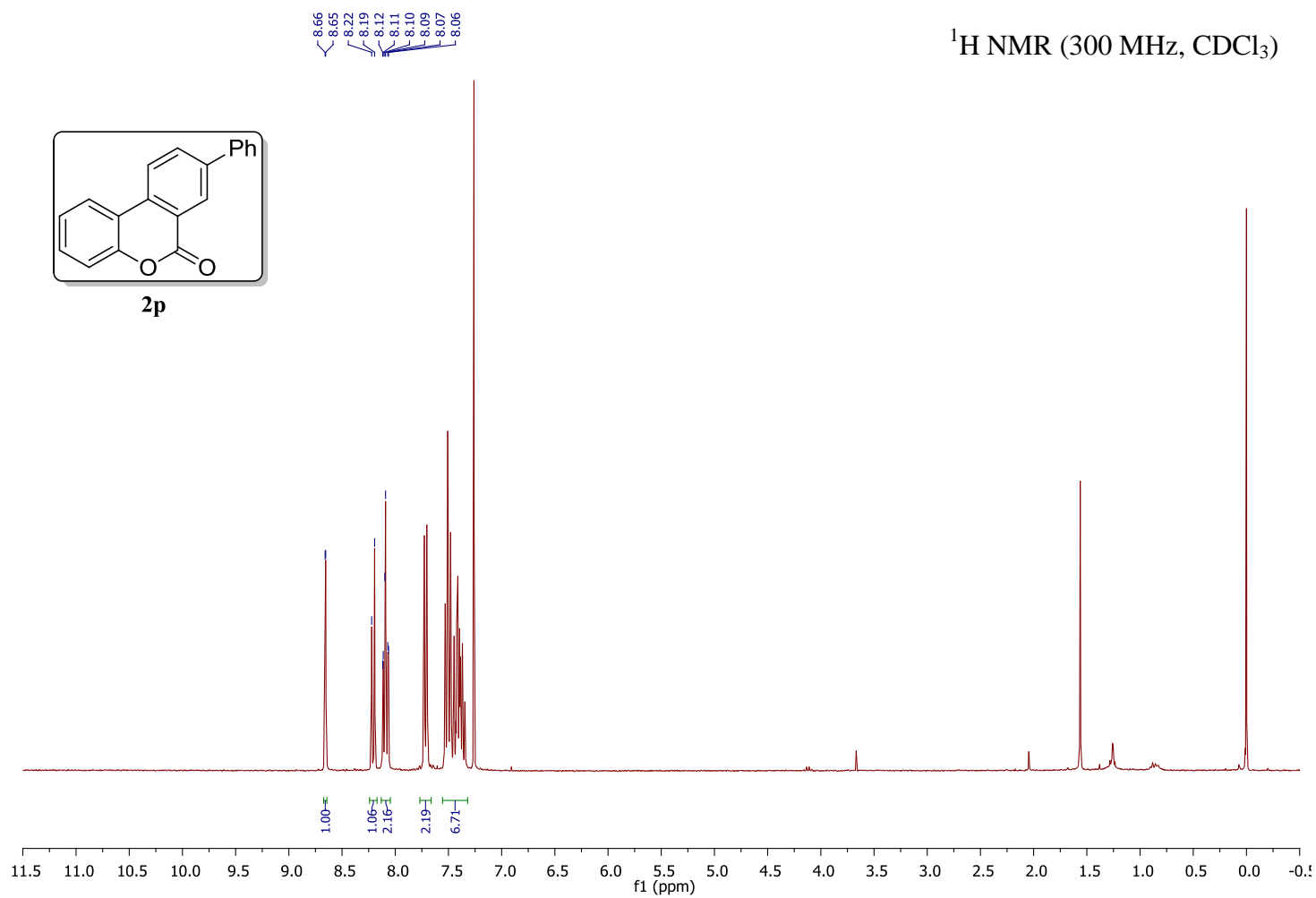
2o

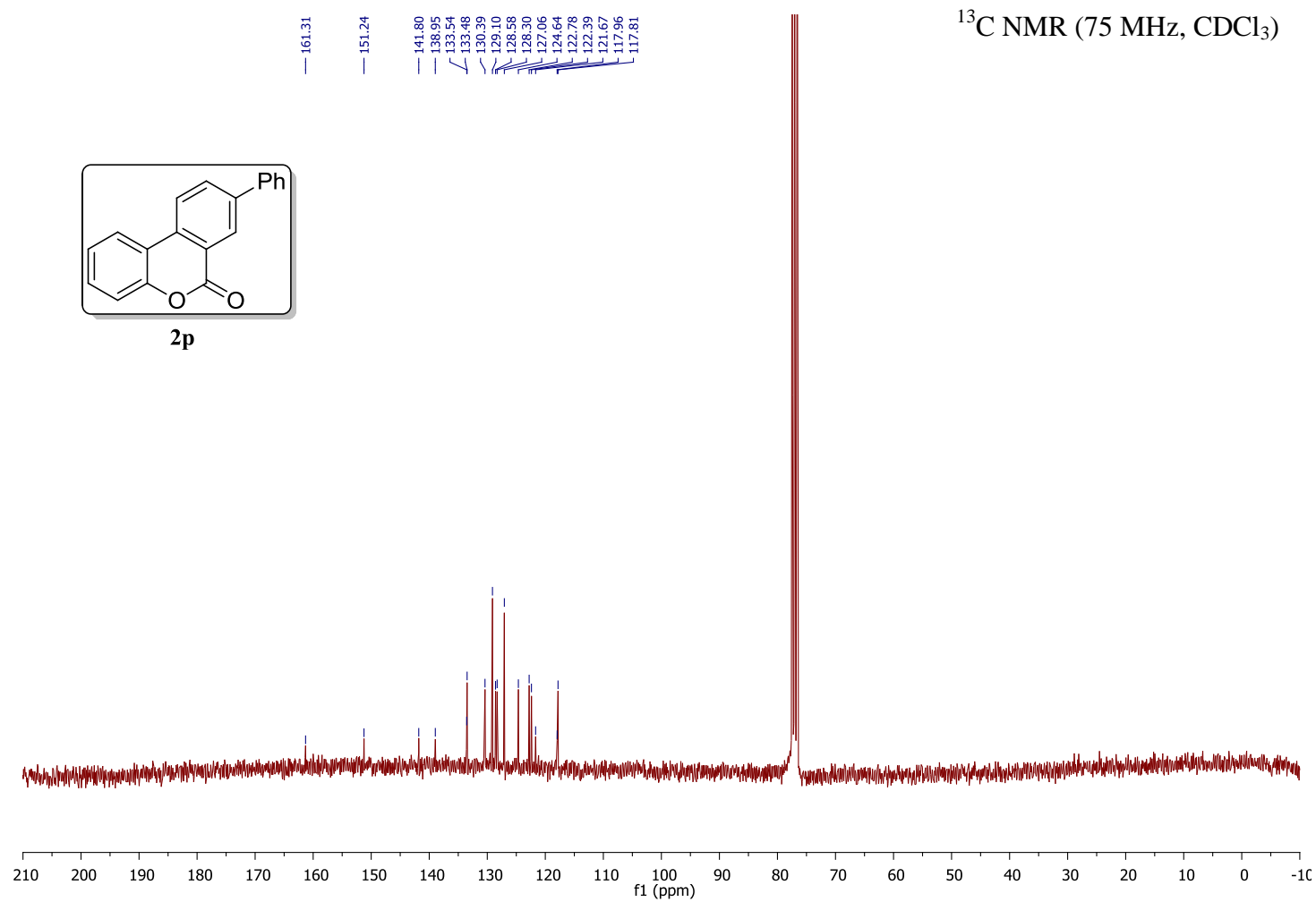
^1H NMR (400 MHz, CDCl_3)

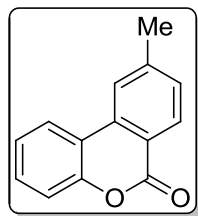
8.32
8.32
7.99
7.96
7.78
7.77
7.76
7.75
7.11
7.09
7.07



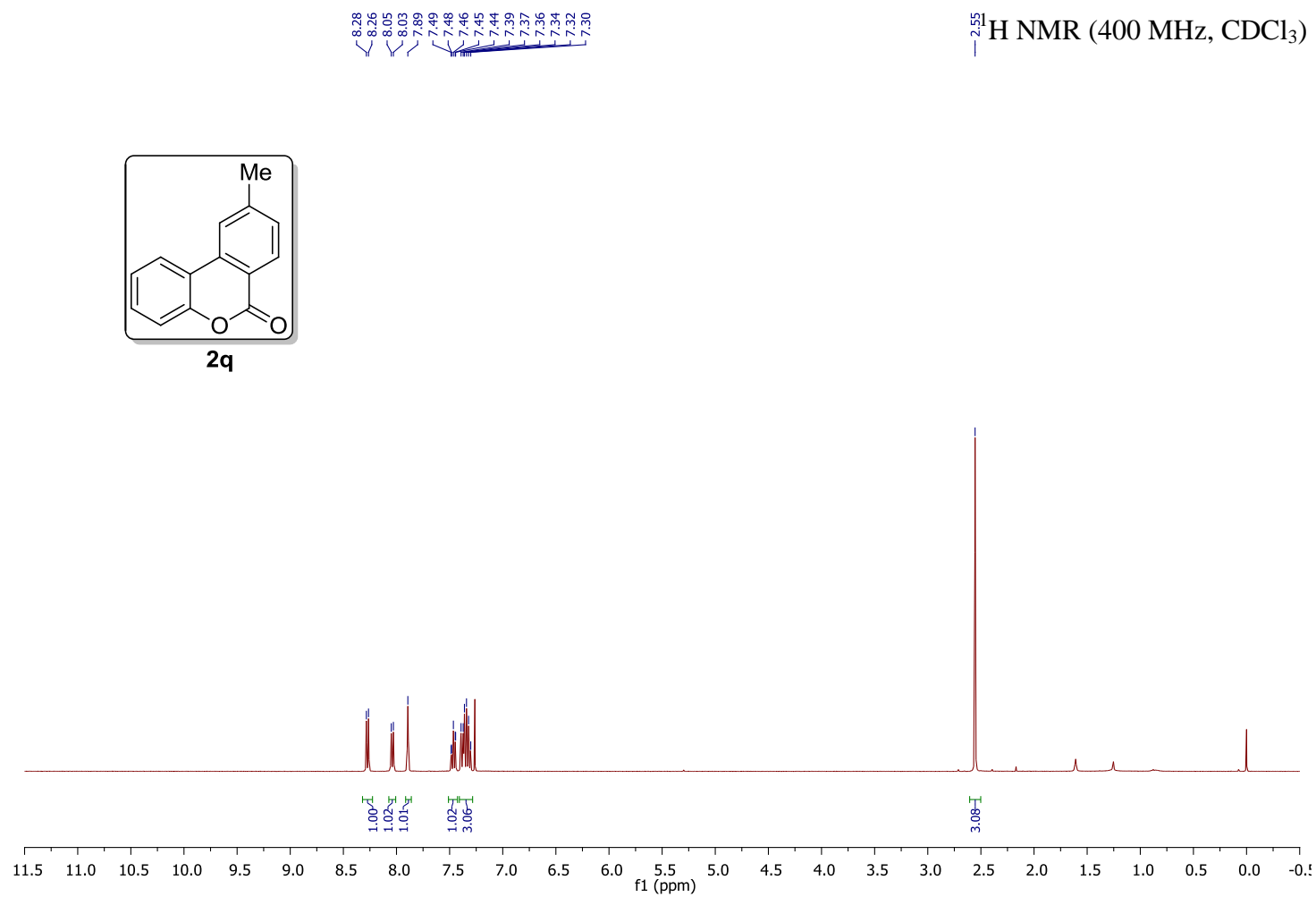


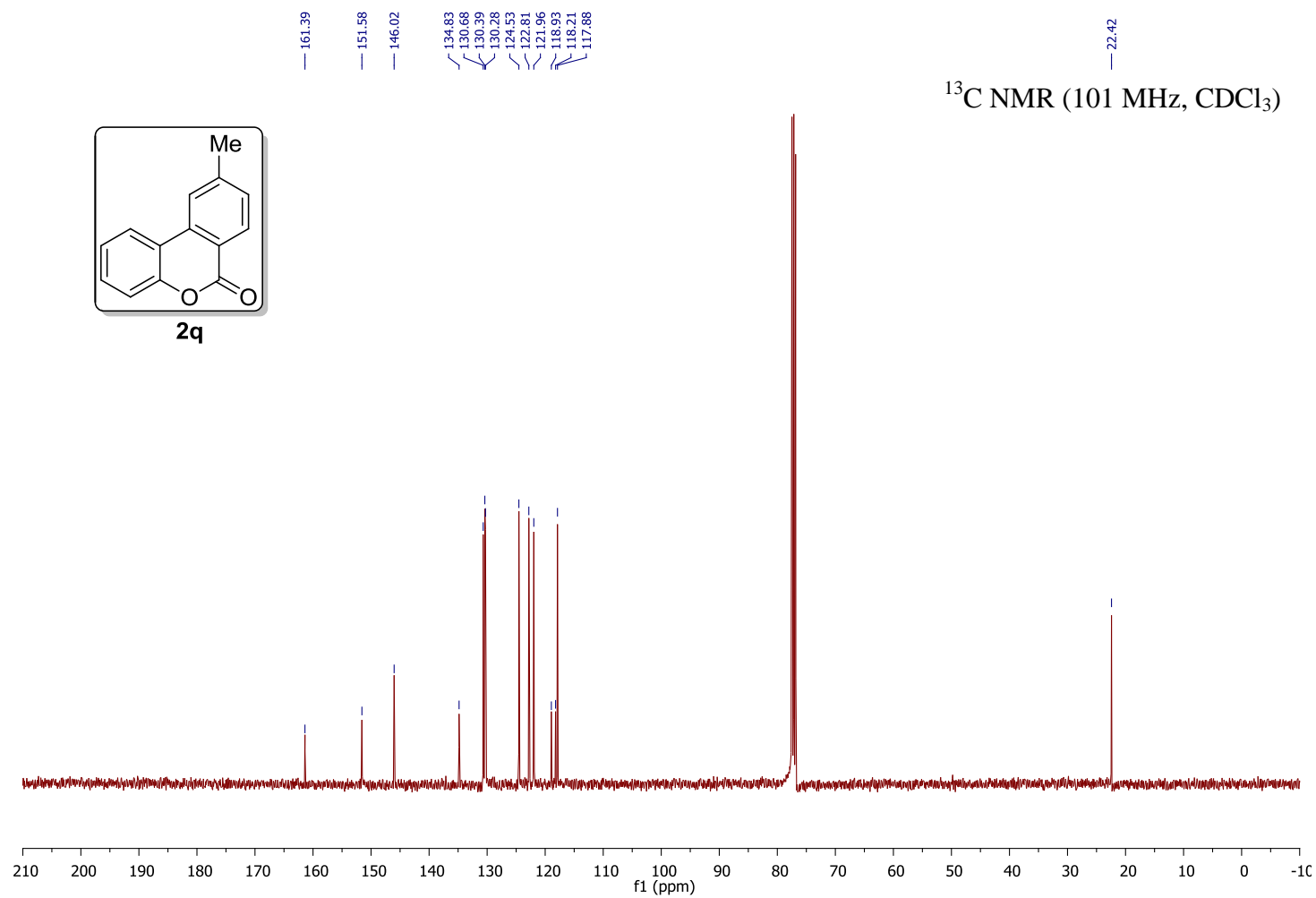


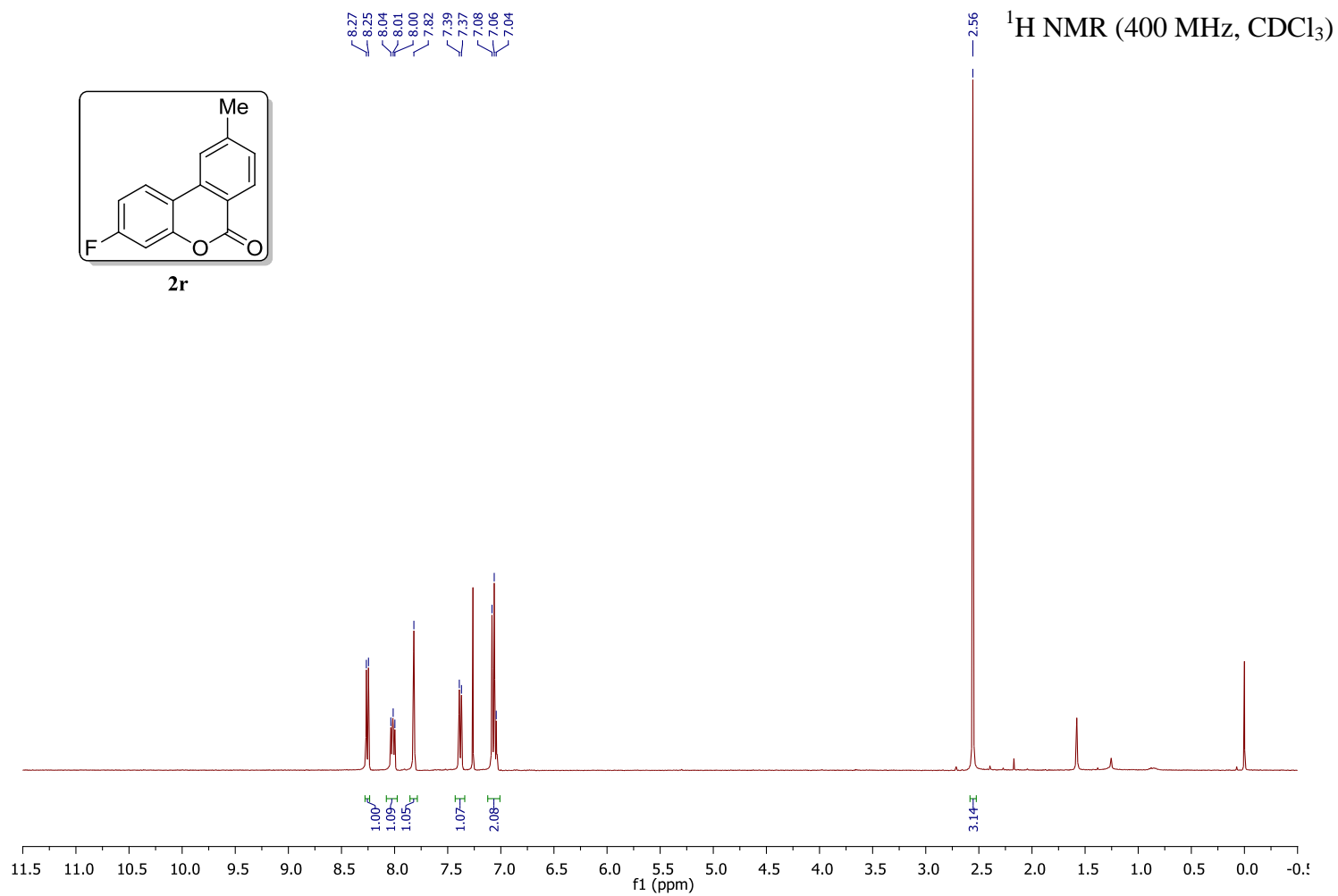


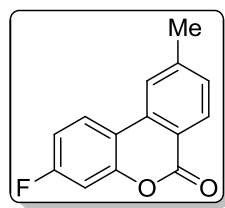


2q





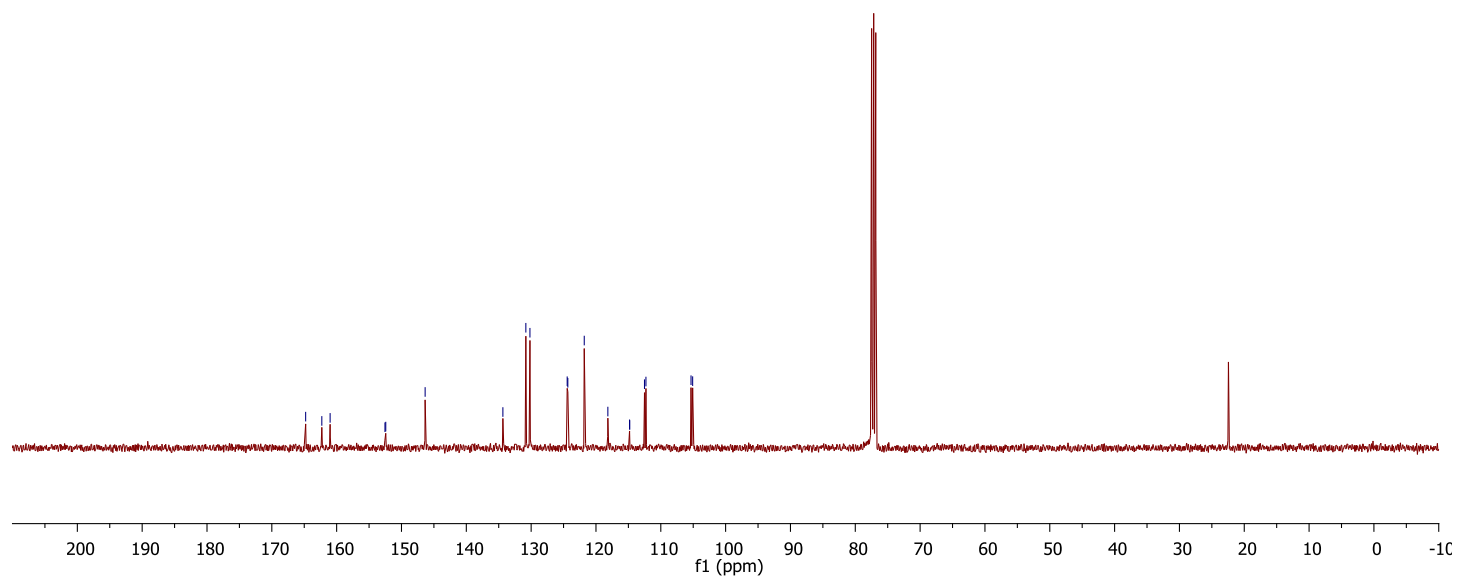


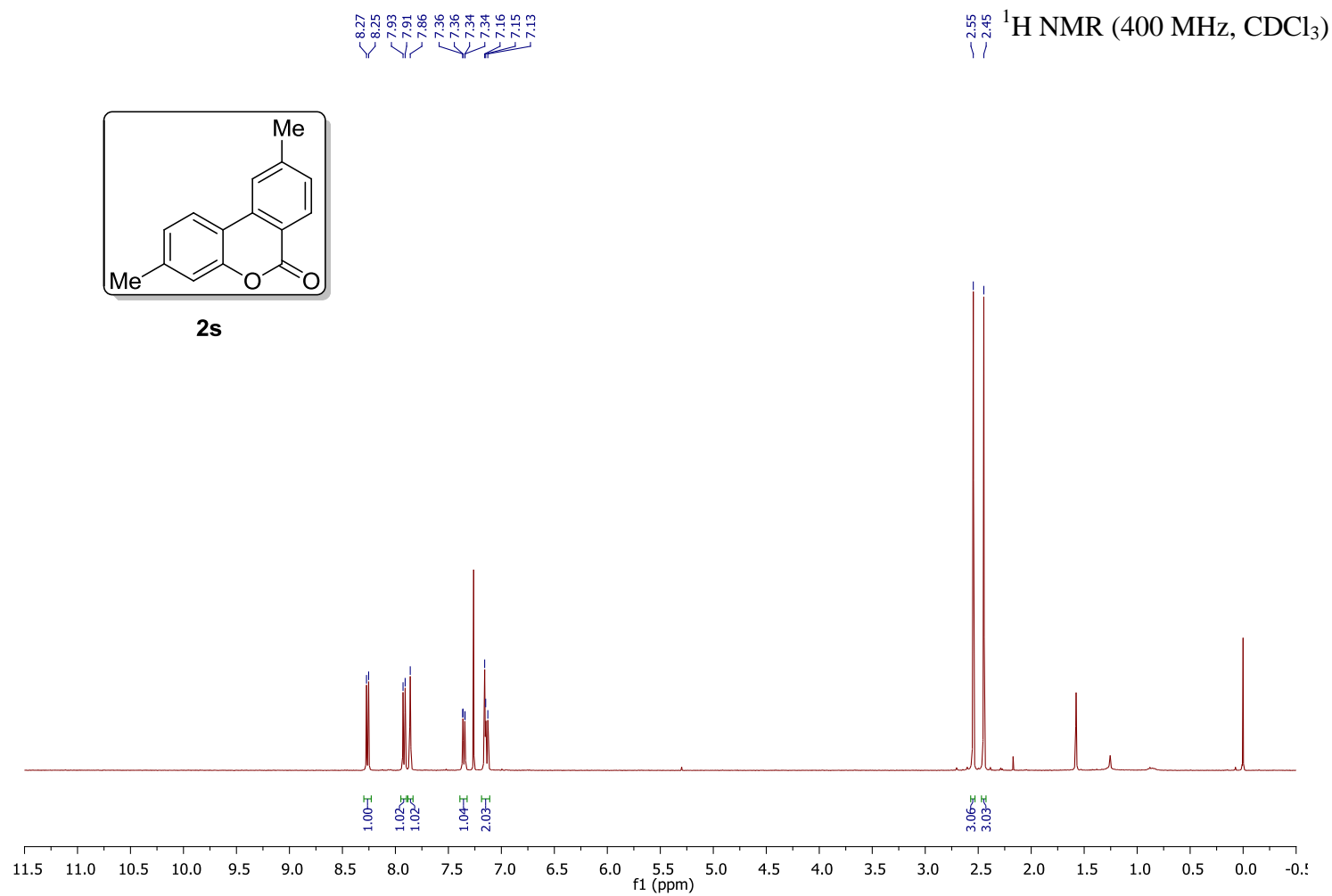


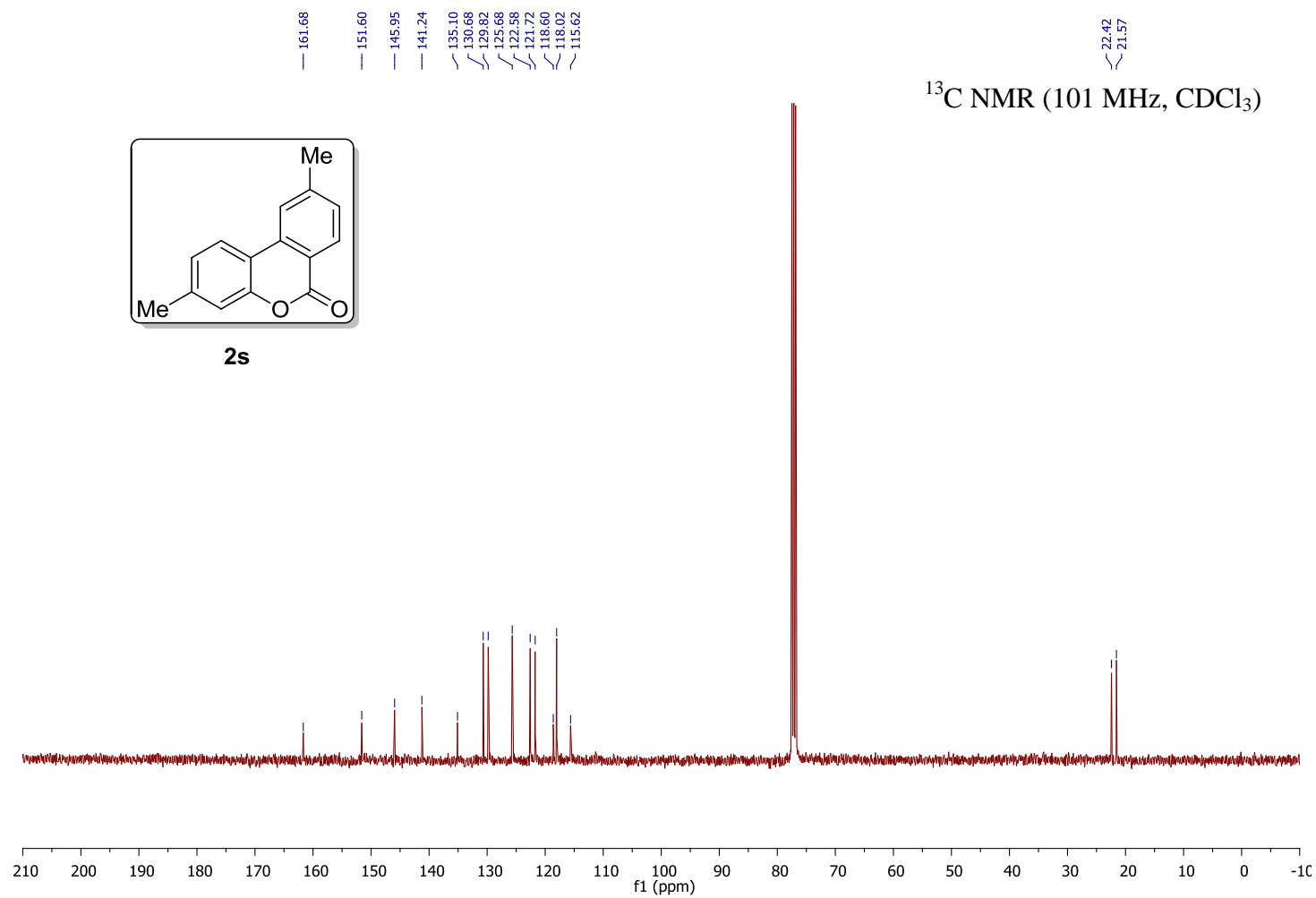
2r

164.78
162.29
161.01
152.55
152.43
146.35
134.36
130.82
130.19
124.44
124.34
121.81
118.17
114.82
112.51
106.34
105.09

^{13}C NMR (101 MHz, CDCl_3)







11. ¹H NMR and ¹³C NMR Spectra of Deuterated Acid 1a-D₅ and Deuterated Benzo-3,4-coumarin 2a-D₄

