Supplementary Information for:

Base-Free Nickel-Catalysed Decarbonylative Suzuki-Miyaura Couplings of Acid Fluorides

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Table of Contents

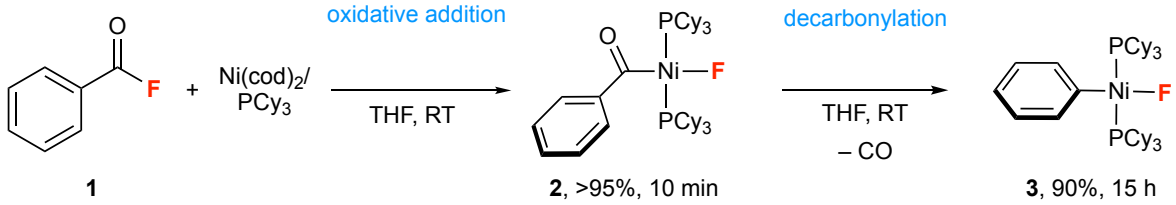
I. General Information

All NMR experiments were recorded using Varian MR400 (400.52 MHz for ^{1}H, 100.71 MHz for ^{13}C, 376.87 MHz for ^{19}F), Varian vnmrs 500 (500.01 MHz for ^{1}H, 125.75 MHz for ^{13}C, 470.56 MHz for 19F), or Varian nmrs 700 (699.76 MHz for ^{1}H, 175.95 MHz for ^{13}C) spectrometers. Chemical shifts (δ) are reported in ppm, and coupling constants (*J*) are reported in Hz. The 7.26 resonance of residual $CHCl_3$ for proton spectra and the 77.23 ppm resonance of $CDCl_3$ for carbon spectra were used as internal references. High-resolution mass spectrometry data (HRMS) were obtained on a Micromass AutoSpec Ultima Magnetic Sector instrument. GCMS analyses were performed on a Shimadzu GCMS-QP2010 gas chromatograph mass spectrometer. Infrared spectroscopy was performed on a Perkin-Elmer Spectrum BX FT-IR spectrometer, and peaks are reported in cm^{-1}. Melting points were determined with a Mel-Temp 3.0 (Laboratory Devices, Inc.) and are uncorrected. Chromatographic purifications were performed by column chromatography using 40-63 micron flash silica gel or a CombiFlash Torrent® system using RediSep® Rf columns packed with silica gel. X-ray crystallographic data were obtained on a Rigaku AFC10K Saturn 944+ CCD-based X-ray diffractometer.

II. Materials and Methods

All commercially available reagents were used as received unless otherwise stated. $Ni(cod)_2$, PCy_3, and PPh_2Me were purchased from Sigma Aldrich and stored in a glovebox. Benzoyl fluoride **1** (SynQuest) and 4-trifluoromethylbenzoyl fluoride **15**-COF (SynQuest) were purchased from commercial sources and used as received. Tetramethylfluoroformamidiniun hexafluorophosphate (TFFH, Chem Impex), proton sponge (Sigma), CsF (Alfa Aesar), and *o*-tolyl$(PPh_2Me)_2NiCl$ (Sigma) were purchased from commercial sources and stored under an inert atmosphere. Aryl and akenyl boronic acids were purchased from commercial sources (Sigma, Alfa Aesar, Frontier Scientific, Synquest) and used as received. Deuterated solvents were purchased from Cambridge Isotope Laboratories, Inc.

III. Stoichiometric Studies on Oxidative Addition and Decarbonylation of Benzoyl Fluoride 1



In a glovebox, a solution of $Ni(cod)_2$ (11 mg, 0.04 mmol) and PCy_3 (22.4 mg, 0.08 mmol) in THF (0.25 mL) was stirred in a 4 mL vial at room temperature for 10 min. In a separate 4 mL vial, a solution of benzoyl fluoride (2.5 mg, 0.02 mmol) and 2-fluoromesitylene (0.02 mmol, internal standard) in THF (0.25 mL) was stirred for 5 min. Both vials were cooled to –35 °C by placing inside the glovebox freezer for 20-30 min. Both vials were removed from the freezer, the solutions were combined, and then the resulting solution was transferred to a J. Young tube. The tube was sealed and removed from the glove box. Starting at 5 min from the time of mixing the reaction mixture was analyzed by ^{19}F NMR spectroscopy.

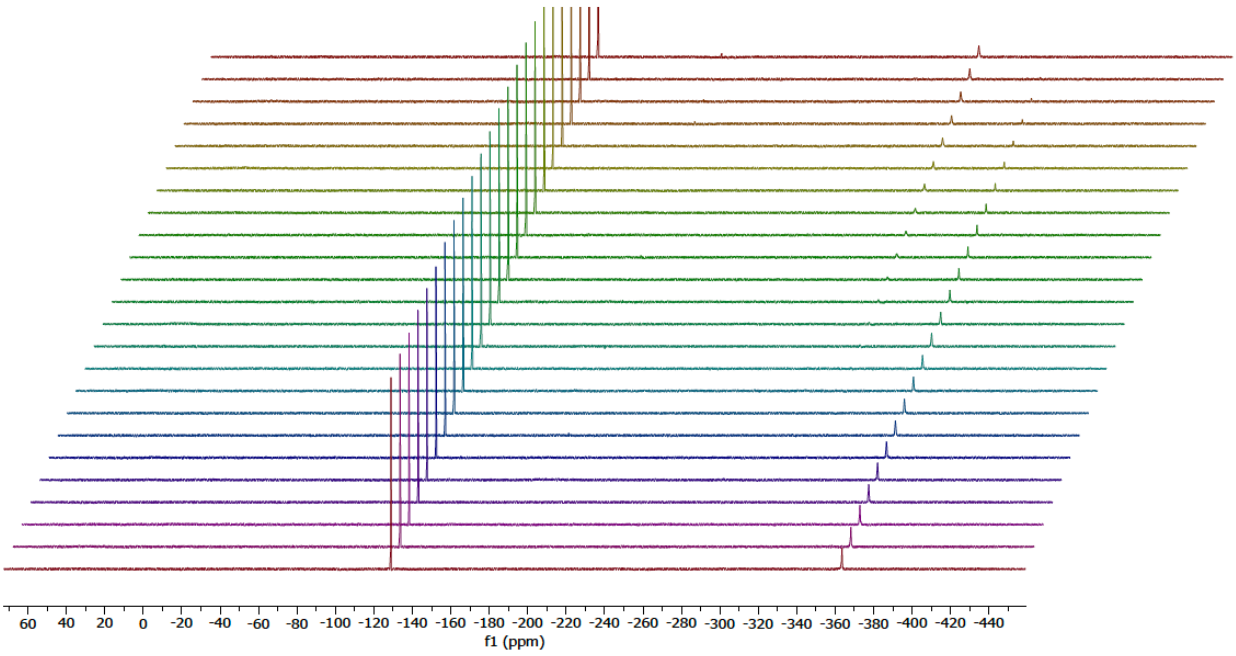


Figure S1. Representative ^{19}F NMR spectral array monitoring the stoichiometric decarbonylation of benzoyl fluoride **1** with $Ni(cod)_2$ and PCy_3 at RT in THF over 16 h.

The starting benzoyl fluoride **1** was completely consumed within 10 min, with concomitant formation of the oxidative addition product (PhCO)Ni(F)(PCy_3)$_2$ **2** (>95% ^{19}F NMR yield, 10 min): **^{19}F NMR** –327.9 (t, *J* = 46 Hz). Complex **2** then underwent decarbonylation to form (Ph)Ni(F)(PCy_3)$_2$ **3** (90% ^{19}F NMR yield after 15 h): **^{19}F NMR** –363.7 (t, *J* = 42 Hz). Under these stoichiometric studies at room temperature, $Ni(CO)_2(PCy_3)_2$ was observed as a byproduct, as confirmed by ^{31}P NMR (40.6 ppm) and FTIR analysis (CO stretches at 1980 and 1915 cm^{-1}).[1]

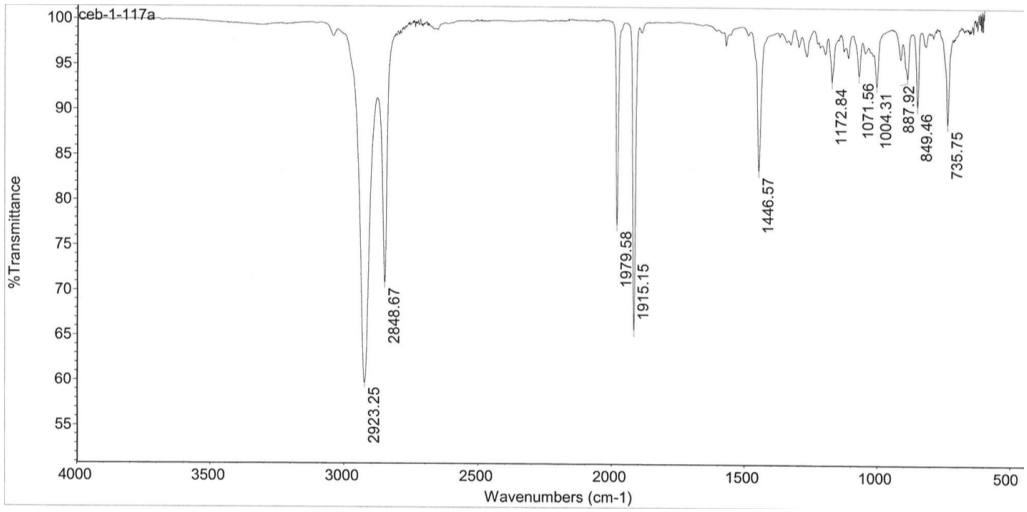
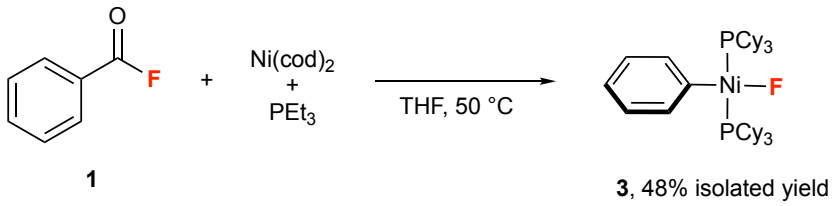
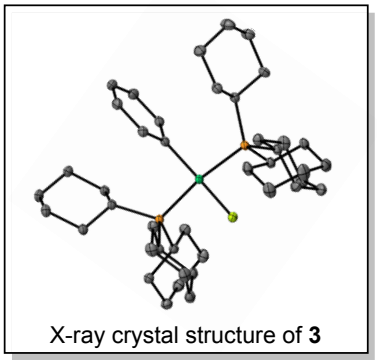


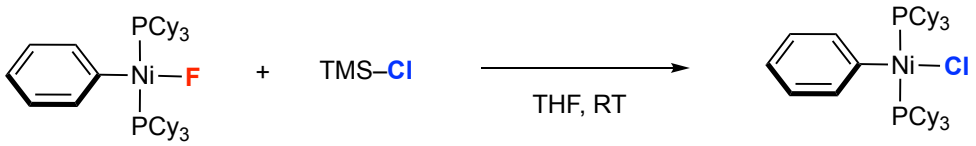
Figure S2. FTIR spectrum of the reaction mixture obtained after the decarbonylation of **1**. The peaks at 1980 and 1915 cm^{-1} correspond to the reported literature values for $Ni(CO)_2(PCy_3)_2$.[1]

IV. Synthesis of Phenyl Nickel Fluoride Complexes 3, 7, and 8



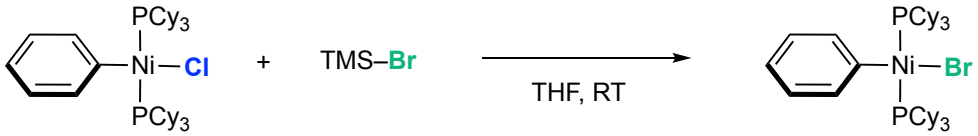

X-ray crystal structure of **3**

Synthesis of 3 [$(PCy_3)_2Ni(F)(Ph)$]: In a glovebox, a 50 mL round bottom flask was charged with $Ni(cod)_2$ (300 mg, 1.10 mmol, 1 equiv), PCy_3 (665 mg, 2.37 mmol, 2.15 equiv), THF (20 mL), and a magnetic stir bar. The solution was stirred at room temperature for 25 min until all of the $Ni(cod)_2$ dissolved. A rubber septum was added to the flask, and the solution was placed in a –35 ºC freezer for 20 min. While the Ni solution cooled, a 4 mL vial was charged with PhCOF (165 mg, 1.33 mmol, 1.20 equiv) and THF (1 mL). This solution was added in one portion to the rapidly stirring solution of $Ni(cod)_2/PCy_3$. Upon mixing, the solution rapidly changed from a dark orange to a bright orange. After stirring for 5 min, an additional 30 mL of THF was added. The flask was then sealed with a rubber septum, removed from the glovebox, and placed in a preheated (50 ºC) oil bath. While still in the oil bath, the solution was sparged with a gentle stream of N_2 for 1 h. The flask was removed from the oil bath, allowed to cool to room temperature, and brought back into the glovebox. The volatiles were removed under reduced pressure until the volume was approximately 15 mL, at which point Et_2O (20 mL) was added to precipitate a yellow solid. The yellow precipitate was collected on a frit, washed with of Et_2O (2 x 10 mL) and pentanes (10 mL), and dried under vacuum to yield **3** as a bright yellow powder (376 mg, 48% yield): **^{1}H NMR** (700 MHz, C_6D_6) δ 7.68 (d, *J* = 7.3 Hz, 2H), 6.88 (t, *J* = 7.3 Hz, 2H), 6.73 (t, *J* = 7.3 Hz, 2H), 2.18-2.07 (br, 12H), 1.89-1.60 (multiple peaks, 36H), 1.27-1.04 (multiple peaks, 18H); **^{13}C NMR** (176 MHz, C_6D_6) δ 150.22 (m), 140.52, 125.41, 120.74, 32.98 (t, *J* = 8.2 Hz), 30.44, 28.49 (t, *J* = 5.1 Hz), 27.40; **^{31}P NMR** (283 MHz, C_6D_6) δ 15.77 (d, *J* = 42.0 Hz); **Elemental analysis** calculated for $C_{42}H_{71}FP_2Ni$, C: 70.49 H: 10.00; Found C: 70.18 H: 9.92; **X-ray** quality crystals of **3** were obtained by vapor diffusion of diethyl ether into at room temperature. See section XIV for X-ray crystal structure data of **3**.



3 **7**

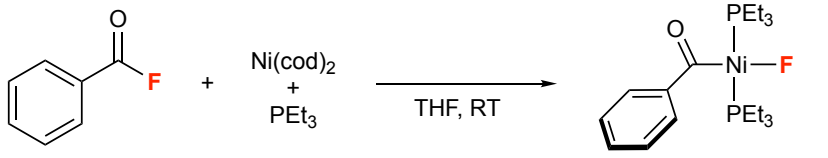
Synthesis of 7 [$(PCy_3)_2Ni(Cl)(Ph)$]: In a glovebox, a 20 mL vial was charged with **3** (75 mg, 0.10 mmol, 1 equiv) and THF (2 mL). To this solution was added TMSCl as a freshly prepared stock solution (0.1 M in THF, 1.25 mL, 1.2 equiv). The vial was capped, gently shaken, and allowed to stand at room temperature. Over the course of 2 h the solution changed color from bright yellow to orange. After 2 h, the volatiles were removed under reduced pressure, and the resultant yellow solid was triturated with Et_2O (3 mL) and then dried under vacuum. Complex **7** was obtained as a yellow powder (55 mg, 72% yield): **^{1}H NMR** (700 MHz, C_6D_6) δ 7.69 (d, *J* = 7.4 Hz, 2H), 6.87 (t, *J* = 7.4 Hz, 2H), 6.73 (t, *J* = 7.3 Hz, 1H), 2.11-1.97 (multiple peaks, 18H), 1.82-1.58 (multiple peaks, 30H), 1.20-1.06 (multiple peaks, 18H); **^{13}C NMR** (176 MHz, C_6D_6) δ 150.09 (t, *J* = 32.6 Hz), 139.71 (t, *J* = 3.1 Hz), 125.30 (t, *J* = 2.4 Hz), 120.70 (t, *J* = 2.3 Hz), 33.77 (t, *J* = 8.6 Hz), 29.99, 27.81 (t, *J* = 4.8 Hz), 26.65; **^{31}P NMR** (283 MHz, C_6D_6) δ 12.20; **Elemental analysis**: calculated for $C_{42}H_{71}P_2ClNi$, C: 68.90 H: 9.78; found C: 68.77 H: 9.68.



7 **8**

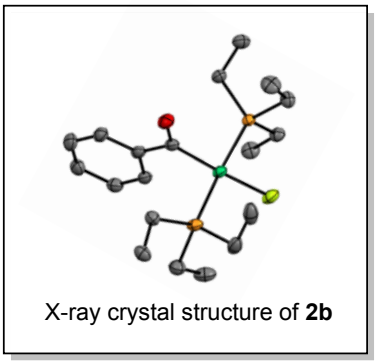
Synthesis of 8 [$(PCy_3)_2Ni(Br)(Ph)$]: In a glovebox, a 20 mL vial was charged with **3** (75 mg, 0.10 mmol, 1 equiv) and THF (2 mL). To this solution was added TMSBr as a freshly prepared stock solution (0.1 M in THF, 1.25 mL, 1.2 equiv). The vial was capped, gently shaken, and allowed to stand at room temperature. Over the course of 10 min the solution changed color from bright yellow to a dark orange. After 10 min, the volatiles were removed under reduced pressure and the resultant yellow solid was triturated with Et_2O (3 mL) and dried under vacuum. Complex **8** was obtained as a yellow powder (52 mg, 65% yield); **^{1}H NMR** (700 MHz, C_6D_6) δ 7.70 (d, *J* = 7.4 Hz, 2H), 6.86 (t, *J* = 7.4 Hz, 2H), 6.72 (t, *J* = 7.3 Hz, 1H), 2.13-2.09 (multiple peaks, 18H), 1.78-1.57 (multiple peaks, 30H), 1.19-1.09 (multiple peaks, 18H); **^{13}C NMR** (176 MHz, C_6D_6) δ 150.71 (t, *J* = 34.8 Hz), 139.60, 125.30 (d, *J* = 2.8 Hz), 120.92, 34.48 (t, *J* = 8.6 Hz), 30.13, 27.80 (t, *J* = 4.8 Hz), 26.61; **^{31}P NMR** (202 MHz, C_6D_6) δ 11.42. Isolated complex contains traces of $O{=}PCy_3$ based on the ^{31}P NMR spectrum. **Elemental analysis**: calculated for $C_{42}H_{71}P_2BrNi$, C: 64.96 H: 9.22; found C: 64.68 H: 9.45.

V. Synthesis of Benzoyl Nickel Fluoride Complex 2b



1

2b, 55% isolted yield



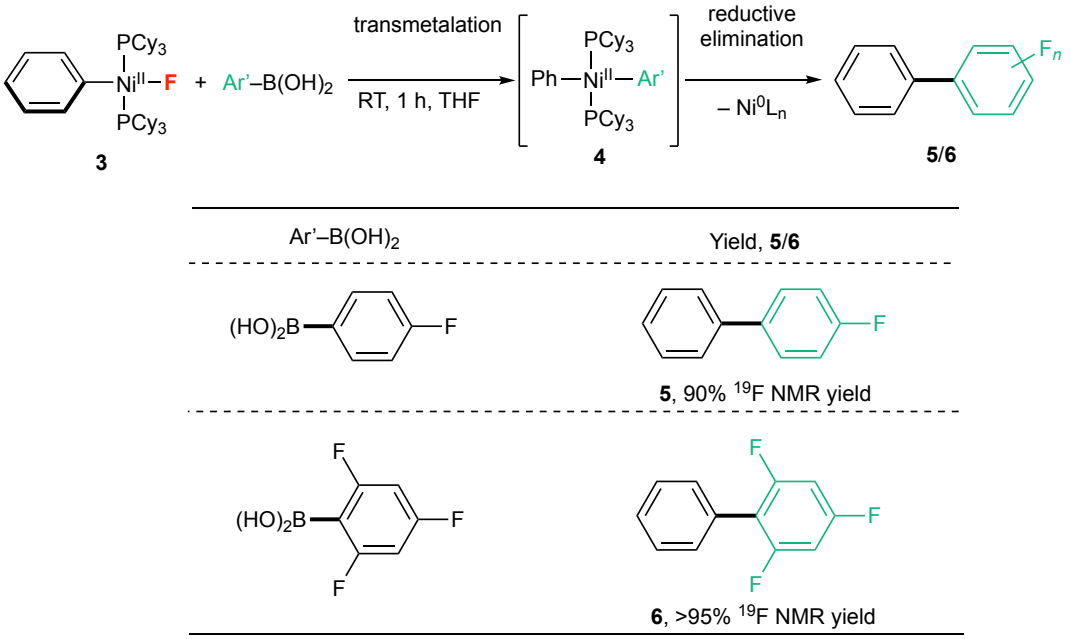
X-ray crystal structure of **2b**

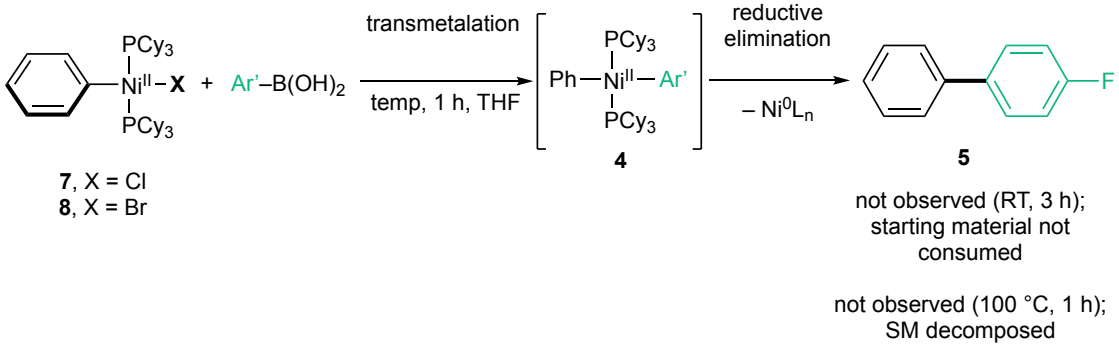
In a glovebox, a pre-stirred solution of $Ni(cod)_2$ (55 mg, 0.20 mmol) and PEt_3 (52 mg, 0.44 mmol) in THF (3.0 mL) was added to a stirred solution of benzoyl fluoride (37 mg, 0.30 mmol) in THF (2.0 mL). The resulting reaction mixture was allowed to stir at room temperature for 30 min. The solvent was removed under vacuum, and the resulting crude solid was washed with pentane (2 x 5 mL). The residue was redissolved in minimal volume of ether (~1 mL) followed by the addition of pentane (5 mL). This solution was allowed to stand at –35 ºC for 3 h, during which time light yellow crystals formed. The supernatant was decanted, and the crystals were dried *in vacuo* to afford complex **2b** as a light yellow crystalline solid (46 mg, 55% yield): **^{1}H NMR** (C_6D_6, 500 MHz) δ 8.67 (br, 2H), 7.20-7.11 (br, 3H), 1.39 (br, 6H), 1.25 (br, 6H), 1.02 (br, 18H); **^{13}C NMR** (C_6D_6, 125 MHz) δ 141.19, 137.14, 130.56, 127.08, 13.48, (t, J = 11.4 Hz), 7.63 (the acyl carbon attached to Ni was difficult to observe; **^{19}F NMR** (C_6D_6, 470 MHz) δ –324.19 (t, J = 46.0 Hz); **^{31}P NMR** (C_6D_6, 202 MHz) δ 10.04 (d, J = 46.0 Hz); **FTIR** 2967, 2938, 2881, 1603 (C=O stretch; lit.[2] value 1605 cm^{-1}), 1357, 1149, 719 cm^{-1}; **X-ray** quality crystals of **2b** were obtained by recrystallization from cold pentane. See section XIV for X-ray crystal structure data of **2b**.

VI. Stoichiometric Transmetalation and Reductive Elimination Studies

In a glovebox, $PhNi(PCy_3)_2F$ **3** (7.2 mg, 0.01 mmol) was weighed into a 4 mL vial. (4-Fluorophenyl)boronic acid (0.015 mmol, 1.5 equiv) and 2-fluoromesitylene (0.01 mmol, 1.0 equiv) were added from a stock solution in THF resulting in a total volume of 0.6 mL. The reaction mixture was stirred at room temperature. After 1 h, the reaction mixture was transferred to an NMR tube and then analyzed by ^{19}F NMR spectroscopy. Chemical shifts for **5** (δ –115.8 ppm), **6** (δ –112.9, 2F and –115.0, 1F),[3] and 2-fluoromesitylene (δ –129.3 ppm).

Table S1. Transmetalation and reductive elimination of phenyl Ni-halides **3, 7** and **8** with aryl boronic acids.





The [$Ph(PCy_3)_2Ni(F)$] complex **3** underwent fast transmetalation/reductive elimination with 4-fluorophenyl and 2,4,6-trifluorophenyl boronic acids providing >90% yields of the biaryl products at RT in 1 h. Under these conditions, only trace amount of fluorobenzene and 1,3,5-trifluorobenzene (the result of protodeboronation) were detected. These results imply that the rate of transmetalation/reductive elimination is much faster than the rate of protodeboronation. The utility of 4-fluorophenyl and 2,4,6-trifluorophenyl boronic acids in catalysis are demonstrated in the synthesis of probenecid analogs **41** and **60**. The extent of their protodeboronation under the catalytic conditions are discussed (see Section XII).

Following conditions from the above reaction, phenyl nickel chloride (**7**) and bromide (**8**) were reacted with (4-fluorophenyl)boronic acid. At room temperature, no detectable reaction was observed by ^{31}P or ^{19}F NMR spectroscopy after 3 h. At 100 °C, no detectable amount of **5** was observed and both complexes **7** and **8** decomposed giving primarily biphenyl.

VII. Optimization Studies

General procedure: In a nitrogen-filled glovebox, acid fluoride **9** or **24-COF** (1 equiv, 0.1 mmol) was weighed into a 10 mL vial equipped with a 10 μm magnetic stir bar (see Figure S3, set up **C**). A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.01 mmol) and ligand (0.2 equiv, 0.02 mmol) in THF (0.2 mL) and a stock solution (0.1 mL) of neopentylbenzene as internal standard (1 equiv, 0.1 mmol) in THF were added. The aryl boronic acid **10** (2 equiv, 0.4 mmol) was added, and the reaction mixture was capped and removed from the glovebox. The reaction mixture was stirred at the given temperature for 16 h. The reaction mixture was cooled to room temperature, diluted with DCM, and analyzed by GC.

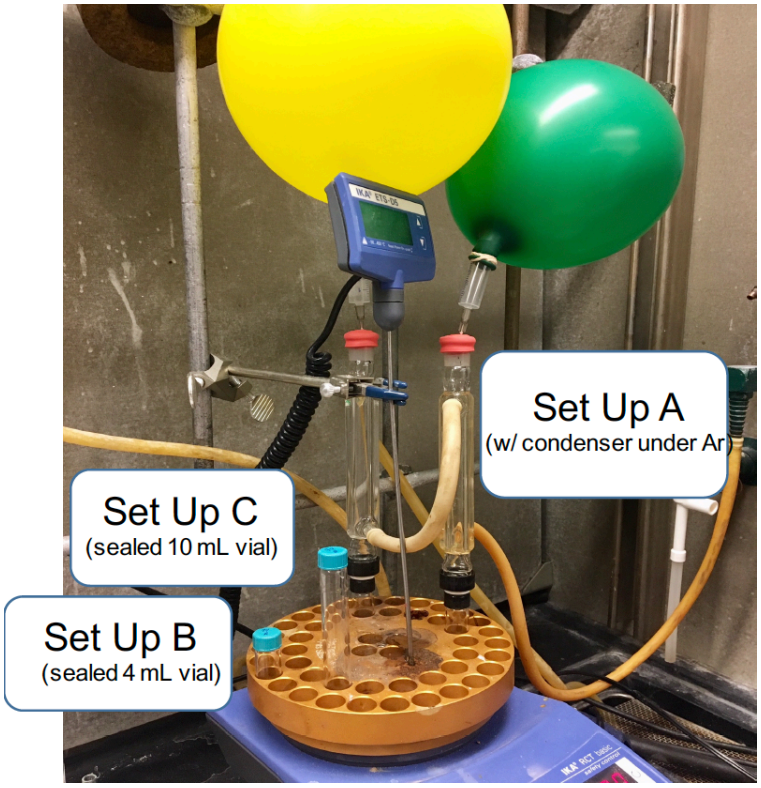
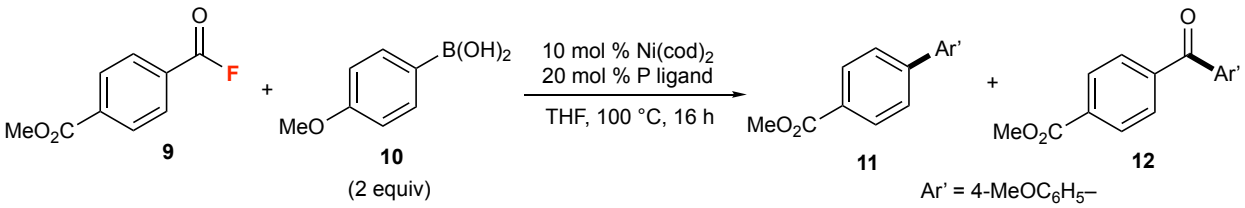


Figure S3. Reaction set up. Set up **A**: a 4 mL vial equipped with a condenser under Ar balloon. This is the set-up used for reactions at 0.3 to 0.5 mmol scale (equivalent to 0.9 to 1.5 mL of THF as solvent). Set up **B**: a sealed 4 mL vial under N_2 atmosphere. This set-up typically gives low selectivities for ketone versus biaryl product. Set up **C**: a sealed 10 mL vial under N_2 atmosphere. This is the set-up used for optimization reactions and reactions at 0.1 to 0.2 mmol scale (equivalent to 0.3 to 0.6 mL of THF as solvent).

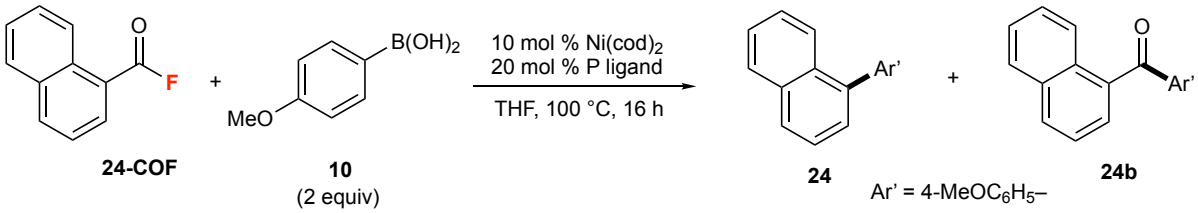
Table S2. Ligand Screen with **9**



entry	ligand	[a]yield of **11** (%)	ratio **11:12**
1	none	<2	-
2	PCy_3	82	85:15
3	PPh_2Me	95	>99:1
4	PEt_3	15	30:70

[a]Yields by gas chromatography using neopentylbenzene as internal standard.

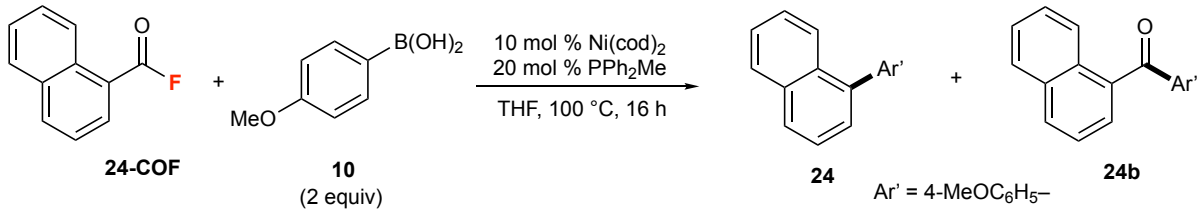
Table S3. Additional ligand screen with **22-COF**



entry	ligand	[a]yield of **24** (%)	ratio **24:24b**
1	PPh_2Me	95	>99:1
2[b]	PPh_2Me, 60°C	70	90:10
3	PCy_3	85	93:7
4	PEt_3	60	60:40
5	P^nBu_3	35	-
6	PPh_3	40	-
7	$P(o\text{-tol})_3$	48	-
8	$PAd_2{}^nBu$	34	-
9	XantPhos	20	-
10	dppf	30	-
11	dppe	<2	-
12	iPr	5	-
13	SiPr	5	-

[a]Yields determined by gas chromatography using neopentylbenzene as internal standard. *Most reactions that did not provide significant yields of **24** showed unreacted SM and/or the protodecarbonylated byproduct, naphthalene. [b]Reaction time of 24 hours.

Table S4. Optimization with other conditions



24-COF **10** (2 equiv) **24** **24b** Ar' = 4-$MeOC_6H_5$–

entry	variation from scheme	yield of **24** (%)	ratio **24:24b**
1	none	95	>99:1
2[b]	5 mol % $Ni(cod)_2$, 10 mol % PPh_2Me	65	>99:1
3[b]	60 °C, 16 h	62	90:10
4[b]	60 °C, 48 h	70	90:10
5	1.5 equiv of **10**	86	>99:1
6	1.0 equiv of **10**	58	>99:1
7[b]	$Ni(OAc)_2$ instead of $Ni(cod)_2$	55	95:5
8	reaction set-up **B**	80	80:20
9	with Na_2CO_3 (2 equiv)	35	-
10	with KF (2 equiv)	5	-
11[c]	$Pd(dba)_2$ instead of $Ni(cod)_2$	0	-
12	$Pd(dba)_2$ and PCy_3	5	10:90
13[c]	$Pd(dba)_2$ and SiPr (10 mol %)	0	-
14[c]	$Pd(dba)_2$ and iPr (10 mol %)	0	-

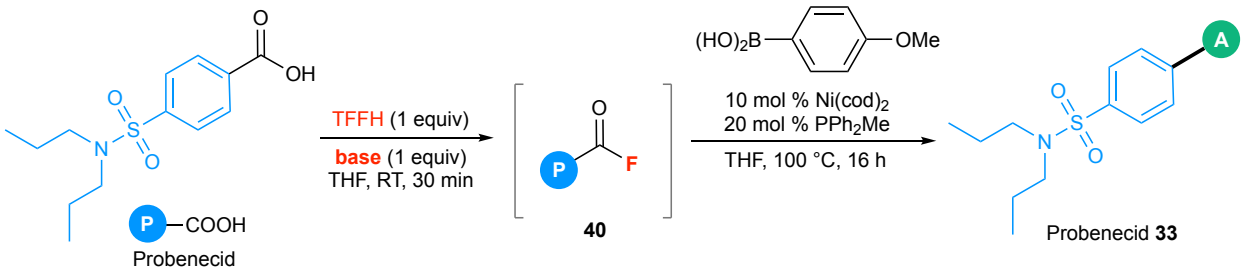
[a]Yields determined by gas chromatography using neopentylbenzene as internal standard. [b]Unreacted starting material was observed by ^{19}F NMR spectroscopy. [c]Mainly unreacted starting material remained.

The catalytic decarbonylative Suzuki coupling of acid fluoride **24-COF** with aryl boronic acid **10** was optimized based on ligands, temperature, equivalents of **10**, and several other parameters. The optimized conditions were found as follows: 10 mol % $Ni(cod)_2$, 20 mol % PPh_2Me in THF at 100 °C. Under these conditions, the reaction of 1 equiv of **24-COF** with 2 equiv of **10** gave 95% yield of Suzuki product **24** with exceptional selectivity (Table S4, entry 1). The conditions presented in entry 1 were utilized to investigate the scope of the reaction, unless stated otherwise.

However, we note that the reaction affords reasonable yields of the desired product at lower catalyst loading (entry 2), at lower temperature (entries 3 and 4), at lower equiv of boronic acid (entries 5 and 6), and with air-stable $Ni(OAc)_2$ as the Ni pre-catalyst (entry 7).

In situ reaction, general procedure: In a nitrogen-filled glovebox, probenecid (1 equiv, 0.1 mmol), tetramethylfluoroformamidinium hexafluorophosphate (TFFH) (1 equiv, 0.1 mmol), and base (1 equiv, 0.1 mmol) were weighed into a 10 mL tall vial equipped with a 10 μm magnetic stir bar (see Figure S1, Set up **C**). THF (0.2 mL) was added, and the reaction mixture was stirred at room temperature for 15 min. A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.01 mmol) and PPh_2Me (0.2 equiv, 0.02 mmol) in THF (0.1 mL) and a stock THF solution (0.1 mL) of neopentylbenzene as internal standard (1 equiv, 0.1 mmol) were added. The aryl boronic acid **10** (2 equiv, 0.4 mmol) was added, and the reaction mixture was capped and removed from the glovebox. The reaction was stirred at 100 ºC for 16 h. The reaction mixture was cooled to room temperature, and then diluted with dichloromethane and analyzed by GC.

Table S5. Optimization for Ni-catalysed decarbonylative Suzuki reaction via *in situ* formation of acid fluoride from probenecid.



entry	base (1.0 equiv)	[a]yield of **33** (%)
1	DIPEA	20
2	Et_3N	18
3	pyridine	20
3	proton sponge	95
4[b]	NaH	0
5	KH	40
6[b]	NaO^tBu	0
7	proton sponge (1.2 equiv)	92

[a]GC yields using neopentyl benzene as internal standard. Reactions that afforded low yields of **33** showed mainly protodecarboxylated byproduct. [b]The *in situ* formation of acid fluoride was found to be inefficient as observed by ^{19}F NMR spectroscopic analysis.

We next pursued generating the carboxylic acid fluorides *in situ* using a deoxyfluorinating reagents and base in THF at room temperature. The use of other commercial deoxyfluorinating reagents were also investigated for the formation of acid fluoride with DIPEA, but afforded lower yields than TFFH. Performing the Suzuki reaction after *in situ* generation of acid fluoride **40** showed that the use of TFFH and proton sponge gave superior result over other bases. Other bases provided mainly protodecarbonylated products. The exceptional result obtained from the combination of TFFH and proton sponge can be explained from the formation of highly insoluble conjugate acid salt.

Overall, this Ni-catalysed decarbonylative cross-coupling presents the first base-free Suzuki-Miyaura type coupling of organoboron reagents with carboxylic acid derivatives. During the preparation of this manuscript, Schoenebeck and co-workers communicated a related advance in the decarbonylative coupling of aryl carboxylic acid fluorides.[4] This work utilized Pd(0)/XantPhos catalysis to promote the decarbonylative coupling of acid fluorides with triethyl(trifluoromethyl)silane to form trifluoromethylated products (**Fig. S4a**). In this system, the use of 20 mol % of K_3PO_4 as base and elevated temperature (170 ºC) were found necessary to obtain good yields of trifluoromethylated products. In particular, the elevated temperature was required to promote decarbonylation relative to formation of trifluoromethylated ketone byproduct. While the role of catalytic K_3PO_4 was not investigated in their work, they speculate that K_3PO_4 is necessary to activate $TESCF_3$ for transmetalation or, alternatively, to promote decarbonylation.

In the current work, the catalytic reaction is performed in the absence of exogeneous base and at 100 ºC (**Fig. S4b**). These developed catalytic conditions are consistent with our stoichiometric studies showing: (i) that oxidative addition and decarbonylation of acid fluorides with Ni(0)/PR_3 (PR_3 = PCy_3 or PPh_2Me) can proceed at room temperature, (ii) that selectivity for biaryl versus ketone can be achieved by appropriate tuning of the ligand, and (iii) that transmetalation with $ArB(OH)_2$/reductive elimination proceeds without the requirement for added base.

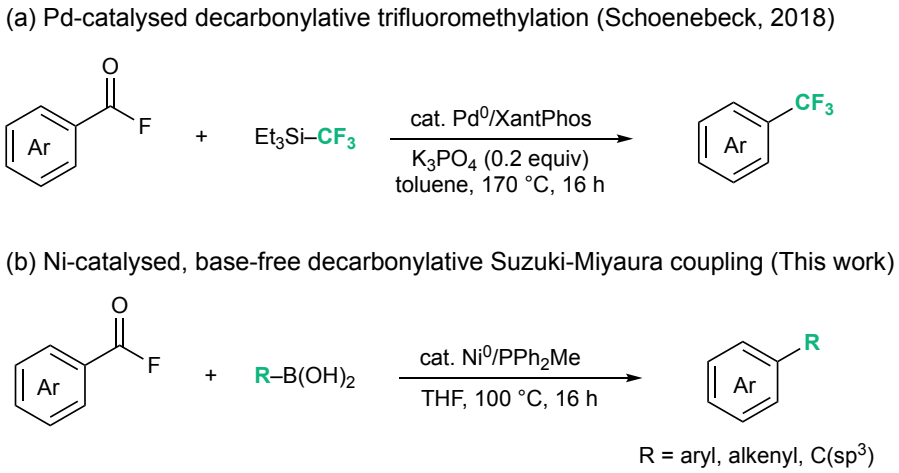


Figure S4. Catalytic decarbonylative coupling of carboxylic acid fluorides.

VIII. Ligand Effects: Stoichiometric Decarbonylation Studies

To understand the observed selectivity for the formation of decarbonylative cross-coupling product (biaryl) versus the the non-decarbonylated cross-coupling byproduct (ketone) with different ligands, we performed several stoichiometric decarbonylation studies. Using benzoyl fluoride **1** as the substrate, we conducted decarbonylation studies with $Ni(cod)_2$ and various phosphine ligands (PCy_3, PPh_2Me, PEt_3). Following the procedure described for the stoichiometric decarbonylation studies (SI–Section III), we found that decarbonylation is much faster with PPh_2Me (~50% conversion to **3** in 1 h) compared to PCy_3 (~50% conversion to **3** in 9 h) as the ligand. Furthermore, with PEt_3, we observed very slow decarbonylation. We also note that the benzoyl–Ni–F complex **2c** was not detected at room temperature, presumably due to its facile decarbonylation to form **3c**. Based on these initial studies, we propose that the selectivity observed with PPh_2Me results from the facile decarbonylation of the oxidative addition adduct **2c**. Attempts to isolate pure samples of phenyl–Ni–F complex **3c** were unsuccessful due to its instability.

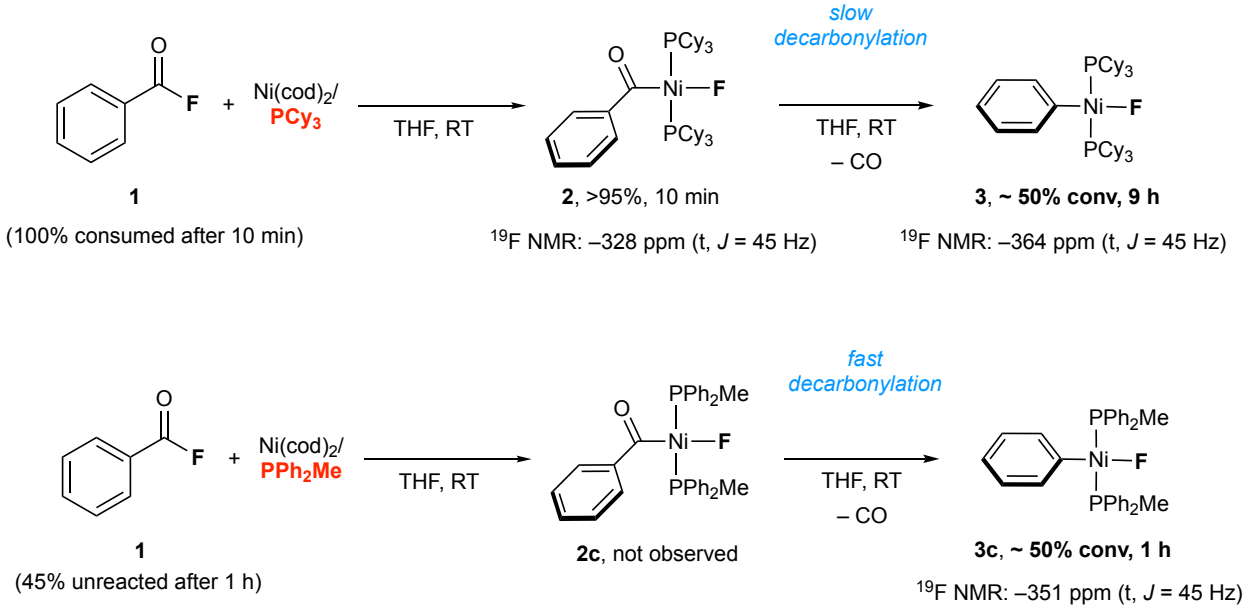


Figure S5. Stoichiometric studies for oxidative addition and decarbonylation of 1 with $Ni(cod)_2$ and phosphine ligands (PCy_3 and PPh_2Me) at RT in THF. Percent conversions and yields are based on ^{19}F NMR spectroscopy using 2-fluoromesitylene as internal standard.

We also performed similar decarbonylation studies using *o*-toluoyl fluoride as the substrate. Again, a Ni acyl intermediate (**2a**) was not observed; instead, the decarbonylated complex **3a** appeared directly (~50% yield after 1 h). An authetic sample of compound **3a** was formed *in situ* via an alternate ligand exchange method, as follows. First, Ni–Cl complex **7a**[5] was treated with PPh_2Me to afford the known complex **7b**[5] in 100% conversion. Reaction of complex **7b** with TMAF under literature conditions[6] resulted in the formation of a new complex with identical ^{19}F and ^{31}P NMR

resonances to those observed in the decarbonylation reaction. Notably, complex **3a** (formed by either synthetic route) also decomposes during isolation attempts.

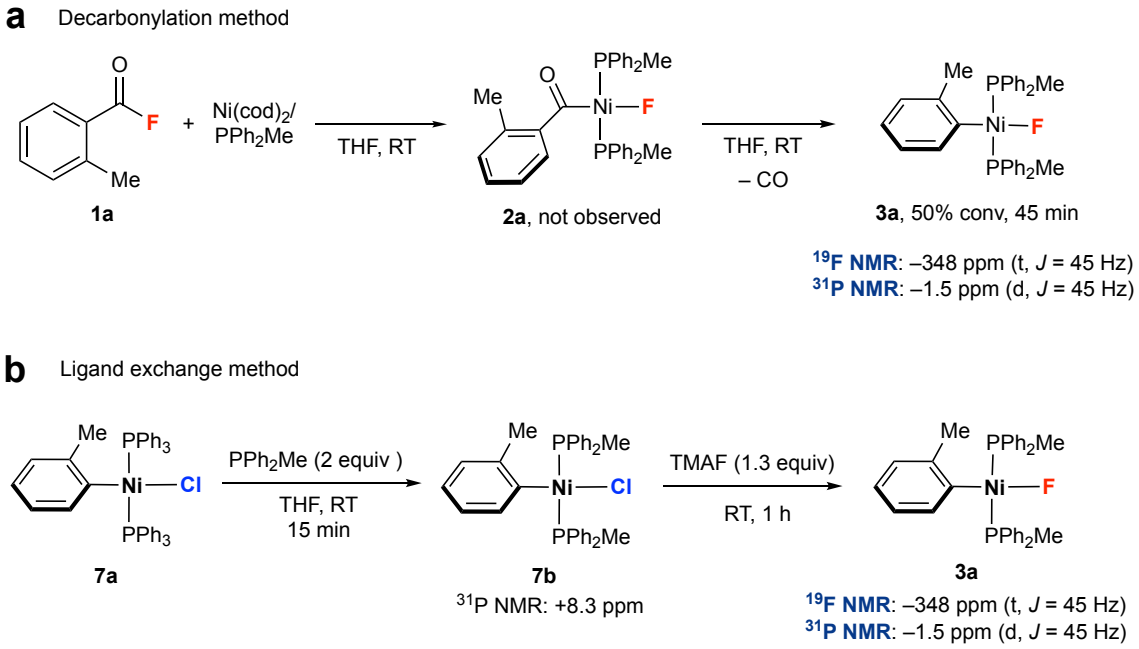
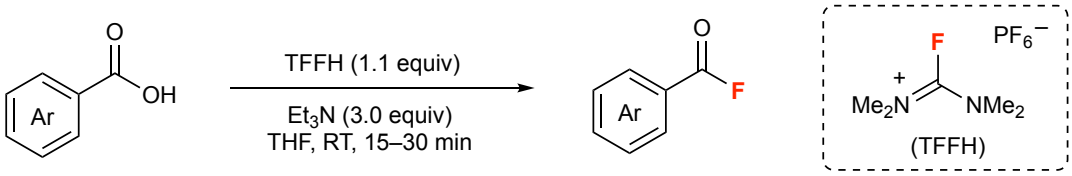
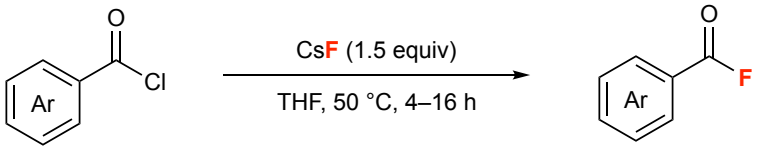


Figure S6. Stoichiometric *in situ* formation and characterization of *o*-toluoyl Ni-F complex **3a** via: (a) decarbonylation of *o*-toluoyl fluoride **1a** with $Ni(cod)_2$ and PPh_2Me, and (b) ligand exchange method following literature procedure.[5,6]

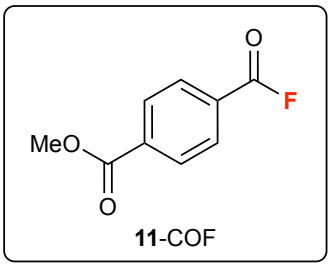
IX. Synthesis of Acid Fluorides



General procedure for the synthesis of acid fluorides from carboxylic acids (Method A): Based on a modified literature procedure,[7,8] a 20-mL vial equipped with a magnetic stir bar was charged with carboxylic acid (2.0 mmol, 1.0 equiv), TFFH (2.2 mmol, 1.1 equiv), and triethylamine (6.0 mmol, 3.0 equiv) in anhydrous THF (10 mL). The reaction mixture was stirred at room temperature. Within 5 min, the carboxylic acid and TFFH completely dissolve to form a homogeneous colorless solution. After 15-30 min, the reaction mixture was diluted with EtOAc (10 mL) and washed with ice-cold water (10 mL x 2). The organic layer was dried over Na_2SO_4, filtered, and concentrated *in vacuo* to form the acid fluoride. Based on ^{1}H NMR spectroscopic analysis, the resulting product was typically ~95% pure and was thus used without further purification. If purification was necessary, silica gel column chromatography was performed using 5% EtOAc/hexanes.

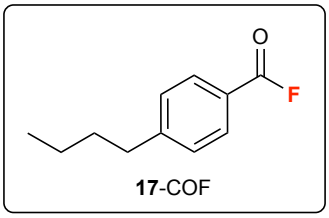


General procedure for the synthesis of acid fluorides from acid chlorides (Method B): Based on a modified literature procedure,[9] a 20-mL vial equipped with a magnetic stir bar was charged with CsF (3.0 mmol, 1.5 equiv), and the appropriate carboxylic acid chloride (2.0 mmol, 1.0 equiv) in anhydrous MeCN (6 mL). The reaction mixture was stirred at 50 ºC until complete conversion (usually 4 to 16 h). The reaction suspension was allowed to settle, and the MeCN solution decanted from the precipitate and then filtered. The precipitate was rinsed with MeCN (6 mL), and the washes was filtered. The combined MeCN washes was concentrated *in vacuo*. Based on ^{1}H NMR spectroscopic analysis, the resulting product was typically ~95% pure and was thus used without further purification. If purification was necessary, silica gel column chromatography was performed using 5% EtOAc/hexanes.



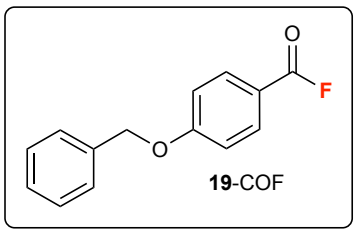
11-COF

Methyl 4-(fluorocarbonyl)benzoate (11-COF). Following the general procedure (Method B) using methyl 4-(chlorocarbonyl)benzoate,[10] methyl 4-(fluorocarbonyl)benzoate (**11**-COF) was obtained as a white solid (328 mg, 90% yield): **mp** 70-71 ºC; **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 8.13 (d, *J* = 8.7 Hz, 2H), 8.07 (d, *J* = 8.7 Hz, 2H), 3.94 (s, 3H); **^{13}C NMR** ($CDCl_3$, 126 MHz) δ 165.70, 156.62 (d, *J* = 345.7 Hz), 136.15, 131.46 (d, *J* = 3.8 Hz), 130.17, 128.69 (d, *J* = 61.7 Hz), 52.81; **^{19}F NMR** ($CDCl_3$, 471 MHz) δ 19.88; **HRMS** (EI) calcd for $C_9H_7FO_3$ $[M]^+$ *m/z* 182.0379, found 182.0381.



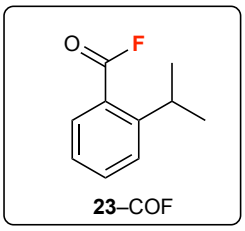
17-COF

4-Butylbenzoyl fluoride (17-COF). Following the general procedure (Method B) using commercial 4-butylbenzoyl chloride, **17**-COF was obtained as a colorless oil (331 mg, 92% yield): **^{1}H NMR** ($CDCl_3$, 400 MHz) δ 7.93 (d, *J* = 8.3 Hz, 2H), 7.30 (d, *J* = 8.3 Hz, 2H), 2.68 (dd, *J* = 8.6, 6.8 Hz, 2H), 1.61 (tt, *J* = 7.9, 6.8 Hz, 2H), 1.35 (m, 2H), 0.92 (t, *J* = 7.3 Hz, 3H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ 157.69 (d, *J* = 342.8 Hz), 151.66, 131.69 (d, *J* = 4.0 Hz), 129.32 (d, *J* = 1.3 Hz), 122.45 (d, *J* = 60.9 Hz), 36.06, 33.27, 22.48, 14.02; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ 17.37; **HRMS** (EI) calcd for $C_{11}H_{13}FO$ $[M]^+$ *m/z* 180.0950, found 180.0951.



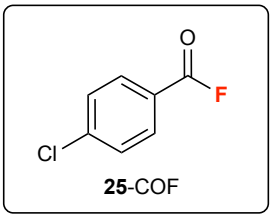
19-COF

4-(Benzyloxy)benzoyl fluoride (19-COF). Following the general procedure (Method B) using commercial 4-(benzyloxy)benzoyl chloride, **19**-COF was obtained as a white solid (130 mg, 63% yield): **mp:** 99-100 °C; **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 8.00 (d, *J* = 8.6 Hz, 2H), 7.48–7.31 (multiple peaks, 5H), 7.06 (d, *J* = 8.6 Hz, 2H), 5.16 (s, 2H); **^{13}C NMR** ($CDCl_3$, 126 MHz) δ 164.05, 156.97 (d, *J* = 339.4 Hz), 135.41, 133.53, 128.51, 128.17, 127.22, 116.84 (d, *J* = 62.0 Hz), 114.97, 70.10; **^{19}F NMR** ($CDCl_3$, 471 MHz) δ 16.07; **HRMS** (ESI) calcd for $NaC_{14}H_{11}FO_2$ $[M+Na]^+$ *m/z* 253.0635, found 253.0639.



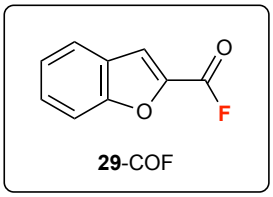
23–COF

2-Isopropylbenzoyl fluoride (23-COF). Following the general procedure (Method A) using commercial 2-isopropylbenzoic acid, **23**-COF was obtained as a colorless oil (108 mg, 40% yield): **^{1}H NMR** ($CDCl_3$, 400 MHz) δ 7.92 (d, *J* = 7.9 Hz, 1H), 7.60 (t, *J* = 7.6 Hz, 1H), 7.50 (d, *J* = 8.0 Hz, 1H), 7.29 (t, *J* = 7.6 Hz, 1H), 3.89 (p, *J* = 6.8 Hz, 1H), 1.26 (d, *J* = 6.8 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 156.78 (d, *J* = 346.6 Hz), 153.92 (d, *J* = 7.7 Hz), 134.93, 132.40 (d, *J* = 2.1 Hz), 127.10 (d, *J* = 4.2 Hz), 126.19, 123.15 (d, *J* = 55.7 Hz), 29.60 (d, *J* = 1.2 Hz), 23.85; **^{19}F NMR** ($CDCl_3$, 376 MHz) δ 33.56; **HRMS** (EI) calcd for $C_{10}H_{11}FO$ $[M]^+$ *m*/*z* 166.0794, found 166.0799.



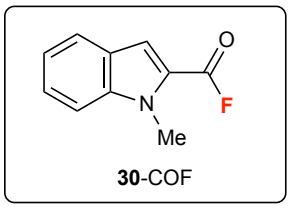
25-COF

4-Chlorobenzoyl fluoride (25-COF). Following the general procedure (Method B) using commercial 4-chlorobenzoyl chloride, **25**-COF was obtained as a white solid (257 mg, 81% yield):[11] **mp** 56-57 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.99 (d, *J* = 7.0 Hz, 2H), 7.51 (d, *J* = 8.3 Hz, 2H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ 156.78 (d, *J* = 343.5 Hz), 142.41, 132.92 (d, *J* = 3.9 Hz), 129.77 (d, *J* = 1.1 Hz), 123.56 (d, *J* = 62.6 Hz); **^{19}F NMR** ($CDCl_3$, 377 MHz) δ 18.19; **HRMS** (EI) calcd for C_7H_4ClFO $[M]^+$ *m*/*z* 157.9935, found 157.9937.



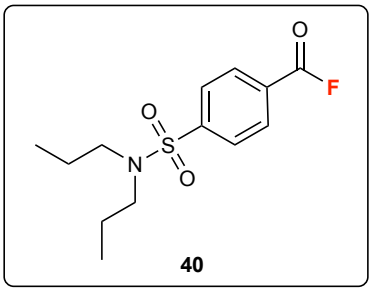
29-COF

Benzofuran-2-carbonyl fluoride (29-COF). Following the general procedure (Method B) using commercial benzofuran-2-carbonyl chloride, **29**-COF was obtained as a light yellow solid (298 mg, 91% yield): **mp** 77-78 ºC; **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 7.76 (multiple peaks, 2H), 7.67-7.60 (m, 1H), 7.58-7.54 (m, 1H), 7.42-7.35 (m, 1H); **^{13}C NMR** ($CDCl_3$, 126 MHz) δ 157.11 (d, *J* = 2.4 Hz), 149.61 (d, *J* = 329.9 Hz), 140.04 (d, *J* = 89.6 Hz), 129.71, 126.48, 124.79, 123.74, 119.54, 112.88; **^{19}F NMR** ($CDCl_3$, 471 MHz) δ 17.38; **HRMS** (EI) calcd for $C_9H_5FO_2$ $[M]^+$ *m*/*z* 164.0274, found 164.0279.



30-COF

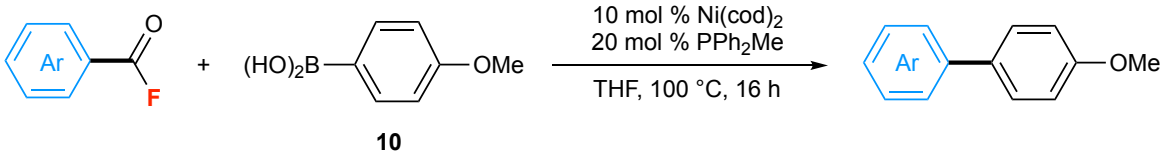
1-Methyl-1*H*-indole-2-carbonyl fluoride (30-COF). Following the general procedure (Method A) using commercial 1-methyl-1*H*-indole-2-carboxylic acid, **30**-COF was obtained as a white solid (301 mg, 85% yield): **mp** 77-78 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.73 (dd, *J* = 8.1, 0.8 Hz, 1H), 7.49 (s, 1H), 7.47-7.44 (m, 1H), 7.43-7.40 (m, 1H), 7.23-7.12 (m, 1H), 4.07 (s, 3H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ 152.26 (d, *J* = 328.5 Hz), 141.21 (d, *J* = 5.0 Hz), 127.23, 125.77, 123.60, 121.97 (d, *J* = 81.9 Hz), 121.63, 115.16 (d, *J* = 2.6 Hz), 110.75, 31.68; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ 22.20; **HRMS** (EI) calcd for $C_{10}H_8FNO$ $[M]^+$ *m*/*z* 177.0590, found 177.0588.



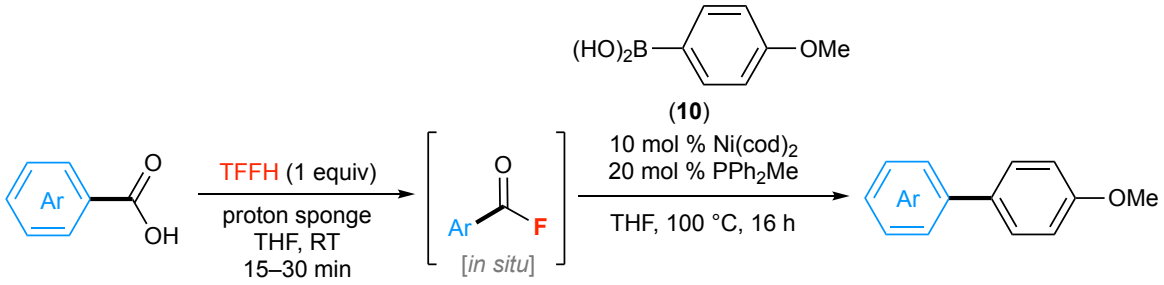
40

4-(*N*,*N*-Dipropylsulfamoyl)benzoyl fluoride (40). Following the general procedure (Method A) using probenecid, **40** was obtained after column chromatography as a white solid (470 mg, 82% yield): **mp** 61-62 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.15 (d, *J* = 8.1 Hz, 2H), 7.94 (d, *J* = 8.1 Hz, 2H), 3.49-2.65 (m, 4H), 1.53 (q, *J* = 7.5 Hz, 4H), 0.85 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ 156.16 (d, *J* = 345.8 Hz), 146.86, 132.18 (d, *J* = 3.2 Hz), 128.23 (d, *J* = 62.5 Hz), 127.68, 50.08, 22.08, 11.25; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ 20.19; **HRMS** (EI) calcd for $C_{13}H_{18}FNO_3S$ $[M]^+$ *m*/*z* 287.0991, found 287.0994.

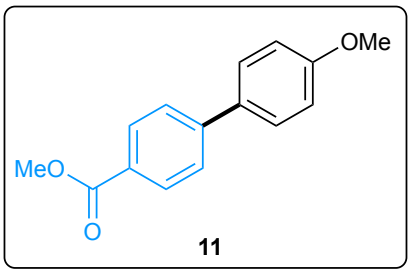
X. Ni-Catalysed Decarbonylative Suzuki Reaction with $ArB(OH)_2$ (10)



General procedure for decarbonylative Suzuki reaction (Method A, from acid fluoride): In a nitrogen-filled glovebox, acid fluoride (1 equiv, 0.2 mmol) was weighed into a 10 mL tall vial equipped with a 10 μm magnetic stir bar. A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.02 mmol) and PPh_2Me (0.2 equiv, 0.04 mmol) in THF (0.6 mL) was added. The boronic acid **10** (2 equiv, 0.4 mmol) was added, and the reaction mixture was capped and removed from the glovebox. The reaction mixture was stirred at 100 ºC for 16 h. The reaction was then cooled to room temperature, and EtOAc (5 mL) and brine (5 mL) were added. The organic layer was collected, and the aqueous solution was further extracted with EtOAc (2 x 5 mL). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by flash column chromatography on silica gel using EtOAc in hexanes.

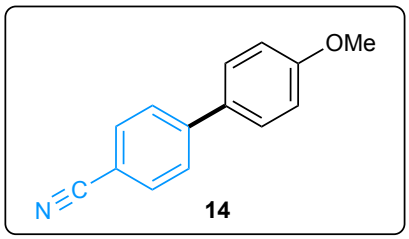


General procedure for decarbonylative Suzuki reaction (Method B, in situ, from carboxylic acid): In a nitrogen-filled glovebox, carboxylic acid (1 equiv, 0.2 mmol), TFFH (1 equiv, 0.2 mmol), and proton sponge (1 equiv, 0.2 mmol) were weighed into a 10 mL tall vial equipped with a 10 μm magnetic stir bar. THF (0.4 mL) was added, and the reaction mixture was stirred at room temperature for 15 to 30 min. A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.02 mmol) and PPh_2Me (0.2 equiv, 0.04 mmol) in THF (0.2 mL) was added. The boronic acid **10** (2 equiv, 0.4 mmol) was added, and the reaction mixture was capped and removed from the glovebox. The reaction mixture was stirred at 100 ºC for 16 h. The reaction was then cooled to room temperature, and EtOAc (5 mL) and brine (5 mL) were added. The organic layer was collected, and the aqueous solution was further extracted with EtOAc (2 x 5 mL). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by flash column chromatography on silica gel using EtOAc in hexanes.



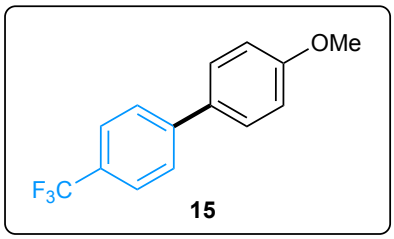
11

Methyl 4'-methoxybiphenyl]-4-carboxylate (11). Followed Method A using **11**-COF (36 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **11** as a white solid (46 mg, 95% yield). *In situ* reaction following Method B gave **11** in 86% yield. **mp** 170-172 ºC; **^{1}H NMR** ($CDCl_3$, 400 MHz) δ 8.08 (dd, *J* = 6.6, 1.6 Hz, 2H), 7.62 (dd, *J* = 6.6, 1.6 Hz, 2H), 7.57 (dd, *J* = 6.7, 2.0 Hz, 2H), 6.99 (dd, *J* = 6.7, 2.0 Hz, 2H), 3.93 (s, 3H), 3.86 (s, 3H); **^{13}C NMR** ($CDCl_3$, 100 MHz) δ 189.4, 167.3, 160.0, 145.4, 132.6, 130.3, 128.6, 126.7, 114.6, 55.6, 52.3; **HRMS** (ESI) calcd for $C_{15}H_{15}O_3$ $[M+H]^+$ *m*/*z* 243.1021, found 243.1020.



14

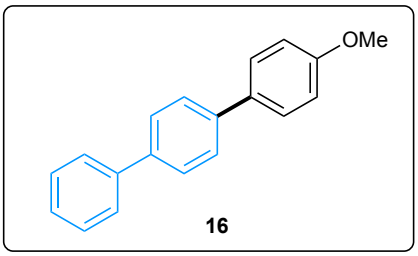
4'-Methoxybiphenyl]-4-carbonitrile (14). Followed Method B (*in situ*) using 4-cyanobenzoic acid (30 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **14** as a white solid (32 mg, 76% yield): **mp** 102-104 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.69 (d, *J* = 8.1 Hz, 2H), 7.64 (d, *J* = 8.1 Hz, 2H), 7.54 (d, *J* = 8.7 Hz, 2H), 7.01 (d, *J* = 8.7 Hz, 2H), 3.87 (s, 1H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 160.40, 145.41, 132.76, 131.69, 128.55, 127.30, 119.29, 114.75, 110.30, 55.60; **HRMS** (EI) calcd for $C_{14}H_{11}NO$ $[M]^+$ *m*/*z* 209.0841, found 209.0840.



15

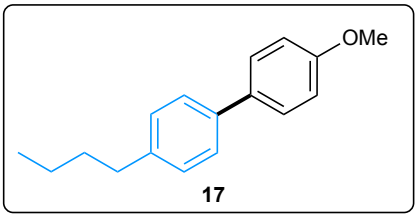
4-Methoxy-4'-(trifluoromethyl)biphenyl (15). Followed Method A using commercial 4-(trifluoromethyl)benzoyl fluoride (38 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 97:3) afforded **15** as a white

solid (29 mg, 58% yield): **mp** 121-122 ºC; **^{1}H NMR** ($CDCl_3$, 400 MHz) δ 7.67 (d, *J* = 8.9 Hz, 2H), 7.65 (d, *J* = 8.9 Hz, 2H), 7.55 (d, *J* = 8.7 Hz, 2H), 7.01 (d, *J* = 8.7 Hz, 2H), 3.87 (s, 3H); **^{13}C NMR** ($CDCl_3$, 126 MHz) δ 160.07, 144.50, 132.39, 128.89, (q, *J* = 32.2 Hz), 128.56, 127.08, 125.88, (q, *J* = 3.7 Hz), 124.54 (q, *J* = 271.6 Hz), 114.65, 55.59; **^{19}F NMR** (376 MHz, $CDCl_3$) δ –62.34 (CF_3); **HRMS** (EI) calcd for $C_{14}H_{11}F_3O$ $[M]^+$ *m*/*z* 252.0762, found 252.0760.



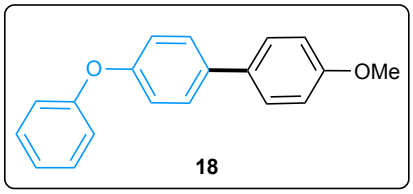
16

4-Methoxyterphenyl (16). Followed Method B (*in situ*) using biphenyl-4-carboxylic acid (40 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Reaction was performed at 115 ºC. Purification by flash chromatography on silica gel (hexanes/EtOAc, 99:1) afforded **16** as a white solid (36 mg, 69% yield): **mp** 220-222 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.66-7.62 (multiple peaks, 6H), 7.57 (dd, *J* = 8.6, 1.3 Hz, 2H), 7.47-7.44 (multiple peaks, 2H), 7.35 (tt, *J* = 7.4, 1.2 Hz, 1H), 7.01 (dd, *J* = 8.5, 1.3 Hz, 2H), 3.87 (3H, s); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 159.42, 140.98, 139.94, 139.70, 133.42, 129.01, 128.96, 128.27, 127.67, 127.45, 127.25, 127.21, 114.47, 55.58; **HRMS** (EI) calcd for $C_{19}H_{16}O$ $[M]^+$ *m*/*z* 260.1201, found 260.1203.



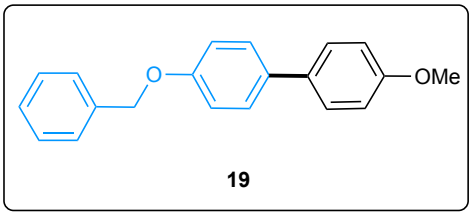
17

4-Butyl-4'-methoxybiphenyl (17). Followed Method A using **17**-COF (36 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). *GCMS analysis of the reaction crude mixture showed the formation of ketone as byproduct.* Purification by flash chromatography on silica gel (hexanes/EtOAc, 99:1) afforded **17** as a white solid (17 mg, 35% yield): **mp** 69-70 ºC; **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 7.54 (d, *J* = 8.3 Hz, 2H), 7.49 (d, *J* = 8.7 Hz, 2H), 7.25 (d, *J* = 8.3 Hz, 2H), 6.99 (d, *J* = 8.7 Hz, 2H), 3.86 (s, 3H); 2.66 (dd, *J* = 8.6, 6.8 Hz, 2H), 1.64 (m, 2H), 1.41 (m, 2H), 0.97 (t, *J* = 7.3 Hz, 3H); **^{13}C NMR** ($CDCl_3$, 126 MHz) δ 159.12, 141.61, 138.36, 133.99, 128.99, 128.17, 126.76, 114.35, 55.53, 35.48, 33.89, 22.63, 14.20; **HRMS** (EI) calcd for $C_{17}H_{20}O$ $[M]^+$ *m*/*z* 240.1514, found 240.1515.



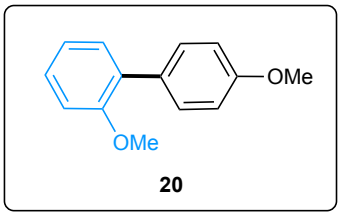
18

4-Methoxy-4'-phenoxybiphenyl (18). Followed Method B (*in situ*) using 4-phenoxybenzoic acid (43 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 98:2) afforded **18** as a white solid (29 mg, 51% yield): **mp** 130-132 ºC; **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 7.52 (d, *J* = 7.3 Hz, 2H), 7.50 (d, *J* = 7.3 Hz, 2H), 7.37-7.34 (multiple peaks, 2H), 7.12 (m, 1H), 7.08-7.05 (multiple peaks, 4H), 6.98 (d, *J* = 8.8 Hz, 2H), 3.85 (s, 3H); **^{13}C NMR** ($CDCl_3$, 126 MHz) δ 159.19, 157.52, 156.49, 136.24, 133.37, 129.97, 128.20, 128.13, 123.46, 119.36, 119.09, 114.44, 55.58; **HRMS** (EI) calcd for $C_{19}H_{16}O_2$ $[M]^+$ *m*/*z* 276.1150, found 276.1146.



19

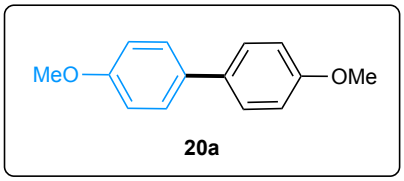
4-(Benzyloxy)-4'-methoxybiphenyl (19). Followed Method A using **19-**COF (46 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). *GCMS analysis of the reaction crude mixture showed the formation of ketone byproduct.* Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **19** as a white solid (51 mg, 59% yield): **mp** 168-170 ºC; **^{1}H NMR** (700 MHz, $CDCl_3$) δ 7.50-7.43 (multiple peaks, 6H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.34 (t, *J* = 7.4 Hz, 1H), 7.03 (d, *J* = 8.6 Hz, 2H), 6.96 (d, *J* = 8.7 Hz, 2H), 5.11 (s, 2H), 3.84 (s, 3H); **^{13}C NMR** (176 MHz, $CDCl_3$) δ 158.93, 158.13, 137.27, 133.96, 133.66, 128.82, 128.19, 127.96, 127.95, 127.69, 115.34, 114.38, 70.33, 55.57. **HRMS** (EI) calcd for $C_{20}H_{18}O_2$ $[M]^+$ *m*/*z* 290.1307, found 290.1308.



20

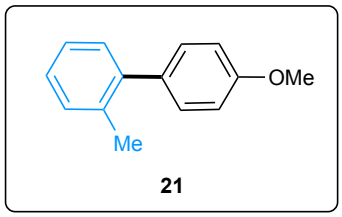
2,4'-Dimethoxybiphenyl (20). Followed Method A using 2-methoxybenzoyl fluoride[12] (46 mg, 0.3 mmol) and aryl boronic acid **10** (90 mg, 0.6 mmol). *^{19}F NMR analysis of the reaction crude mixture showed unreacted acid fluoride.* Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **20** as a colorless oil (34 mg, 52% yield): **^{1}H NMR** (700 MHz, $CDCl_3$) δ 7.51 (d, *J* = 8.7 Hz, 2H), 7.34-7.31 (multiple peaks, 2H), 7.05 (td, *J* = 7.4, 1.1 Hz, 1H), 7.01-6.98 (multiple peaks, 3H), 3.87 (s, 3H), 3.84 (s, 3H); **^{13}C NMR** (176 MHz, $CDCl_3$) δ 158.83,

156.64, 131.09, 130.86, 130.78, 130.52, 128.35, 121.01, 113.67, 111.38, 55.72, 55.45; **HRMS** (EI) calcd for $C_{14}H_{14}O_2$ $[M]^+$ *m/z* 214.0994, found 214.0996.



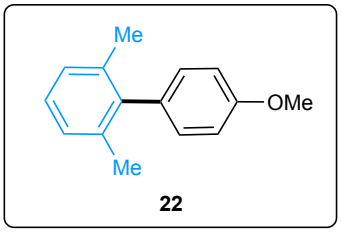
20a

4,4'-Dimethoxybiphenyl (20a). Followed Method A using 4-methoxybenzoyl fluoride[9] (46 mg, 0.3 mmol) and aryl boronic acid **10** (90 mg, 0.6 mmol). *GCMS analysis of the reaction crude mixture showed the formation of ketone byproduct. We note that product **20a** in this reaction can not not be distinguished from the potential homo-coupling of the boronic acid **10**, so we chose not to include these results from the body of the manuscript.* Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **20a** as a white solid (21 mg, 32% yield): **mp** 172-174 °C; **^{1}H NMR** (401 MHz, $CDCl_3$) δ 7.48 (d, *J* = 8.8 Hz, 4H), 6.96 (d, *J* = 8.8 Hz, 4H), 3.85 (s, 6H); **^{13}C NMR** (176 MHz, $CDCl_3$) δ 158.90, 133.70, 127.94, 114.38, 55.56; **HRMS** (EI) calcd for $C_{14}H_{14}O_2$ $[M]^+$ *m/z* 214.0994, found 214.0994.



21

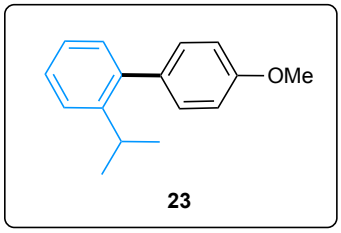
4'-Methoxy-2-methylbiphenyl (21).[13] Followed Method A using 2-methylbenzoyl fluoride[14] (41.5 mg, 0.3 mmol) and aryl boronic acid **10** (90 mg, 0.6 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 97:3) afforded **21** as a colorless oil (36 mg, 60% yield): **^{1}H NMR** (700 MHz, $CDCl_3$) δ 7.26-7.22 (multiple peaks, 6H), 6.96 (d, *J* = 8.6 Hz, 2H), 3.86 (s, 3H), 2.28 (s, 3H); **^{13}C NMR** (176 MHz, $CDCl_3$) δ 158.72, 141.76, 135.69, 134.59, 130.49, 130.45, 130.11, 127.17, 125.95, 113.70, 55.50, 20.76; **HRMS** (EI) calcd for $C_{14}H_{14}O$ $[M]^+$ *m/z* 198.1045, found 198.1052.



22

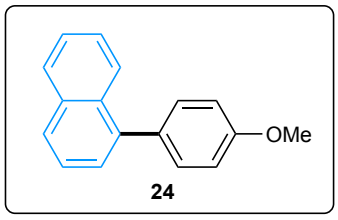
4'-Methoxy-2,6-dimethylbiphenyl (22). Followed Method B (*in situ*) using 2,6-dimethylbenzoic acid (45 mg, 0.3 mmol) and aryl boronic acid **10** (90 mg, 0.6 mmol). *^{19}F NMR analysis of the crude mixture showed unreacted carboxylic acid fluoride.* Purification by flash chromatography on silica

gel (hexanes/EtOAc, 98:2) afforded **22** as a colorless oil (29 mg, 46% yield): **^{1}H NMR** (700 MHz, $CDCl_3$) δ 7.15 (dd, *J* = 8.1, 6.9 Hz, 1H), 7.10 (d, *J* = 7.5 Hz, 2H), 7.06 (d, *J* = 8.6 Hz, 2H), 6.97 (d, *J* = 8.6 Hz, 2H), 3.86 (s, 3H), 2.04 (s, 6H); **^{13}C NMR** (176 MHz, $CDCl_3$) δ 158.46, 141.72, 136.74, 133.53, 130.27, 127.44, 127.09, 114.01, 55.44, 21.13; **HRMS** (EI) calcd for $C_{15}H_{16}O$ $[M]^+$ *m*/*z* 212.1201, found 212.1201.



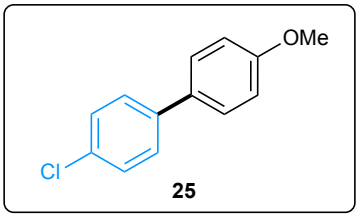
23

2-Isopropyl-4'-methoxybiphenyl (23).[15] Followed Method A using **23**-COF (50 mg, 0.3 mmol) and aryl boronic acid **10** (90 mg, 0.6 mmol). *^{19}F NMR analysis of the crude mixture showed unreacted carboxylic acid fluoride.* Purification by flash chromatography on silica gel (hexanes/EtOAc, 98:2) afforded **23** as a colorless oil (31 mg, 45% yield): **^{1}H NMR** (700 MHz, $CDCl_3$) δ 7.42 (m, 1H), 7.37–7.32 (multiple peaks, 2H), 7.22 (d, *J* = 8.6 Hz, 1H), 7.19–7.15 (m, 1H), 6.95 (d, *J* = 8.6 Hz, 2H), 3.86 (s, 3H), 3.08 (p, *J* = 6.9 Hz, 1H), 1.16 (d, *J* = 6.9 Hz, 6H; **^{13}C NMR** (176 MHz, $CDCl_3$) δ 158.66, 146.78, 140.89, 134.66, 130.53, 130.36, 127.64, 125.71, 125.46, 113.59, 55.50, 29.53, 24.50; **HRMS** (EI) calcd for $C_{16}H_{18}O$ $[M]^+$ *m*/*z* 226.1358, found 226.1364.



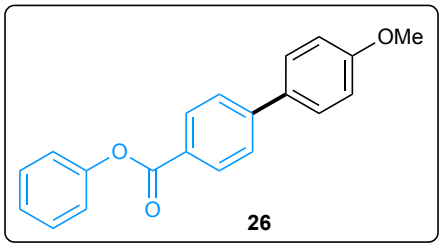
24

1-(4-Methoxyphenyl)naphthalene (24). Followed Method B (*in situ*) using 1-naphthoic acid (35 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 99:1) afforded **24** as a white solid (43 mg, 92% yield): **mp** 113-114 ºC; **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 7.95 (d, *J* = 8.6 Hz, 1H), 7.92 (d, *J* = 8.2 Hz, 1H), 7.85 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.56-7.48 (multiple peaks, 2H), 7.45 (d, *J* = 8.6 Hz, 2H), 7.47-7.41 (multiple peaks, 2H), 7.05 (d, *J* = 8.6 Hz, 2H), 3.91 (s, 3H); **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 159.2, 140.1, 134.1, 133.3, 132.0, 131.3, 128.5, 127.5, 127.1, 126.3, 126.1, 125.9, 125.6, 113.9, 55.6; **HRMS** (EI) calcd for $C_{17}H_{14}O$ $[M]^+$ *m*/*z* 234.1045, found 234.1047.



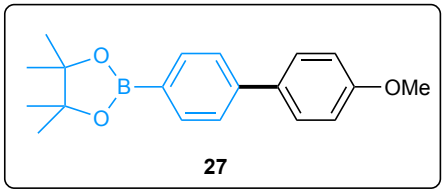
25

4-Chloro-4'-methoxybiphenyl (25). Followed Method A using **25**-COF (32 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 99:1) afforded **25** as a white solid (27 mg, 65% yield): **mp** 111-112 ºC; **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 7.49 (d, *J* = 8.5 Hz, 2H), 7.47 (d, *J* = 8.2 Hz, 2H), 7.38 (d, *J* = 8.2 Hz, 2H), 6.98 (d, *J* = 8.5 Hz, 2H), 3.85 (s, 3H); **^{13}C NMR** ($CDCl_3$, 125 MHz) δ 159.58, 139.48, 132.88, 132.70, 129.04, 128.22, 128.13, 114.52, 55.57; **HRMS** (EI) calcd for $C_{13}H_{11}ClO$ $[M]^+$ *m*/*z* 218.0498, found 218.0499.



26

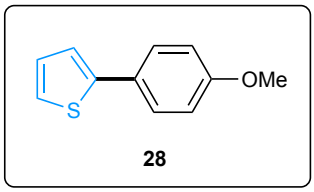
Phenyl 4'-methoxybiphenyl-4-carboxylate (26). Followed Method B (*in situ*) using 4-(phenoxycarbonyl)benzoic acid (49 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **26** as a white solid (50 mg, 83% yield): **mp** 152-154 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.24 (d, *J* = 8.3 Hz, 2H), 7.70 (d, *J* = 8.3 Hz, 2H), 7.61 (d, *J* = 8.6 Hz, 2H), 7.48-7.38 (multiple peaks, 2H), 7.29 (m, 1H), 7.24 (d, *J* = 8.2 Hz, 2H), 7.02 (d, *J* = 8.6 Hz, 2H), 3.88 (s, 3H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 165.36, 160.17, 151.21, 146.11, 132.45, 130.94, 129.71, 128.65, 127.79, 126.85, 126.07, 121.97, 114.64, 55.62; **HRMS** (ESI) calcd for $C_{17}H_{14}O$ $[M+H]^+$ *m*/*z* 305.1178, found 305.1183.



27

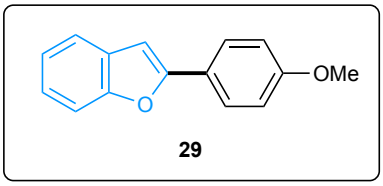
2-(4'-Methoxy-[1,1'-biphenyl]-4-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (27). Followed Method B (*in situ*) using 4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzoic acid (50 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **27** as a colorless solid (52 mg, 84% yield): **mp** 147-149 °C; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.88 (d, *J* = 7.6 Hz, 2H), 7.59-7.57 (multiple peaks, 4H), 6.99 (d, *J* = 8.6 Hz, 2H), 3.86 (s, 3H), 1.37 (s, 12H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 159.60, 143.67, 135.46,

133.69, 128.44, 126.17, 114.42, 83.95, 55.54, 25.09 (the carbon attached to boron was not observed); **HRMS** (EI) calcd for $C_{19}H_{23}BO_3$ $[M]^+$ *m*/*z* 310.1740, found 310.1741.



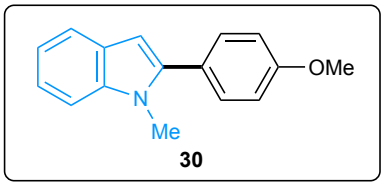
28

2-(4-Methoxyphenyl)thiophene (28). Followed Method A using **28-**COF (26 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 92:8) afforded **28** as a white solid (25 mg, 65% yield): **mp** 108-109 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.54 (d, *J* = 8.4 Hz, 2H), 7.21 (d, *J* = 5.1 Hz, 1H), 7.20 (d, *J* = 3.5 Hz, 1H), 7.05 (dd, *J* = 5.1, 3.5 Hz, 1H), 6.92 (d, *J* = 8.4 Hz, 2H), 3.84 (s, 3H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 159.39, 144.55, 128.12, 127.52, 127.44, 124.04, 122.29, 114.49, 55.58; **HRMS** (EI) calcd for $C_{11}H_{10}OS$ $[M]^+$ *m*/*z* 190.0452, found 190.0459.



29

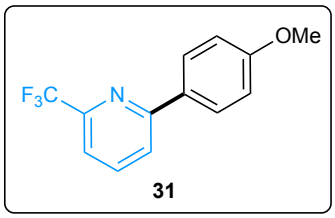
2-(4-Methoxyphenyl)benzofuran (29). Followed Method A using **29-**COF (33 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **29** as a white solid (24 mg, 54% yield): **mp** 125-127 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.81 (d, *J* = 8.8 Hz, 2H), 7.56 (d, *J* = 7.1 Hz, 1H), 7.51 (m, 1H), 7.28-7.17 (multiple peaks, 2H), 6.99 (d, *J* = 8.8 Hz, 2H), 6.89 (s, 1H), 3.86 (s, 3H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 160.19, 156.26, 154.91, 129.70, 126.62, 123.94, 123.56, 123.03, 120.77, 114.46, 111.19, 99.88, 55.56; **HRMS** (ESI) calcd for $C_{15}H_{13}O_2$ $[M+H]^+$ *m*/*z* 225.0916, found 225.0913.



30

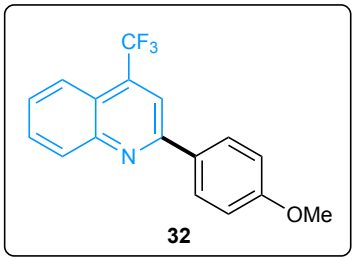
2-(4-Methoxyphenyl)-1-methyl-1*H*-indole (30). Followed Method A using **30-**COF (35 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **30** as a white solid (32 mg, 68% yield): **mp** 121-122 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.64 (d, *J* = 7.8 Hz, 1H), 7.45 (d, *J* = 8.6 Hz, 2H), 7.36 (d, *J* = 8.2 Hz, 1H), 7.25 (m, 1H), 7.15 (m, 1H), 7.02 (d, *J* = 8.6 Hz, 2H), 6.52 (s, 1H), 3.88 (s, 3H), 3.74 (s, 3H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 159.63, 141.62, 138.32, 130.82, 128.18, 125.46, 121.58, 120.46,

119.97, 114.15, 109.71, 101.20, 55.57, 31.28; **HRMS** (ESI) calcd for $C_{16}H_{16}NO$ $[M+H]^+$ *m*/*z* 238.1232, found 238.1226.



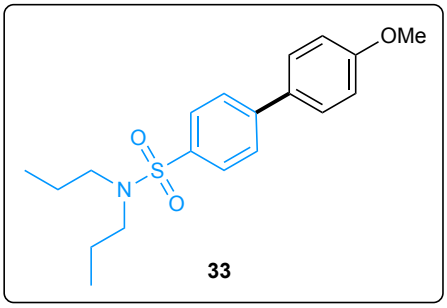
31

2-(4-Methoxyphenyl)-6-(trifluoromethyl)pyridine (31). Followed Method B (*in situ*) using 6-(trifluoromethyl)picolinic acid (38 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **31** as a white solid (35 mg, 69% yield): **mp** 98-100 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.89 (s, 1H), 8.00 (d, *J* = 8.9 Hz, 2H), 7.89 (m, 1H), 7.74 (d, *J* = 8.3 Hz, 1H), 7.01 (d, *J* = 8.9 Hz, 2H), 3.86 (s, 3H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 161.51, 160.39, 146.64 (q, *J* = 4.0 Hz), 133.92 (q, *J* = 3.4 Hz), 130.62, 128.83, 124.14 (q, *J* = 37.8 Hz), 124.06, (q, *J* = 272.2 Hz), 119.17, 114.49, 55.53; **^{19}F NMR** ($CDCl_3$, 471 MHz) δ –62.20 (s, CF_3); **HRMS** (ESI) calcd for $C_{13}H_{11}F_3NO$ $[M+H]^+$ *m*/*z* 254.0793, found 254.0791.



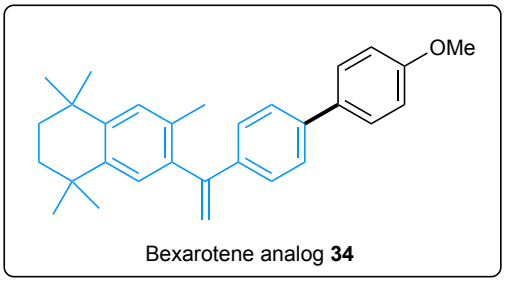
32

2-(4-Methoxyphenyl)-4-(trifluoromethyl)quinoline (32). Followed Method B (*in situ*) using 4-(trifluoromethyl)quinoline-2-carboxylic acid (12 mg, 0.05 mmol) and aryl boronic acid **10** (15 mg, 0.1 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **32** as a light brown solid (11 mg, 73% yield): **mp** 128-130 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.22 (d, *J* = 8.4 Hz, 1H), 8.17 (d, *J* = 8.3 Hz, 2H), 8.13-8.11 (multiple peaks, 2H), 7.79 (dd, *J* = 8.4, 7.0 Hz, 1H), 7.62 (dd, *J* = 8.4, 7.0 Hz, 1H), 7.07 (d, *J* = 8.3 Hz, 2H), 3.90 (s, 3H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ; 161.57, 156.37, 149.33, 135.06 (q, *J* = 31.2 Hz), 131.21, 130.61, 130.51, 129.12, 127.66, 124.05 (q, *J* = 2.3 Hz), 123.85 (d, *J* = 274.3 Hz), 121.73, 115.77 (q, *J* = 5.4 Hz), 114.64, 55.67; **HRMS** (ESI) calcd for $C_{17}H_{13}F_3NO$ $[M+H]^+$ *m*/*z* 304.0949, found 304.0948.



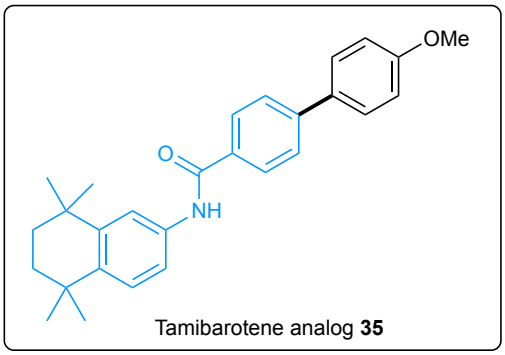
33

4'-Methoxy-*N*,*N*-dipropylbiphenyl-4-sulfonamide (33). Followed Method A using **40** (57 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **33** as a white solid (67 mg, 96% yield). *In situ* reaction following Method B gave **33** in 92% yield. **Mp** 89-90 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.83 (d, *J* = 8.4 Hz, 2H), 7.66 (d, *J* = 8.4 Hz, 2H), 7.56 (d, *J* = 8.7 Hz, 2H), 7.00 (d, *J* = 8.7 Hz, 2H), 3.87 (s, 3H), 3.23-2.93 (multiple peaks, 4H), 1.68-1.54 (multiple peaks, 4H), 0.89 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 160.21, 144.86, 138.24, 132.00, 128.60, 127.80, 127.16, 114.69, 55.62, 50.34, 22.33, 11.45; **HRMS** (ESI) calcd for $C_{19}H_{26}NO_3S$ $[M+H]^+$ *m*/*z* 348.1633, found 348.1637.



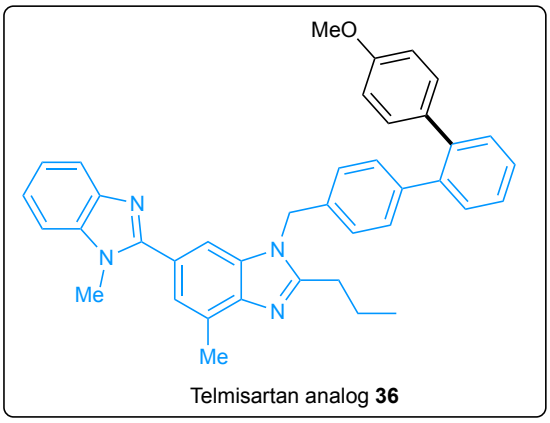
Bexarotene analog **34**

6-(1-(4'-Methoxybiphenyl-4-yl)vinyl)-1,1,4,4,7-pentamethyl-1,2,3,4-tetrahydronaphthalene (34). Followed Method B (*in situ*) using bexarotene (70 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **34** as a white solid (64 mg, 76% yield): **mp** 129-131 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.54 (d, *J* = 8.7 Hz, 2H), 7.49 (d, *J* = 8.4 Hz, 2H), 7.34 (d, *J* = 8.4 Hz, 2H), 7.17 (s, 1H), 7.10 (s, 1H), 6.98 (d, *J* = 8.7 Hz, 2H), 5.78 (s, 1H), 5.22 (s, 1H), 3.85 (s, 3H), 2.03 (s, 3H), 1.72 (s, 4H), 1.32 (s, 6H), 1.30 (s, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 159.36, 149.58, 144.16, 142.32, 139.97, 139.47, 138.91, 133.53, 133.07, 128.26, 128.17, 128.06, 127.16, 126.67, 114.54, 114.43, 55.56, 35.50, 35.48, 34.21, 34.12, 32.17, 32.15, 20.18; **HRMS** (EI) calcd for $C_{30}H_{34}O$ $[M]^+$ *m*/*z* 410.2610, found 410.2612.



Tamibarotene analog **35**

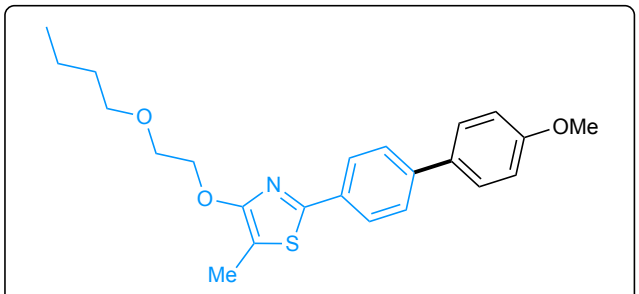
4'-Methoxy-*N*-(5,5,8,8-tetramethyl-5,6,7,8-tetrahydronaphthalen-2-yl)-biphenyl-4-carboxamide (35). Followed Method B (*in situ*) using tamibarotene (70 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **35** as a white solid (68 mg, 83% yield): **mp** 126-128 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.92 (d, *J* = 8.0 Hz, 2H), 7.76 (s, 1H), 7.67 (d, *J* = 8.0 Hz, 2H), 7.58 (d, *J* = 8.5 Hz, 2H), 7.56 (s, 1H), 7.44 (d, *J* = 8.5 Hz, 1H), 7.32 (d, *J* = 8.5 Hz, 1H), 7.01 (d, *J* = 8.5 Hz, 2H), 3.87 (s, 3H), 1.70 (s, 4H), 1.31 (s, 6H), 1.28 (s, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 165.52, 160.00, 146.02, 144.35, 141.60, 135.60, 133.34, 132.57, 128.51, 127.72, 127.47, 127.06, 118.32, 118.29, 114.62, 55.61, 35.31, 35.27, 34.67, 34.23, 32.09, 32.05; **HRMS** (ESI) calcd for $C_{28}H_{32}NO_2$ $[M+H]^+$ *m*/*z* 414.2433, found 414.2439.



Telmisartan analog **36**

3'-((4''-Methoxy-[1,1':2',1''-terphenyl]-4-yl)methyl)-1,7'-dimethyl-2'-propyl-1*H*,3'*H*-2,5'-bibenzo[*d*]imidazole (36). Followed Method B (*in situ*) using telmisartan (103 mg, 0.2 mmol) and aryl boronic acid **10** (60 mg, 0.4 mmol). Purification by flash chromatography on silica gel (DCM/MeOH, 90:10) followed by a second column chromatography on silica gel (hexanes/EtOAc/DCM/MeOH; 70:20:5:5) afforded **36** as a white solid (48 mg, 42% yield): **mp** 152-154 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.72-7.68 (multiple peaks, 2H), 7.63 (m, 1H), 7.55 (dd, *J* = 7.7, 1.3 Hz, 2H), 7.41-7.37 (multiple peaks, 3H), 7.34 (s, 1H), 7.30 (d, *J* = 8.0 Hz, 2H), 7.27-7.22 (m, 4H), 7.11 (d, *J* = 8.8 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 6.65 (d, *J* = 8.6 Hz, 2H), 5.31 (s, 2H), 3.66 (s, 3H), 3.65 (s, 3H), 2.820 (m, 2H), 2.71 (s, 3H), 1.79 (h, *J* = 7.5 Hz, 1H), 0.97 (t, *J* = 7.3 Hz, 2H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 156.46, 156.41, 154.62, 143.18, 142.83, 139.90,

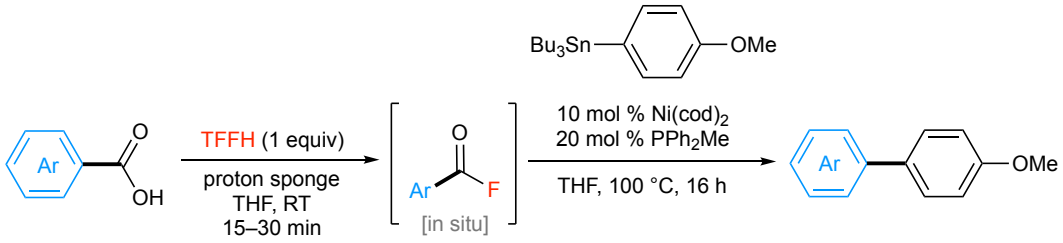
138.73, 136.69, 135.96, 135.40, 135.07, 131.00, 130.54, 130.48, 130.31, 130.22, 129.49, 129.37, 128.79, 128.73, 128.67, 127.75, 126.54, 123.92, 123.90, 122.56, 122.35, 121.80, 119.46, 114.00, 109.67, 108.80, 55.43, 46.92, 31.83, 29.83, 21.83, 16.97, 14.14; **HRMS** (ESI) calcd for $C_{39}H_{37}N_4O$ $[M+H]^+$ *m*/*z* 577.2967, found 577.2969.



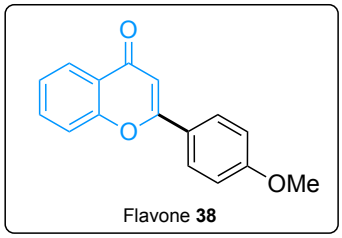
a RARβ2 agonist analog **37**

4-(2-Butoxyethoxy)-2-(4'-methoxy-biphenyl-4-yl)-5-methylthiazole (37). Followed Method B (*in situ*) using commercial 4-(4-(2-butoxyethoxy)-5-methylthiazol-2-yl)benzoic acid (34 mg, 0.1 mmol) and aryl boronic acid **10** (30 mg, 0.2 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **37** as a white solid (21 mg, 52% yield). *GCMS analysis of the isolated product showed the presence of protodecarboxylated carboxylic acid (~5% by ^{1}H NMR analysis) as an inseparable impurity*. **Mp** 88-89 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.88 (d, *J* = 8.3 Hz, 2H), 7.58 (d, *J* = 8.3 Hz, 2H), 7.56 (d, *J* = 8.7 Hz, 2H), 6.99 (d, *J* = 8.7 Hz, 2H), 4.52 (m, 2H), 3.86 (s, 3H), 3.78 (m, 2H), 3.54 (t, *J* = 6.7 Hz, 2H), 2.32 (s, 3H), 1.59 (m, 2H), 1.39 (m, 2H), 0.93 (t, *J* = 7.4 Hz, 3H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 159.75, 159.63, 159.36, 141.79, 133.07, 132.60, 128.23, 127.12, 125.94, 125.54, 114.50, 71.41, 69.99, 69.73, 55.59, 31.99, 19.51, 14.17, 9.63; **HRMS** (ESI) calcd for $C_{23}H_{28}NO_3S$ $[M+H]^+$ *m*/*z* 398.1790, found 398.1794.

XI. Ni-Catalysed Decarbonylative Stille Reaction with $ArSnBu_3$

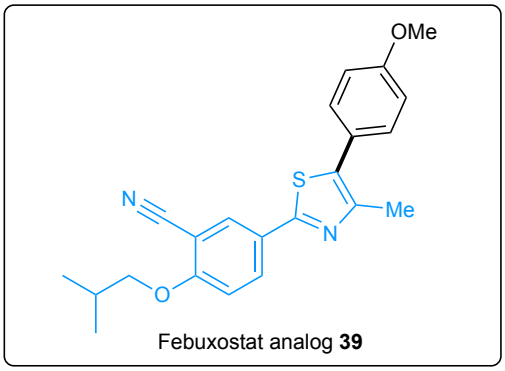


General procedure for decarbonylative Stille reaction (Method C, in situ, from carboxylic acid): In a nitrogen-filled glovebox, carboxylic acid (1 equiv, 0.2 mmol), TFFH (1 equiv, 0.2 mmol) and proton sponge (1 equiv, 0.2 mmol) were weighed into a 10 mL tall vial equipped with a 10 μm magnetic stir bar. THF (0.4 mL) was added, and the reaction mixture was stirred at room temperature for 15 to 30 min. A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.02 mmol) and PPh_2Me (0.2 equiv, 0.04 mmol) in THF (0.2 mL) was added. The aryl stannane (1.5 equiv, 0.4 mmol) was added, and the reaction mixture was capped and removed from the glovebox. The reaction mixture was stirred at 100 ºC for 16 h. The reaction was then cooled to room temperature, and EtOAc (5 mL) and brine (5 mL) were added. The organic layer was collected, and the aqueous solution was further extracted with EtOAc (2 x 5 mL). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by flash column chromatography on silica gel using EtOAc in hexanes.



Flavone **38**

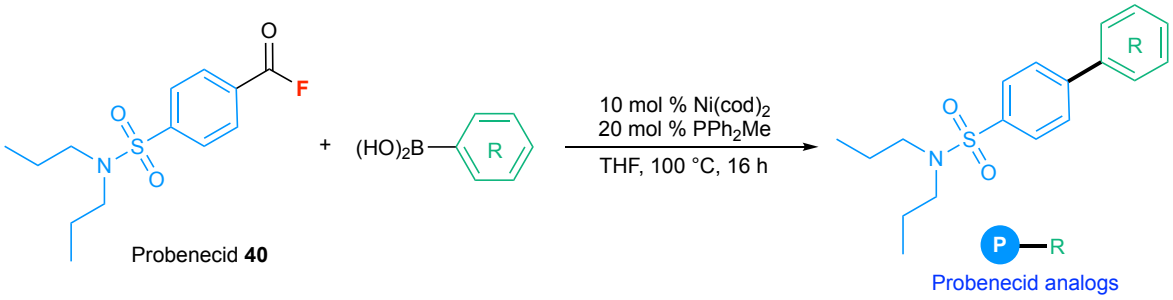
2-(4-Methoxyphenyl)-4*H*-chromen-4-one (38). Followed Method C (*in situ*) using 4-oxo-4*H*-chromene-2-carboxylic acid (38 mg, 0.2 mmol) and aryl stannane (119 mg, 0.3 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **38** as a white solid (46 mg, 92% yield): **mp** 156-158 ºC; **^{1}H NMR** ($CDCl_3$, 500 MHz) δ 8.21 (dd, *J* = 8.0, 1.7 Hz, 1H), 7.87 (d, *J* = 8.8 Hz, 2H), 7.67 (m, 1H), 7.53 (d, *J* = 8.4 Hz, 1H), 7.38 (m, 1H), 7.01 (d, *J* = 8.8 Hz, 2H), 6.73 (s, 1H), 3.88 (s, 3H); **^{13}C NMR** ($CDCl_3$, 126 MHz) δ 178.54, 163.58, 162.59, 156.37, 133.73, 128.19, 125.85, 125.26, 124.23, 124.14, 118.15, 114.66, 106.39, 55.70; **HRMS** (ESI) calcd for $C_{16}H_{13}O_3$ $[M+H]^+$ *m*/*z* 253.0865, found 253.0868.



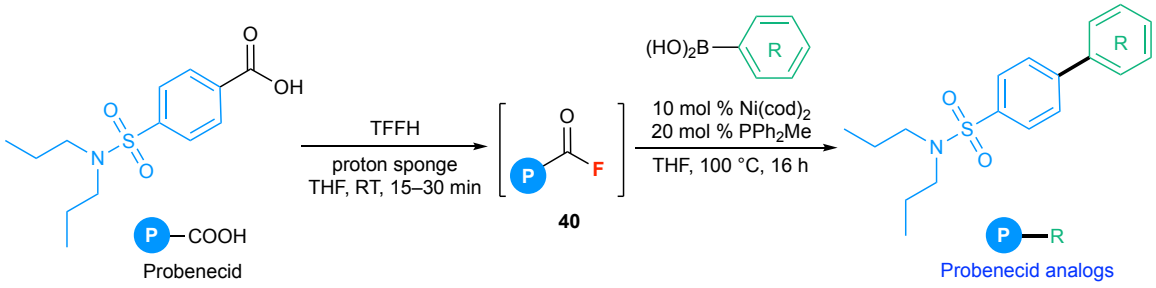
Febuxostat analog **39**

2-Isobutoxy-5-(5-(4-methoxyphenyl)-4-methylthiazol-2-yl)benzonitrile (39). Followed Method C (*in situ*) using febuxostat (63 mg, 0.2 mmol) and aryl stannane (119 mg, 0.3 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **39** as a white solid (67 mg, 88% yield): **mp** 130-132 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.12 (s, 1H), 8.06 (dd, *J* = 8.7, 1.9 Hz, 1H), 7.39 (d, *J* = 8.6 Hz, 2H), 6.99 (d, *J* = 8.9 Hz, 1H), 6.97 (d, *J* = 8.6 Hz, 2H), 3.89 (d, *J* = 6.4 Hz, 2H), 3.86 (s, 3H), 2.51 (s, 3H), 2.20 (m, 1H), 1.09 (d, *J* = 6.7 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 161.93, 161.81, 159.66, 148.59, 132.51, 132.08, 131.60, 130.63, 127.21, 124.32, 115.96, 114.45, 112.73, 102.93, 75.79, 55.61, 28.41, 19.31, 16.41; **HRMS** (ESI) calcd for $C_{22}H_{23}N_2O_2S$ $[M+H]^+$ *m*/*z* 379.1480, found 379.1486.

XII. Ni-Catalysed Decarbonylative Suzuki Reaction of Probenecid with Various Aryl Boronic Acids

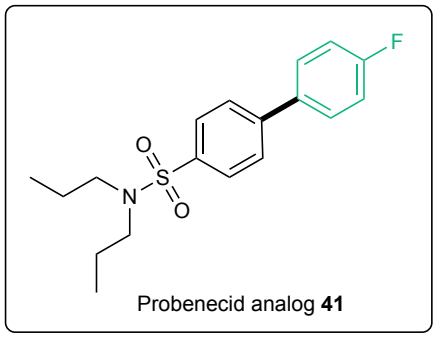


General procedure for decarbonylative Suzuki reaction (Method D, from acid fluoride): In a nitrogen-filled glovebox, probenecid acid fluoride **40** (1 equiv, 0.2 mmol) was weighed into a 10 mL tall vial equipped with a 10 μm magnetic stir bar. A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.02 mmol) and PPh_2Me (0.2 equiv, 0.04 mmol) in THF (0.6 mL) was added. The boronic acid (2 equiv, 0.4 mmol) was added, and the reaction mixture was removed from the glovebox. The reaction mixture was stirred at 100 ºC for 16 h. The reaction was then cooled to room temperature, and EtOAc (5 mL) and brine (5 mL) were added. The organic layer was collected, and the aqueous solution was further extracted with EtOAc (2 x 5 mL). The combined organic extracts were dried over Na_2SO_4, filtered and concentrated *in vacuo*. The crude product was purified by flash column chromatography on silica gel using EtOAc in hexanes.



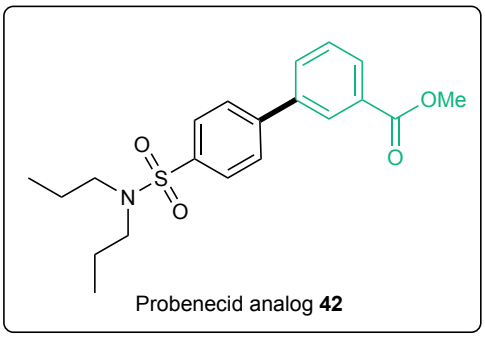
General procedure for decarbonylative Suzuki reaction (Method E, in situ, from carboxylic acid): In a nitrogen-filled glovebox, probenecid (1 equiv, 0.2 mmol), TFFH (1 equiv, 0.2 mmol), and proton sponge (1 equiv, 0.2 mmol) were weighed into a 10 mL tall vial equipped with a 10 μm magnetic stir bar. THF (0.4 mL) was added, and the reaction mixture was stirred at room temperature for 15 to 30 min. A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.02 mmol) and PPh_2Me (0.2 equiv, 0.04 mmol) in THF (0.2 mL) was added. The aryl boronic acid (2 equiv, 0.4 mmol) was added, and the reaction mixture was removed from the glovebox. The reaction mixture was stirred at 100 ºC for 16 h. The reaction was then cooled to room temperature, and EtOAc (5 mL) and brine (5 mL) were added. The organic layer was collected, and the aqueous solution was further

extracted with EtOAc (2 x 5 mL). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by flash column chromatography on silica gel using EtOAc in hexanes.



Probenecid analog **41**

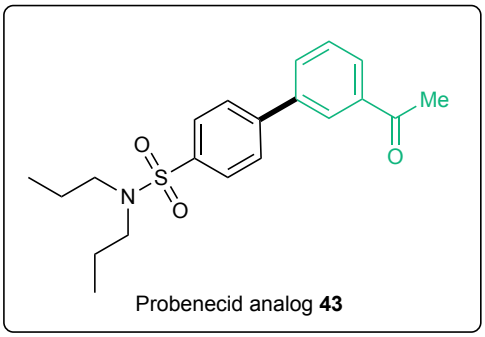
4'-Fluoro-(*N*,*N*-dipropyl)biphenyl-4-sulfonamide (**41**). Followed Method D using **40** (57 mg, 0.2 mmol) and and (4-fluorophenyl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **41** as a white solid (55 mg, 82% yield). *^{19}F NMR analysis of the crude reaction mixture showed a trace amount of fluorobenzene, the result of protodeboronation of (4-fluorophenyl)boronic acid. In situ* reaction following Method E gave **41** in 82% yield: **mp** 87-88 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.86 (d, *J* = 8.2 Hz, 2H), 7.65 (d, *J* = 8.2 Hz, 2H), 7.57 (dd, *J* = 8.6, 5.4 Hz, 2H), 7.17 (t, *J* = 8.6 Hz, 2H), 3.11 (m, 4H), 1.57 (m, 4H), 0.89 (t, *J* = 7.4 Hz, 3H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 163.26 (d, *J* = 248.1 Hz), 144.23, 139.07, 135.74 (d, *J* = 3.4 Hz), 129.17 (d, *J* = 8.2 Hz), 127.85, 127.61, 116.21 (d, *J* = 21.8 Hz), 50.32, 22.31, 11.43; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ –113.80 (m); **HRMS** (ESI) calcd for $C_{18}H_{23}FNO_2S$ $[M+H]^+$ *m*/*z* 336.1434, found 336.1439.



Probenecid analog **42**

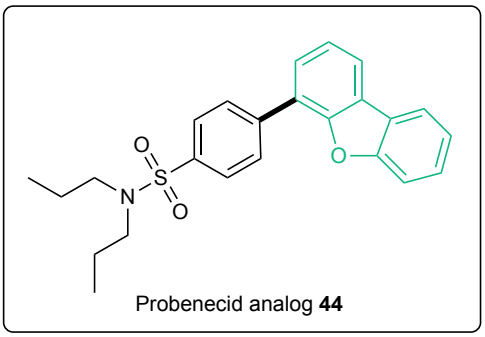
Methyl 4'-(*N*,*N*-dipropylsulfamoyl)biphenyl-3-carboxylate (**42**). Followed Method D using **40** (57 mg, 0.2 mmol) and (3-(methoxycarbonyl)phenyl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **42** as a thick oil (56 mg, 75% yield): **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.28 (s, 1H), 8.08 (d, *J* = 7.7 Hz, 1H), 7.89 (d, *J* = 8.2 Hz, 2H), 7.80 (d, *J* = 7.7 Hz, 1H), 7.73 (d, *J* = 8.1 Hz, 2H), 7.55 (t, *J* = 7.7 Hz, 1H), 3.95 (s, 3H), 3.11 (dd, *J* = 8.5, 6.8 Hz, 4H), 1.58 (m, 4H), 0.89 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz)

δ 166.92, 144.12, 139.88, 139.50, 131.79, 131.16, 129.57, 129.36, 128.60, 127.86, 127.84, 52.54, 50.27, 22.26, 11.41; **HRMS** (ESI) calcd for $C_{20}H_{26}NO_4S$ $[M+H]^+$ *m*/*z* 376.1583, found 376.1590.



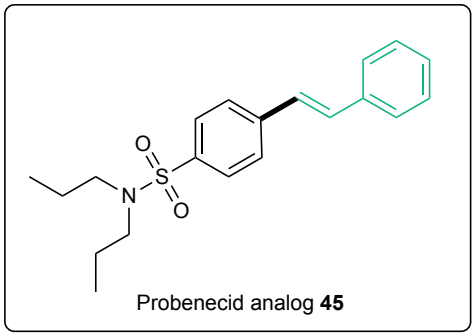
Probenecid analog **43**

3'-Acetyl-*N*,*N*-dipropylbiphenyl-4-sulfonamide (43). Followed Method D using **40** (57 mg, 0.2 mmol) and (3-acetylphenyl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **43** as a thick oil (64 mg, 89% yield): **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.19 (s, 1H), 7.98 (d, *J* = 7.2 Hz, 1H), 7.89 (d, *J* = 6.7 Hz, 2H), 7.81 (m, 1H), 7.73 (d, *J* = 6.7 Hz, 2H), 7.58 (m, 1H), 3.12 (m, 4H), 2.67 (s, 3H), 1.58 (m, 4H), 0.89 (t, *J* = 6.8 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 197.93, 144.20, 140.19, 139.66, 138.03, 131.97, 129.56, 128.49, 127.91, 127.90, 127.18, 50.29, 26.97, 22.28, 11.43; **HRMS** (ESI) calcd for $C_{20}H_{25}NO_3S$ $[M+H]^+$ *m*/*z* 360.1633, found 360.1635.



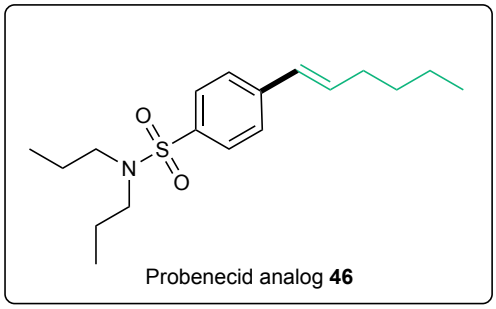
Probenecid analog **44**

4-(Dibenzo[*b*,*d*]furan-4-yl)-*N*,*N*-dipropylbenzenesulfonamide (44). Followed Method D using **40** (57 mg, 0.2 mmol) and dibenzo[*b*,*d*]furan-4-ylboronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **44** as a white solid (75 mg, 92% yield): **mp** 105-107 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.06 (d, *J* = 8.0 Hz, 2H), 8.01-7.99 (multiple peaks, 2H), 7.96 (d, *J* = 7.5 Hz, 2H), 7.62-7.61 (multiple peaks, 2H), 7.50 (m, 1H), 7.47 (m, 1H), 7.39 (t, *J* = 7.5 Hz, 1H), 3.16 (dd, *J* = 8.7, 6.7 Hz, 4H), 1.63 (m, 4H), 0.92 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 156.30, 153.42, 140.59, 139.21, 129.37, 127.74, 127.60, 127.00, 125.44, 124.15, 124.11, 123.58, 123.26, 121.02, 120.99, 112.04, 50.49, 22.45, 11.46; **HRMS** (ESI) calcd for $C_{24}H_{26}NO_3S$ $[M+H]^+$ *m*/*z* 408.1633, found 408.1630.



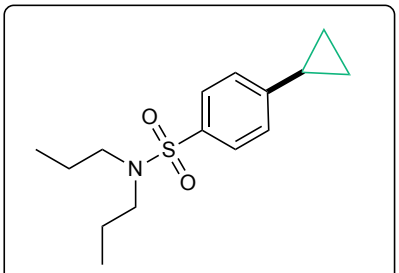
Probenecid analog **45**

(*E*)-*N*,*N*-Dipropyl-4-styrylbenzenesulfonamide (45). Followed Method D using **40** (57 mg, 0.2 mmol) and (*E*)-styrylboronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **45** as a white solid (47 mg, 69% yield): **mp** 102-104 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.78 (d, *J* = 8.1 Hz, 2H), 7.60 (d, *J* = 8.2 Hz, 2H), 7.53 (d, *J* = 7.3 Hz, 2H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.32 (m, 1H), 7.21 (d, *J* = 16.3 Hz, 1H), 7.11 (d, *J* = 16.3 Hz, 1H), 3.09 (dd, *J* = 8.7, 6.7 Hz, 4H), 1.56 (m, 4H), 0.88 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 141.46, 138.83, 136.73, 131.96, 129.03, 128.63, 127.73, 127.09, 127.03, 126.96, 50.23, 22.25, 11.43; **HRMS** (ESI) calcd for $C_{20}H_{26}NO_2S$ $[M+H]^+$ *m*/*z* 344.1684, found 344.1691.



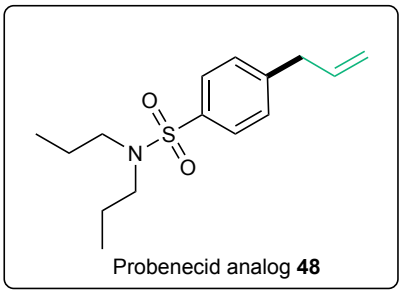
Probenecid analog **46**

(*E*)-4-(hex-1-en-1-yl)-*N*,*N*-dipropylbenzenesulfonamide (46). Followed Method D using **40** (86 mg, 0.3 mmol) and (*E*)-hex-1-en-1-ylboronic acid (2 equiv, 0.6 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **46** as a colorless oil (71 mg, 73% yield): **^{1}H NMR** (700 MHz, $CDCl_3$) δ 7.71 (d, *J* = 8.3 Hz, 2H), 7.42 (d, *J* = 8.3 Hz, 2H), 6.41-6.34 (multiple peaks, 2H), 3.06 (m, 4H), 2.24 (q, *J* = 6.9 Hz, 2H), 1.55 (m, 4H), 1.47 (m, 2H), 1.38 (m, 2H), 0.93 (t, *J* = 7.3 Hz, 3H), 0.87 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** (176 MHz, $CDCl_3$) δ 142.09, 138.07, 134.99, 128.63, 127.57, 126.39, 50.24, 33.01, 31.47, 22.49, 22.25, 14.14, 11.42; **HRMS** (ESI) calcd for $C_{18}H_{30}NO_2S$ $[M+H]^+$ *m*/*z* 324.1997, found 324.2001.



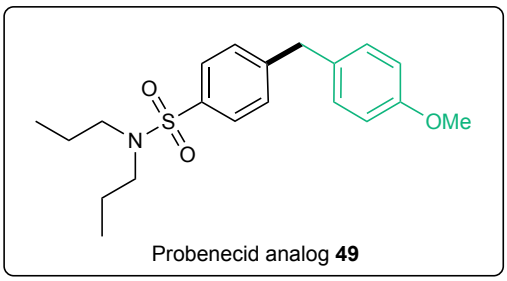
Probenecid analog **47**

4-Cyclopropyl-*N*,*N*-dipropylbenzenesulfonamide (47). Followed Method D using **40** (86 mg, 0.3 mmol) and cyclopropylboronic acid (2 equiv, 0.6 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 97:3) afforded **47** as a colorless oil (47 mg, 56% yield): **^{1}H NMR** (700 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.4 Hz, 2H), 7.13 (d, *J* = 8.4 Hz, 2H), 3.00 (m, 4H), 1.93 (tt, *J* = 8.5, 5.0 Hz, 1H), 1.54 (m, 4H), 1.05 (m, 2H), 0.86 (t, *J* = 7.4 Hz, 6H), 0.75 (dt, *J* = 6.7, 4.8 Hz, 2H); ^{13}C NMR (176 MHz, $CDCl_3$) δ 149.47, 136.99, 127.30, 126.03, 50.29, 22.27, 15.71, 11.39, 10.52; **HRMS** (ESI) calcd for $C_{15}H_{24}NO_2S$ $[M+H]^+$ *m*/*z* 282.1528, found 252.1529.



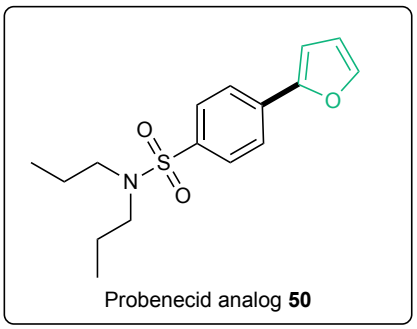
Probenecid analog **48**

4-Allyl-*N*,*N*-dipropylbenzenesulfonamide (48). Followed Method D using **40** (86 mg, 0.3 mmol) and allylboronic acid[16] (2 equiv, 0.6 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 97:3) afforded **48** as a colorless oil (36 mg, 42% yield): **^{1}H NMR** ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.1 Hz, 2H), 7.31 (d, *J* = 8.1 Hz, 2H), 5.95 (ddt, *J* = 16.8, 10.0, 6.7 Hz, 1H), 5.13 (dd, *J* = 10.0, 1.6 Hz, 1H), 5.10 (dd, *J* = 17.0, 1.6 Hz, 1H), 3.45 (d, *J* = 6.7 Hz, 2H), 3.06 (m, 4H), 1.55 (m, 4H), 0.87 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** (176 MHz, $CDCl_3$) δ 145.02, 138.12, 136.26, 129.33, 127.46, 117.14, 50.29, 40.13, 22.29, 11.42; **HRMS** (ESI) calcd for $C_{15}H_{24}NO_2S$ $[M+H]^+$ *m*/*z* 282.1528, found 252.1532.



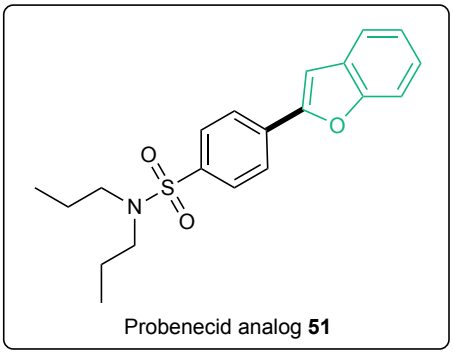
Probenecid analog **49**

4-(4-Methoxybenzyl)-*N*,*N*-dipropylbenzenesulfonamide (49). Followed Method D using **40** (86 mg, 0.3 mmol) and (4-methoxybenzyl)boronic acid[17] (2 equiv, 0.6 mmol). *GCMS analysis of the isolated product showed the presence of ketone byproduct (7% by ^{1}H NMR analysis).* Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **49** as a colorless oil (55 mg, 51% yield): **^{1}H NMR** (700 MHz, $CDCl_3$) δ 8.16 (d, *J* = 8.5 Hz, 2H), 7.85 (d, *J* = 8.5 Hz, 2H), 7.39 (d, *J* = 8.6 Hz, 2H), 6.92 (d, *J* = 8.6 Hz, 2H), 5.32 (s, 2H), 3.82 (s, 3H), 3.08 (m, 4H), 1.54 (m, 4H), 0.86 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** (176 MHz, $CDCl_3$) δ 165.38, 144.48, 133.78, 130.53, 130.51, 127.80, 127.18, 114.28, 67.43, 55.53, 50.11, 22.12, 11.37; **HRMS** (ESI) calcd for $C_{20}H_{28}NO_3S$ $[M+H]^+$ *m*/*z* 362.1790, found 362.1790.



Probenecid analog **50**

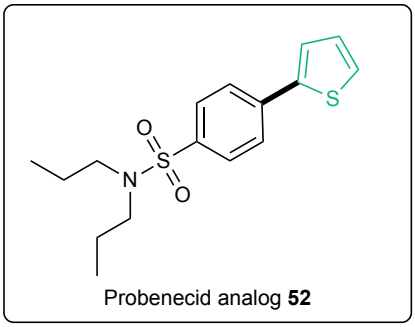
4-(Furan-2-yl)-*N*,*N*-dipropylbenzenesulfonamide (50). Followed Method D using **40** (57 mg, 0.2 mmol) and furan-2-ylboronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **50** as a white solid (36 mg, 58% yield): **mp** 80-81 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.80 (d, *J* = 8.3 Hz, 2H), 7.76 (d, *J* = 8.3 Hz, 2H), 7.53 (s, 1H), 6.79 (d, *J* = 3.4 Hz, 1H), 6.52 (m, 1H), 3.10 (dd, *J* = 8.5, 6.9 Hz, 4H), 1.56 (m, 4H), 0.88 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 152.47, 143.56, 134.44, 129.15, 127.22, 124.07, 112.31, 107.73, 50.16, 22.18, 11.42; **HRMS** (EI) calcd for $C_{15}H_{22}NO_3S$ $[M+H]^+$ *m*/*z* 308.1320, found 308.1315.



Probenecid analog **51**

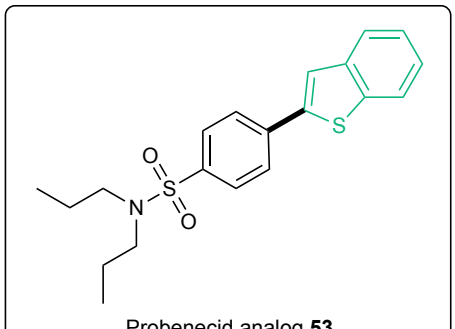
4-(Benzofuran-2-yl)-*N*,*N*-dipropylbenzenesulfonamide (51). Followed Method D using **40** (57 mg, 0.2 mmol) and benzofuran-2-ylboronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **51** as a white solid (58 mg, 82% yield): **mp** 86-87 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.92 (d, *J* = 8.2 Hz, 2H), 7.84 (d, *J* = 8.4 Hz,

2H), 7.59 (d, *J* = 7.7 Hz, 1H), 7.50 (d, *J* = 8.2 Hz, 1H), 7.32 (t, *J* = 7.7 Hz, 1H), 7.22 (m, 1H), 7.12 (s, 1H), 3.08 (dd, *J* = 8.6, 6.7 Hz, 4H), 1.54 (m, 4H), 0.85 (t, *J* = 7.3 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 155.36, 154.12, 139.71, 134.17, 128.95, 127.80, 125.46, 125.29, 123.52, 121.58, 111.56, 103.94, 50.19, 22.21, 11.41; **HRMS** (ESI) calcd for $C_{20}H_{24}NO_3S$ $[M+H]^+$ *m*/*z* 358.1477, found 358.1475.



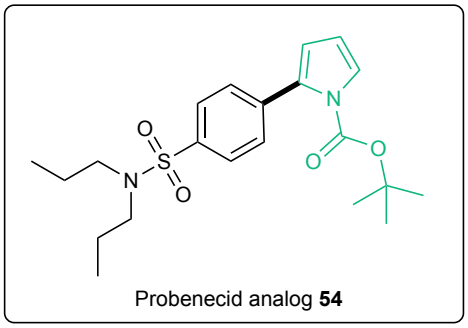
Probenecid analog **52**

***N*,*N*-Dipropyl-4-(thiophen-2-yl)benzenesulfonamide (52).** Followed Method D using **40** (57 mg, 0.2 mmol) and thiophen-2-ylboronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **52** as a white solid (46 mg, 71% yield): **mp** 77-78 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.79 (d, *J* = 8.2 Hz, 2H), 7.71 (d, *J* = 8.2 Hz, 2H), 7.41 (d, *J* = 3.7 Hz, 1H), 7.37 (d, *J* = 5.0 Hz, 1H), 7.12 (dd, *J* = 5.0, 3.7 Hz, 1H), 3.08 (dd, *J* = 8.6, 6.7 Hz, 4H), 1.54 (m, 4H), 0.88 (t, *J* = 7.2 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 142.56, 138.82, 138.33, 128.62, 127.98, 126.78, 126.21, 124.95, 50.26, 22.26, 11.44; **HRMS** (ESI) calcd for $C_{16}H_{22}NO_2S_2$ $[M+H]^+$ *m*/*z* 324.1092, found 324.1089.



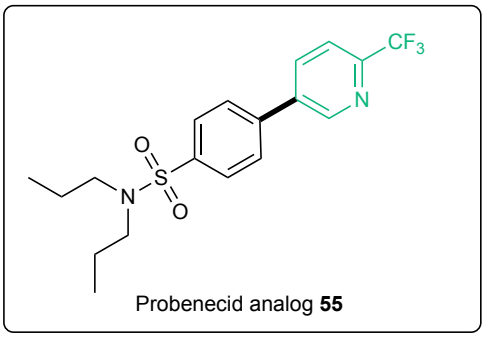
Probenecid analog **53**

4-(Benzo[*b*]thiophen-2-yl)-*N*,*N*-dipropylbenzenesulfonamide (53). Followed Method D using **40** (57 mg, 0.2 mmol) and benzo[*b*]thiophen-2-ylboronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **53** as a white solid (62 mg, 83% yield): **mp** 82-83 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.85 (d, *J* = 8.7 Hz, 2H), 7.84-7.82 (multiple peaks, 2H), 7.81 (d, *J* = 8.7 Hz, 2H), 7.66 (s, 1H), 7.40-7.35 (multiple peaks, 2H), 3.12 (dd, *J* = 8.7, 6.7 Hz, 4H), 1.59 (m, 4H), 0.90 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 142.22, 140.61, 140.09, 139.64, 138.28, 127.98, 126.90, 125.35, 125.09, 124.26, 122.60, 121.57, 50.31, 22.30, 11.44; **HRMS** (ESI) calcd for $C_{20}H_{24}NO_2S_2$ $[M+H]^+$ *m*/*z* 374.1248, found 374.1251.



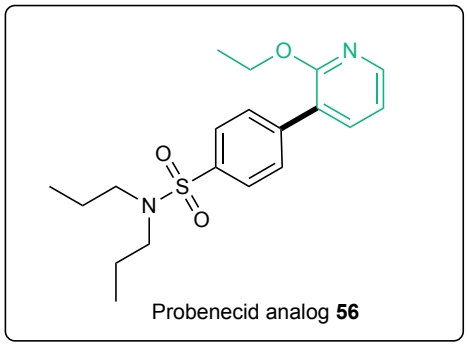
Probenecid analog **54**

***tert*-Butyl-2-(4-(*N*,*N*-dipropylsulfamoyl)phenyl)-1*H*-pyrrole-1-carboxylate (54).** Followed Method D (but with a reaction temperature of 60 ºC) using **40** (57 mg, 0.2 mmol) and (1-(*tert*-butoxycarbonyl)-1*H*-pyrrol-2-yl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 95:5) afforded **54** as a colorless oil (35 mg, 43% yield; 58% yield, based on recovered SM): **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.77 (d, *J* = 8.0 Hz, 2H), 7.46 (d, *J* = 7.4 Hz, 2H), 7.42-7.32 (m, 1H), 6.26-6.25 (multiple peaks, 2H), 3.09 (dd, *J* = 8.6, 6.8 Hz, 4H), 1.59 (m, 4H), 1.37 (s, 9H), 0.89 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 149.29, 138.63, 138.55, 133.40, 129.61, 126.61, 123.96, 116.05, 111.11, 84.42, 50.50, 27.90, 22.46, 11.44; **HRMS** (ESI) calcd for $C_{21}H_{31}N_2O_4S$ $[M+H]^+$ *m*/*z* 407.2005, found 407.2011.



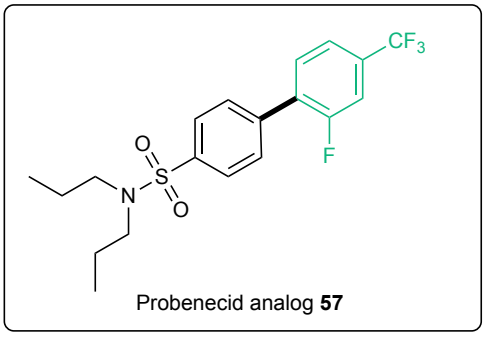
Probenecid analog **55**

***N*,*N*-Dipropyl-4-(6-(trifluoromethyl)pyridin-3-yl)benzenesulfonamide (55).** Followed Method D using **40** (57 mg, 0.2 mmol) and (6-(trifluoromethyl)pyridin-3-yl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 90:10) afforded **55** as a white solid (57 mg, 77% yield): **mp** 78-79 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.96 (d, *J* = 2.2 Hz, 1H), 8.07 (m, 1H), 7.95 (d, *J* = 8.5 Hz, 2H), 7.80 (dd, *J* = 8.2, 0.9 Hz, 1H), 7.73 (d, *J* = 8.5 Hz, 2H), 3.12(m, 4H), 1.58 (m, 4H), 0.89 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 148.70, 147.97 (q, *J* = 35.1 Hz), 140.97, 140.30, 138.04, 136.09, 128.23, 128.15, 120.84 (q, *J* = 2.7 Hz), 121.6 (q, 272.8 Hz), 50.32, 22.30, 11.40; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ –67.86; **HRMS** (ESI) calcd for $C_{18}H_{22}F_3N_2O_2S$ $[M+H]^+$ *m*/*z* 387.1354, found 387.1352.



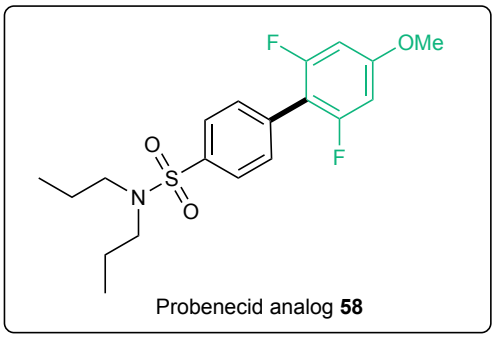
Probenecid analog **56**

4-(2-Ethoxypyridin-3-yl)-*N*,*N*-dipropylbenzenesulfonamide (56). Followed Method D using **40** (57 mg, 0.2 mmol) and (2-ethoxypyridin-3-yl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc, 85:15) afforded **56** as a white solid (67 mg, 93% yield): **mp** 89-90 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 8.17 (dd, *J* = 4.9, 1.9 Hz, 1H), 7.83 (d, *J* = 8.4 Hz, 2H), 7.70 (d, *J* = 8.4 Hz, 2H), 7.62 (m, 1H), 6.97 (dd, *J* = 7.3, 4.9 Hz, 1H), 4.42 (q, *J* = 7.0 Hz, 2H), 3.11 (dd, *J* = 8.7, 6.6 Hz, 4H), 1.58 (m 4H), 1.36 (t, *J* = 7.0 Hz, 3H), 0.88 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 160.59, 146.97, 141.17, 138.90, 138.84, 129.83, 127.02, 122.86, 117.16, 62.17, 50.33, 22.33, 14.74, 11.39; **HRMS** (ESI) calcd for $C_{19}H_{27}N_2O_3S$ $[M+H]^+$ *m*/*z* 363.1742, found 363.1749.



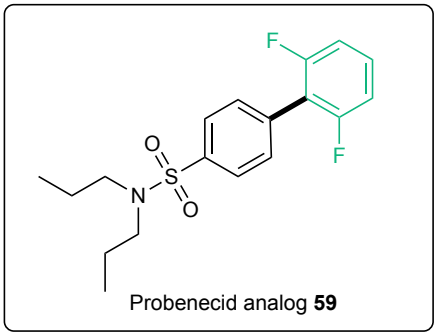
Probenecid analog **57**

2'-Fluoro-*N*,*N*-dipropyl-4'-(trifluoromethyl)biphenyl-4-sulfonamide (57). Followed Method D using **40** (57 mg, 0.2 mmol) and (2-fluoro-4-(trifluoromethyl)phenyl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc/DCM, 95:4.5:0.5) afforded **57** as a colorless oil (67 mg, 93% yield). *GCMS analysis of the isolated product showed the presence of inseparable ketone byproduct (5% by ^{19}F NMR analysis).* **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.90 (d, *J* = 8.2 Hz, 2H), 7.67 (d, *J* = 8.2 Hz, 2H), 7.58 (t, *J* = 7.7 Hz, 1H), 7.53 (dd, *J* = 8.1, 1.6 Hz, 1H), 7.46 (dd, *J* = 10.3, 1.6 Hz, 1H), 3.12 (m, 4H), 1.59 (m, 4H), 0.89 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 159.52 (d, *J* = 251.5 Hz), 140.44, 138.39, 132.47 (dq, *J* = 33.6, 8.1 Hz), 131.56 (d, *J* = 3.3 Hz), 131.27 (d, *J* = 13.3 Hz), 129.77 (d, *J* = 3.1 Hz), 127.58, 123.34 (dq, *J* = 272.3, 2.5 Hz), 121.73 (m), 114.13 (dq, *J* = 26.1, 3.8 Hz), 50.38, 22.35, 11.41; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ –62.84 (s, 3F), –115.12 (m, 1F); **HRMS** (ESI) calcd for $C_{19}H_{22}F_4NO_2S$ $[M+H]^+$ *m*/*z* 404.1307, found 404.1311.



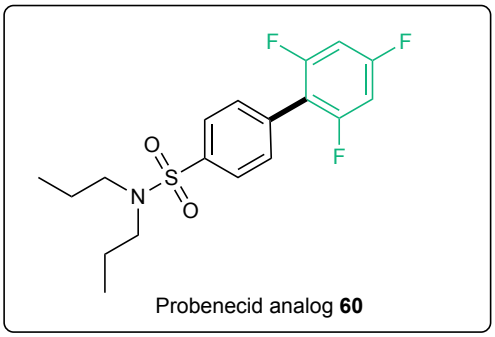
Probenecid analog **58**

2',6'-Difluoro-4'-methoxy-*N*,*N*-dipropylbiphenyl-4-sulfonamide (58). Followed Method D using **40** (57 mg, 0.2 mmol) and (2,6-difluoro-4-methoxyphenyl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc/DCM, 90:9:1) afforded **58** as a thick oil (69 mg, 86% yield): **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.84 (d, *J* = 8.2 Hz, 2H), 7.56 (d, *J* = 6.5 Hz, 2H), 6.56 (m, 2H), 3.84 (s, 3H), 3.11 (m, 4H), 1.58 (m, 4H), 0.89 (t, 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 160.8 (dd, *J* = 245.1, 10.7 Hz), 159.0 (t, *J* = 14.2 Hz), 139.32, 133.84, 131.08, (t, *J* = 19.3 H), 129.16, 127.09, 98.69 (m), 56.12, 50.43, 22.41, 11.42; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ –113.55 (d, *J* = 11.1 Hz); **HRMS** (ESI) calcd for $C_{19}H_{24}F_2O_3SN$ $[M+H]^+$ *m*/*z* 384.1445, found 384.1444.



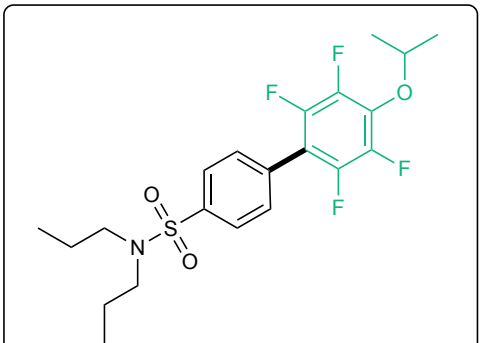
Probenecid analog **59**

2',6'-Difluoro-*N*,*N*-dipropylbiphenyl-4-sulfonamide (59). Followed Method D using **40** (57 mg, 0.2 mmol) and (2,6-difluorophenyl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc/DCM, 95:4.5:0.5) afforded **59** as a white solid (51 mg, 72% yield). Following Method E (*in situ*) using probenecid (57 mg, 0.2 mmol) and (2,6-difluorophenyl)boronic acid (2 equiv, 0.4 mmol) compound **59** was obtained in comparable yield (53 mg, 70% yield): **mp**: 78-79 ºC; **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.88 (d, *J* = 8.3 Hz, 2H), 7.60 (d, *J* = 8.0 Hz, 2H), 7.34 (ddd, *J* = 14.6, 8.3, 6.3 Hz, 1H), 7.02 (t, *J* = 7.8 Hz, 2H), 3.13 (dd, *J* = 8.7, 6.7 Hz, 4H), 1.60 (m, 4H), 0.90 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 160.12 (dd, *J* = 249.9, 6.7 Hz), 140.00, 133.57, 131.16, 130.13 (t, *J* = 10.4 Hz), 127.13, 117.15 (t, *J* = 18.2 Hz), 112.10 (dd, *J* = 21.7, 4.6 Hz), 50.42, 22.40, 11.42; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ –114.36 (t, *J* = 6.8 Hz); **HRMS** (ESI) calcd for $C_{18}H_{22}F_2NO_2S$ $[M+H]^+$ *m*/*z* 354.1339, found 354.1337.



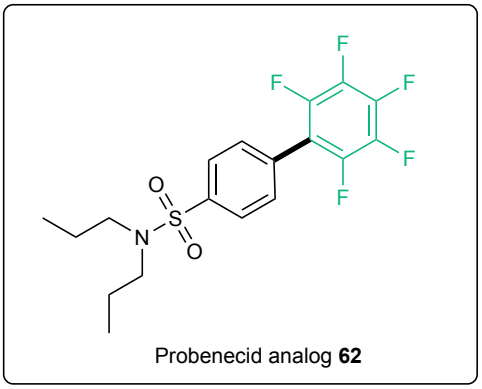
Probenecid analog **60**

2',4',6'-Trifluoro-*N*,*N*-dipropylbiphenyl-4-sulfonamide (60). Followed Method D using **40** (57 mg, 0.2 mmol) and (2,4,6-trifluorophenyl)boronic acid (2 equiv, 0.4 mmol). *^{19}F NMR analysis of the crude reaction mixture showed 1,3,5-trifluorobenzene [20%, based on 2 equiv (2,4,6-trifluorophenyl)boronic acid)], the result of protodeboronation of (2,4,6-trifluorophenyl)boronic acid.* Purification by flash chromatography on silica gel (hexanes/EtOAc/DCM, 95:4.5:0.5) afforded **60** as a colorless oil (45 mg, 60% yield): **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.88 (dd, *J* = 8.3, 1.3 Hz, 2H), 7.56 (dd, *J* = 8.3, 1.3 Hz, 2H), 6.79 (t, *J* = 8.2 Hz, 2H), 3.12 (dd, *J* = 8.6, 6.8 Hz, 4H), 1.58 (m, 4H), 0.89 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 162.53 (dt, *J* = 251.2, 15.6 Hz), 160.34 (ddd, *J* = 250.9, 14.8, 9.5 Hz), 140.16, 132.72, 131.08 (t, *J* = 1.9 Hz), 127.23, 113.67 (dt, *J* = 18.7, 4.7 Hz), 101.02 (t,t *J* = 25.2, 5.9 Hz), 50.38, 22.37, 11.40; **^{19}F NMR** ($CDCl_3$, 471 MHz) δ –107.08 (m, 1F), –111.08 (t, *J* = 7.4 Hz, 2 F); **HRMS** (ESI) calcd for $C_{18}H_{21}F_3NO_2S$ $[M+H]^+$ *m*/*z* 372.1245, found 372.1247.



Probenecid analog **61**

2',3',5',6'-Tetrafluoro-4'-isopropoxy-*N*,*N*-dipropylbiphenyl-4-sulfonamide (61). Followed Method D using **40** (57 mg, 0.2 mmol) and (2,3,5,6-tetrafluoro-4-isopropoxyphenyl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc/DCM, 95:4.5:0.5) afforded **61** as a colorless oil (76 mg, 85% yield): **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.90 (d, *J* = 8.4 Hz, 2H), 7.58 (d, *J* = 8.0 Hz, 2H), 4.63 (h, *J* = 6.2 Hz, 1H), 3.13 (m, 4H), 1.59 (m, 4H), 1.41 (d, *J* = 6.1 Hz, 6H), 0.89 (t, *J* = 7.4 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 144.36 (dddd, *J* = 247.8, 11.6, 7.3, 3.9 Hz), 142.32 (ddt, *J* = 247.4, 15.3, 4.2 Hz); 140.68, 136.73 (tt, *J* = 12.4, 3.5 Hz),131.73, 131.06 (t, *J* = 2.3 Hz), 127.40, 112.95 (t, *J* = 16.6 Hz), 78.69, 50.35, 22.65, 22.35, 11.40; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ –145.15 (dd, *J* = 21.8, 8.6 Hz), –155.80 (dd, *J* = 21.8, 8.6 Hz); **HRMS** (ESI) calcd for $C_{21}H_{26}F_4NO_3S$ $[M+H]^+$ *m*/*z* 448.1570, found 448.1566.

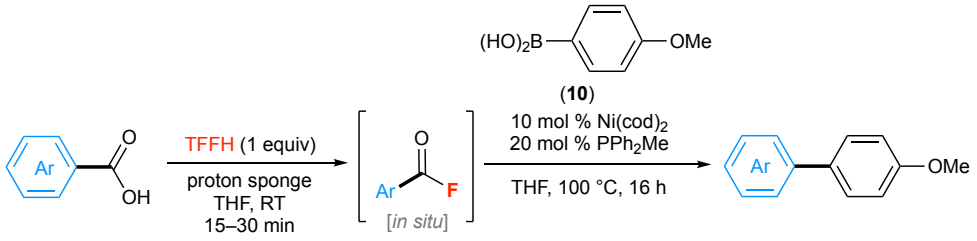


Probenecid analog **62**

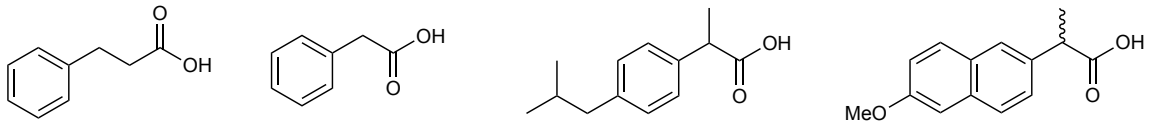
2',3',4',5',6'-Pentafluoro-*N*,*N*-dipropylbiphenyl-4-sulfonamide (62). Followed Method D using **28-COF** (57 mg, 0.2 mmol) and (perfluorophenyl)boronic acid (2 equiv, 0.4 mmol). Purification by flash chromatography on silica gel (hexanes/EtOAc/DCM, 95:4.5:0.5) afforded **62** as a colorless oil (61 mg, 75% yield): **^{1}H NMR** ($CDCl_3$, 700 MHz) δ 7.92 (d, *J* = 8.3 Hz, 2H), 7.56 (d, *J* = 8.0 Hz, 2H), 3.13 (dd, *J* = 8.7, 6.7 Hz, 4H), 1.59 (m, 4H), 0.89 (t, *J* = 7.3 Hz, 6H); **^{13}C NMR** ($CDCl_3$, 176 MHz) δ 144.38 (dm, *J* = 248.2 Hz), 141.38, 141.12 (dm, *J* = 255.2 Hz), 138.14 (dm, *J* = 251.7 Hz), 131.03, 130.61, 127.56, 114.57 (dt, *J* = 15.4, 14.2, 2.8 Hz), 50.35, 22.33, 11.37; **^{19}F NMR** ($CDCl_3$, 377 MHz) δ –142.82 (dd, *J* = 22.6, 8.2 Hz, 2F), –153.51 (t, *J* = 20.9 Hz, 1F), –161.29 (td, *J* = 22.3, 21.8, 8.0 Hz, 2F); **HRMS** (ESI) calcd for $C_{18}H_{19}F_5NO_2S$ $[M+H]^+$ *m*/*z* 408.1057, found 408.1054.

XIII. Additional Substrate Scope

General procedure for decarbonylative Suzuki reaction (Method B, in situ, from carboxylic acid): In a nitrogen-filled glovebox, carboxylic acid (1 equiv, 0.1 mmol), TFFH (1 equiv, 0.1 mmol), and proton sponge (1 equiv, 0.1 mmol) were weighed into a 10 mL tall vial equipped with a 10 μm magnetic stir bar. THF (0.2 mL) was added, and the reaction mixture was stirred at room temperature for 30 min. A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.01 mmol) and PPh_2Me (0.2 equiv, 0.02 mmol) in THF (0.1 mL) was added. The boronic acid **10** (2 equiv, 0.2 mmol) was added, and the reaction mixture was capped and removed from the glovebox. The reaction mixture was stirred at 100 ºC for 16 h. The reaction was then cooled to room temperature, diluted with CH_2Cl_2 and analyzed by GCMS. Examples of carboxylic acids that afforded low or negligible yields under these standard conditions are presented in **Fig. S7** below.

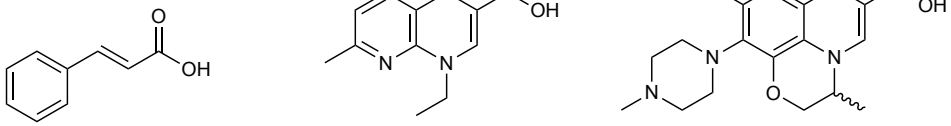


(a) Alkyl carboxylic acids



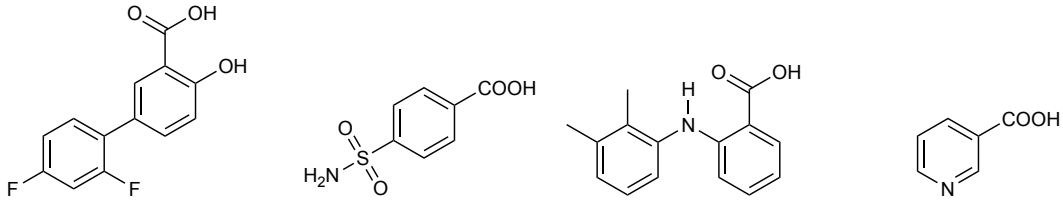
0% 0% ibuprofen, 0% Naproxen, 0%

(b) Alkenyl carboxylic acids



trace Nalidixic acid, 0% Ofloxacin, 0%

(c) Carboxylic acids with reactive functional groups



Diflunisal, 0% 0% Mefenamic acid, <10% trace

Figure S7. Representative examples several carboxylic acids that afforded low or negligible yields under the optimized *in situ* reaction conditions.

General procedure for decarbonylative Suzuki reaction (Method D, from acid fluoride): In a nitrogen-filled glovebox, probenecid acid fluoride **40** (1 equiv, 0.1 mmol) was weighed into a 10 mL tall vial equipped with a 10 μm magnetic stir bar. A pre-mixed solution of $Ni(cod)_2$ (0.1 equiv, 0.01 mmol) and PPh_2Me (0.2 equiv, 0.02 mmol) in THF (0.3 mL) was added. The boronic acid (2 equiv, 0.2 mmol) was added, and the reaction mixture was removed from the glovebox. The reaction mixture was stirred at 100 ºC for 16 h. The reaction was then cooled to room temperature, diluted with CH_2Cl_2 and analyzed by GCMS. Examples of organoboron reagents that afforded low or negligible yields under these standard conditions are presented in **Fig. S8**.

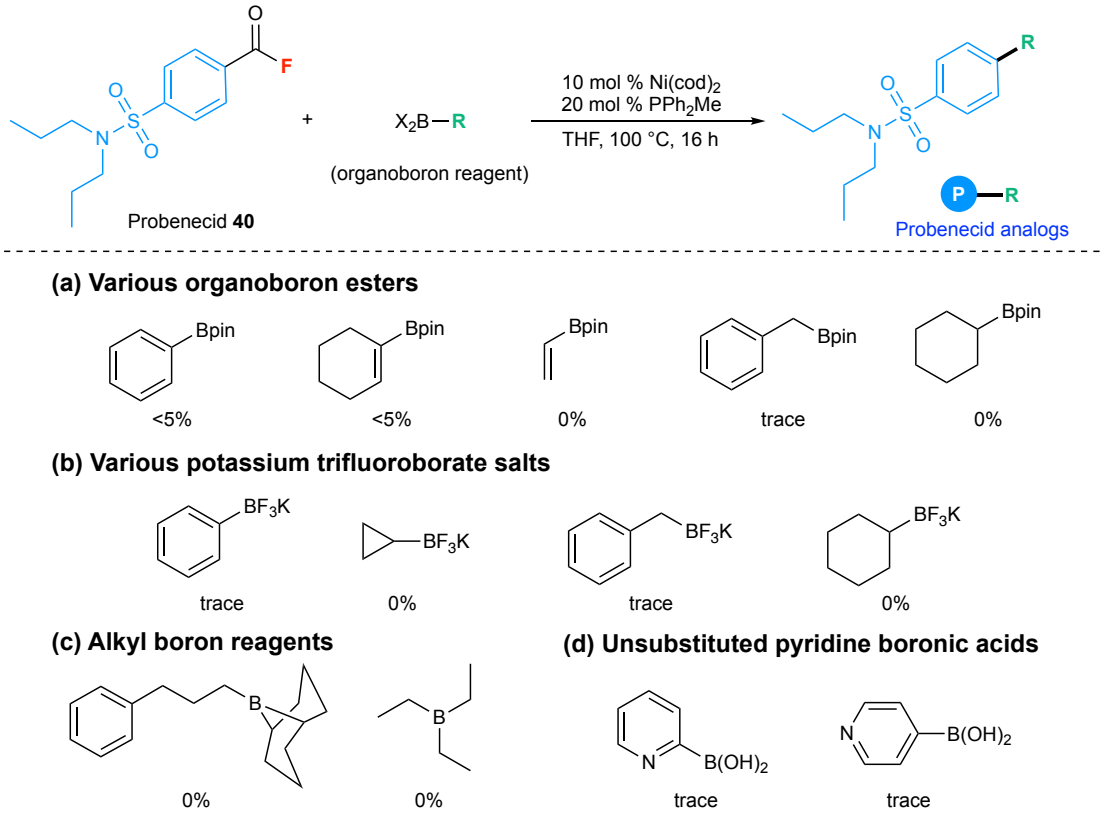
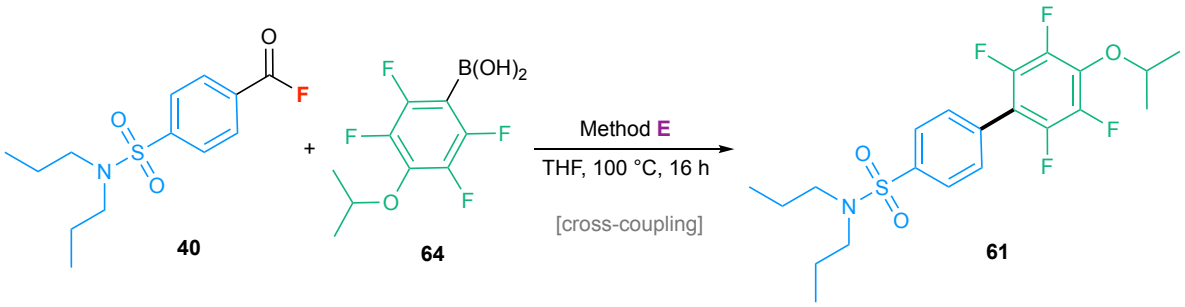
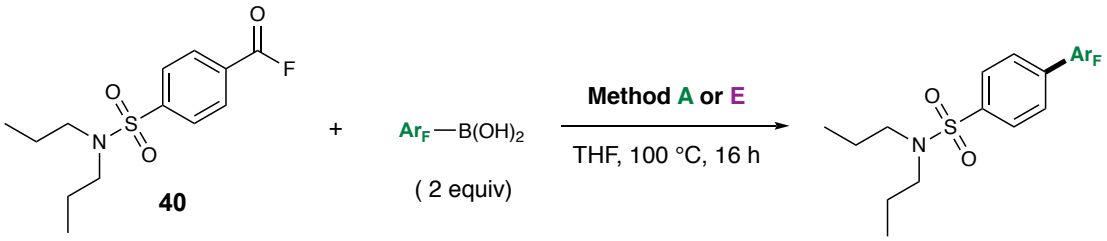


Figure S8. Representative examples of organoboron reagents that afforded low or negligible yields under these standard conditions.

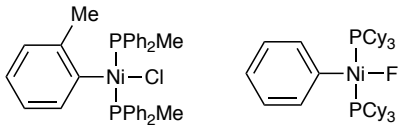
XIV. Use of Air-Stable Pre-Catalyst



Method E: All catalysts/reagents were handled on the bench-top. Into a dry 10 mL tall vial equipped with a stir bar was weighed anhydrous CsF (0.1 equiv, 3.5 mg) and *o*-tolylNi(PPh_2Me)$_2$Cl **63** (0.1 equiv, 12 mg). The vial was immediately sealed with a Teflon-lined cap equipped with a septum and connected to a Schlenk line via a syringe/needle. The vial was evacuated (~2 min) and back-filled with nitrogen (1 min). This cycle was repeated 3 times. Anhydrous THF (0.3 mL) was added, and the resulting suspension was stirred vigorously at room temperature for 30 min. Into a dry 4 mL vial was weighed acid fluoride **40** (1 equiv, 0.2 mmol, 58 mg) and aryl boronic acid **64** (2 equiv, 0.4 mmol, 101 mg), sealed with a Teflon-lined cap equipped with a septum and connected to a Schlenk line via a syringe/needle. The vial was evacuated (~2 min) and back-filled with nitrogen (1 min). This cycle was repeated 3 times. Anhydrous THF (0.3 mL) was added and resulting solution was transferred to the 10 mL vial containing the pre-stirred catalyst. The 4 mL vial was rinsed with THF (0.1 mL), and the resulting solution was added to the reaction mixture. Under a positive nitrogen flow, the cap was replaced with a new Telfon-lined cap. The reaction mixture was stirred at 100 °C for 16 h. The reaction was cooled down to RT and 4-fluorotoluene (1 equiv, 22 mg) dissolved in THF (0.3 mL) was added as internal standard. A representative sample was removed for ^{19}F NMR analysis. **^{19}F NMR** yield: 77%. The reaction mixture was diluted with EtOAc (5 mL) and brine (5 mL). The organic layer was collected, and the aqueous solution was further extracted with EtOAc (2 x 5 mL). The combined organic extracts was dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The crude product was purified by flash column chromatography on silica gel using 5% EtOAc in hexanes. Compound **61** was obtained as a thick oil (59 mg, 66% yield).



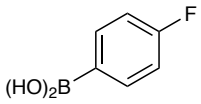
Air-stable nickel pre-catalysts



63 **3**

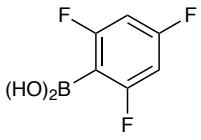
Method A (see Sec X): 10 mol % $Ni(cod)_2$/20 mol % PPh_2Me operated in a glove-box

Method E: 10 mol % **63**, 10 mol % CsF catalysts/reagents handled on bench-top

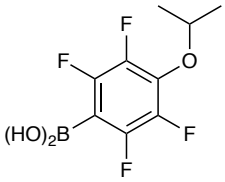


Method	*variations	Result (^{19}F NMR yield)
A	-	88% product, 0% unreacted SM
E	-	67%, 20% SM
E*	20 mol % CsF (instead of 10 %)	70%, 20% SM
E*	TMAF (instead CsF)	21%, 60% SM
E*	0 mol % CsF	trace, 82% SM
E*	**3** was used, 0 mol % CsF (instead of **63**)	45%, 39% SM

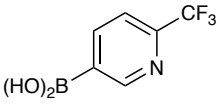
Representative scope with aryl boronic acids:



A: 85%
E: 69%



A: 93%
E: 77% (66% isolated yield)



A: 89%
E: 60%

Figure S9. Optimization for the use of air-stable pre-catalysts and representative scope. Reactions were performed on 0.1 mmol scale of probenecid acid fluoride following Methods A or E, and yields are based on ^{19}F NMR analysis of the crude reaction mixture using 4-fluorotoluene as internal standard. Isolated yield was obtained from 0.2 mmol scale. TMAF, tetramethylammonium fluoride; SM, starting material **40**.

XV. References

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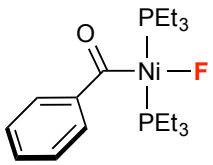
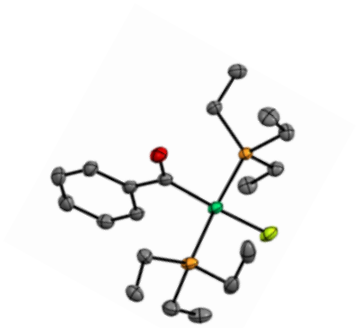
XVI. X-Ray Crystallography Data for 3 and 2b

Structure Determination of 2b



2b



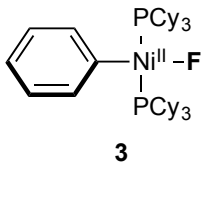
X-ray crystal structure of **2b**

Yellow needles of **2b** were grown from a pentane solution of the compound at −35 °C. A crystal of dimensions 0.22 x 0.06 x 0.06 mm was mounted on a Rigaku AFC10K Saturn 944+ CCD-based X-ray diffractometer equipped with a low temperature device and Micromax-007HF Cu-target micro-focus rotating anode (λ = 1.54187 A) operated at 1.2 kW power (40 kV, 30 mA). The X-ray intensities were measured at 85(1) K with the detector placed at a distance 42.00 mm from the crystal. A total of 2028 images were collected with an oscillation width of 1.0° in ω. The exposure times were 1 sec. for the low angle images, 4 sec. for high angle. Rigaku d*trek images were exported to CrysAlisPro for processing and corrected for absorption. The integration of the data yielded a total of 32529 reflections to a maximum 2θ value of 138.81° of which 3965 were independent and 3953 were greater than 2σ(I). The final cell constants (Table 1) were based on the xyz centroids 22090 reflections above 10σ(I). Analysis of the data showed negligible decay during data collection. The structure was solved and refined with the Bruker SHELXTL (version 2016/6) software package, using the space group P2(1)2(1)2(1) with Z = 4 for the formula $C_{19}H_{35}OFP_2CNi$. All non-hydrogen atoms were refined anisotropically with the hydrogen atoms placed in idealized positions. Full matrix least-squares refinement based on F^2 converged at R1 = 0.0326 and wR2 = 0.0836 [based on I > 2sigma(I)], R1 = 0.0327 and wR2 = 0.0837 for all data. Additional details are presented in Table 1 and are given as Supporting Information in a CIF file. Acknowledgement is made for funding from NSF grant CHE-0840456 for X-ray instrumentation.

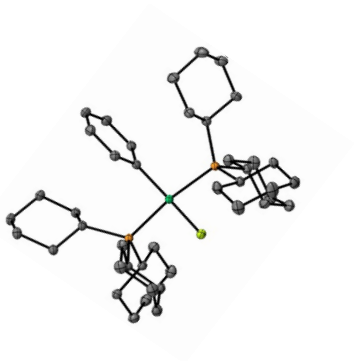
G.M. Sheldrick (2015) "Crystal structure refinement with SHELXL", Acta Cryst., C71, 3-8 (Open Access).
CrystalClear Expert 2.0 r16, Rigaku Americas and Rigaku Corporation (2014), Rigaku Americas, 9009, TX, USA 77381-5209, Rigaku Tokyo, 196-8666, Japan.
CrysAlisPro 1.171.38.41 (Rigaku Oxford Diffraction, 2015).

Empirical Formula	$C_{19}H_{35}FNiOP_2$
Formula Weight	419.12
Temperature	85(2) K
Wavelength	1.54178 A
Crystal System	Orthorhombic
Space Group	P212121
Unit Cell Dimensions	a =10.61253(10) A α = 90 º b = 12.43697(8) A β= 90 º c = 16.20337(16) A γ = 90 º
Volume	2138.65(3) A^3A^3
Z	4
Calculated Density	2.815 mg/m^3
Absorption Coefficient	1.699mm^{-1}
F(000)	896
Crystal Size	0.220 x 0.060 x 0.060 mm
Theta Range for Data Collection	4.482 to 69.403 º
Limiting Indicies	-12<=h<=12, -14<=k<=15, -19<=l<=19
Reflections Collected	32529
Independent Reflections	3965 [R(int) = 0.0531]
Completeness to Theta	67.679 (99.9%)
Absorption Correction	Semi-empirical from equivalents
Max and Min Transmission	1.00000 and 0.6451
Refinement Method	Full-matrix least-squares on F^2
Data / Restraints / Parameters	3965/ 0 / 224
Goodness-of-Fit on F^2	1.057
Final R Indices [I>2σ(I)]	R1 = 0.0326, wR2 = 0.0836
R indices (all data)	R1 = 0.0327, wR2 = 0.0837
Largest Difference Peak and Hole	0.715 and -0.466 A^{-3}

Structure Determination of 3



3

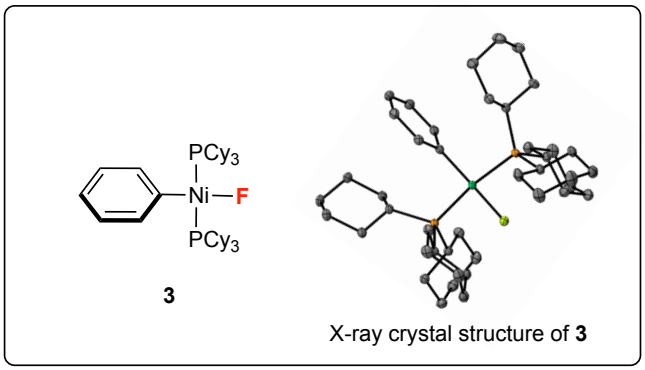


Yellow plates of **3** were grown from vapor diffusion of diethyl ether into tetrahydrofuran at 22 °C. A crystal of dimensions 0.18 x 0.17 x 0.10 mm was mounted on a Rigaku AFC10K Saturn 944+ CCD-based X-ray diffractometer equipped with a low temperature device and Micromax-007HF Cu-target micro-focus rotating anode (λ = 1.54187 A) operated at 1.2 kW power (40 kV, 30 mA). The X-ray intensities were measured at 85(1) K with the detector placed at a distance 42.00 mm from the crystal. A total of 2028 images were collected with an oscillation width of 1.0° in ω. The exposure times were 1 sec. for the low angle images, 4 sec. for high angle. Rigaku d*trek images were exported to CrysAlisPro for processing and corrected for absorption. The integration of the data yielded a total of 29205 reflections to a maximum 2θ value of 138.41° of which 7182 were independent and 7019 were greater than 2σ(I). The final cell constants (Table 1) were based on the xyz centroids of 19927 reflections above 10σ(I). Analysis of the data showed negligible decay during data collection. The structure was solved and refined with the Bruker SHELXTL (version 2016/6) software package, using the space group P1bar with Z = 2 for the formula $C_{42}H_{71}FP_2Ni$. All non-hydrogen atoms were refined anisotropically with the hydrogen atoms placed in idealized positions. Full matrix least-squares refinement based on F^2 converged at R1 = 0.0428 and wR2 = 0.1248 [based on I > 2sigma(I)], R1 = 0.0434 and wR2 = 0.1254 for all data. Additional details are presented in Table 1 and are given as Supporting Information in a CIF file. Acknowledgement is made for funding from NSF grant CHE-0840456 for X-ray instrumentation.

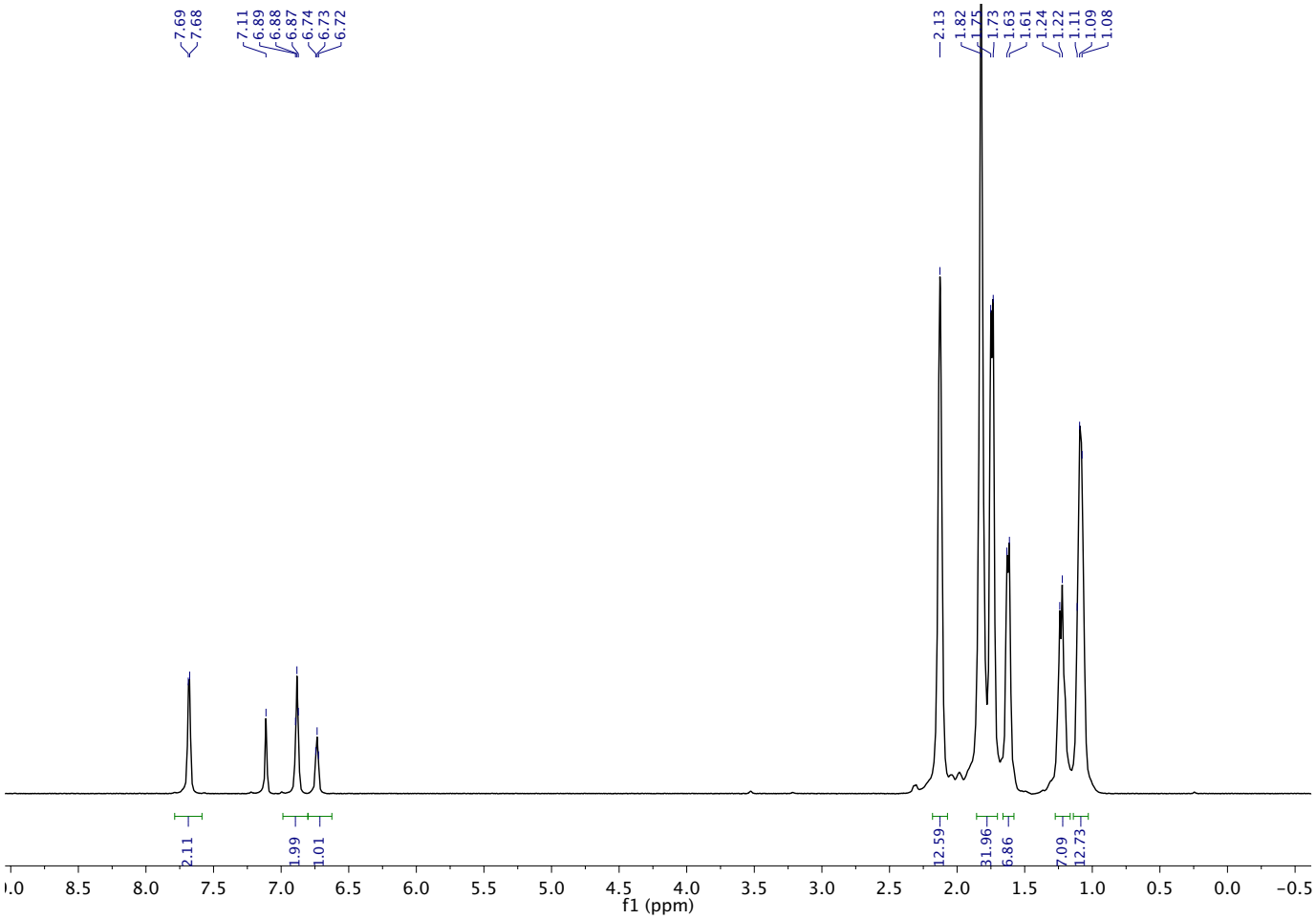
G.M. Sheldrick (2015) "Crystal structure refinement with SHELXL", Acta Cryst., C71, 3-8 (Open Access).
CrystalClear Expert 2.0 r16, Rigaku Americas and Rigaku Corporation (2014), Rigaku Americas, 9009, TX, USA 77381-5209, Rigaku Tokyo, 196-8666, Japan.
CrysAlisPro 1.171.38.41 (Rigaku Oxford Diffraction, 2015).

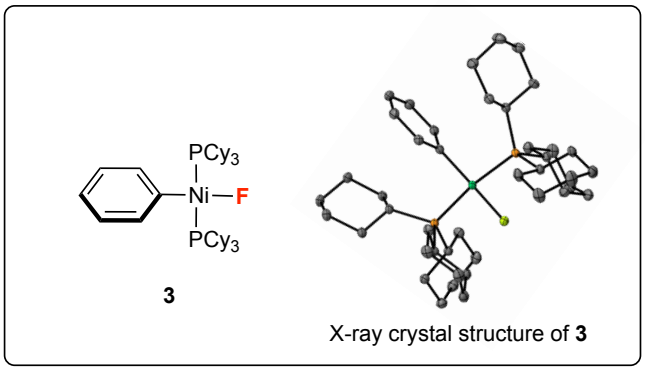
Empirical Formula	$C_{42}H_{71}FP_2Ni$
Formula Weight	715.63
Temperature	85(2) K
Wavelength	1.54184 A
Crystal System	Triclinic
Space Group	P -1
Unit Cell Dimensions	a = 9.6510(2) A α = 96.728(2) º. b = 14.0740(3) A β= 103.554(2) º c = 15.7323(3) A γ = 103.885(2) º
Volume	$1982.34(7)A^3$
Z	2
Calculated Density	$1.199\ mg/m^3$
Absorption Coefficient	$1.699mm^{-1}$
F(000)	780
Crystal Size	0.180 x 0.170 x 0.100 mm
Theta Range for Data Collection	2.939 to 69.206 deg.
Limiting Indicies	-11<=h<=11, -16<=k<=17, -19<=l<=18
Reflections Collected	29205
Independent Reflections	7182 [R(int) = 0.0356]
Completeness to Theta	67.684 (98.4%)
Absorption Correction	Semi-empirical from equivalents
Max and Min Transmission	1.00000 and 0.82906
Refinement Method	Full-matrix least-squares on F^2
Data / Restraints / Parameters	7182 / 0 / 416
Goodness-of-Fit on F^2	1.027
Final R Indices [I>2σ(I)]	R1 = 0.0428, wR2 = 0.1248
R indices (all data)	R1 = 0.0434, wR2 = 0.1254
Largest Difference Peak and Hole	0.544 and -0.556 e.A^-3

XVII. Copies of ^{1}H, ^{13}C, ^{19}F and ^{31}P NMR Spectra

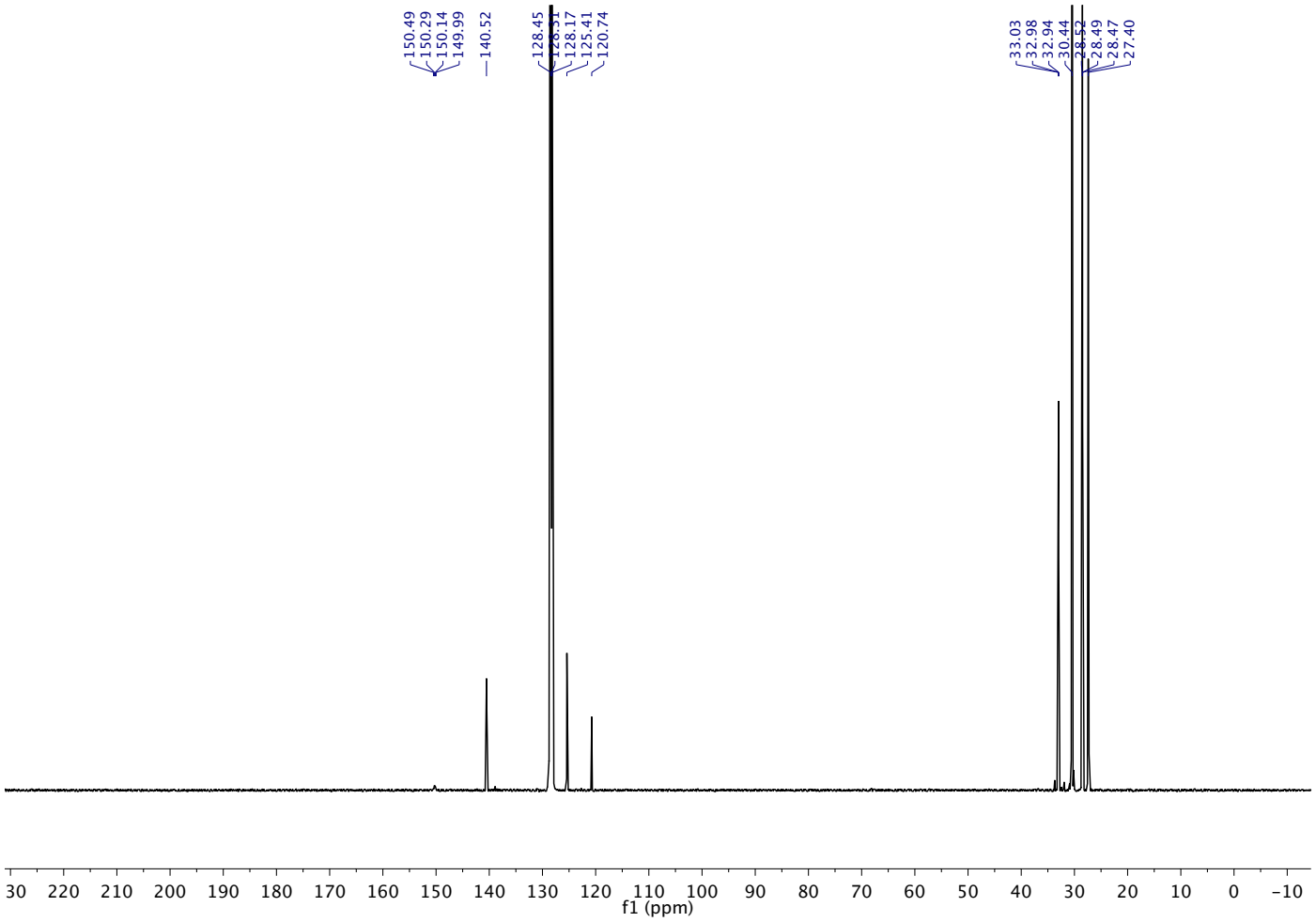

PCy3
Ni
F
PCy3
3
X-ray crystal structure of 3

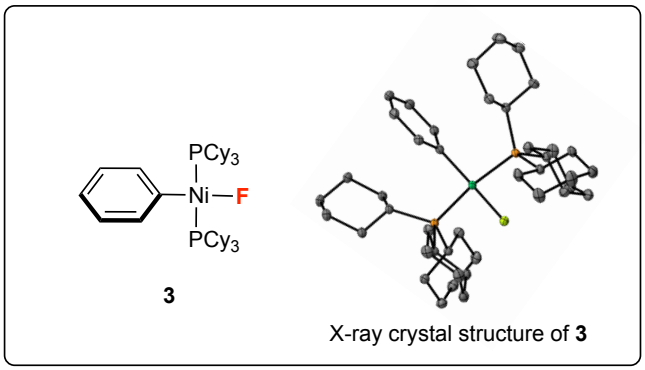
^{1}H NMR


7.69
7.68
7.11
6.89
6.88
6.87
6.74
6.73
6.72
2.13
1.82
1.75
1.73
1.63
1.61
1.24
1.22
1.11
1.09
1.08
2.11
1.99
1.01
12.59
31.96
6.86
7.09
12.73
f1 (ppm)

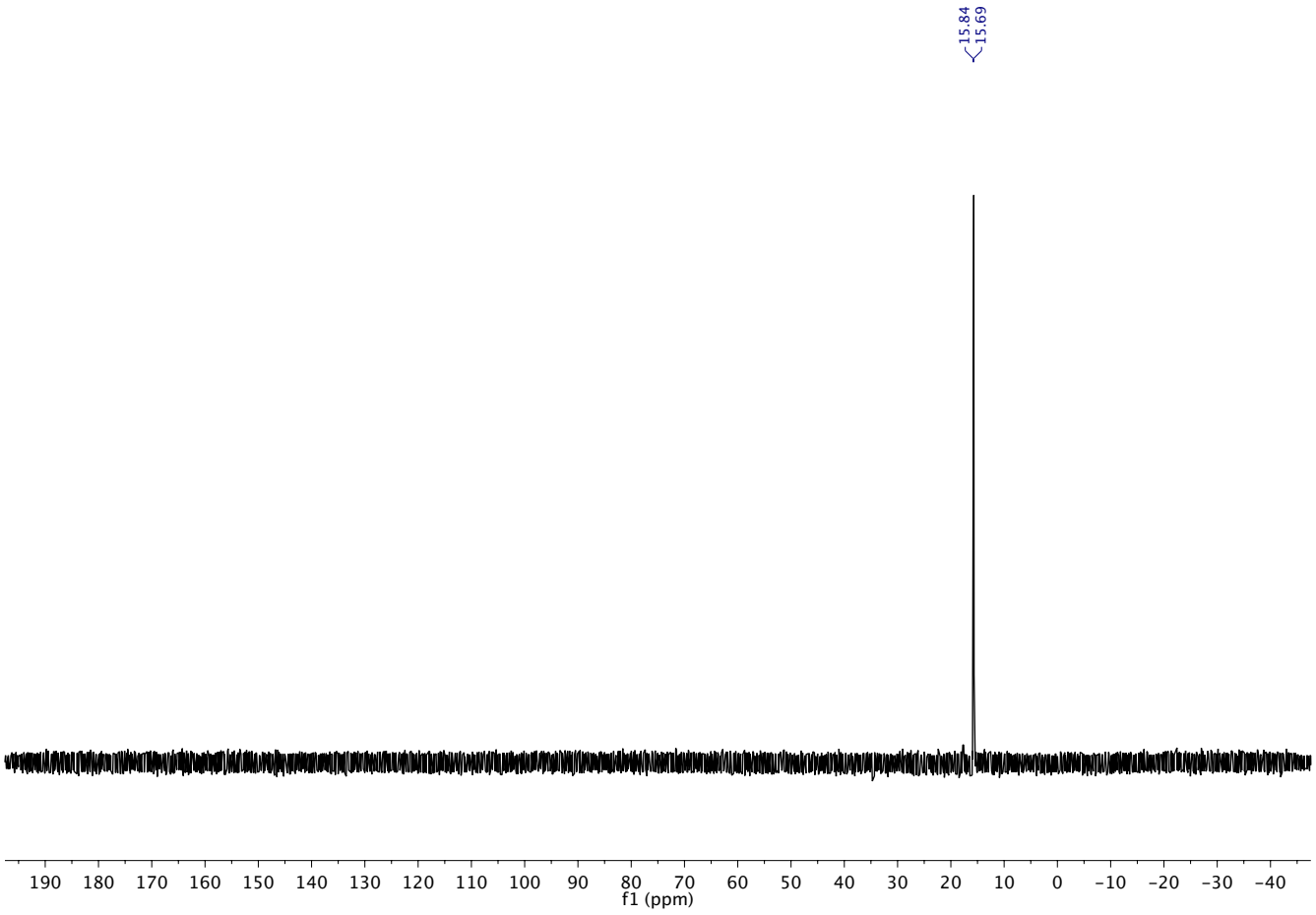

PCy3
Ni
F
PCy3
3
X-ray crystal structure of 3

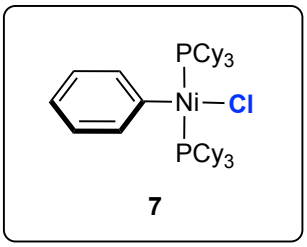
^{13}C NMR


150.49
150.29
150.14
149.99
140.52
128.45
128.31
128.17
125.41
120.74
33.03
32.98
32.94
30.44
28.52
28.49
28.47
27.40
30 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


PCy3
Ni
F
PCy3
3
X-ray crystal structure of 3

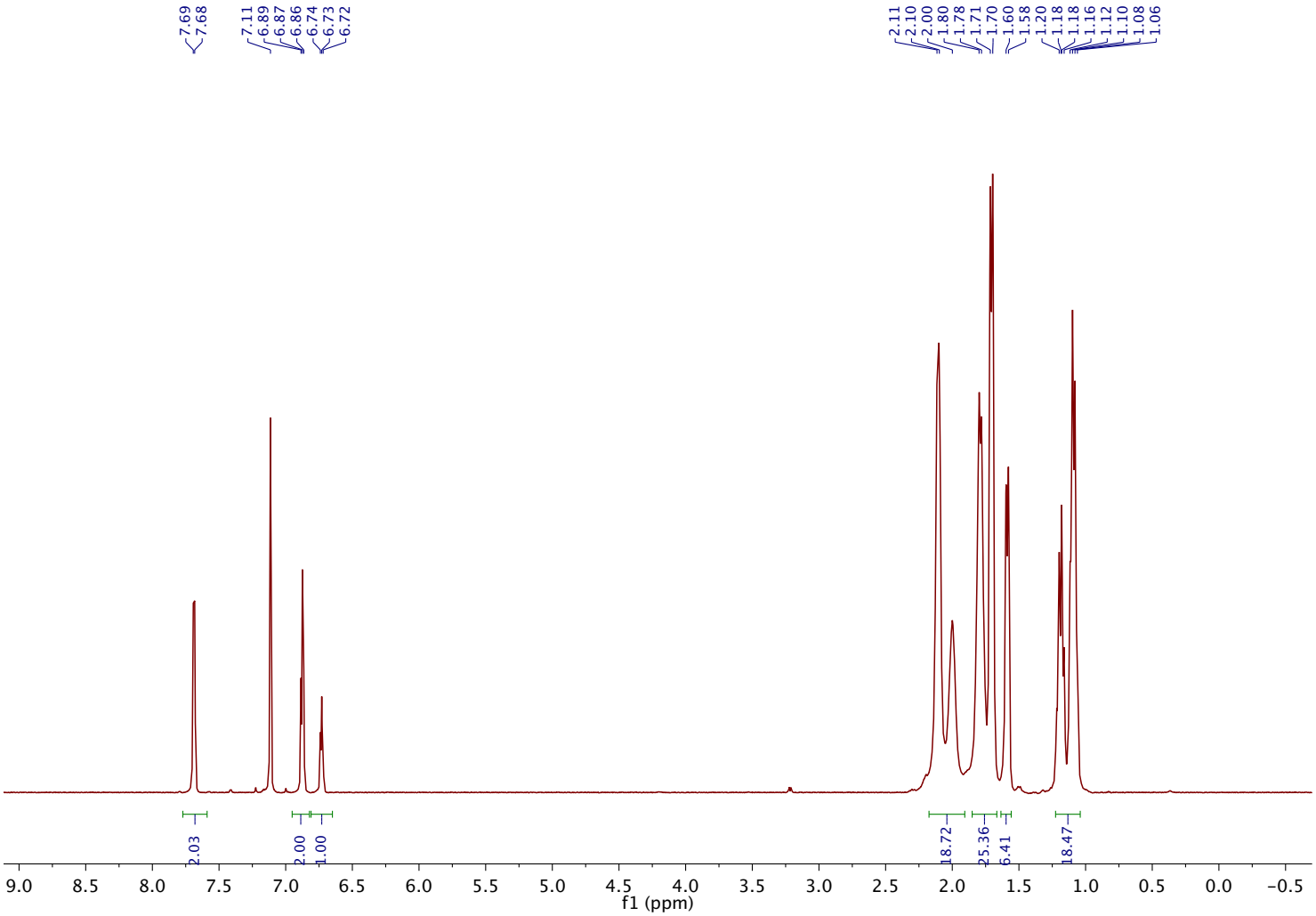
^{31}P NMR

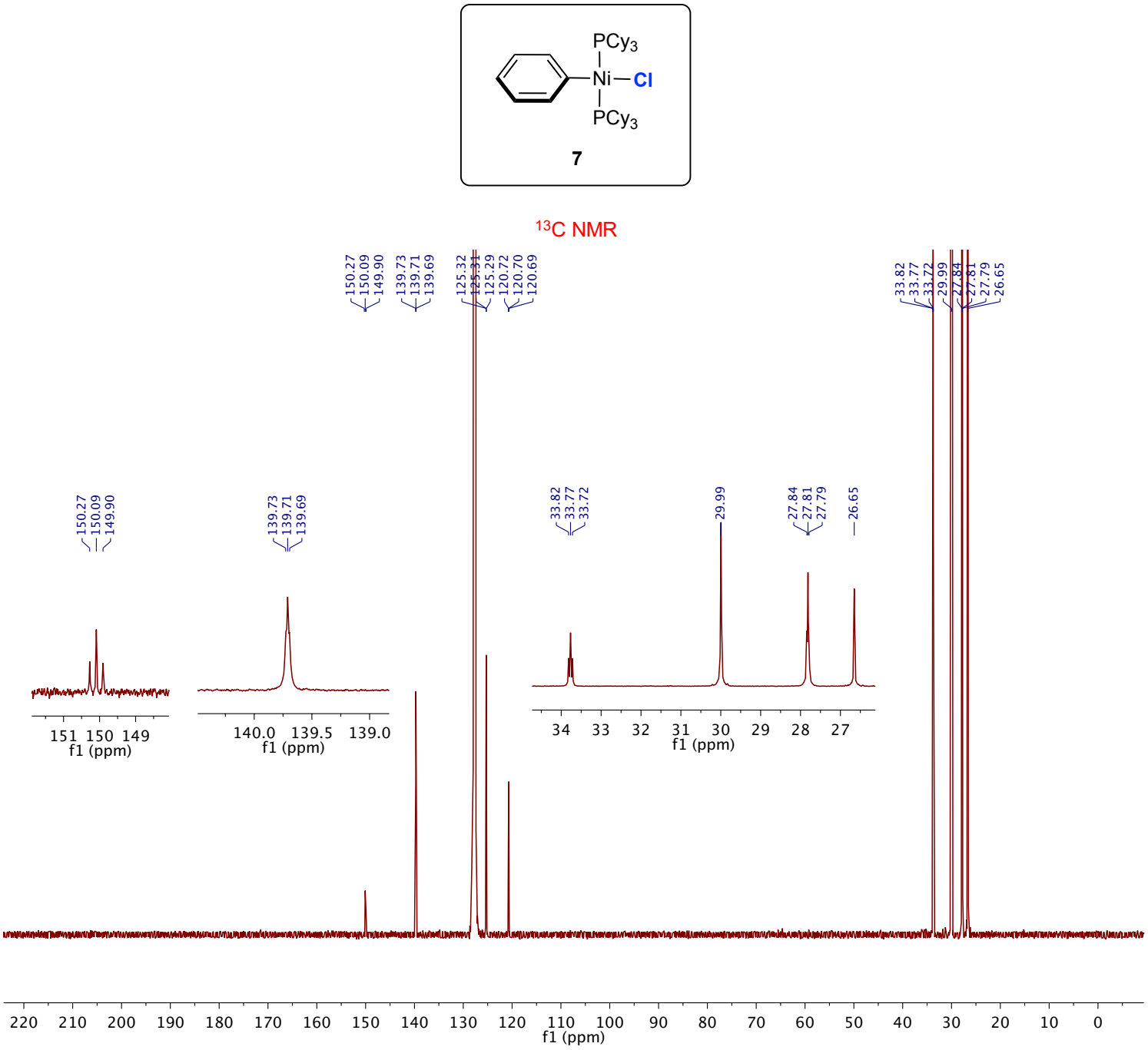

15.84
15.69
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40
f1 (ppm)

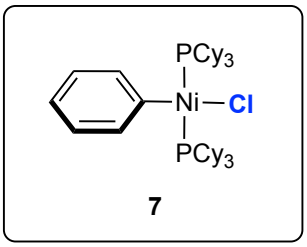

PCy3
Ni
Cl
PCy3

7

^{1}H NMR

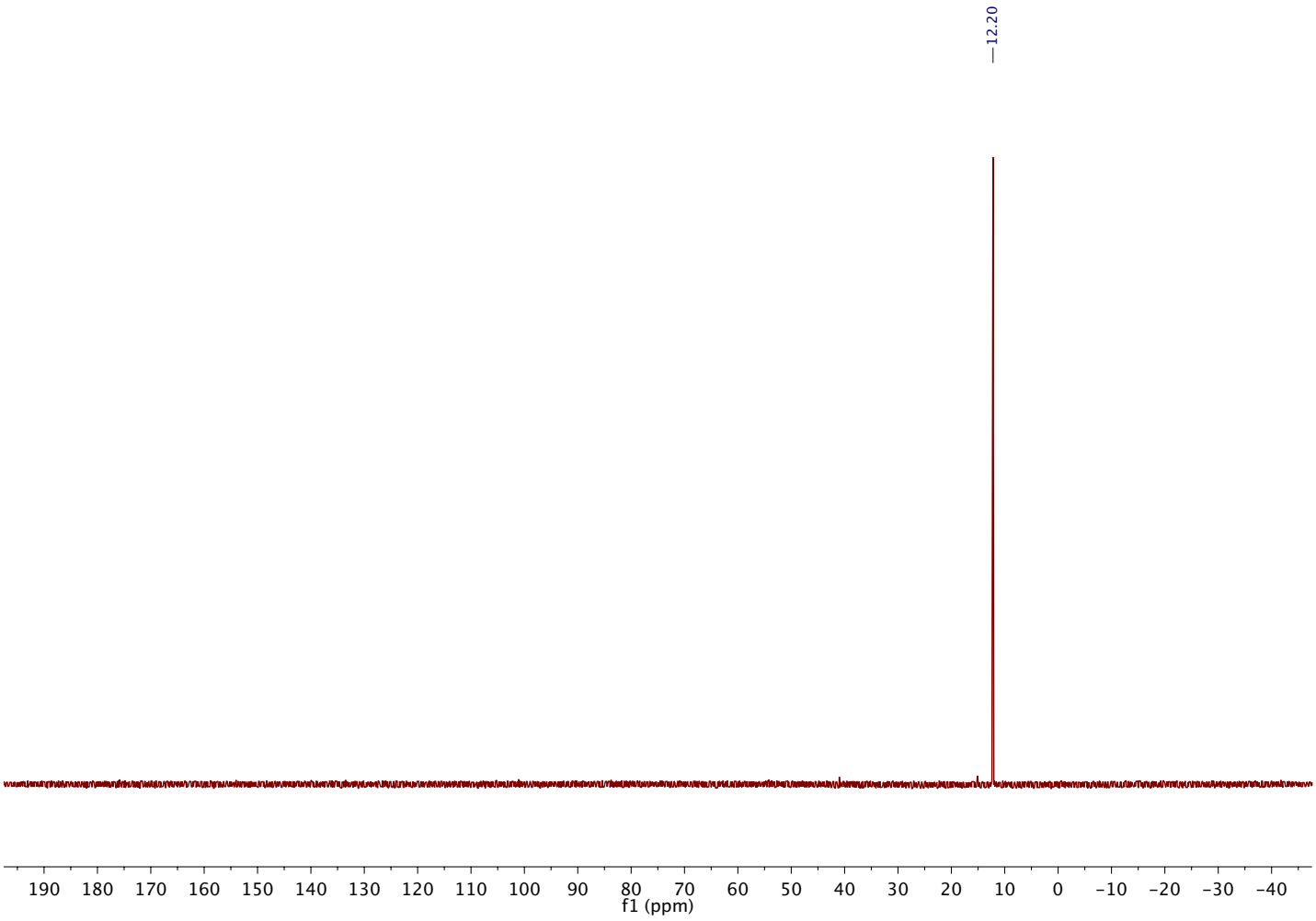

7.69
7.68
7.11
6.89
6.87
6.86
6.74
6.73
6.72
2.11
2.10
2.00
1.80
1.78
1.71
1.70
1.60
1.58
1.20
1.18
1.18
1.16
1.12
1.10
1.08
1.06
2.03
2.00
1.00
18.72
25.36
6.41
18.47
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

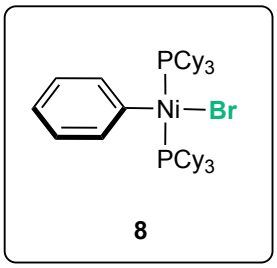

PCy3
Ni—Cl
PCy3
7
13C NMR
150.27
150.09
149.90
139.73
139.71
139.69
125.32
125.31
125.29
120.72
120.70
120.69
33.82
33.77
33.72
29.99
27.84
27.81
27.79
26.65
151 150 149
f1 (ppm)
140.0 139.5 139.0
f1 (ppm)
34 33 32 31 30 29 28 27
f1 (ppm)
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


PCy3
Ni
Cl
PCy3

7

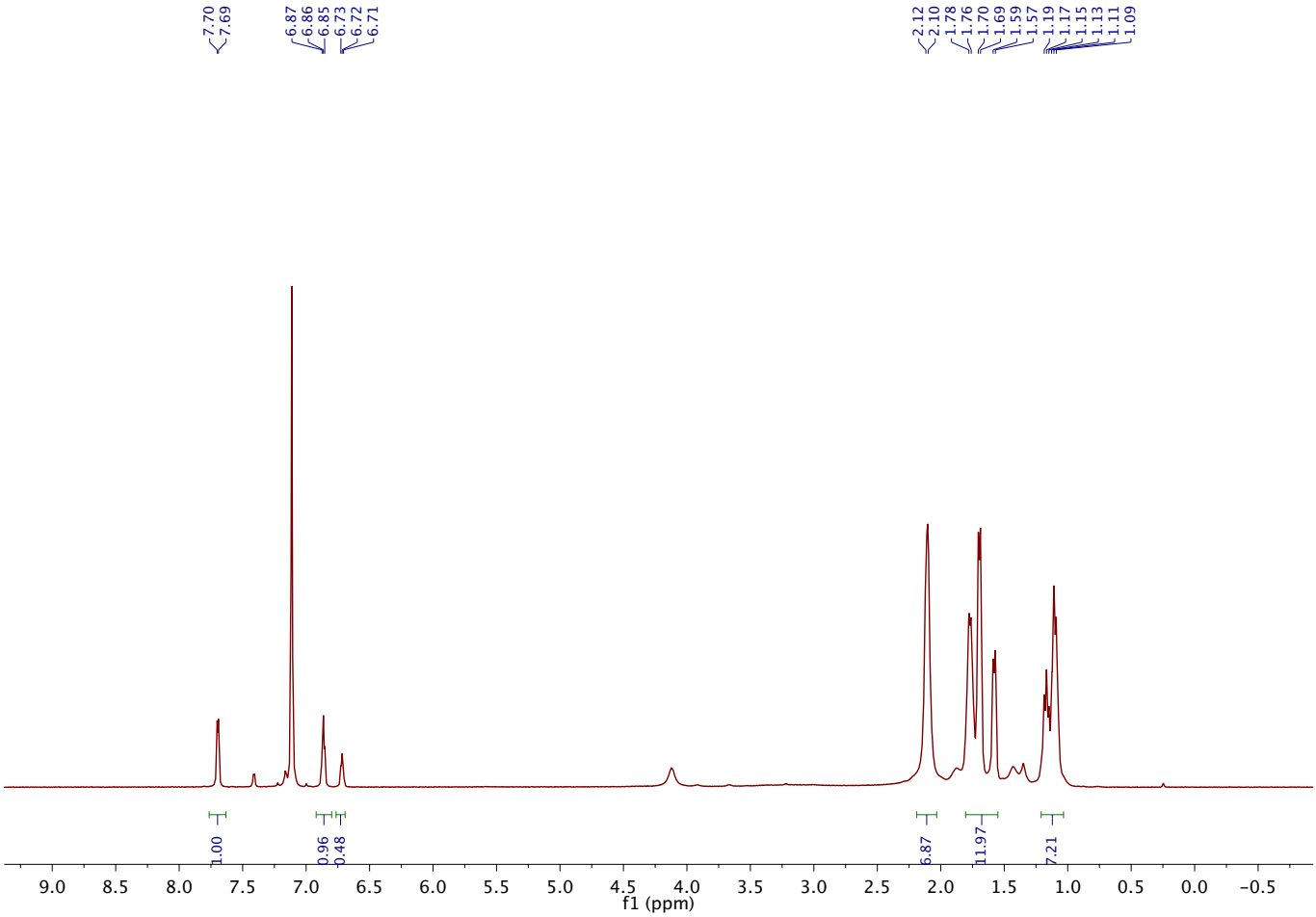
^{31}P NMR

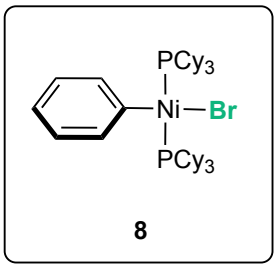

12.20
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40
f1 (ppm)


PCy3
Ni
Br
PCy3

8

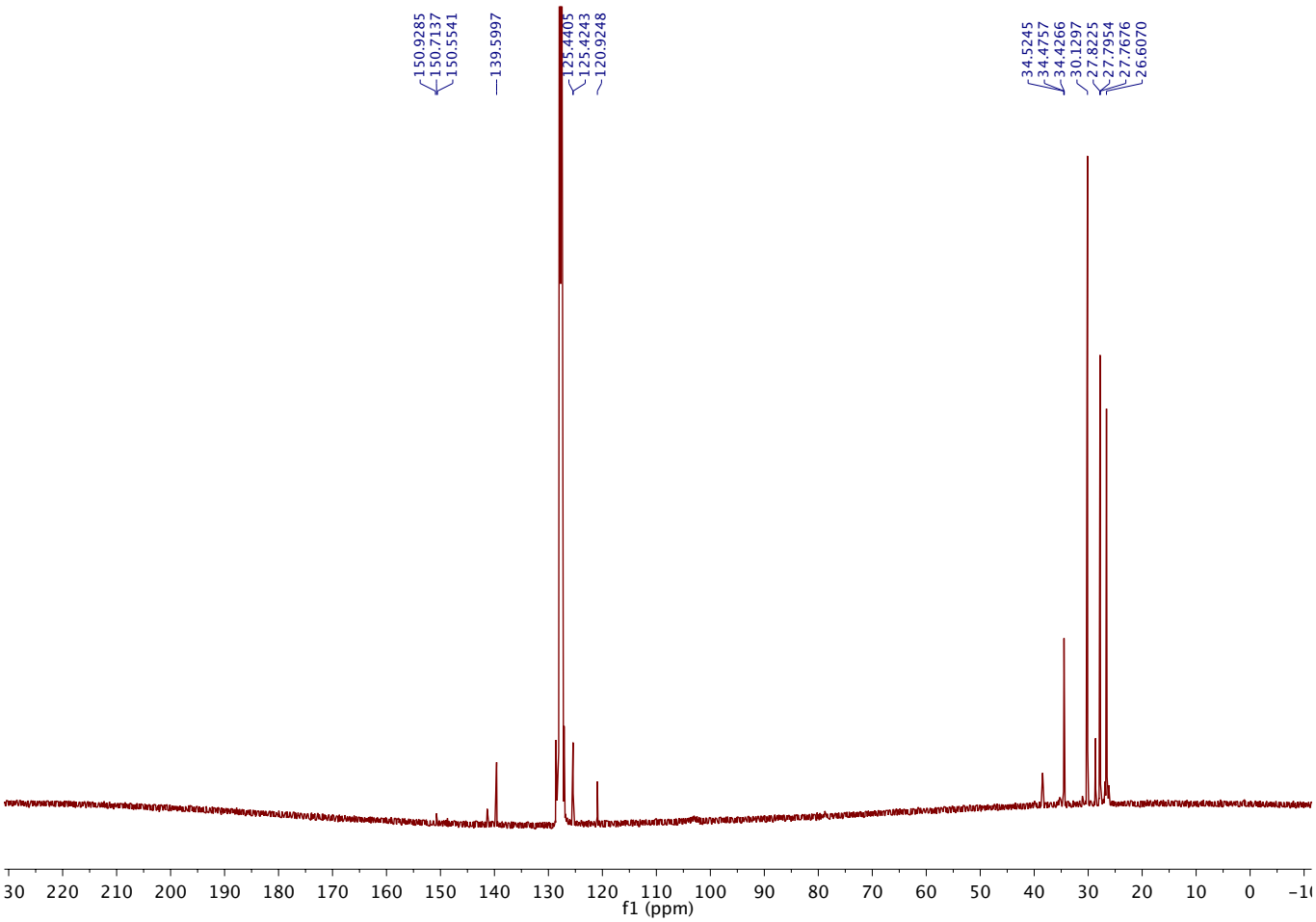
^{1}H NMR

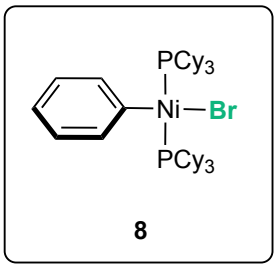

7.70
7.69
6.87
6.86
6.85
6.73
6.72
6.71
2.12
2.10
1.78
1.76
1.70
1.69
1.59
1.57
1.19
1.17
1.15
1.13
1.11
1.09
1.00
0.96
0.48
6.87
11.97
7.21
f1 (ppm)


PCy3
Ni
Br
PCy3

8

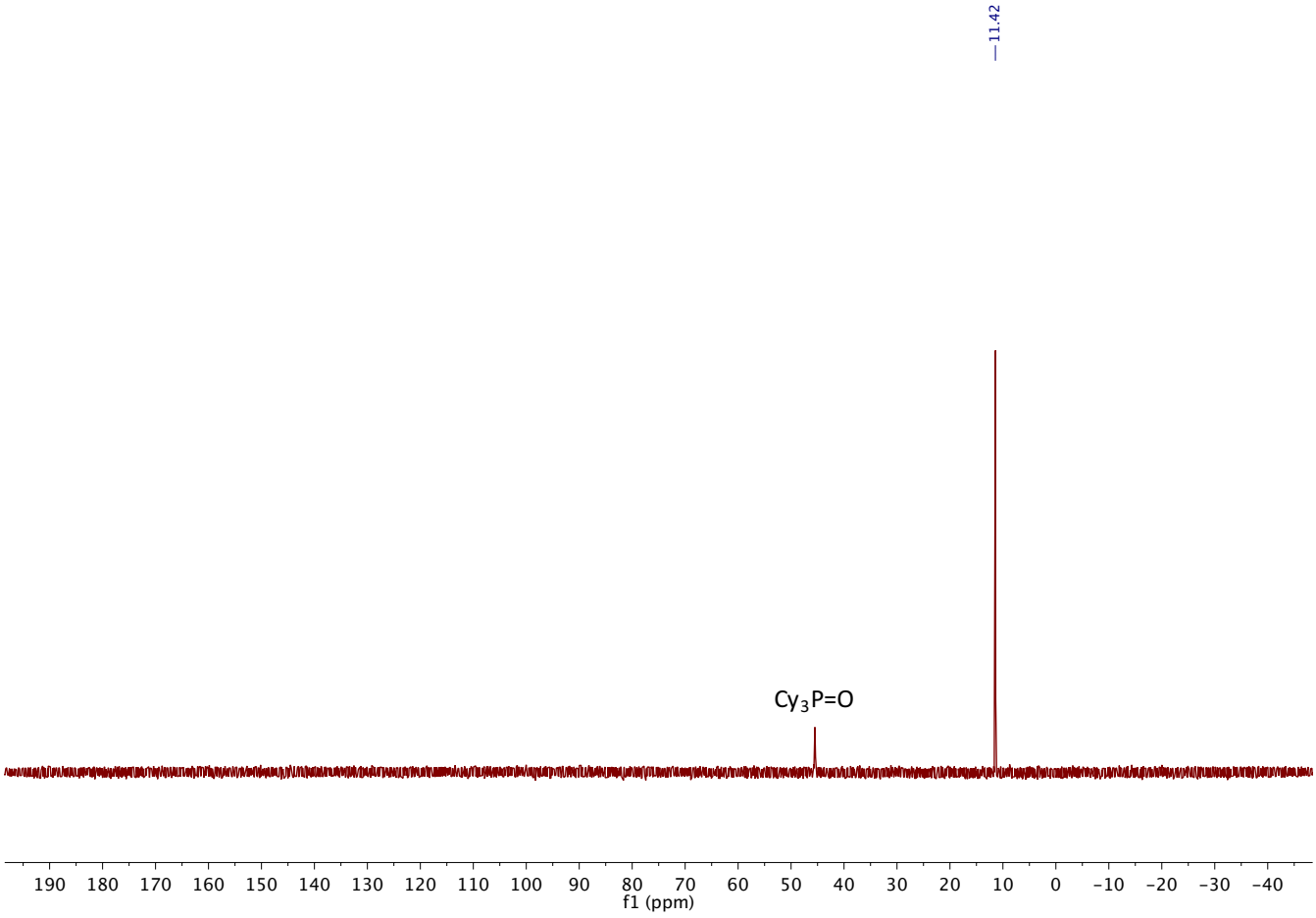
^{13}C NMR

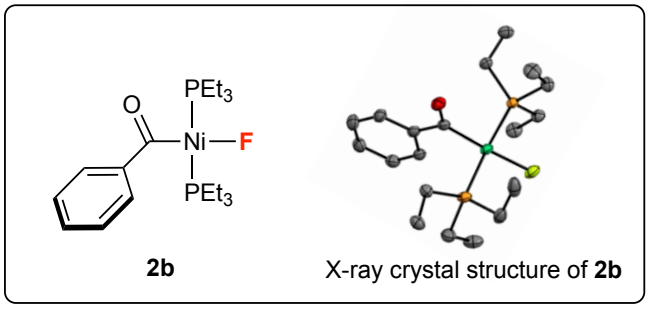

150.9285
150.7137
150.5541
139.5997
125.4405
125.4243
120.9248
34.5245
34.4757
34.4266
30.1297
27.8225
27.7954
27.7676
26.6070
30 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


PCy3
Ni
Br
PCy3

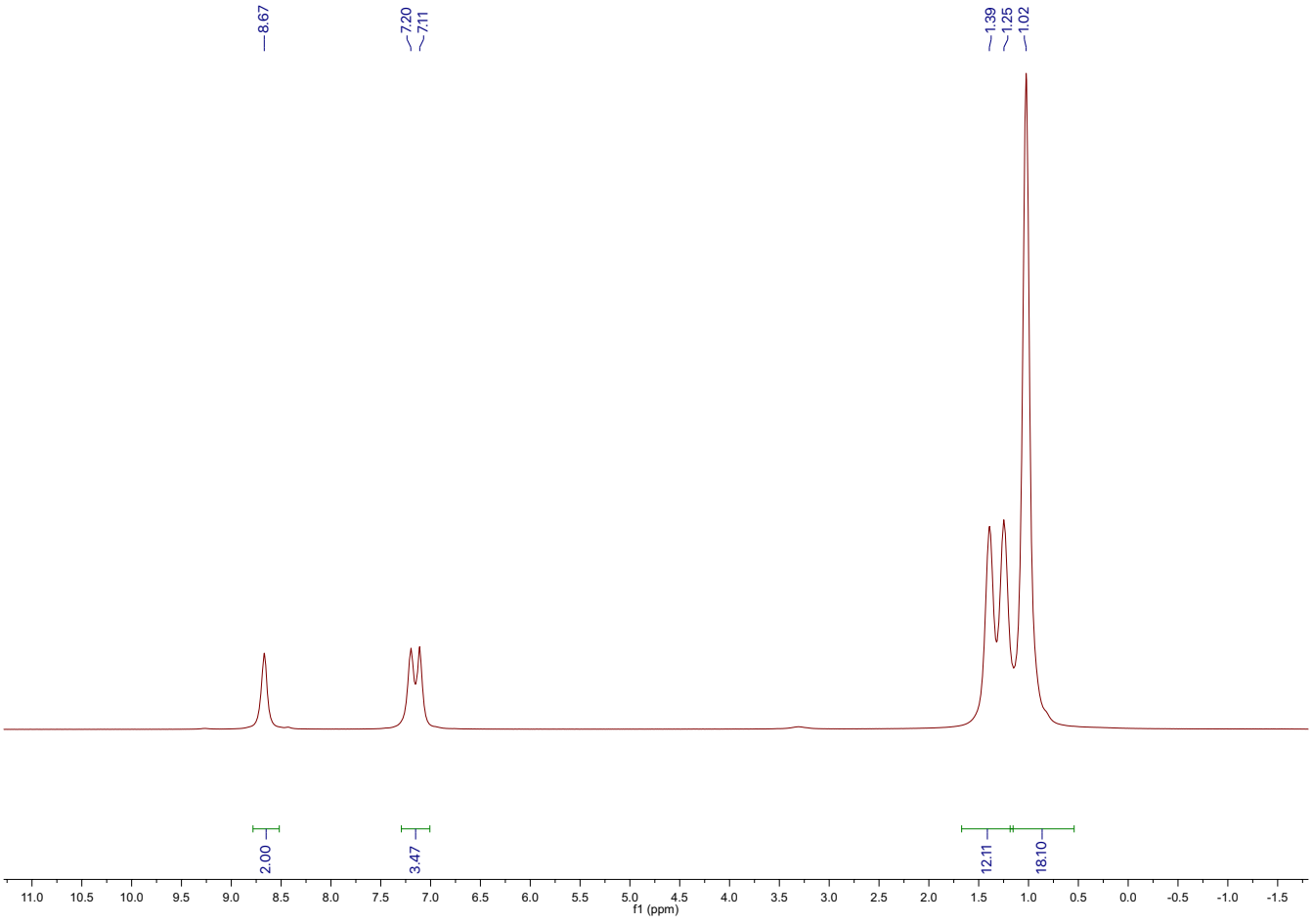
8

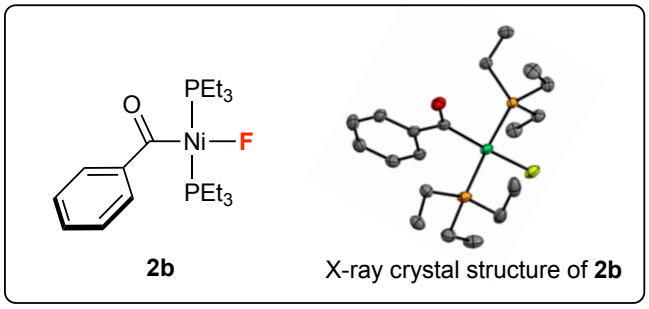
^{31}P NMR


11.42
Cy3P=O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40
f1 (ppm)

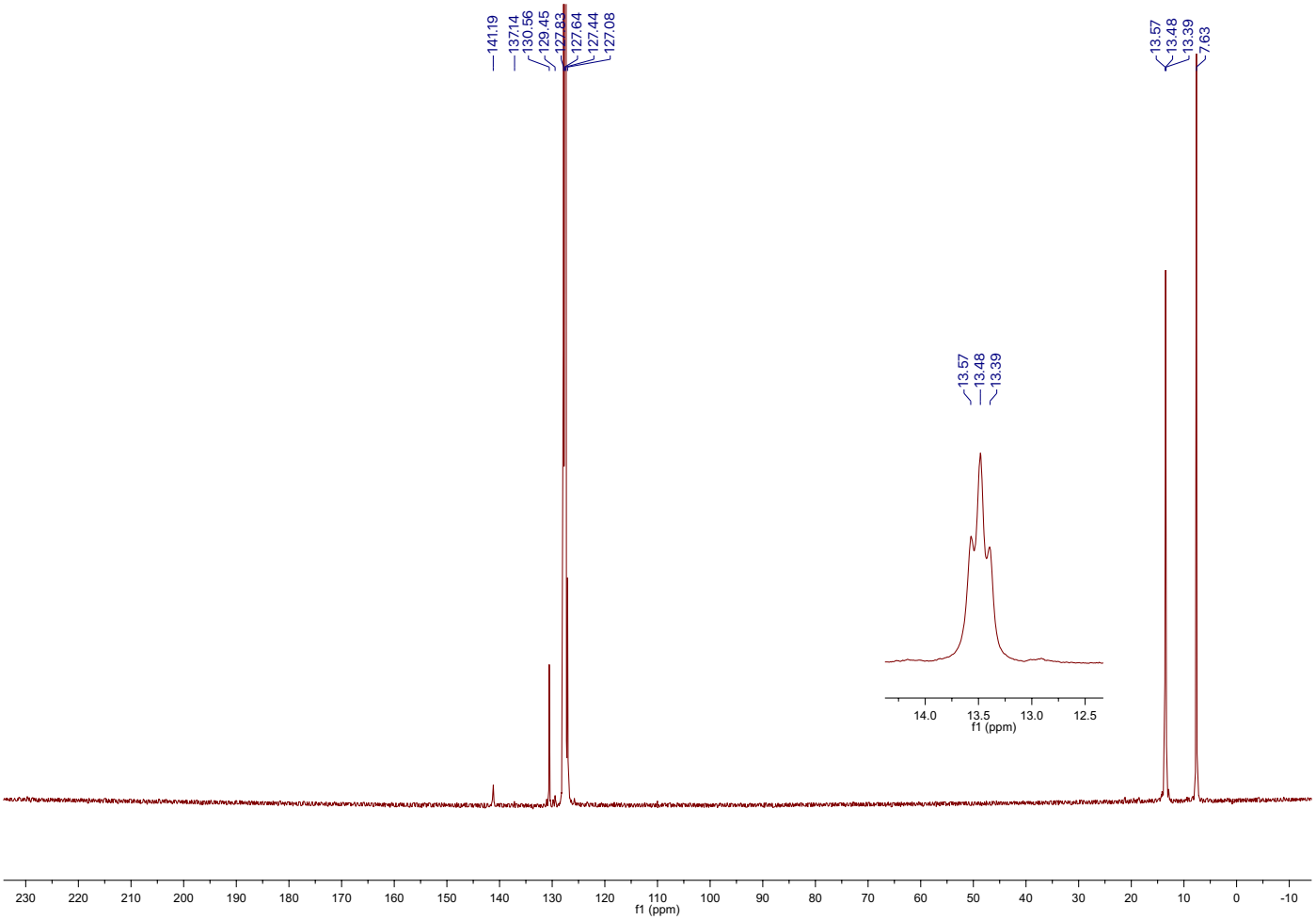

PEt3
O
Ni
F
PEt3
2b
X-ray crystal structure of 2b

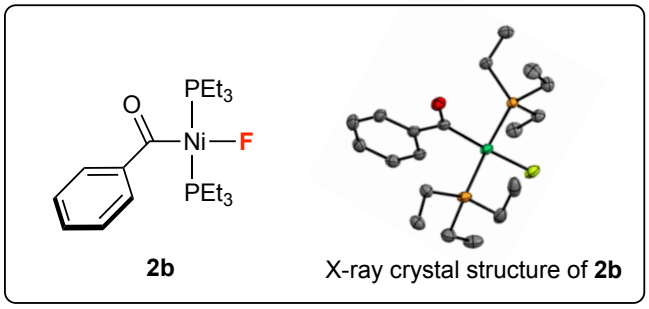
^{1}H NMR


8.67
7.20
7.11
1.39
1.25
1.02
2.00
3.47
12.11
18.10
f1 (ppm)

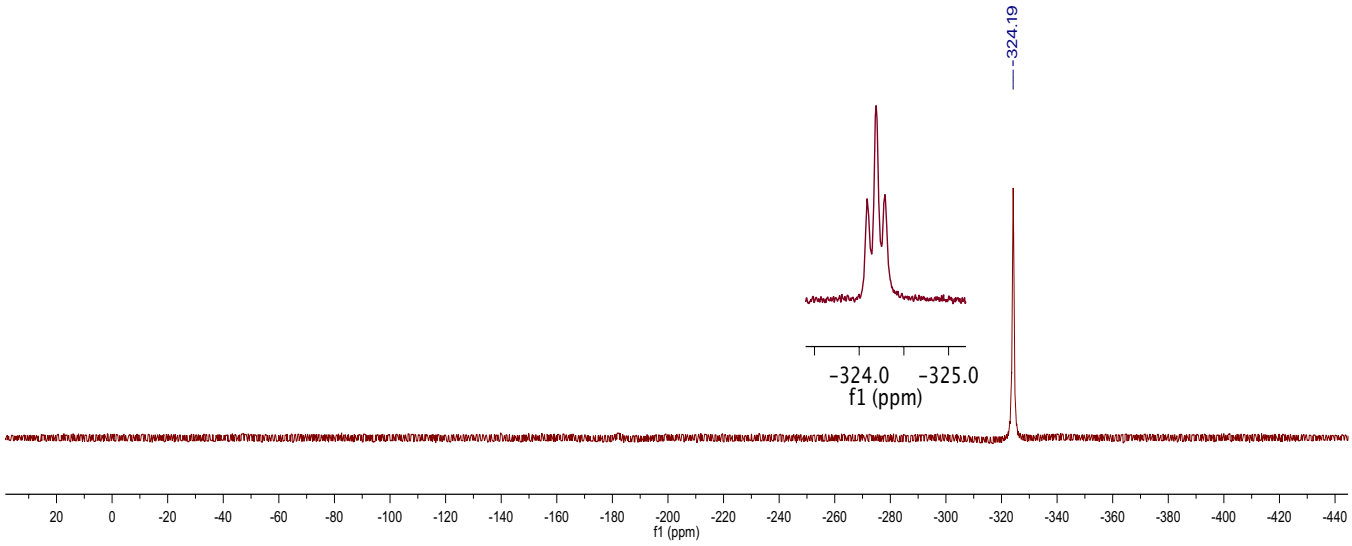

PEt3
O
Ni
F
PEt3
2b
X-ray crystal structure of 2b

^{13}C NMR

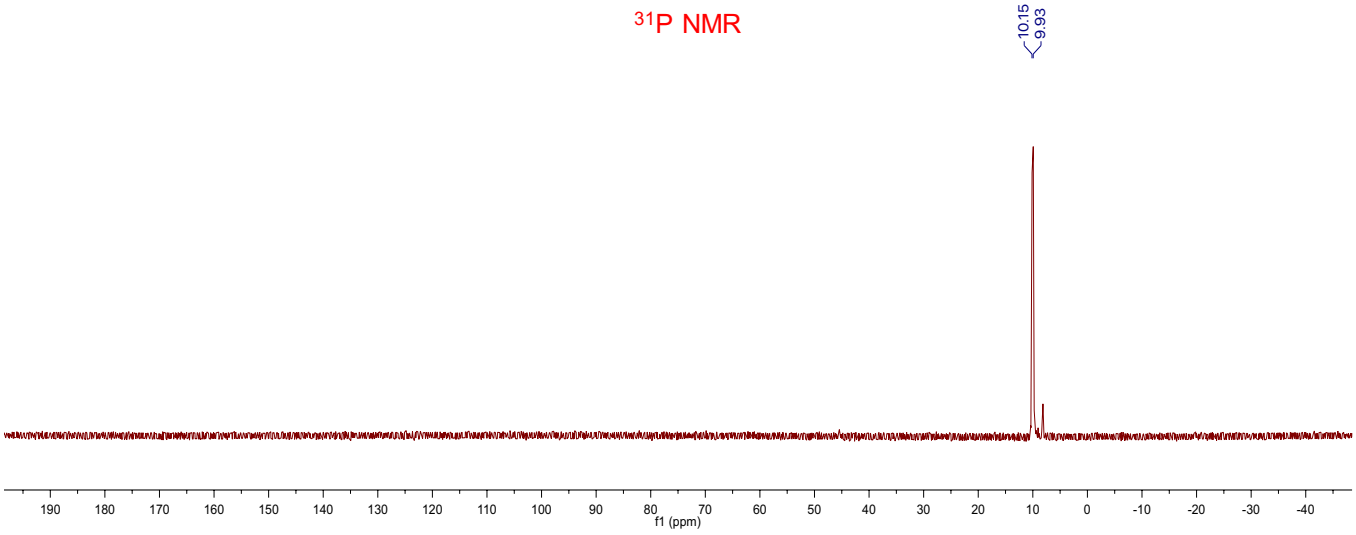

141.19
137.14
130.56
129.45
127.83
127.64
127.44
127.08
13.57
13.48
13.39
7.63
13.57
13.48
13.39
14.0
13.5
13.0
12.5
f1 (ppm)
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

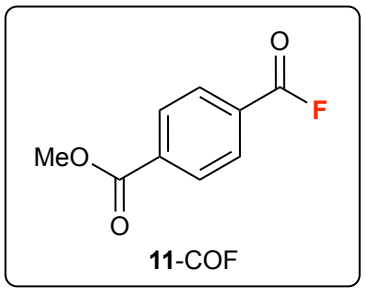


^{19}F NMR



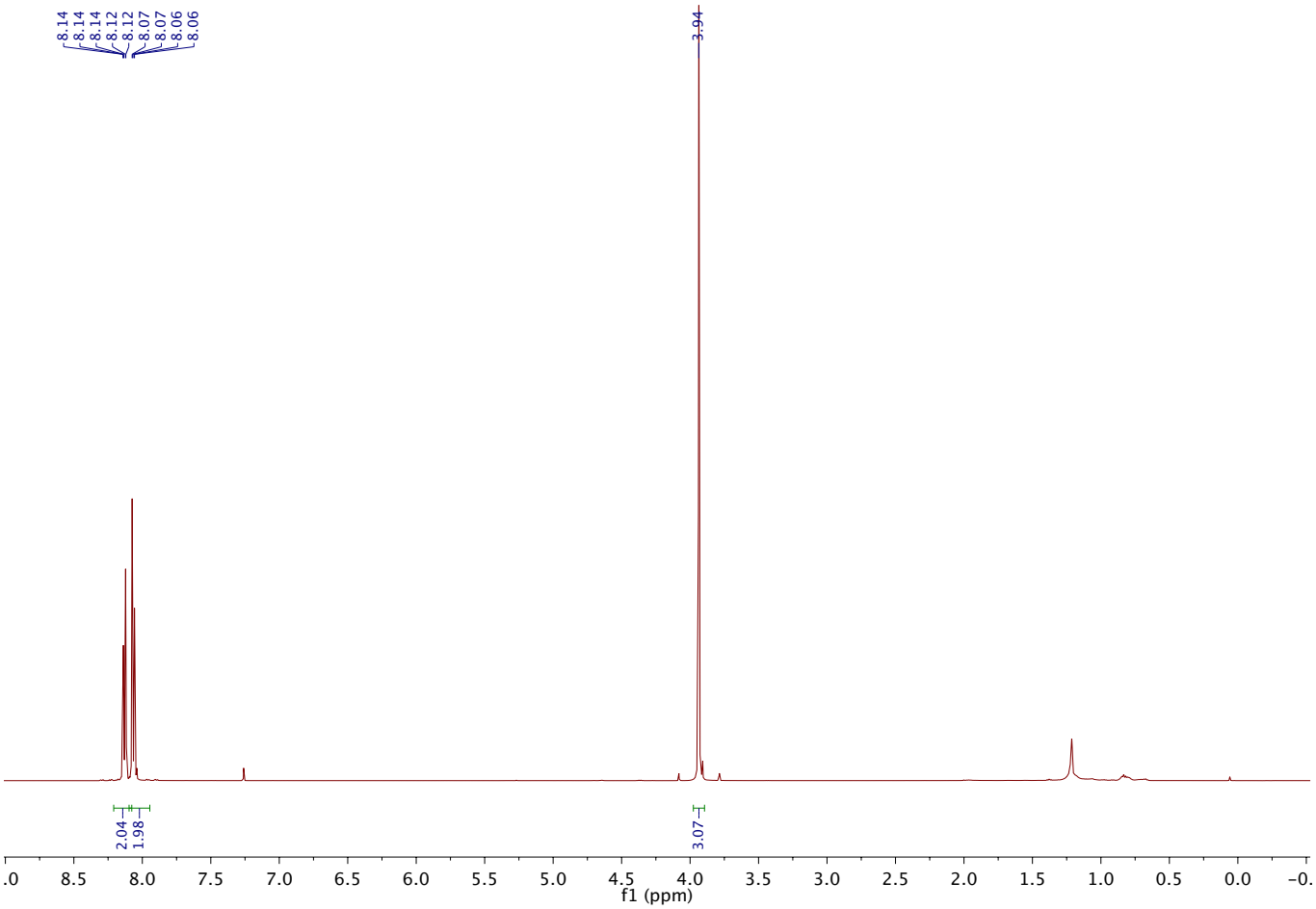
^{31}P NMR

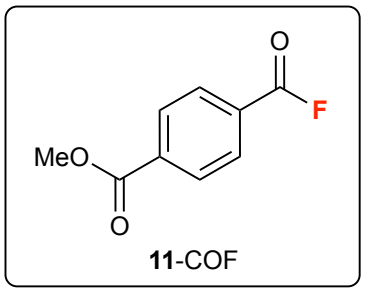



O
F
MeO
O

11-COF

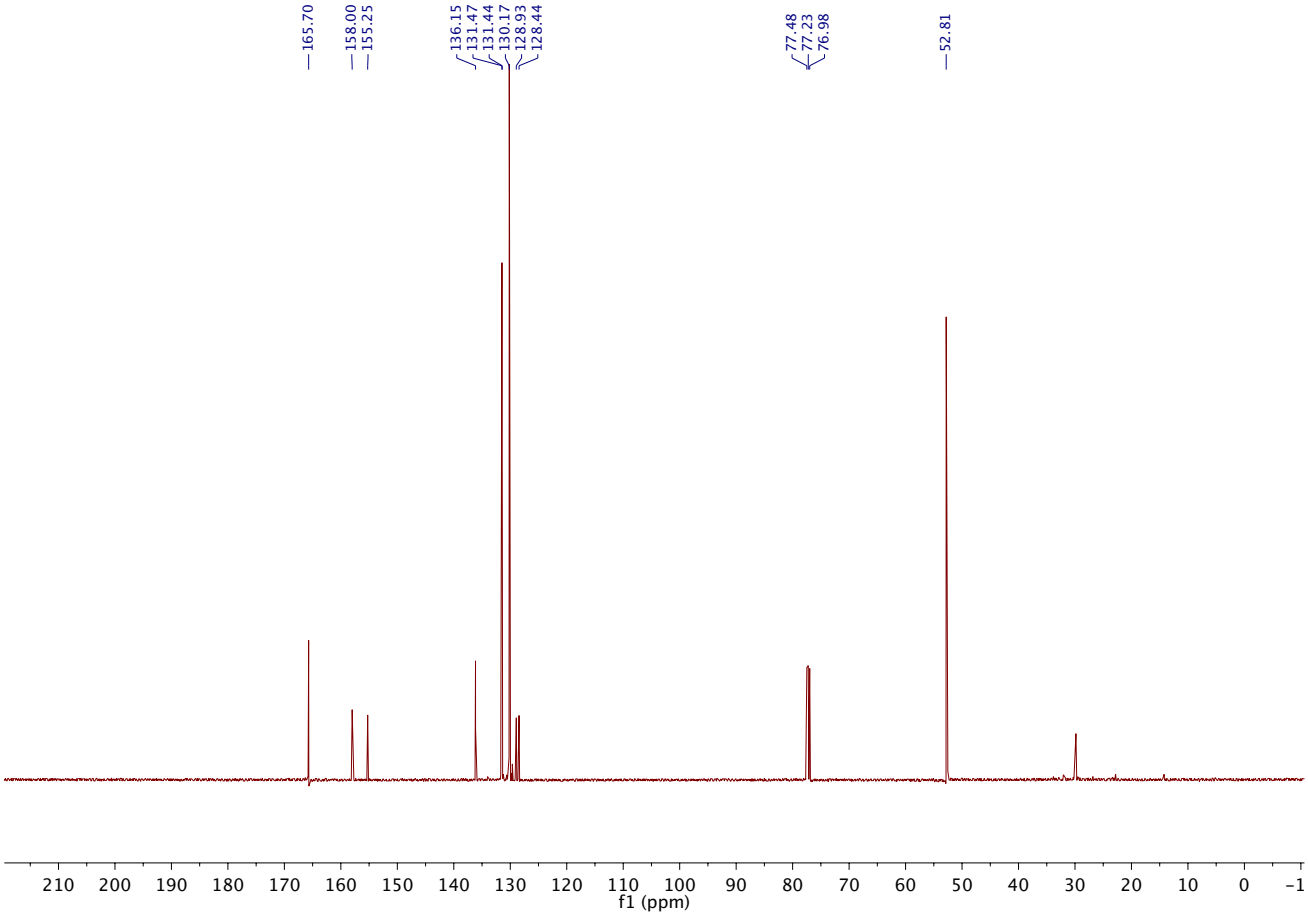
^{1}H NMR

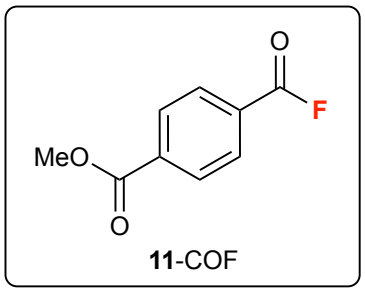

8.14
8.14
8.14
8.12
8.12
8.07
8.07
8.06
8.06
3.94
2.04
1.98
3.07
.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)



11-COF

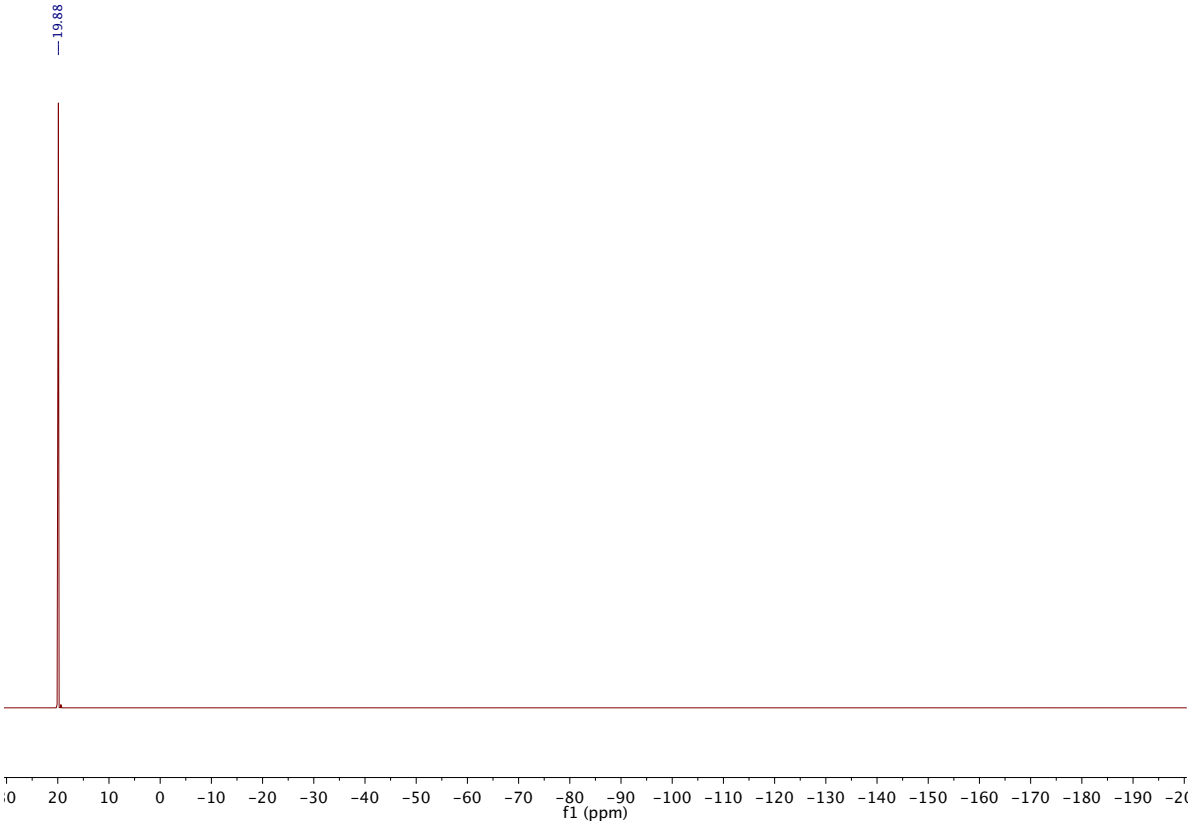
^{13}C NMR

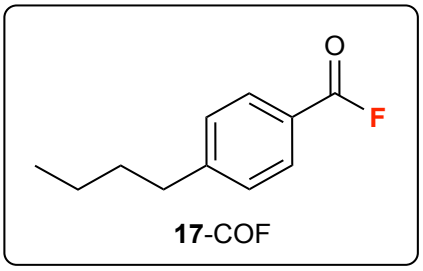




11-COF

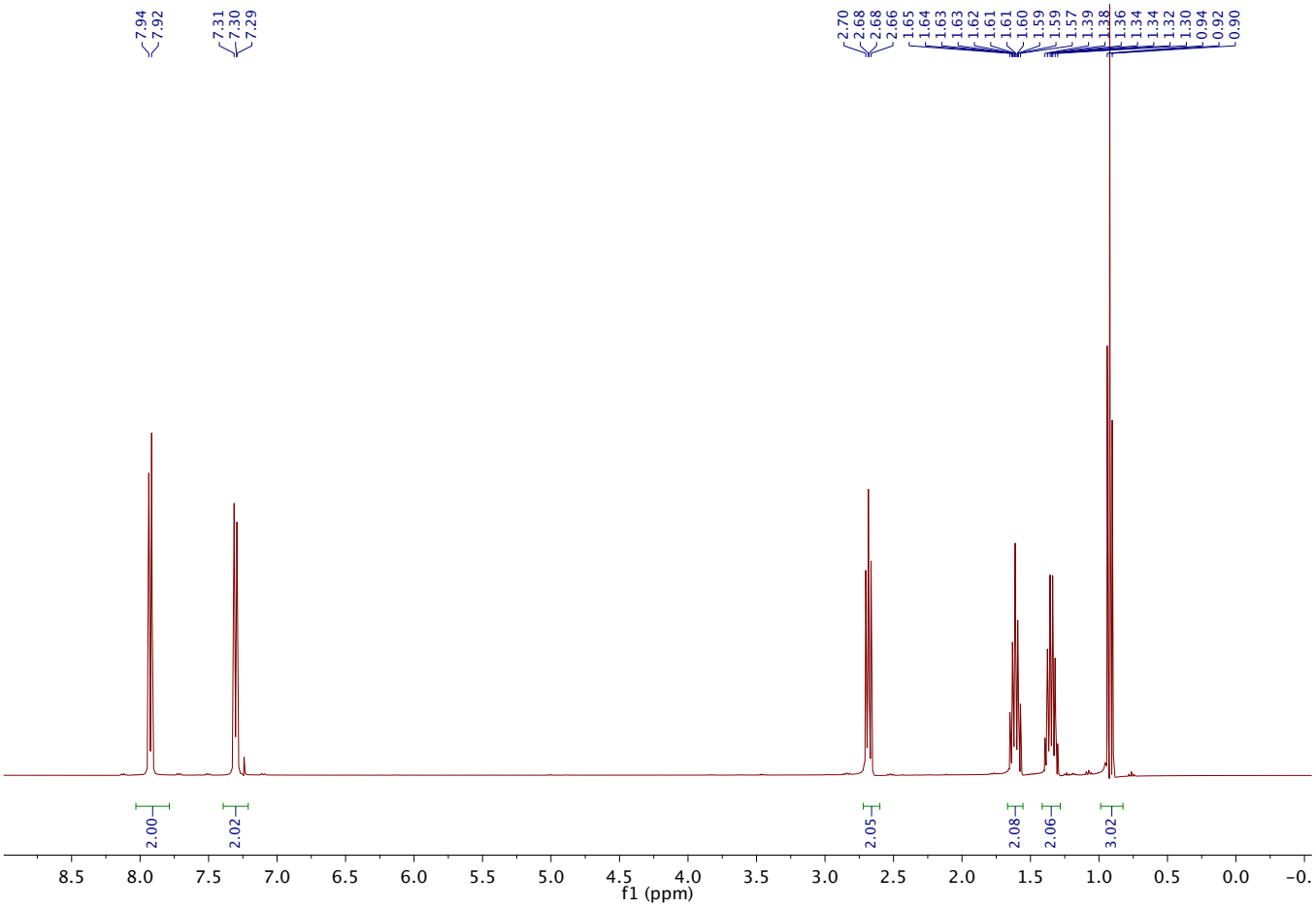
^{19}F NMR

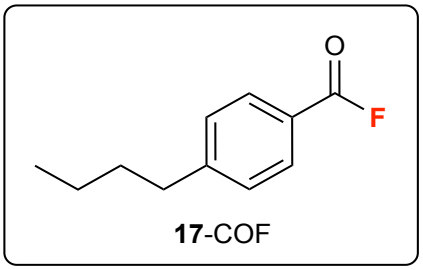



O
F

17-COF

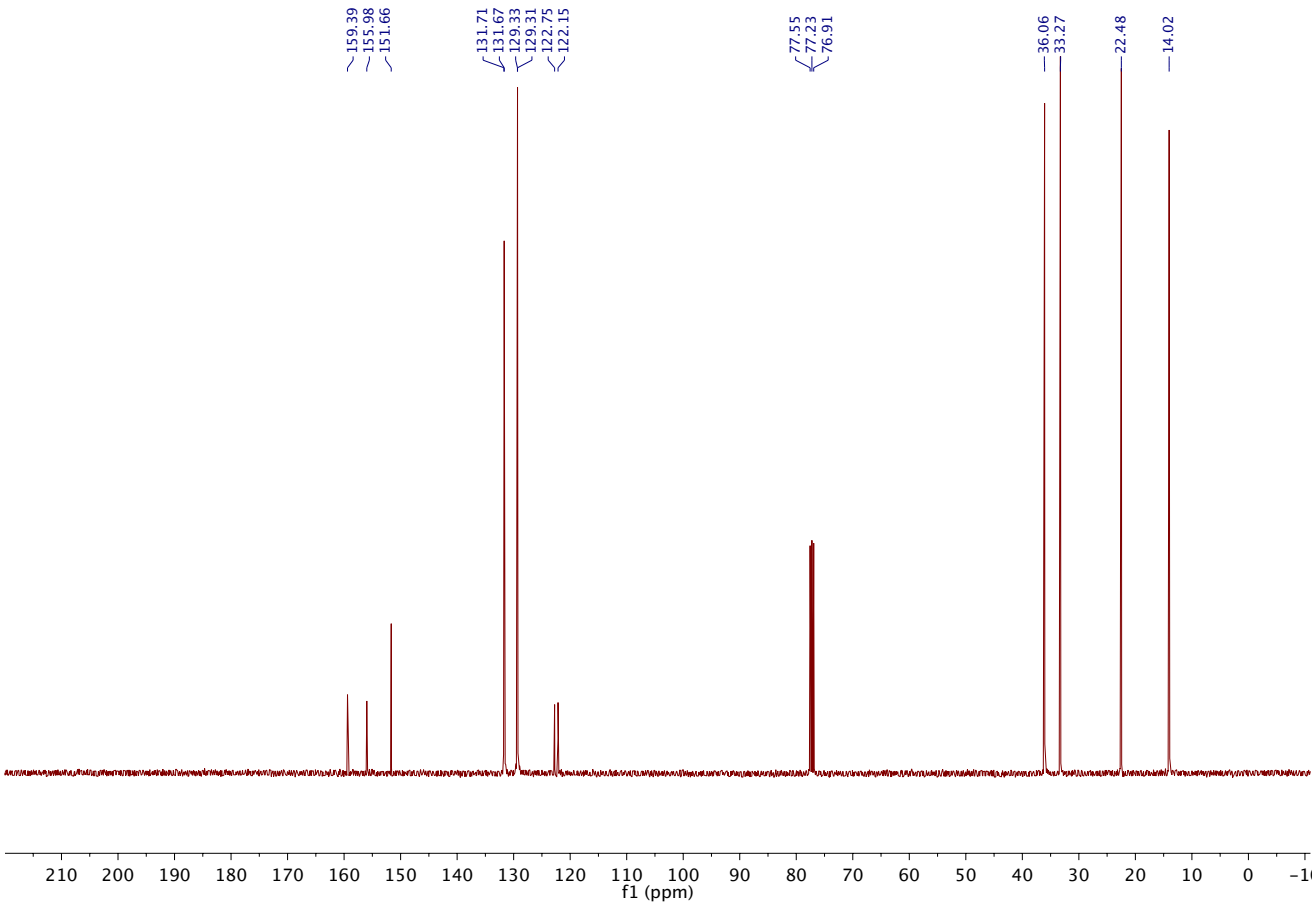
^{1}H NMR

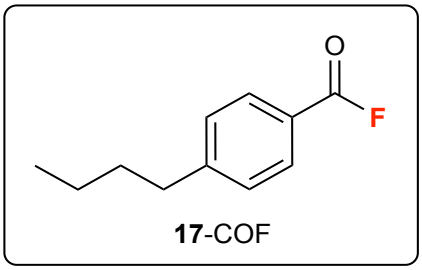

7.94
7.92
7.31
7.30
7.29
2.70
2.68
2.68
2.66
1.65
1.64
1.63
1.63
1.62
1.61
1.61
1.60
1.59
1.59
1.57
1.39
1.38
1.36
1.34
1.34
1.32
1.30
0.94
0.92
0.90
2.00
2.02
2.05
2.08
2.06
3.02
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)



17-COF

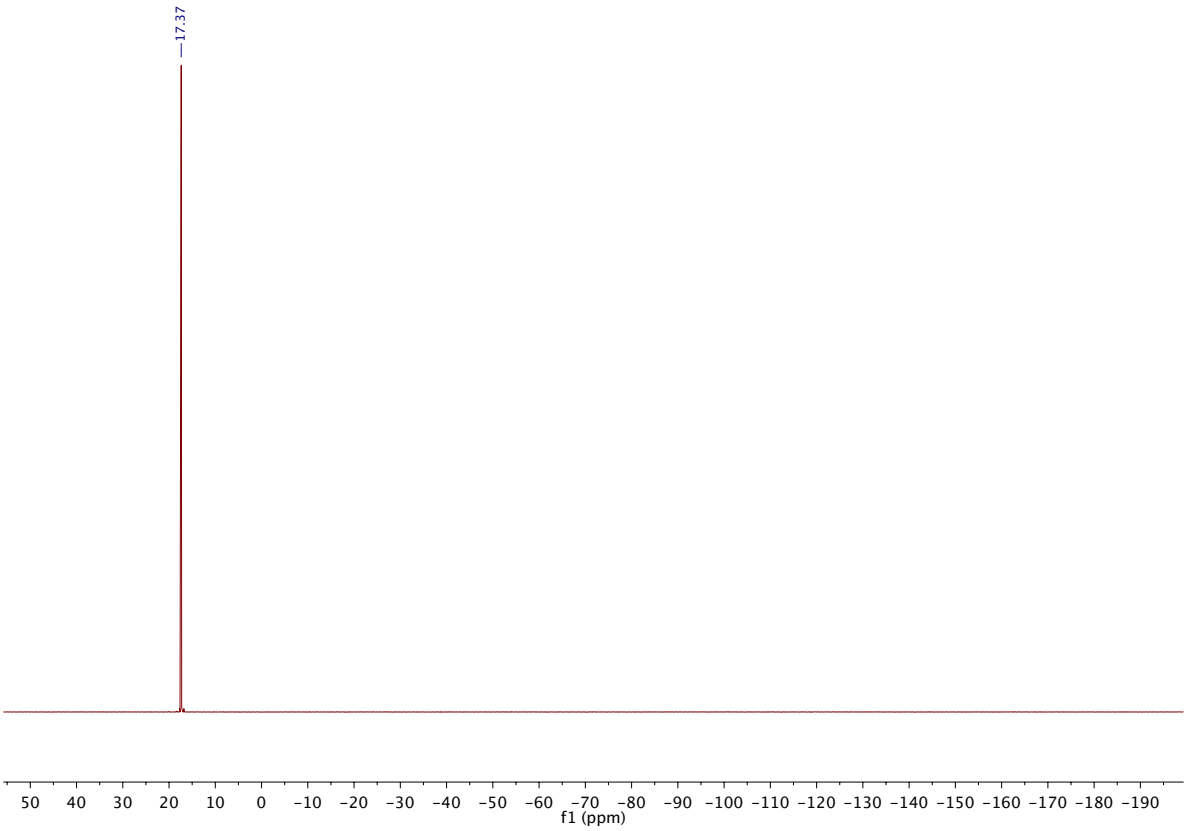
^{13}C NMR

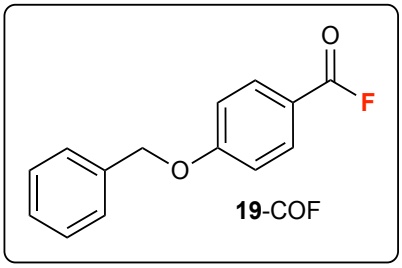




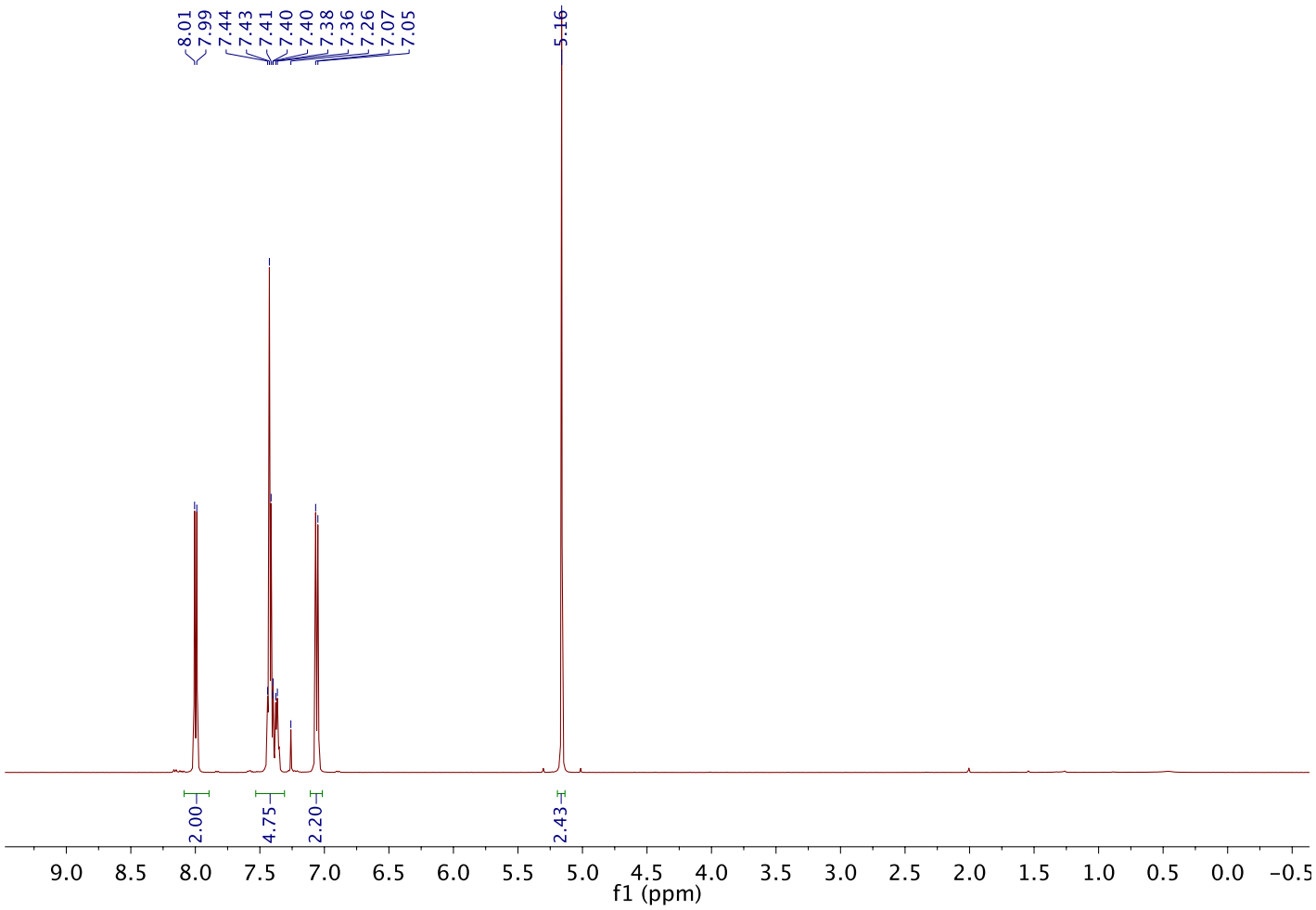
17-COF

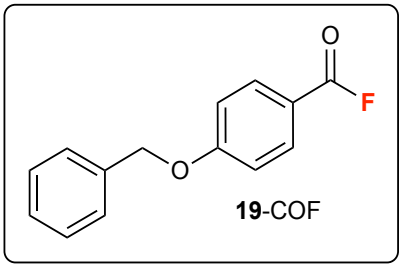
^{19}F NMR



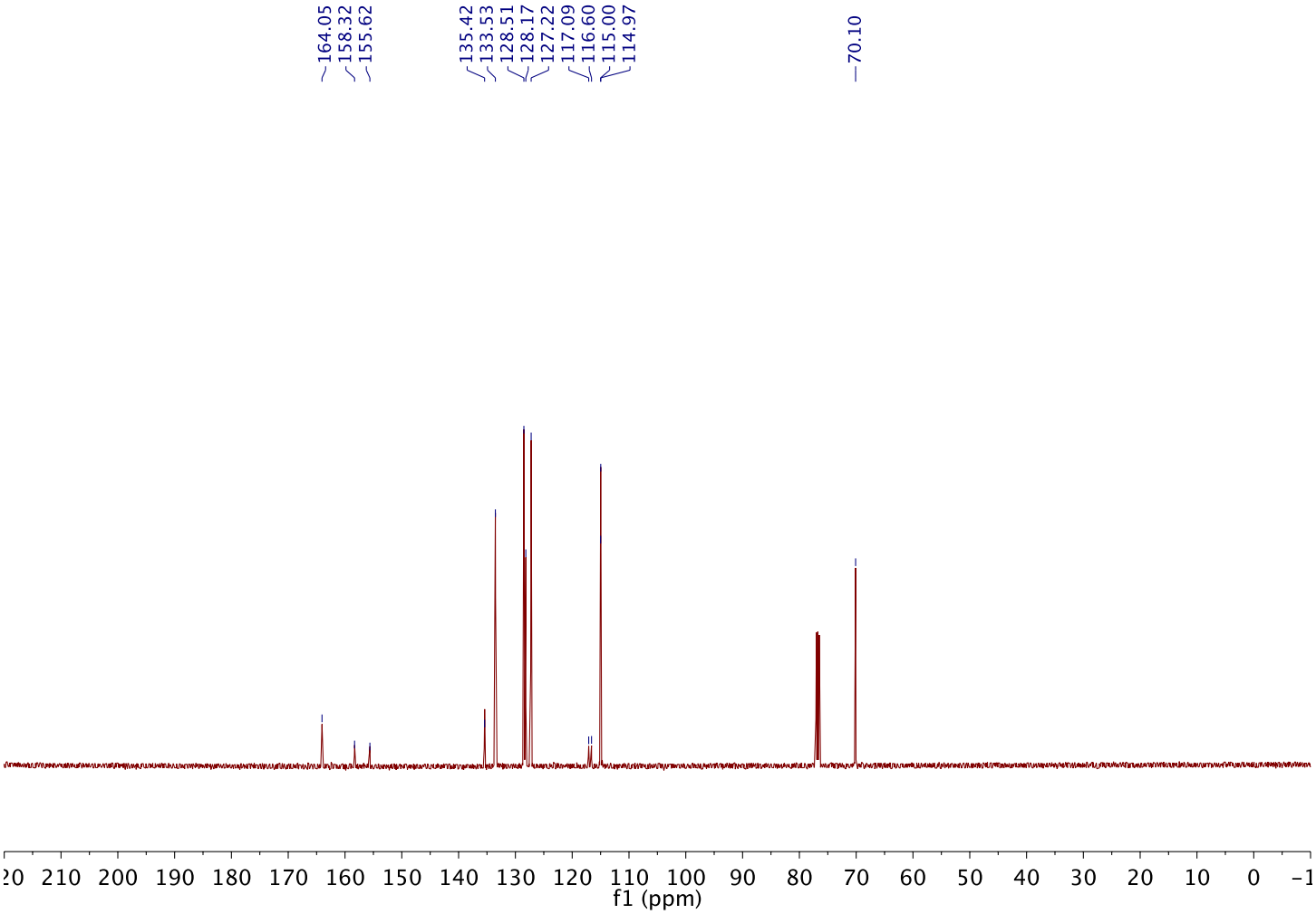

O
F
O
19-COF

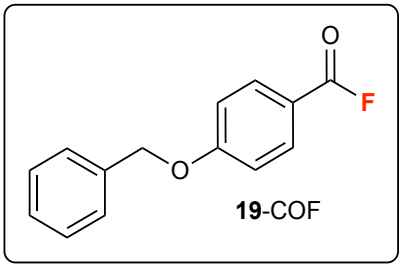
^{1}H NMR


8.01
7.99
7.44
7.43
7.41
7.40
7.40
7.38
7.36
7.26
7.07
7.05
5.16
2.00
4.75
2.20
2.43
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

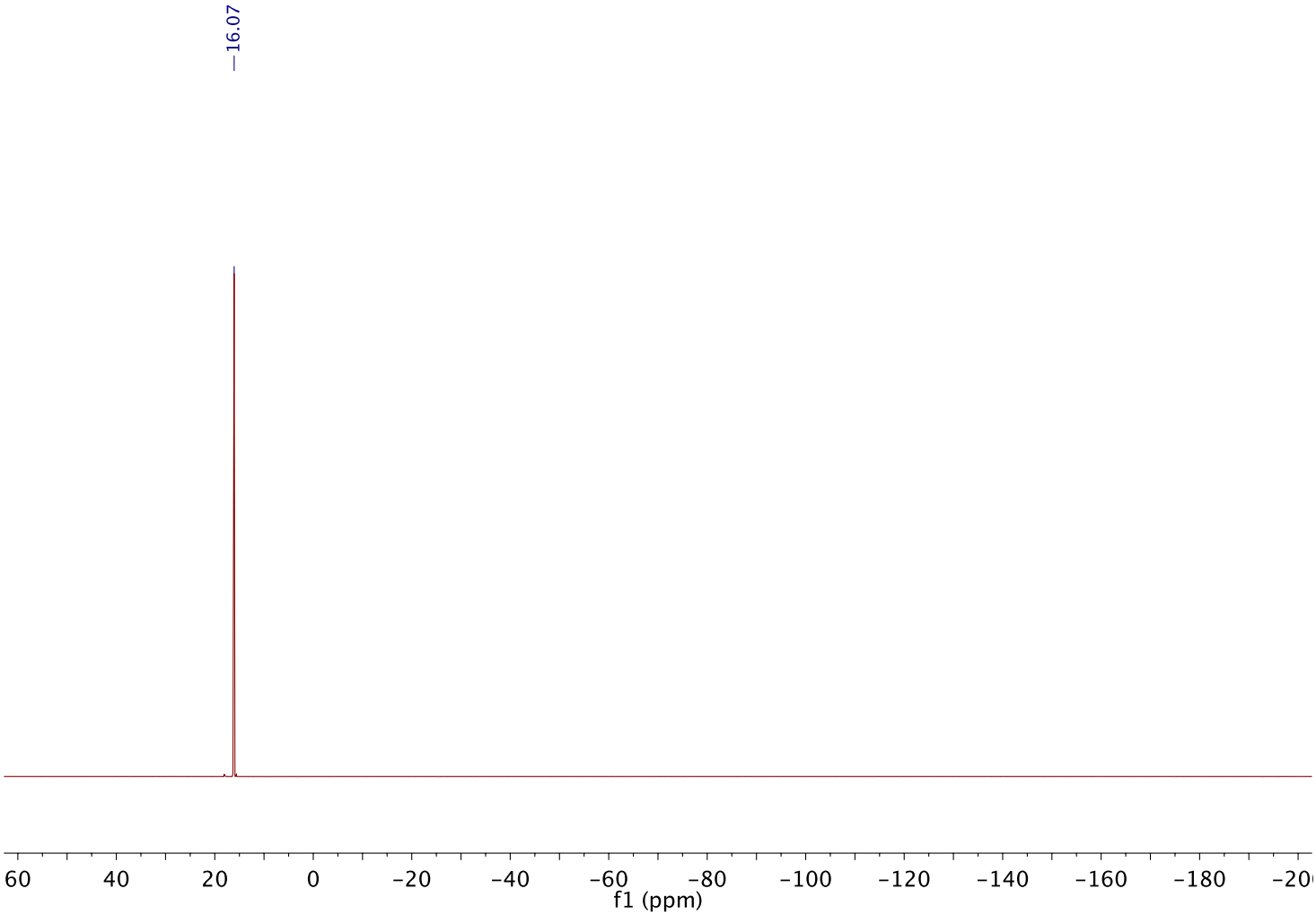

O
F
O
19-COF

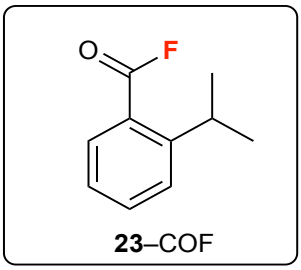
^{13}C NMR


164.05
158.32
155.62
135.42
133.53
128.51
128.17
127.22
117.09
116.60
115.00
114.97
70.10
f1 (ppm)



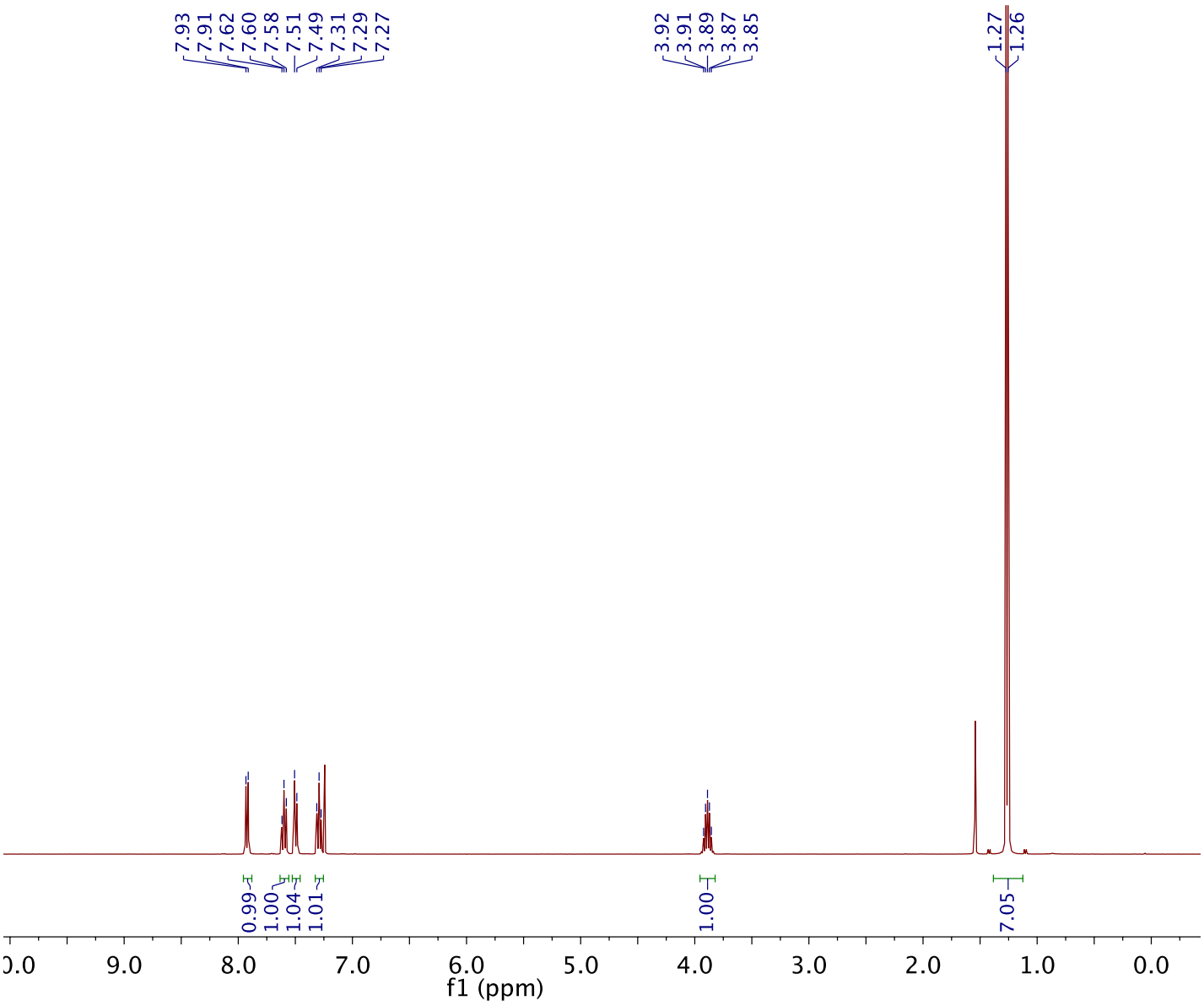
^{19}F NMR

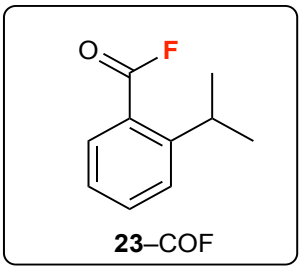



O
F

23–COF

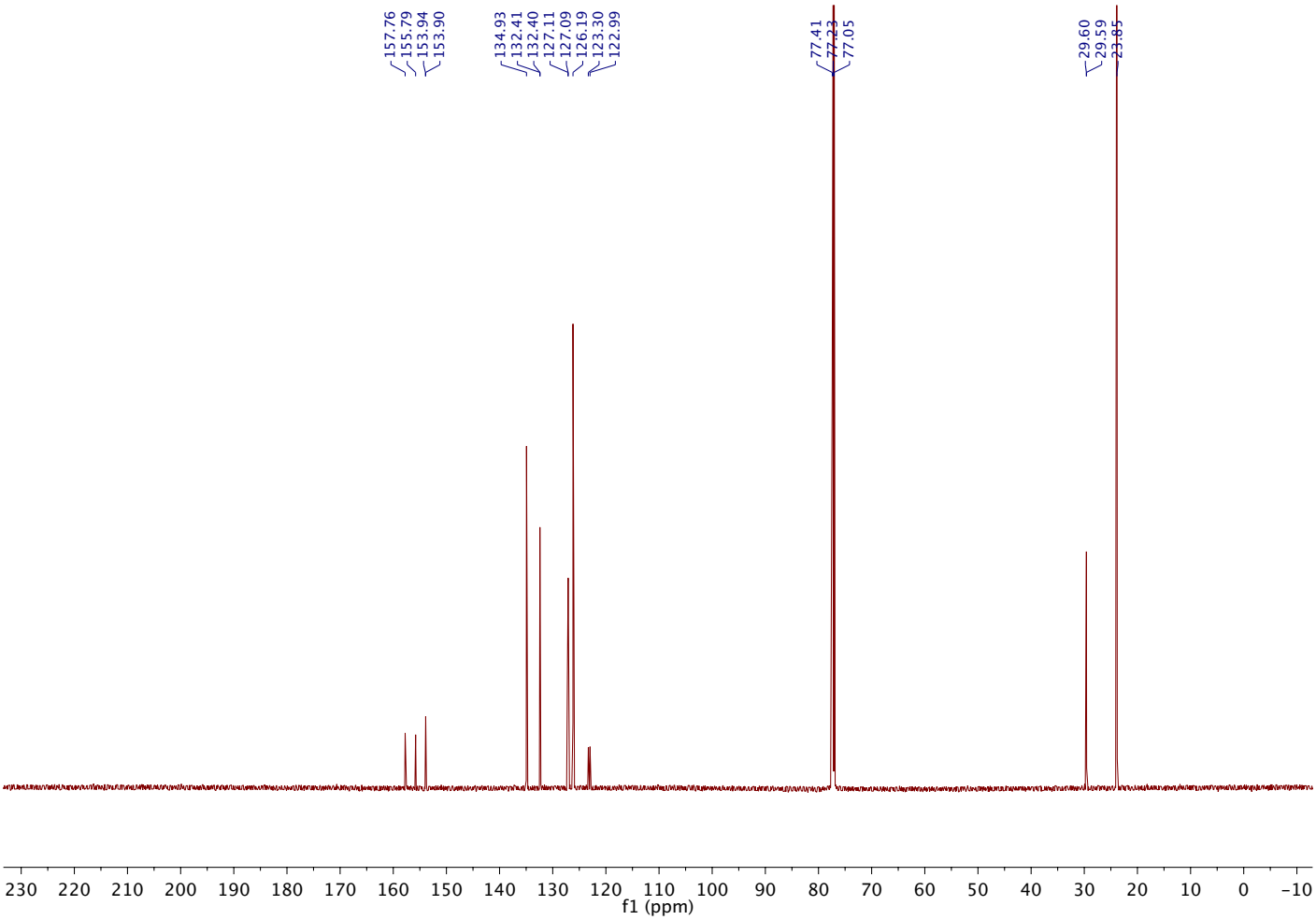
^{1}H NMR

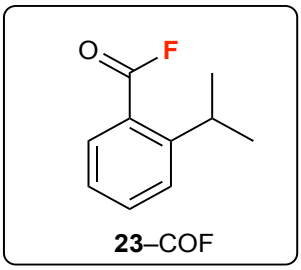

7.93
7.91
7.62
7.60
7.58
7.51
7.49
7.31
7.29
7.27
3.92
3.91
3.89
3.87
3.85
1.27
1.26
0.99
1.00
1.04
1.01
1.00
7.05
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)



23–COF

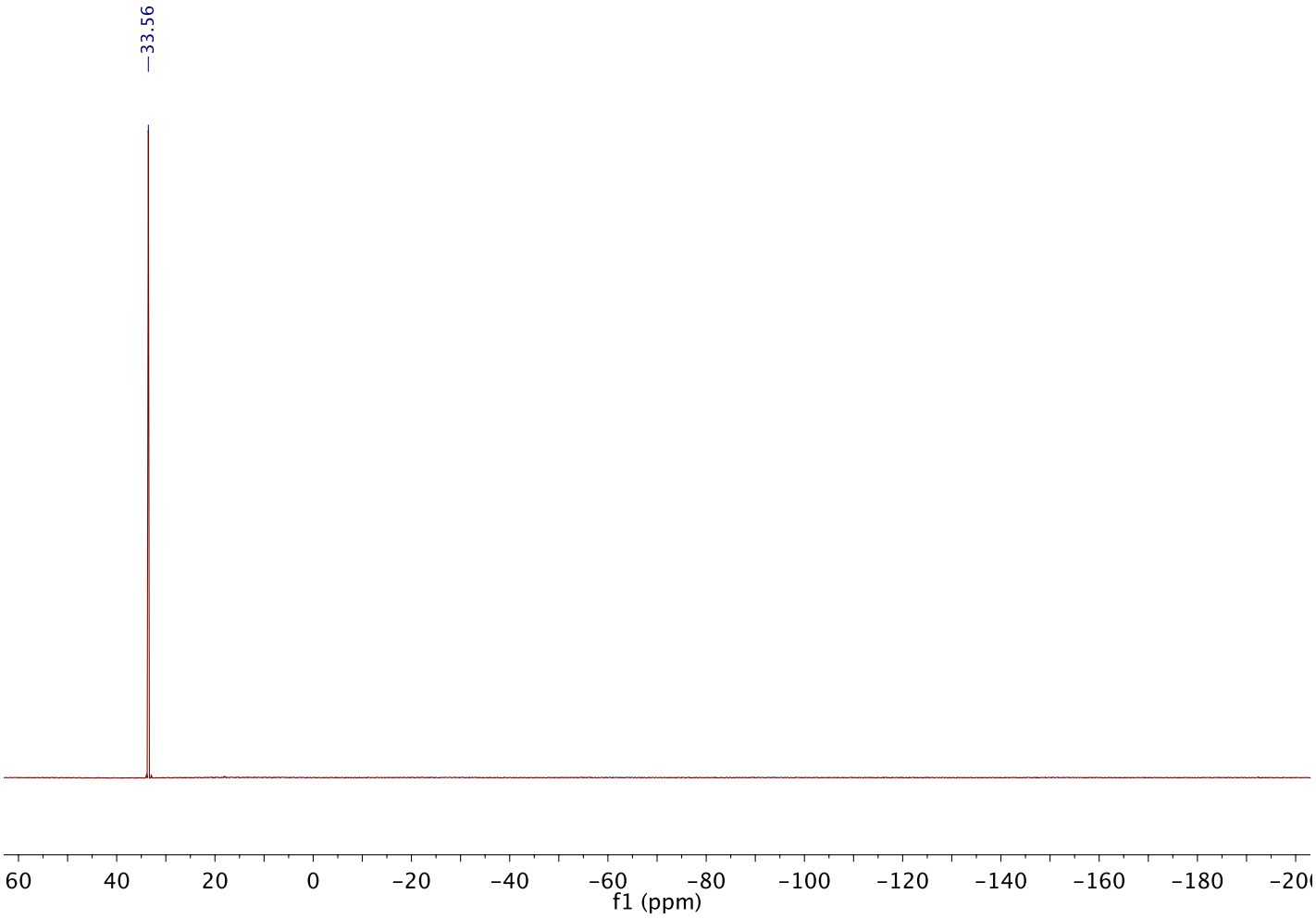
^{13}C NMR

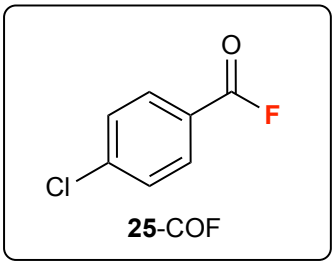




23–COF

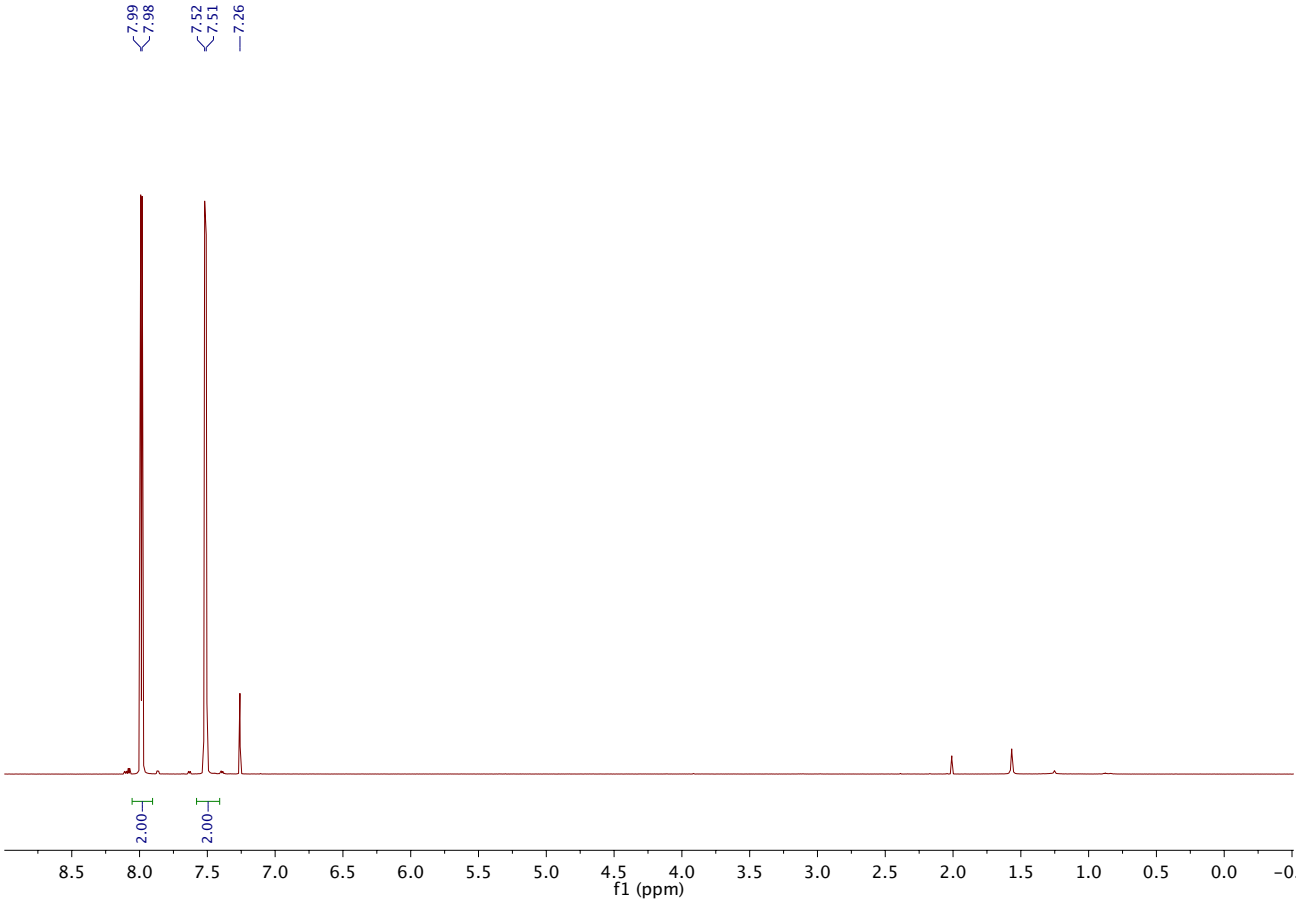
^{19}F NMR

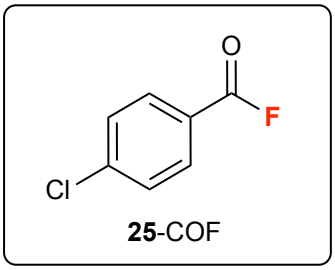



O
F
Cl

25-COF

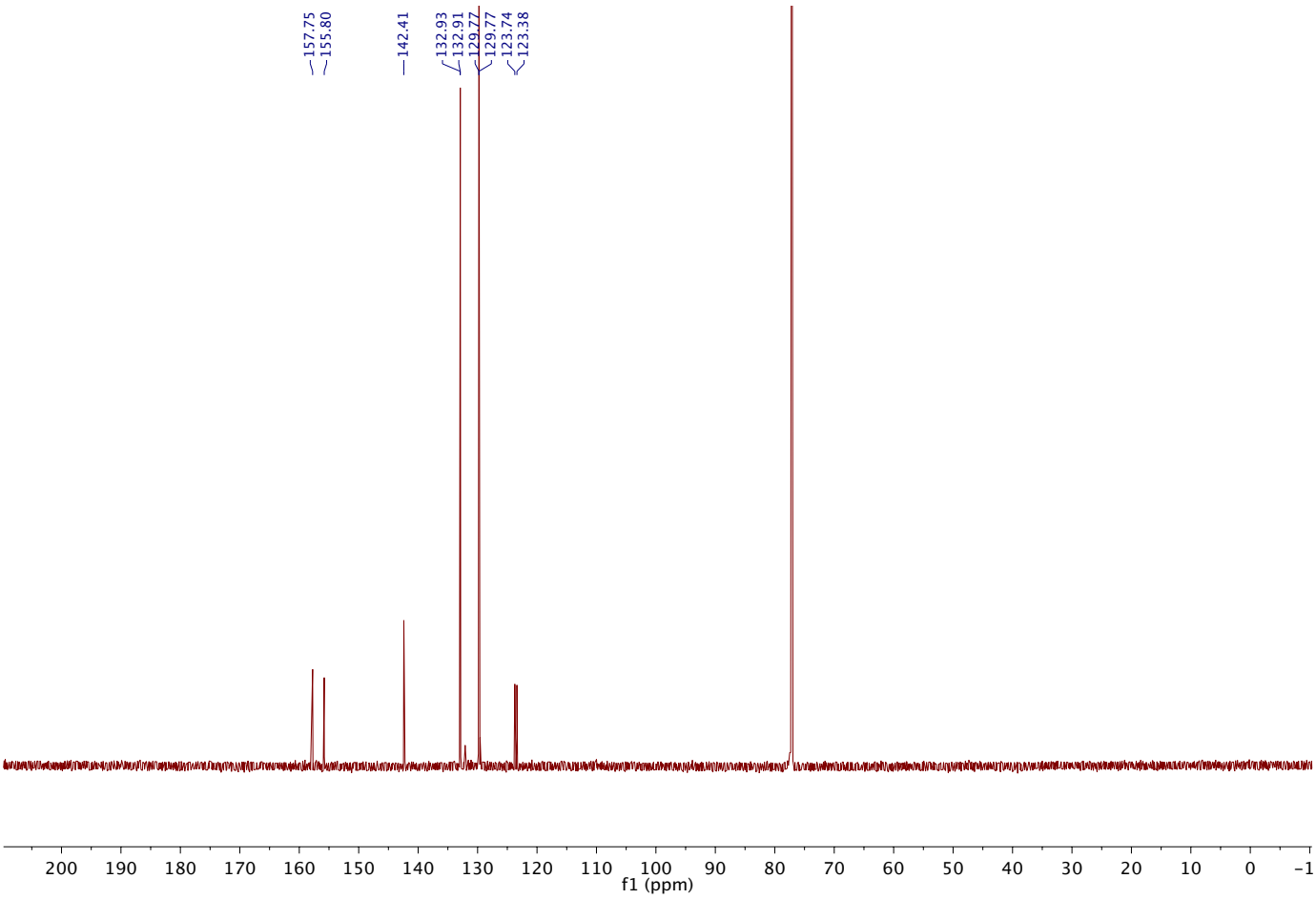
^{1}H NMR

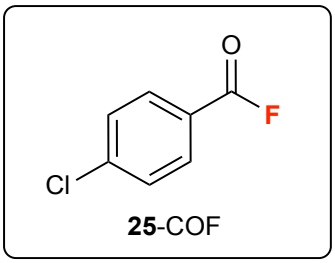

7.99
7.98
7.52
7.51
7.26
2.00
2.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)



25-COF

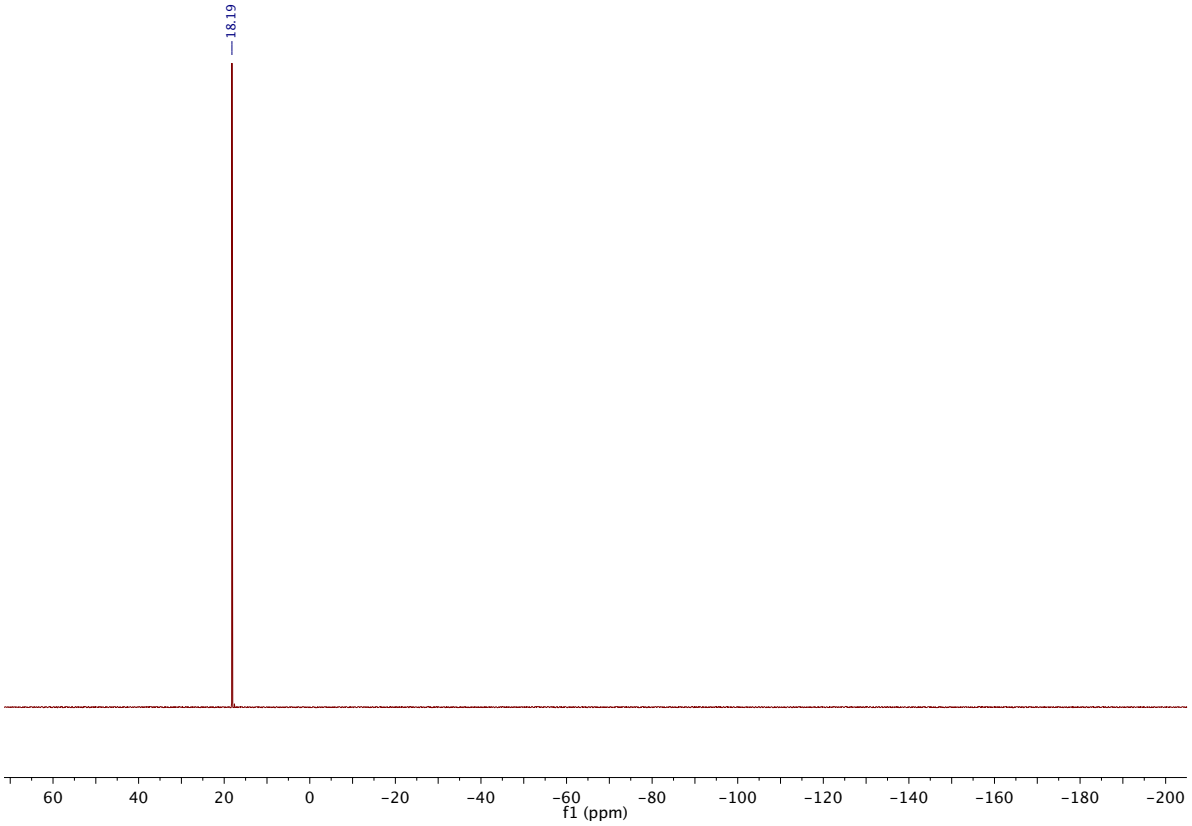
^{13}C NMR

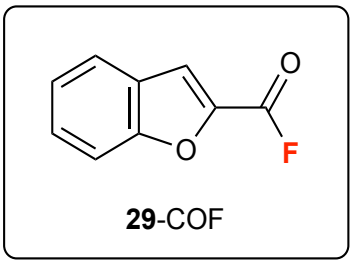




25-COF

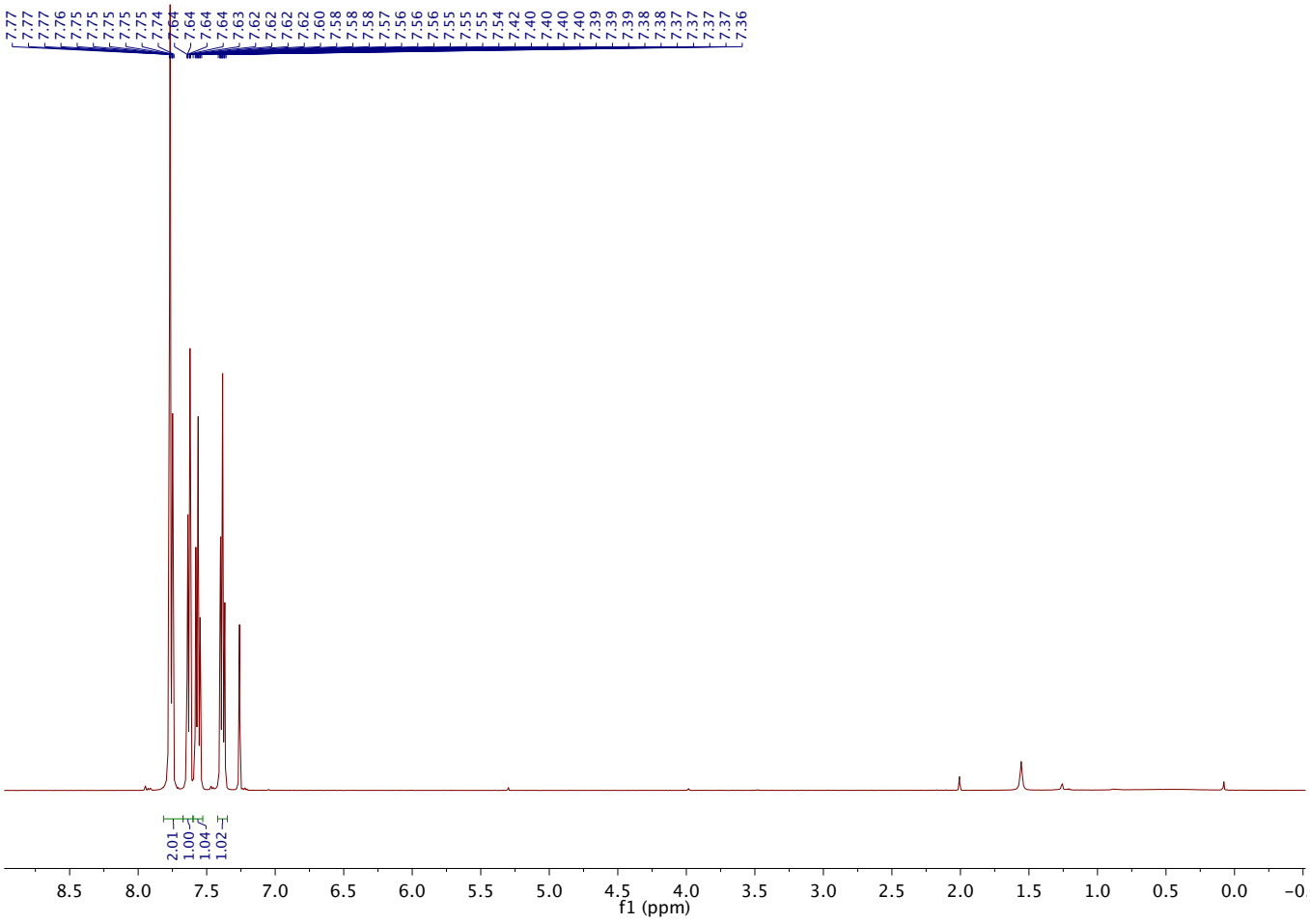
^{19}F NMR

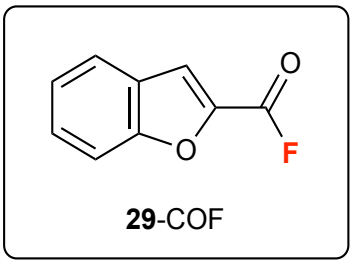




29-COF

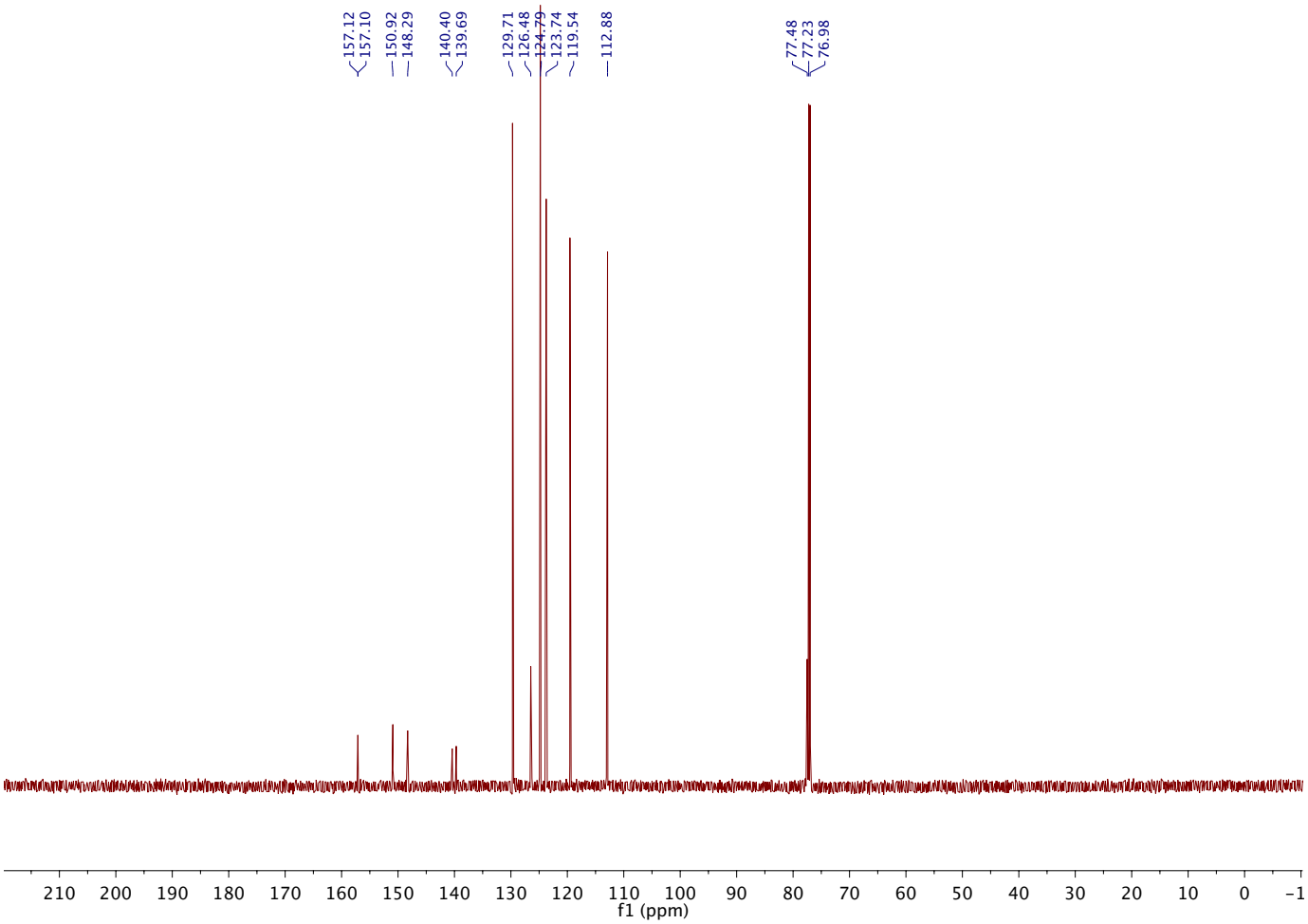
^{19}F NMR

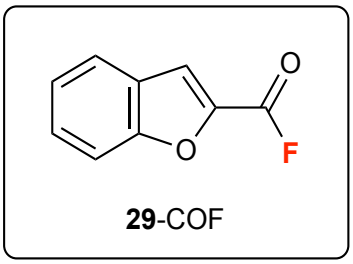




29-COF

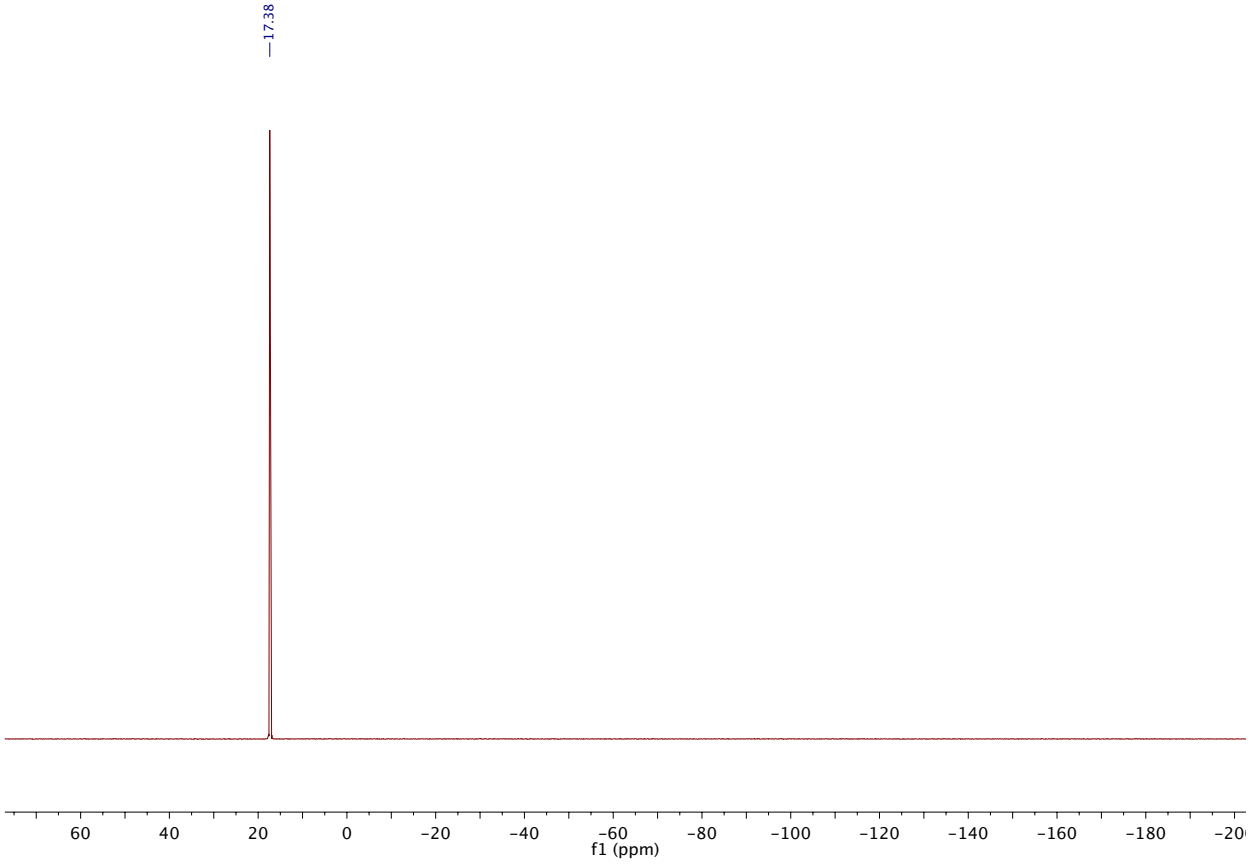
^{19}F NMR

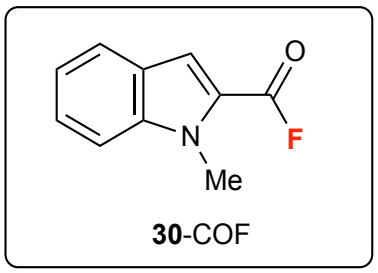




29-COF

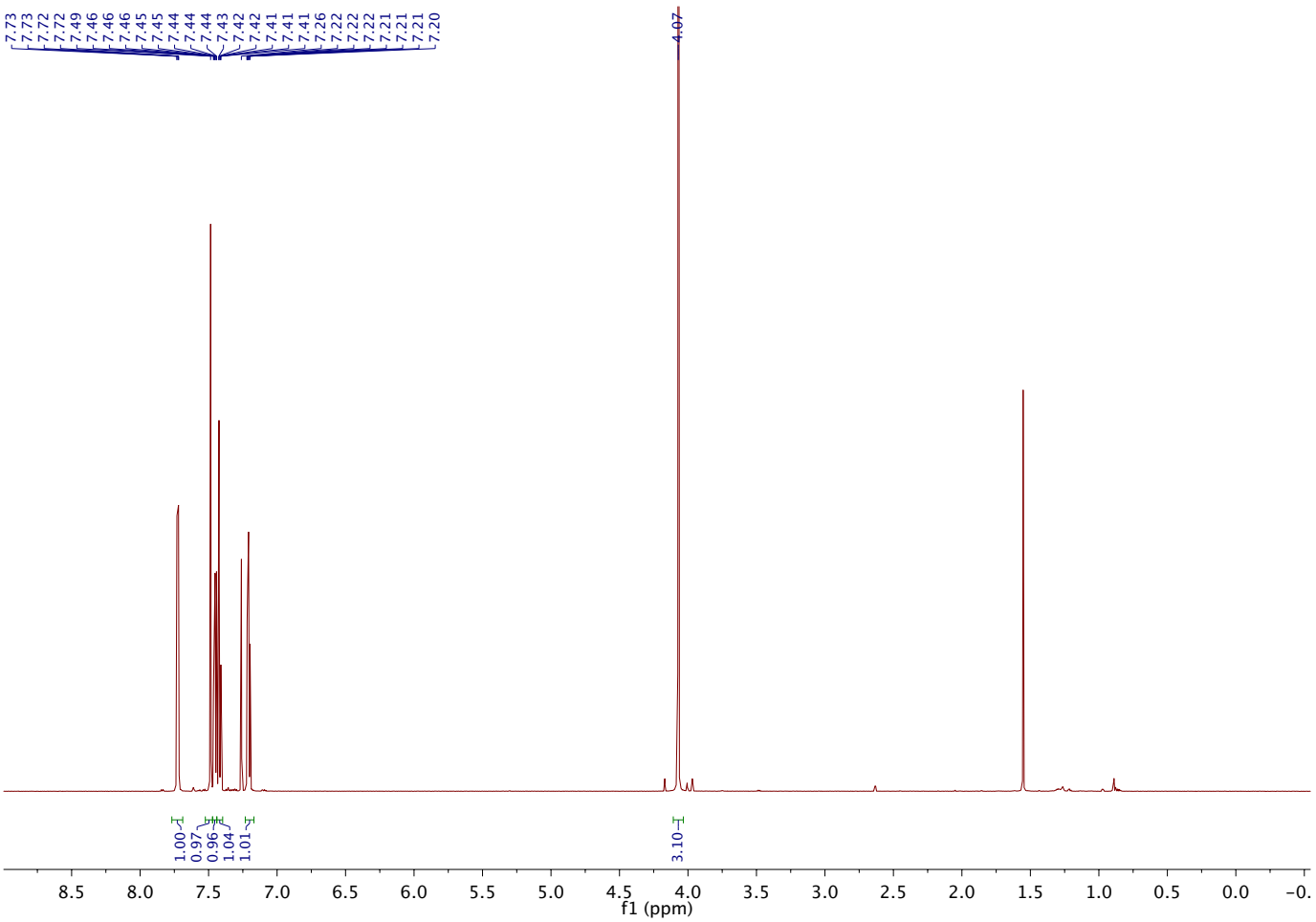
^{19}F NMR

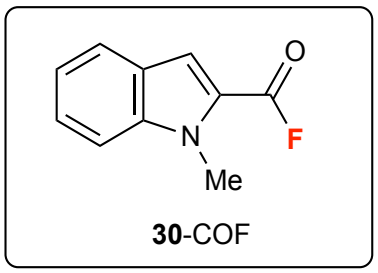



O
N
F
Me

30-COF

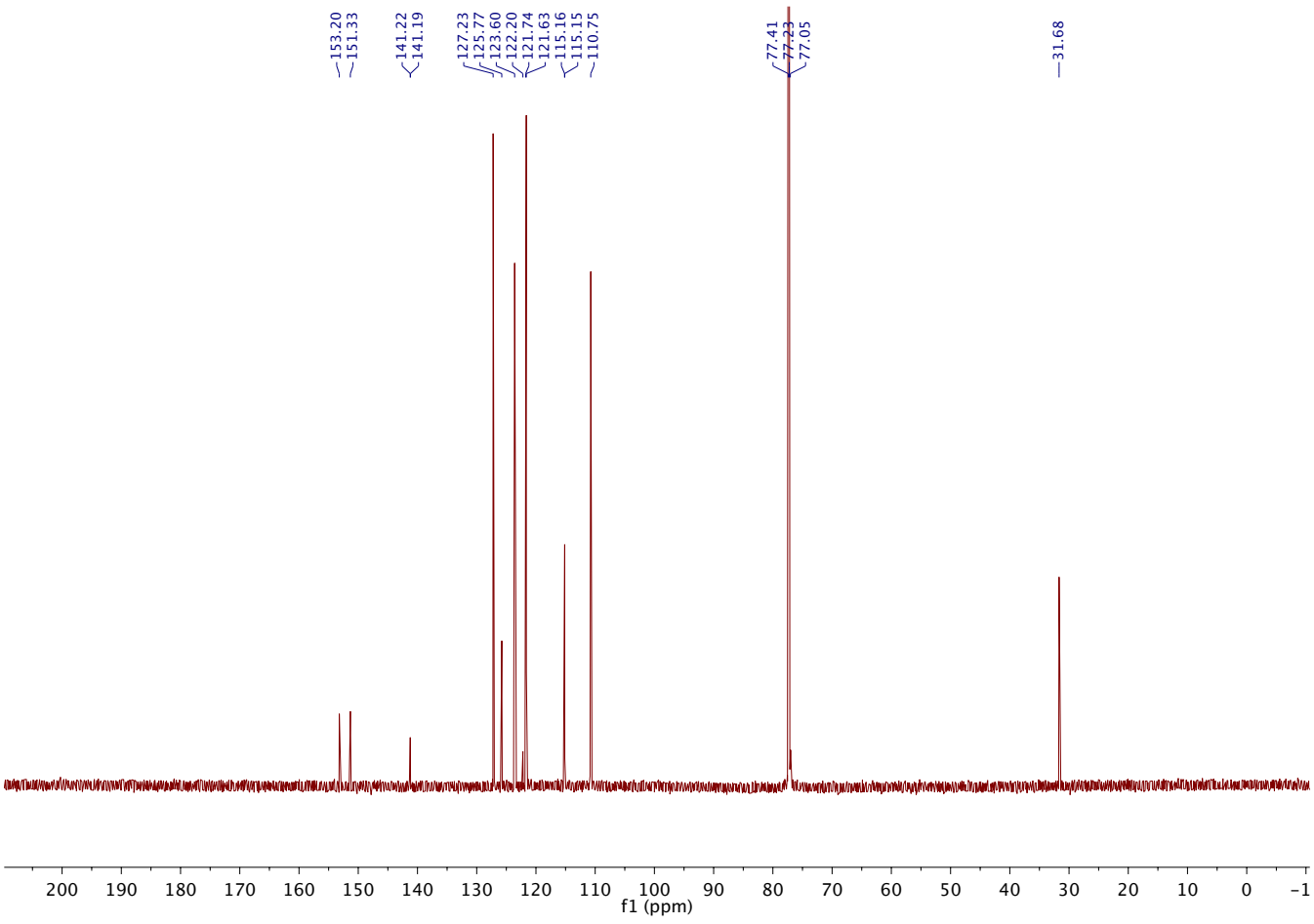
^{1}H NMR

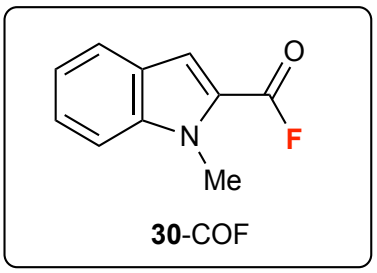

7.73
7.73
7.72
7.72
7.49
7.46
7.46
7.46
7.45
7.45
7.44
7.44
7.44
7.43
7.42
7.42
7.41
7.41
7.41
7.26
7.22
7.22
7.21
7.21
7.21
7.20
4.07
1.00
0.97
0.96
1.04
1.01
3.10
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)



30-COF

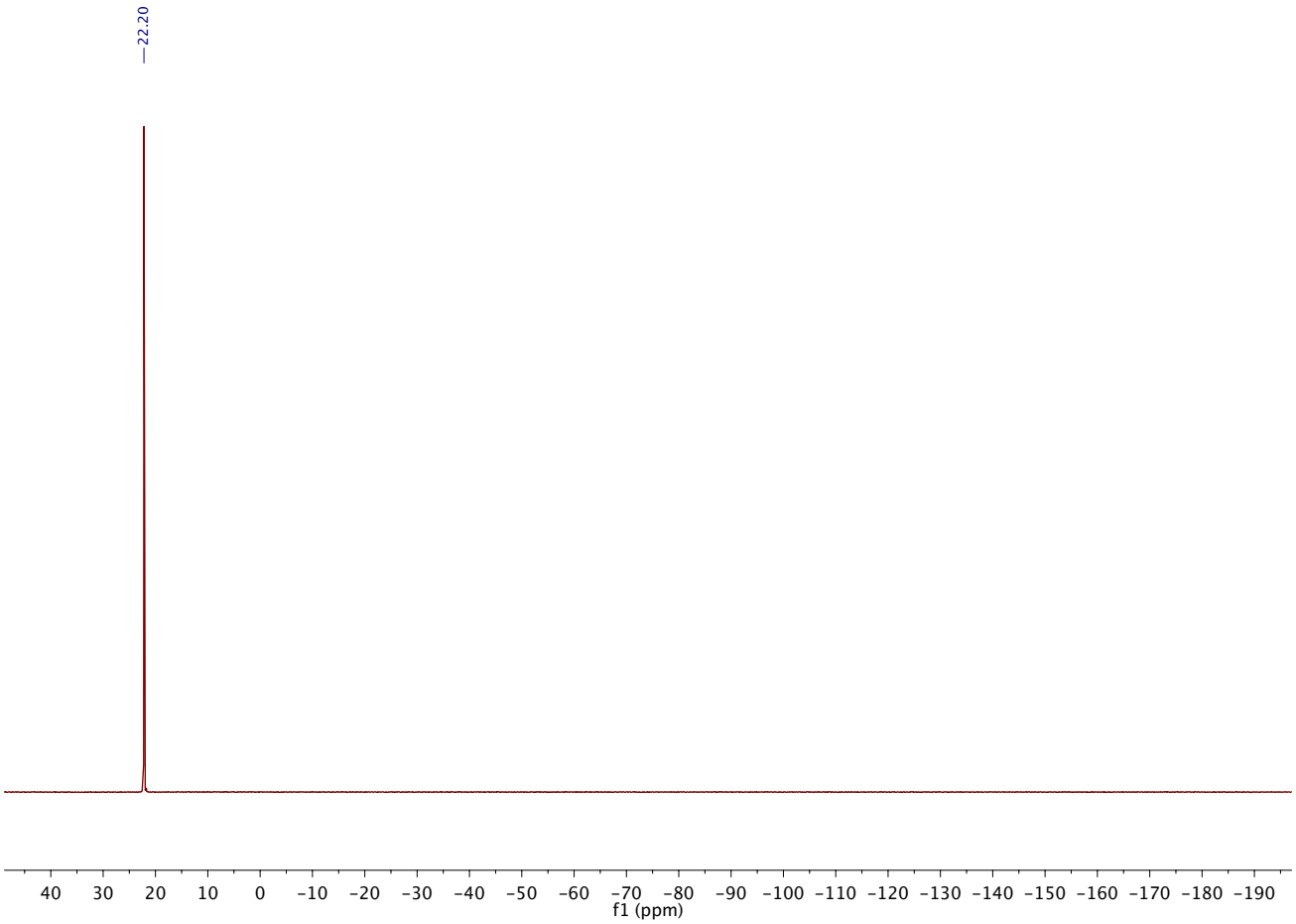
^{13}C NMR

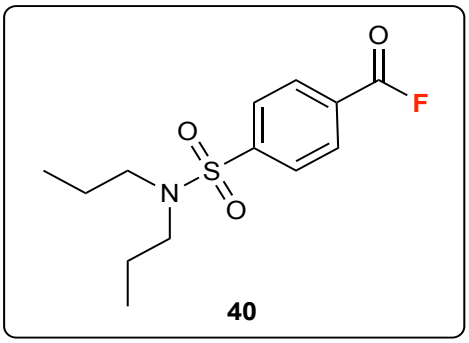




30-COF

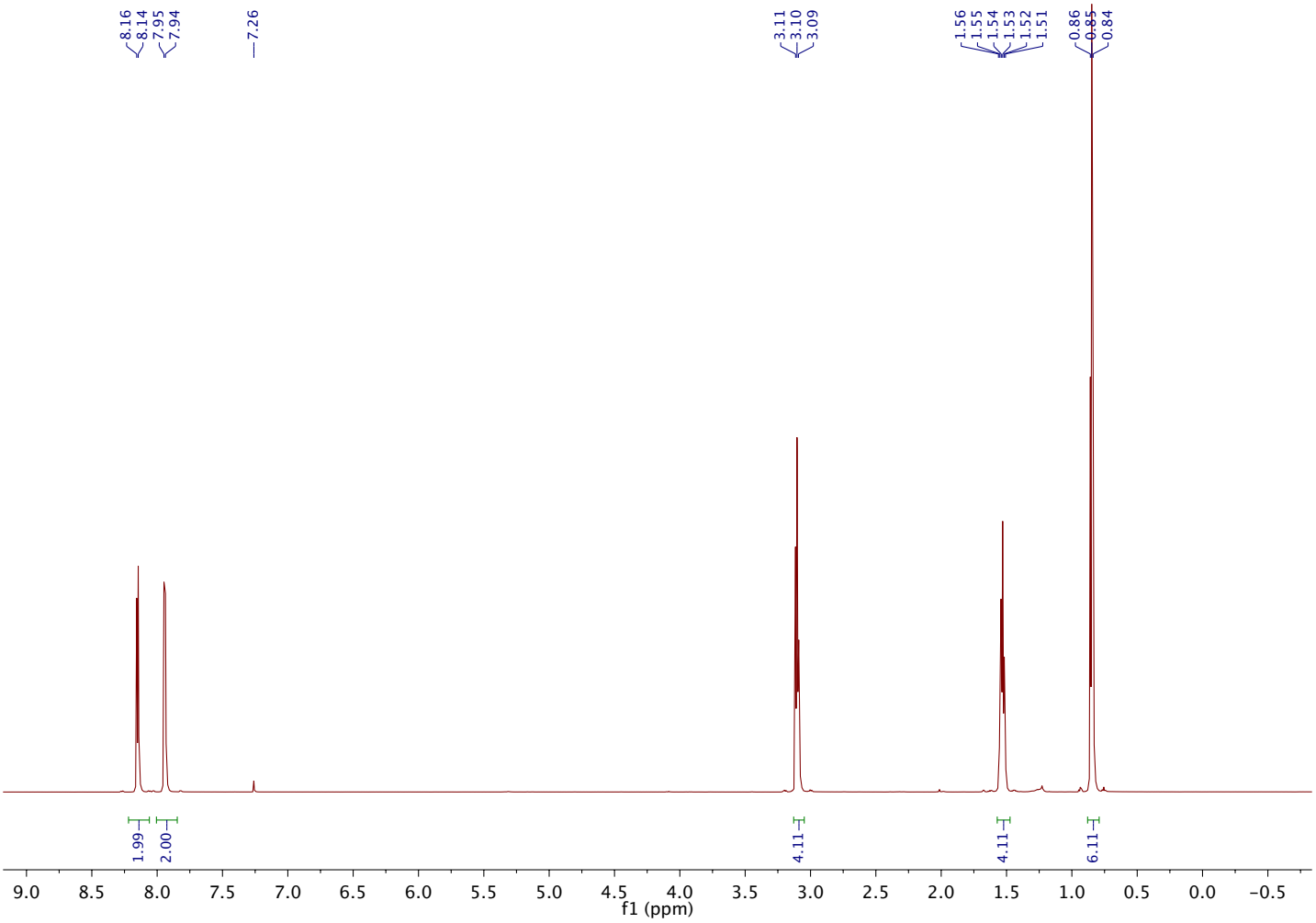
^{19}F NMR

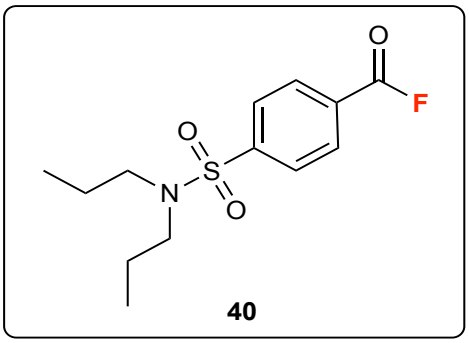



O
F
O
S
N
O

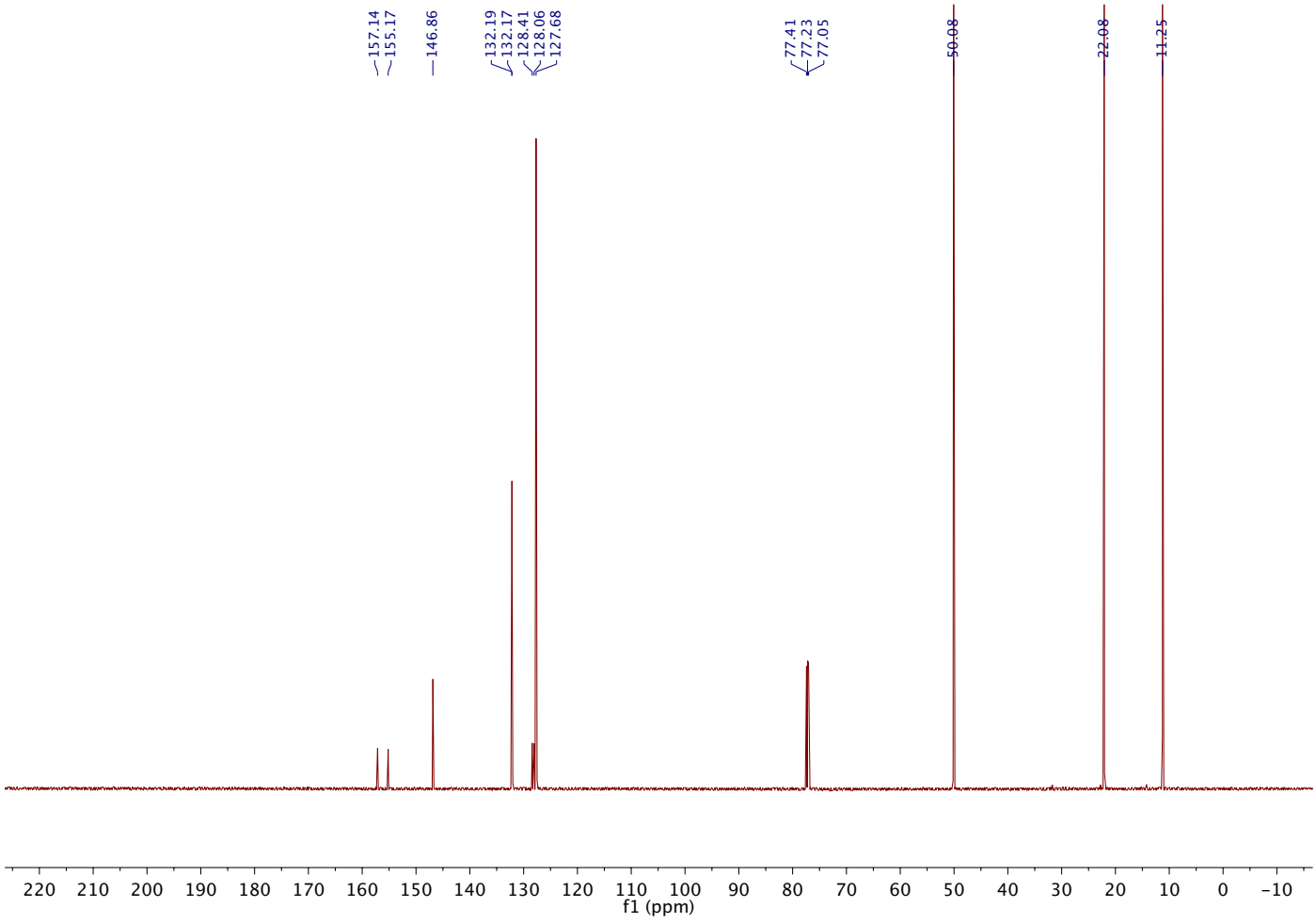
40

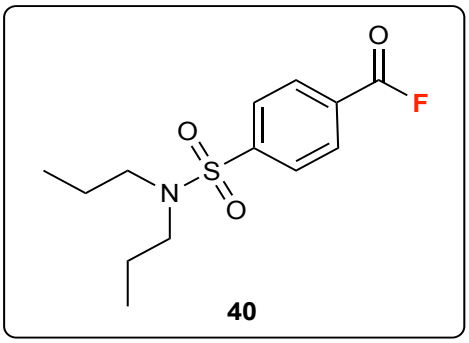
^{1}H NMR


8.16
8.14
7.95
7.94
7.26
3.11
3.10
3.09
1.56
1.55
1.54
1.53
1.52
1.51
0.86
0.85
0.84
1.99
2.00
4.11
4.11
6.11
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


O
F
O
S
N
O
40

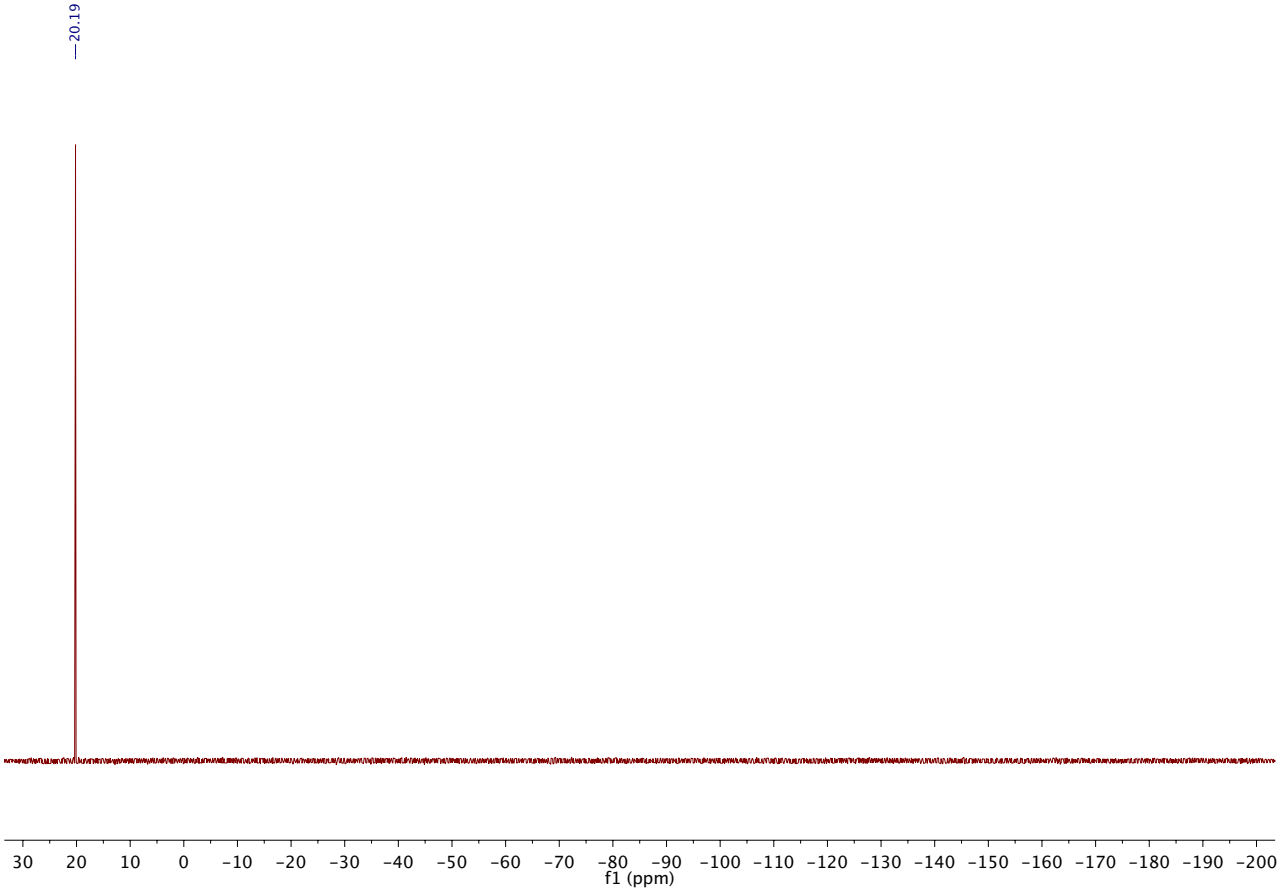
^{13}C NMR

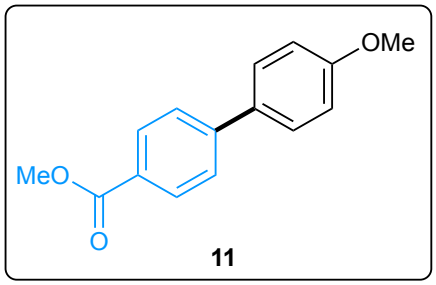

157.14
155.17
146.86
132.19
132.17
128.41
128.06
127.68
77.41
77.23
77.05
50.08
22.98
11.25
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


O
F
O
S
N
O

40

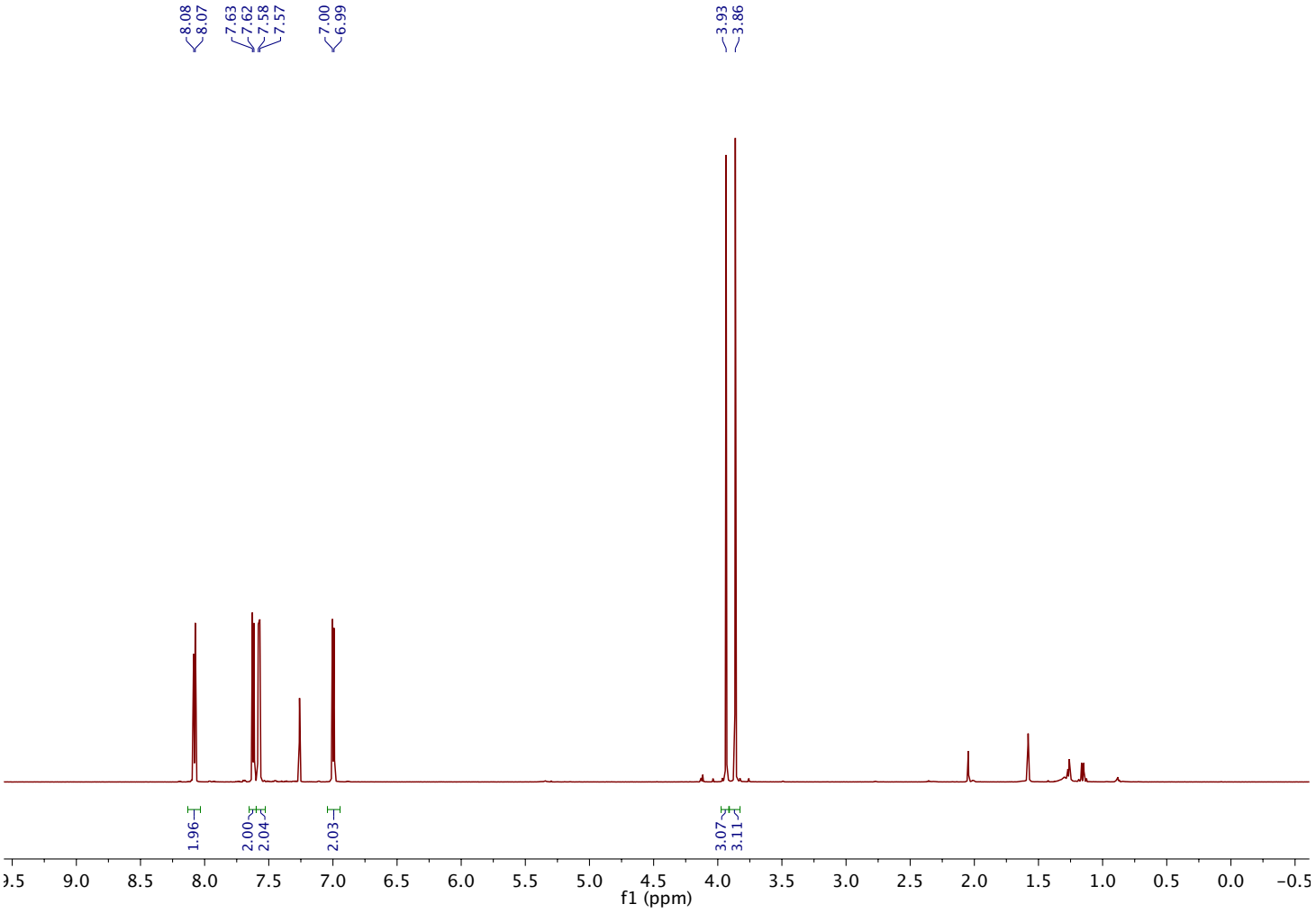
^{19}F NMR

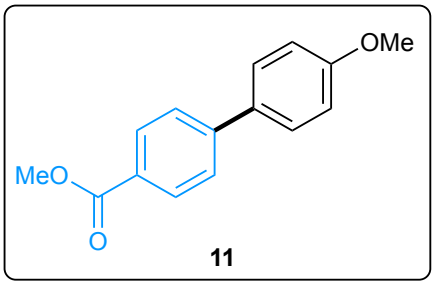

20.19
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


OMe
MeO
O

11

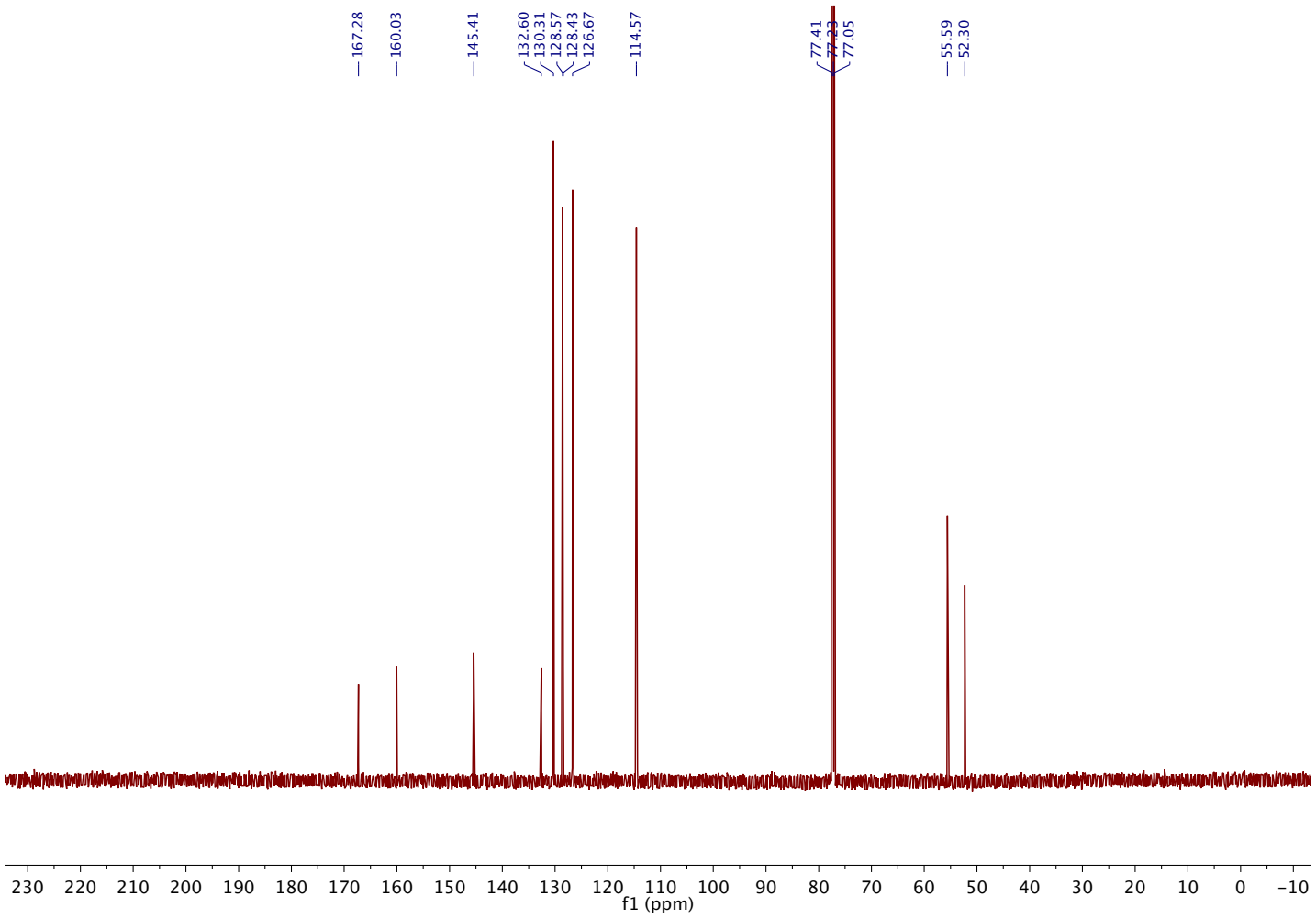
^{1}H NMR

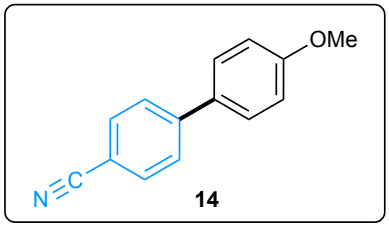

8.08
8.07
7.63
7.62
7.58
7.57
7.00
6.99
3.93
3.86
1.96
2.00
2.04
2.03
3.07
3.11
f1 (ppm)


OMe
MeO
O

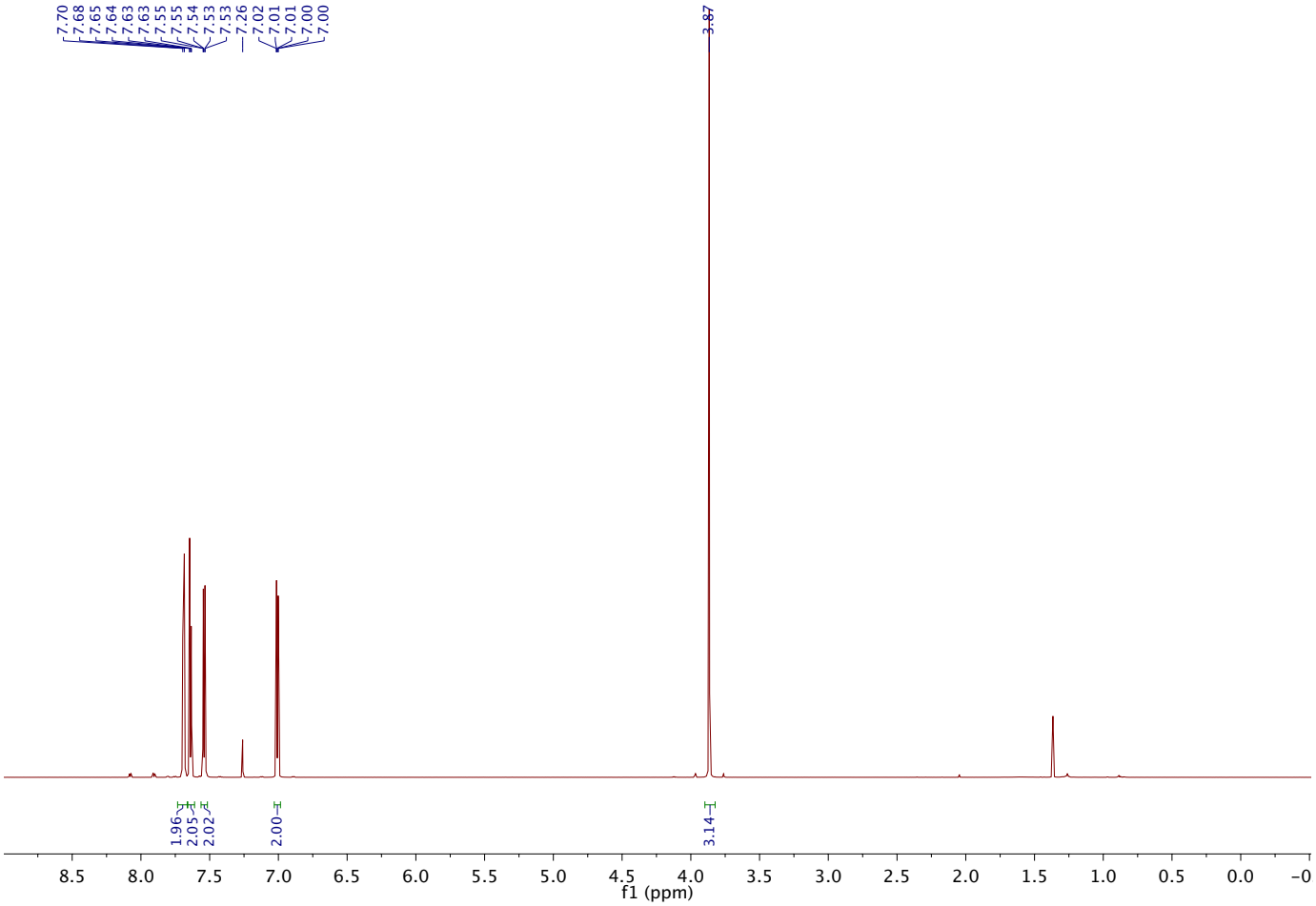
11

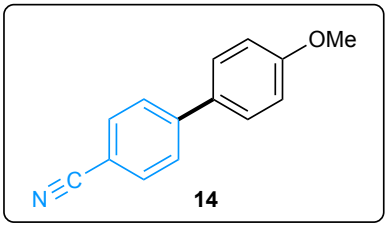
^{13}C NMR


167.28
160.03
145.41
132.60
130.31
128.57
128.43
126.67
114.57
77.41
77.33
77.05
55.59
52.30
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
N≡C
14

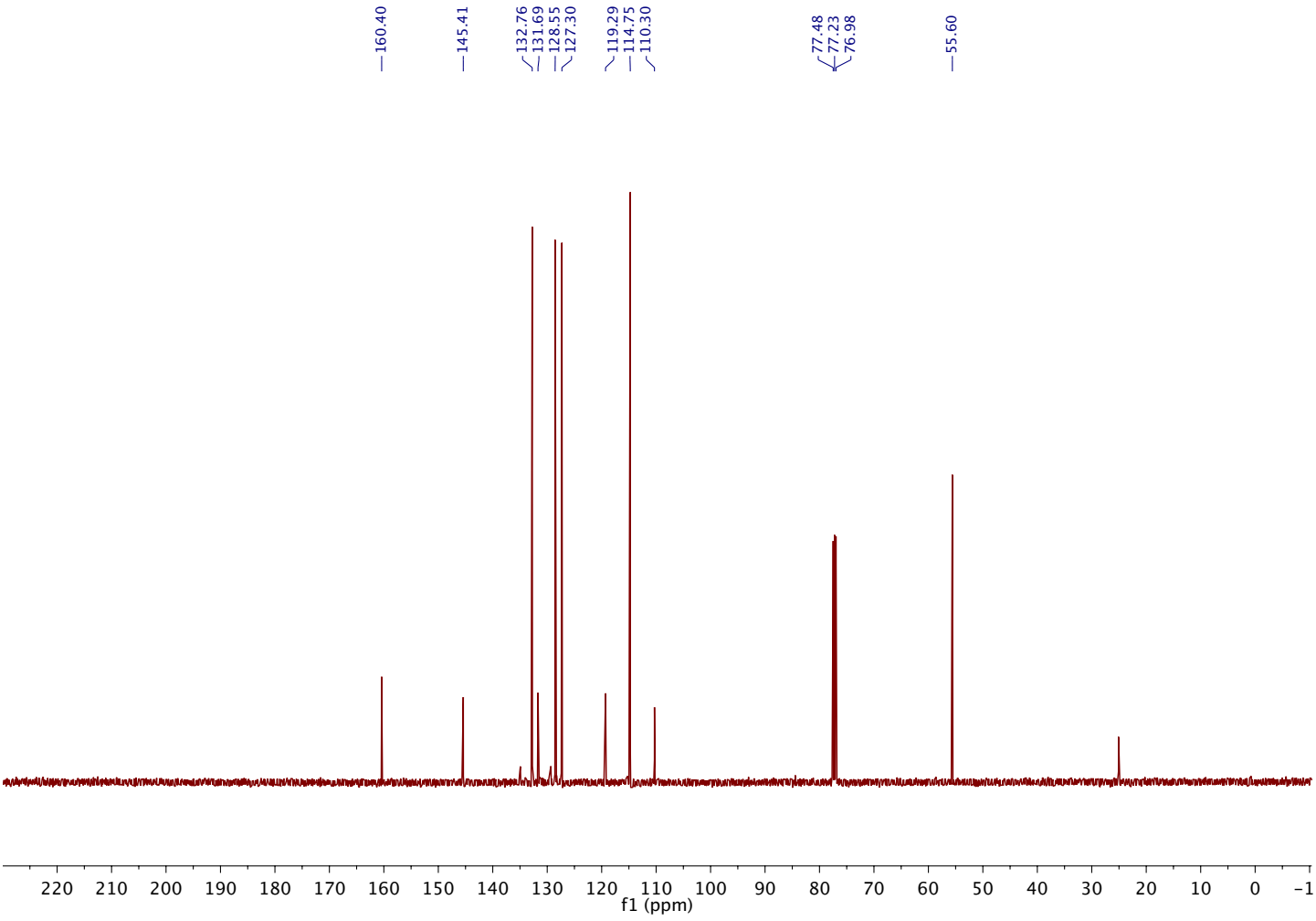
^{1}H NMR

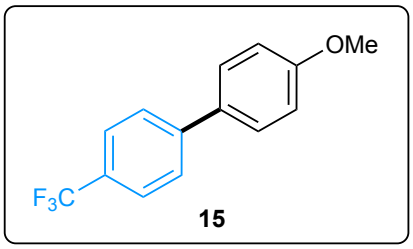

7.70
7.68
7.65
7.64
7.63
7.63
7.55
7.55
7.54
7.53
7.53
7.26
7.02
7.01
7.01
7.00
7.00
3.87
1.96
2.05
2.02
2.00
3.14
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0
f1 (ppm)


OMe
N≡C

14

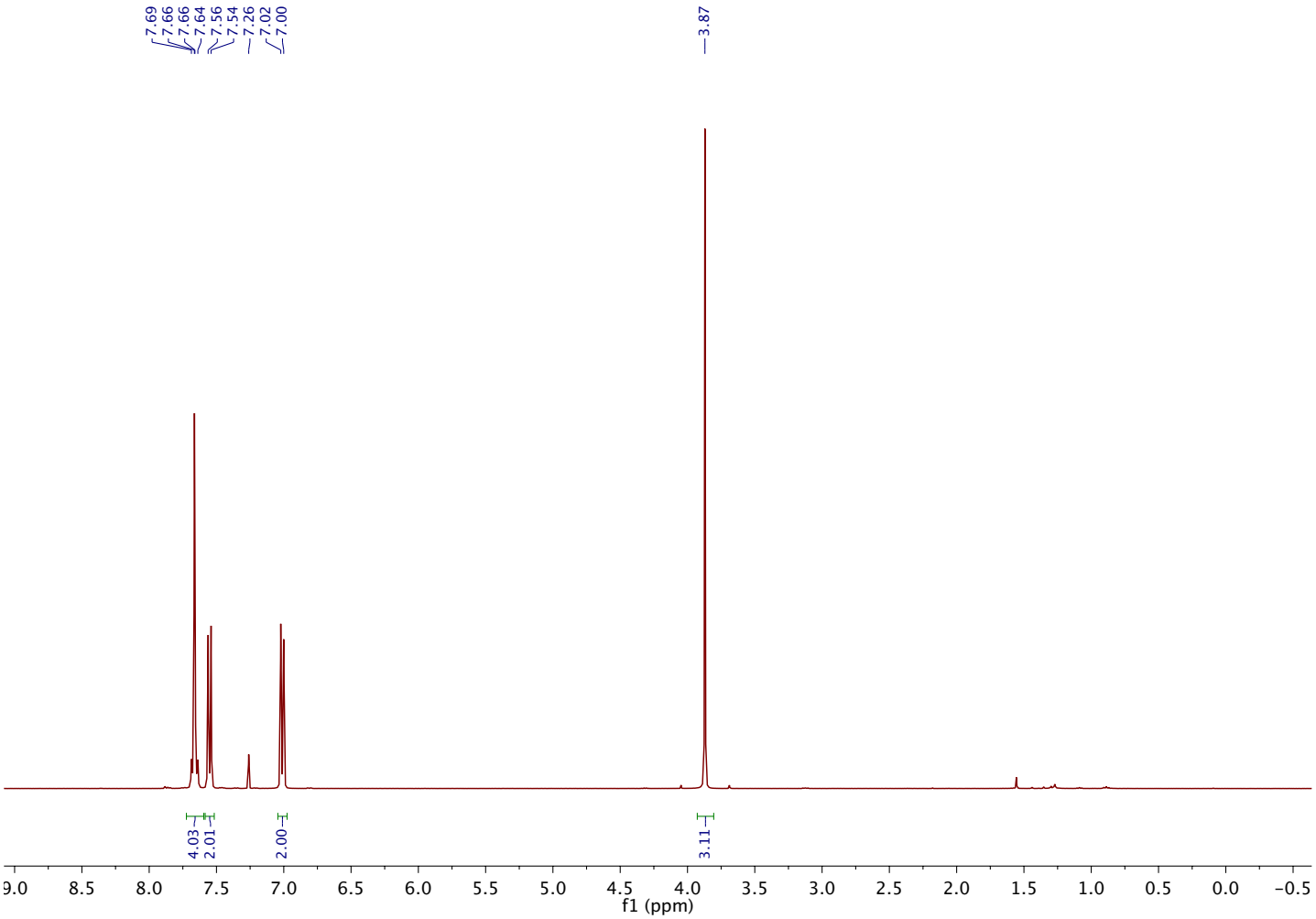
^{13}C NMR

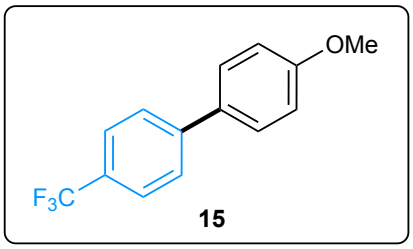

160.40
145.41
132.76
131.69
128.55
127.30
119.29
114.75
110.30
77.48
77.23
76.98
55.60
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)


OMe
F3C

15

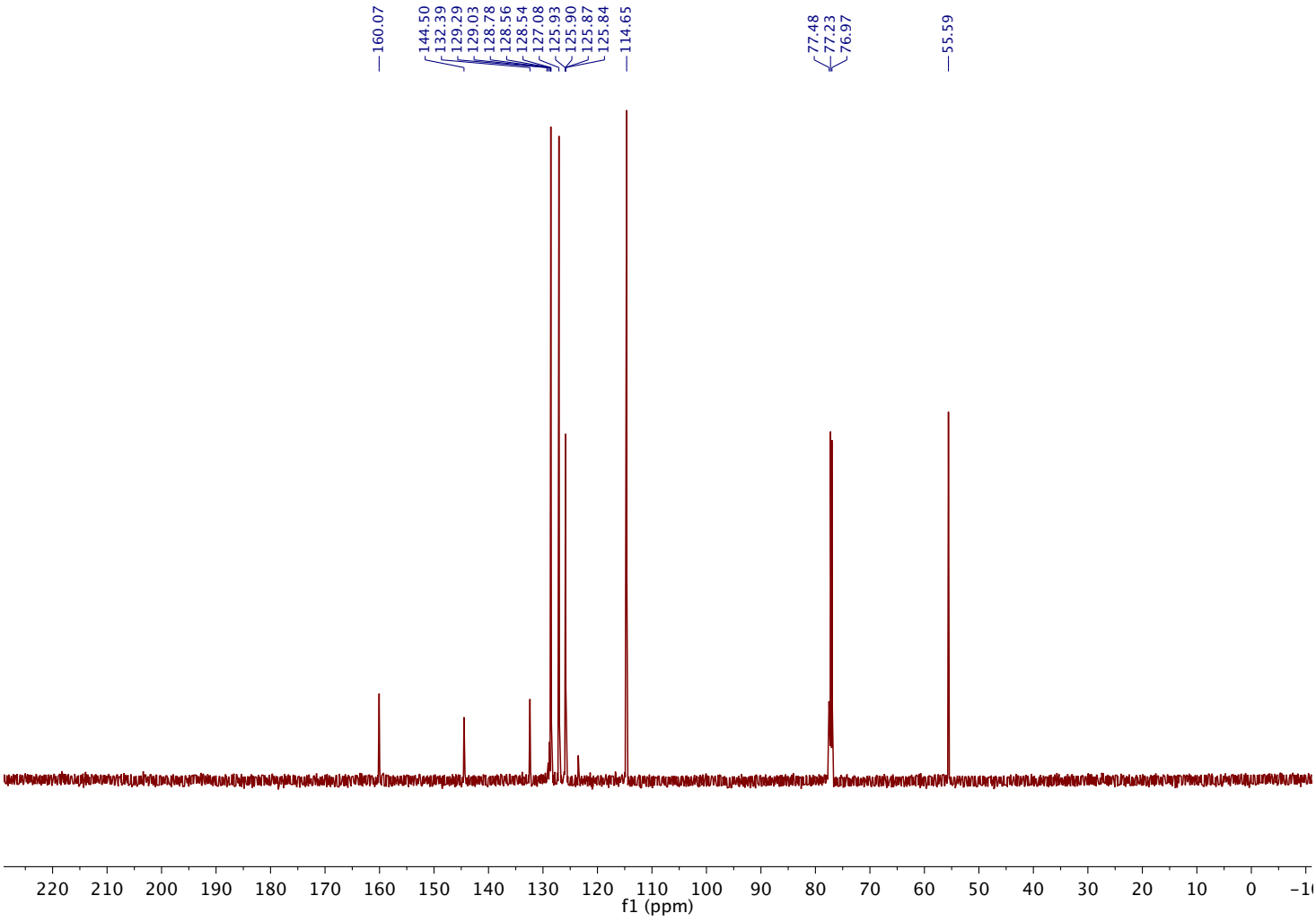
^{1}H NMR

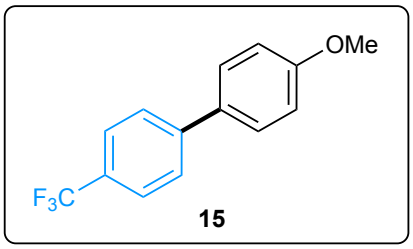

7.69
7.66
7.66
7.64
7.56
7.54
7.26
7.02
7.00
3.87
4.03
2.01
2.00
3.11
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


OMe
F3C

15

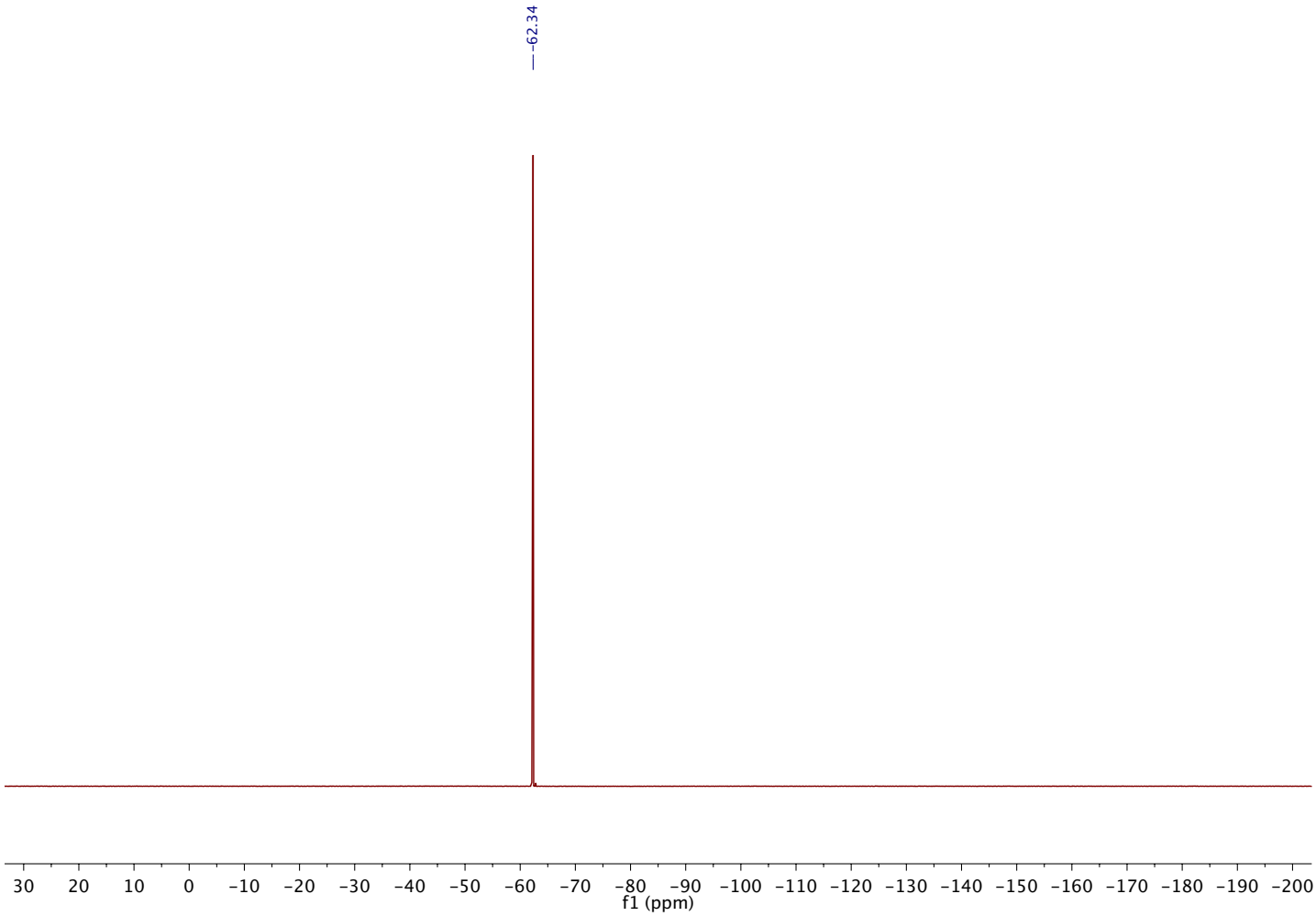
^{13}C NMR

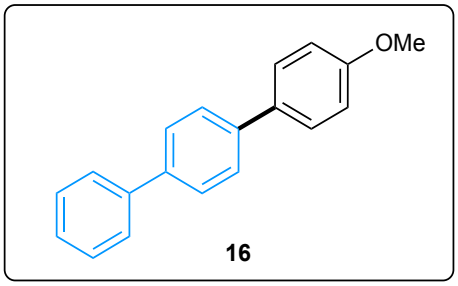

160.07
144.50
132.39
129.29
129.03
128.78
128.56
128.54
127.08
125.93
125.90
125.87
125.84
114.65
77.48
77.23
76.97
55.59
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


OMe
F3C

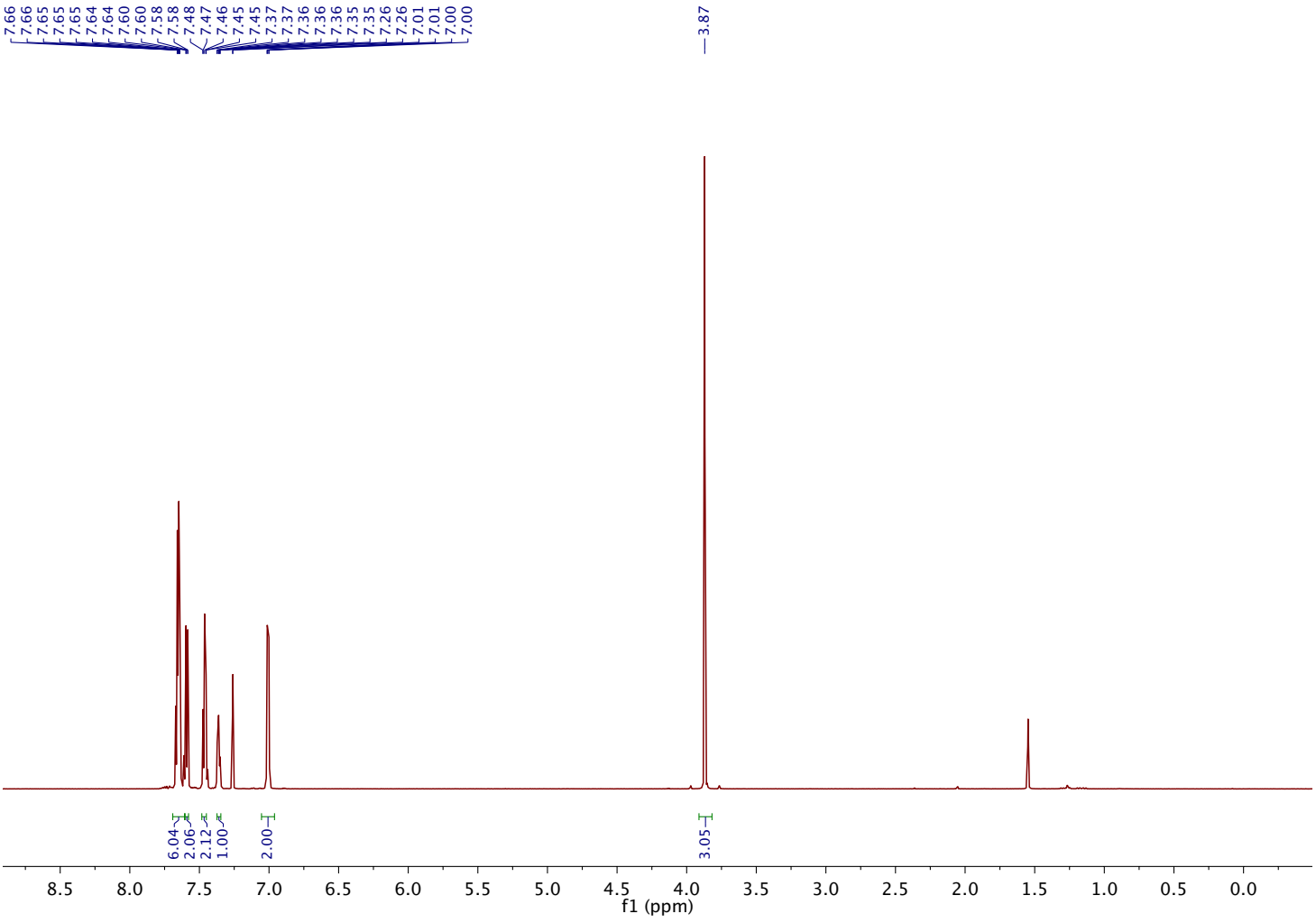
15

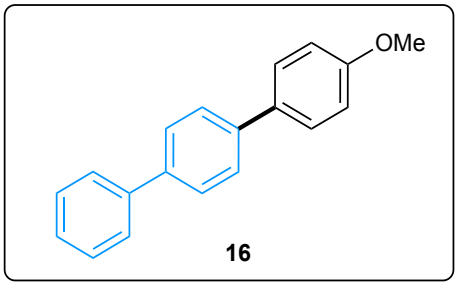
^{19}F NMR


-62.34
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

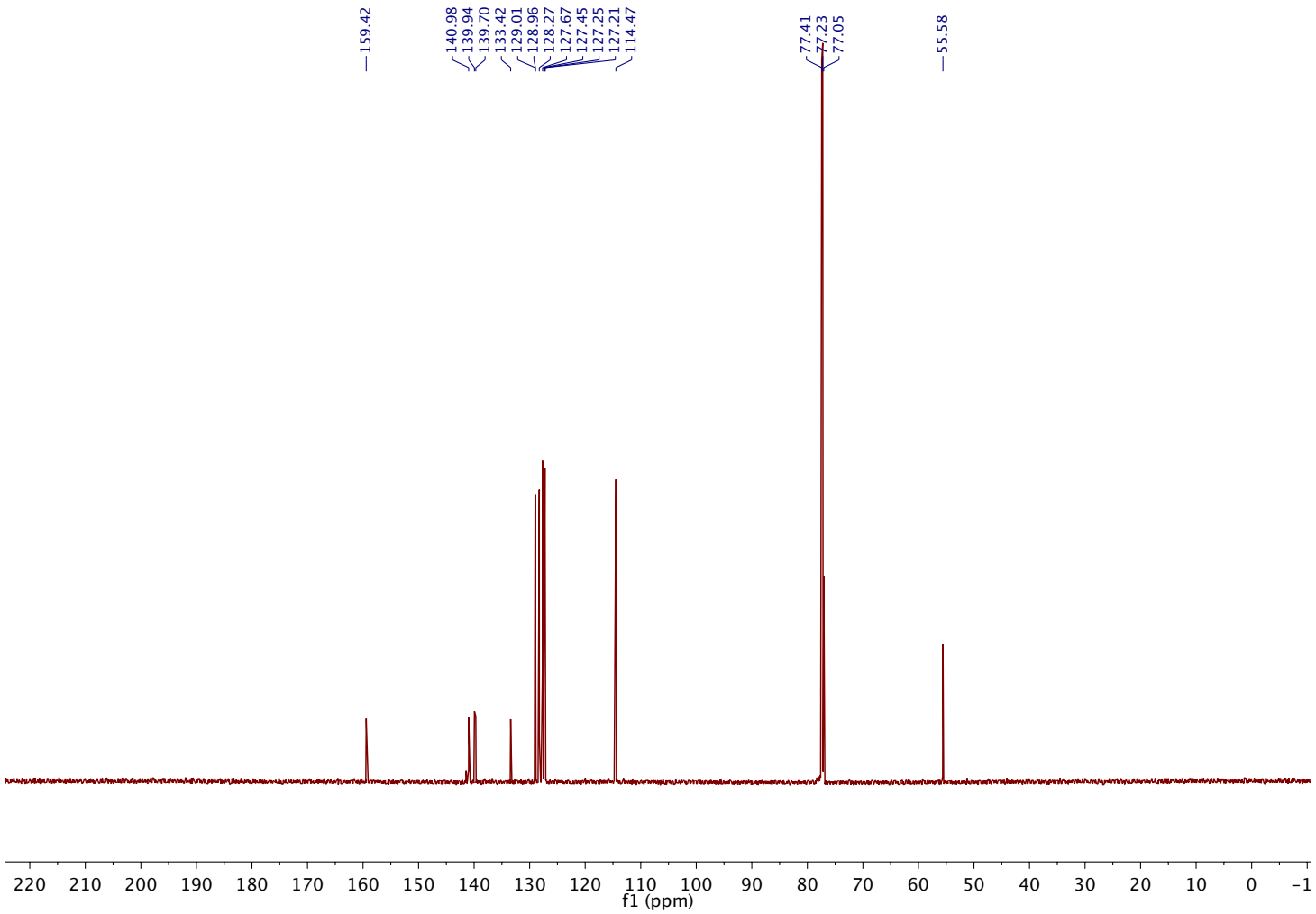

OMe
16

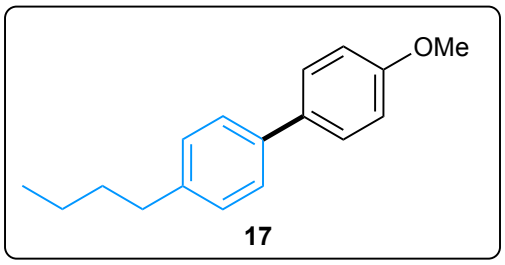
^{1}H NMR


7.66
7.66
7.65
7.65
7.65
7.64
7.64
7.60
7.60
7.58
7.58
7.48
7.47
7.46
7.45
7.45
7.37
7.37
7.36
7.36
7.36
7.35
7.35
7.26
7.01
7.01
7.00
7.00
3.87
6.04
2.06
2.12
1.00
2.00
3.05
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

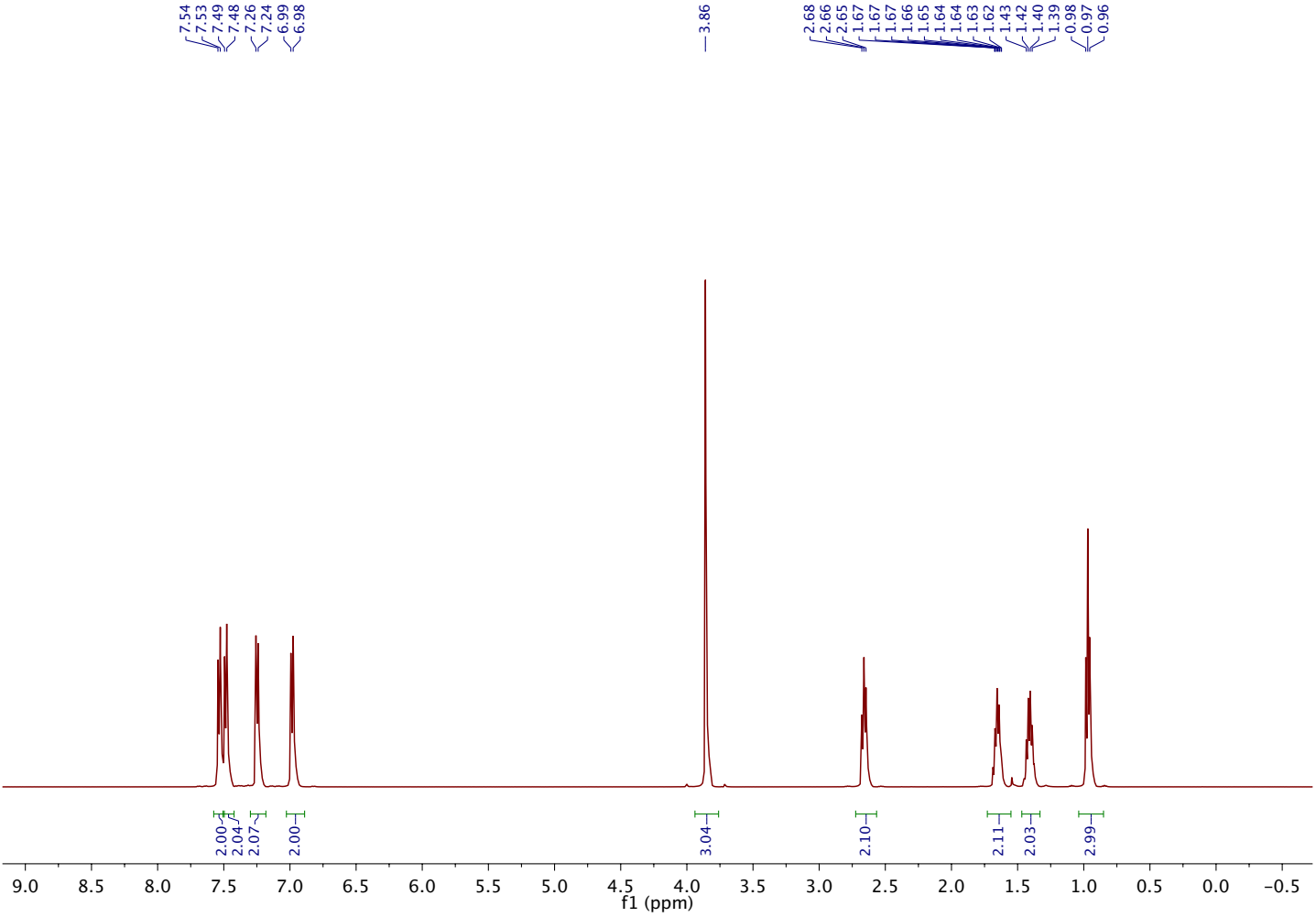

OMe
16

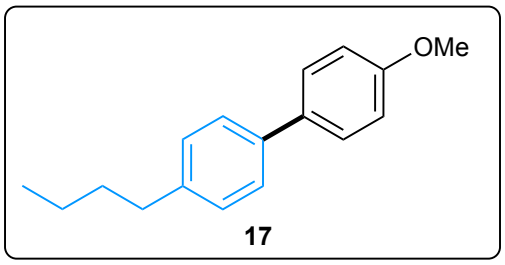
^{13}C NMR


159.42
140.98
139.94
139.70
133.42
129.01
128.96
128.27
127.67
127.45
127.25
127.21
114.47
77.41
77.23
77.05
55.58
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −1
f1 (ppm)


OMe
17

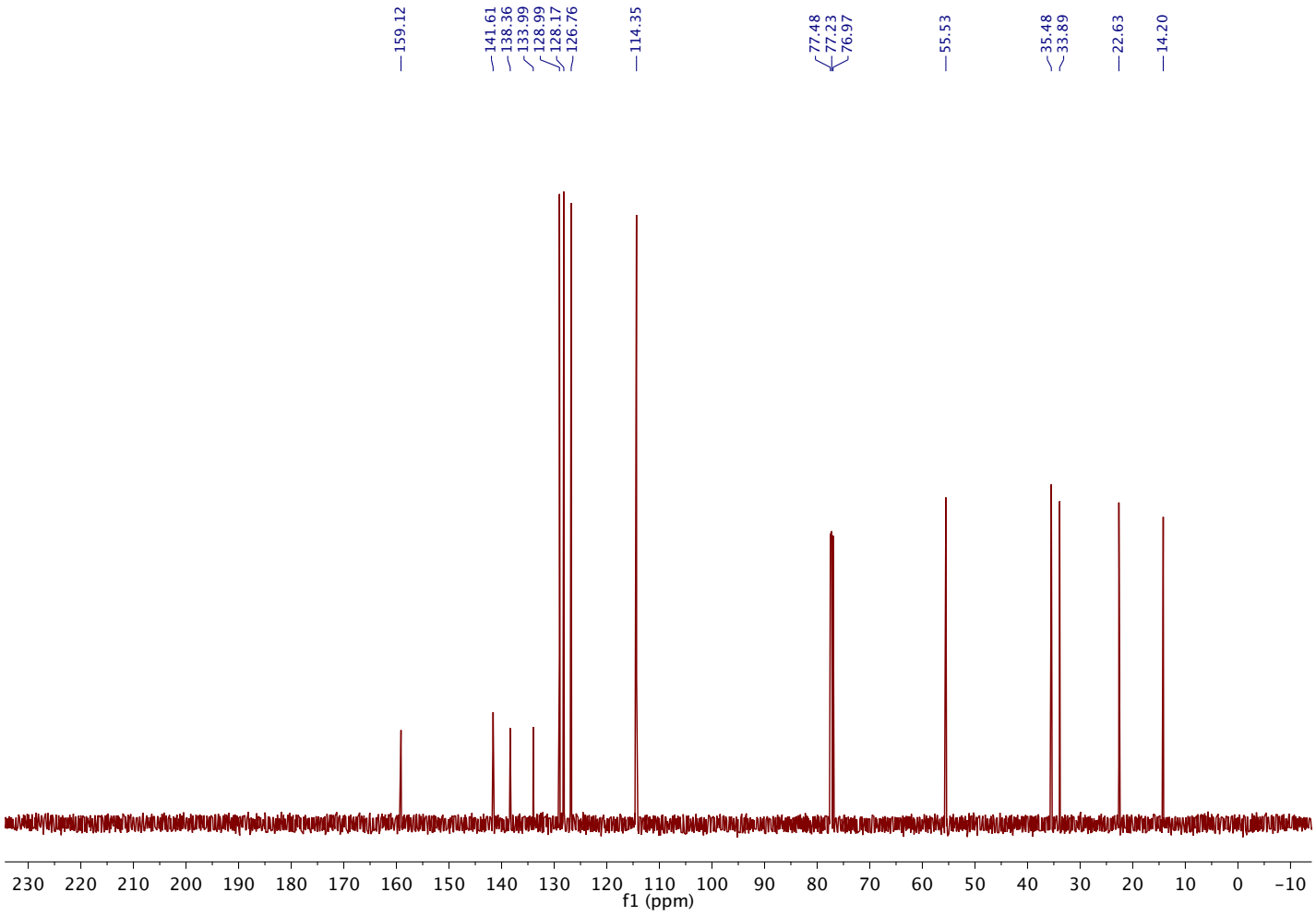
^{1}H NMR

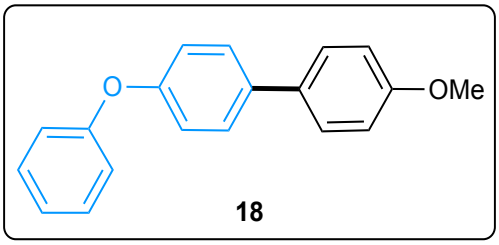

7.54
7.53
7.49
7.48
7.26
7.24
6.99
6.98
3.86
2.68
2.66
2.65
1.67
1.67
1.67
1.66
1.65
1.64
1.64
1.63
1.62
1.43
1.42
1.40
1.39
0.98
0.97
0.96
2.00
2.04
2.07
2.00
3.04
2.10
2.11
2.03
2.99
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


OMe

17

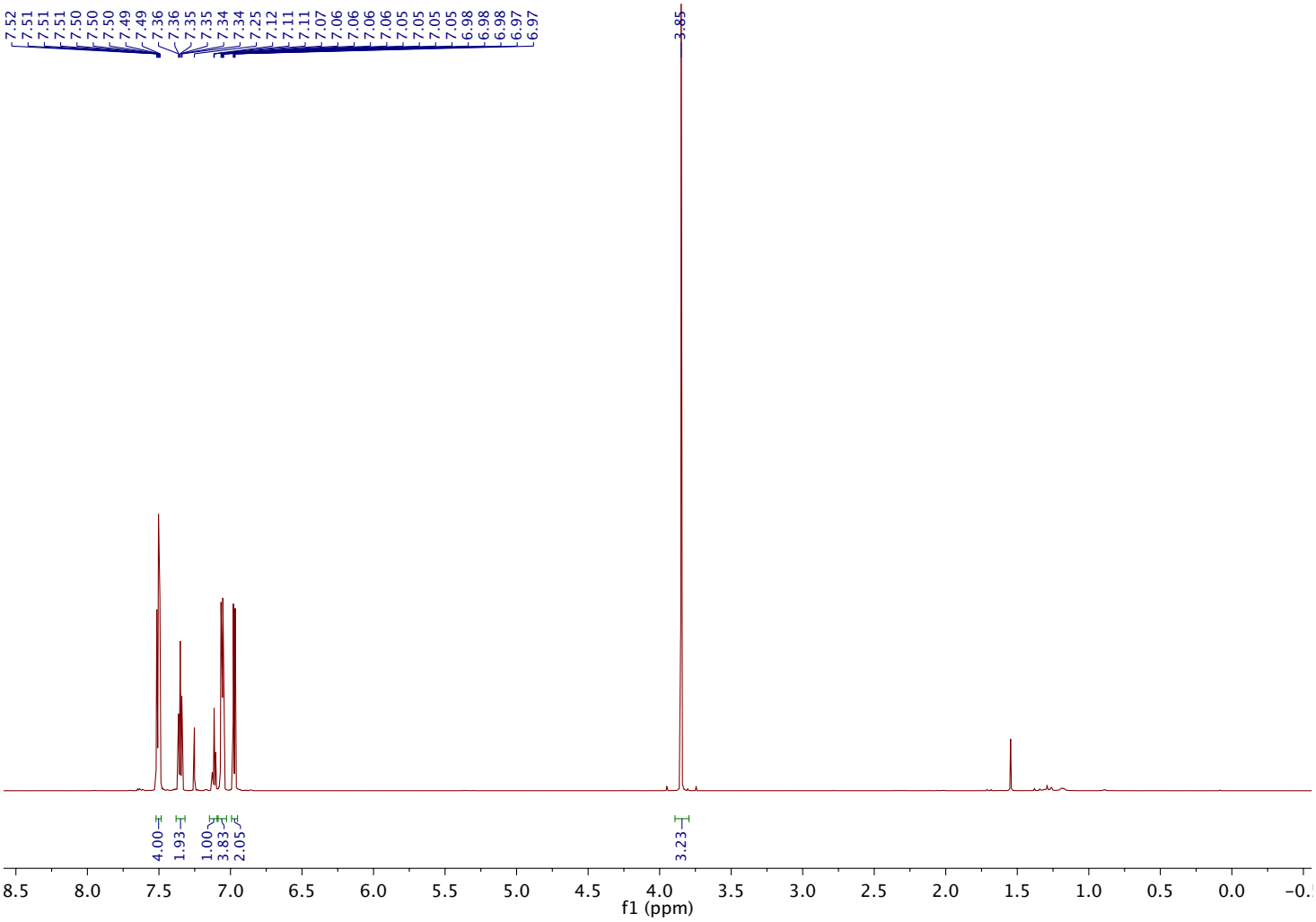
^{13}C NMR

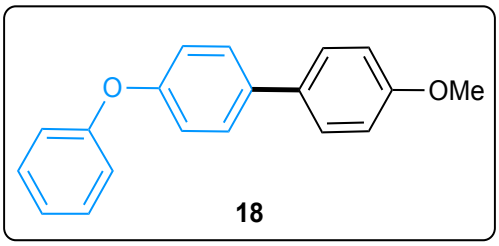

159.12
141.61
138.36
133.99
128.99
128.17
126.76
114.35
77.48
77.23
76.97
55.53
35.48
33.89
22.63
14.20
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


O
OMe

18

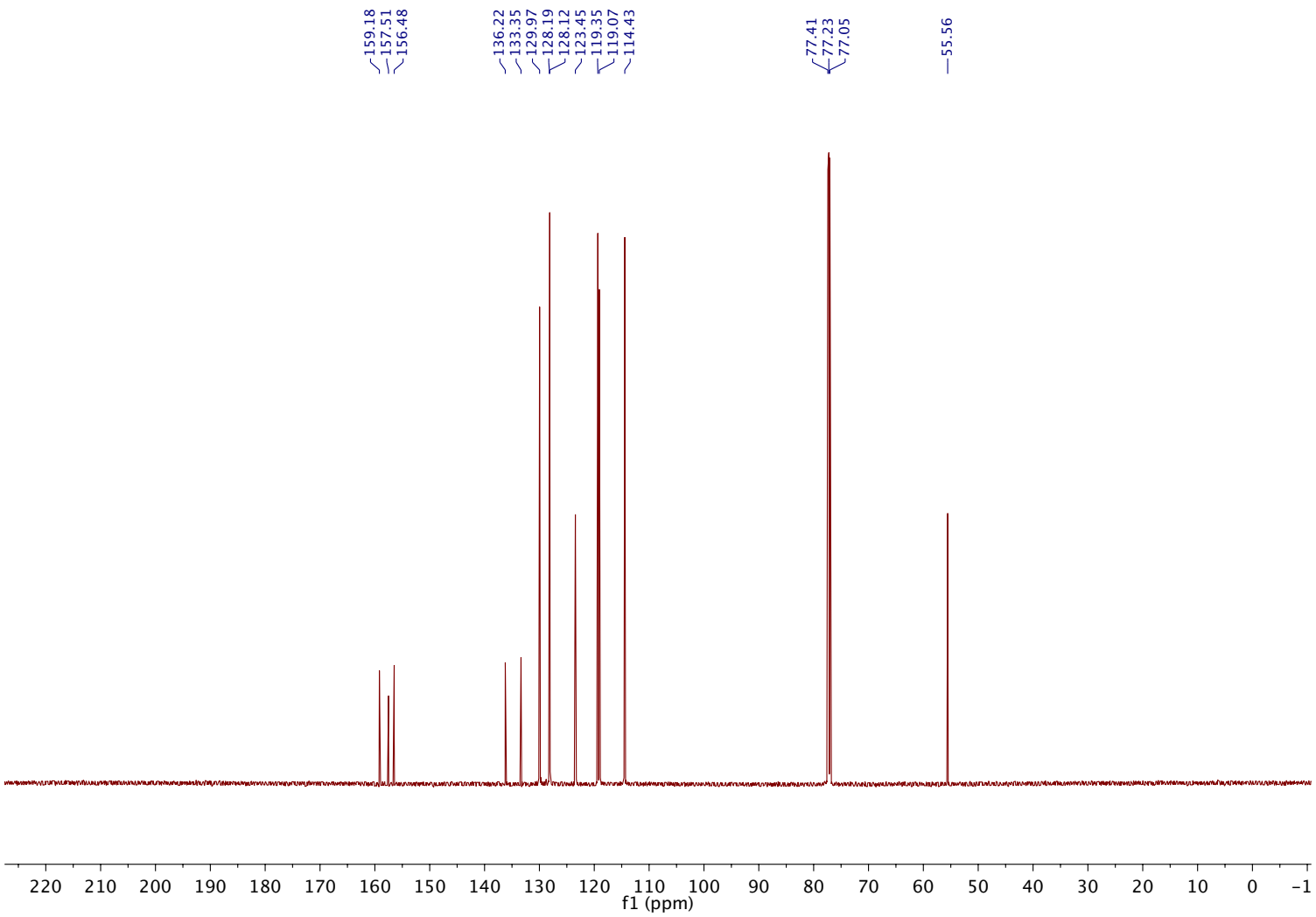
^{1}H NMR

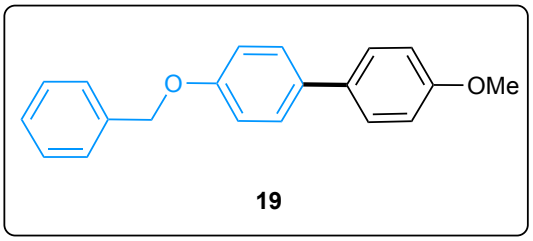

7.52
7.51
7.51
7.51
7.50
7.50
7.50
7.49
7.49
7.36
7.36
7.35
7.35
7.34
7.34
7.25
7.12
7.11
7.11
7.07
7.06
7.06
7.06
7.06
7.05
7.05
7.05
7.05
6.98
6.98
6.98
6.97
6.97
3.85
4.00
1.93
1.00
3.83
2.05
3.23
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


O
OMe

18

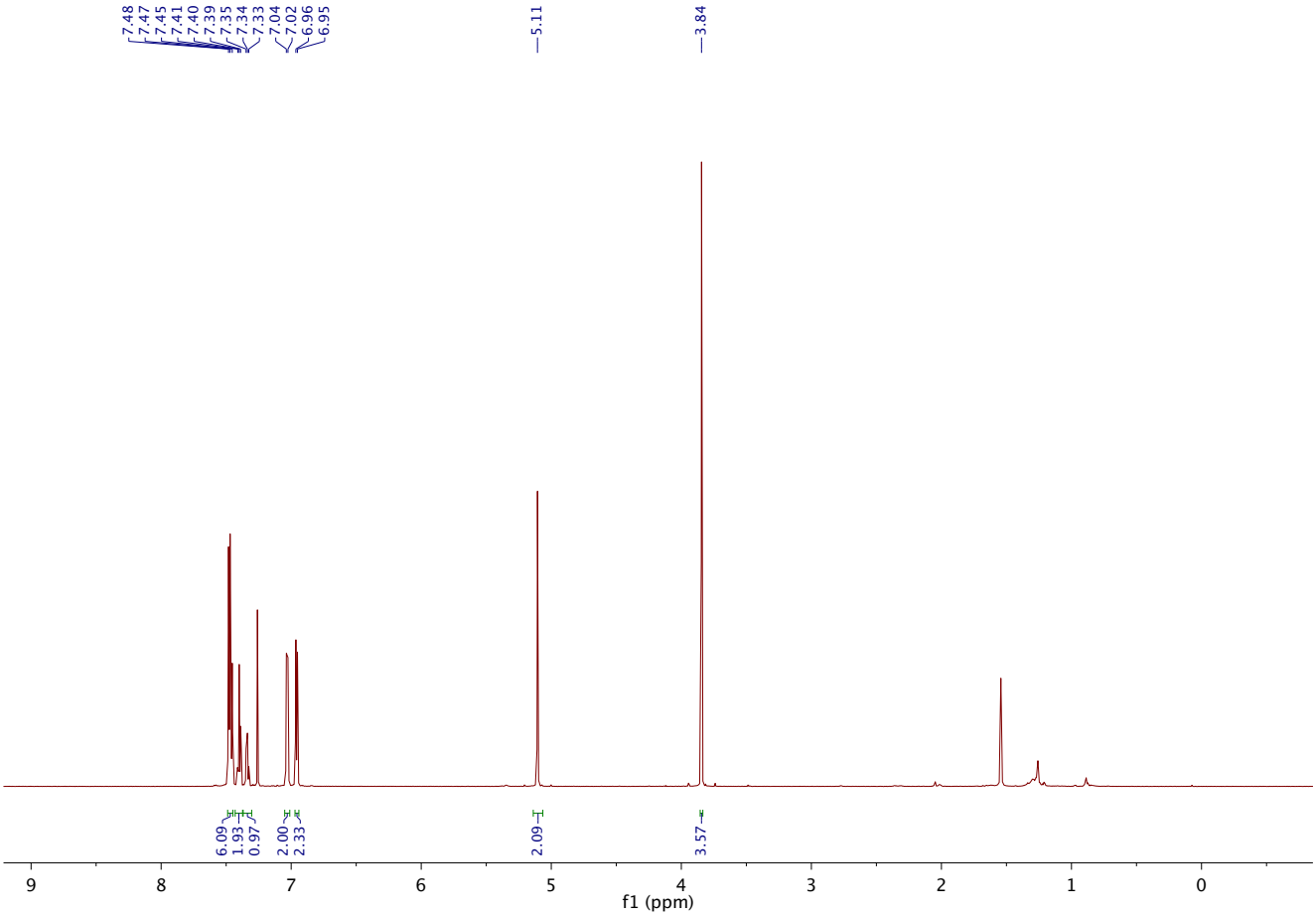
^{13}C NMR

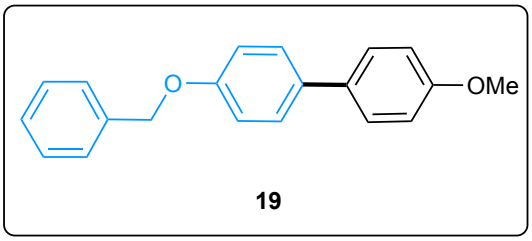

159.18
157.51
156.48
136.22
133.35
129.97
128.19
128.12
123.45
119.35
119.07
114.43
77.41
77.23
77.05
55.56
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)


O
OMe

19

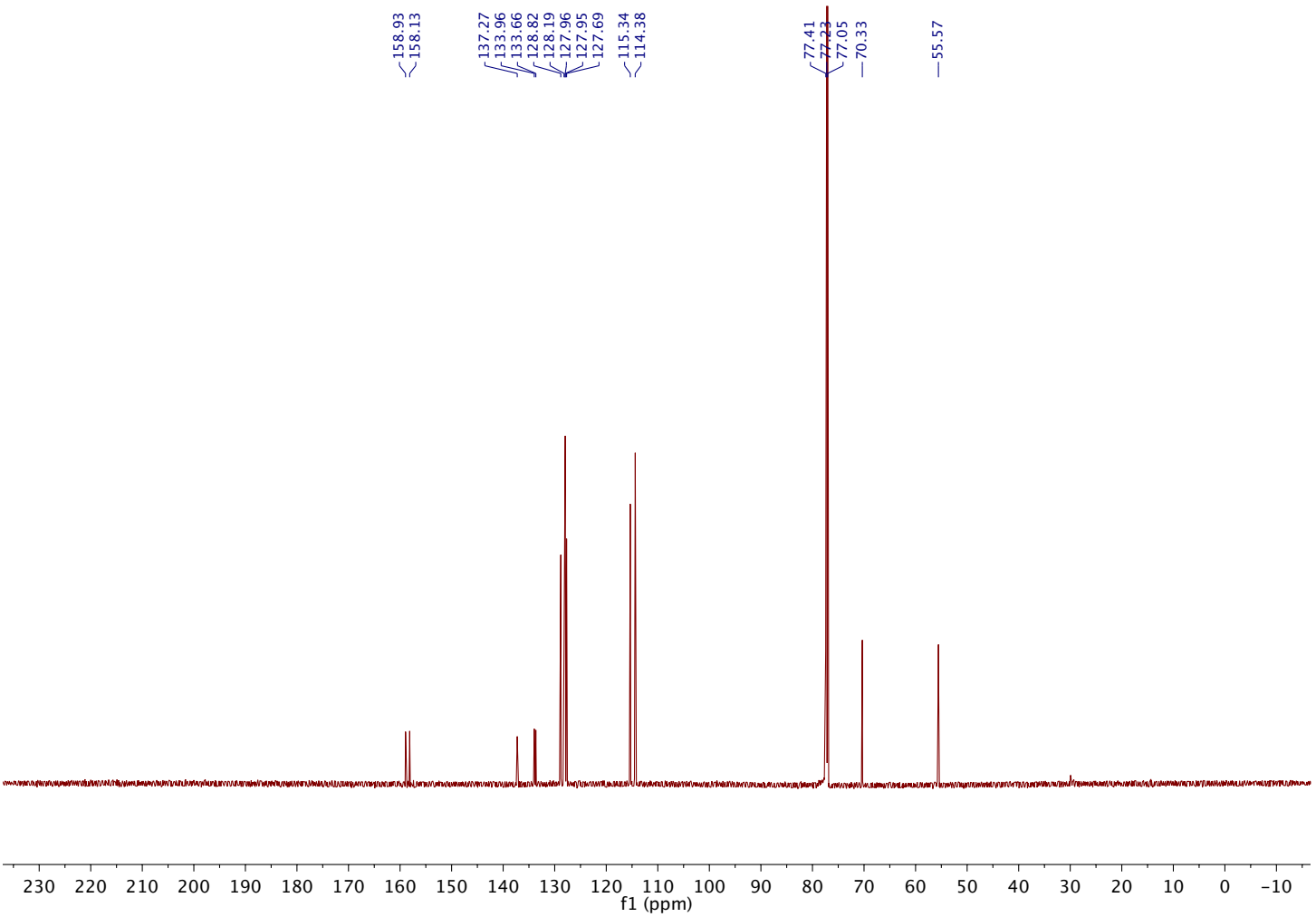
^{1}H NMR

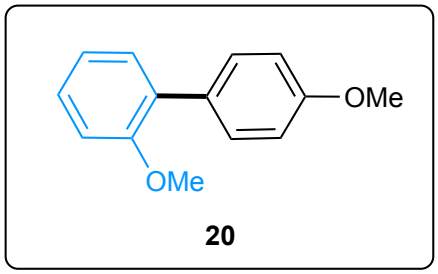

7.48
7.47
7.45
7.41
7.40
7.39
7.35
7.34
7.33
7.04
7.02
6.96
6.95
5.11
3.84
6.09
1.93
0.97
2.00
2.33
2.09
3.57
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


O
OMe

19

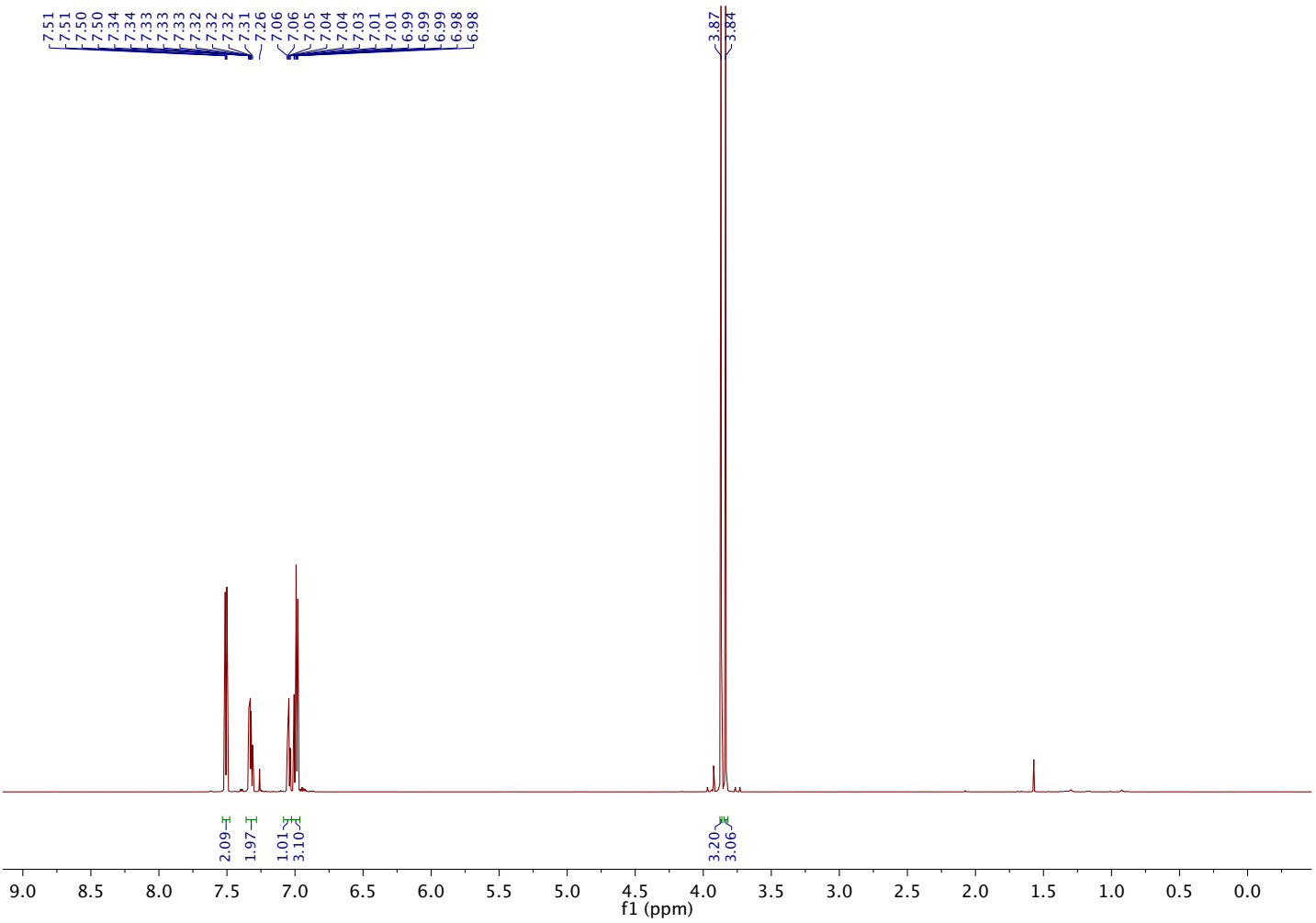
^{13}C NMR

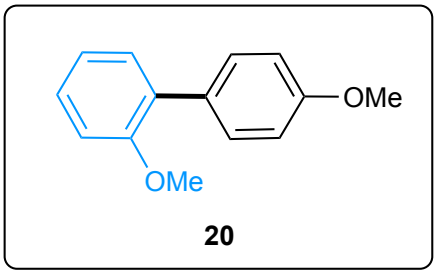

158.93
158.13
137.27
133.96
133.66
128.82
128.19
127.96
127.95
127.69
115.34
114.38
77.41
77.23
77.05
70.33
55.57
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
OMe

20

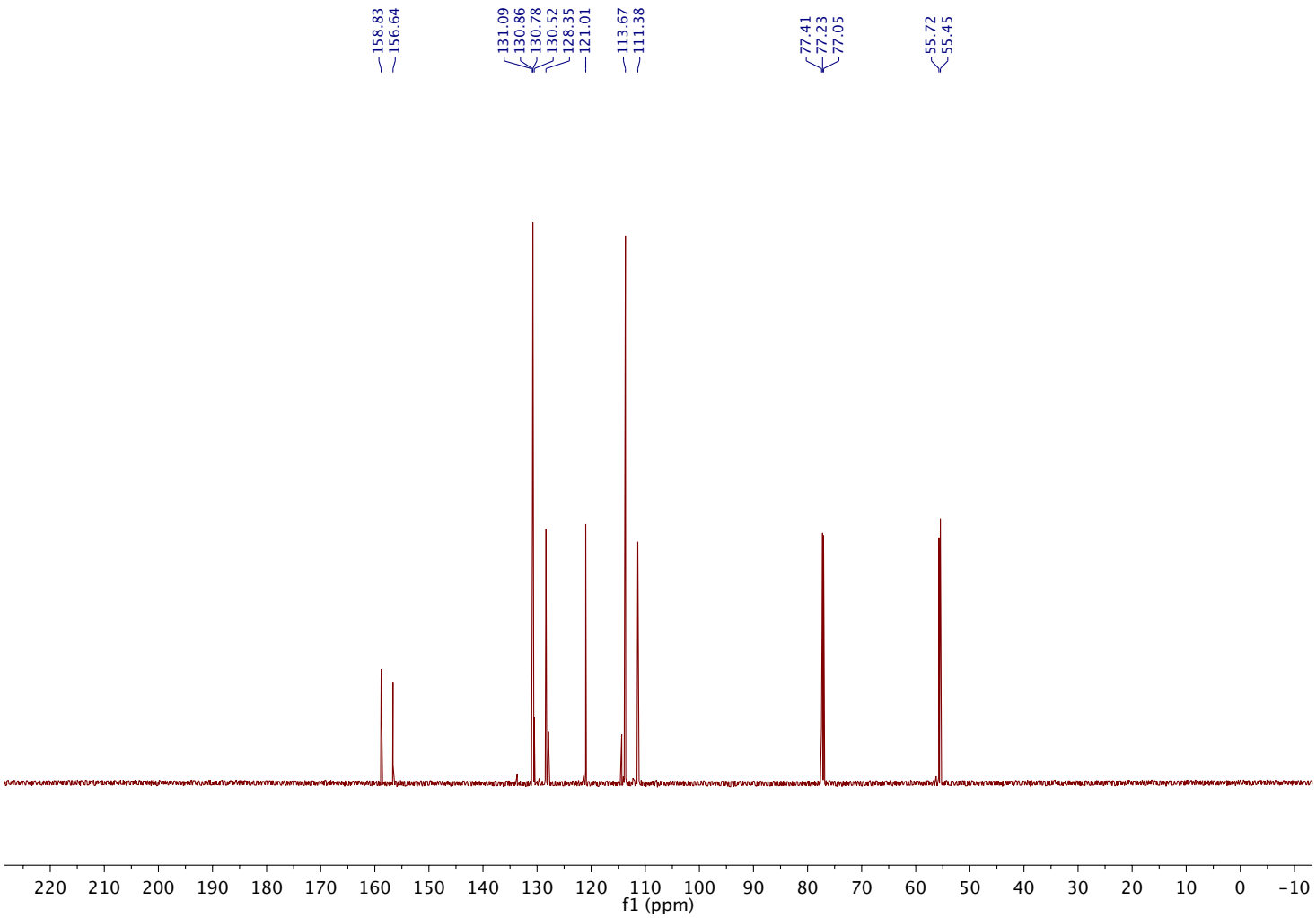
^{1}H NMR

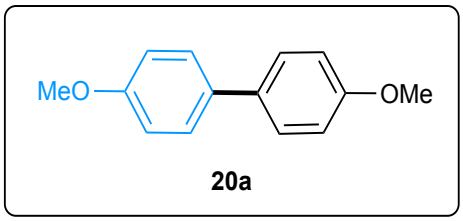

7.51
7.51
7.50
7.50
7.34
7.34
7.33
7.33
7.33
7.32
7.32
7.32
7.31
7.26
7.06
7.06
7.05
7.04
7.04
7.03
7.01
7.01
6.99
6.99
6.99
6.98
6.98
3.87
3.84
2.09
1.97
1.01
3.10
3.20
3.06
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


OMe
OMe

20

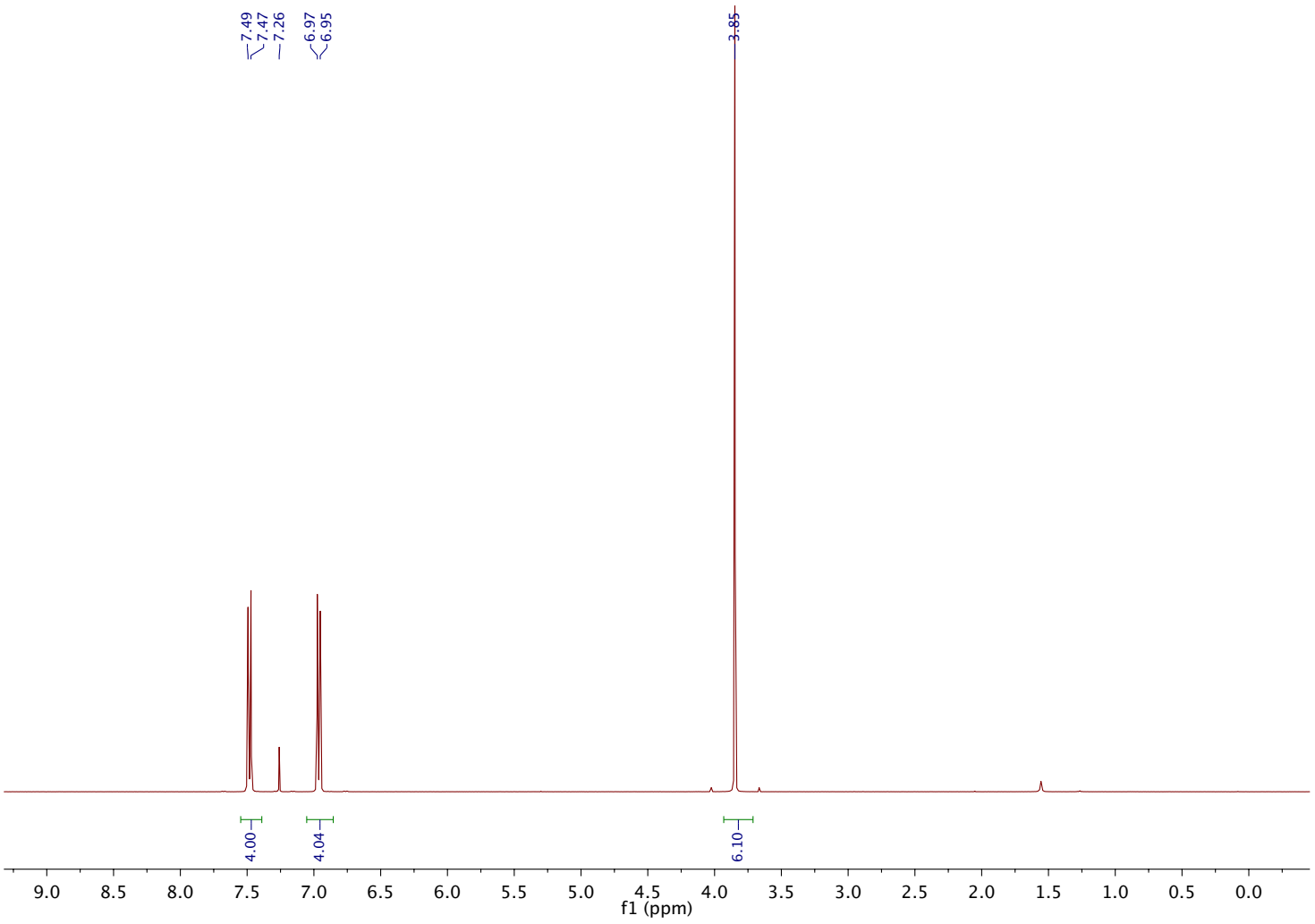
^{13}C NMR

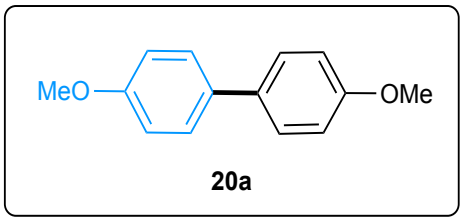

158.83
156.64
131.09
130.86
130.78
130.52
128.35
121.01
113.67
111.38
77.41
77.23
77.05
55.72
55.45
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


MeO
OMe

20a

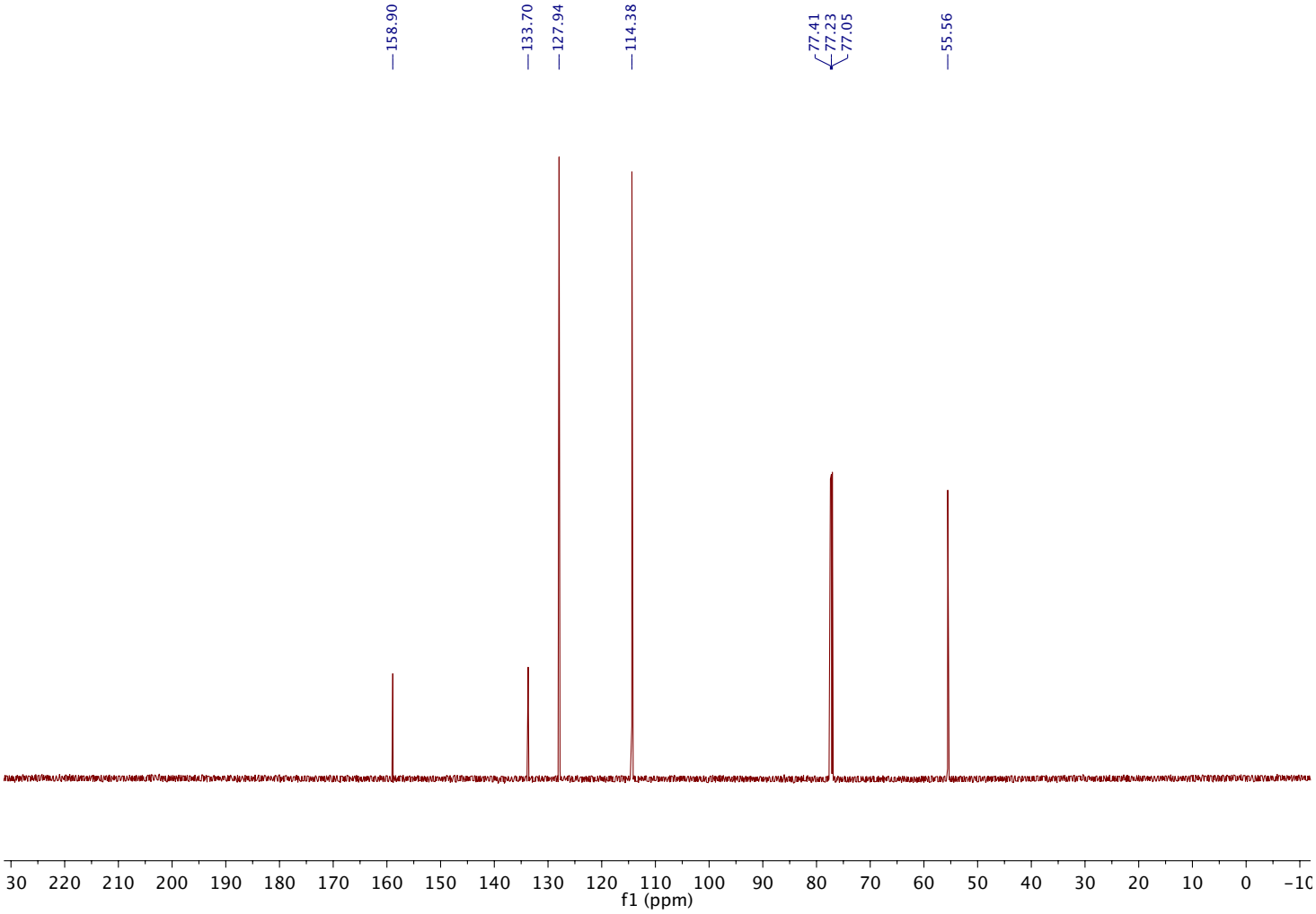
^{1}H NMR

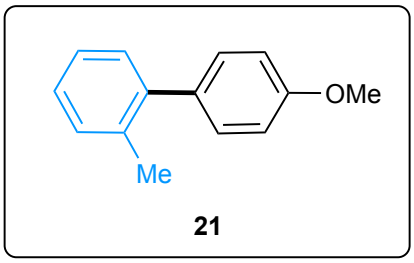

7.49
7.47
7.26
6.97
6.95
3.85
4.00
4.04
6.10
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


MeO
OMe

20a

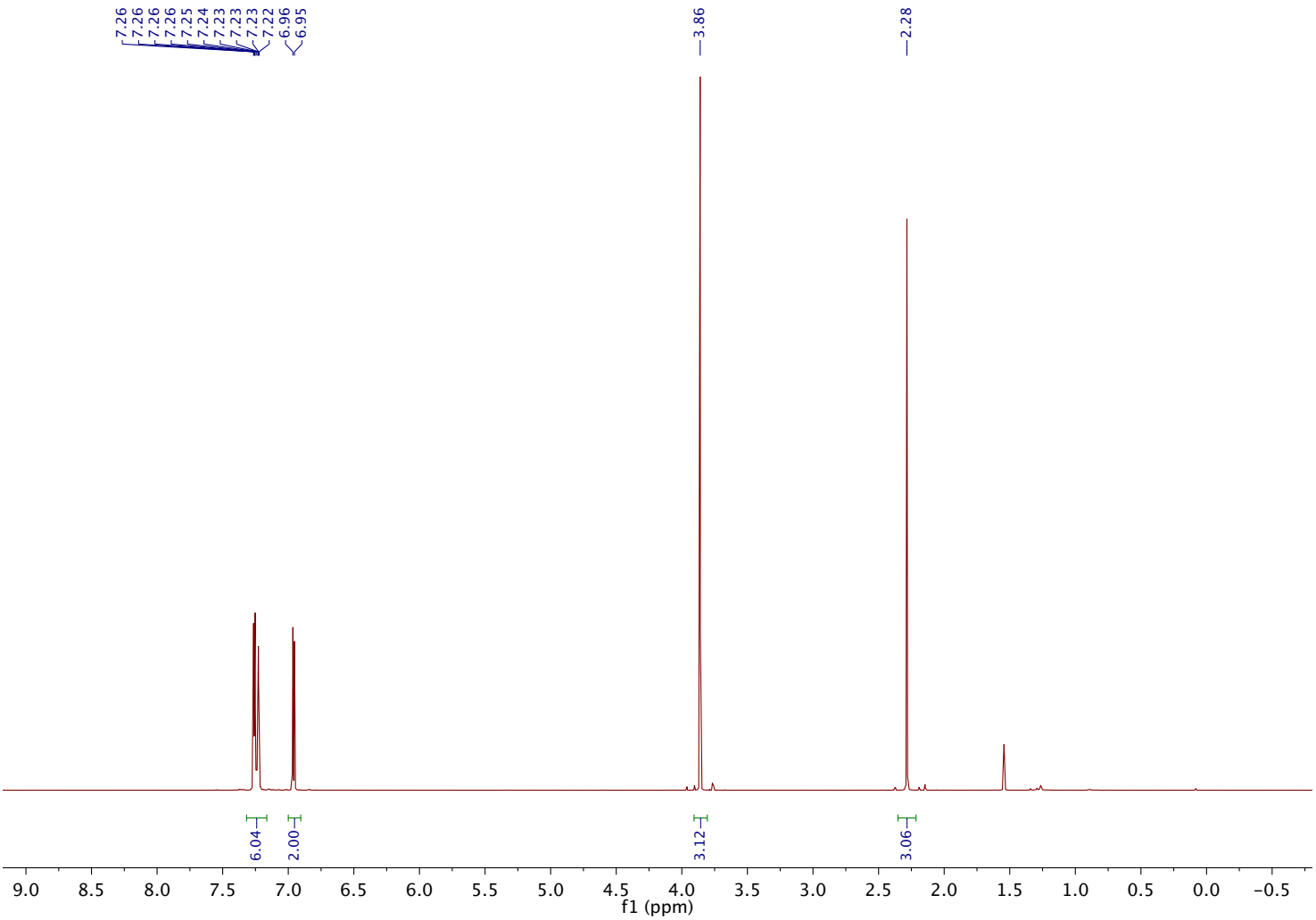
^{13}C NMR

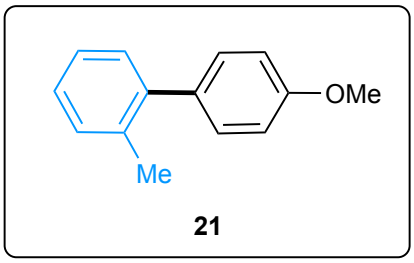

158.90
133.70
127.94
114.38
77.41
77.23
77.05
55.56
30 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
Me

21

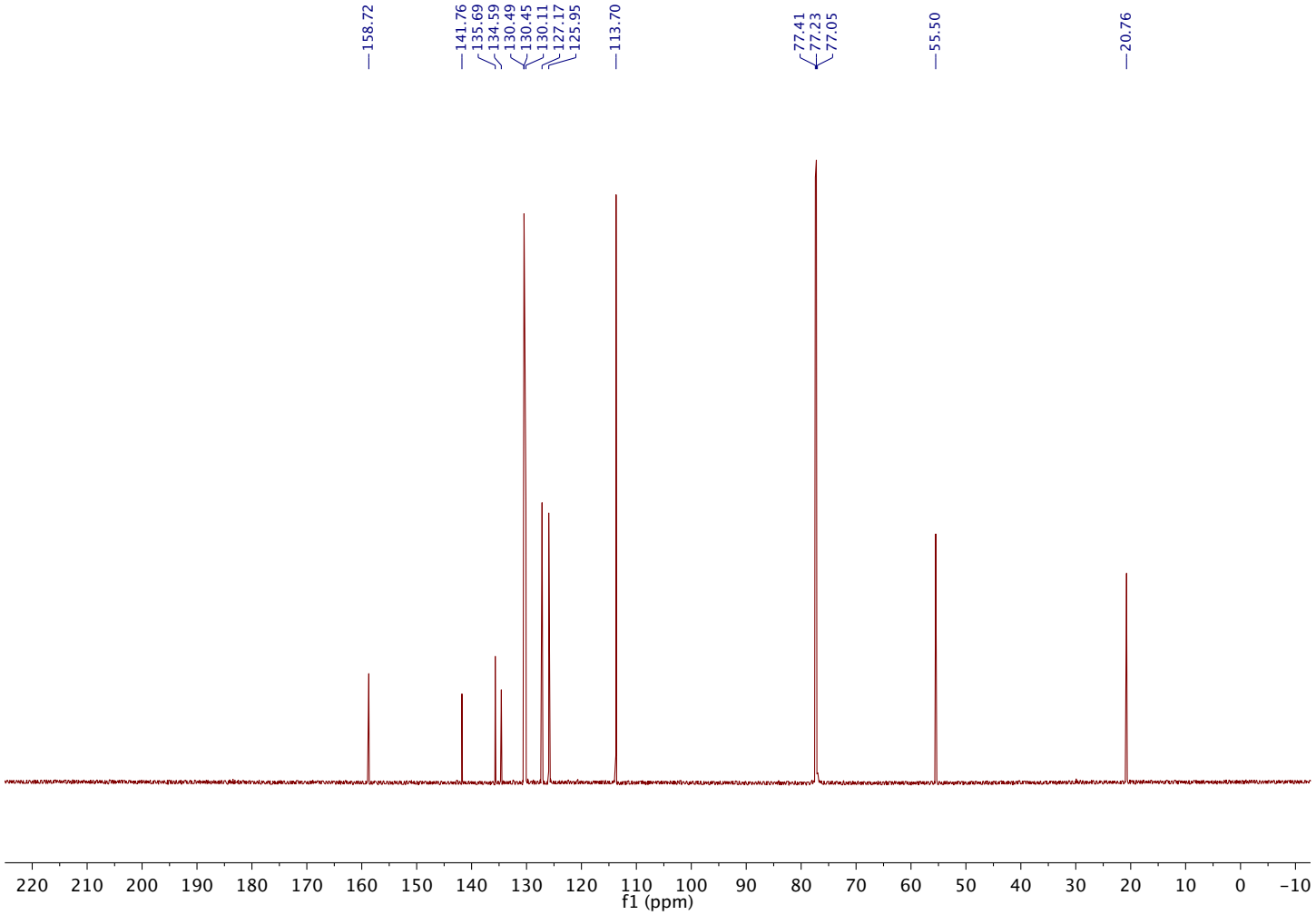
^{1}H NMR

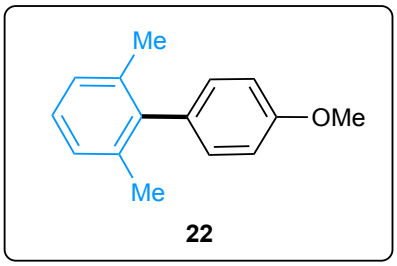

7.26
7.26
7.26
7.26
7.25
7.24
7.23
7.23
7.23
7.22
6.96
6.95
3.86
2.28
6.04
2.00
3.12
3.06
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


OMe
Me

21

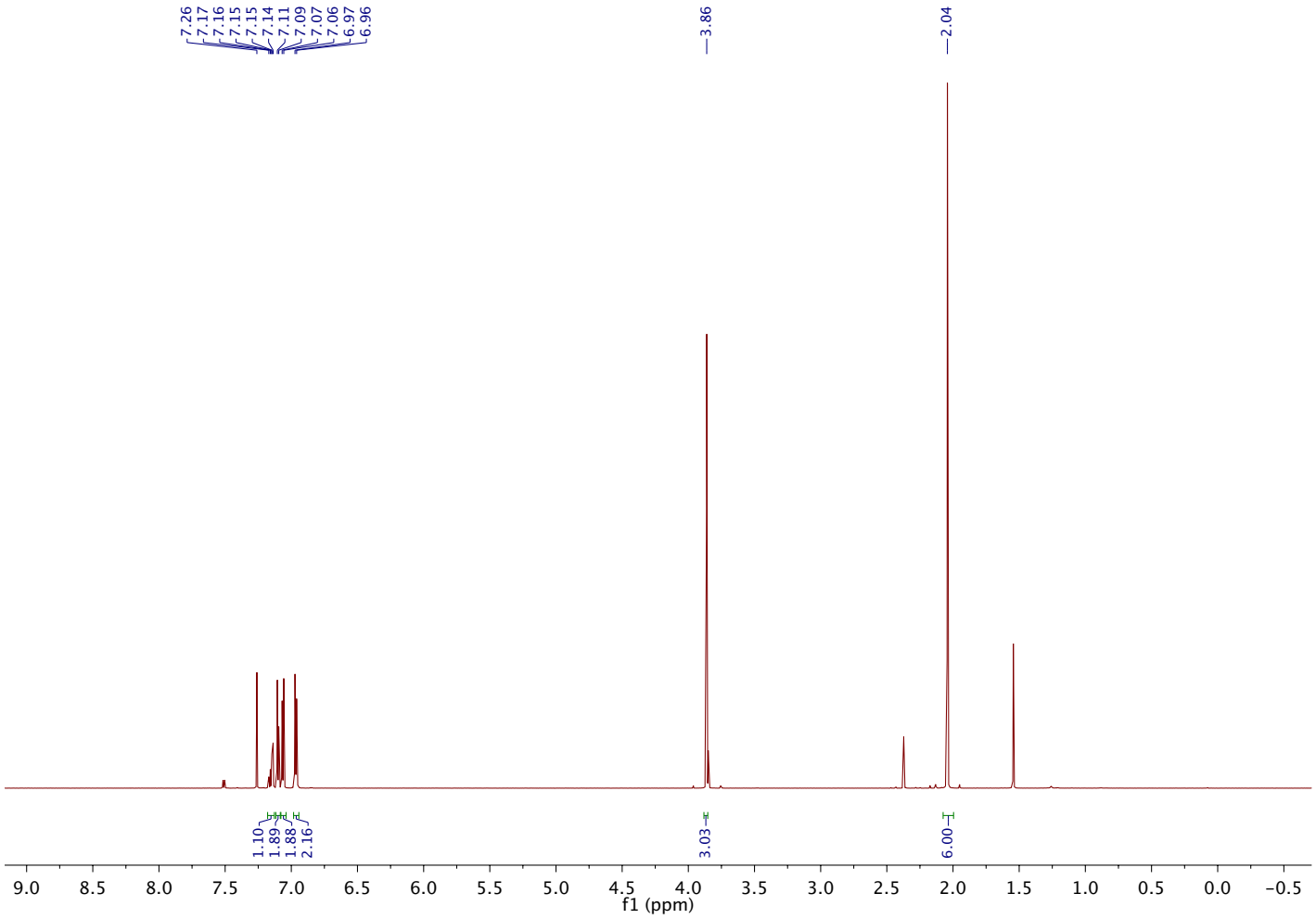
^{13}C NMR

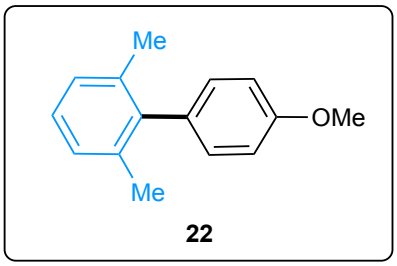

158.72
141.76
135.69
134.59
130.49
130.45
130.11
127.17
125.95
113.70
77.41
77.23
77.05
55.50
20.76
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Me
OMe
Me

22

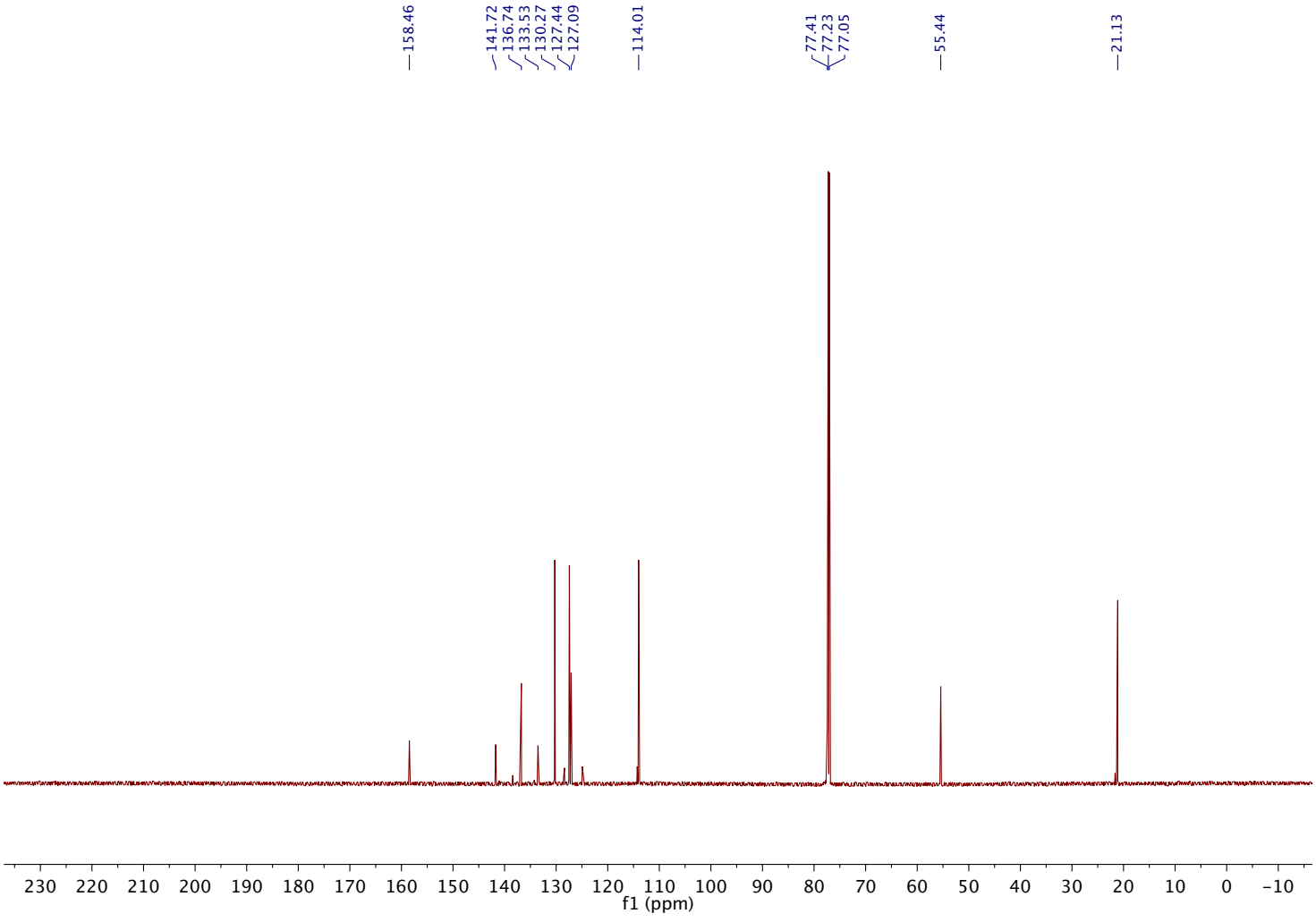
^{1}H NMR

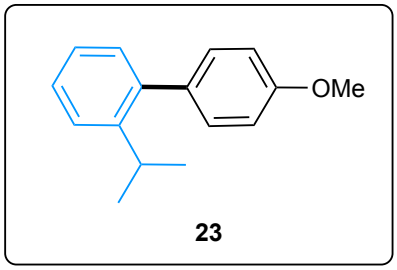

7.26
7.17
7.16
7.15
7.15
7.14
7.11
7.09
7.07
7.06
6.97
6.96
3.86
2.04
1.10
1.89
1.88
2.16
3.03
6.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


Me
OMe
Me

22

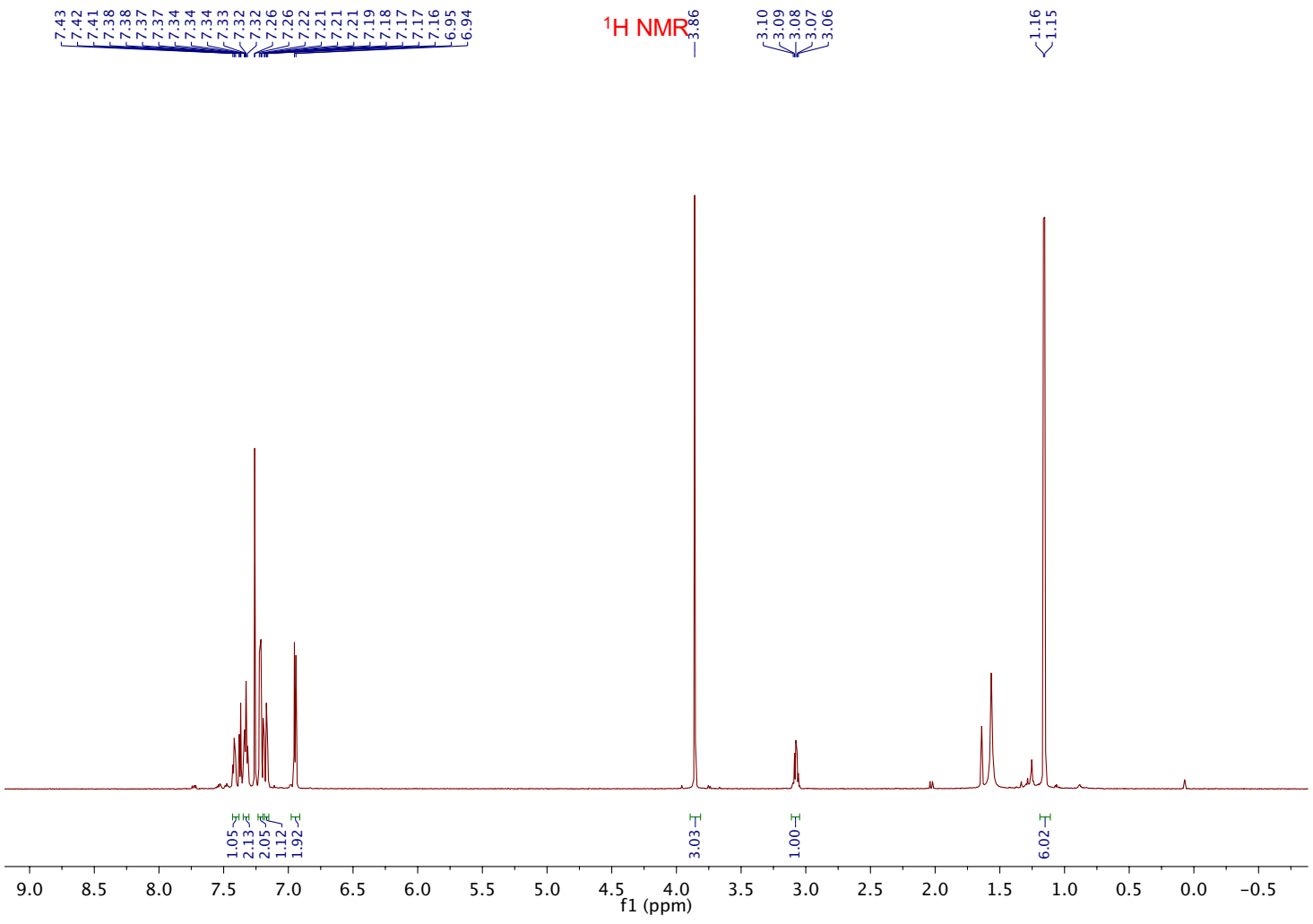
^{13}C NMR

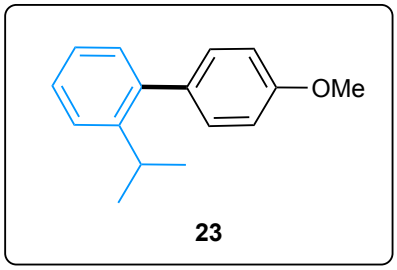

158.46
141.72
136.74
133.53
130.27
127.44
127.09
114.01
77.41
77.23
77.05
55.44
21.13
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe

23

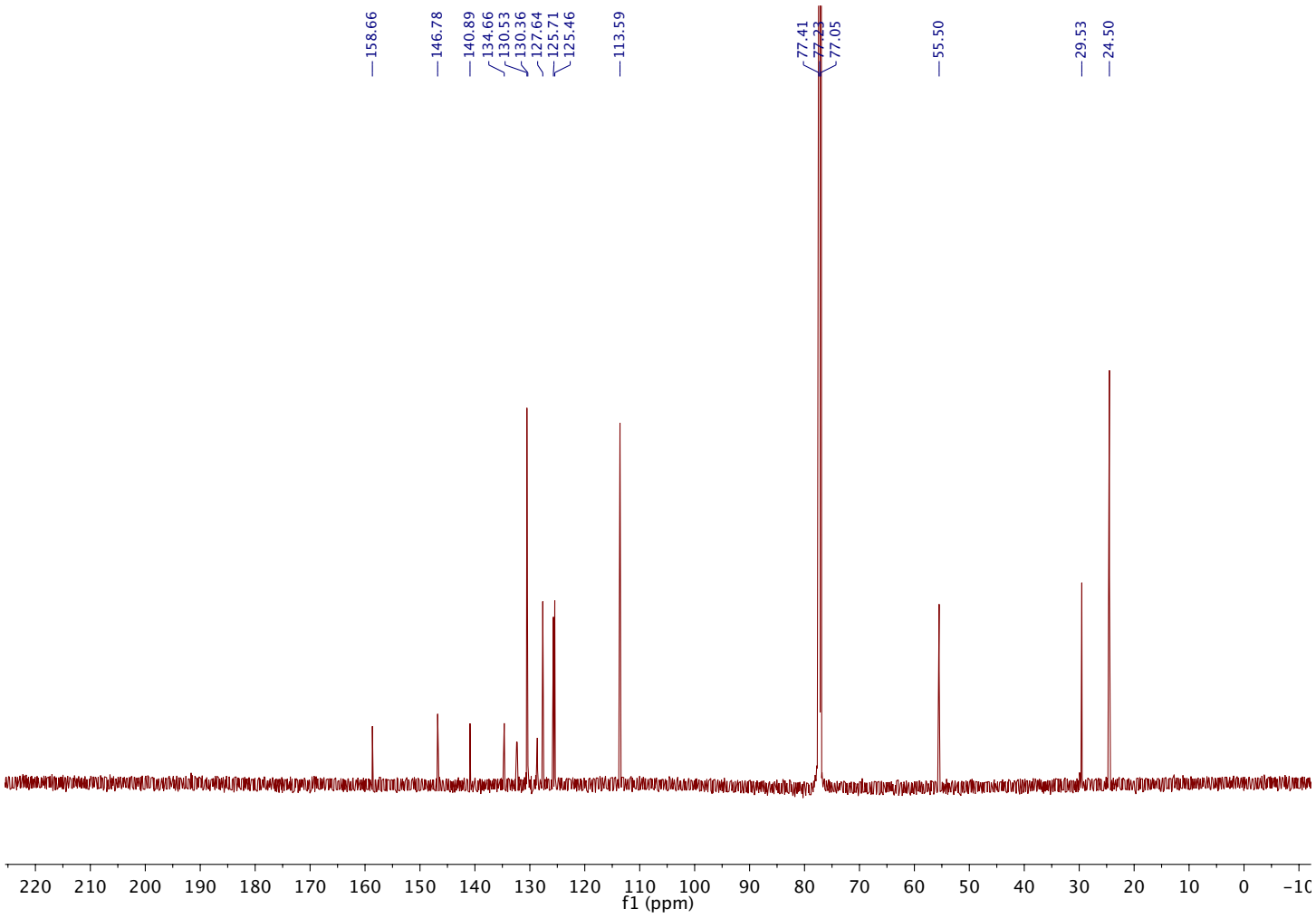
^{1}H NMR

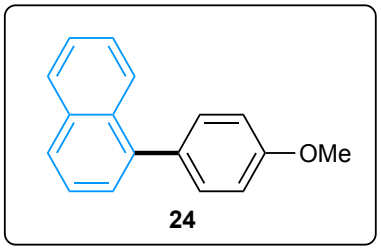

7.43
7.42
7.41
7.38
7.38
7.37
7.37
7.34
7.34
7.34
7.33
7.32
7.32
7.26
7.26
7.22
7.21
7.21
7.21
7.19
7.18
7.17
7.17
7.16
6.95
6.94
3.86
3.10
3.09
3.08
3.07
3.06
1.16
1.15
1.05
2.13
2.05
1.12
1.92
3.03
1.00
6.02
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


OMe

23

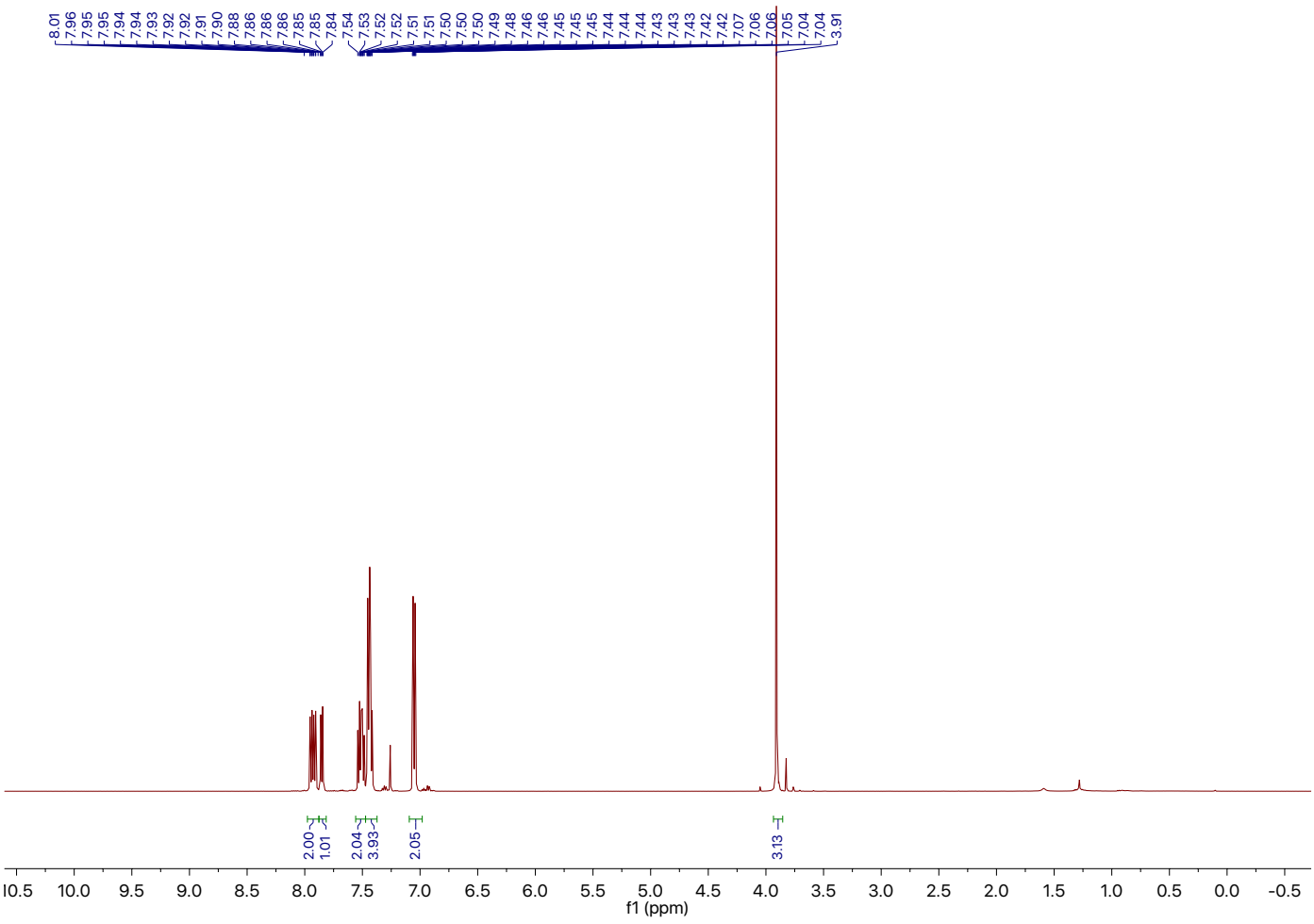
^{13}C NMR

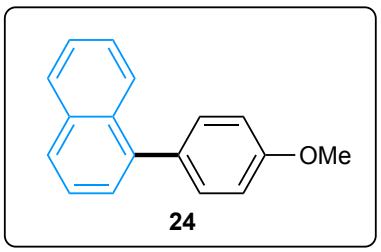

158.66
146.78
140.89
134.66
130.53
130.36
127.64
125.71
125.46
113.59
77.41
77.23
77.05
55.50
29.53
24.50
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe

24

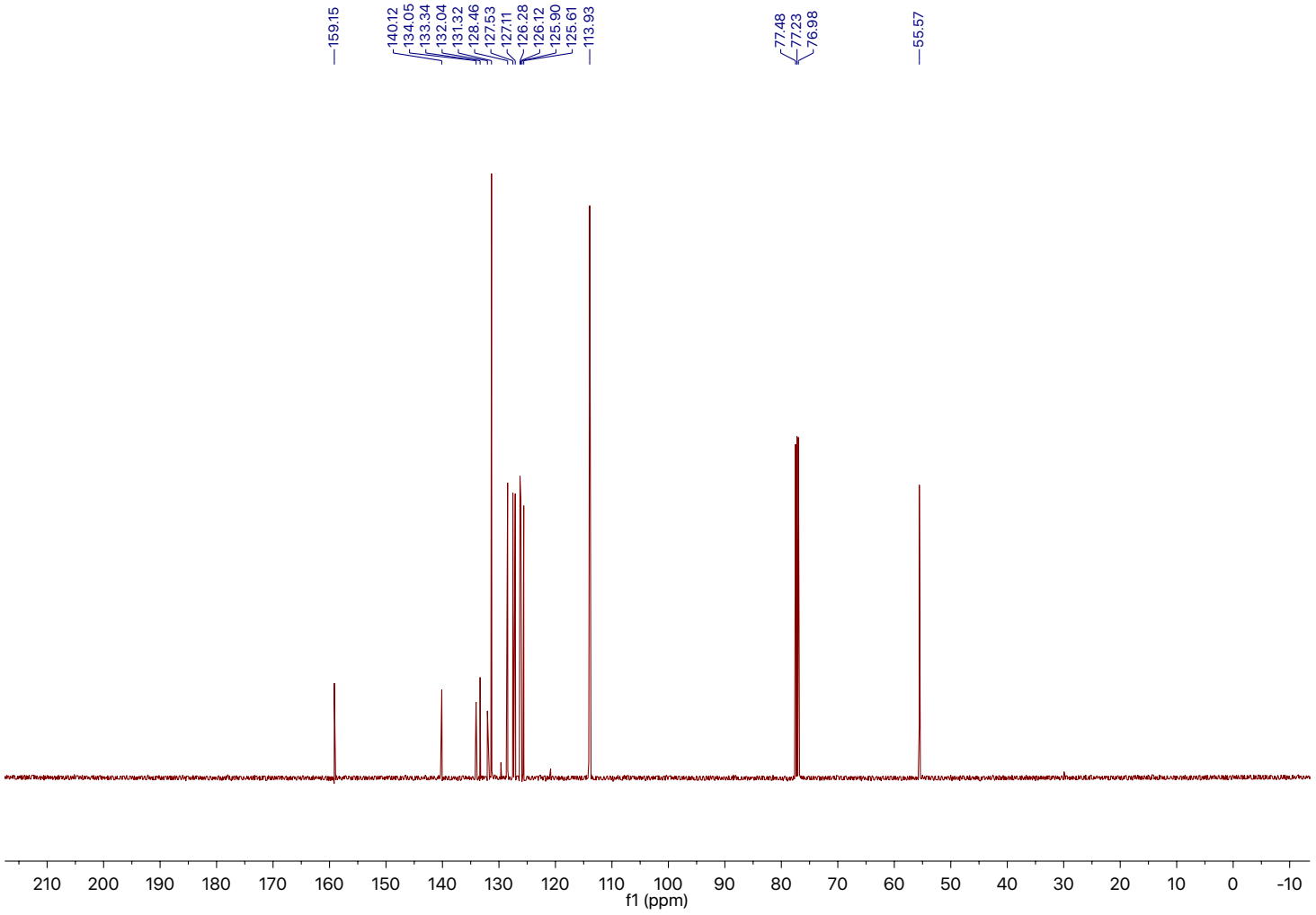
^{1}H NMR

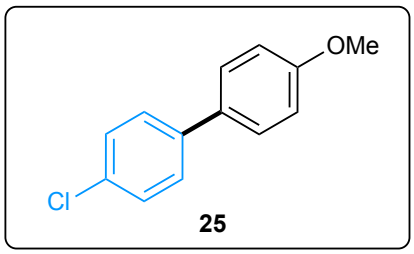

8.01
7.96
7.95
7.95
7.94
7.94
7.93
7.92
7.92
7.91
7.90
7.88
7.86
7.86
7.86
7.85
7.85
7.84
7.54
7.53
7.52
7.52
7.51
7.51
7.50
7.50
7.50
7.49
7.48
7.46
7.46
7.45
7.45
7.45
7.44
7.44
7.44
7.43
7.43
7.43
7.42
7.42
7.07
7.06
7.06
7.05
7.04
7.04
3.91
2.00
1.01
2.04
3.93
2.05
3.13
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


OMe

24

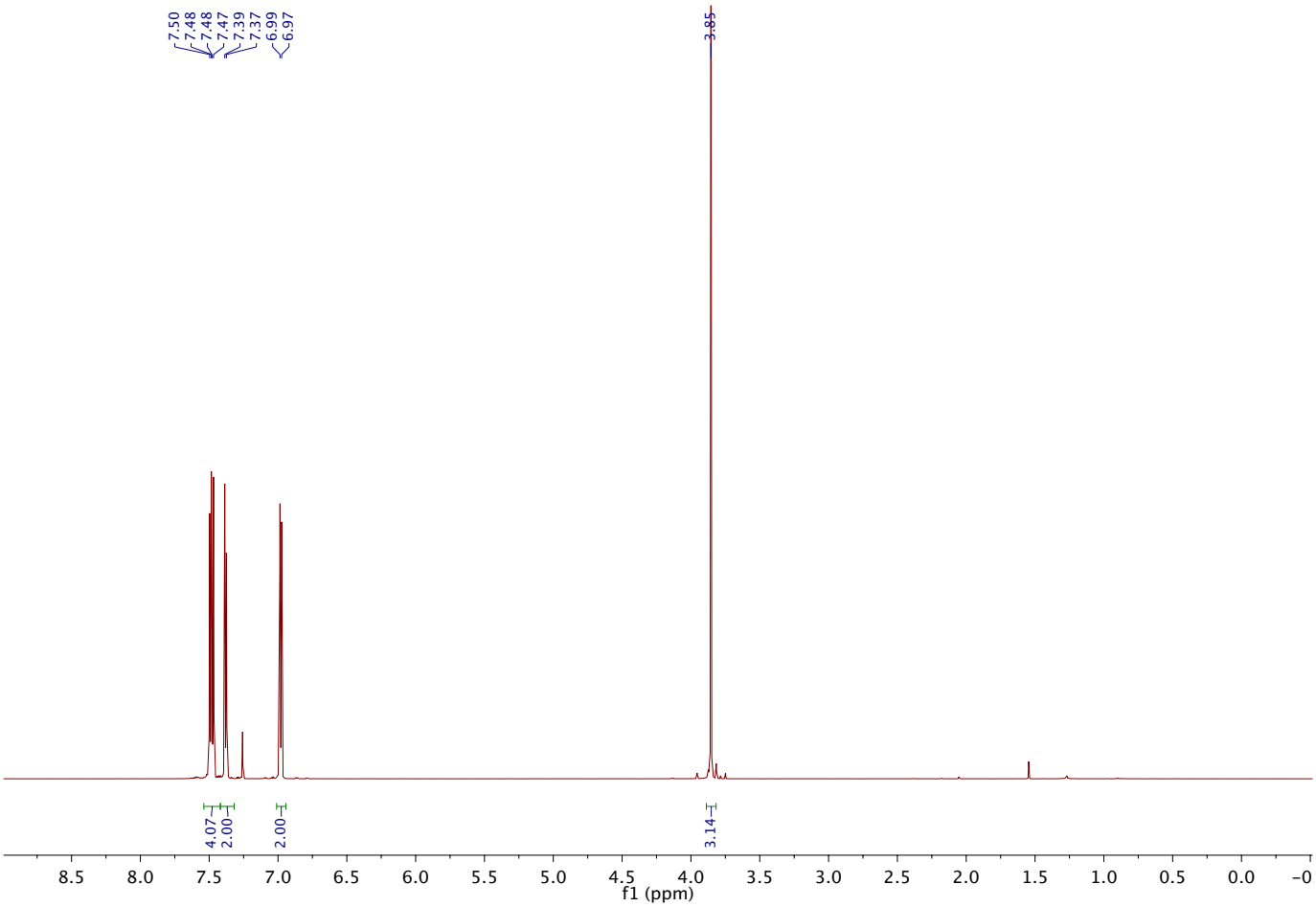
^{13}C NMR

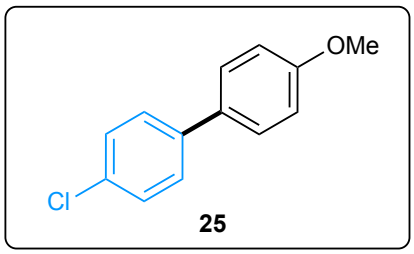

159.15
140.12
134.05
133.34
132.04
131.32
128.46
127.53
127.11
126.28
126.12
125.90
125.61
113.93
77.48
77.23
76.98
55.57
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


OMe
Cl

25

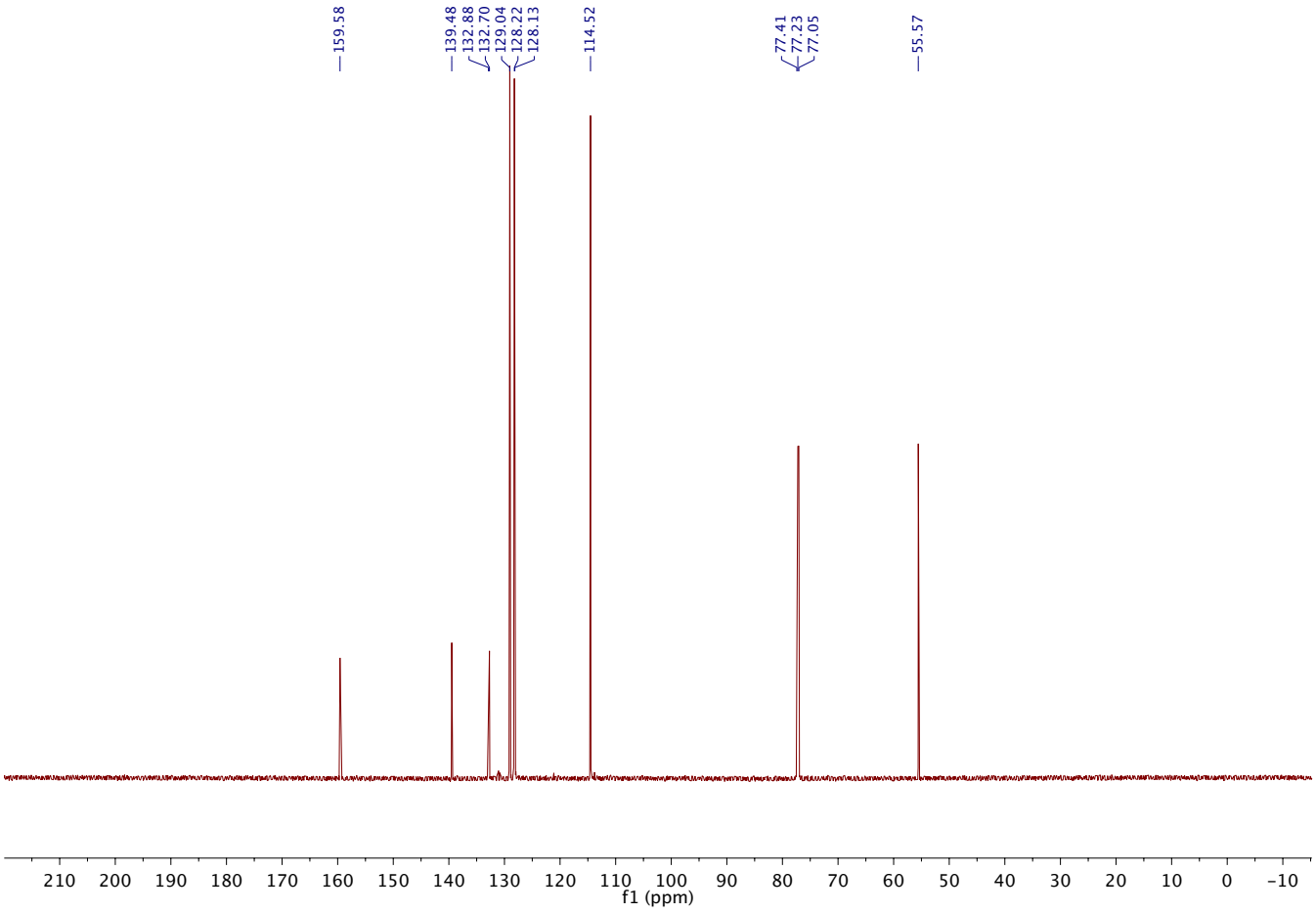
^{1}H NMR

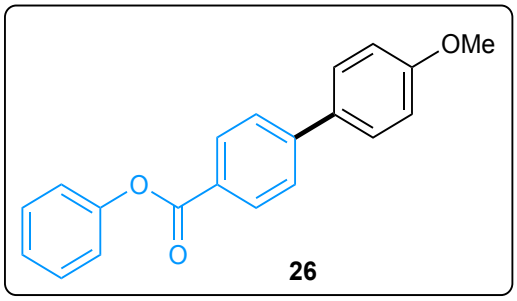

7.50
7.48
7.48
7.47
7.39
7.37
6.99
6.97
3.85
4.07
2.00
2.00
3.14
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)


OMe
Cl

25

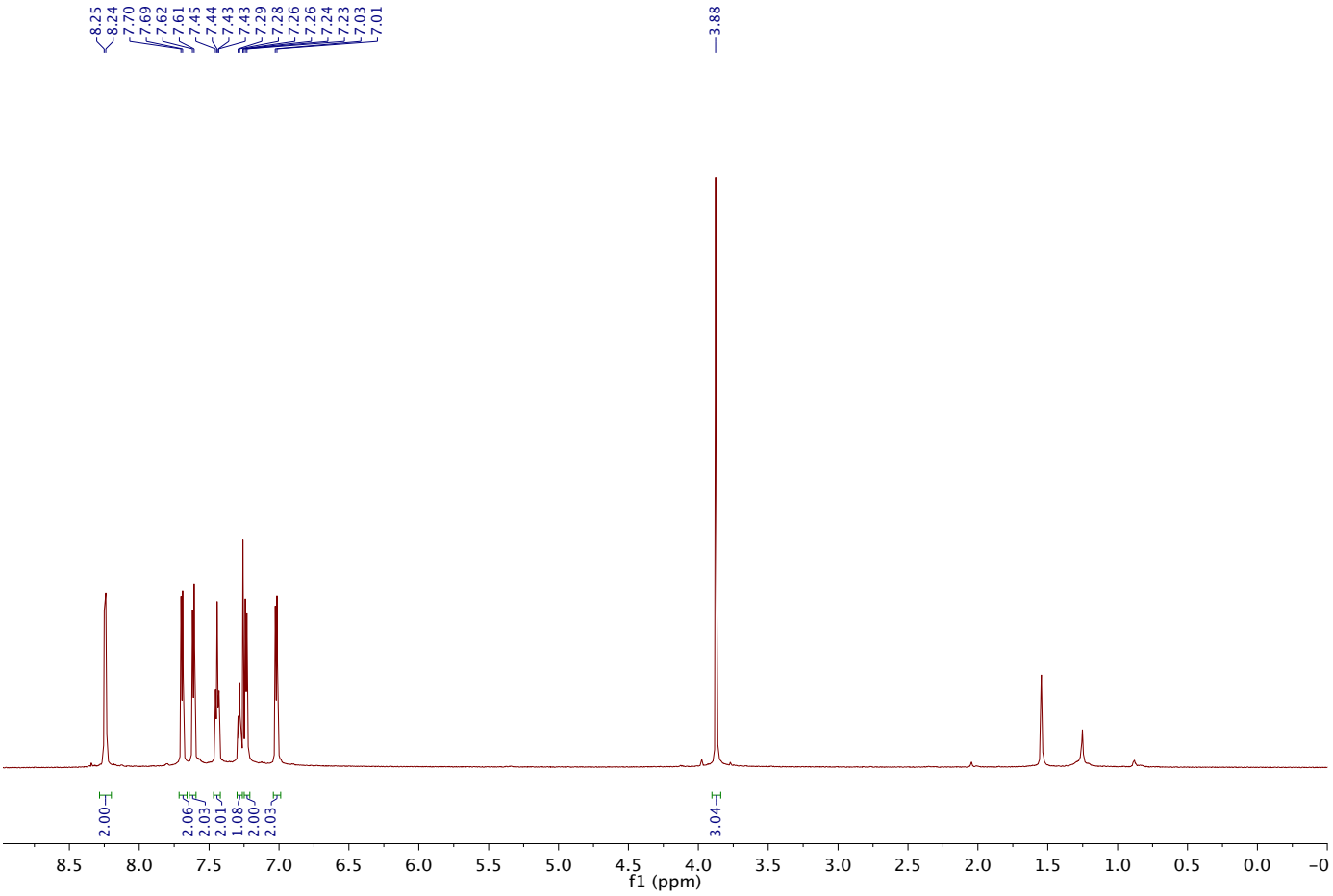
^{13}C NMR

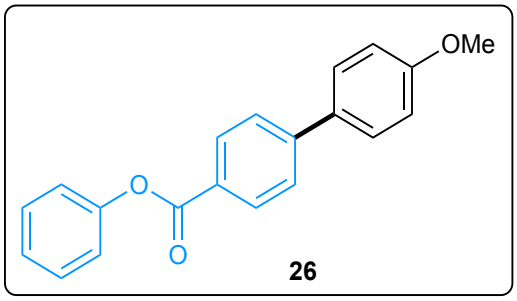

159.58
139.48
132.88
132.70
129.04
128.22
128.13
114.52
77.41
77.23
77.05
55.57
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
O
O

26

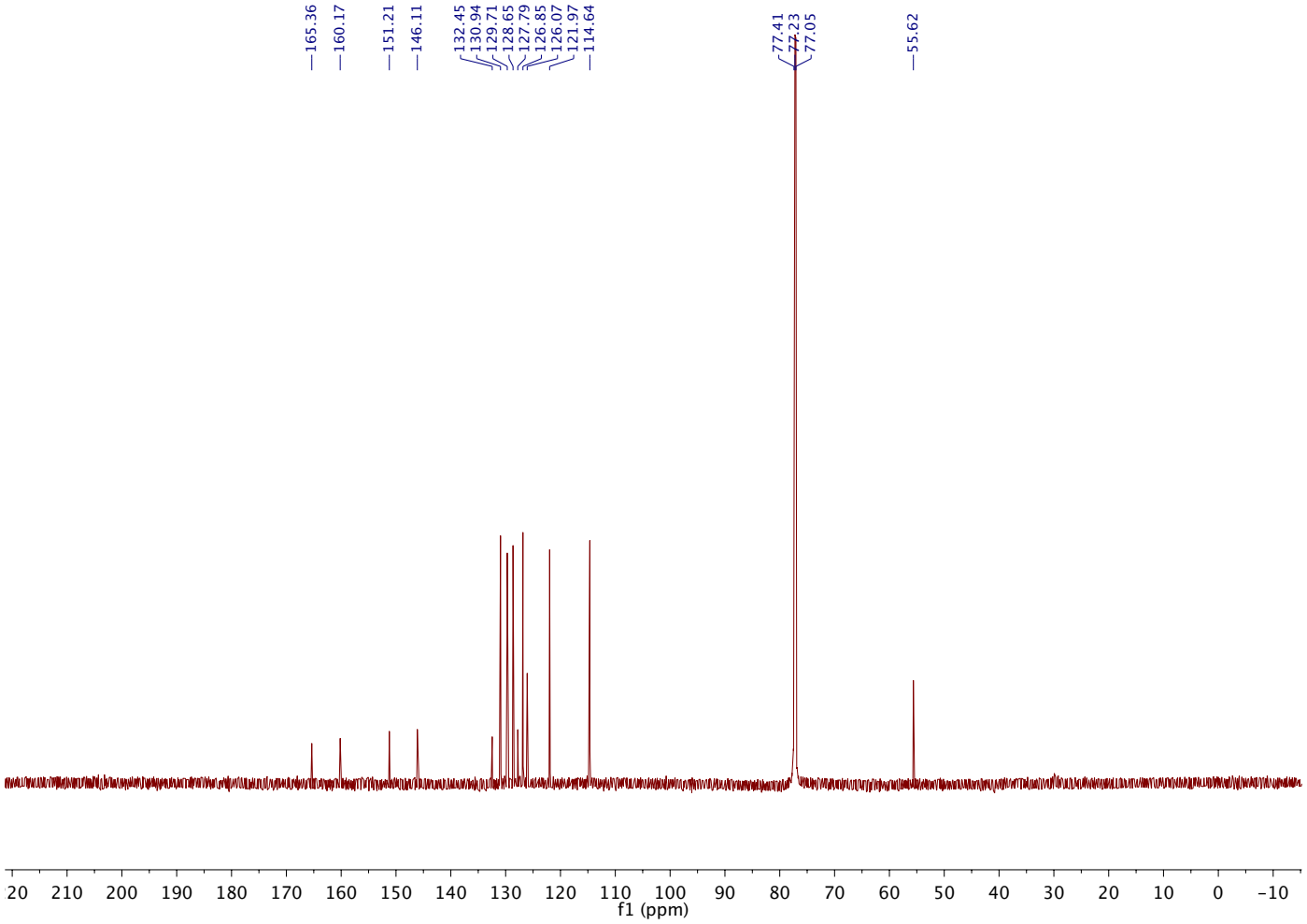
^{1}H NMR

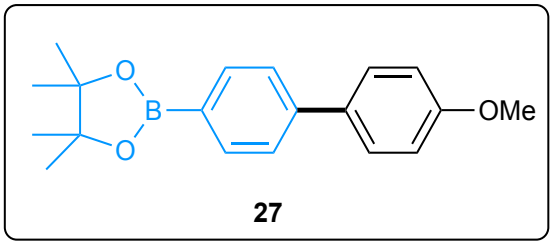

8.25
8.24
7.70
7.69
7.62
7.61
7.45
7.44
7.43
7.43
7.29
7.28
7.26
7.24
7.23
7.03
7.01
3.88
2.00
2.06
2.03
2.01
1.08
2.00
2.03
3.04
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)


OMe
O
O

26

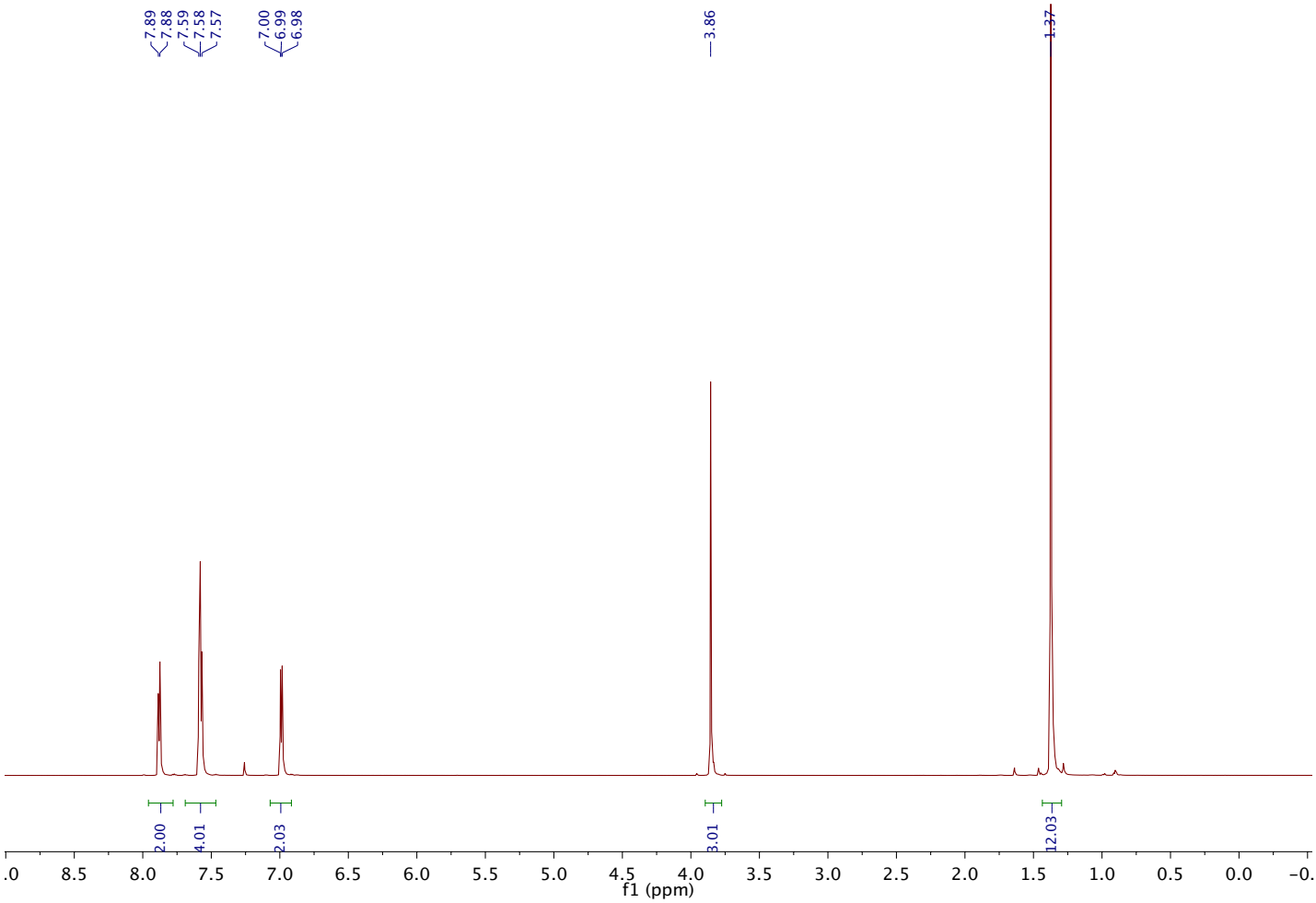
^{13}C NMR

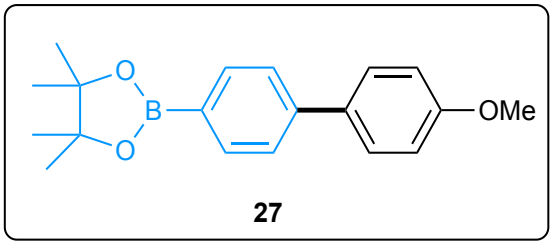

165.36
160.17
151.21
146.11
132.45
130.94
129.71
128.65
127.79
126.85
126.07
121.97
114.64
77.41
77.23
77.05
55.62
f1 (ppm)


O
B
O
OMe

27

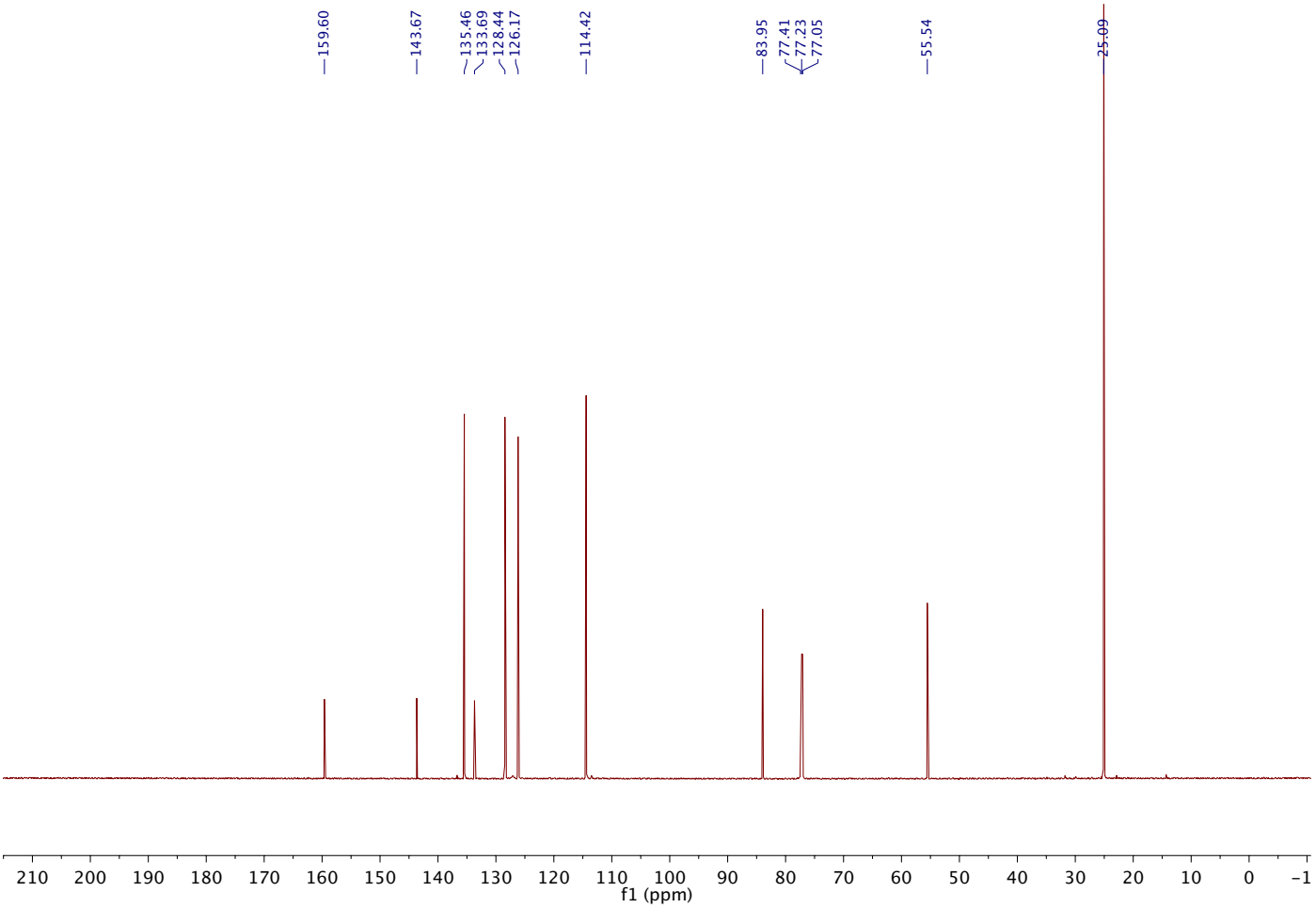
^{1}H NMR

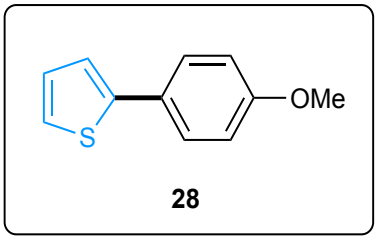

7.89
7.88
7.59
7.58
7.57
7.00
6.99
6.98
3.86
1.37
2.00
4.01
2.03
3.01
12.03
f1 (ppm)


O
B
O
OMe

27

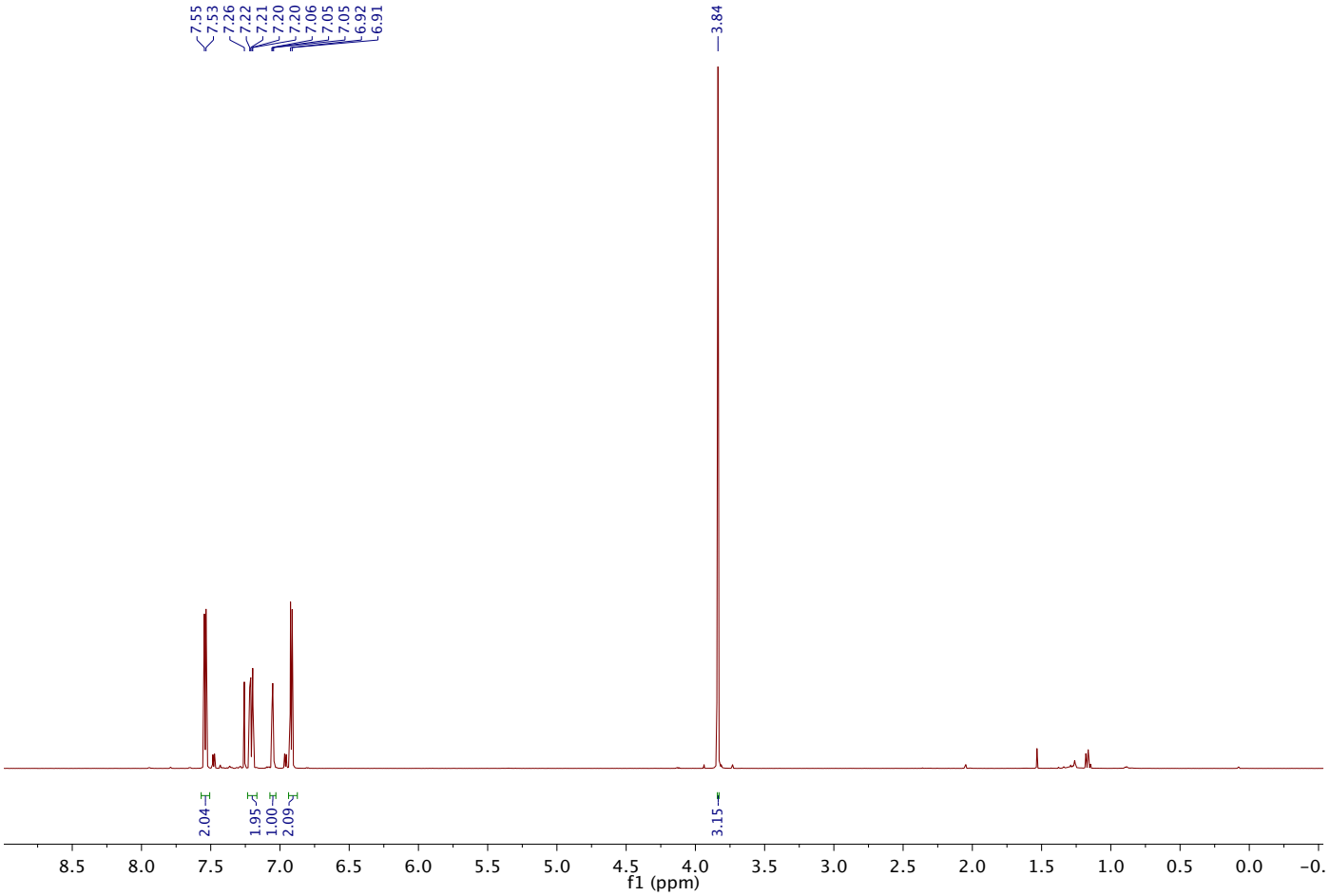
^{13}C NMR

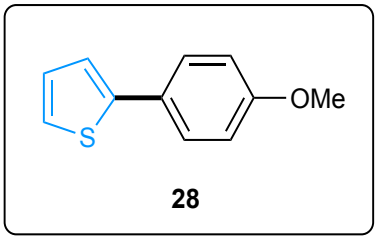

159.60
143.67
135.46
133.69
128.44
126.17
114.42
83.95
77.41
77.23
77.05
55.54
25.09
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)


OMe
S

28

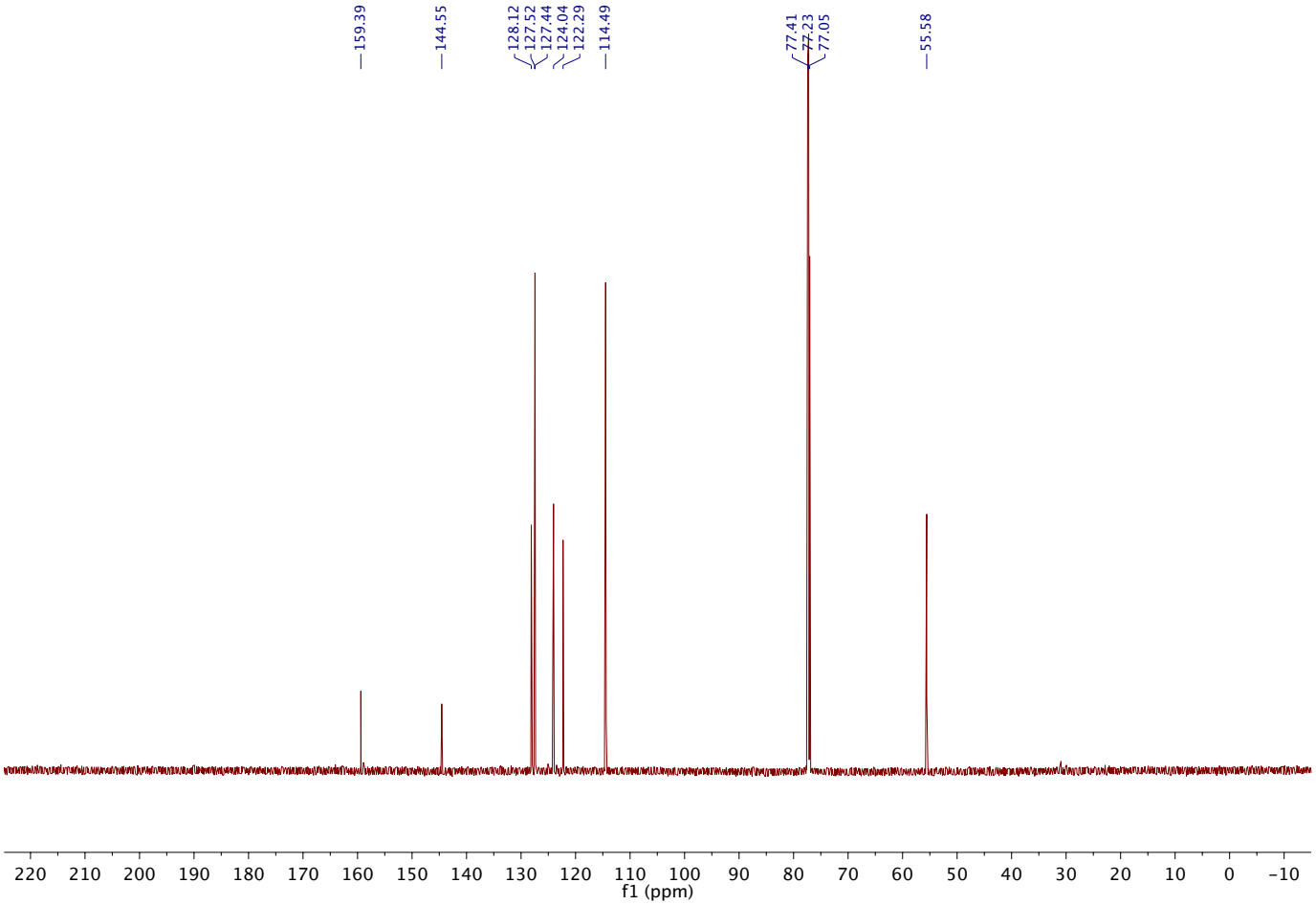
^{1}H NMR

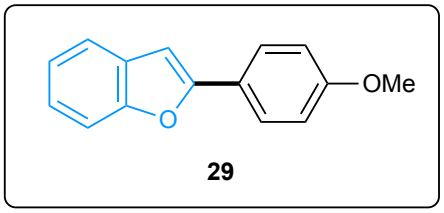

7.55
7.53
7.26
7.22
7.21
7.20
7.20
7.06
7.05
7.05
6.92
6.91
3.84
2.04
1.95
1.00
2.09
3.15
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)


OMe
S

28

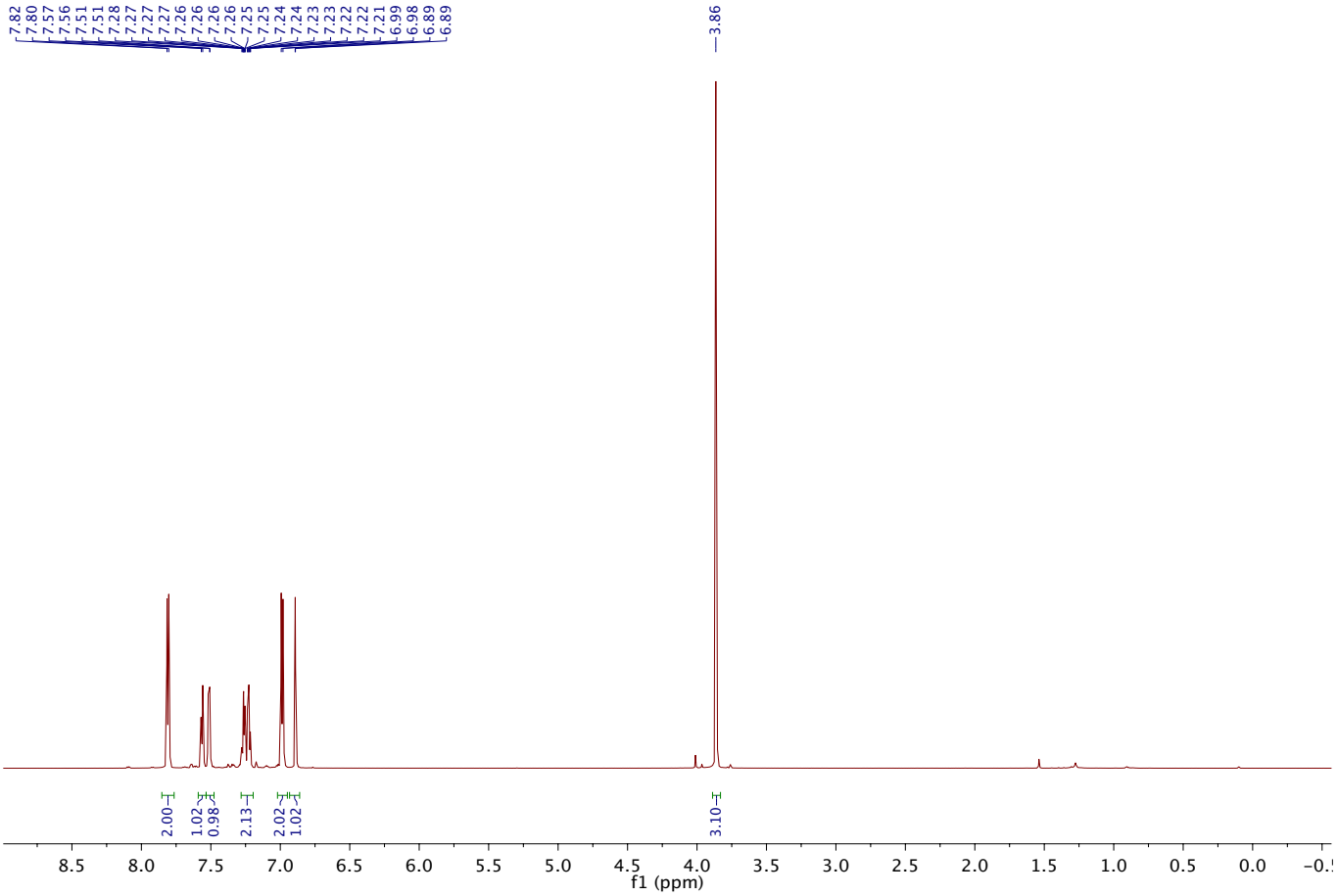
^{13}C NMR

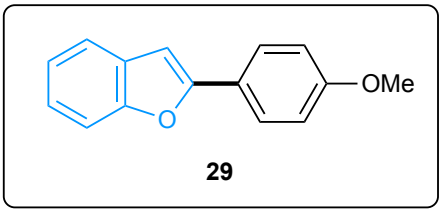

159.39
144.55
128.12
127.52
127.44
124.04
122.29
114.49
77.41
77.23
77.05
55.58
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
O

29

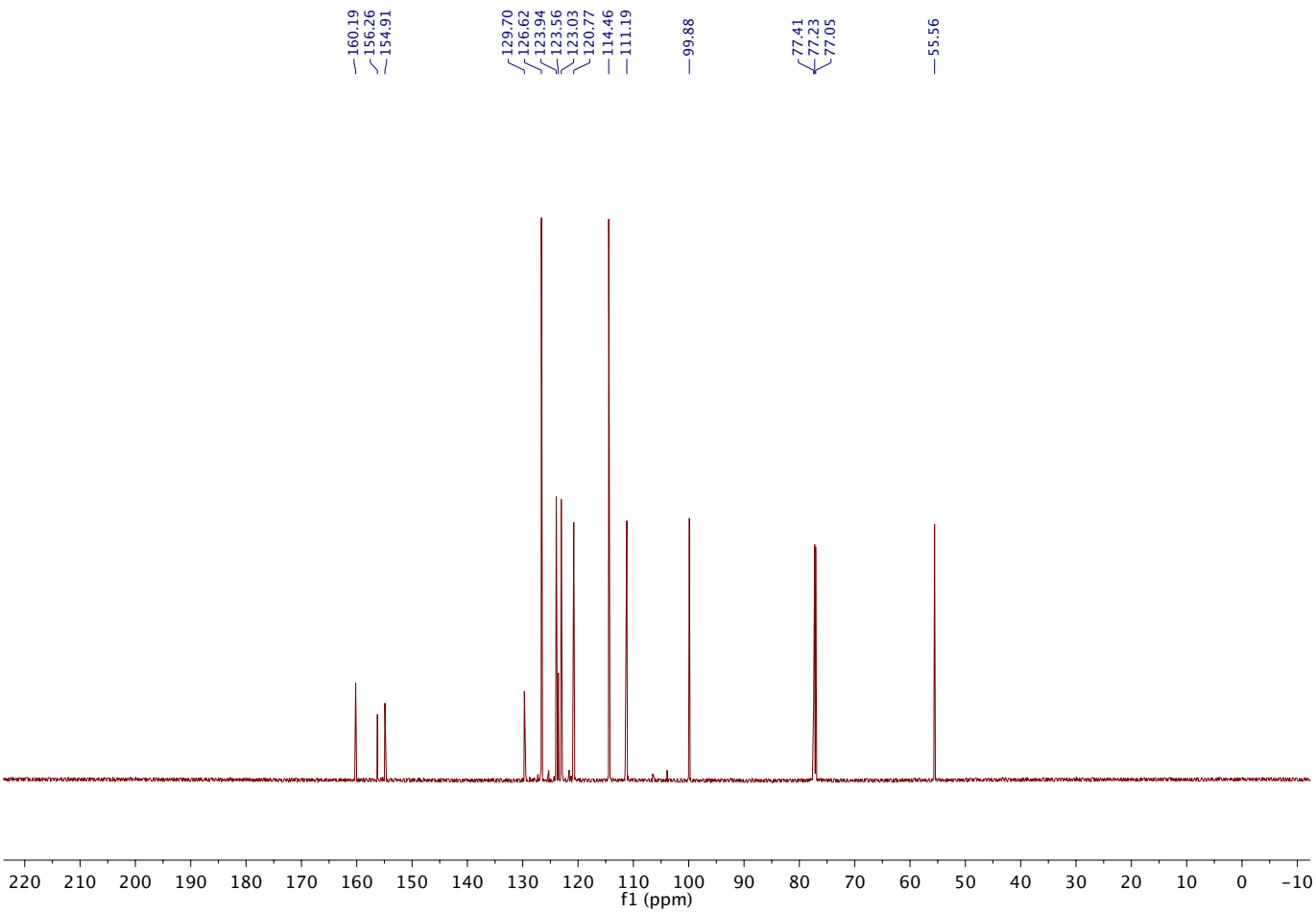
^{1}H NMR

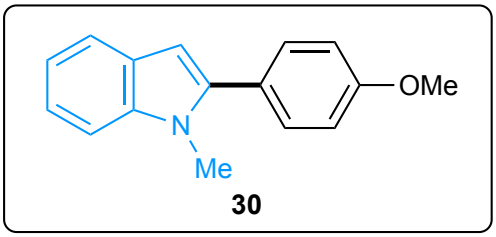

7.82
7.80
7.57
7.56
7.51
7.51
7.28
7.27
7.27
7.27
7.26
7.26
7.26
7.26
7.25
7.25
7.24
7.24
7.23
7.23
7.22
7.22
7.21
6.99
6.98
6.89
6.89
3.86
2.00
1.02
0.98
2.13
2.02
1.02
3.10
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


OMe
O

29

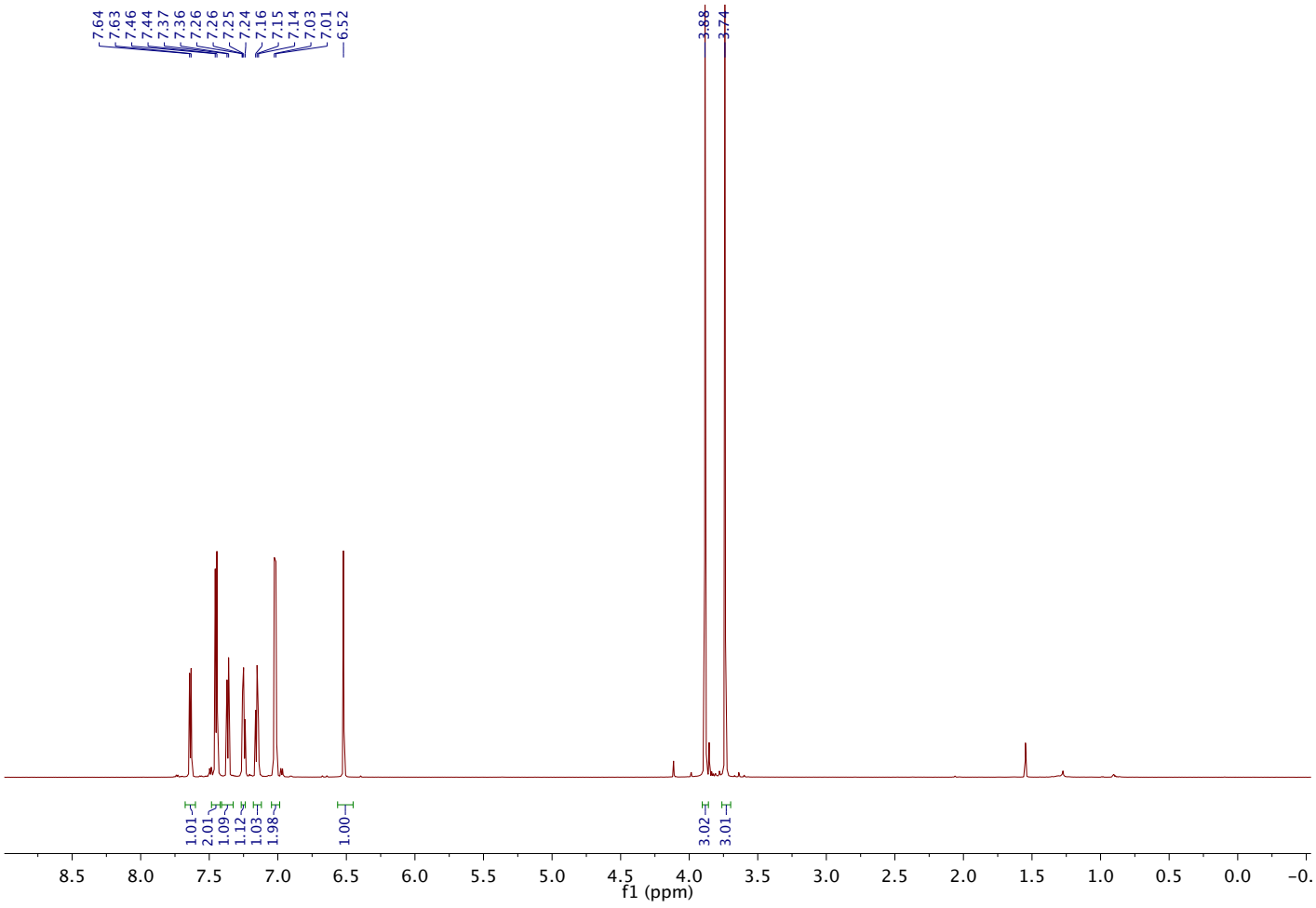
^{13}C NMR

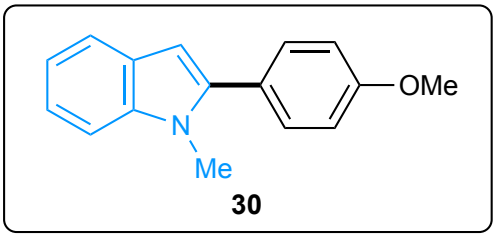

160.19
156.26
154.91
129.70
126.62
123.94
123.56
123.03
120.77
114.46
111.19
99.88
77.41
77.23
77.05
55.56
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
N
Me

30

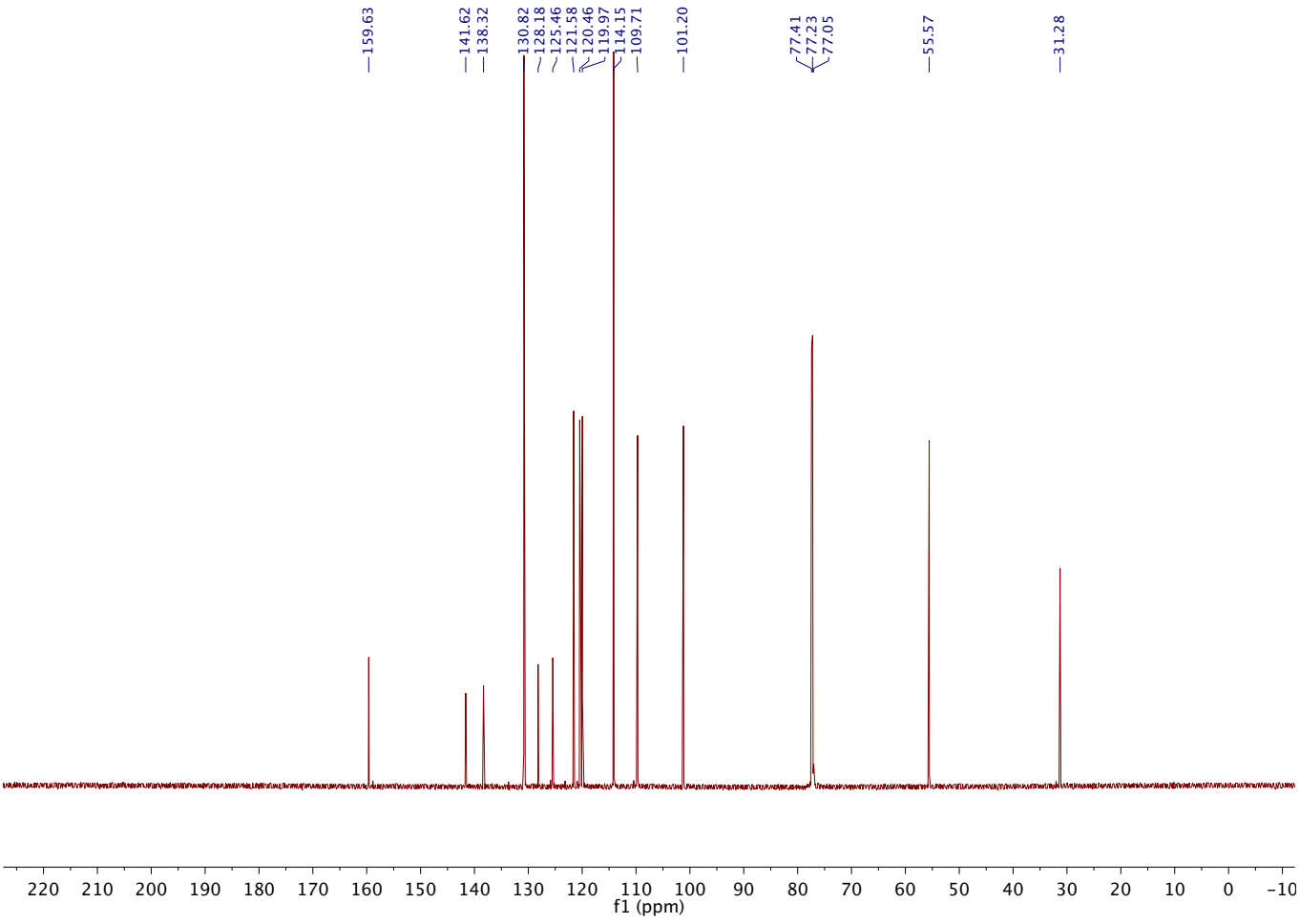
^{1}H NMR

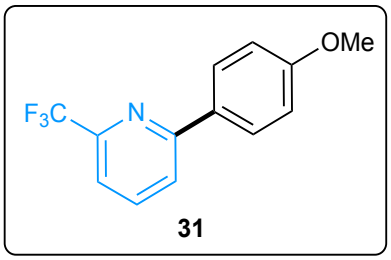

7.64
7.63
7.46
7.44
7.37
7.36
7.26
7.26
7.25
7.24
7.16
7.15
7.14
7.03
7.01
6.52
3.88
3.74
1.01
2.01
1.09
1.12
1.03
1.98
1.00
3.02
3.01
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


OMe
N
Me

30

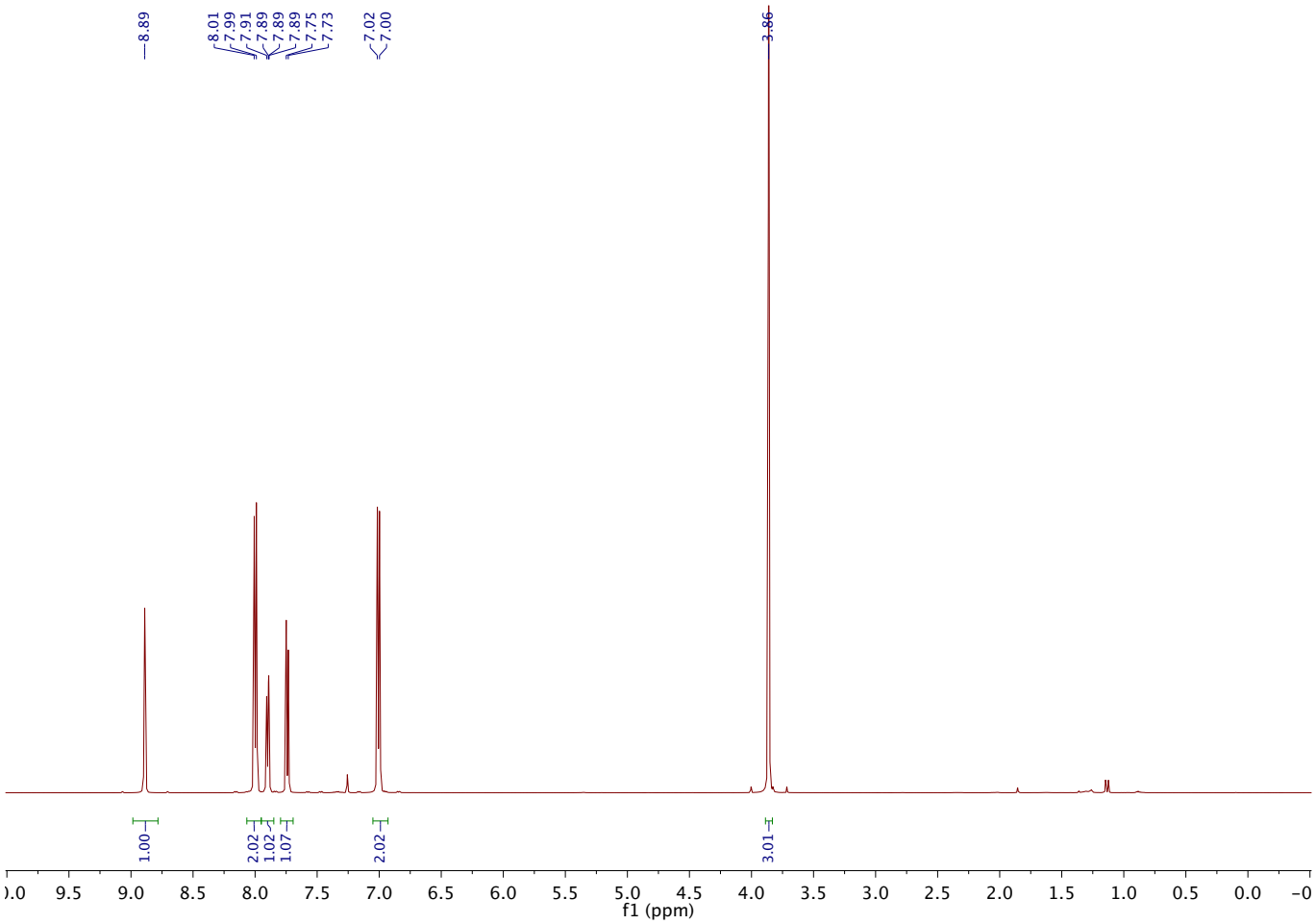
^{13}C NMR

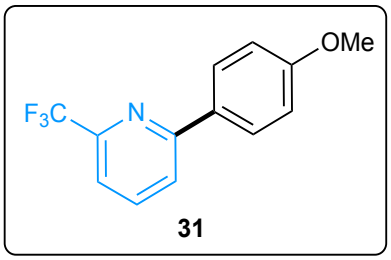

159.63
141.62
138.32
130.82
128.18
125.46
121.58
120.46
119.97
114.15
109.71
101.20
77.41
77.23
77.05
55.57
31.28
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
F3C
N

31

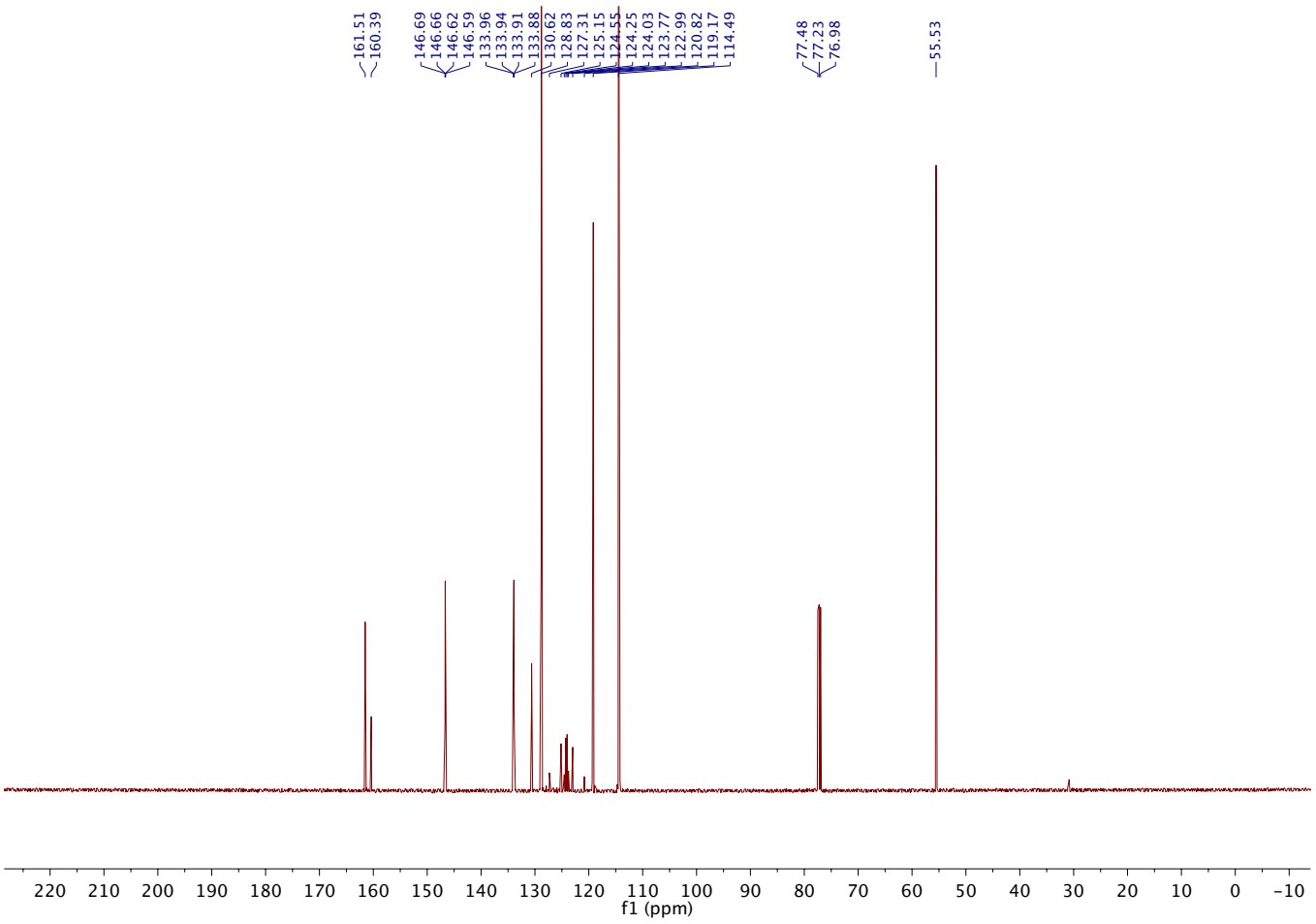
^{1}H NMR

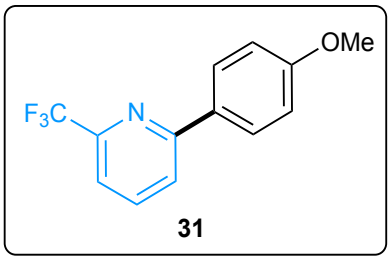

8.89
8.01
7.99
7.91
7.89
7.89
7.89
7.75
7.73
7.02
7.00
3.86
1.00
2.02
1.02
1.07
2.02
3.01
f1 (ppm)


OMe
F3C
N

31

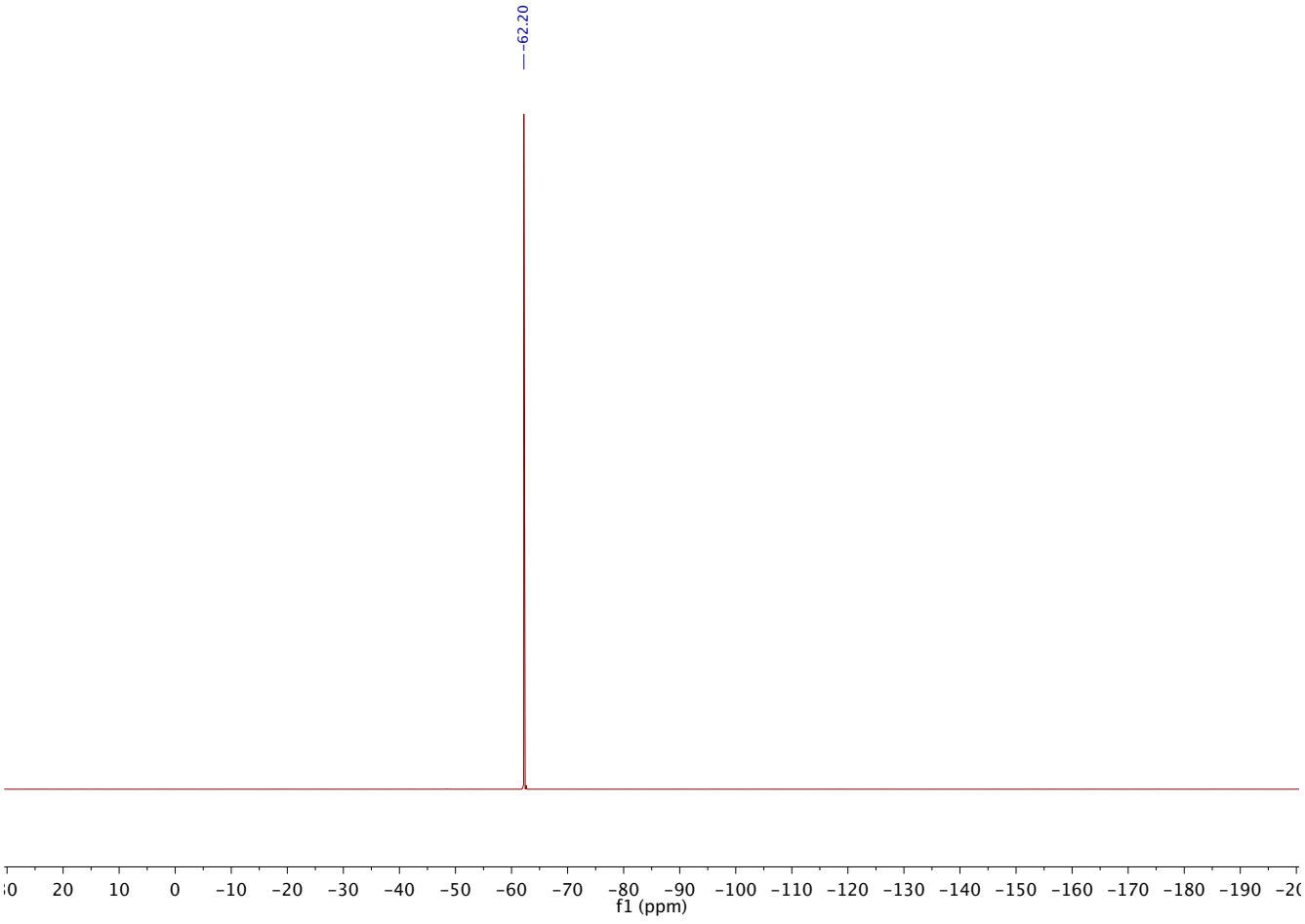
^{13}C NMR

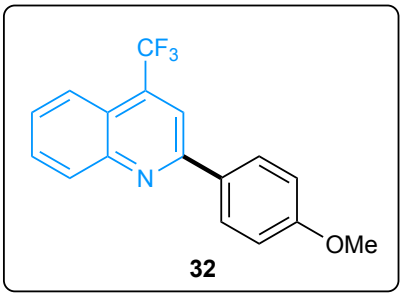

161.51
160.39
146.69
146.66
146.62
146.59
133.96
133.94
133.91
133.88
130.62
128.83
127.31
125.15
124.55
124.25
124.03
123.77
122.99
120.82
119.17
114.49
77.48
77.23
76.98
55.53
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
F3C
N

31

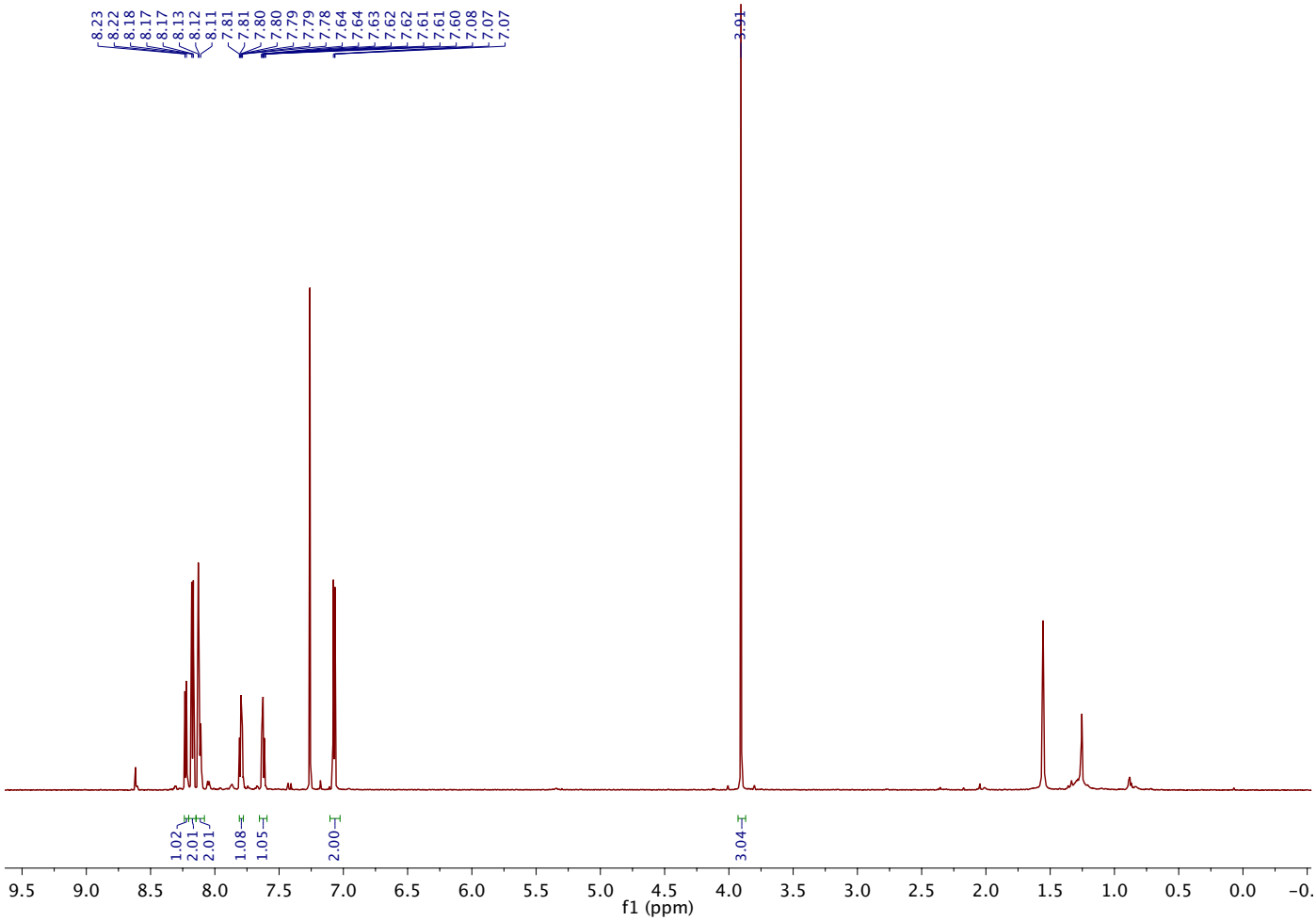
^{19}F NMR

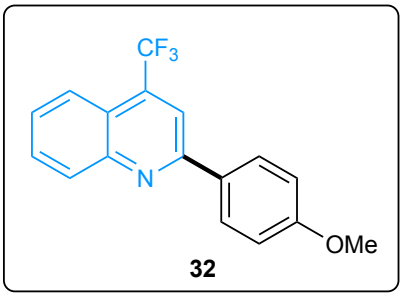

−62.20
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
−110
−120
−130
−140
−150
−160
−170
−180
−190
f1 (ppm)


CF3
N
OMe

32

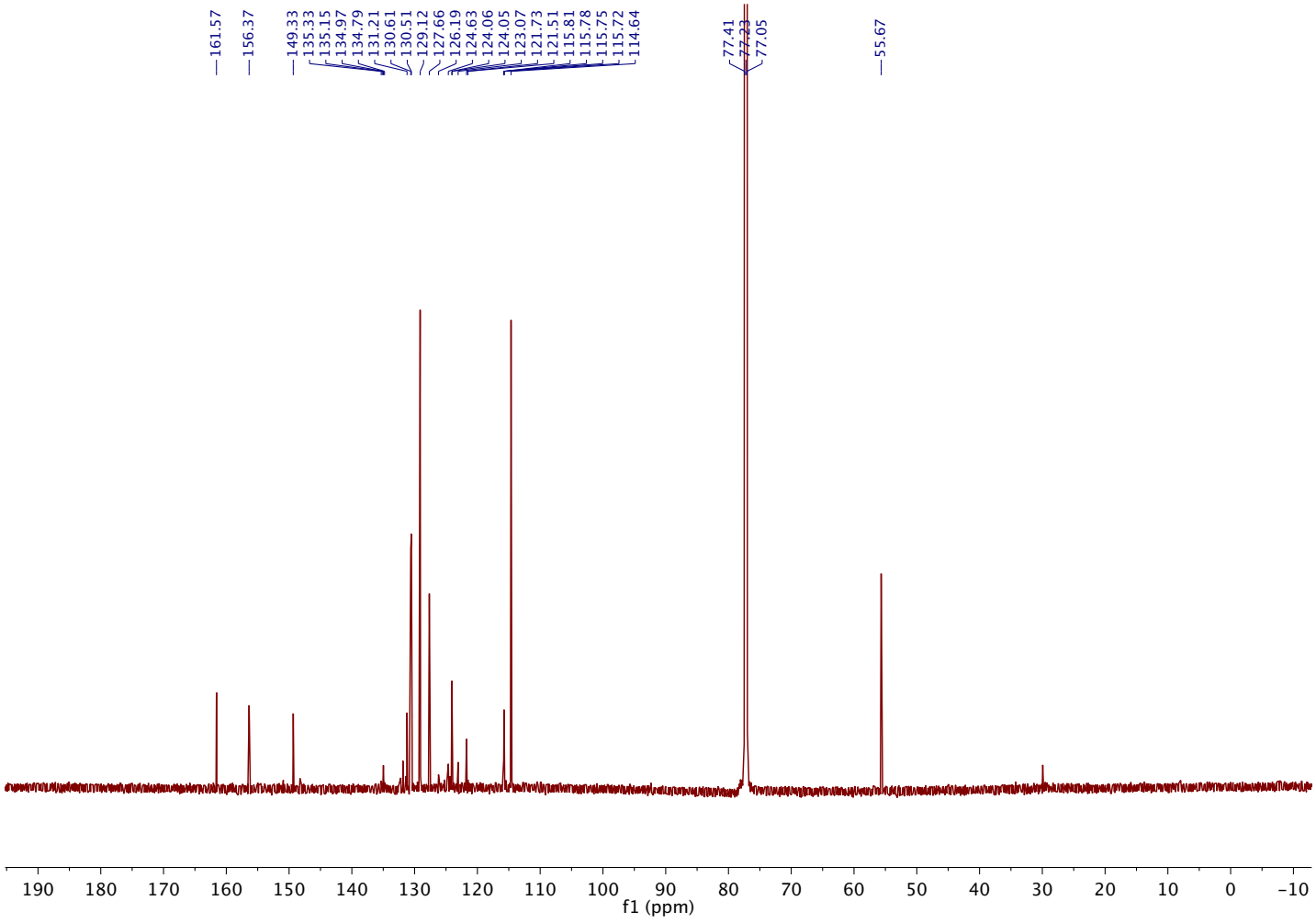
^{1}H NMR

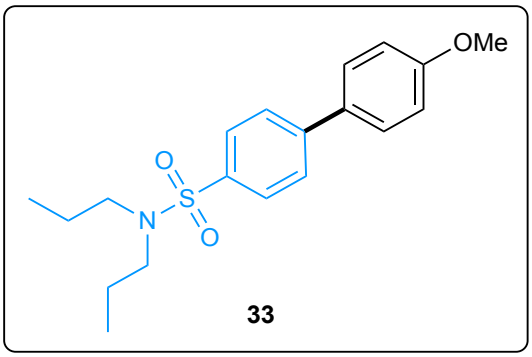

8.23
8.22
8.18
8.17
8.17
8.13
8.12
8.11
7.81
7.81
7.80
7.80
7.79
7.79
7.78
7.64
7.64
7.63
7.62
7.62
7.61
7.61
7.60
7.08
7.07
7.07
3.91
1.02
2.01
2.01
1.08
1.05
2.00
3.04
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


CF3
N
OMe

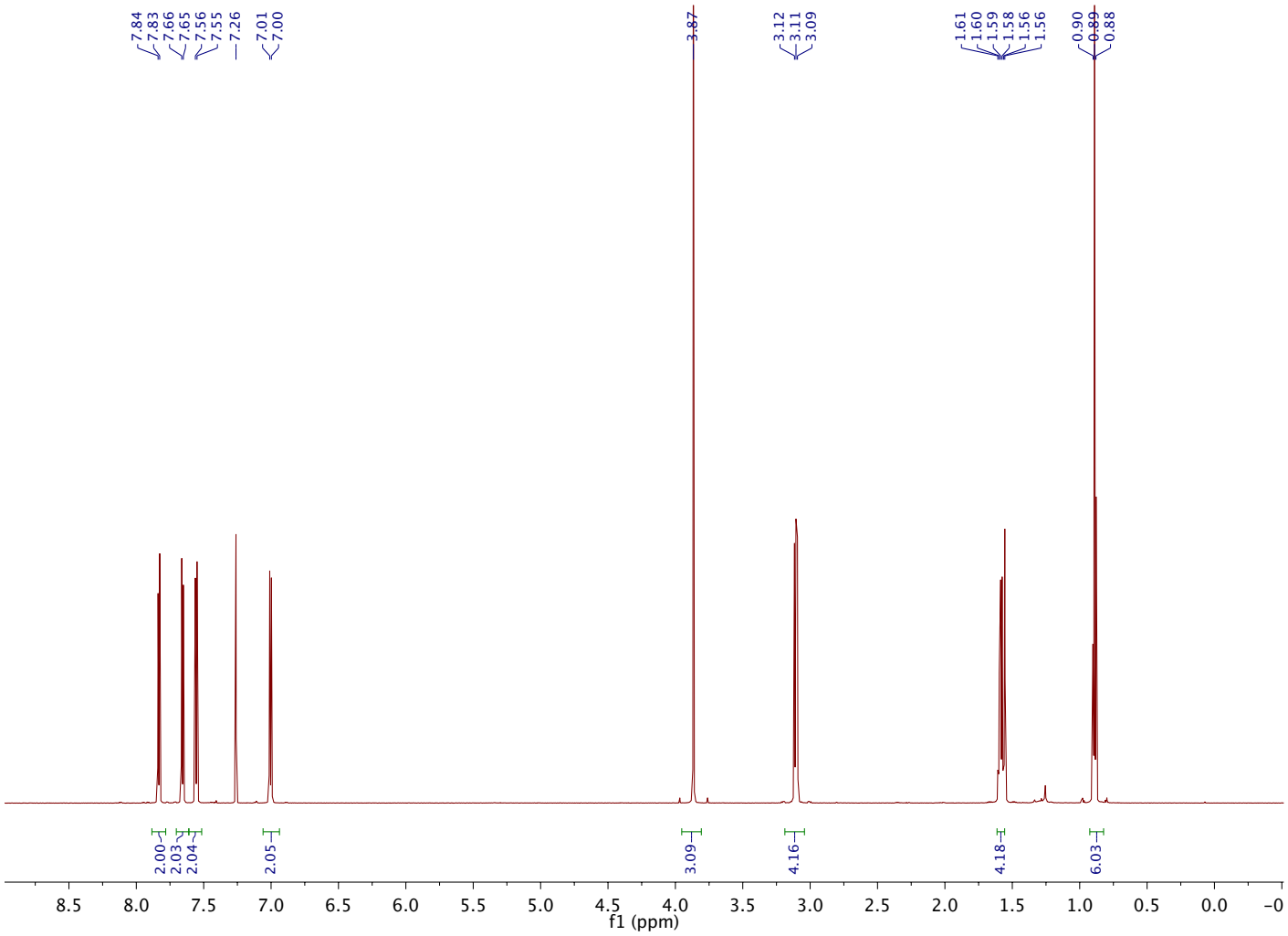
32

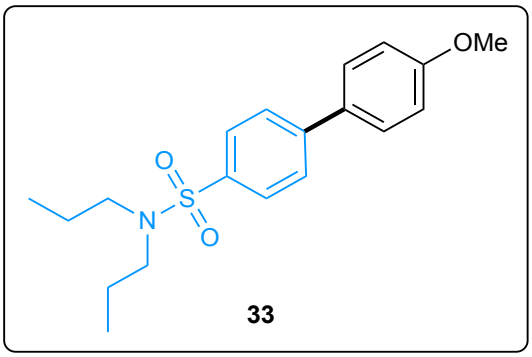
^{13}C NMR


161.57
156.37
149.33
135.33
135.15
134.97
134.79
131.21
130.61
130.51
129.12
127.66
126.19
124.63
124.06
124.05
123.07
121.73
121.51
115.81
115.78
115.75
115.72
114.64
77.41
77.33
77.05
55.67
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
O
S
O
N
33

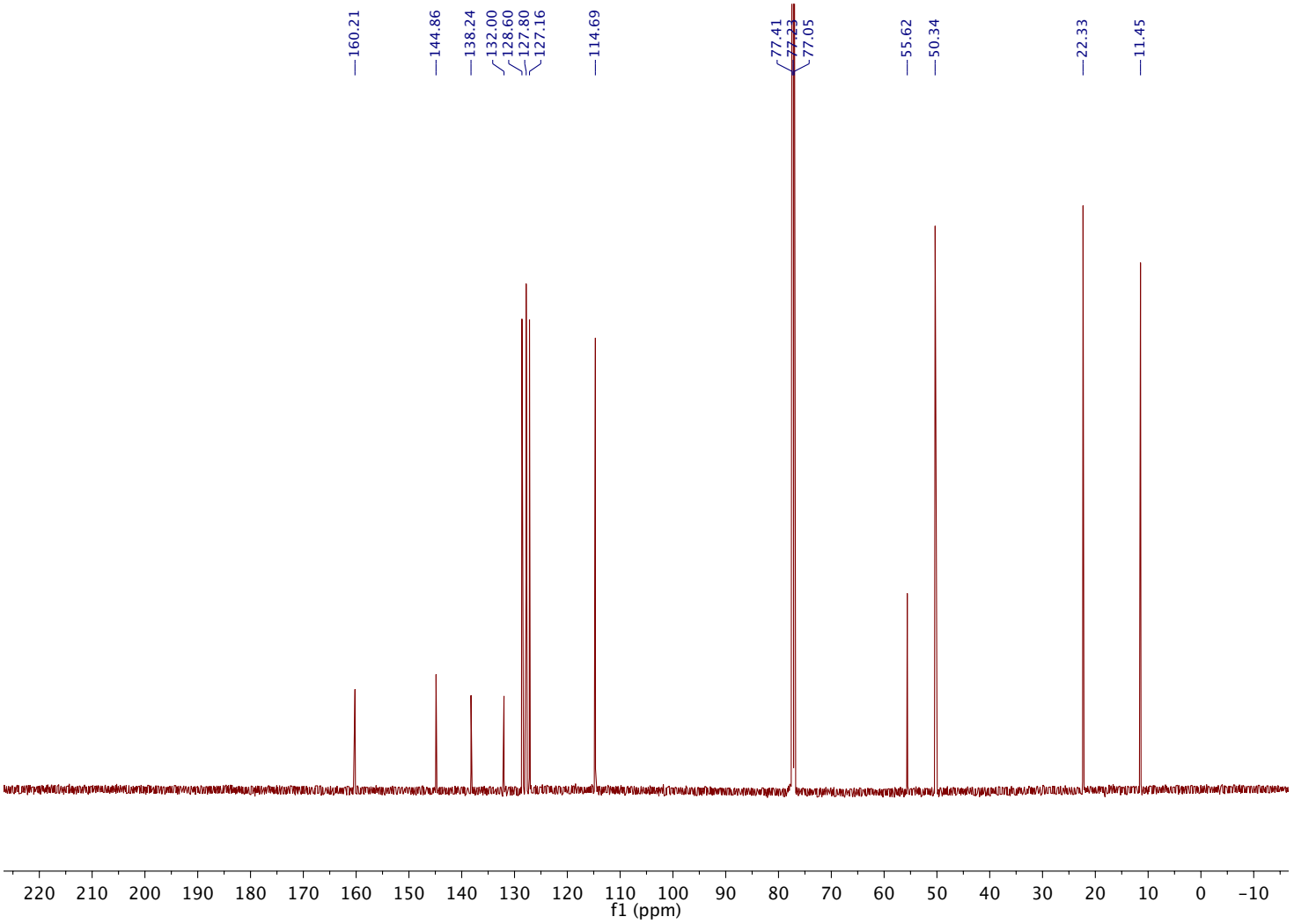
^{1}H NMR

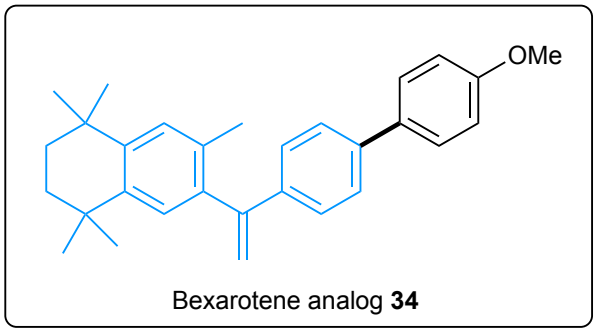

7.84
7.83
7.66
7.65
7.56
7.55
7.26
7.01
7.00
3.87
3.12
3.11
3.09
1.61
1.60
1.59
1.58
1.56
1.56
0.90
0.89
0.88
2.00
2.03
2.04
2.05
3.09
4.16
4.18
6.03
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0
f1 (ppm)


OMe
O
S
O
N

33

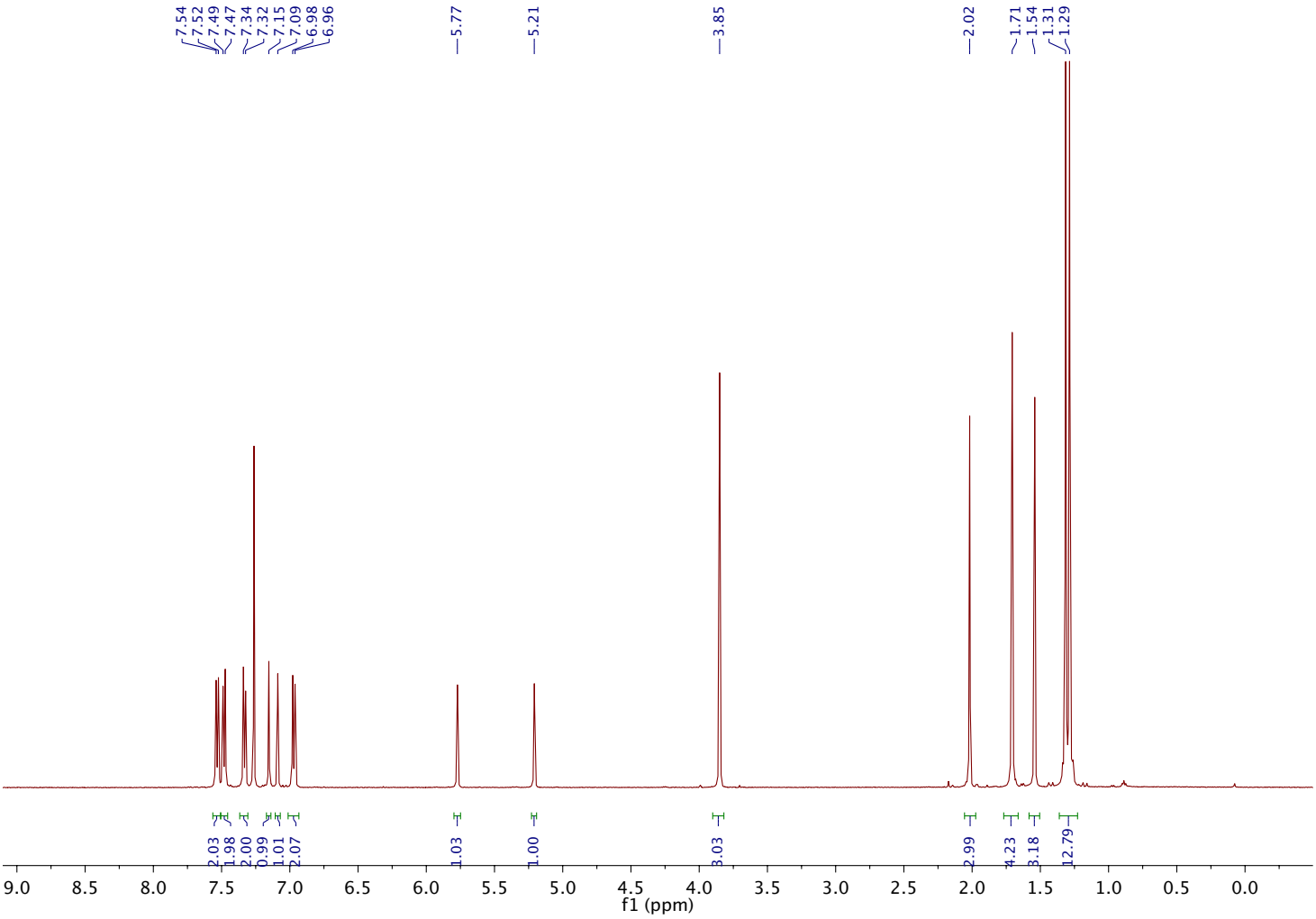
^{13}C NMR

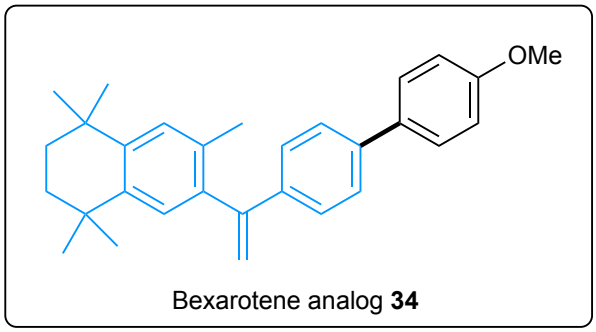

160.21
144.86
138.24
132.00
128.60
127.80
127.16
114.69
77.41
77.33
77.05
55.62
50.34
22.33
11.45
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



Bexarotene analog **34**

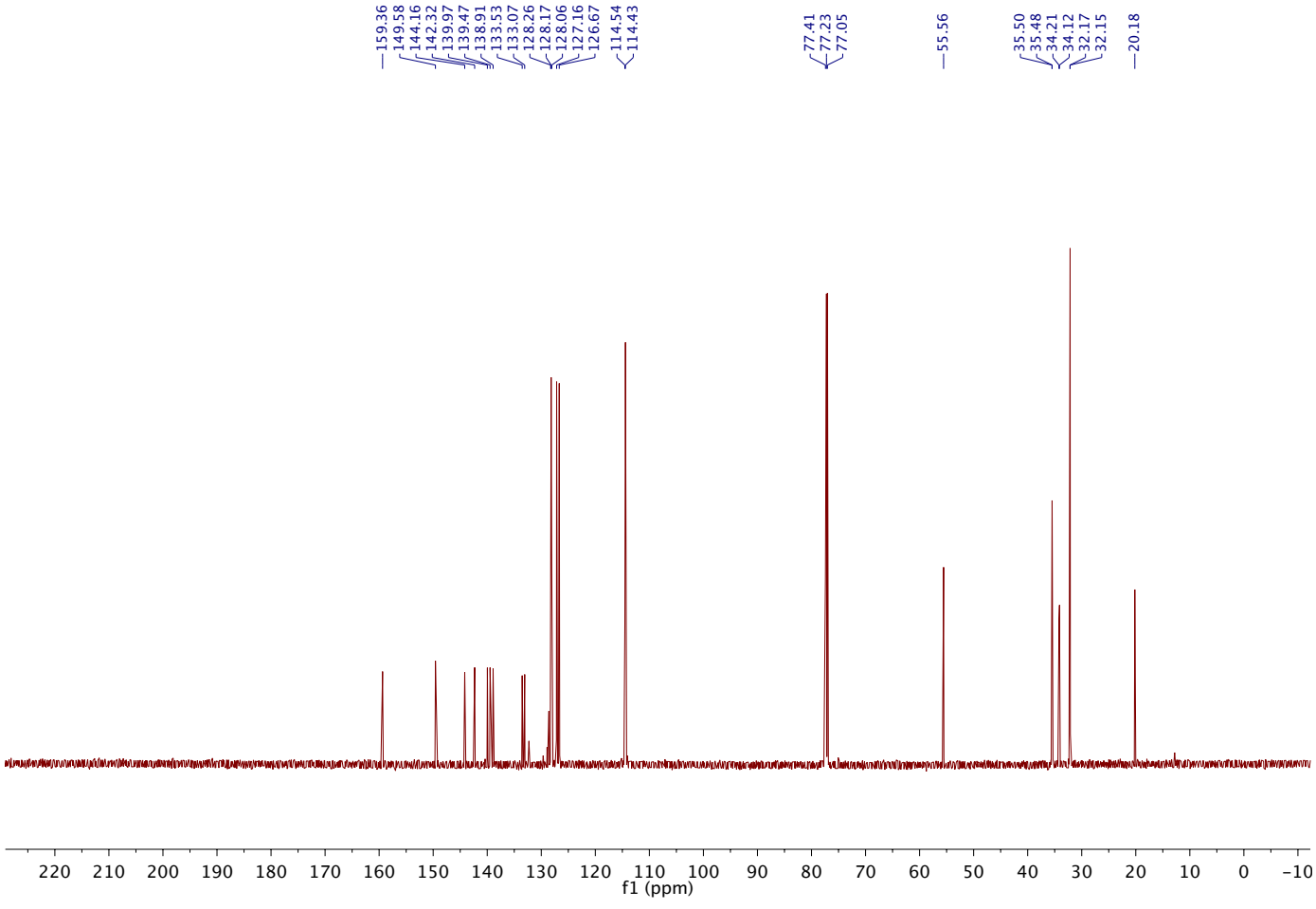
^{1}H NMR

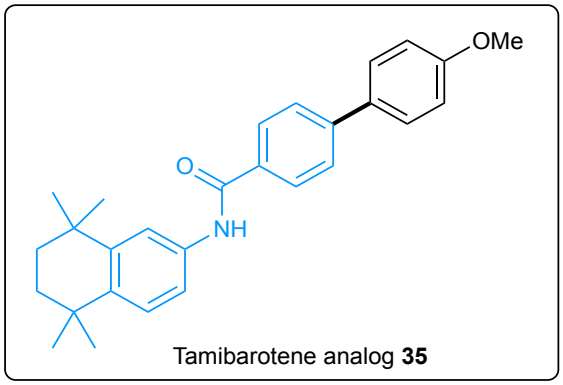




Bexarotene analog **34**

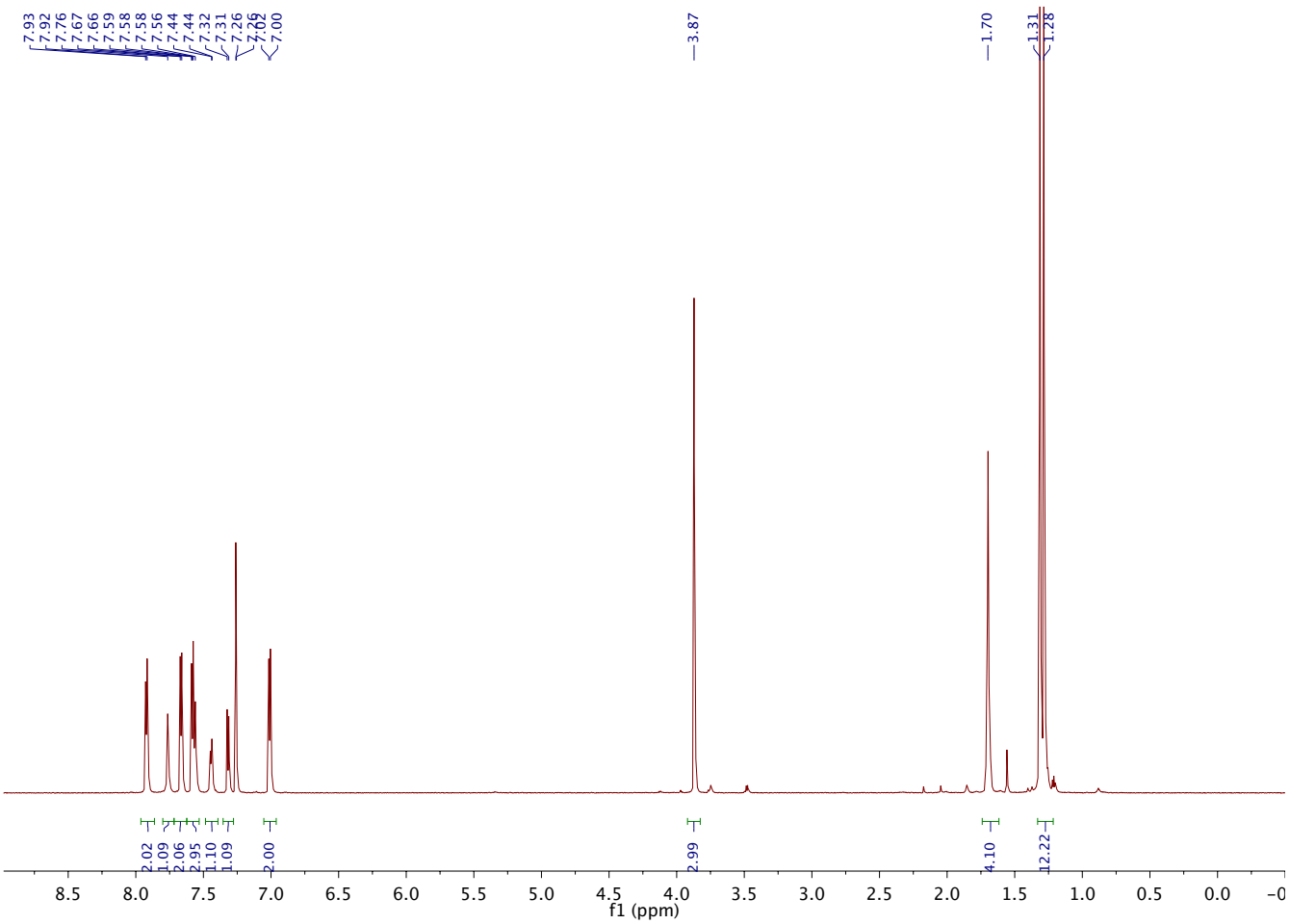
^{13}C NMR

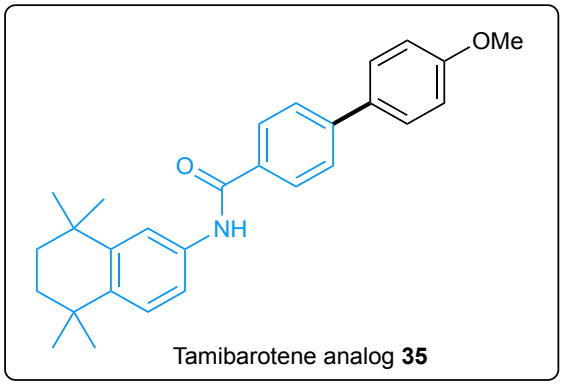




Tamibarotene analog **35**

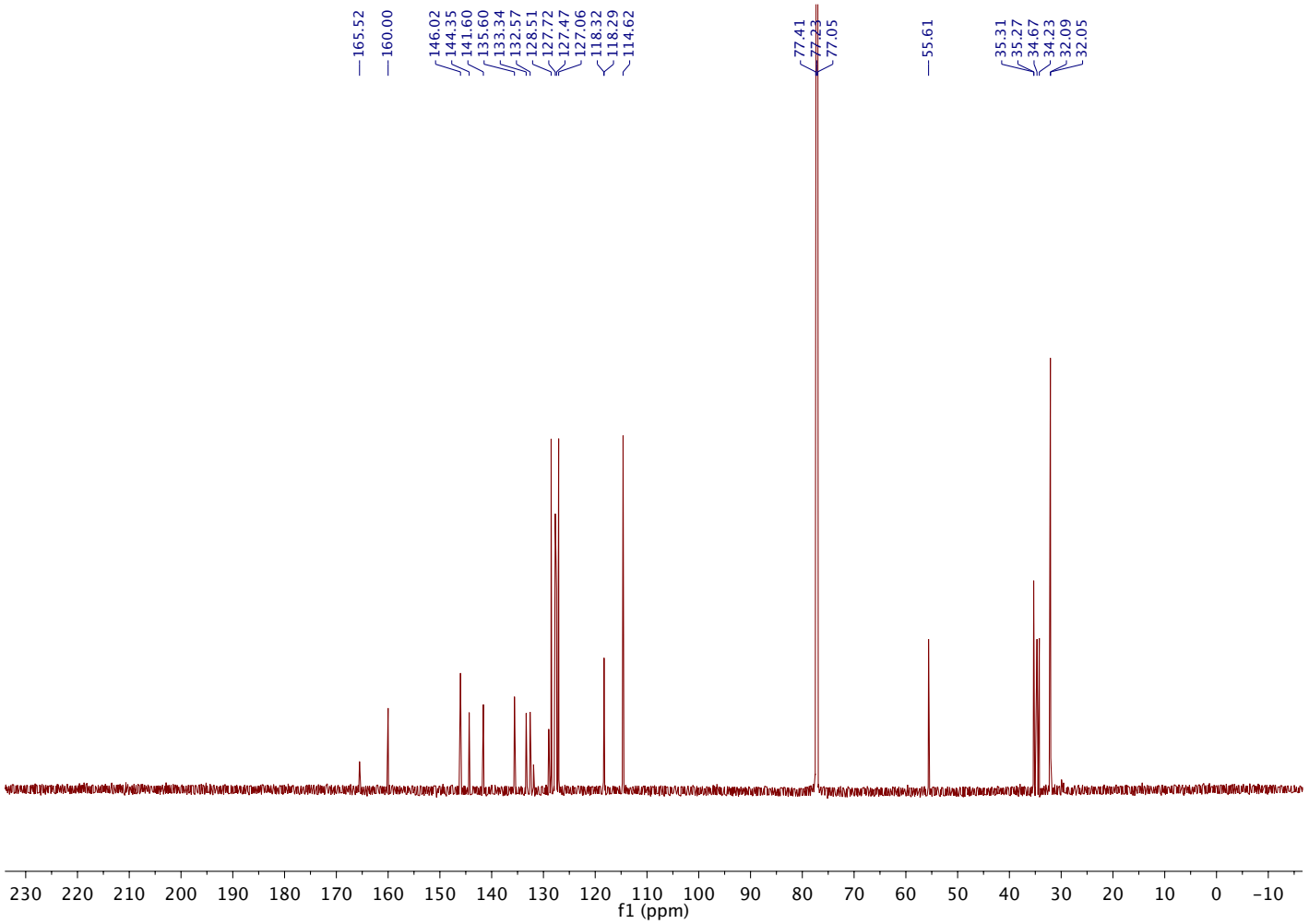
^{1}H NMR

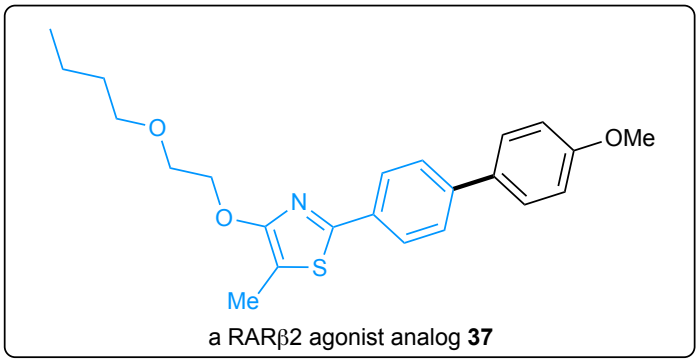




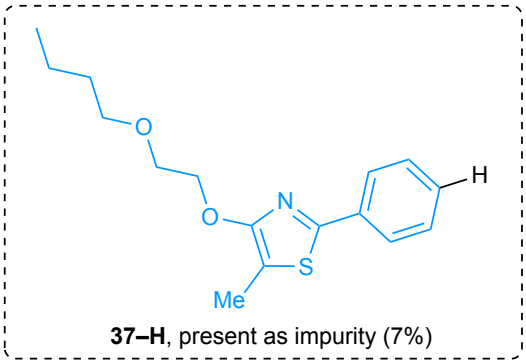
Tamibarotene analog **35**

^{13}C NMR



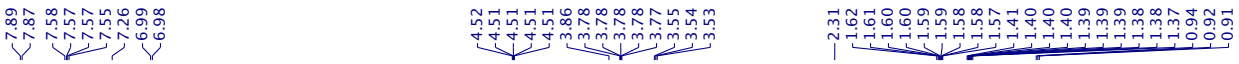


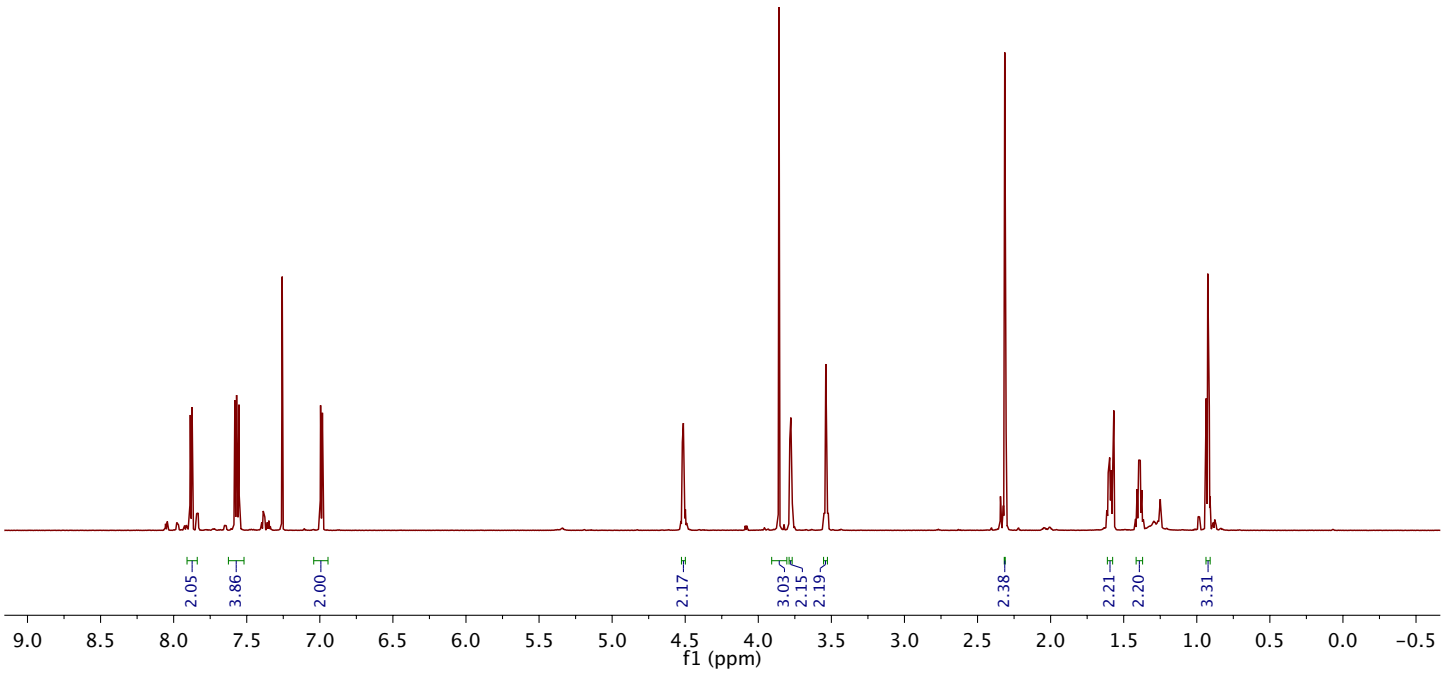
a RARβ2 agonist analog **37**

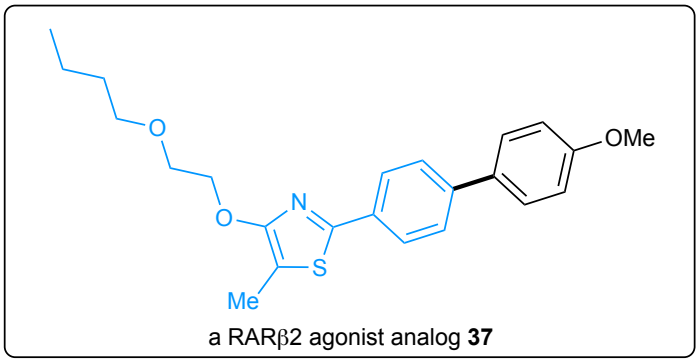


37–H, present as impurity (7%)

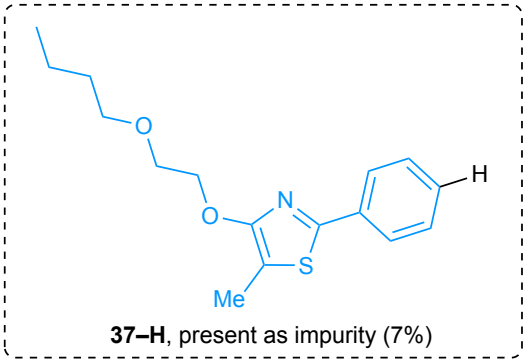
^{1}H NMR





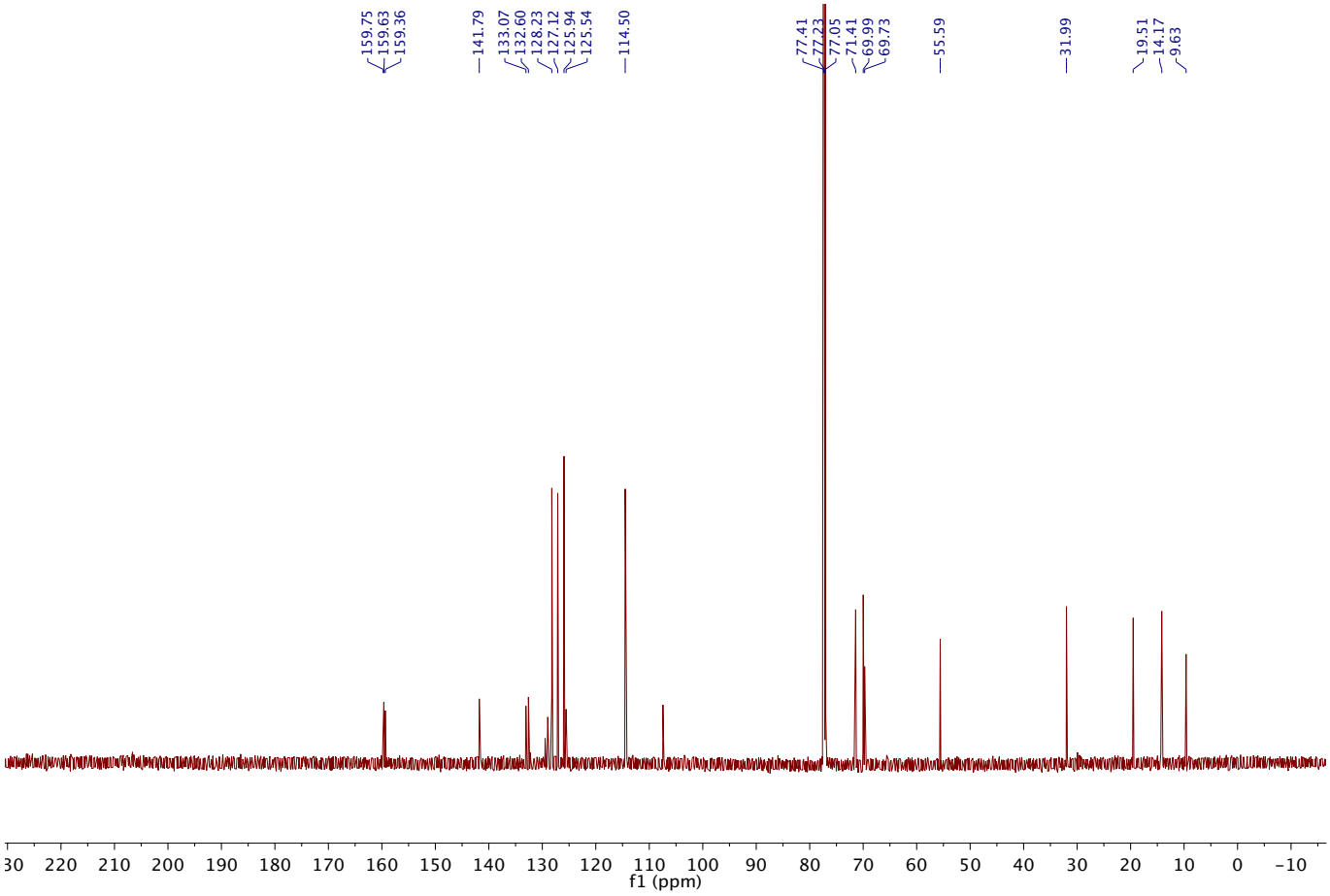


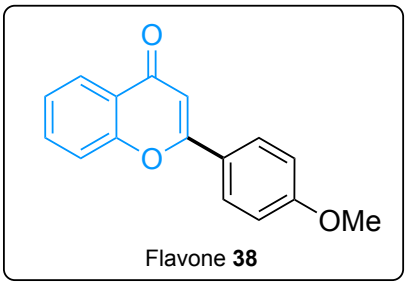
a RARβ2 agonist analog **37**



37–H, present as impurity (7%)

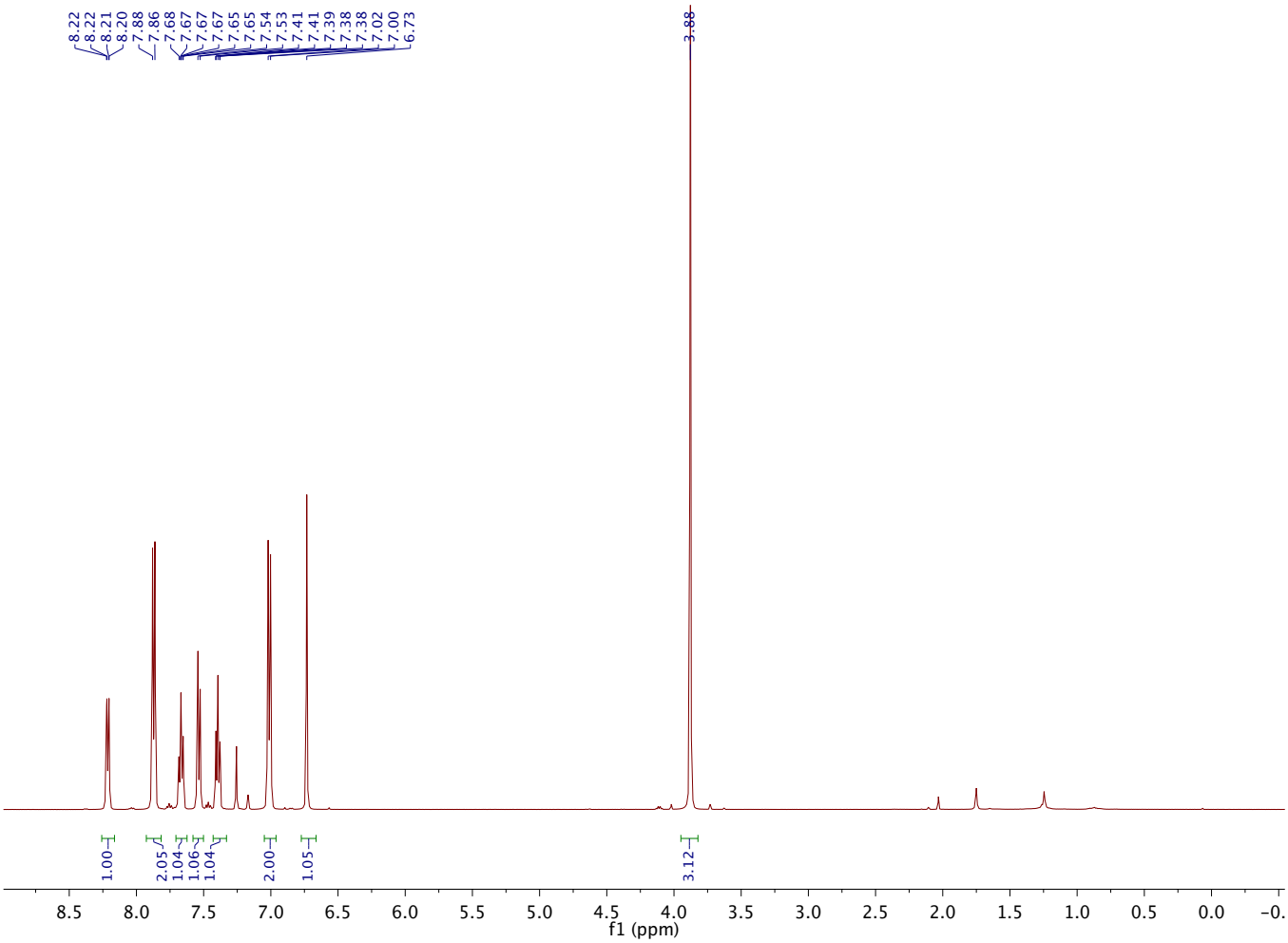
^{13}C NMR

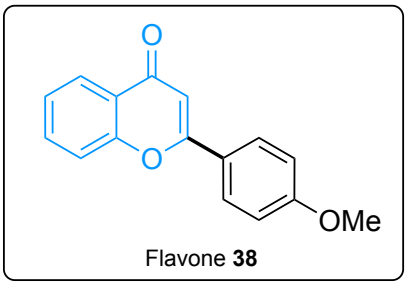




Flavone **38**

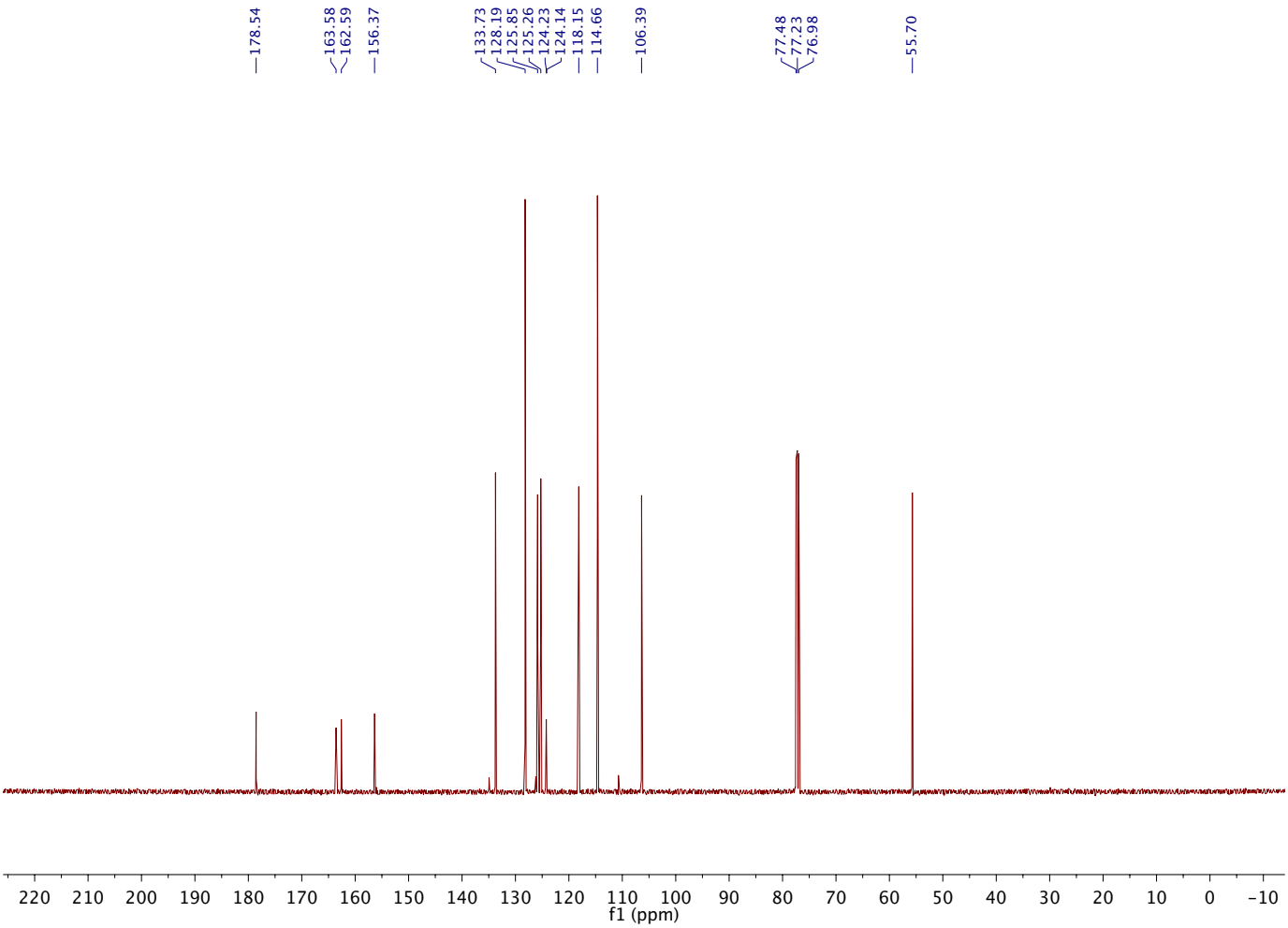
^{1}H NMR

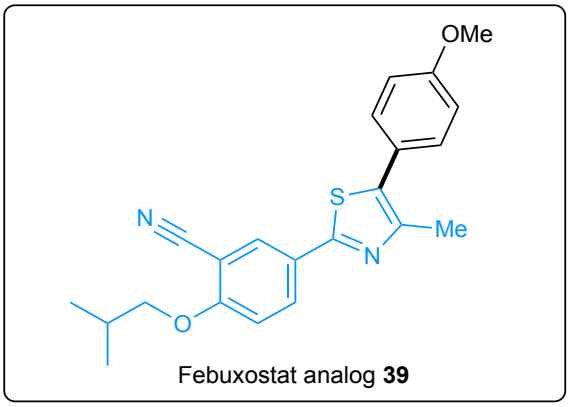




Flavone **38**

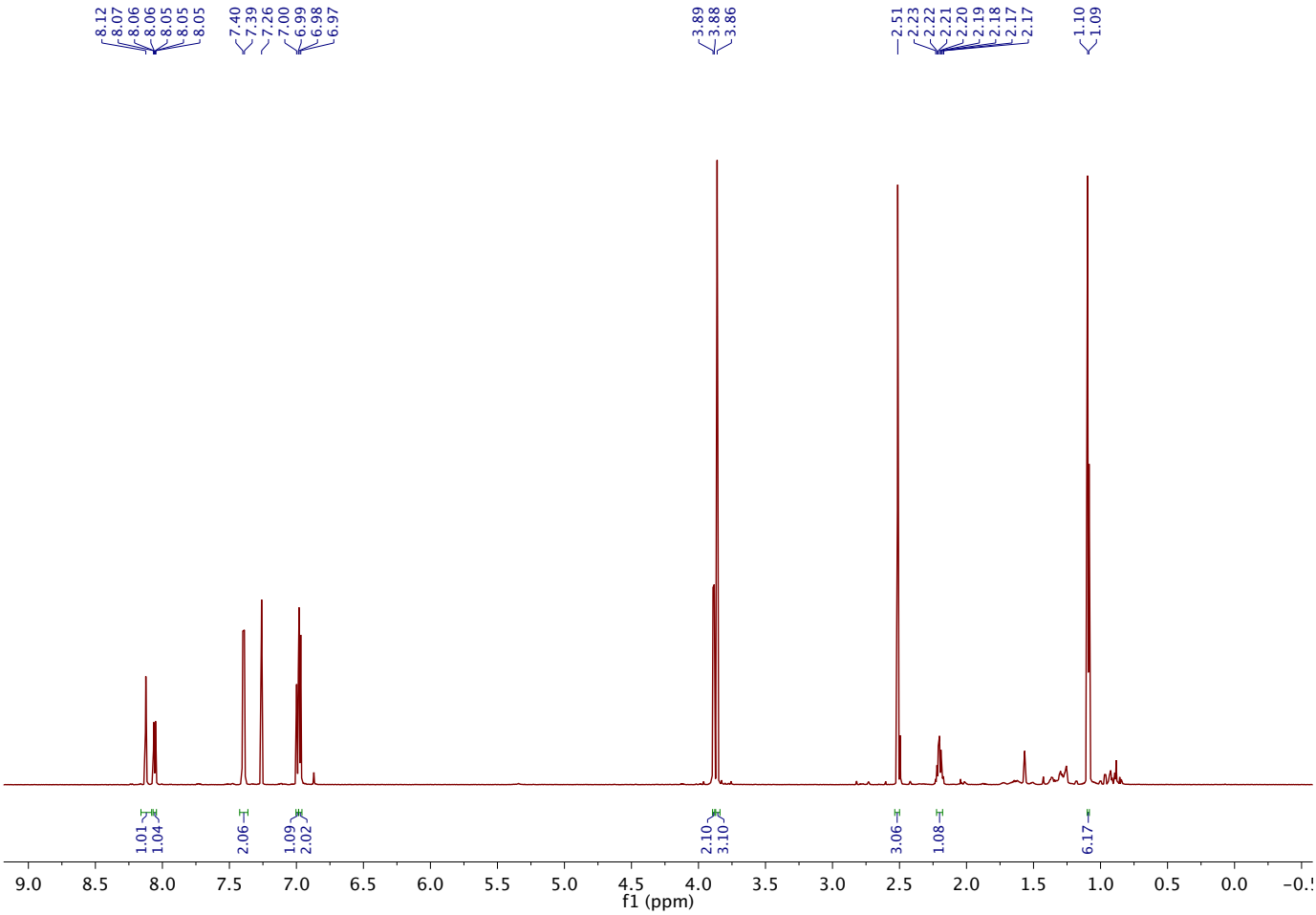
^{13}C NMR

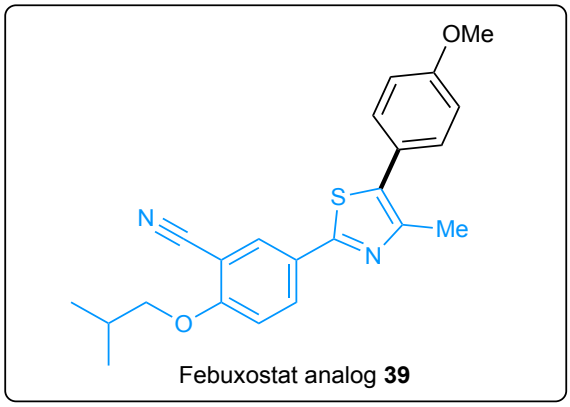




Febuxostat analog **39**

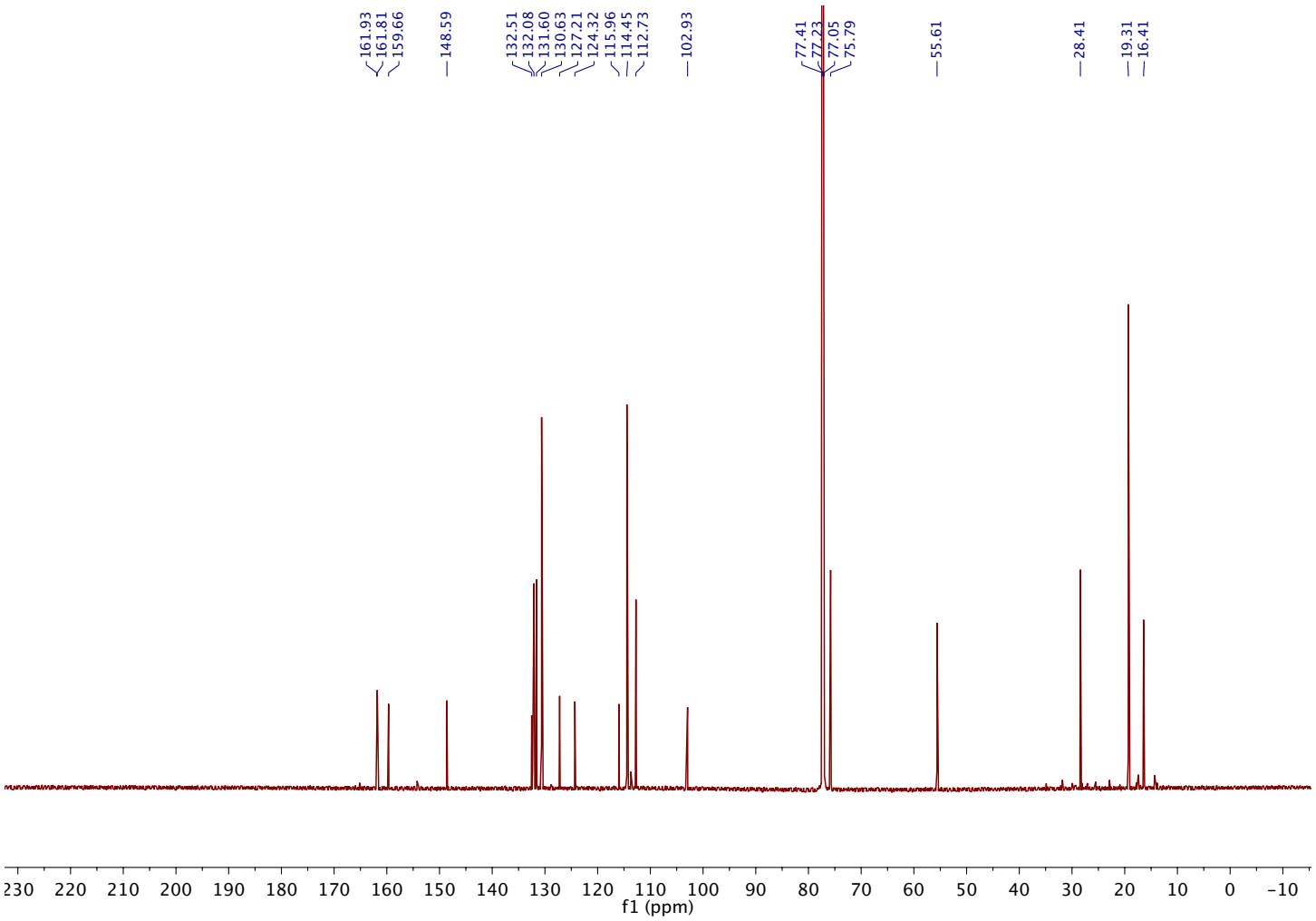
^{1}H NMR

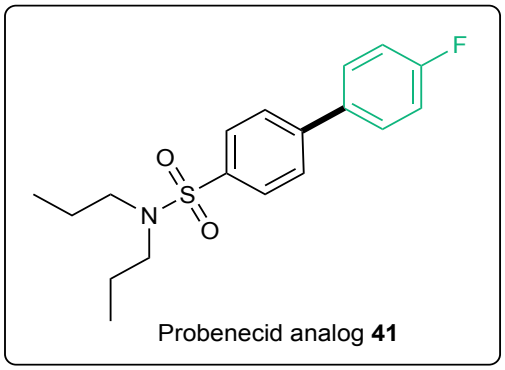




Febuxostat analog **39**

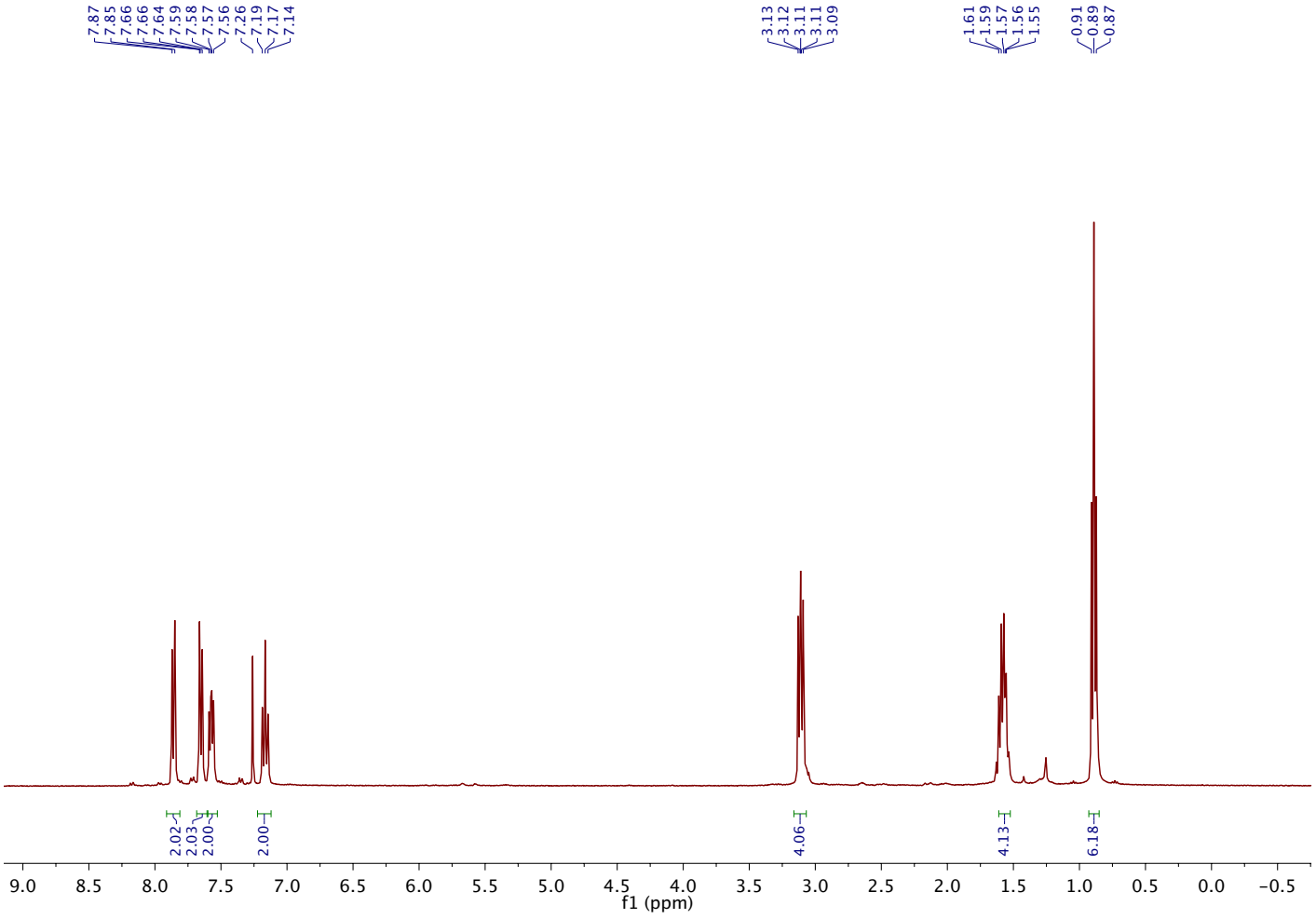
^{13}C NMR

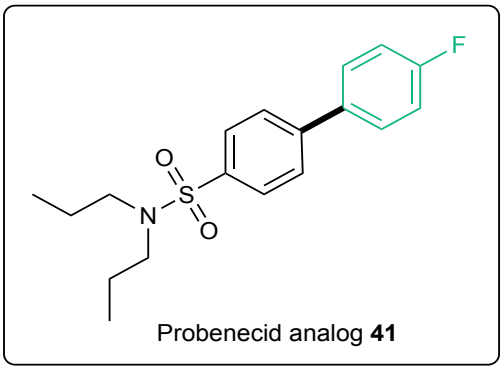




Probenecid analog **41**

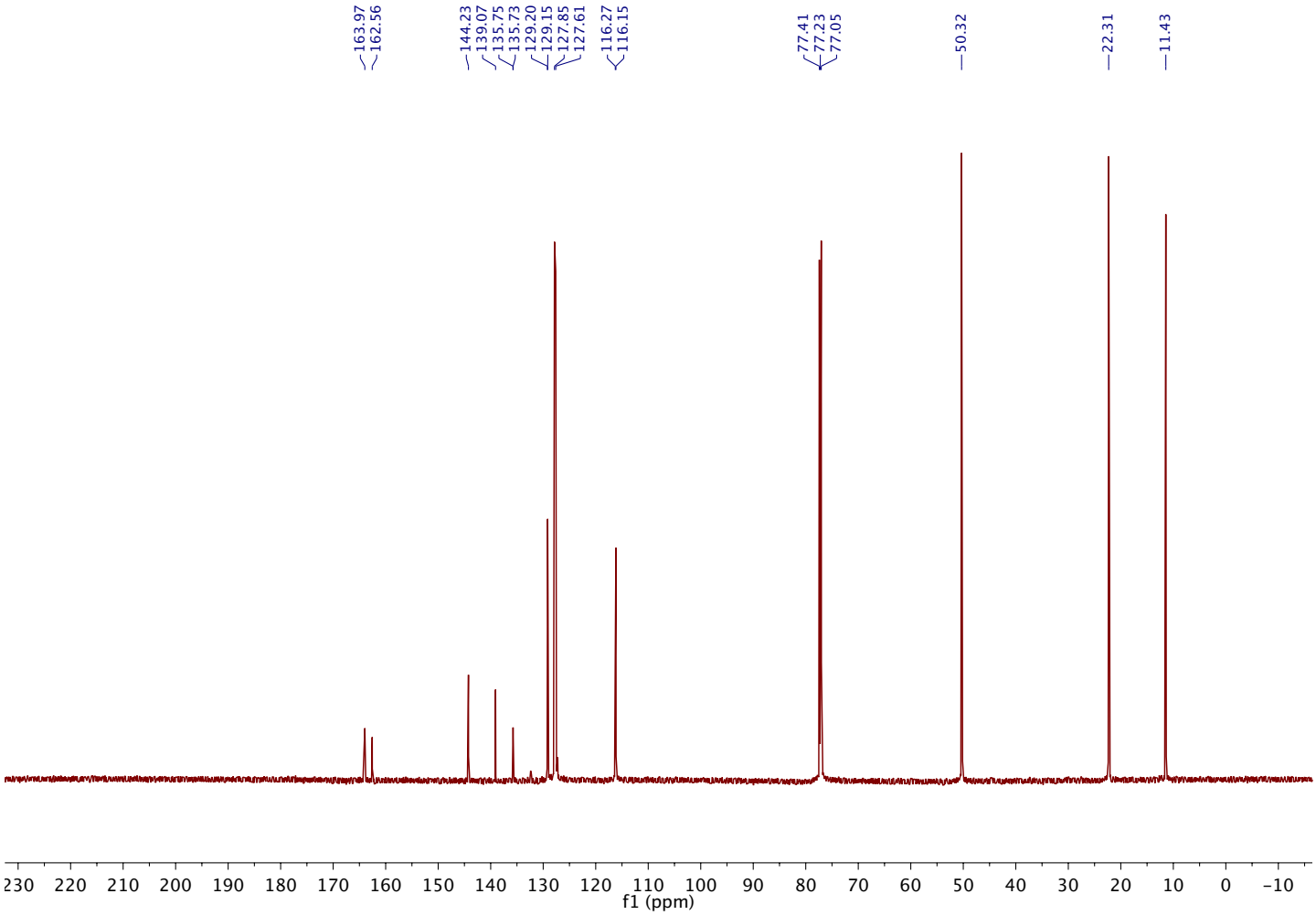
^{1}H NMR

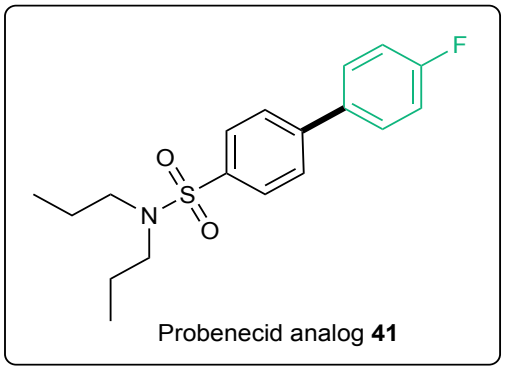




Probenecid analog **41**

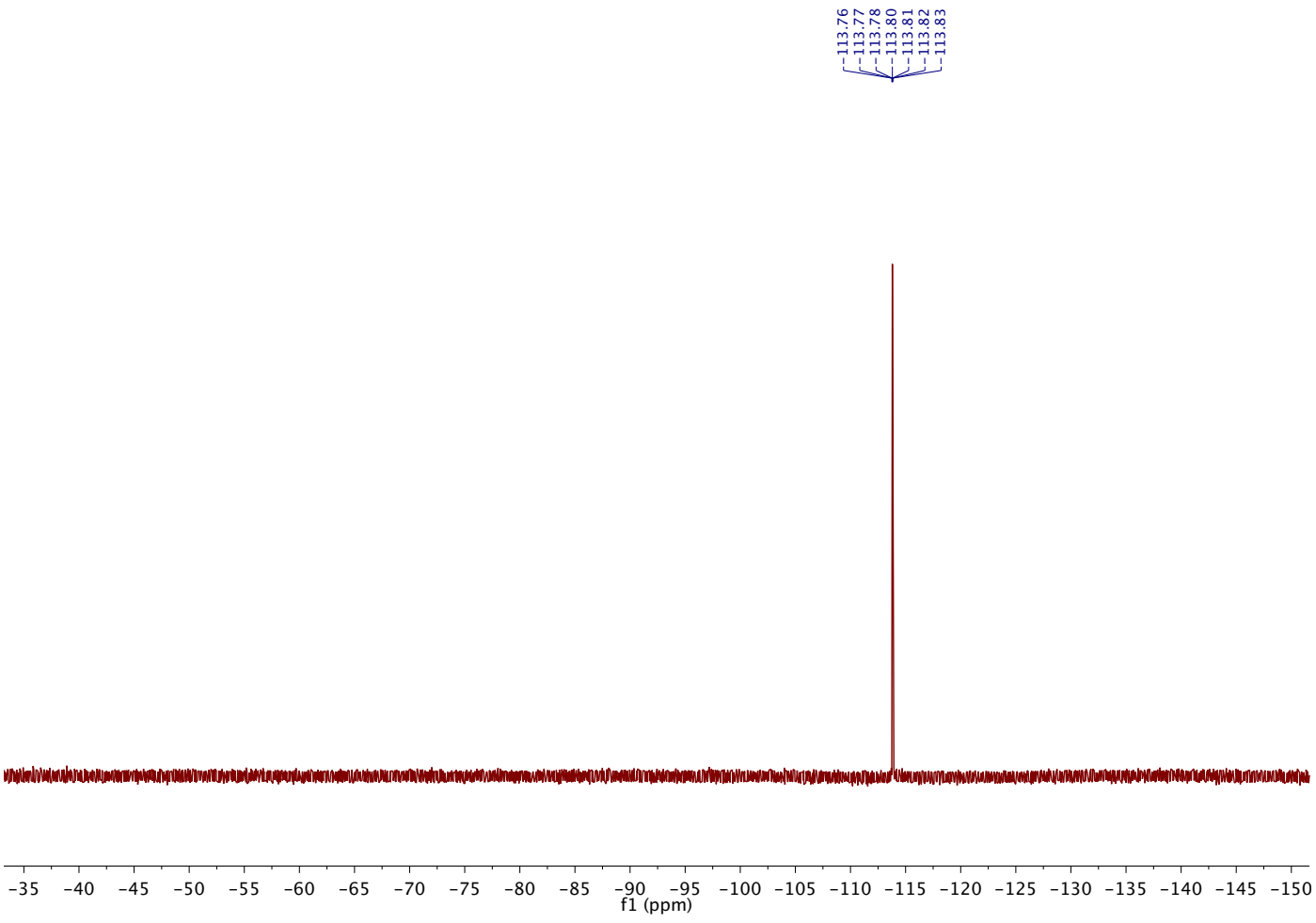
^{13}C NMR

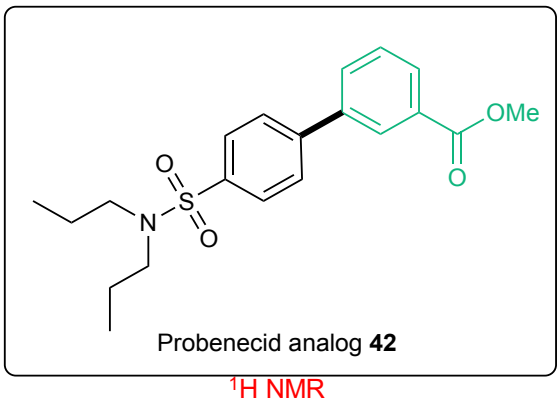




Probenecid analog **41**

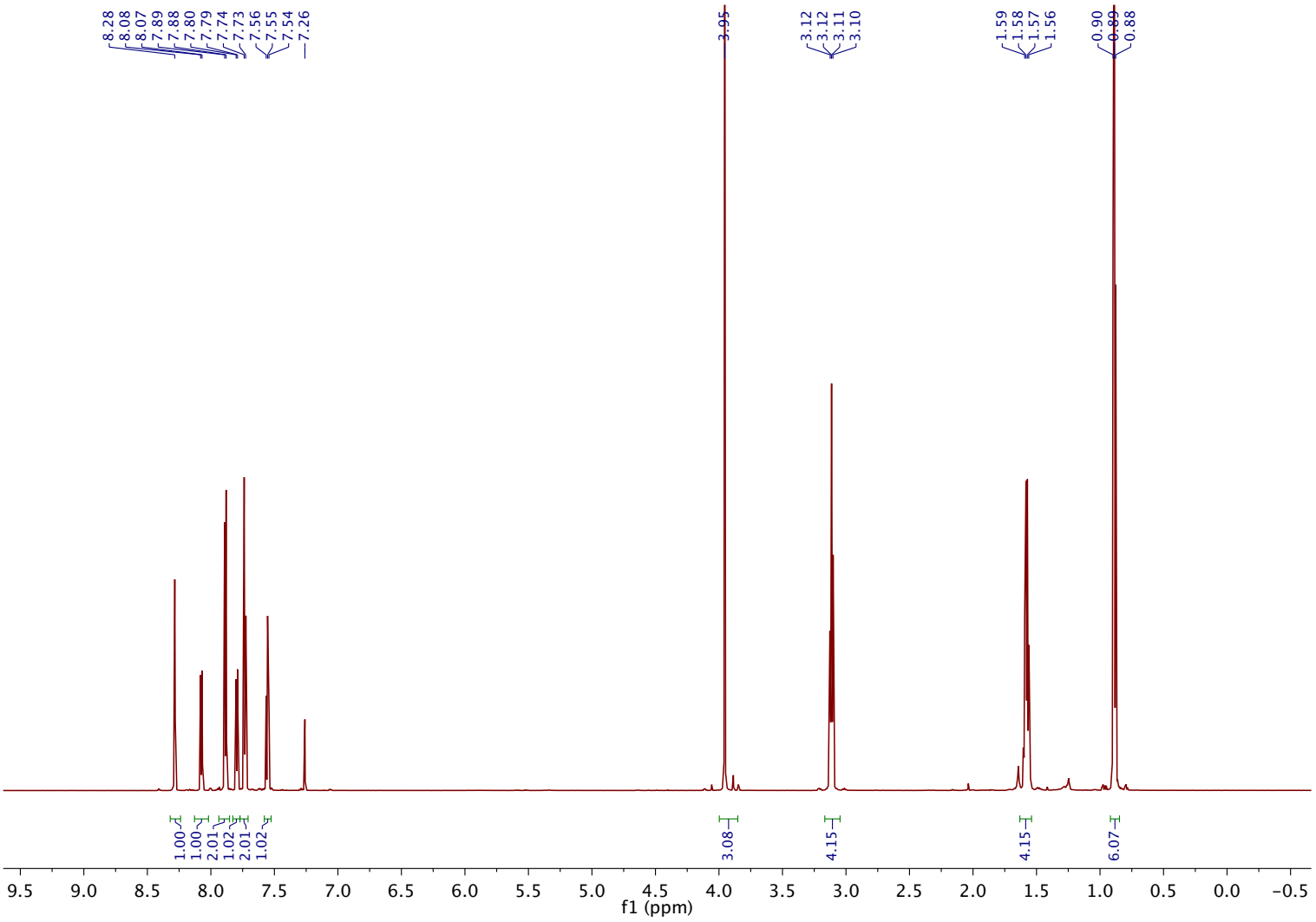
^{19}F NMR

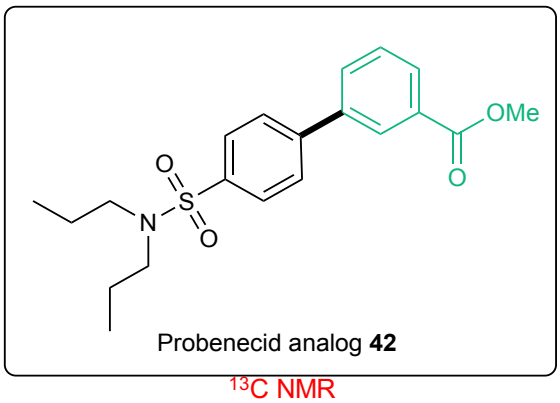




Probenecid analog **42**

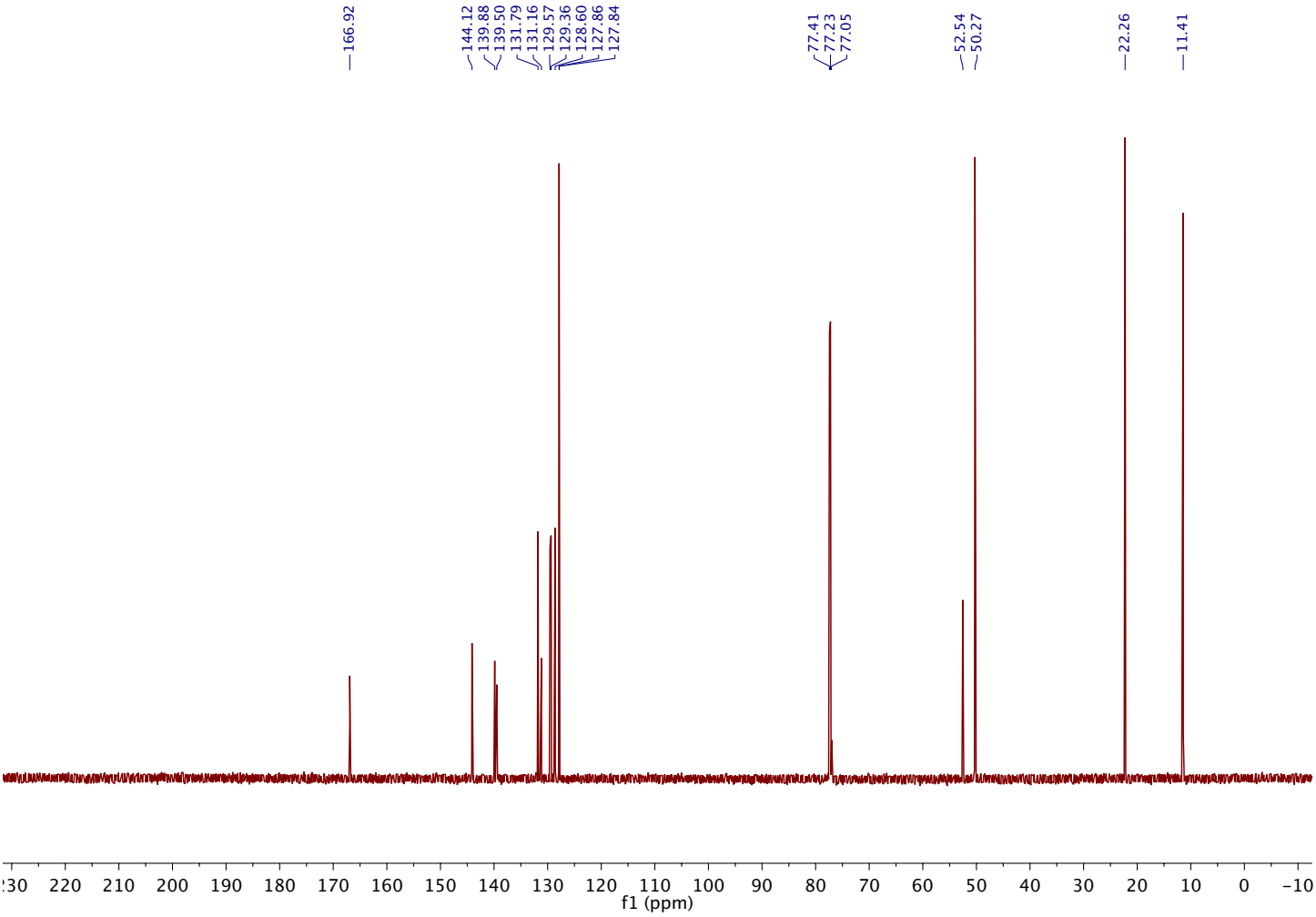
^{1}H NMR

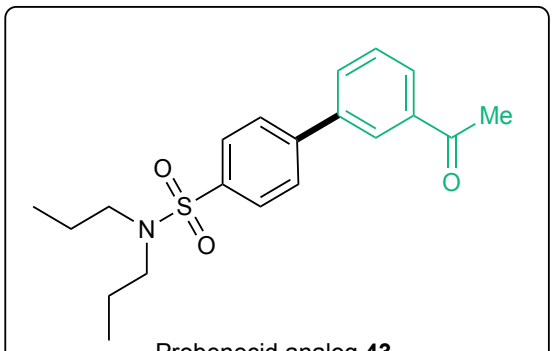




Probenecid analog **42**

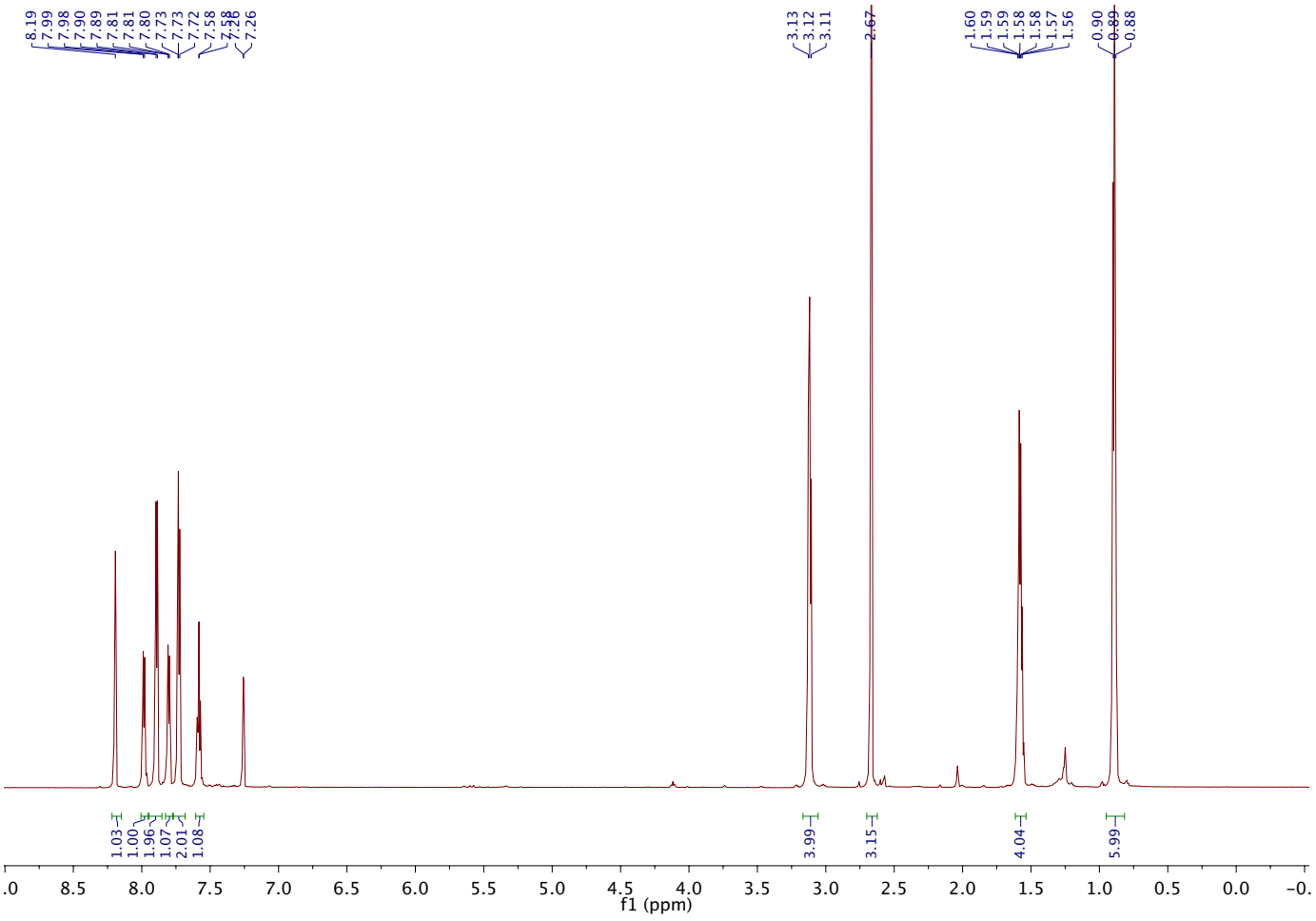
^{13}C NMR

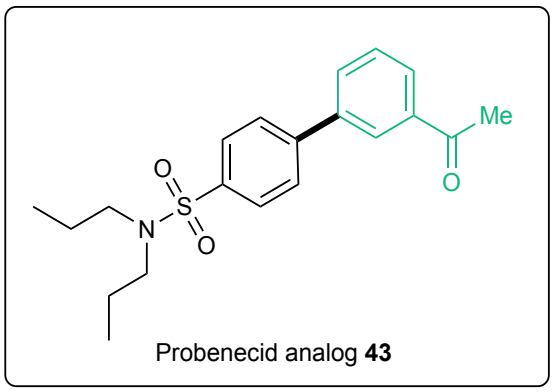




Probenecid analog **43**

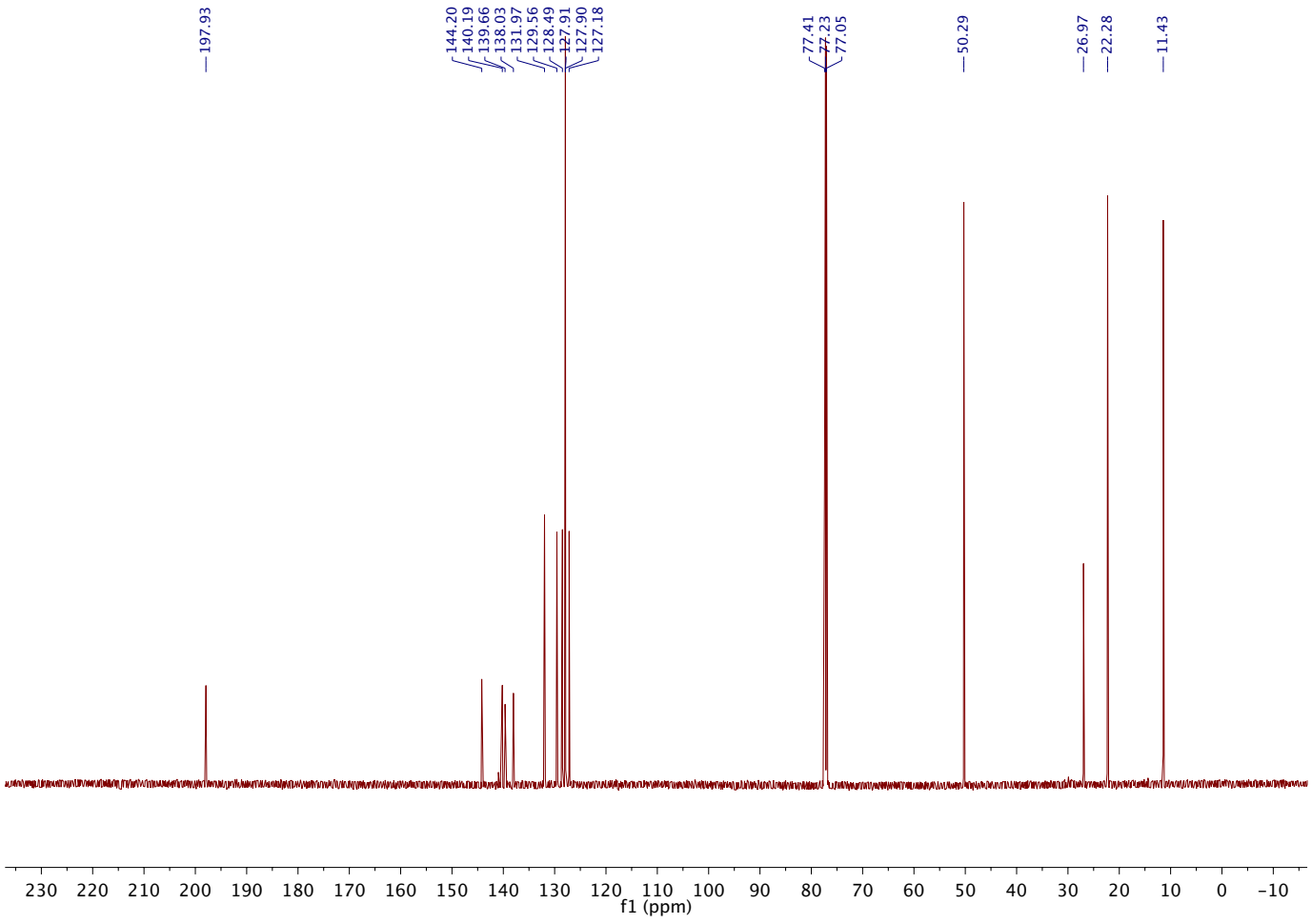
^{1}H NMR

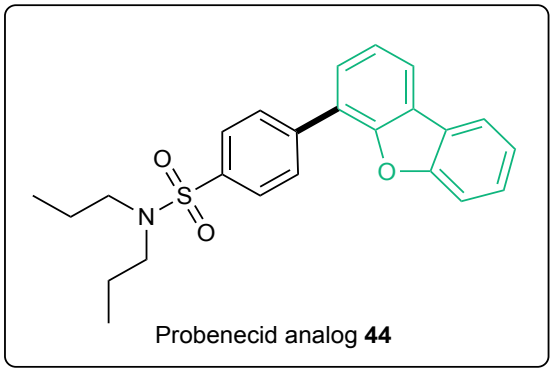




Probenecid analog **43**

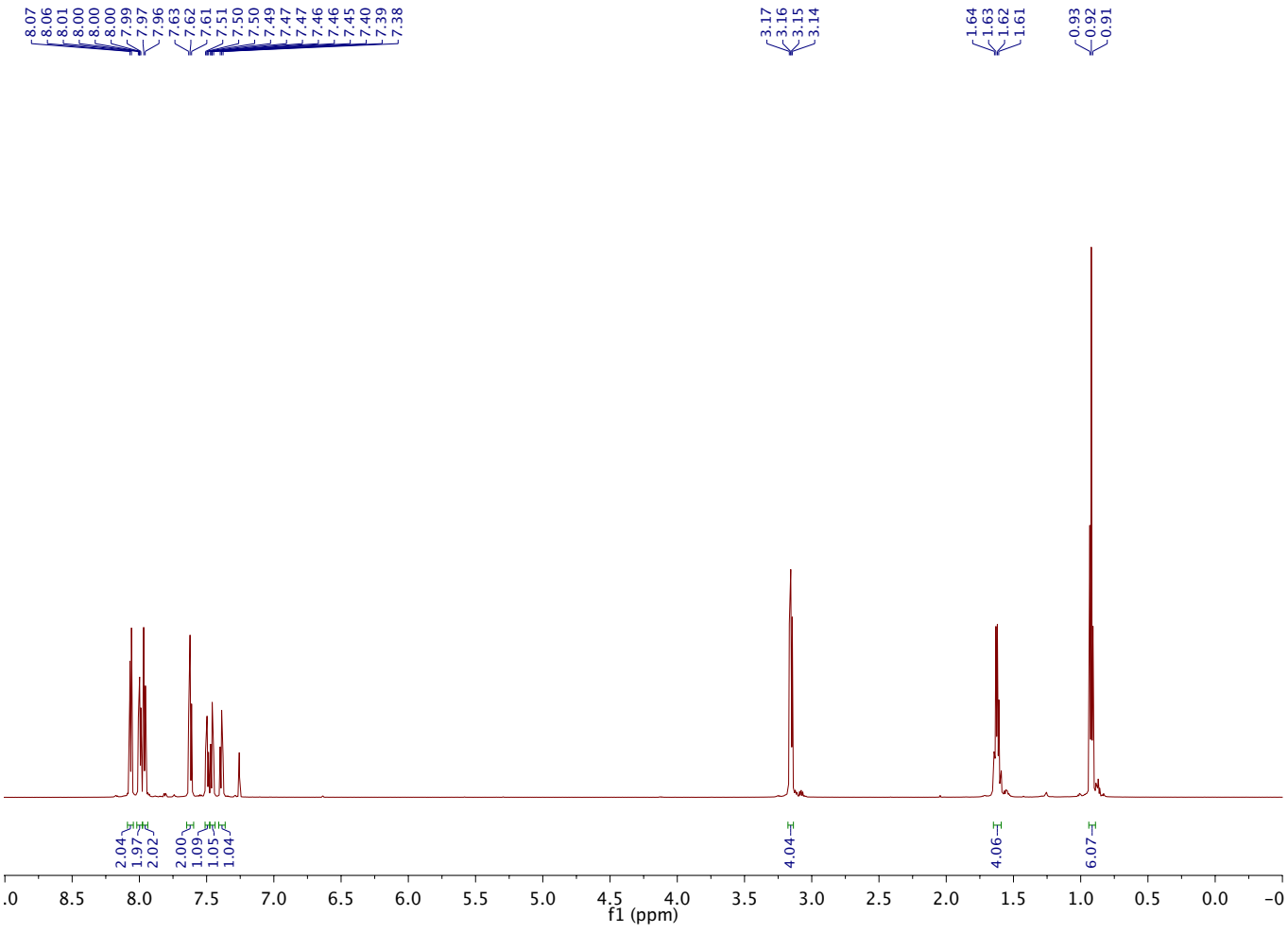
^{13}C NMR

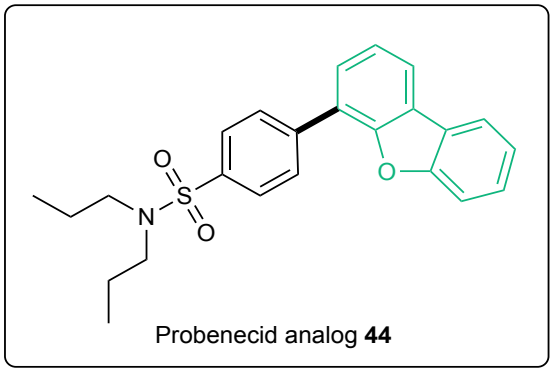




Probenecid analog **44**

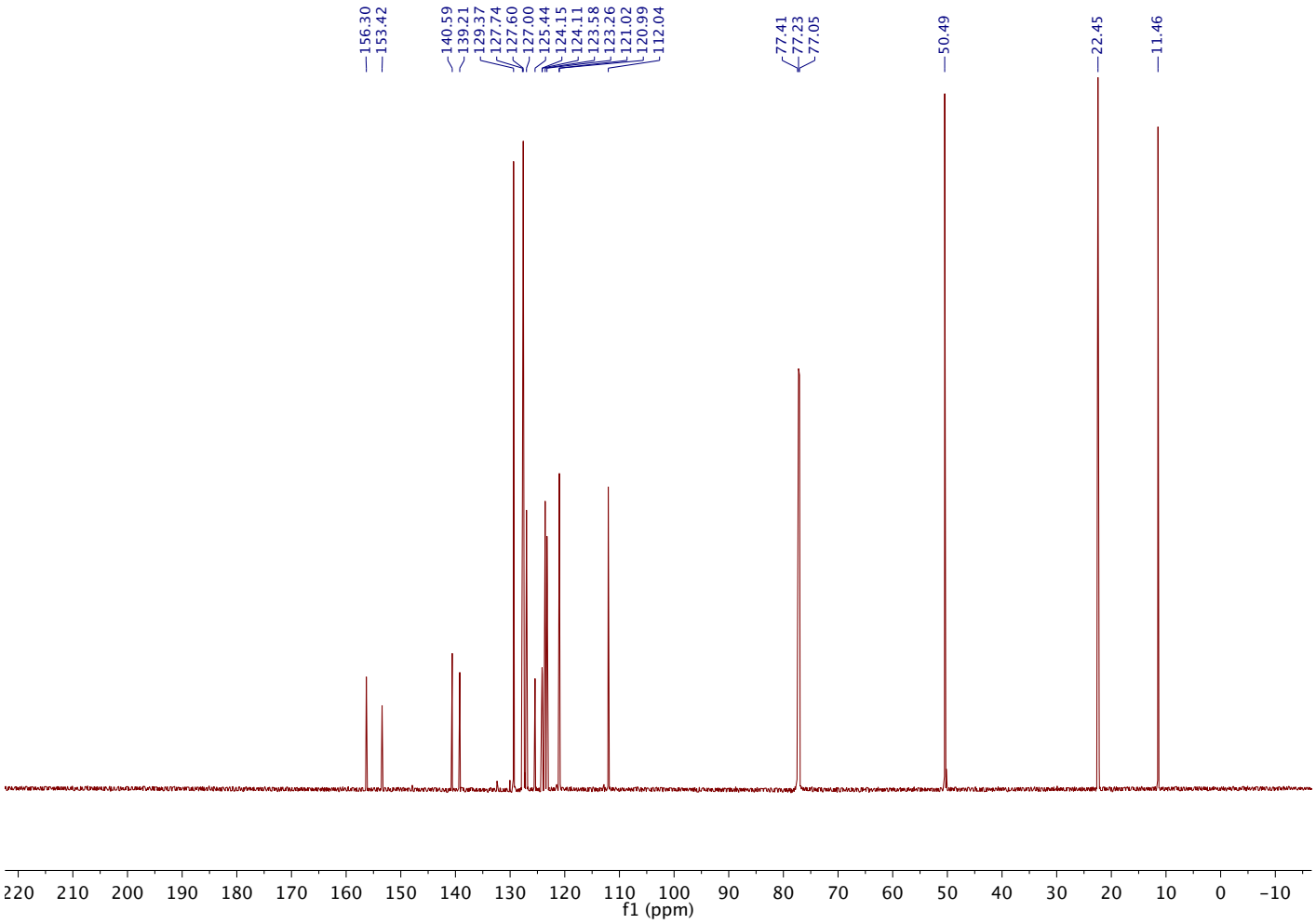
^{1}H NMR

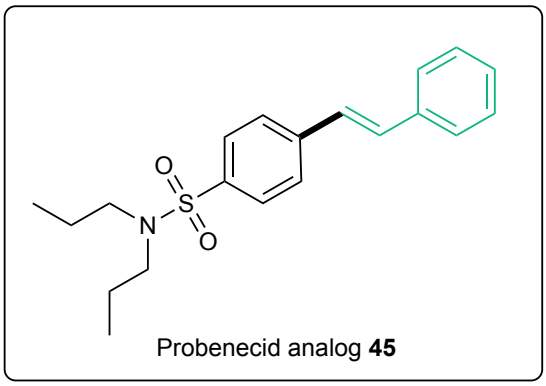




Probenecid analog **44**

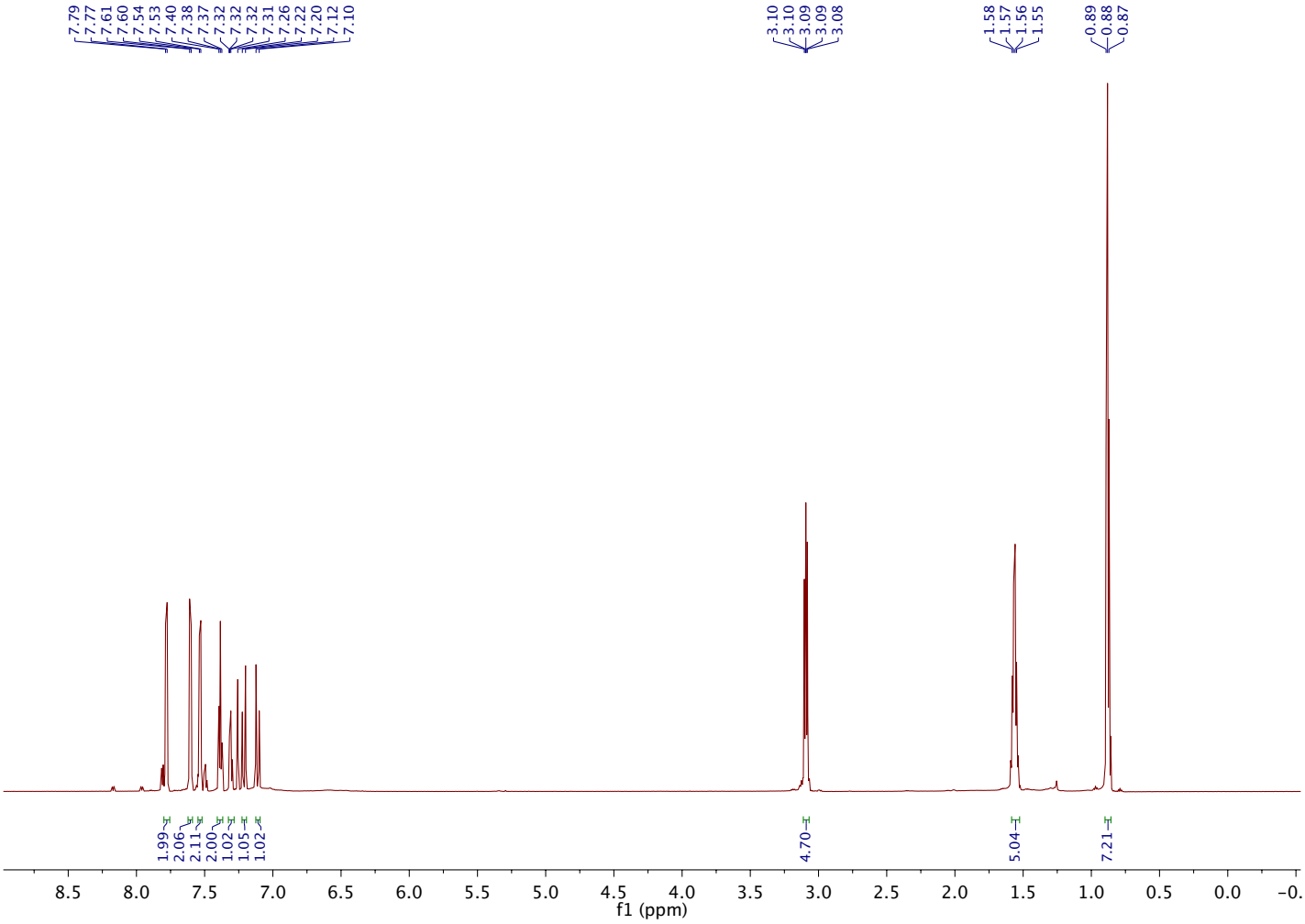
^{13}C NMR

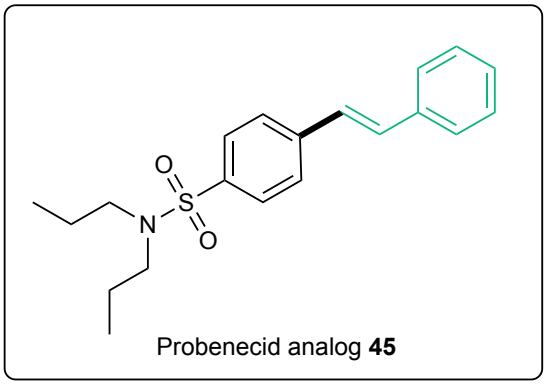




Probenecid analog **45**

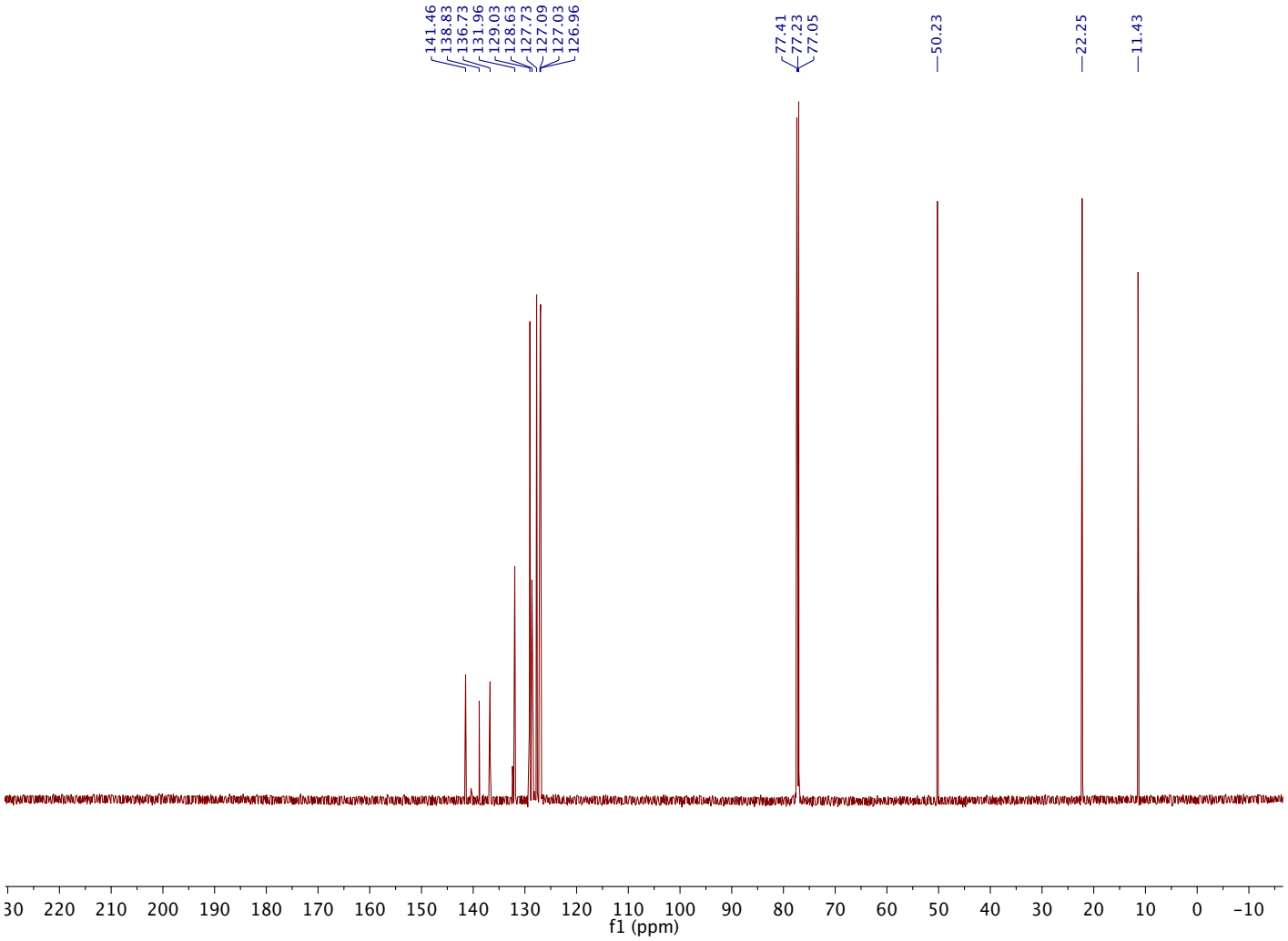
^{1}H NMR

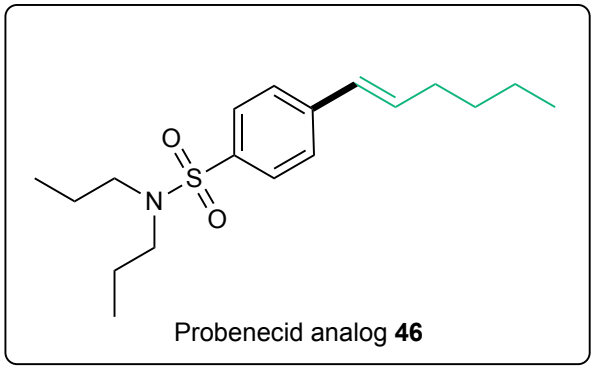




Probenecid analog **45**

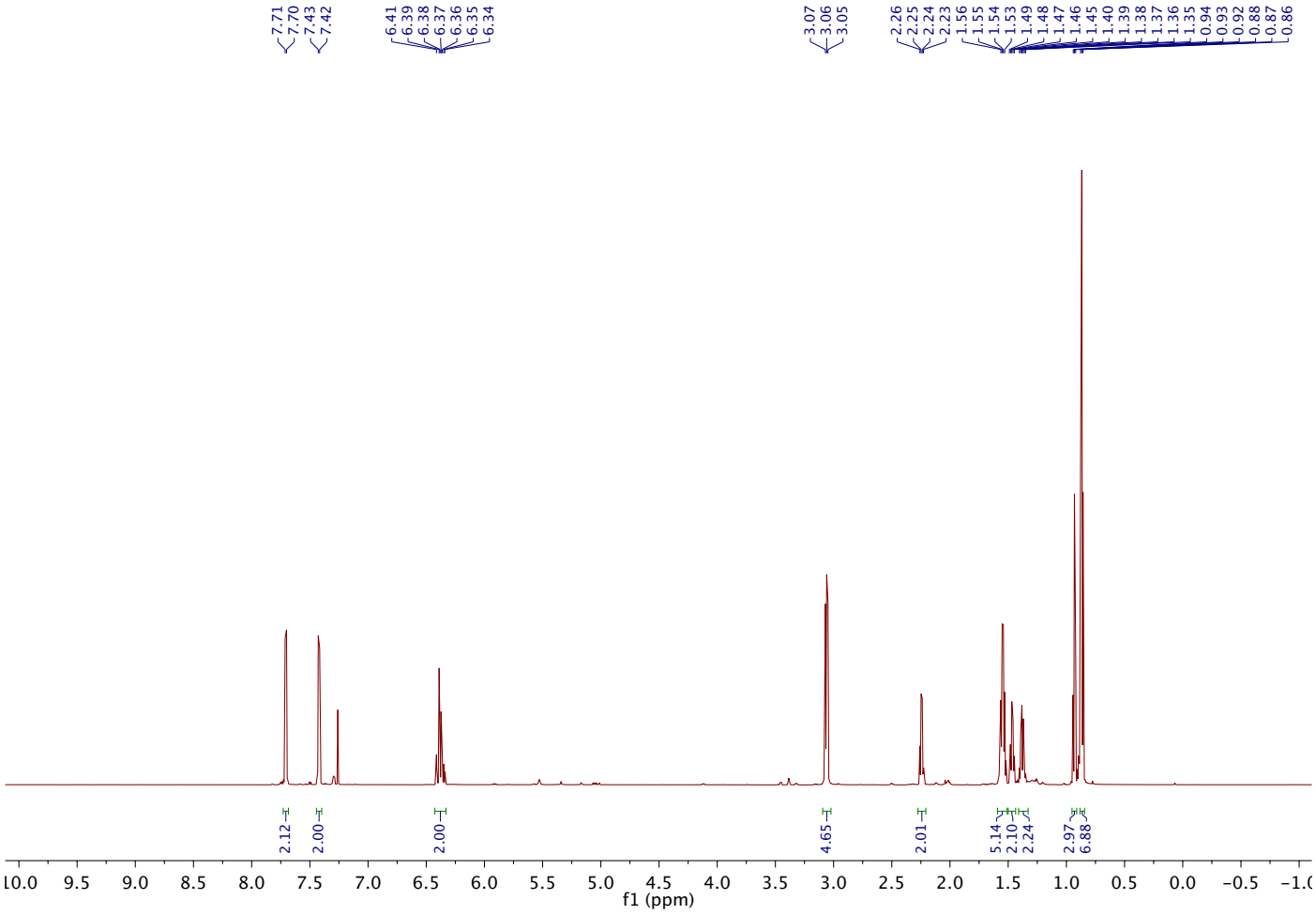
^{13}C NMR

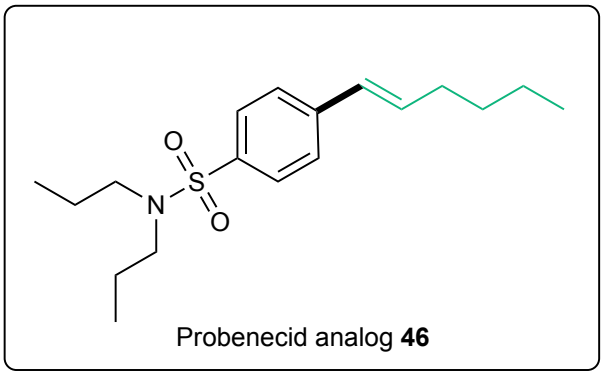




Probenecid analog **46**

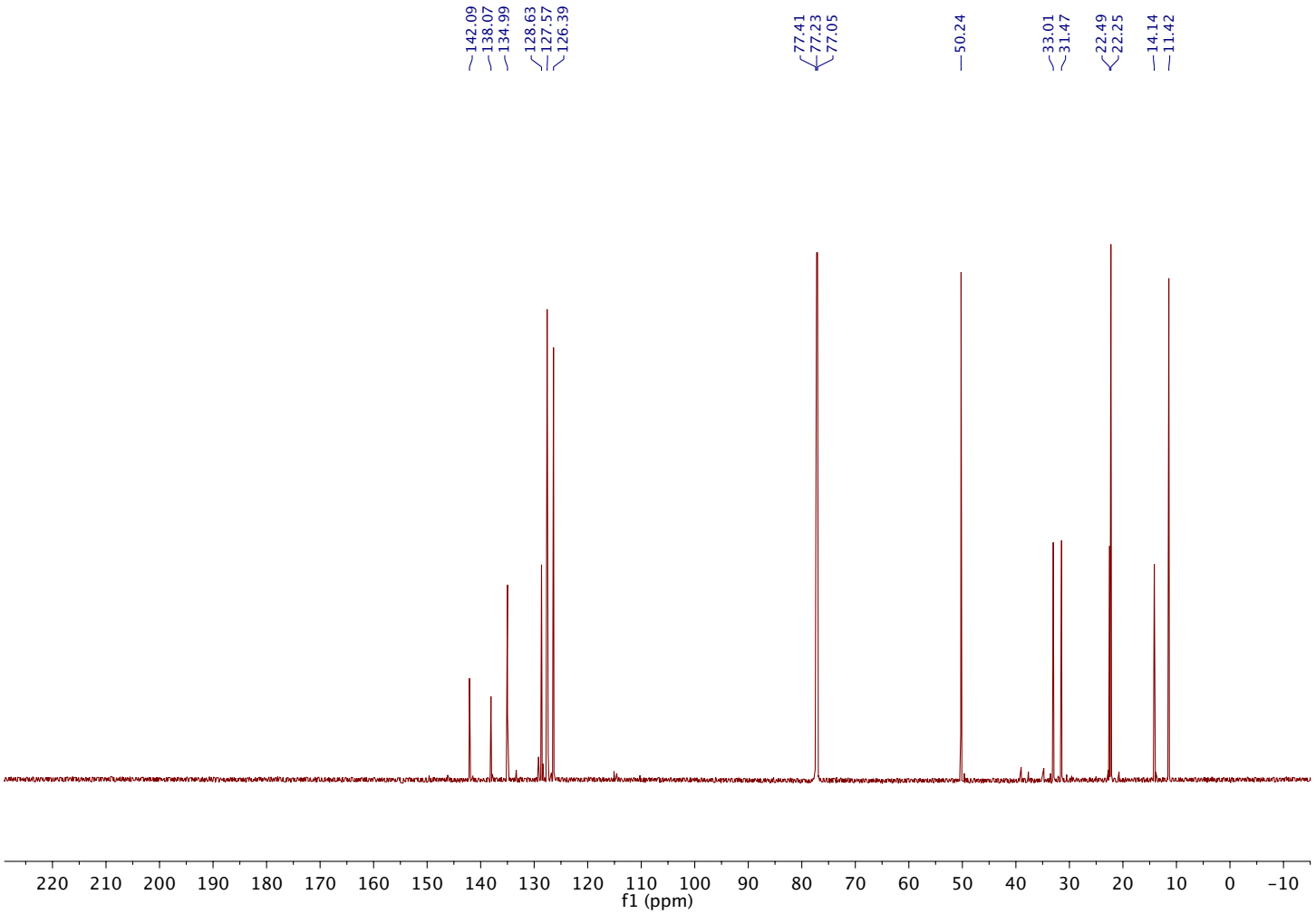
^{1}H NMR

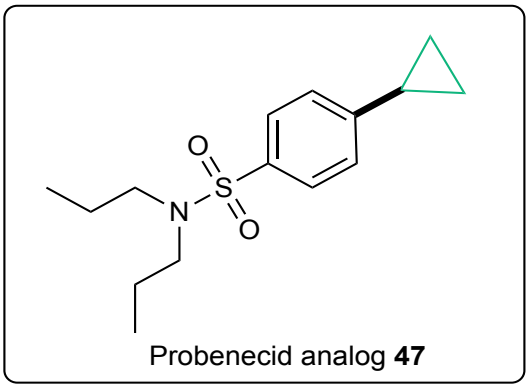




Probenecid analog **46**

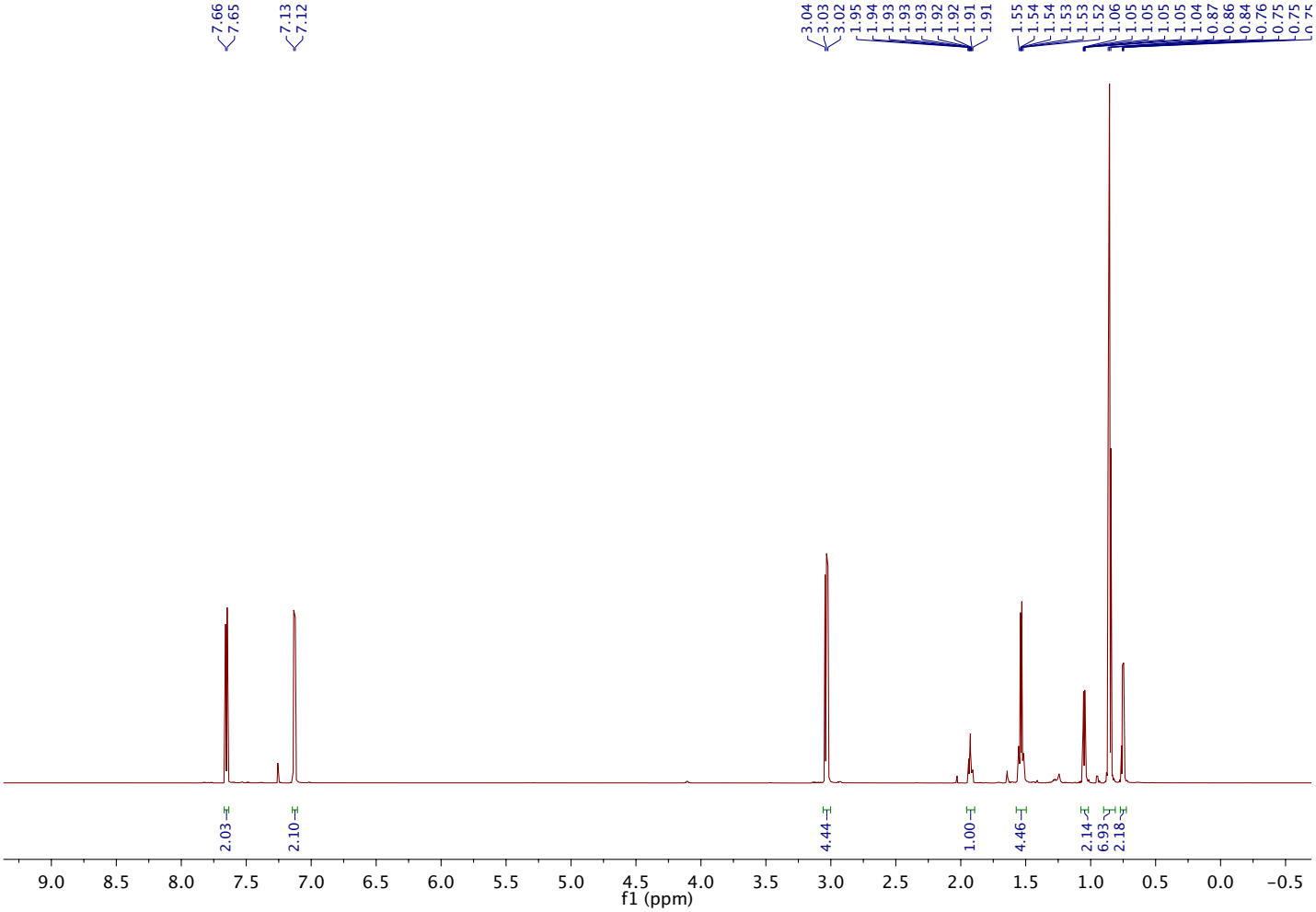
^{13}C NMR

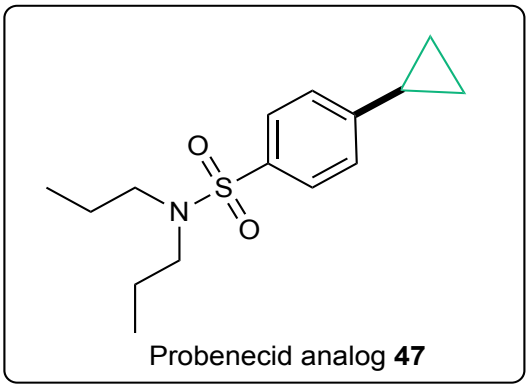




Probenecid analog **47**

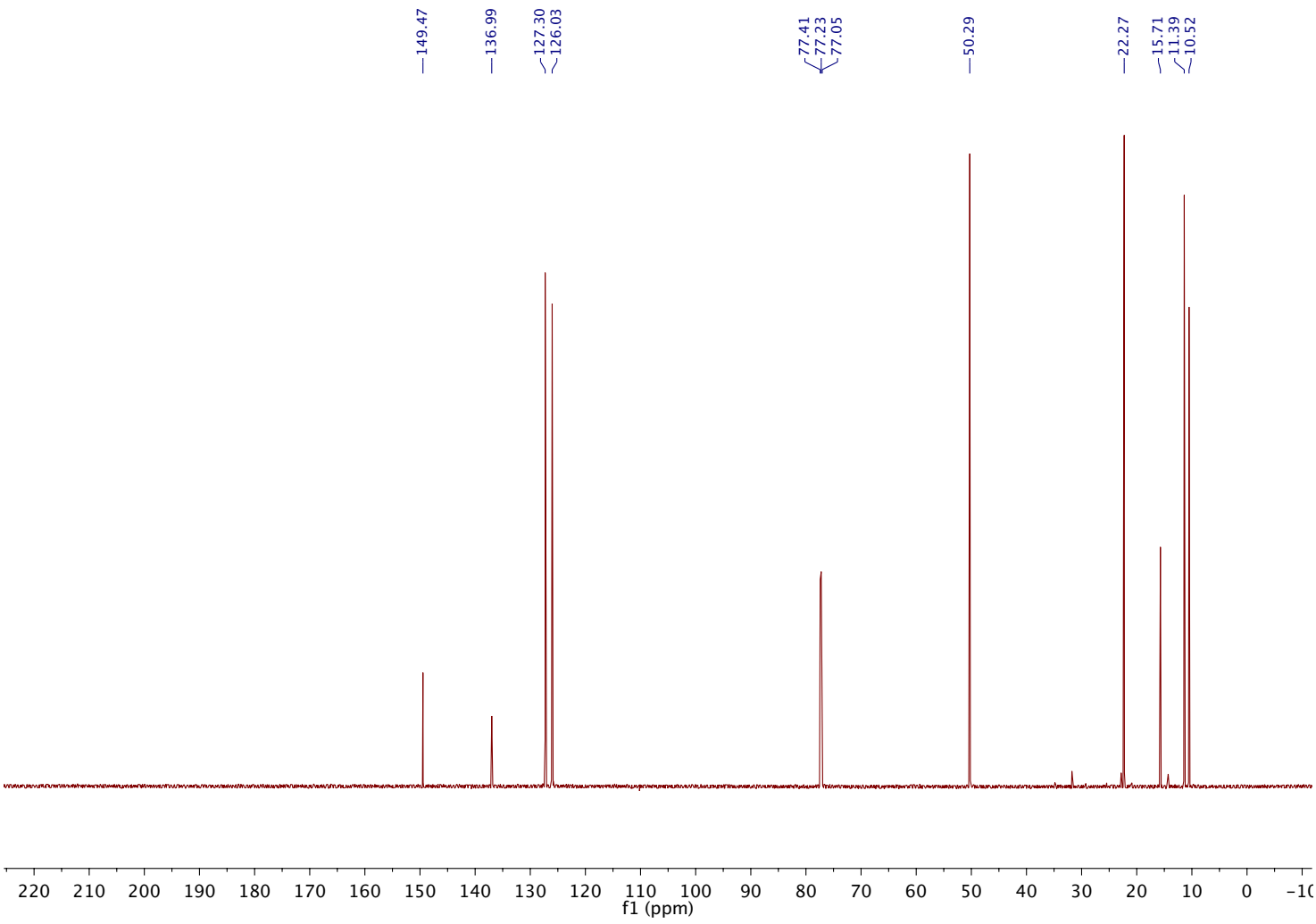
^{1}H NMR

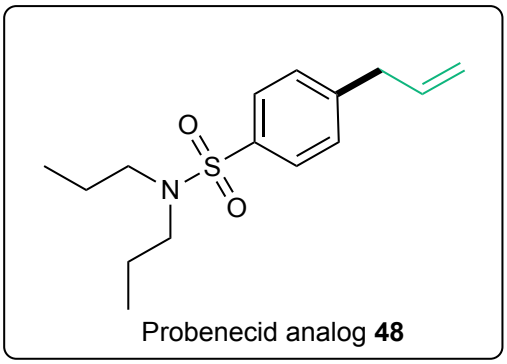




Probenecid analog **47**

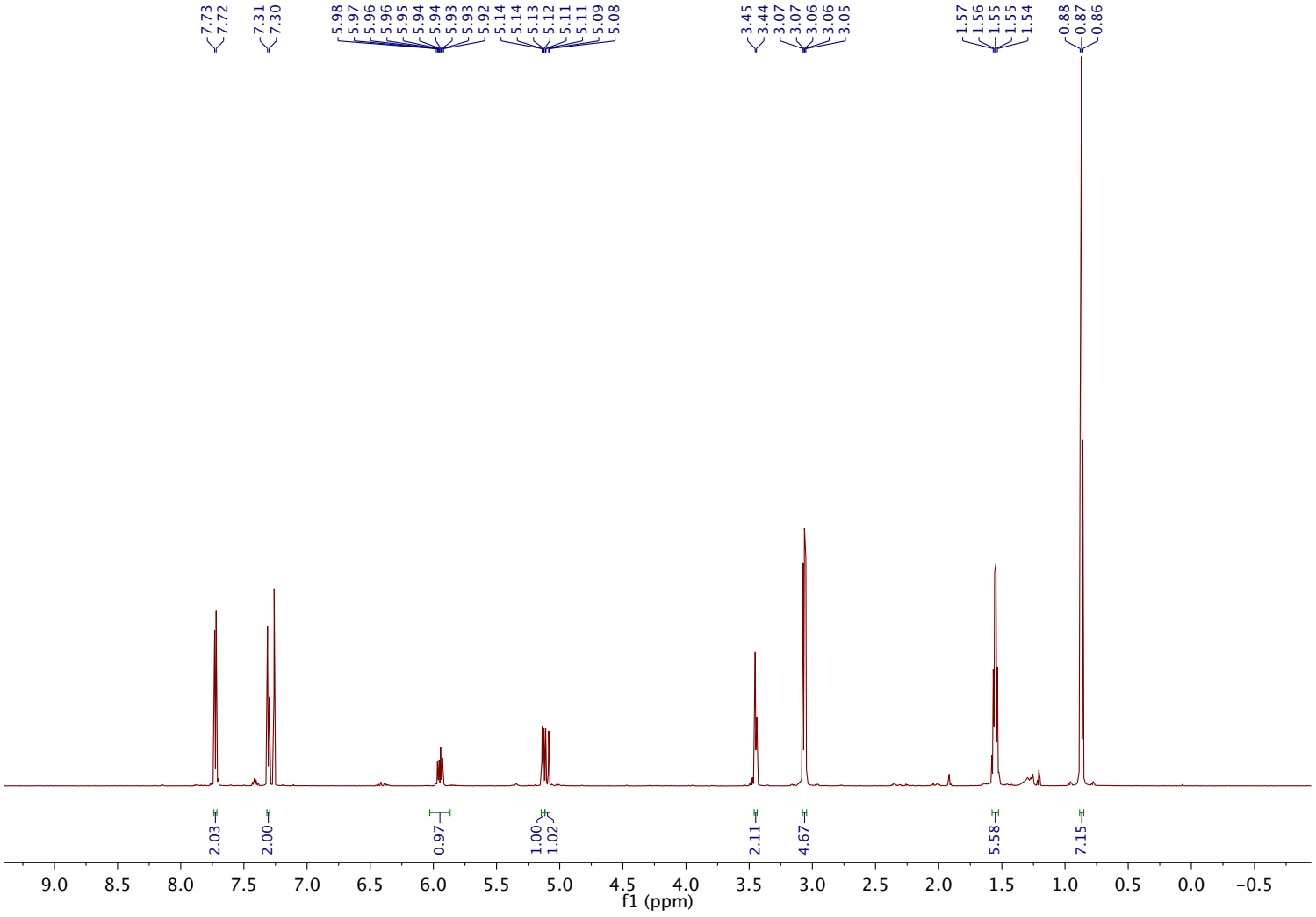
^{13}C NMR

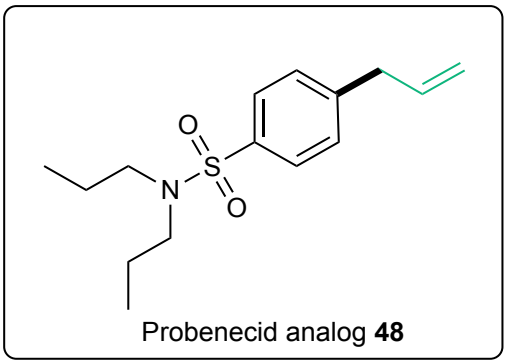




Probenecid analog **48**

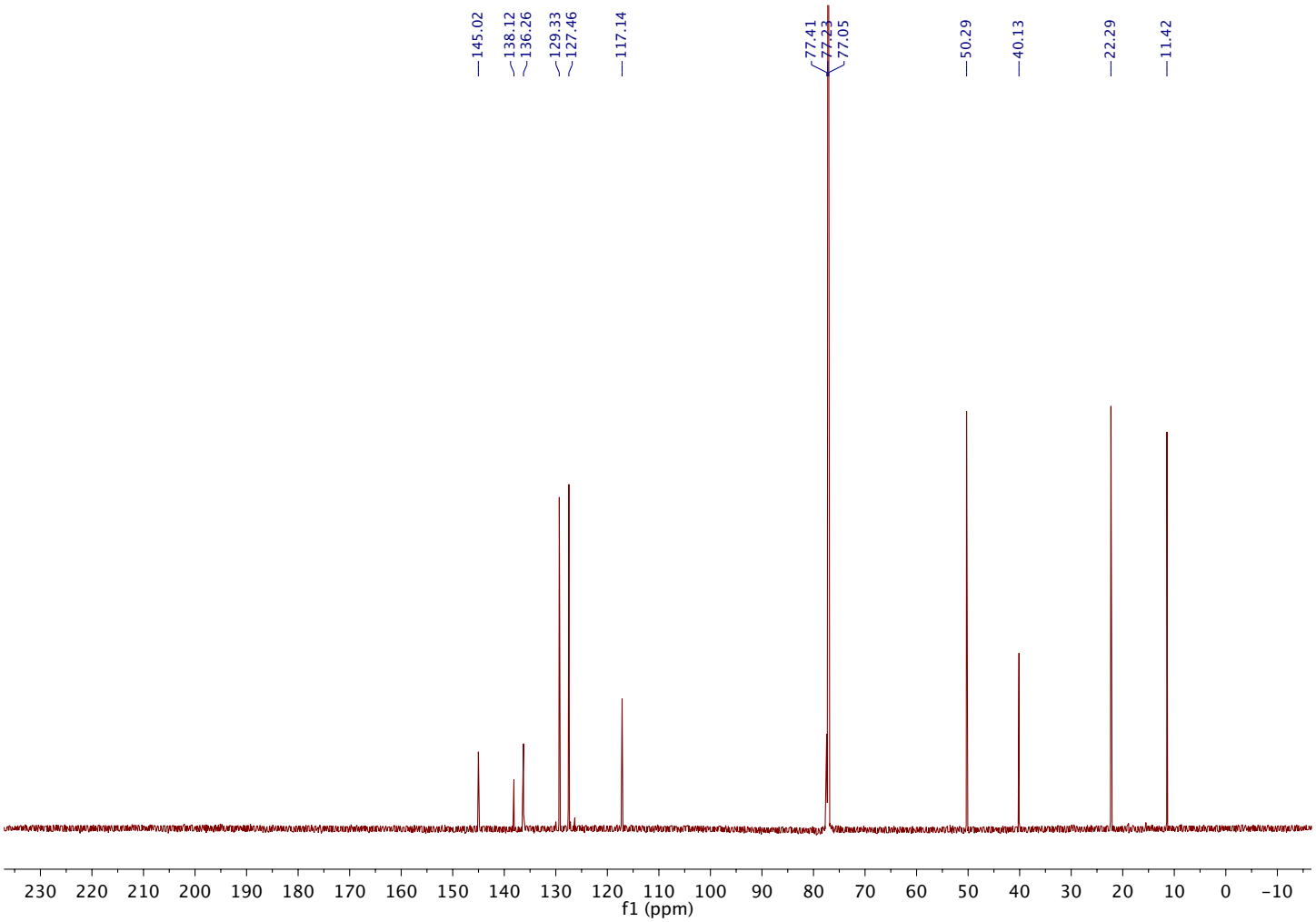
^{1}H NMR

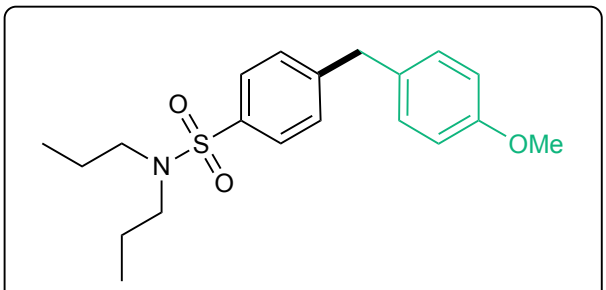




Probenecid analog **48**

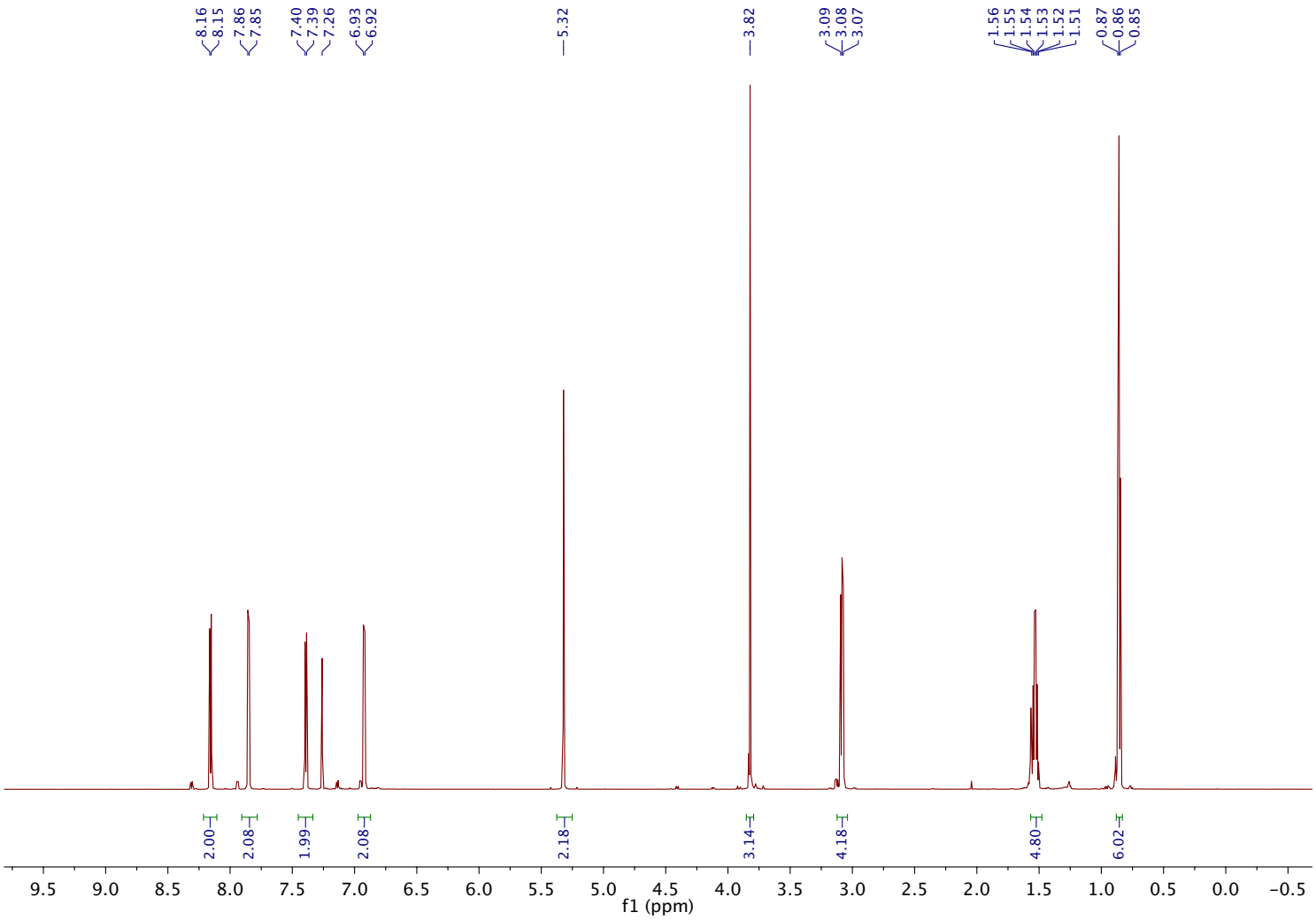
^{13}C NMR

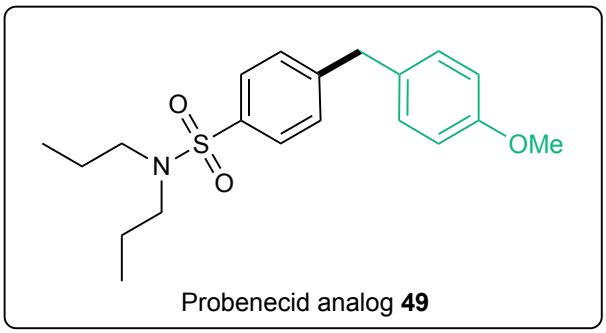




Probenecid analog **49**

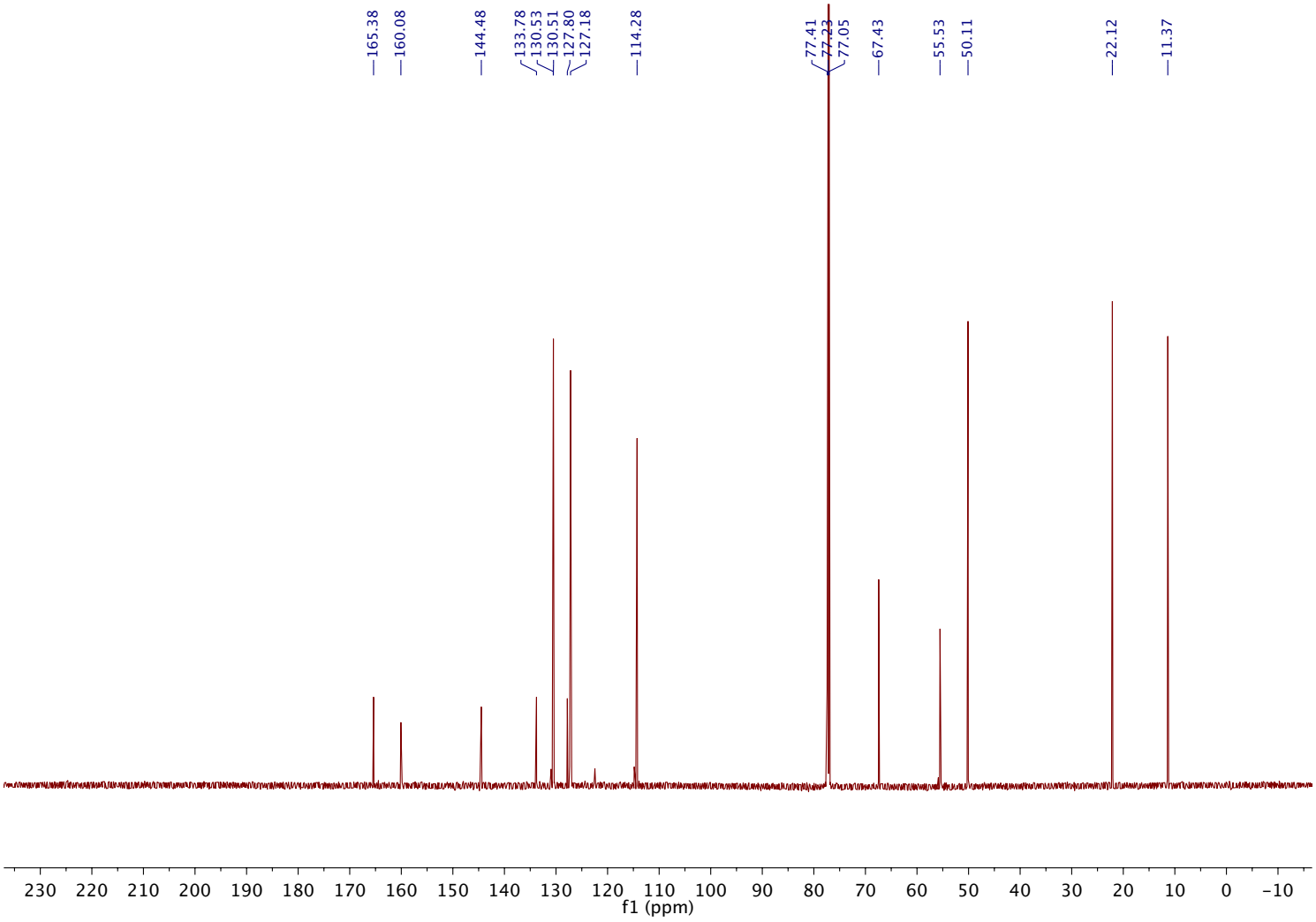
^{1}H NMR

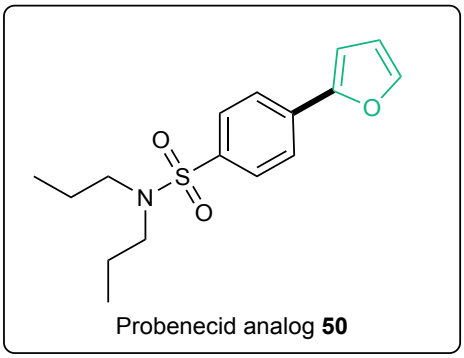




Probenecid analog **49**

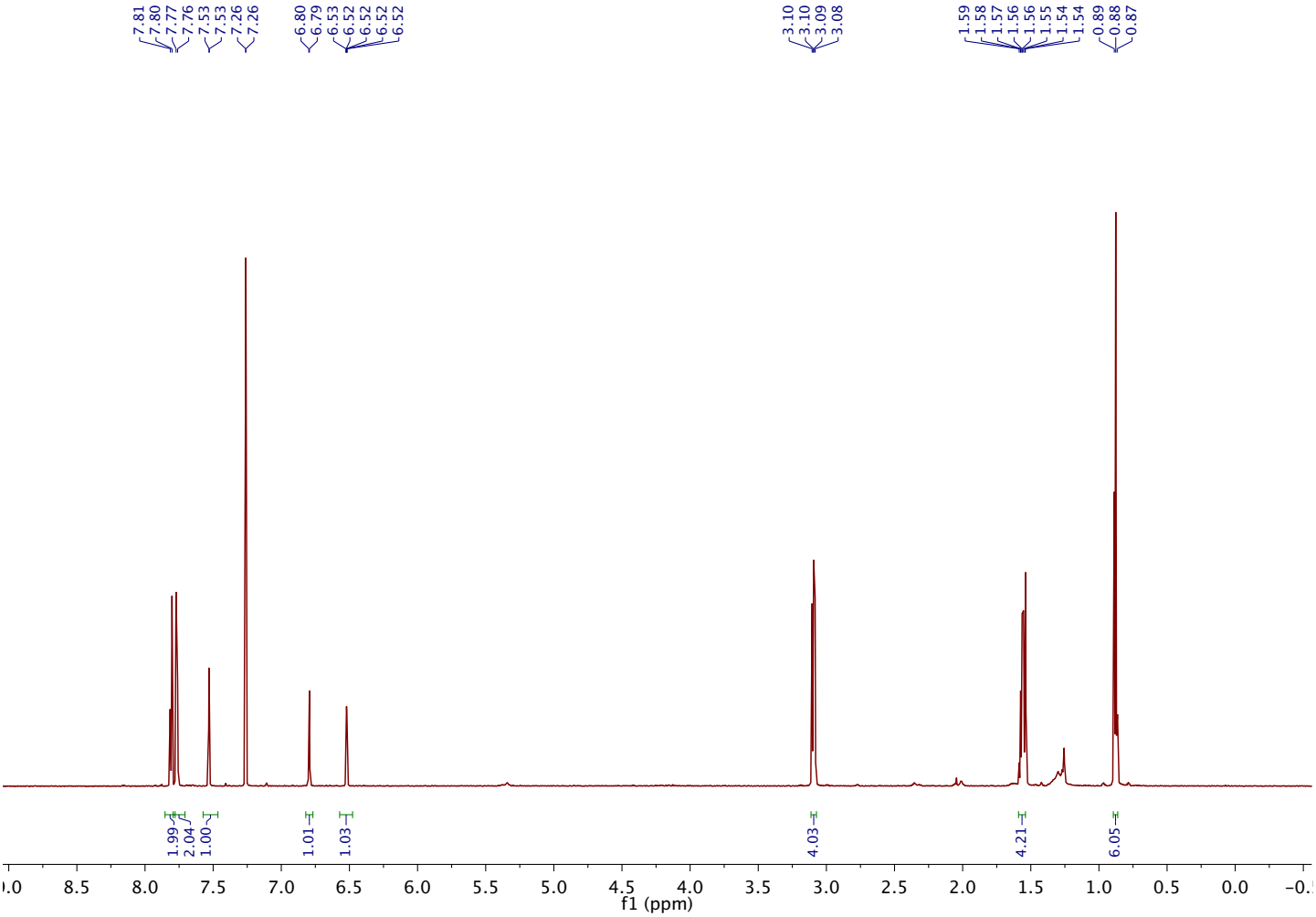
^{13}C NMR

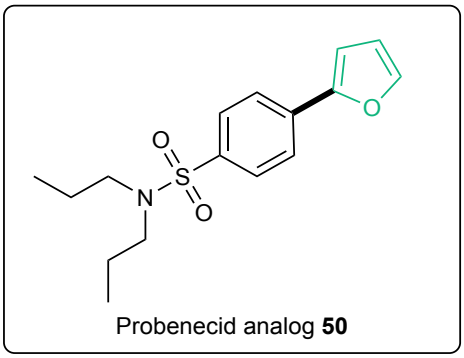




Probenecid analog **50**

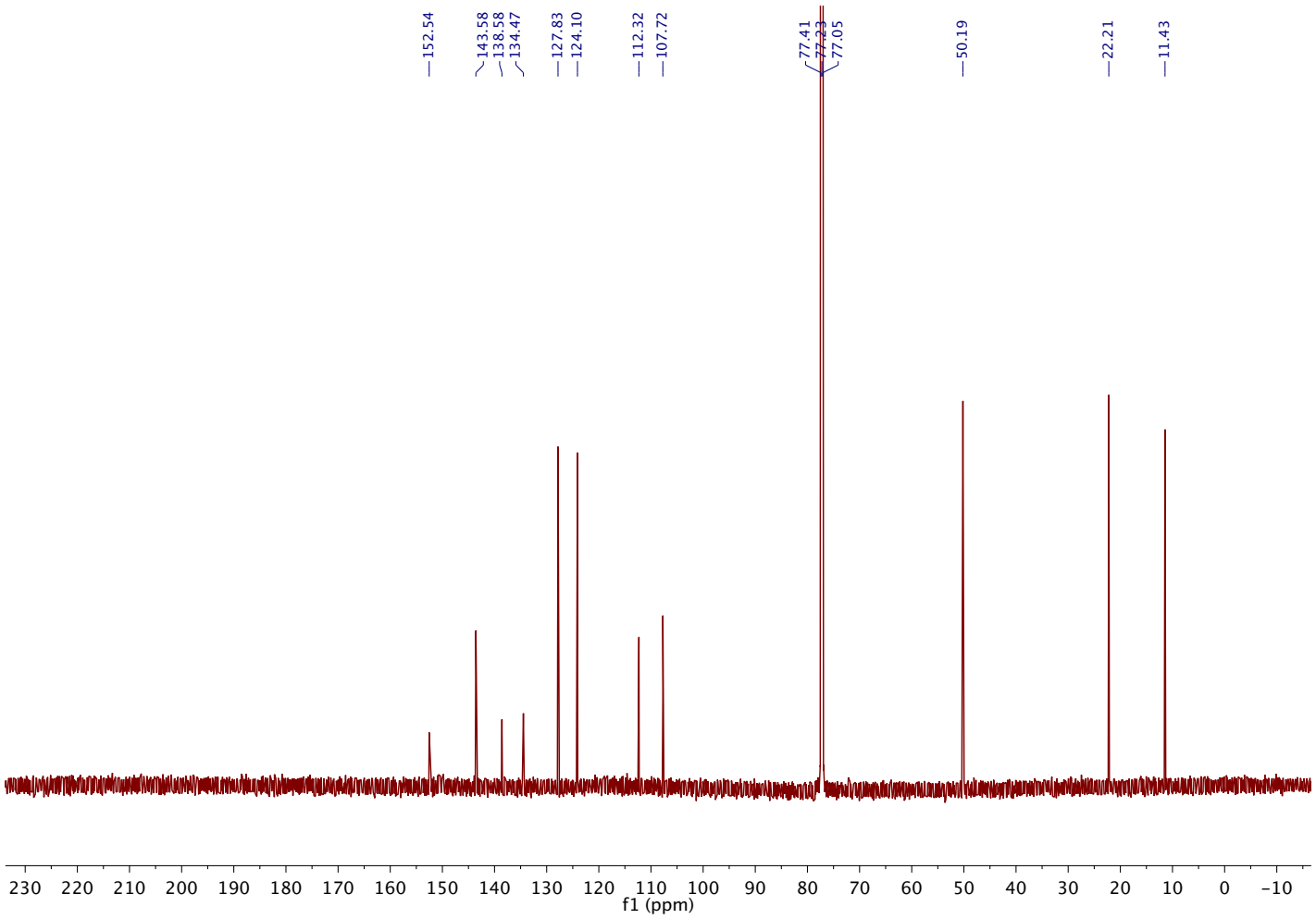
^{1}H NMR

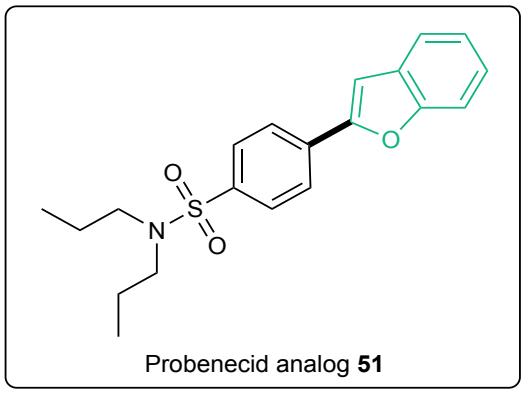




Probenecid analog **50**

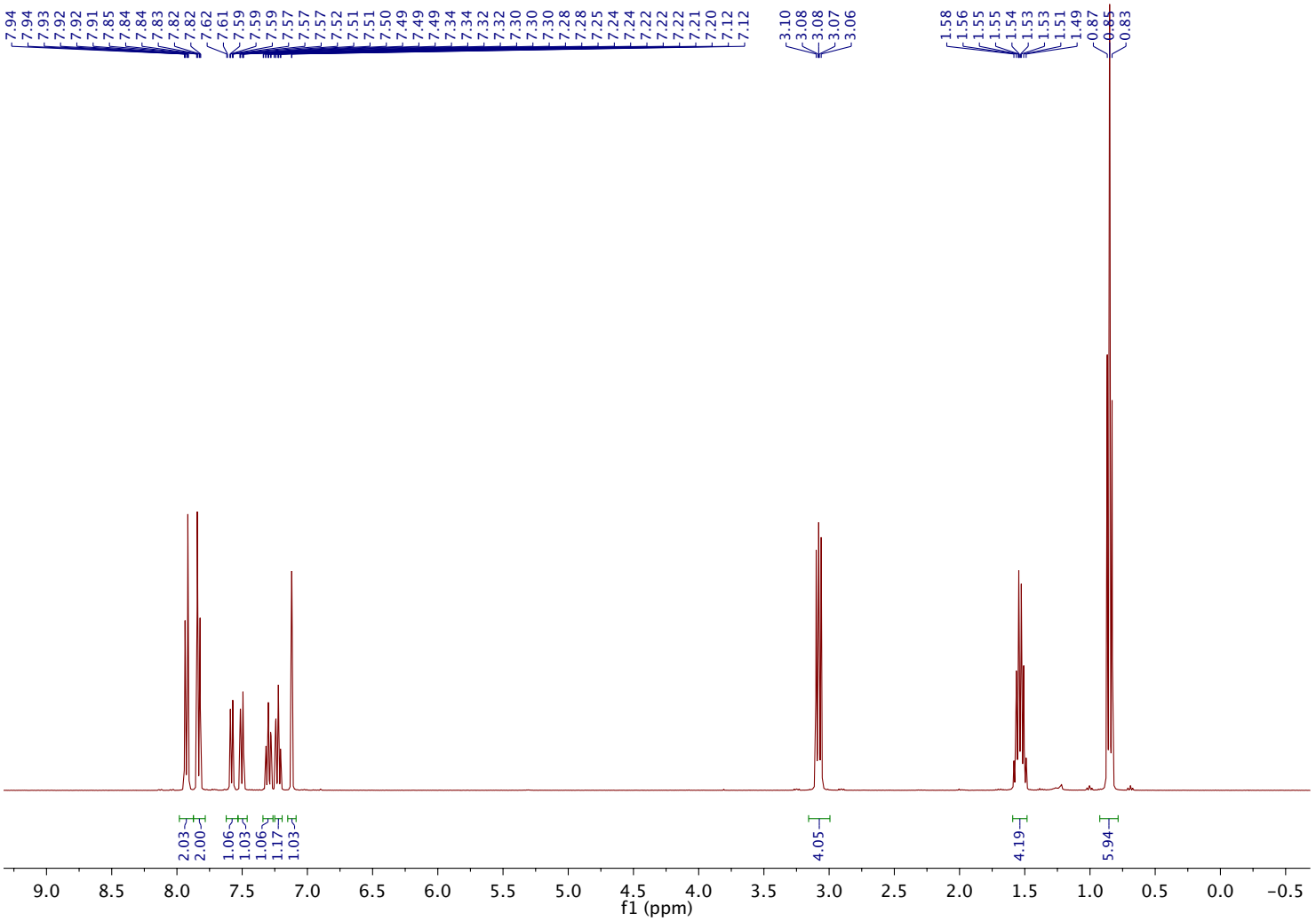
^{13}C NMR

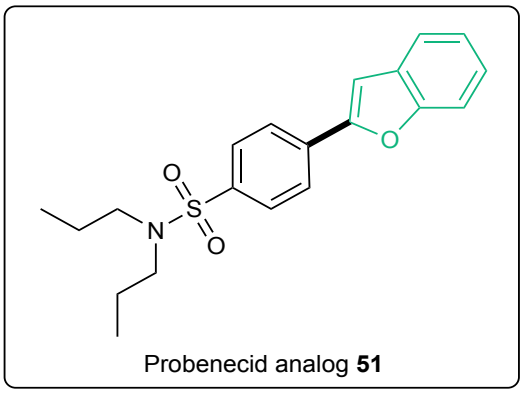




Probenecid analog **51**

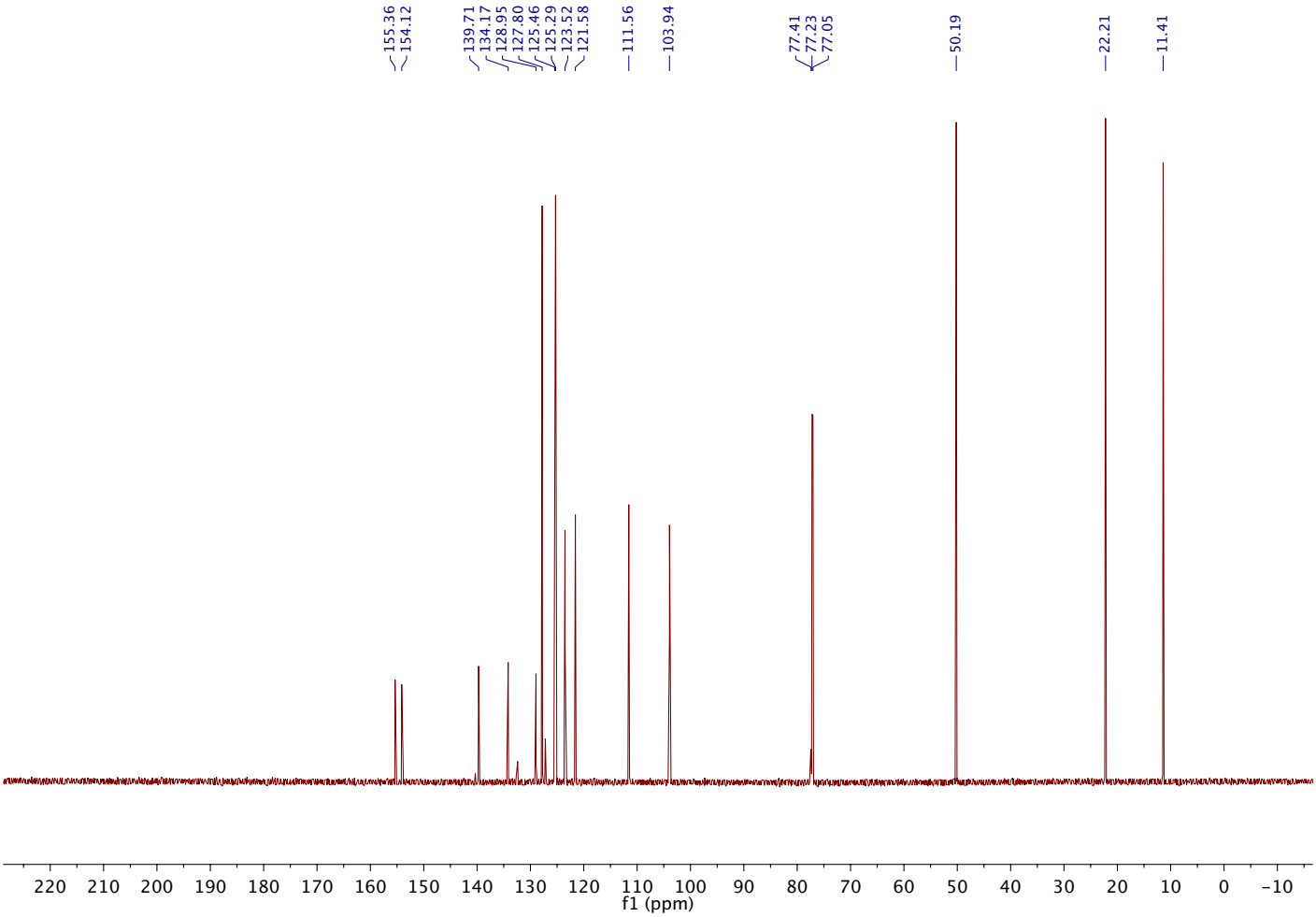
^{1}H NMR

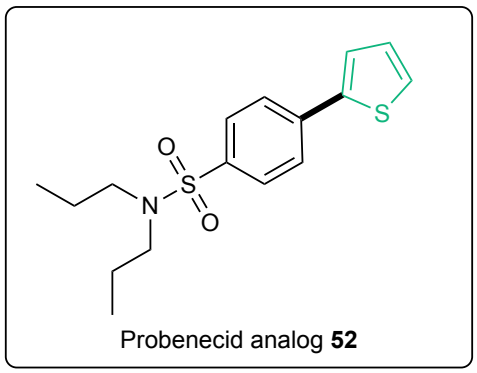




Probenecid analog **51**

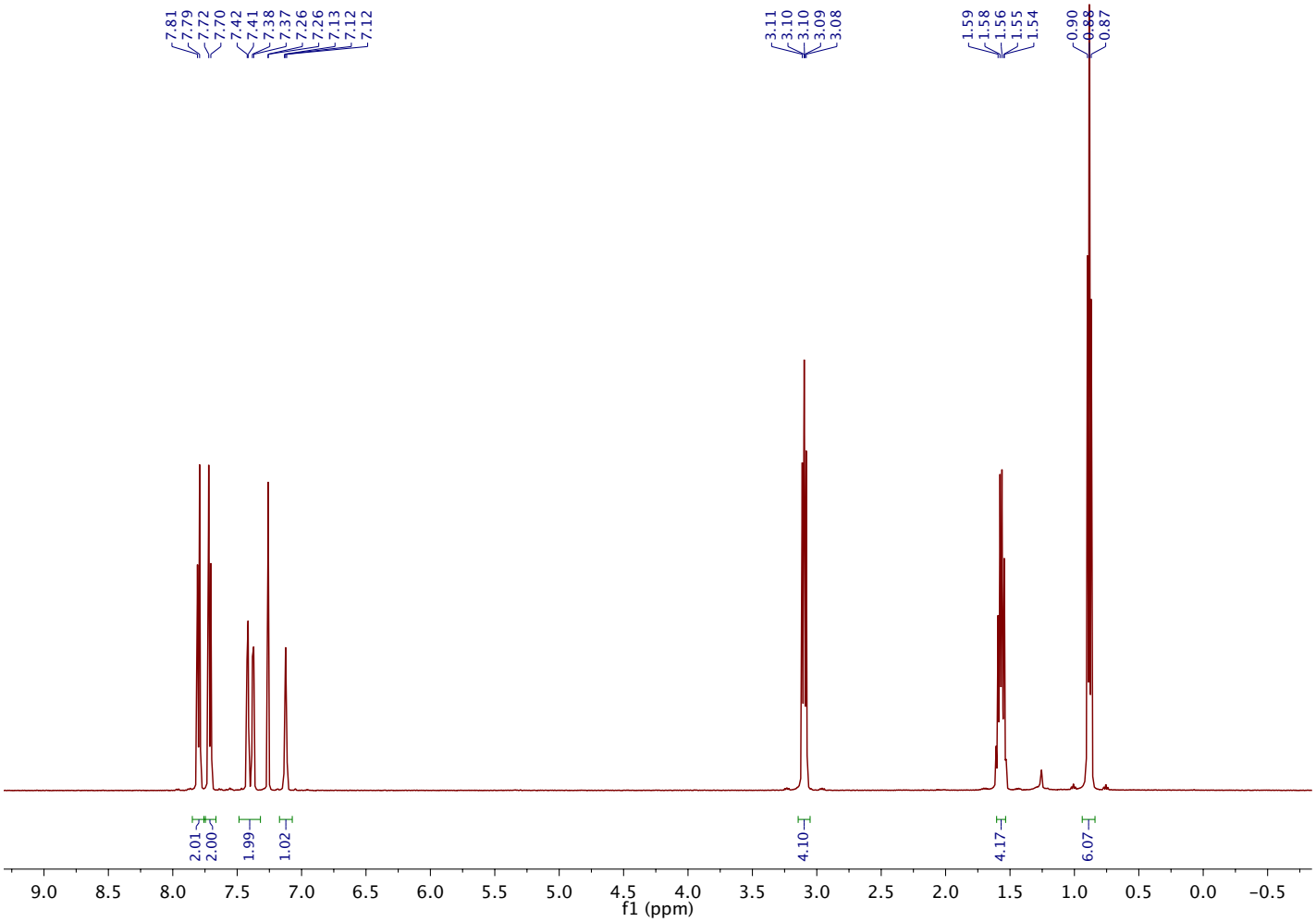
^{13}C NMR

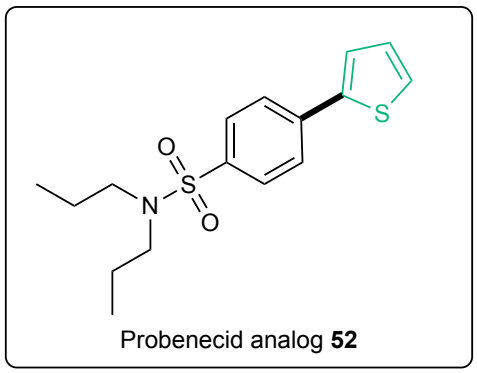




Probenecid analog **52**

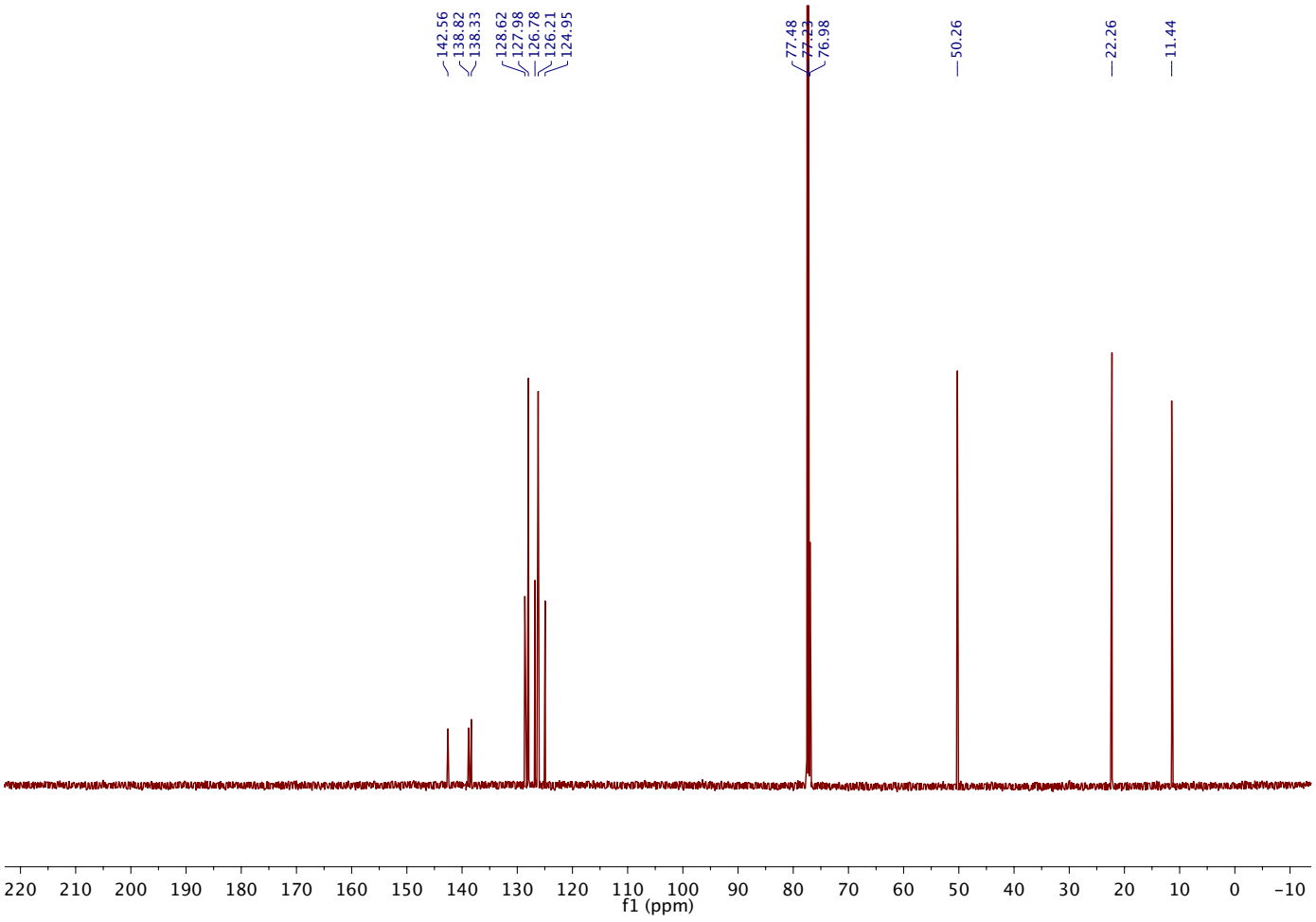
^{13}C NMR

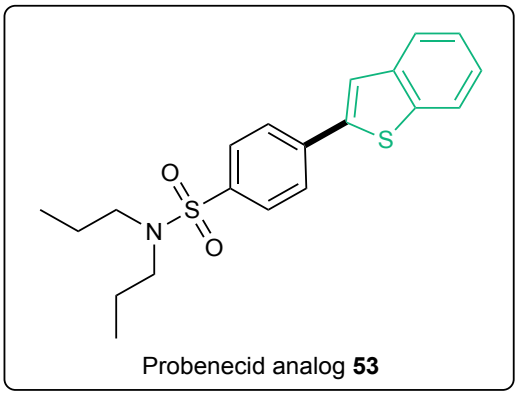




Probenecid analog **52**

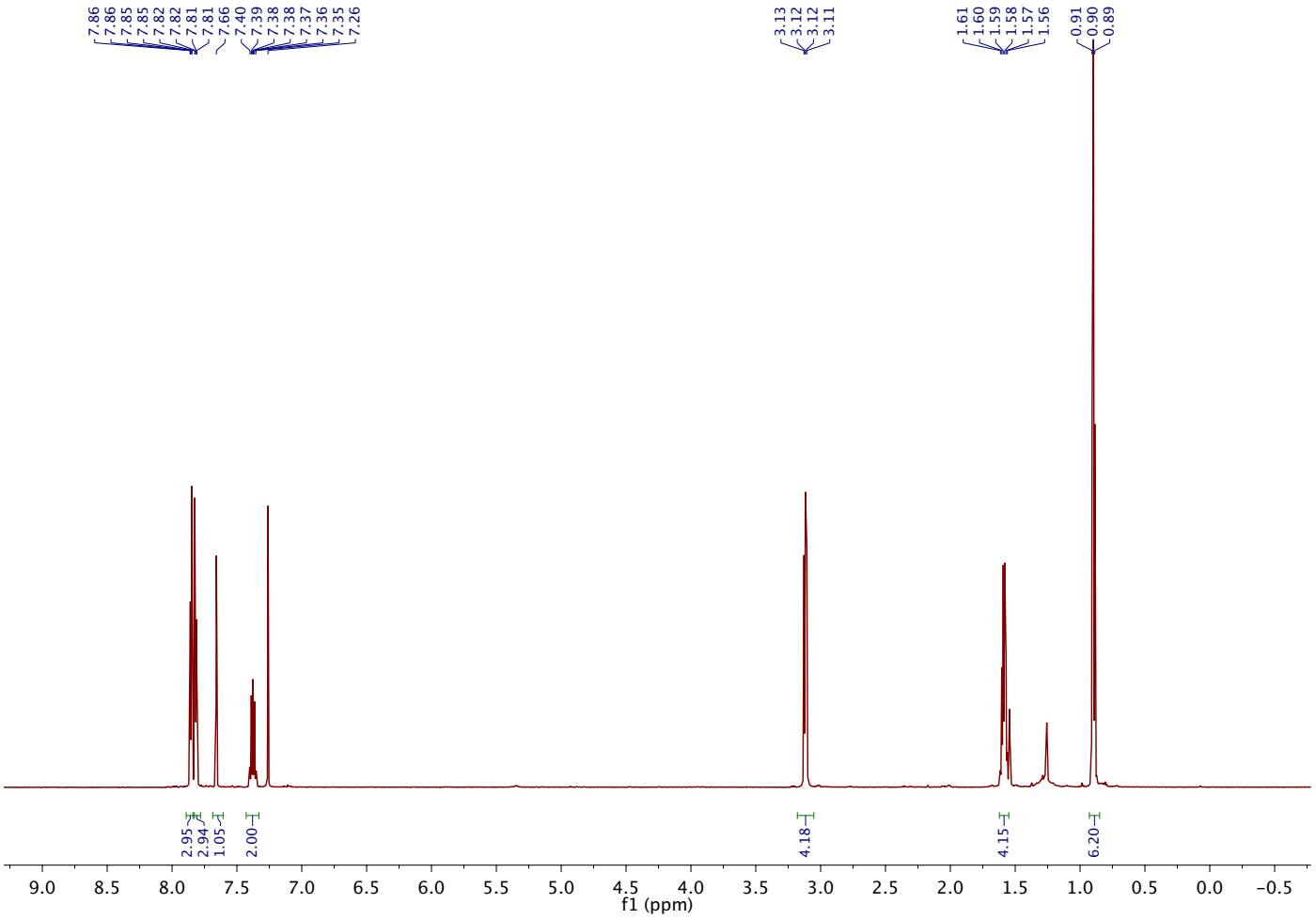
^{13}C NMR

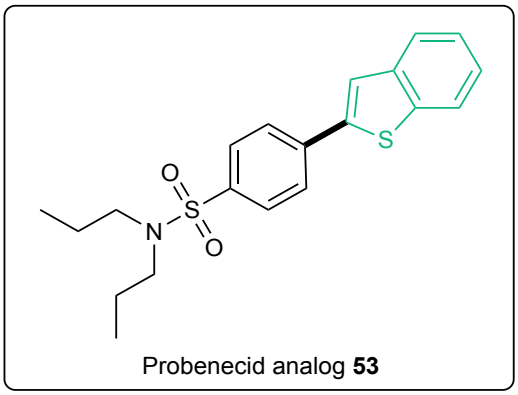




Probenecid analog **53**

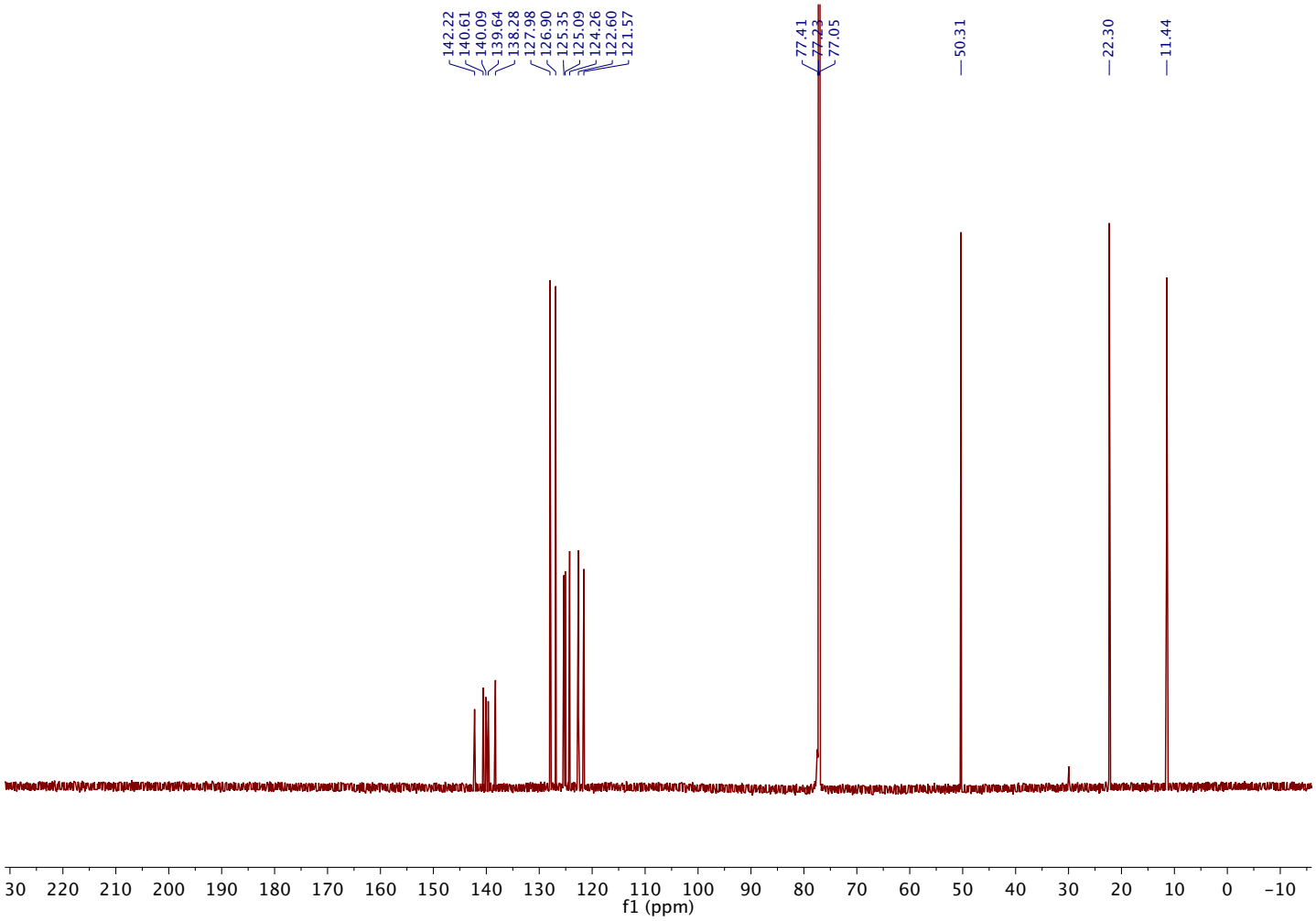
^{1}H NMR

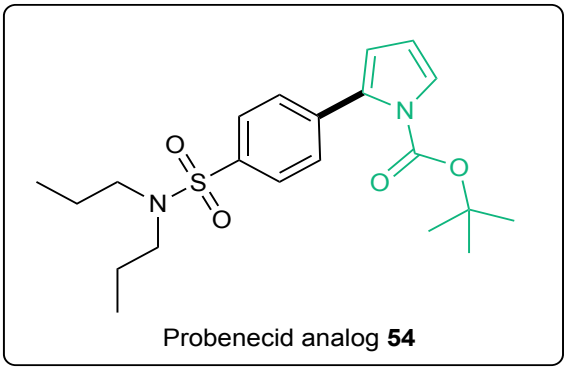




Probenecid analog **53**

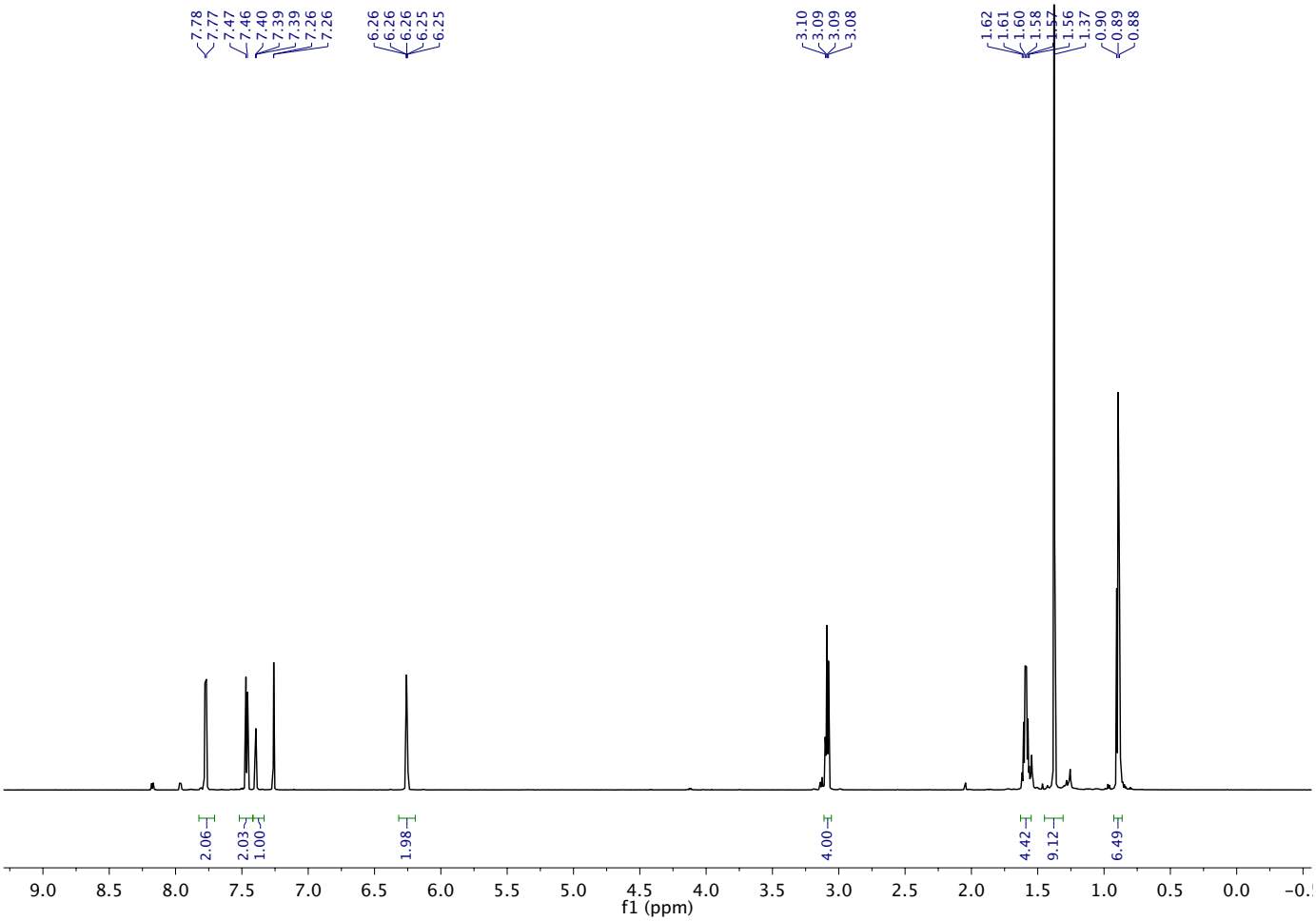
^{13}C NMR

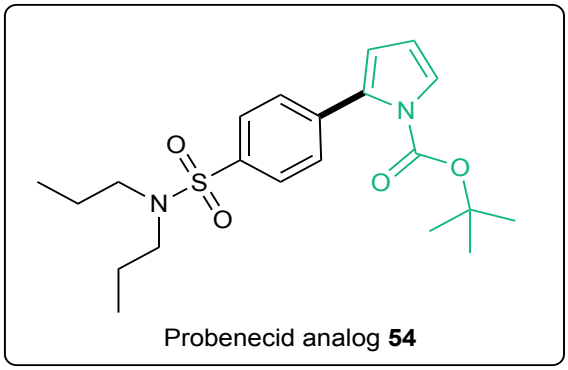




Probenecid analog **54**

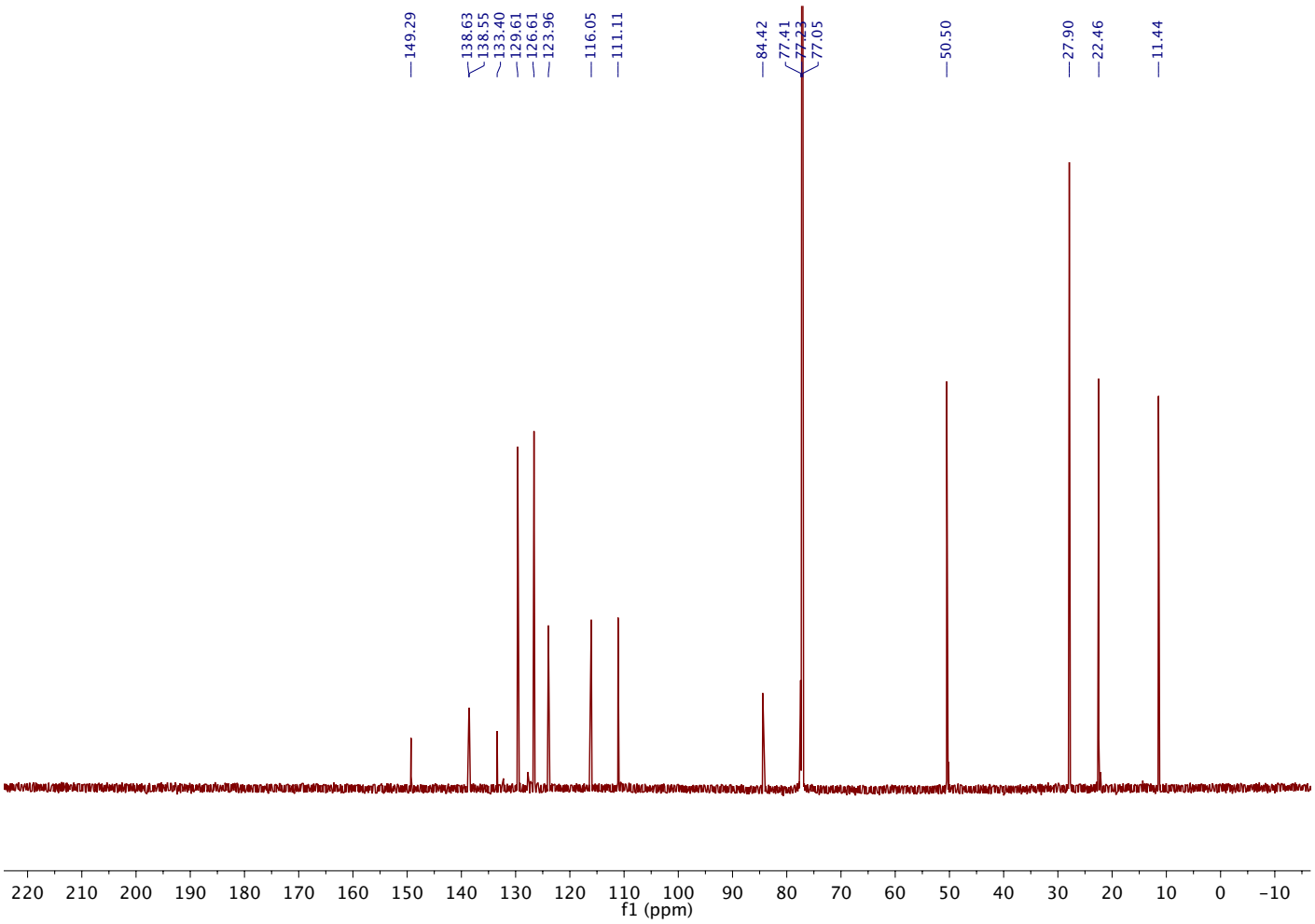
^{1}H NMR

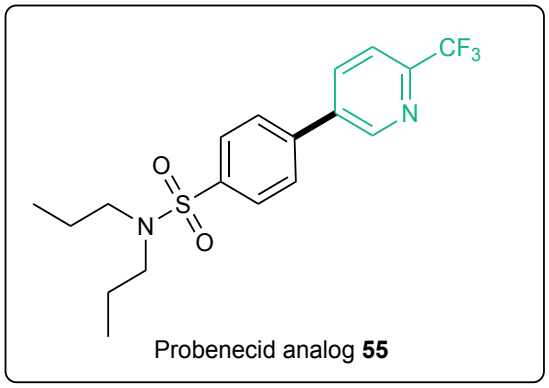




Probenecid analog **54**

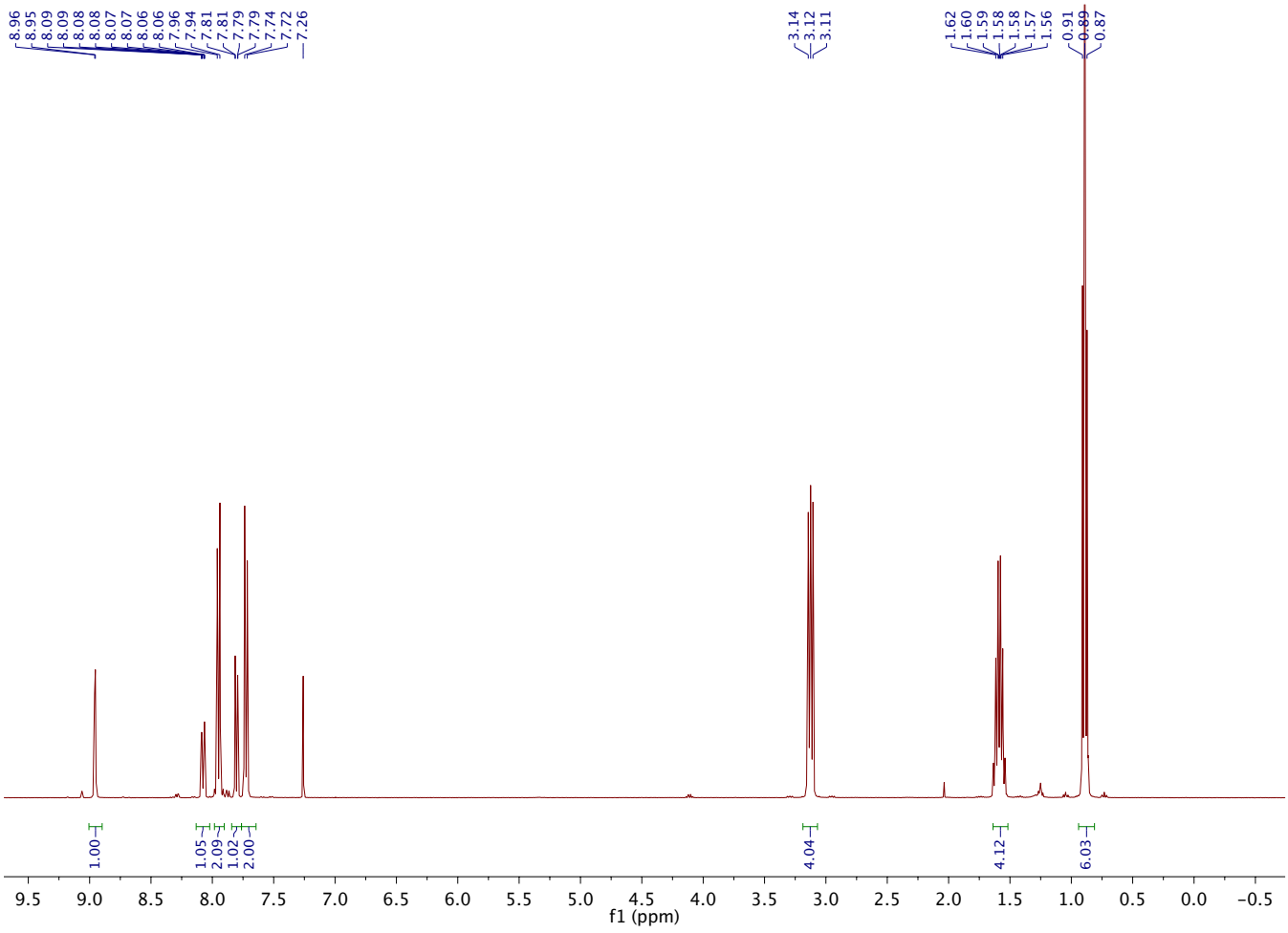
^{13}C NMR

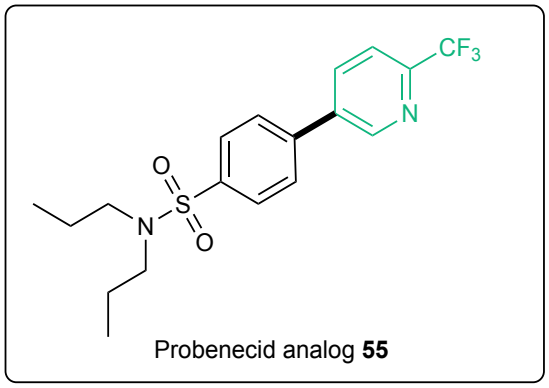




Probenecid analog **55**

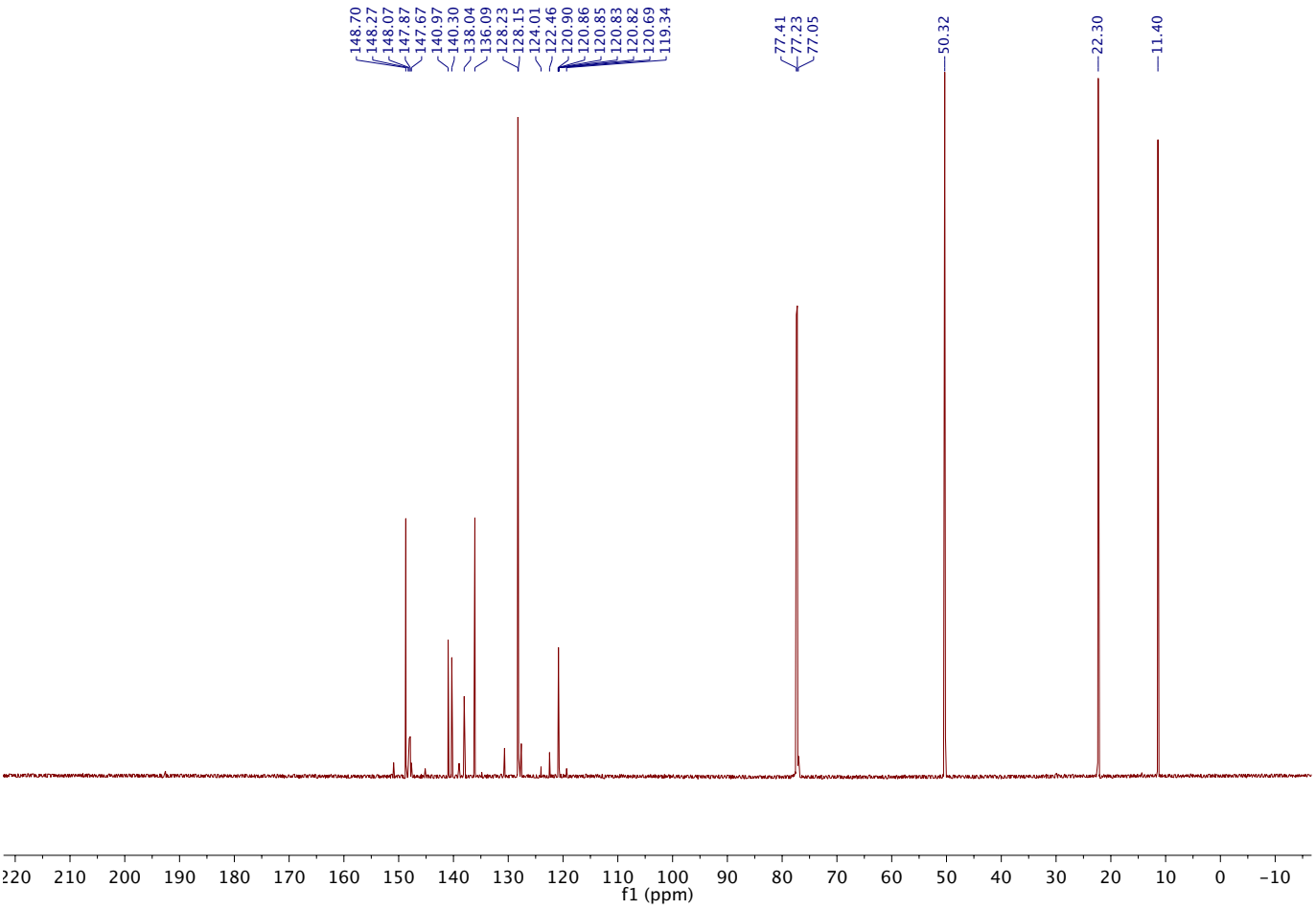
^{1}H NMR

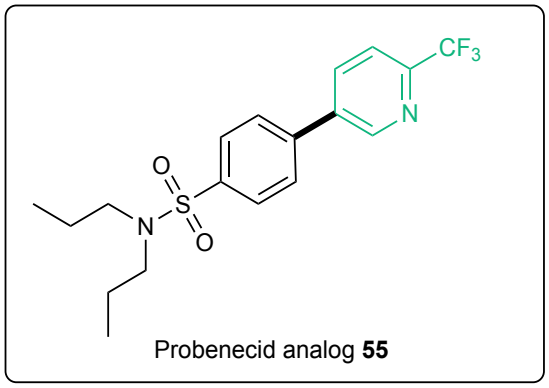




Probenecid analog **55**

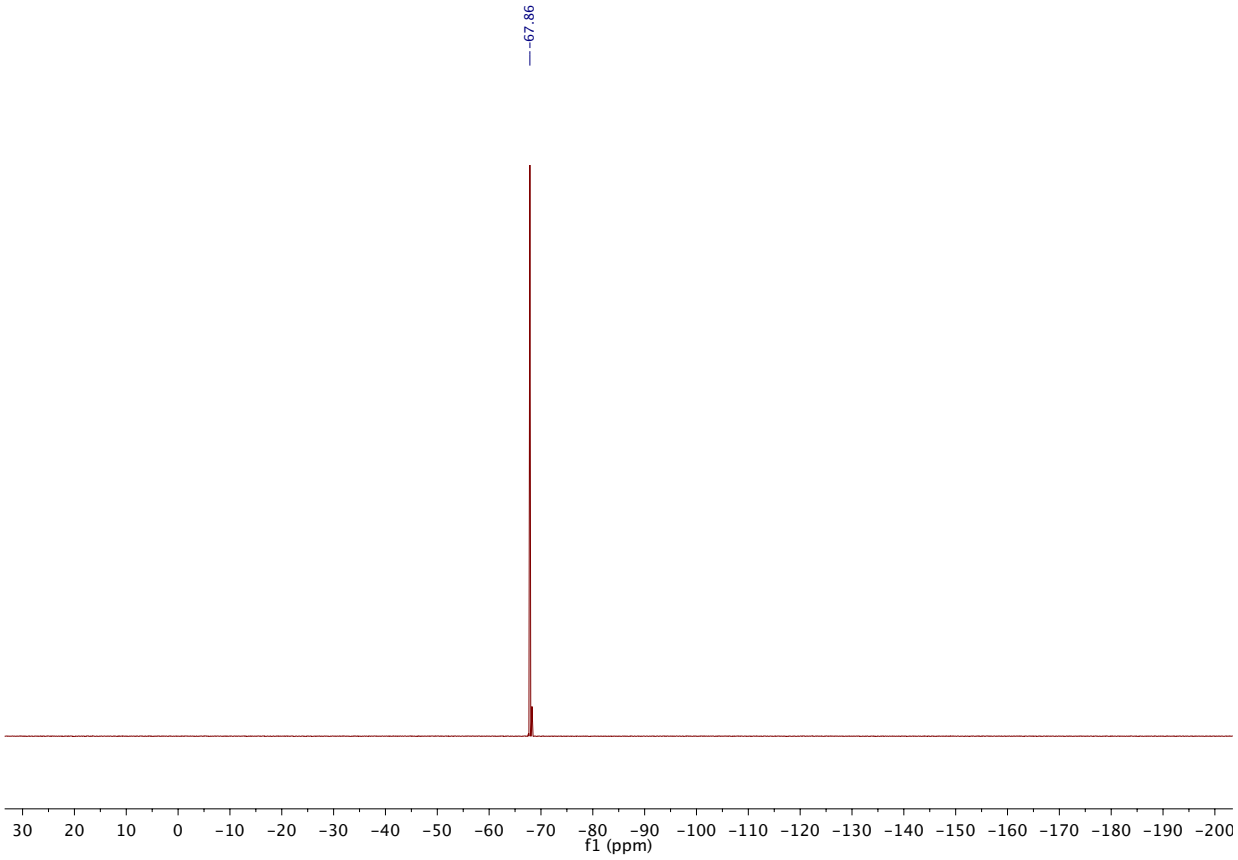
^{13}C NMR

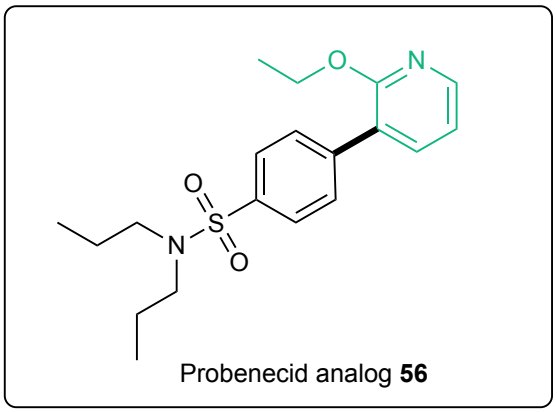




Probenecid analog **55**

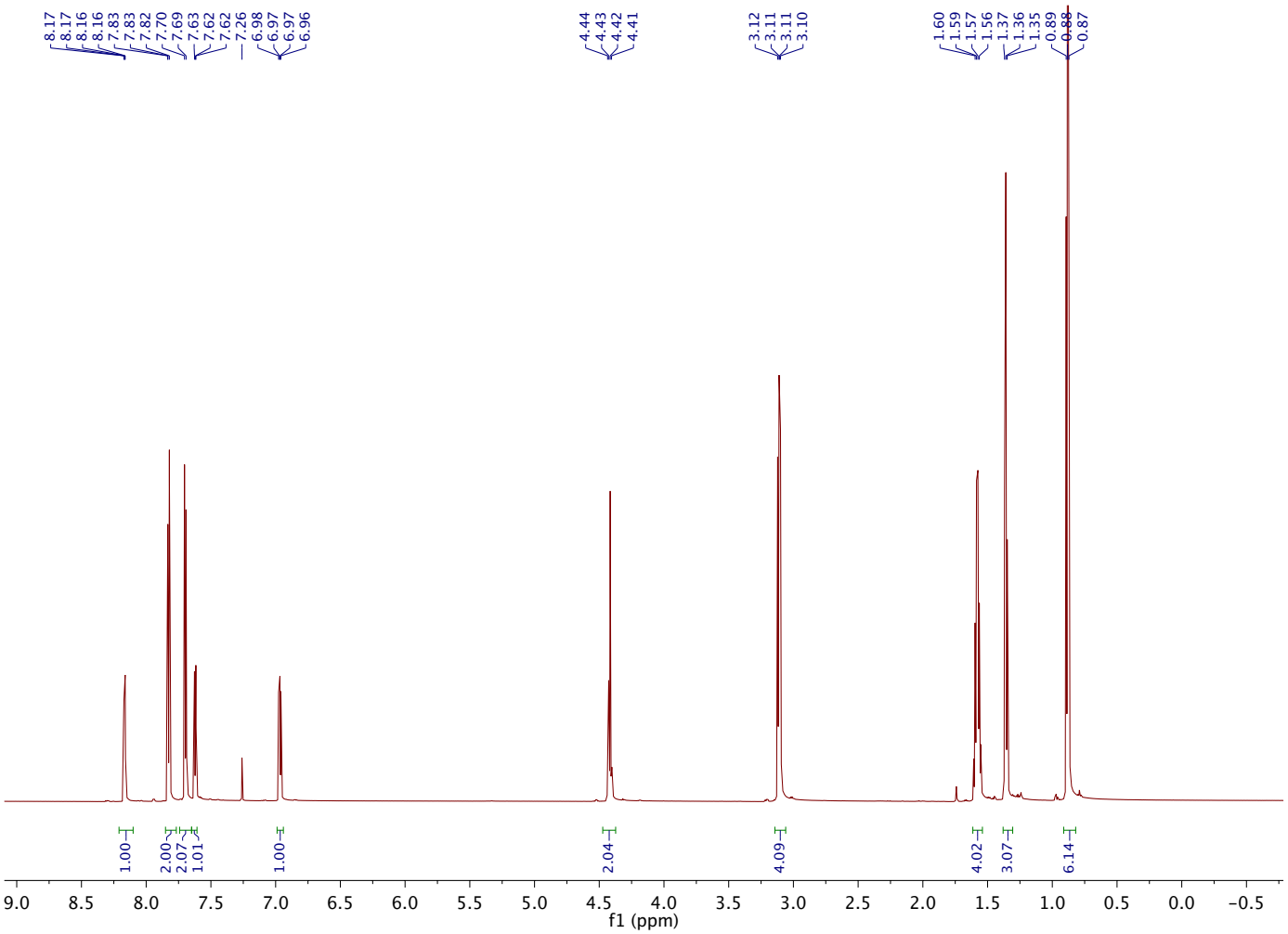
^{19}F NMR

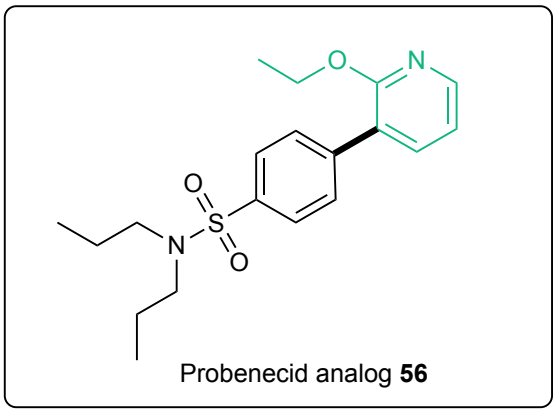




Probenecid analog **56**

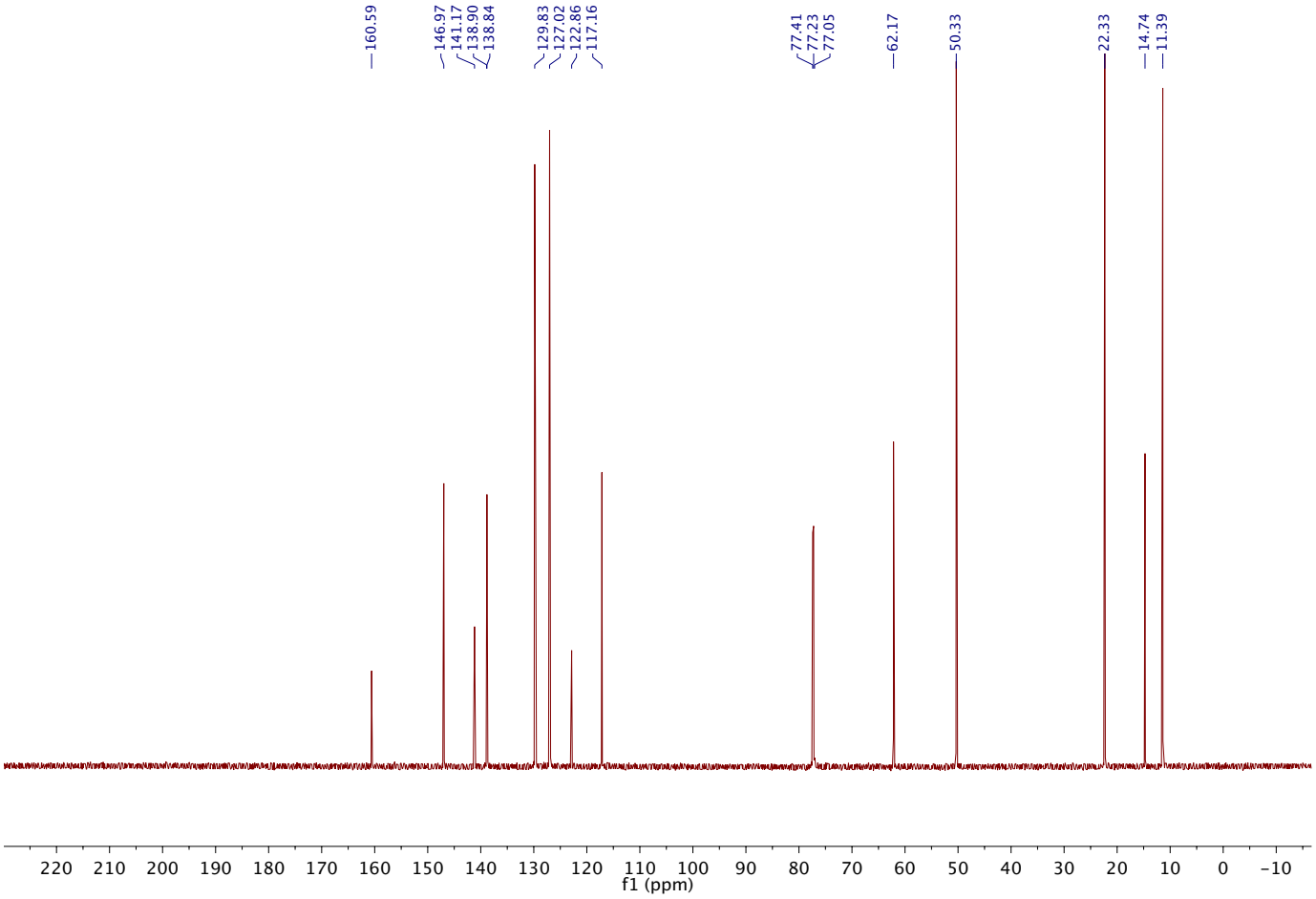
^{1}H NMR

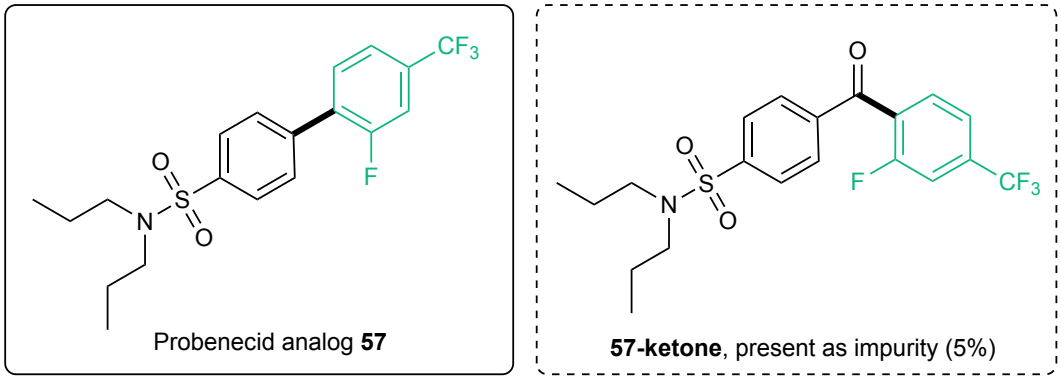




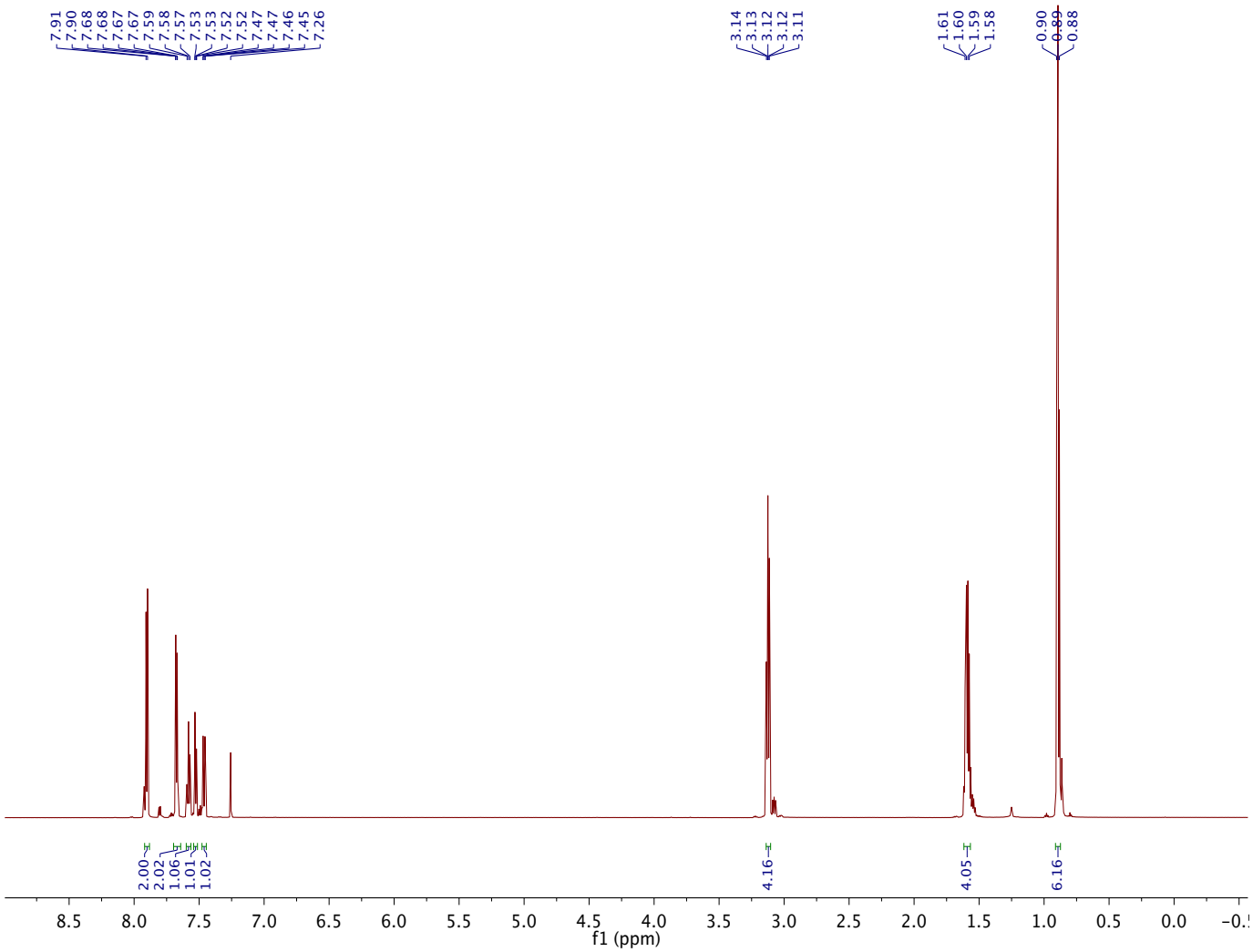
Probenecid analog **56**

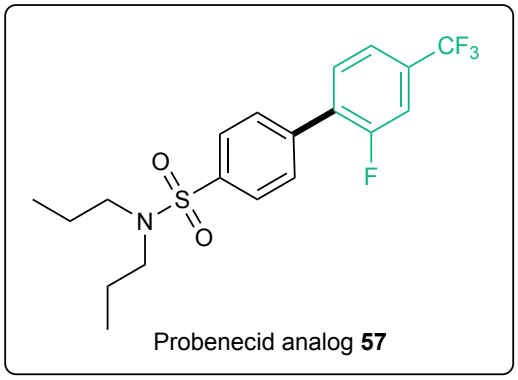
^{13}C NMR



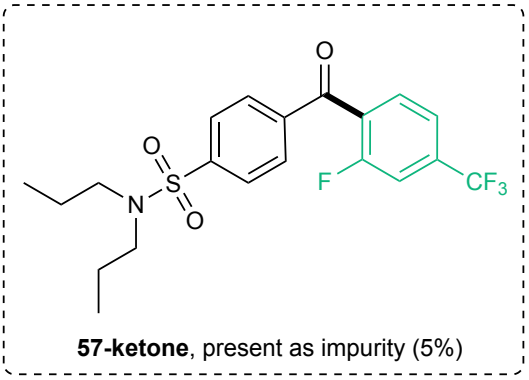

CF3
F
O
S
N
O
O
Probenecid analog 57
O
O
S
N
O
F
CF3
57-ketone, present as impurity (5%)

^{1}H NMR


7.91
7.90
7.68
7.68
7.67
7.67
7.59
7.58
7.57
7.53
7.53
7.52
7.52
7.47
7.47
7.46
7.45
7.26
3.14
3.13
3.12
3.12
3.11
1.61
1.60
1.59
1.58
0.90
0.89
0.88
2.00
2.02
1.06
1.01
1.02
4.16
4.05
6.16
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

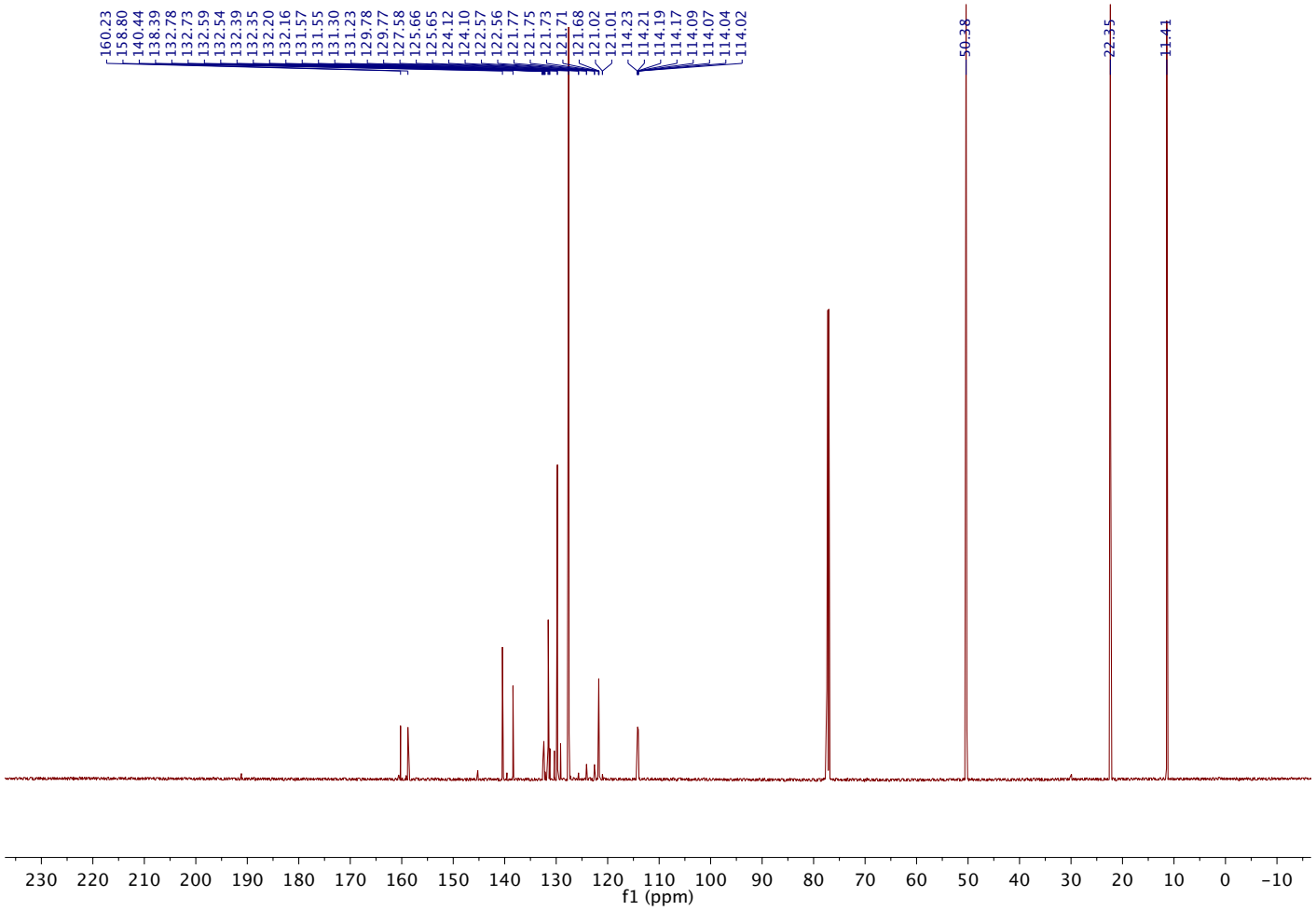


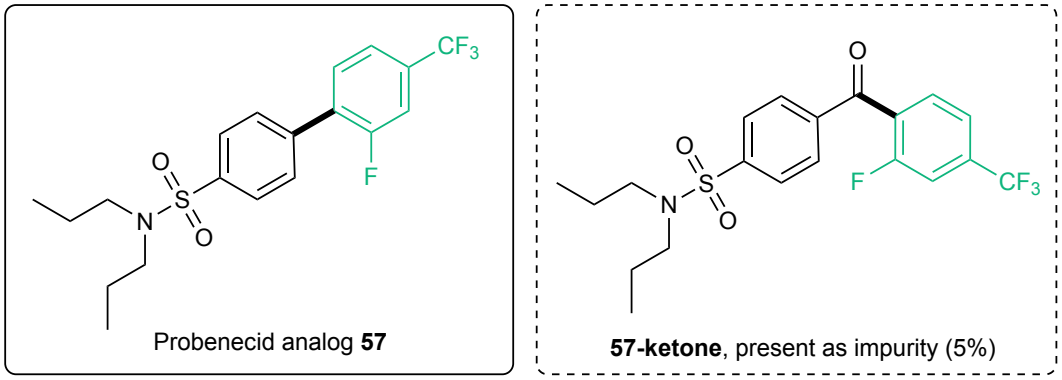
Probenecid analog **57**



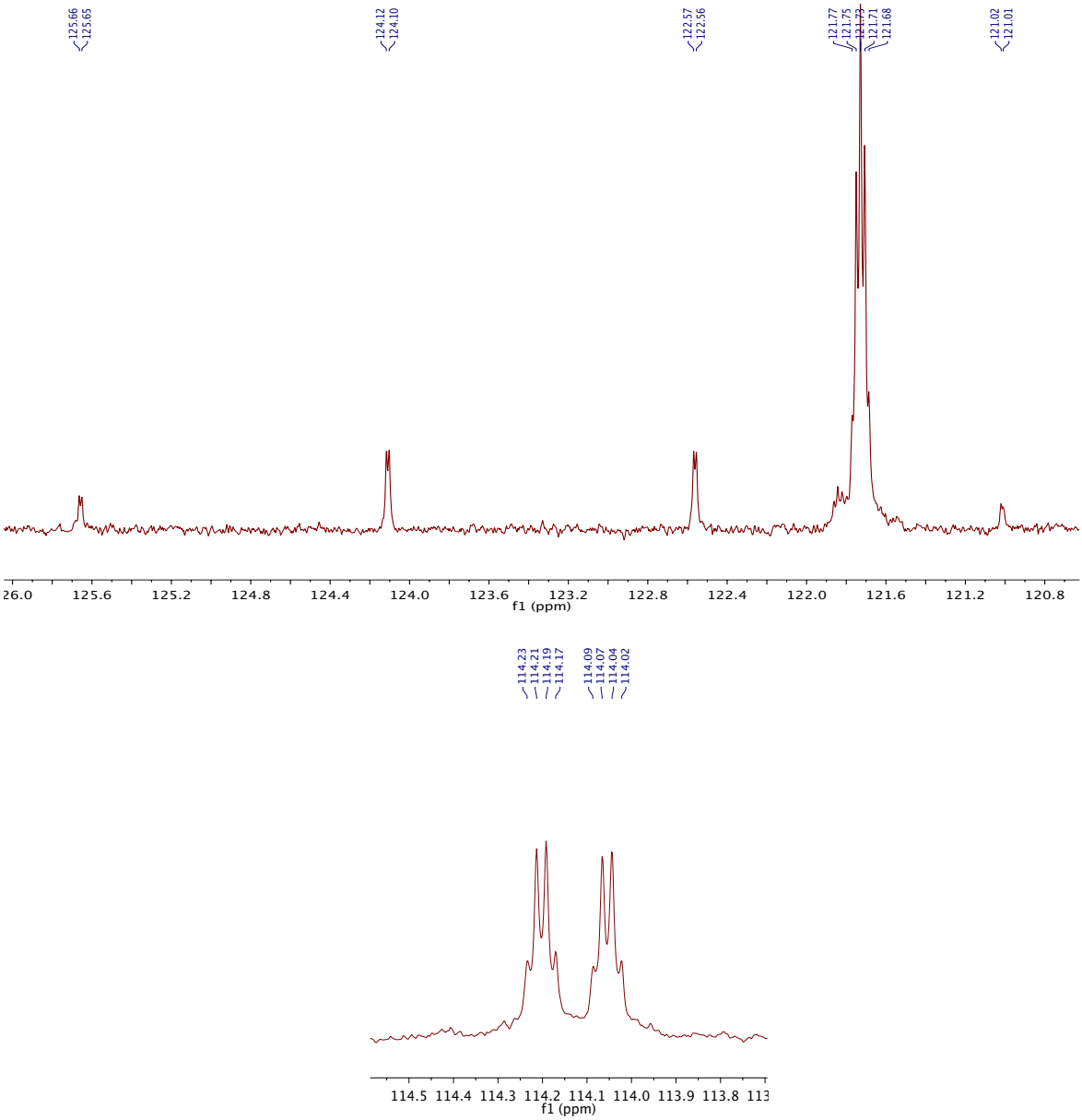
57-ketone, present as impurity (5%)

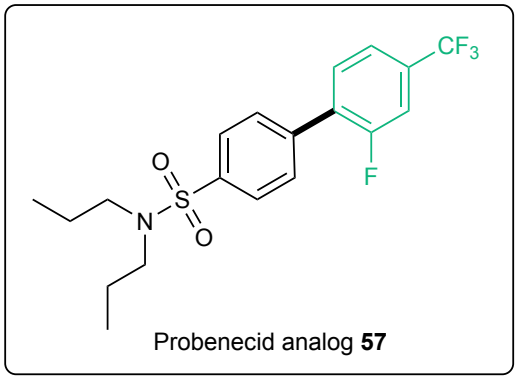
^{13}C NMR



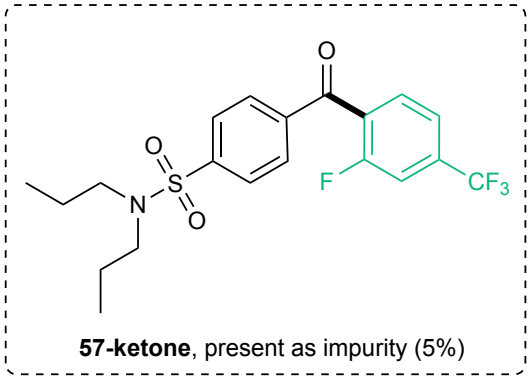

CF3
O
S
N
O
F
Probenecid analog 57
O
O
S
N
O
F
CF3
57-ketone, present as impurity (5%)

^{13}C NMR


125.66
125.65
124.12
124.10
122.57
122.56
121.77
121.75
121.73
121.71
121.68
121.02
121.01
26.0
125.6
125.2
124.8
124.4
124.0
123.6
123.2
122.8
122.4
122.0
121.6
121.2
120.8
f1 (ppm)
114.23
114.21
114.19
114.17
114.09
114.07
114.04
114.02
114.5
114.4
114.3
114.2
114.1
114.0
113.9
113.8
113
f1 (ppm)

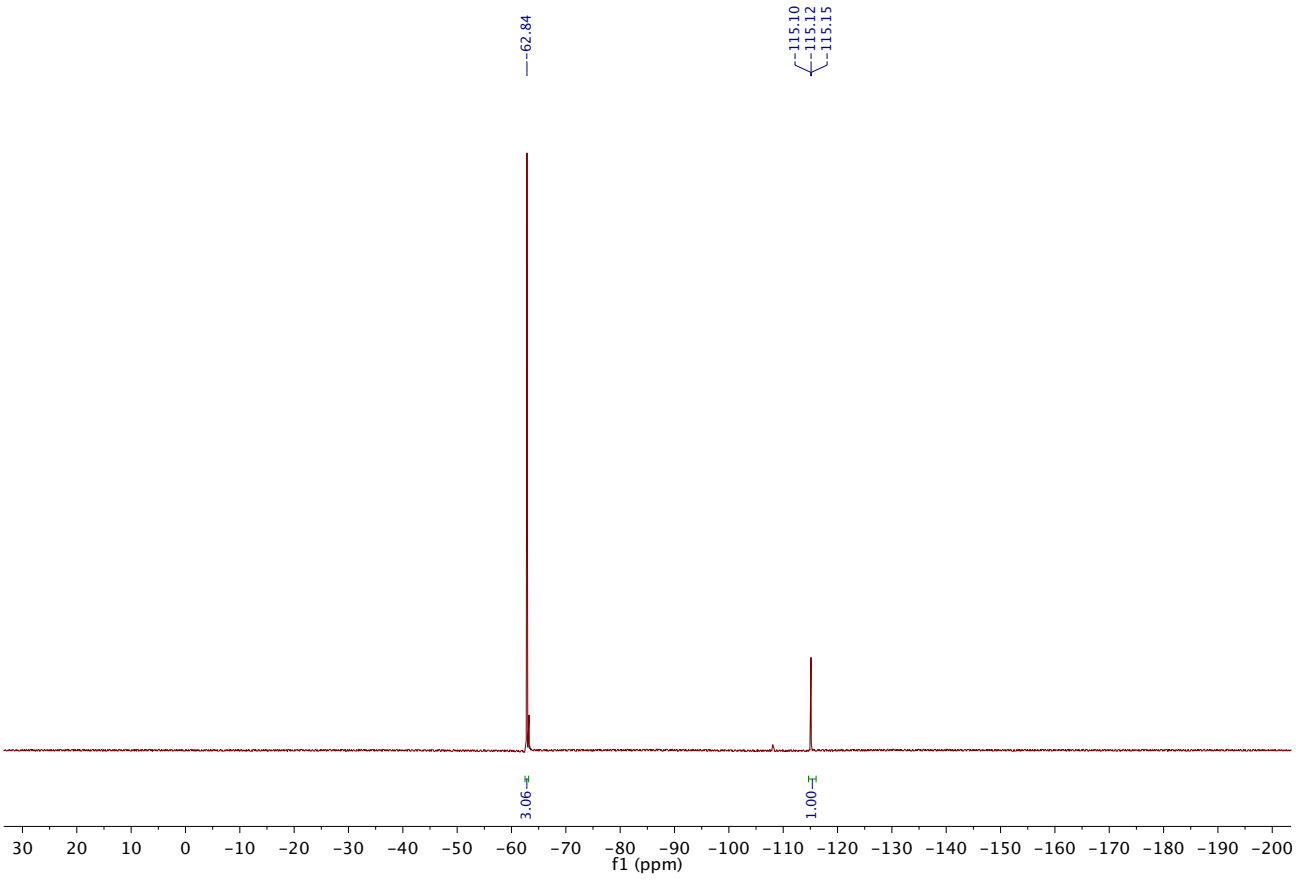


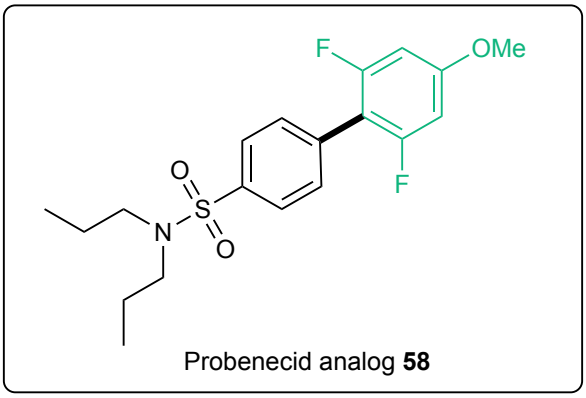
Probenecid analog **57**



57-ketone, present as impurity (5%)

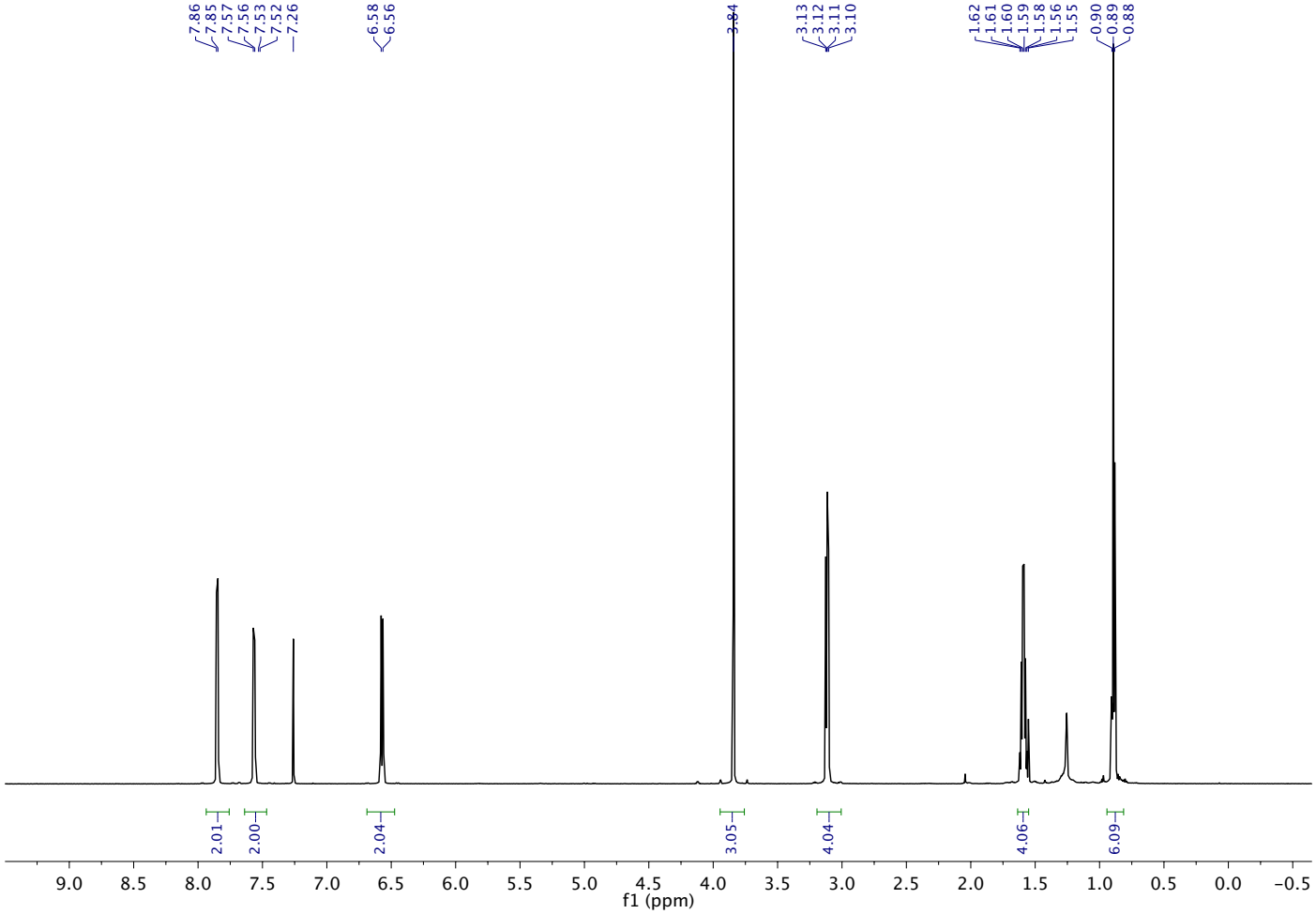
^{19}F NMR

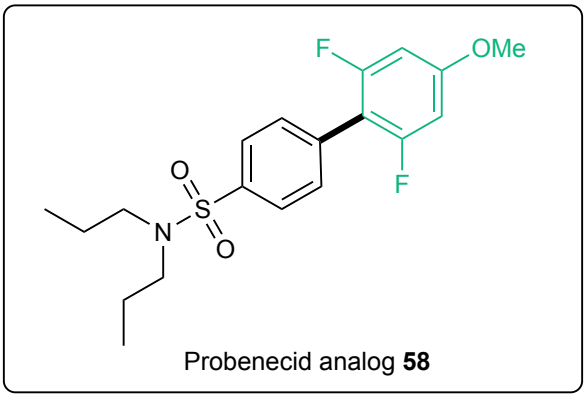




Probenecid analog **58**

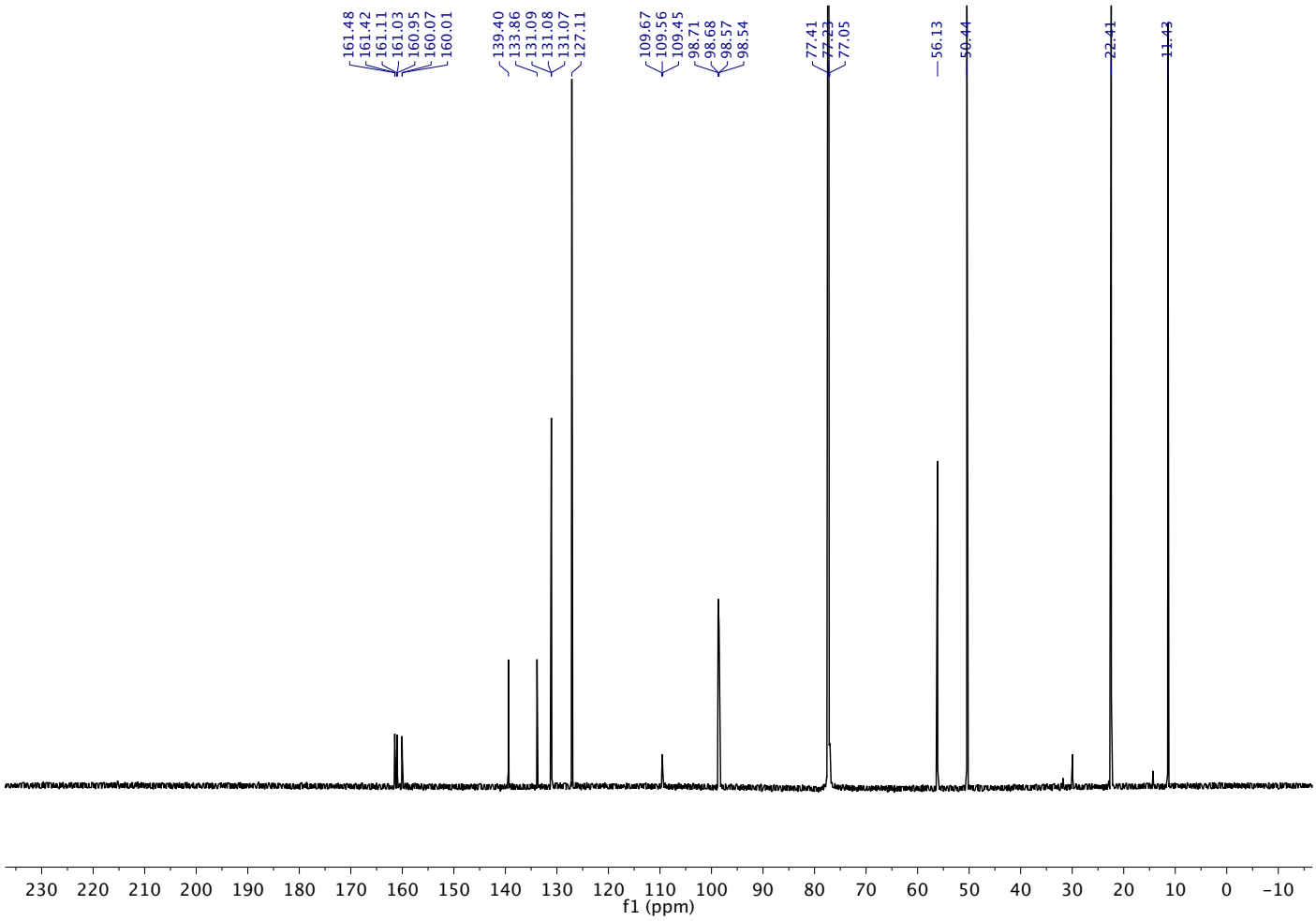
^{1}H NMR

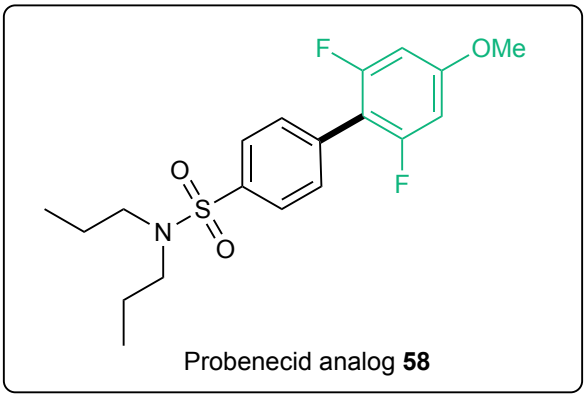




Probenecid analog **58**

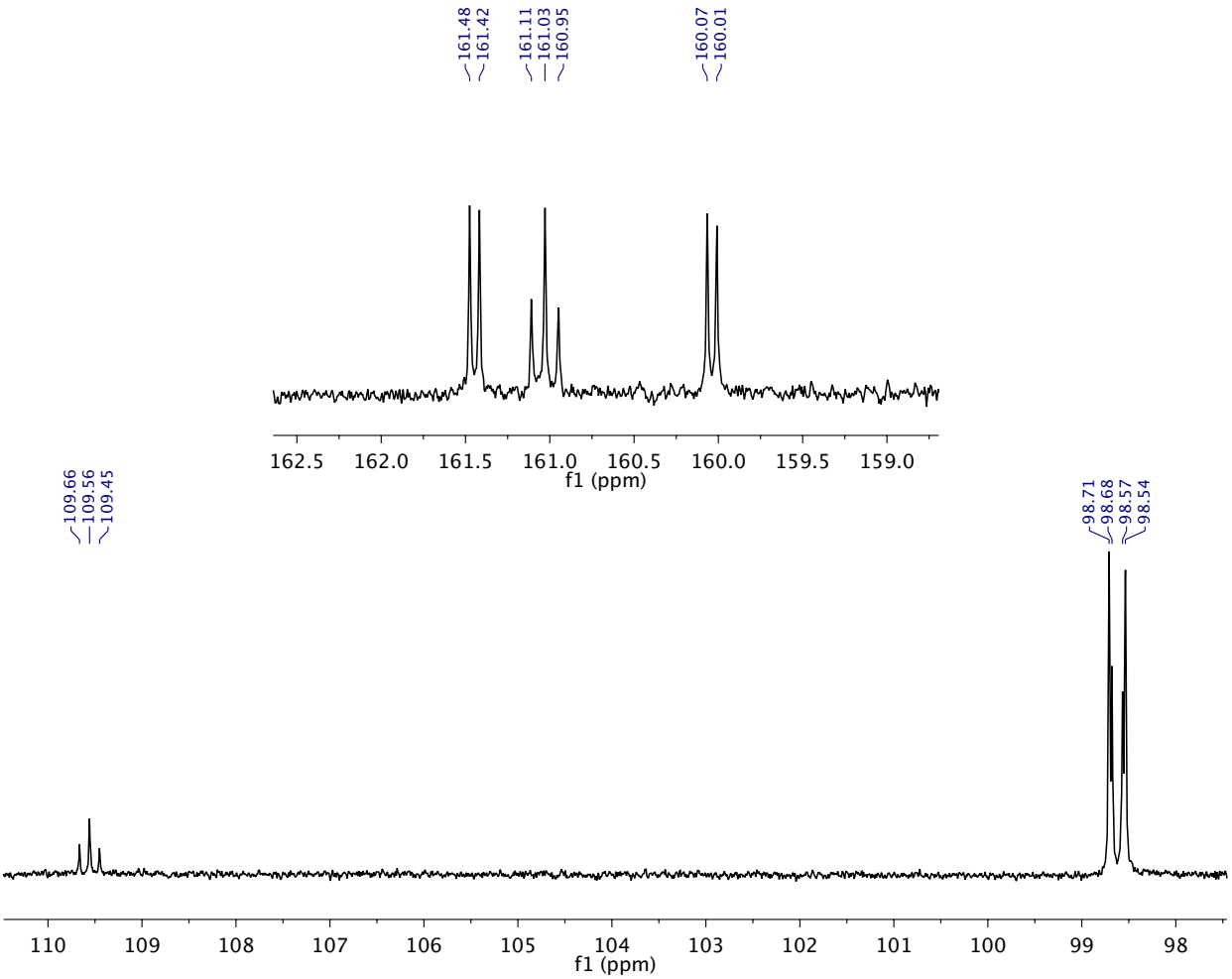
^{13}C NMR

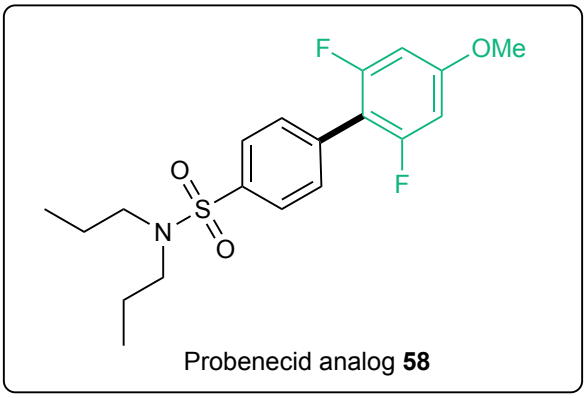




Probenecid analog **58**

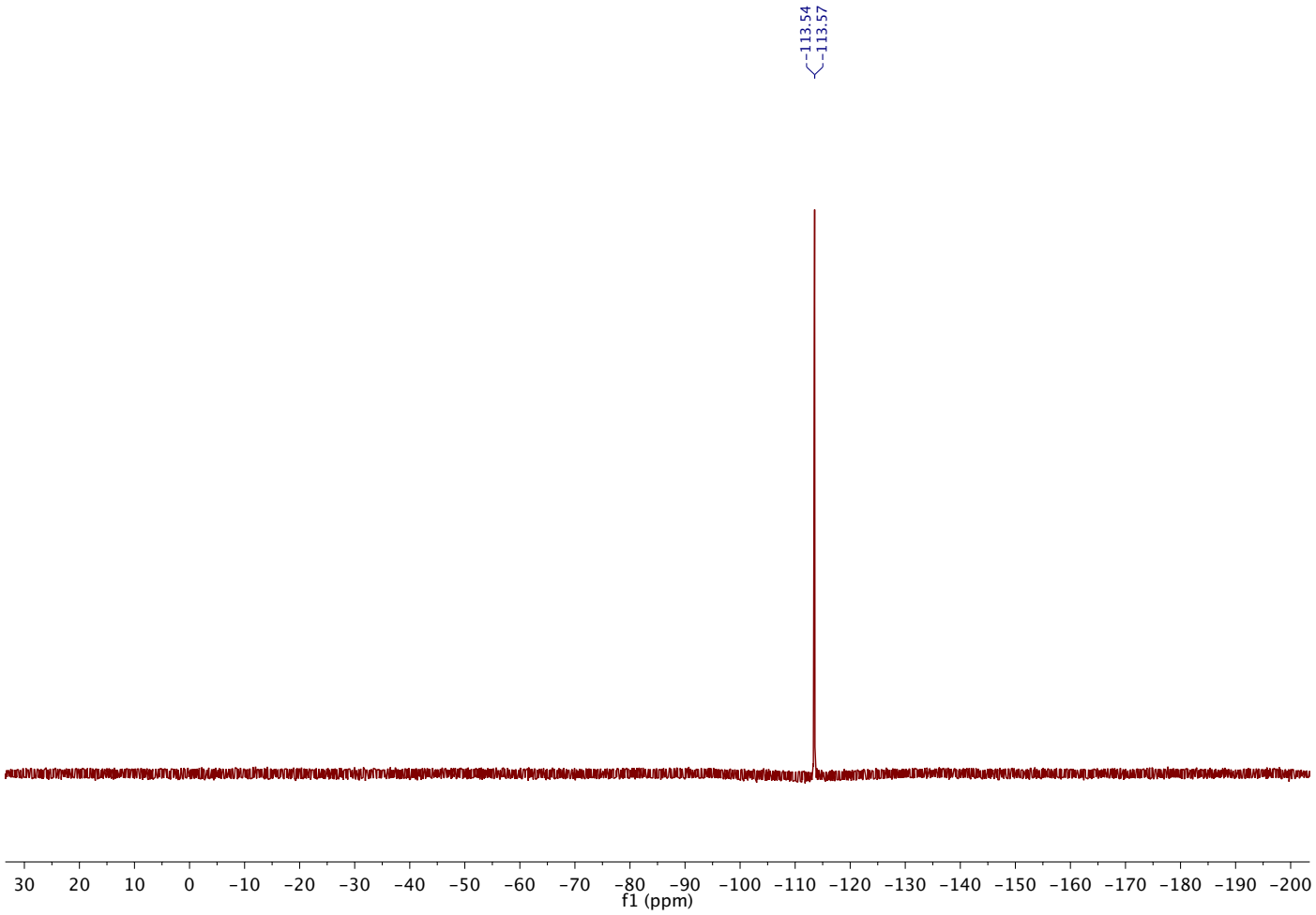
^{13}C NMR

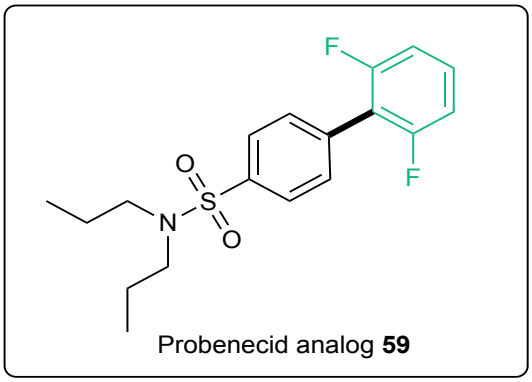




Probenecid analog **58**

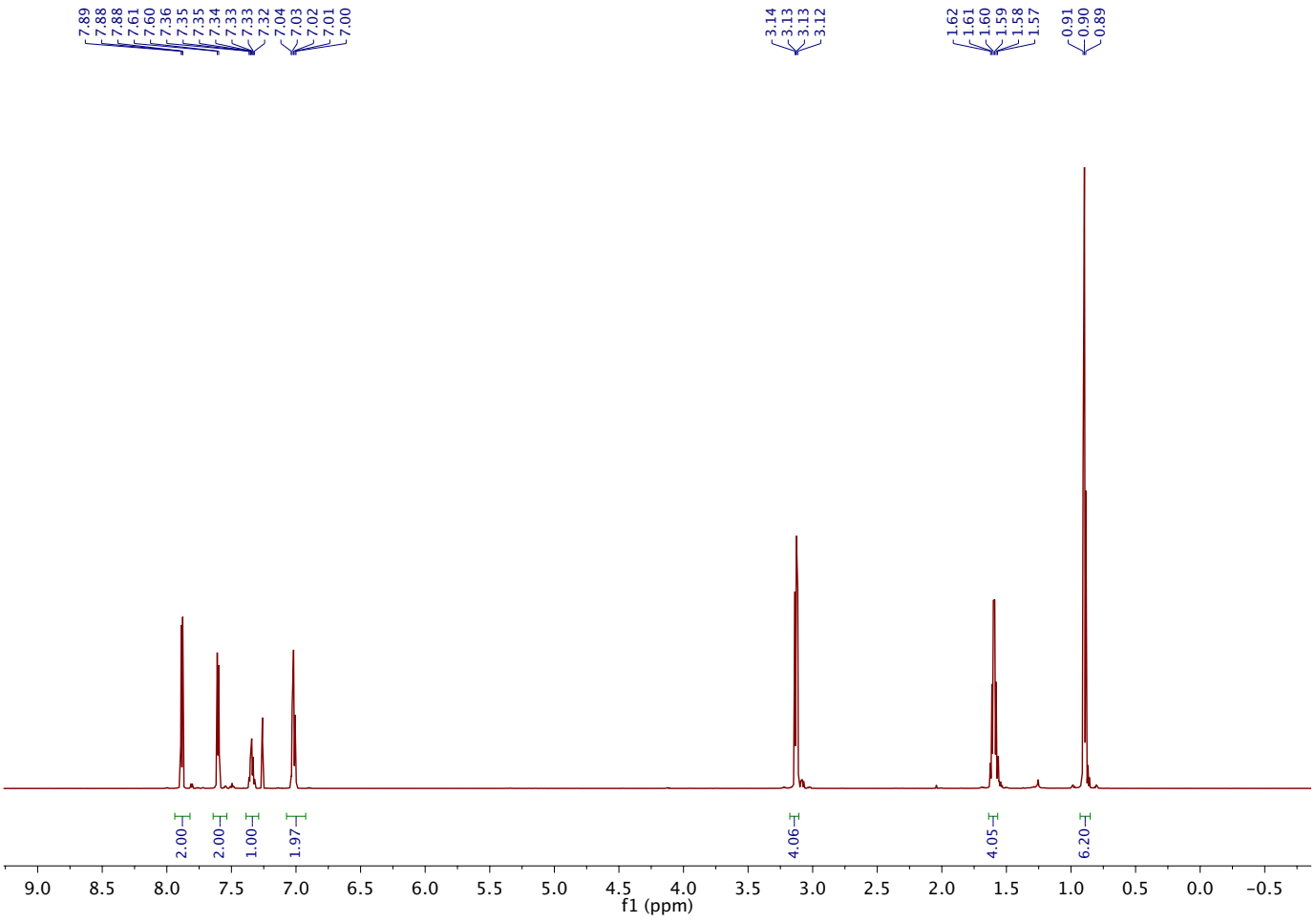
^{19}F NMR

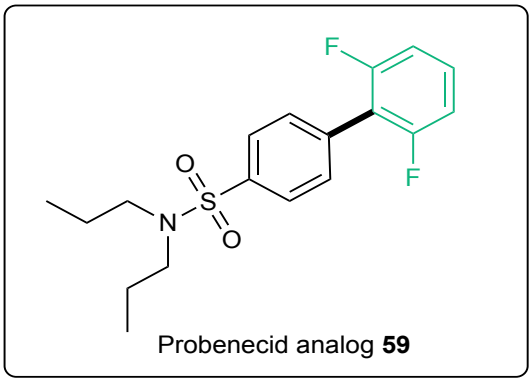




Probenecid analog **59**

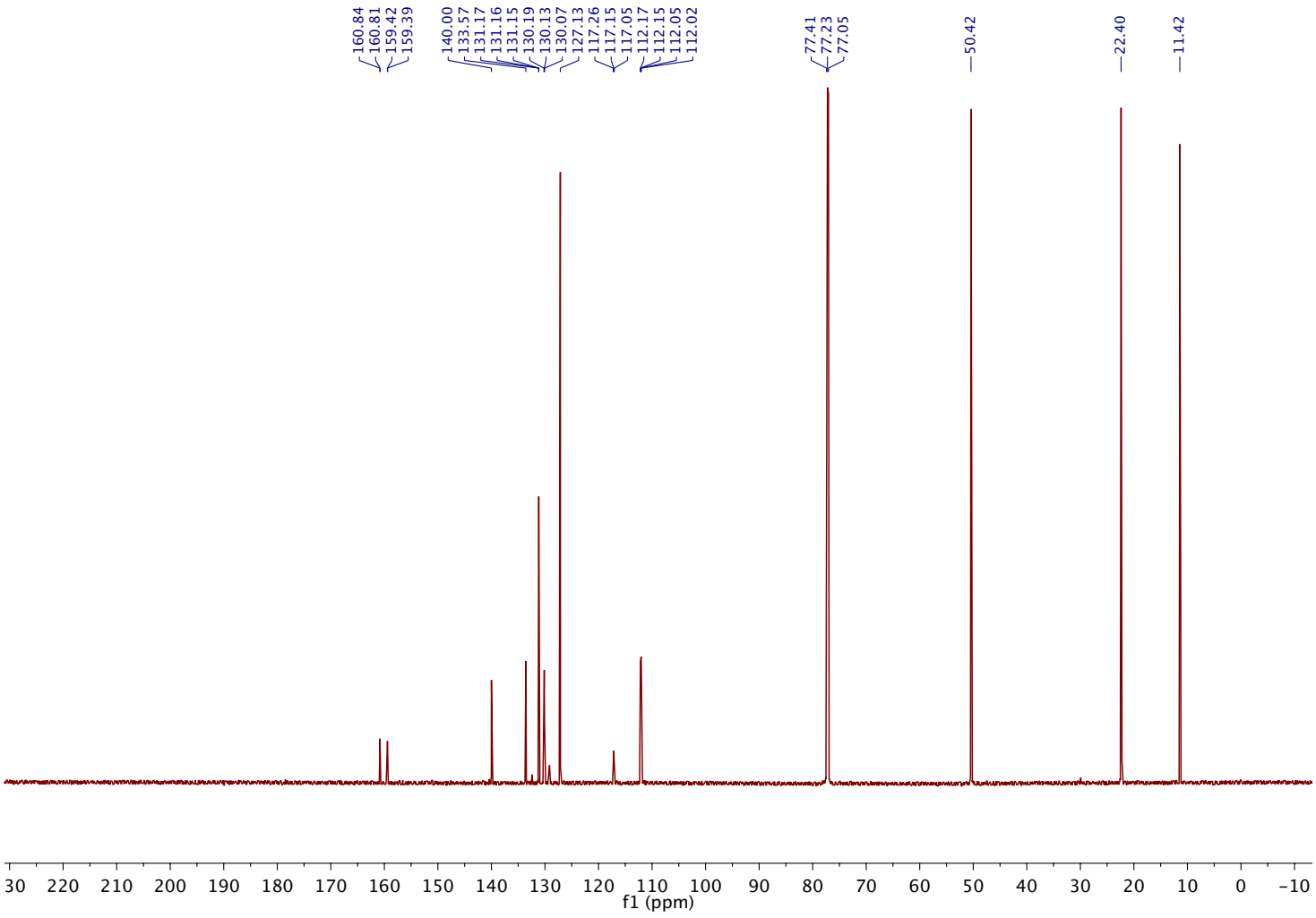
^{1}H NMR

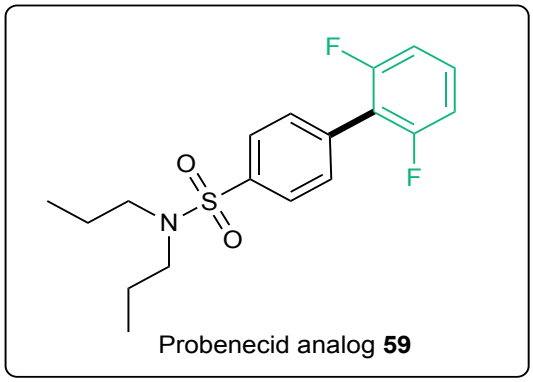




Probenecid analog **59**

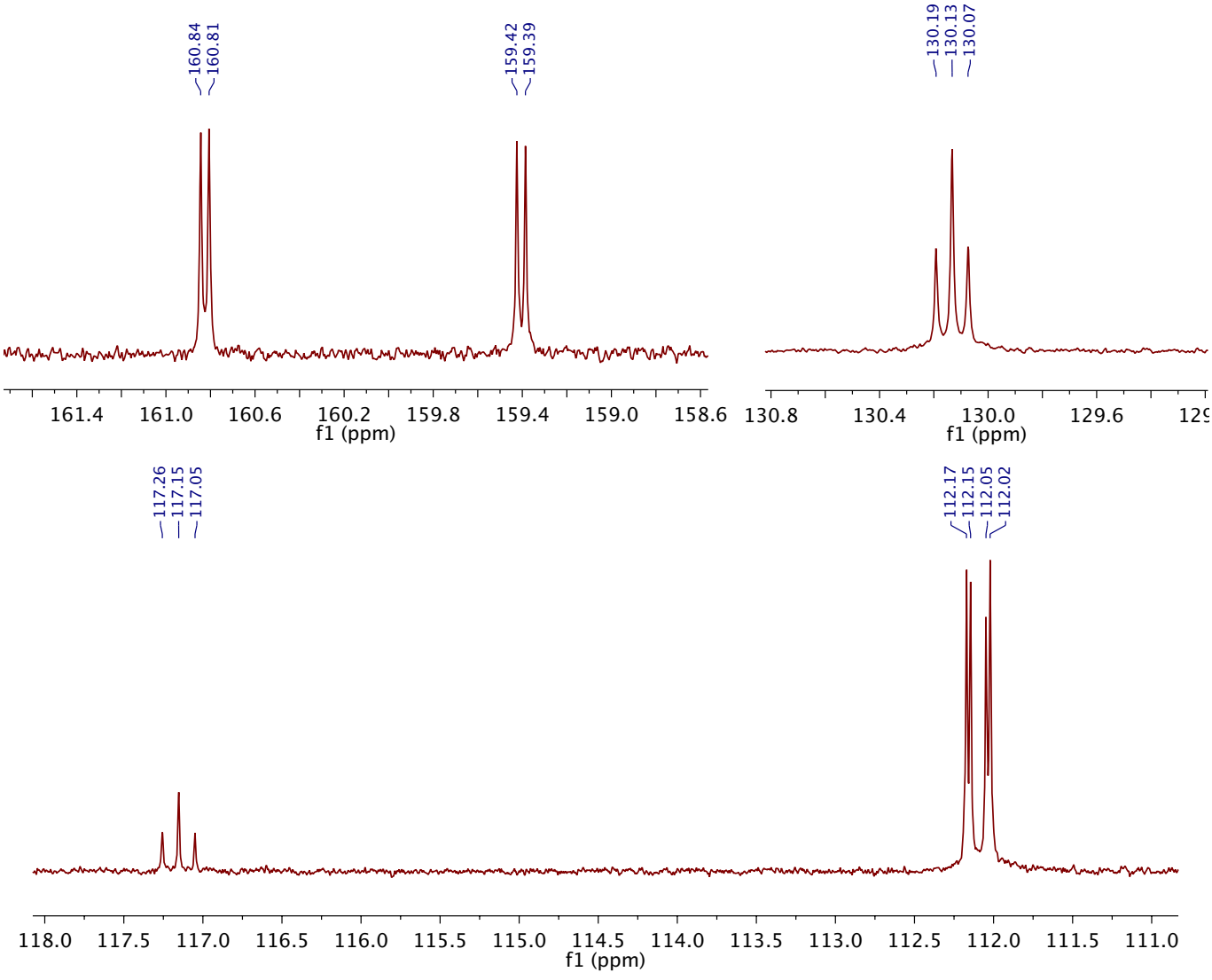
^{13}C NMR

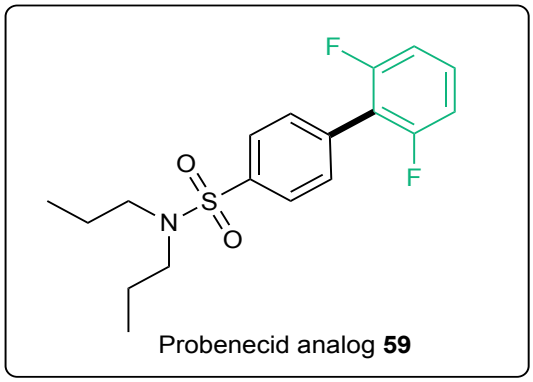




Probenecid analog **59**

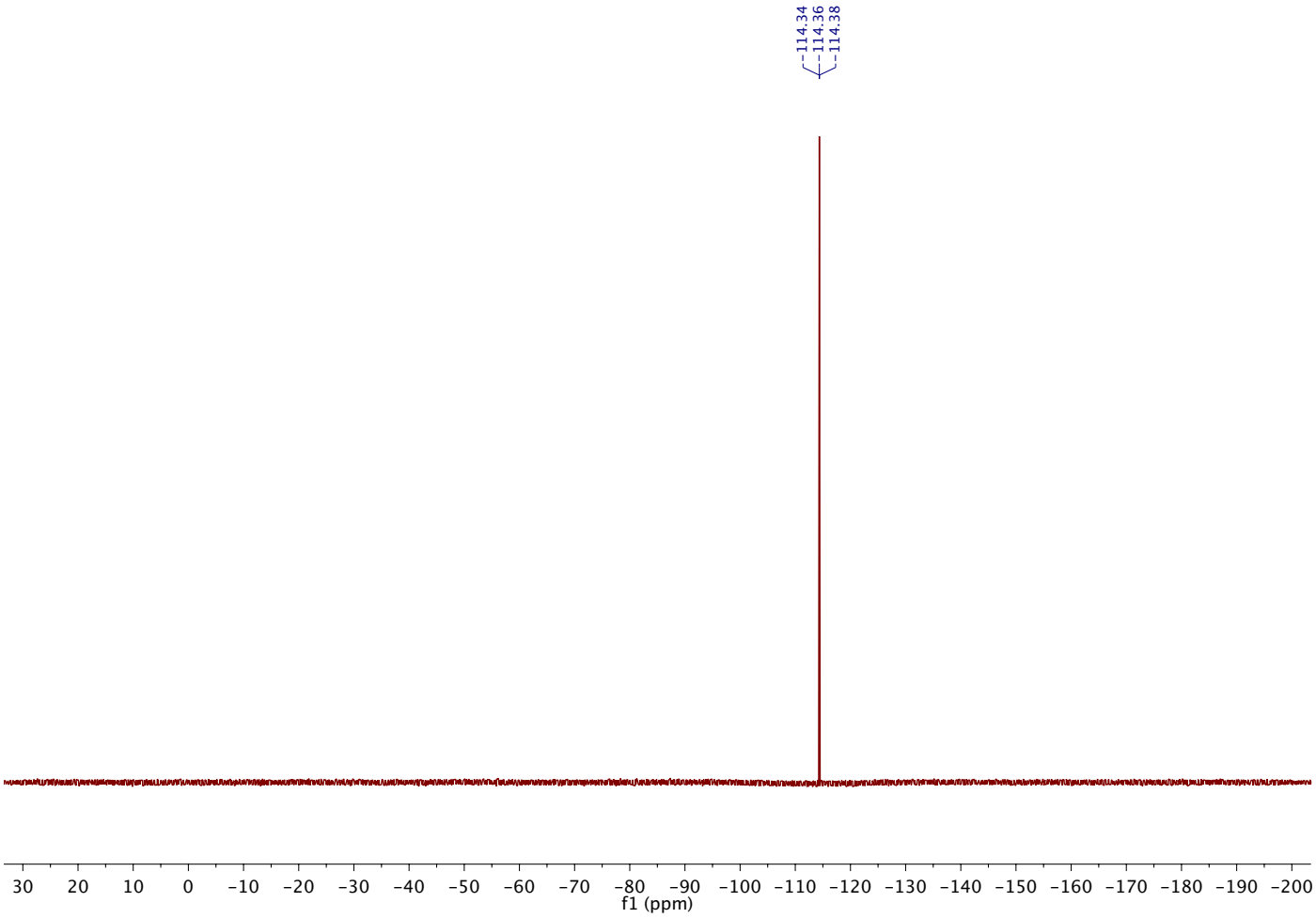
^{13}C NMR

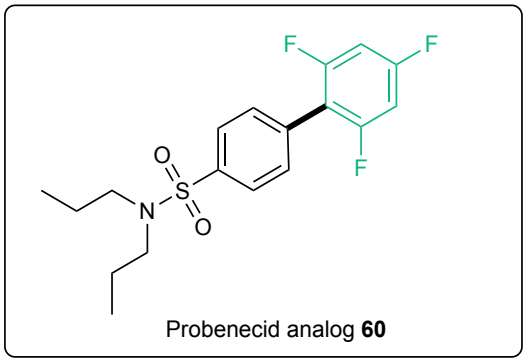




Probenecid analog **59**

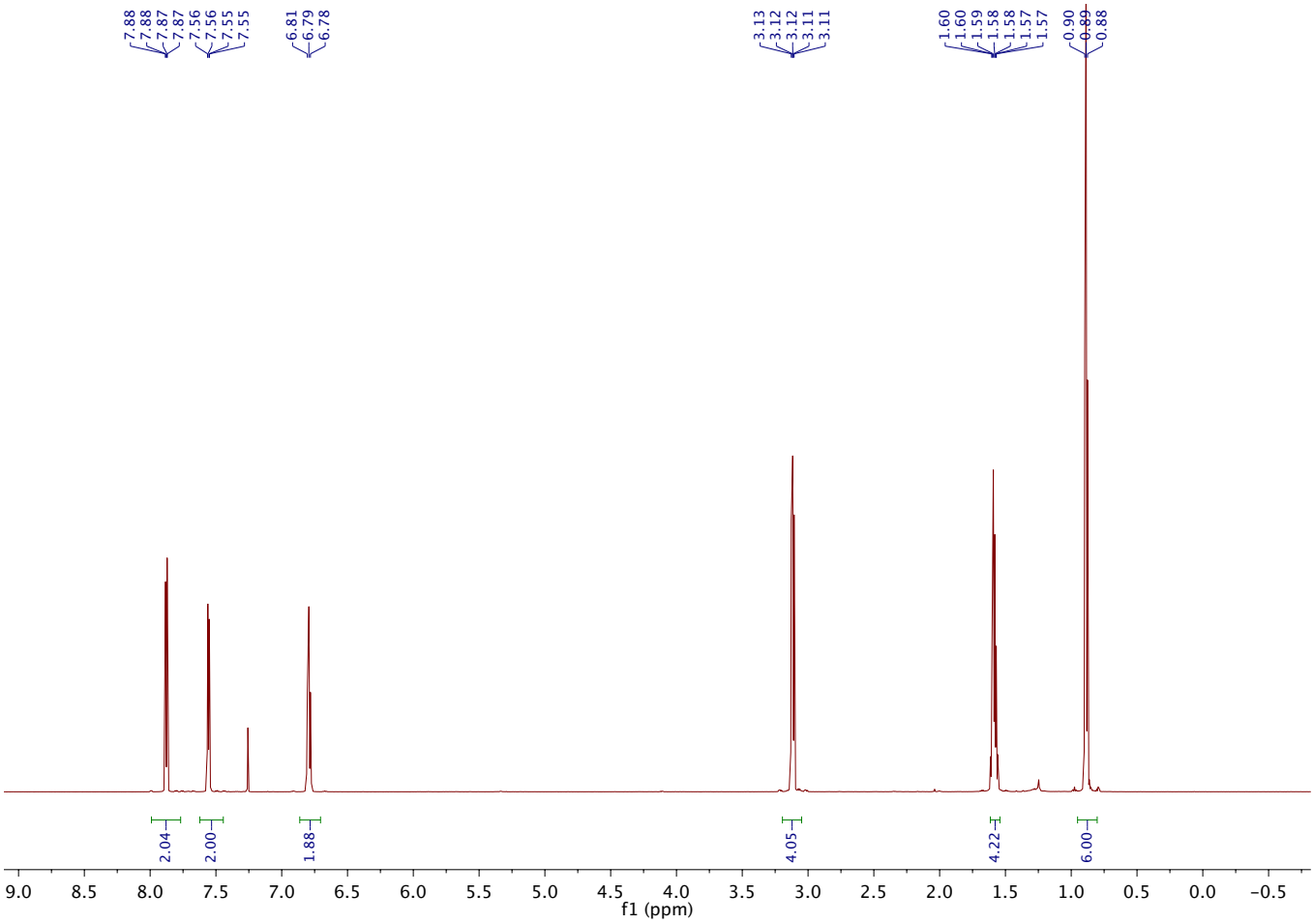
^{19}F NMR

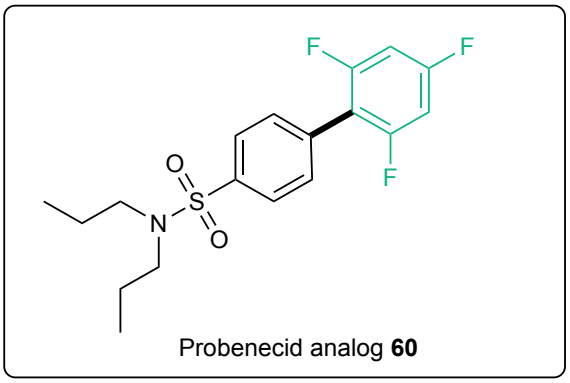




Probenecid analog **60**

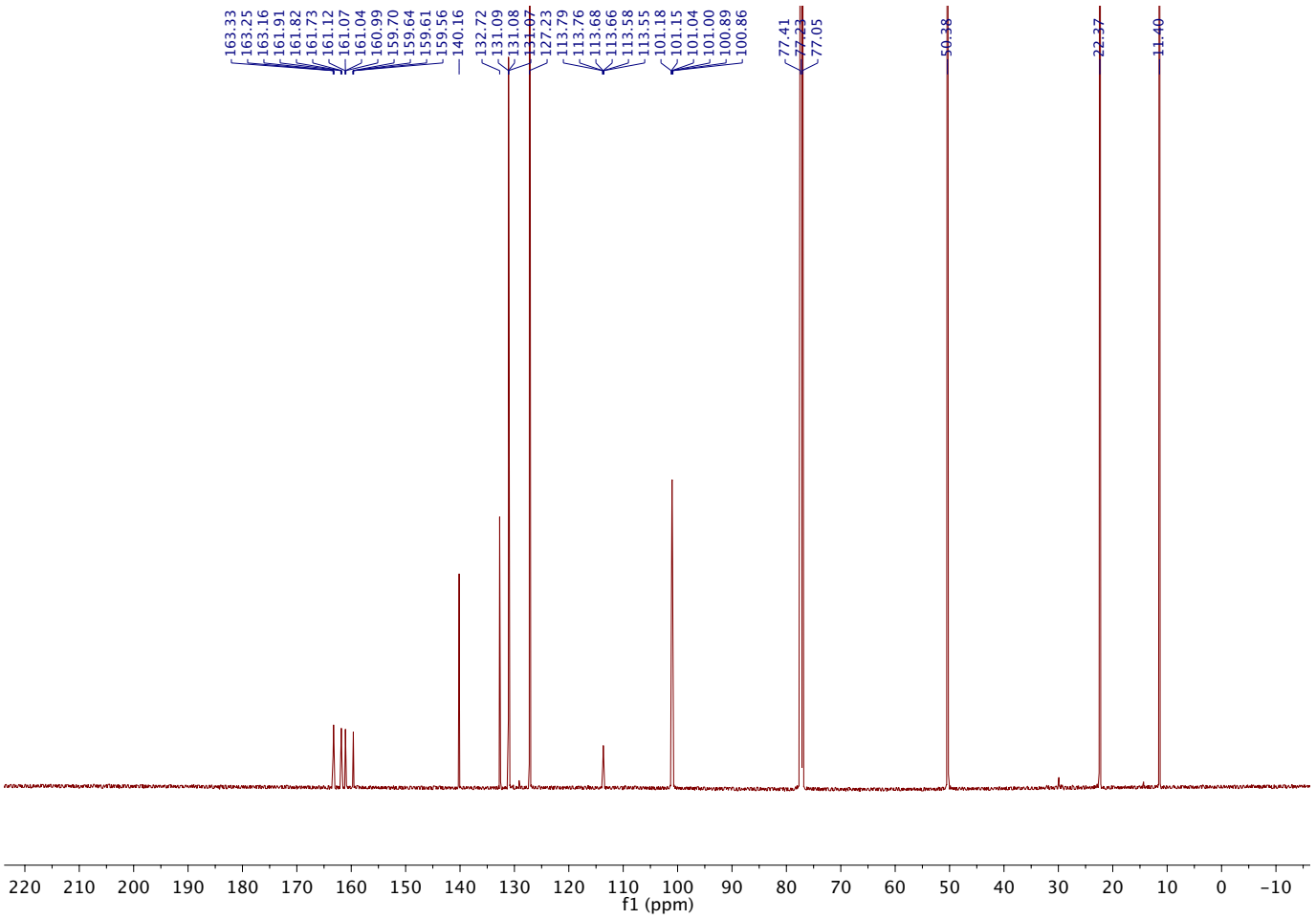
^{1}H NMR

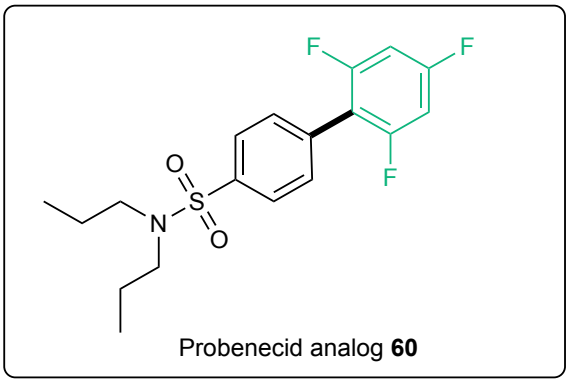




Probenecid analog **60**

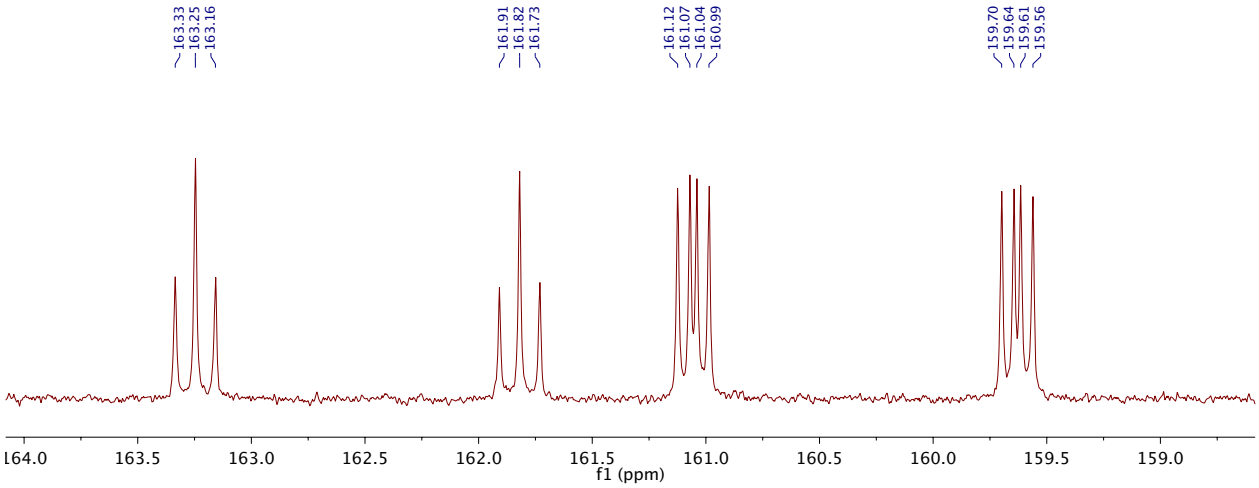
^{13}C NMR

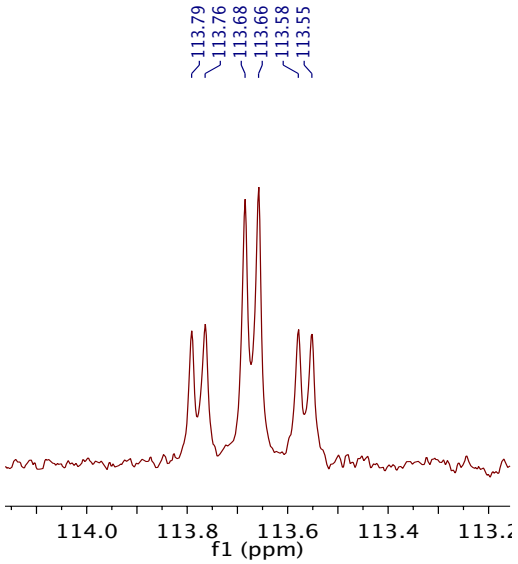


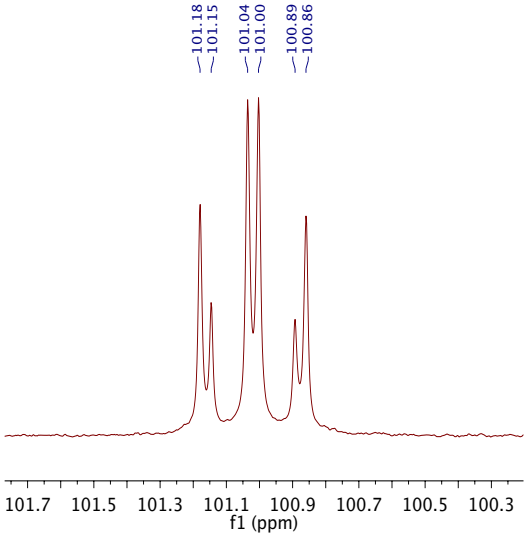


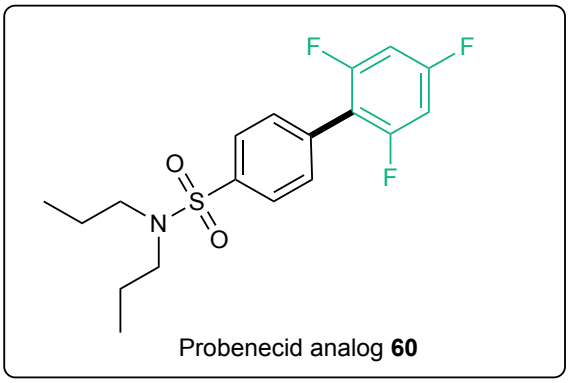
Probenecid analog **60**

^{13}C NMR



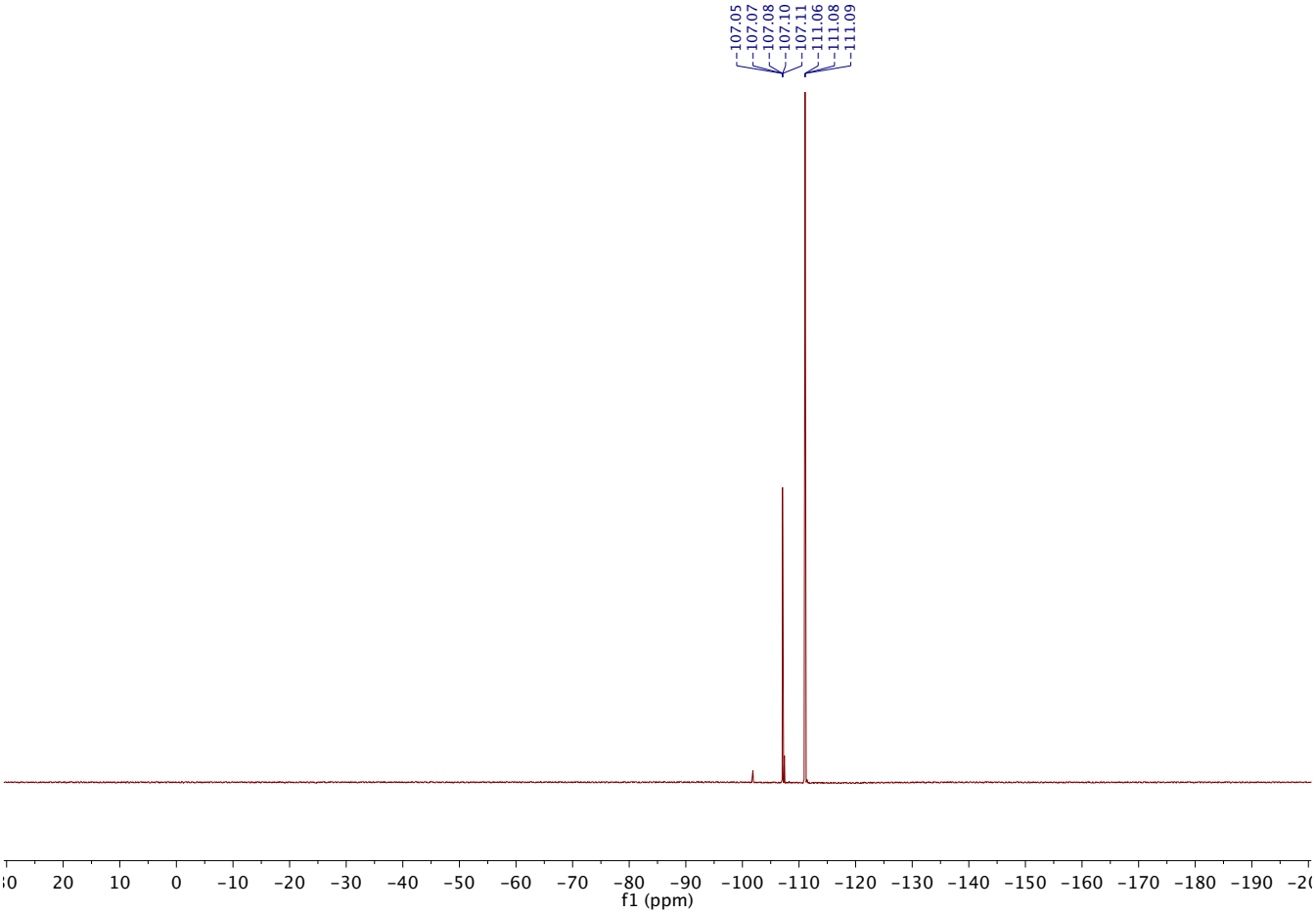


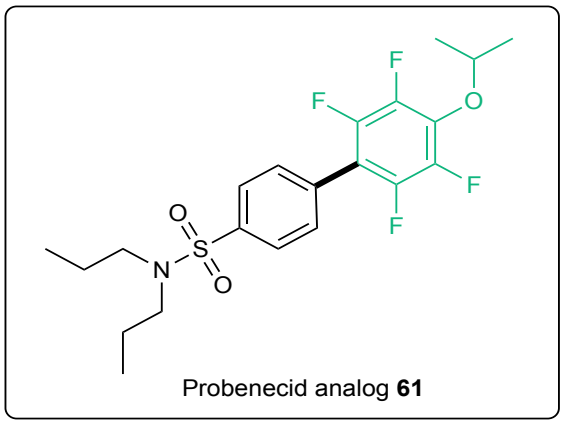




Probenecid analog **60**

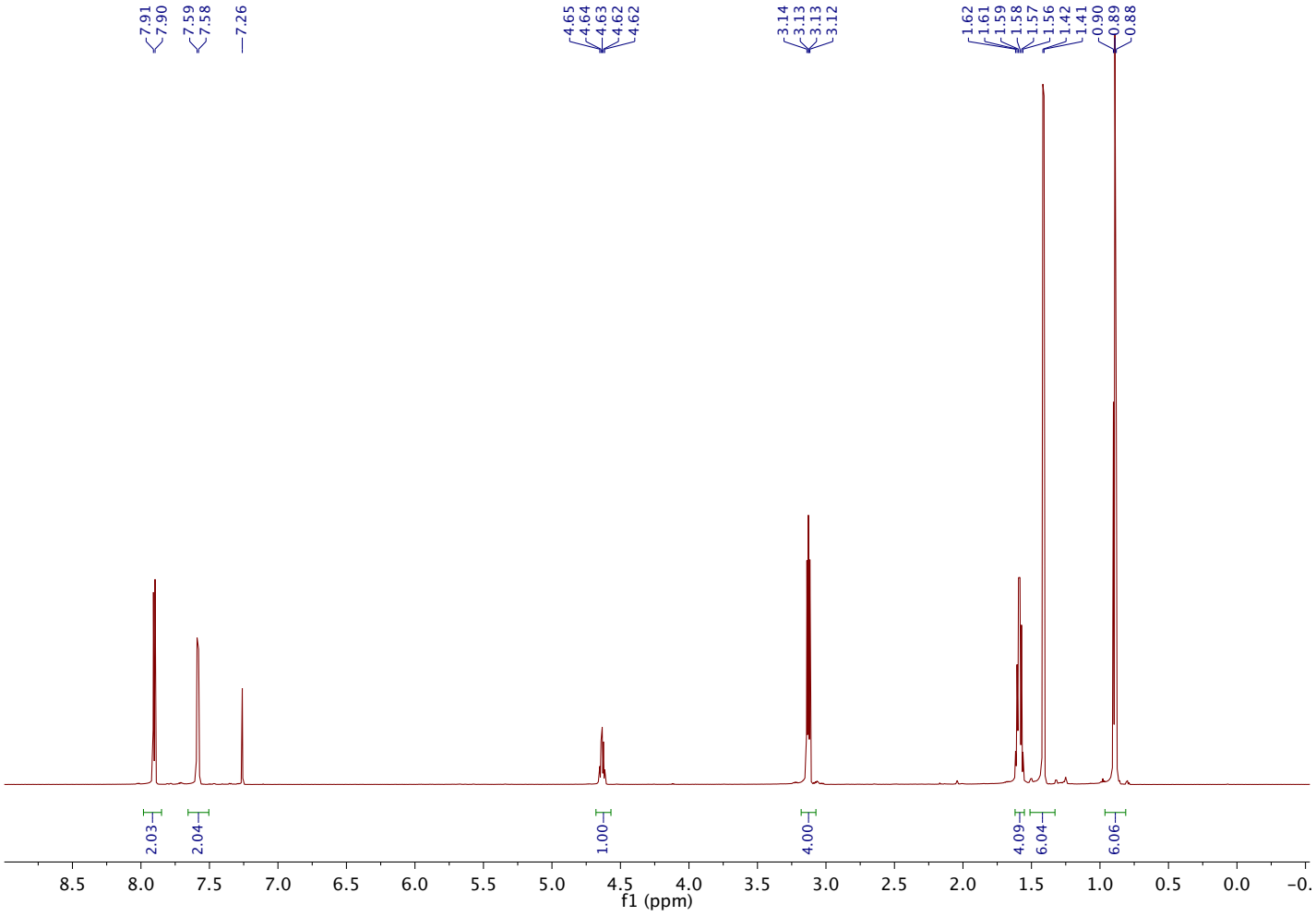
^{19}F NMR

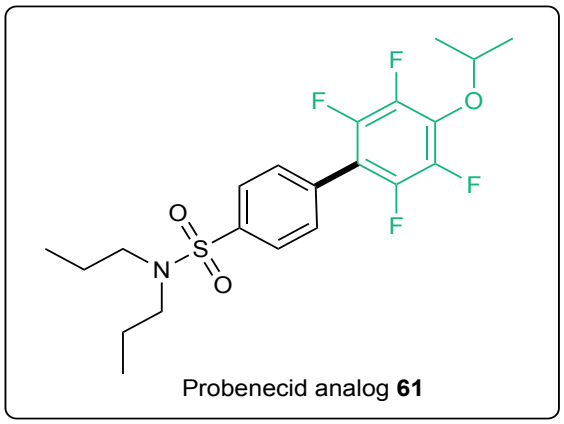




Probenecid analog **61**

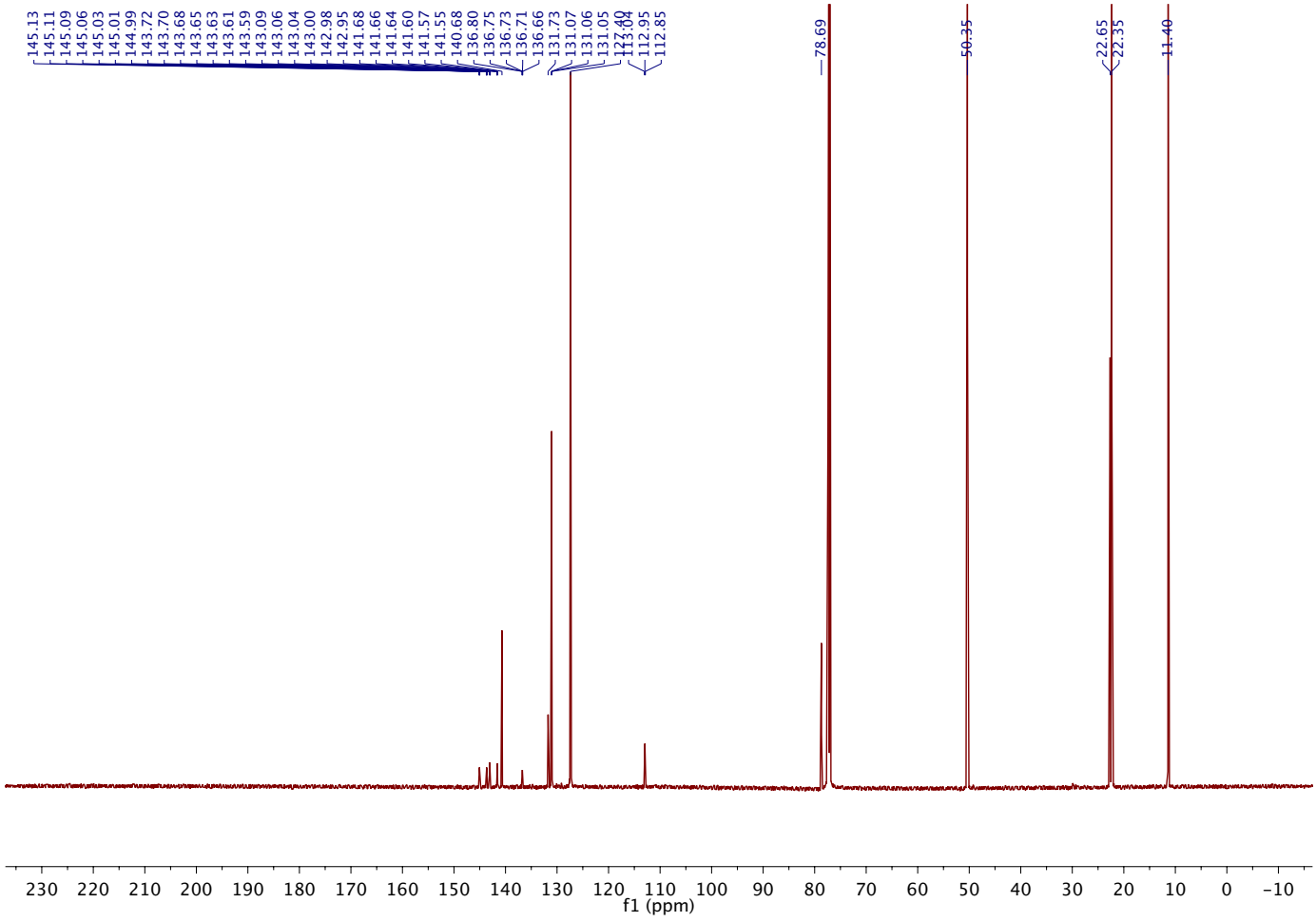
^{1}H NMR

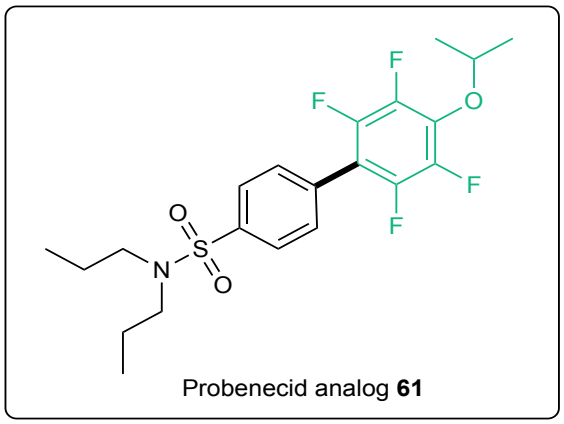




Probenecid analog **61**

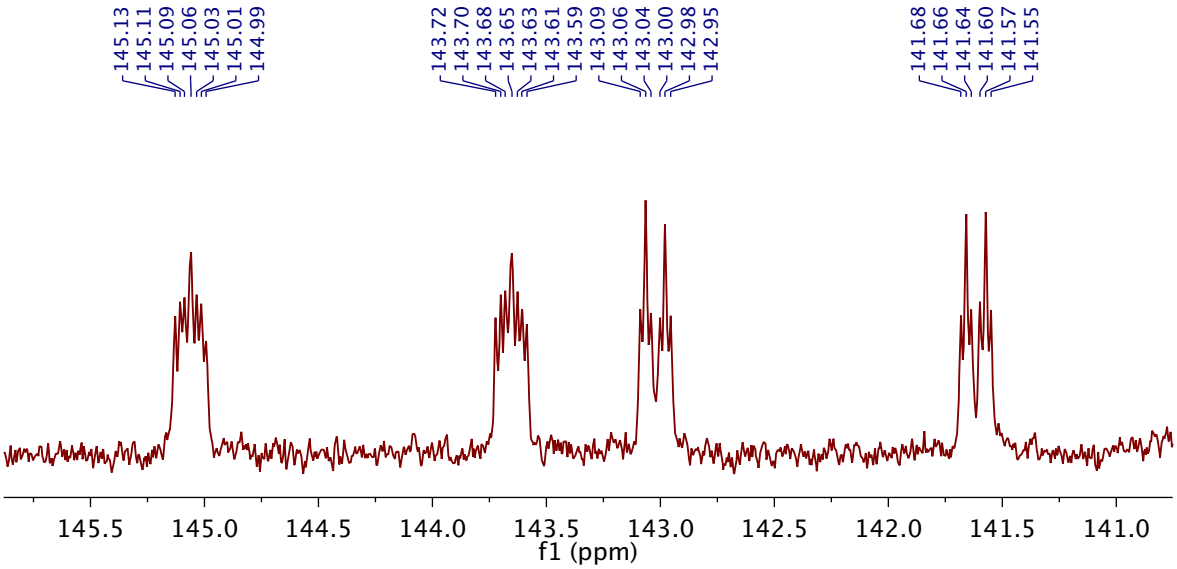
^{13}C NMR

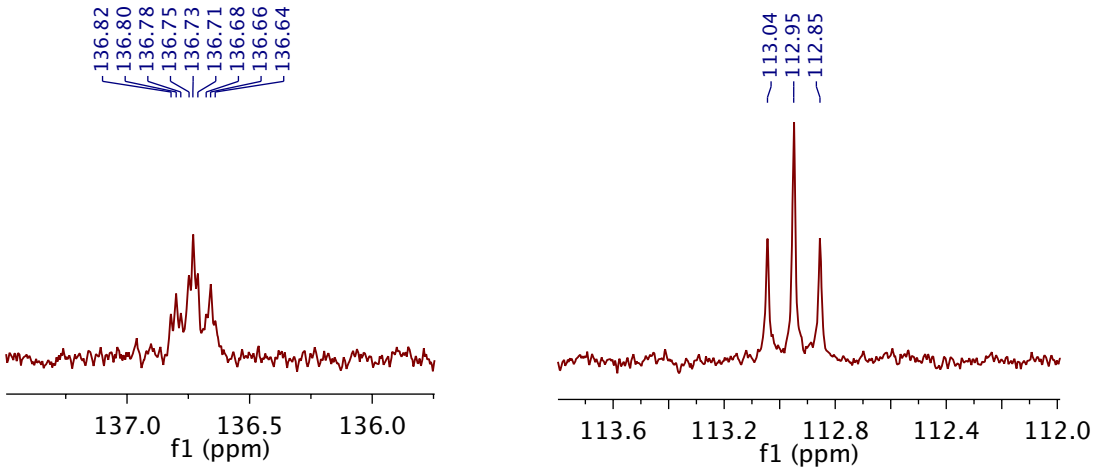


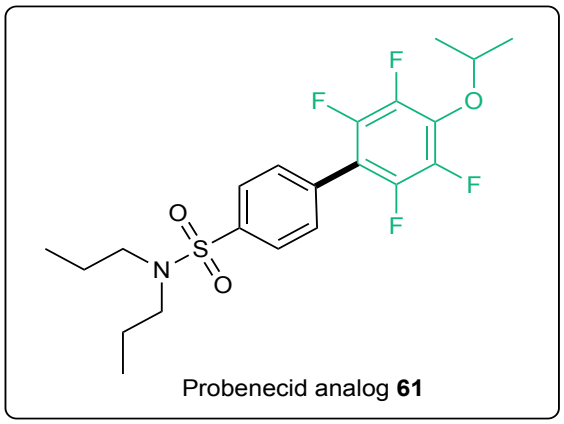


Probenecid analog **61**

^{13}C NMR

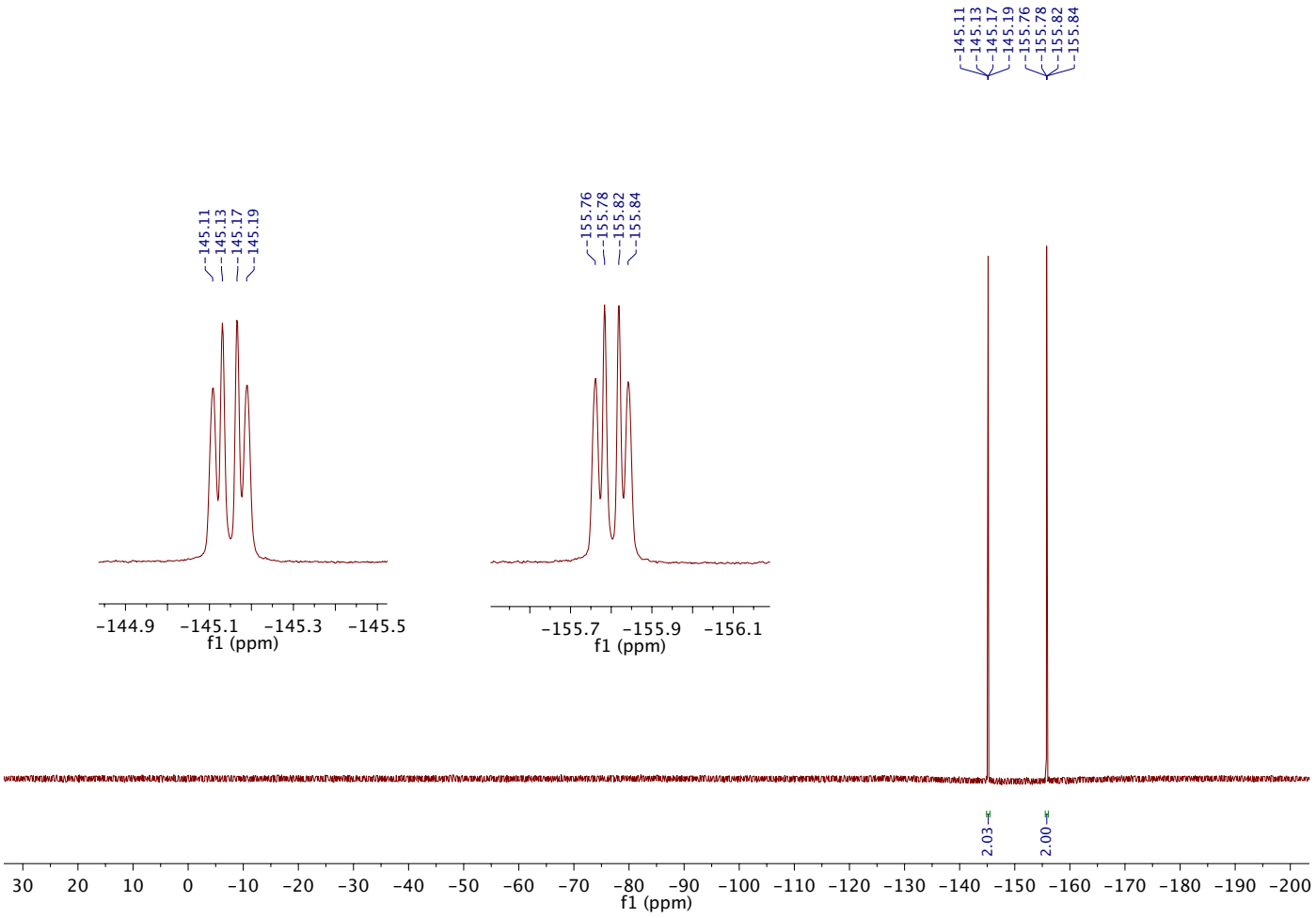


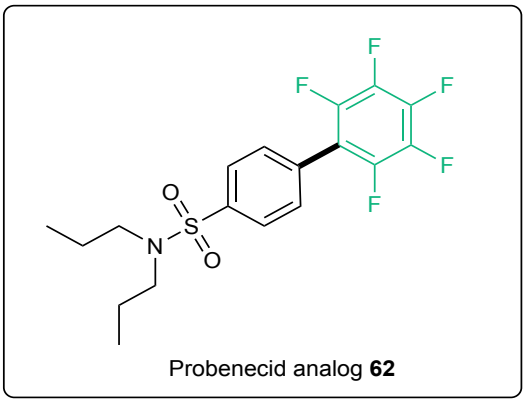




Probenecid analog **61**

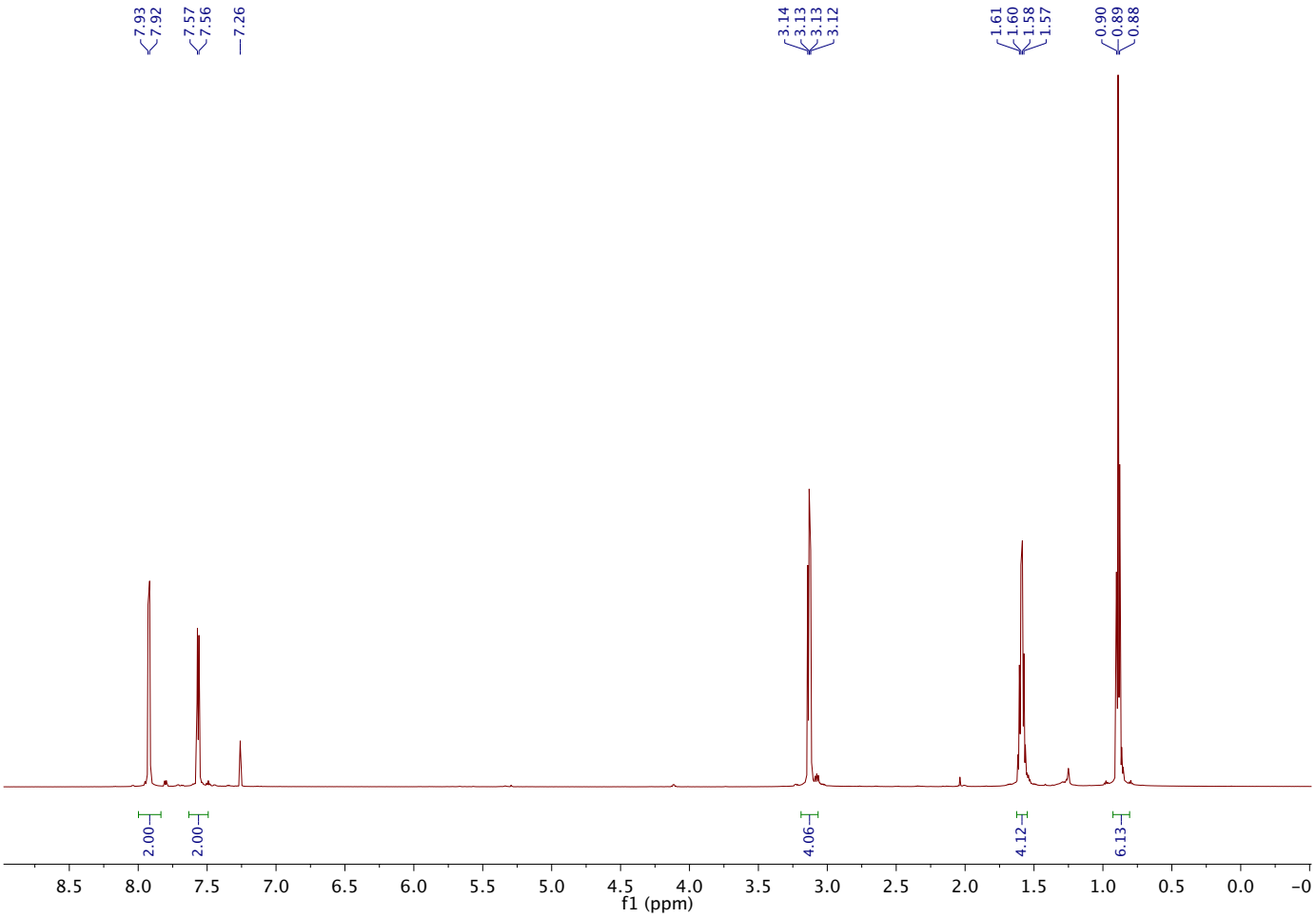
^{19}F NMR

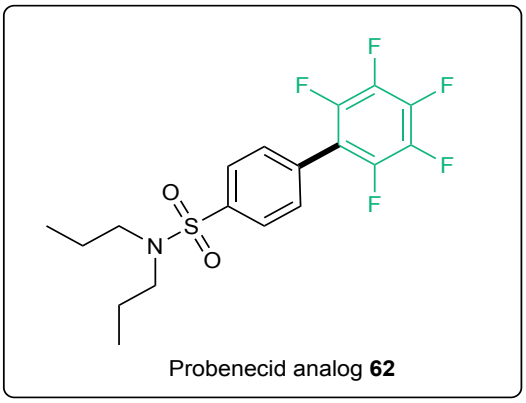




Probenecid analog **62**

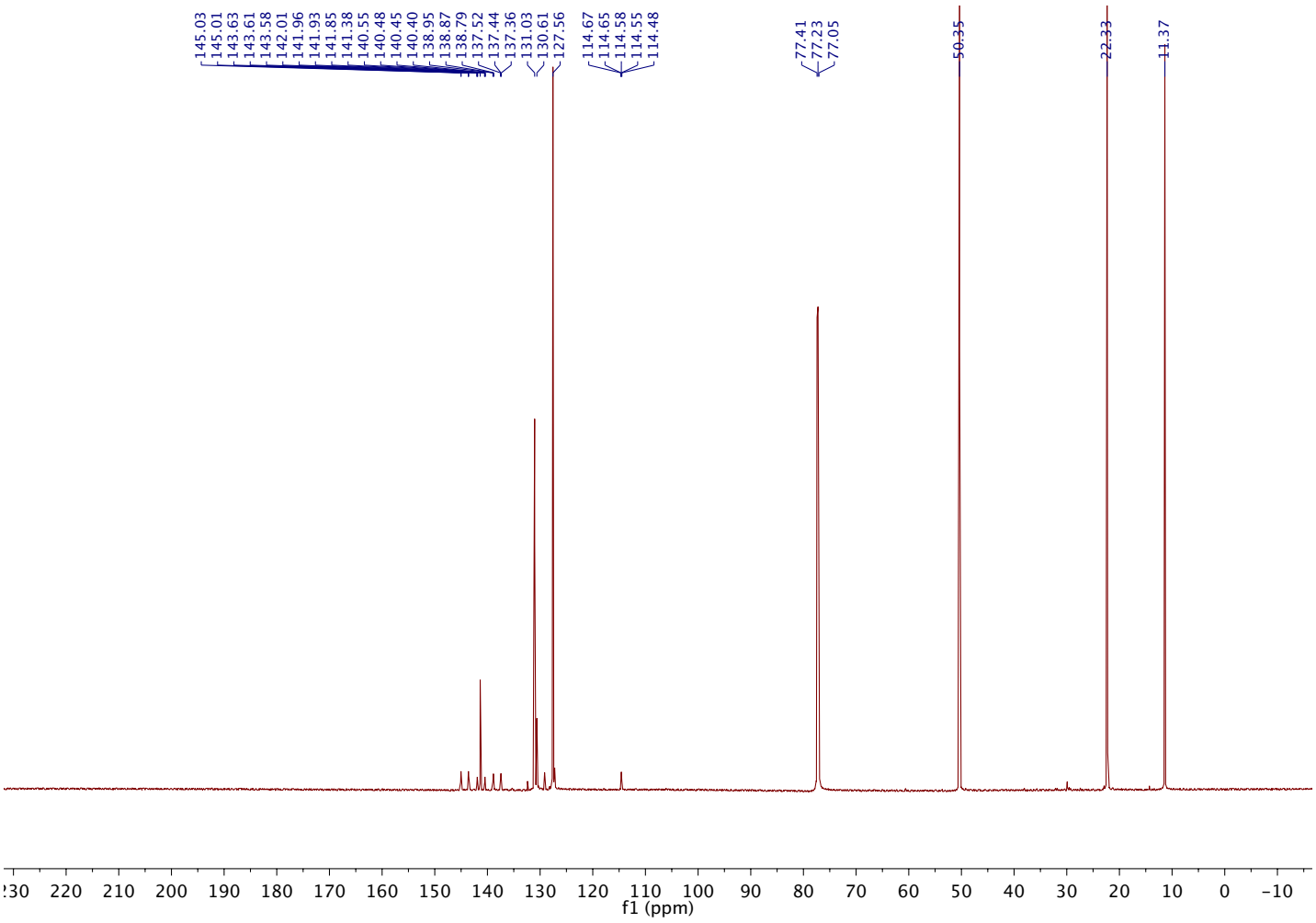
^{1}H NMR

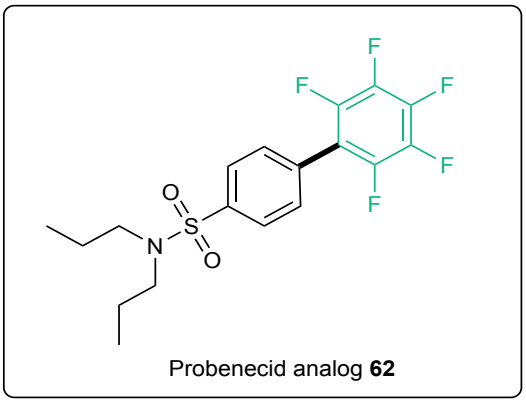




Probenecid analog **62**

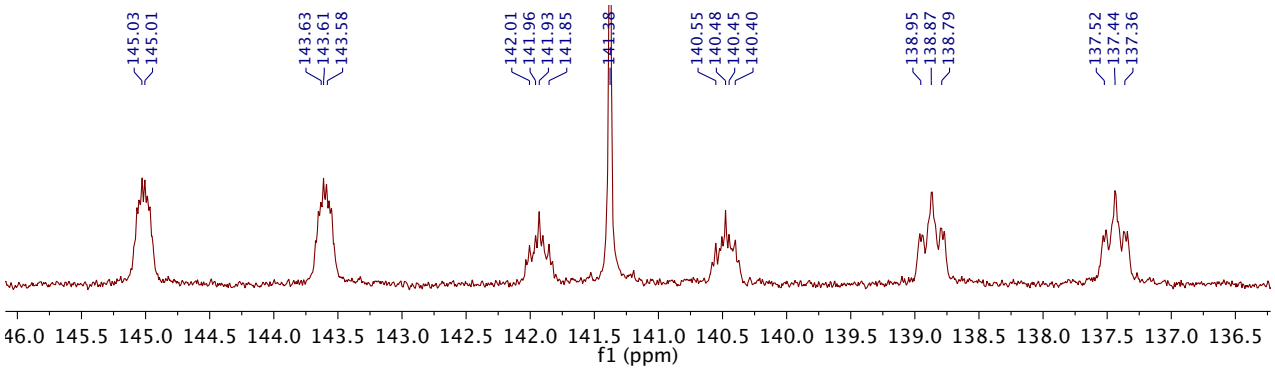
^{13}C NMR

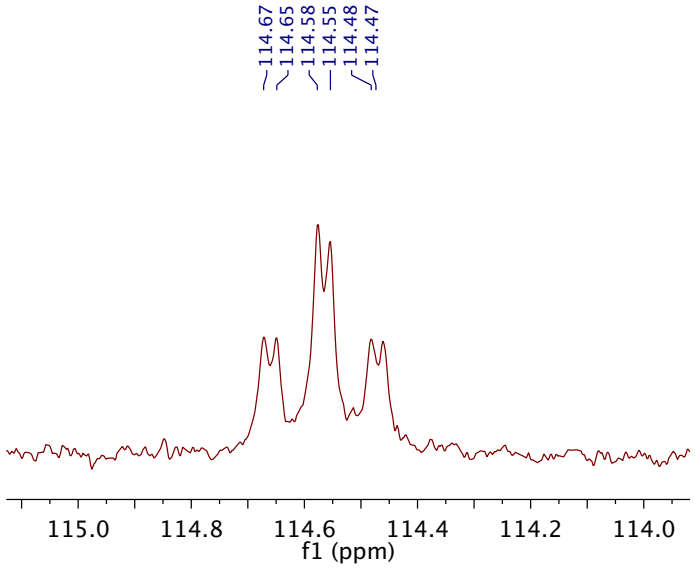


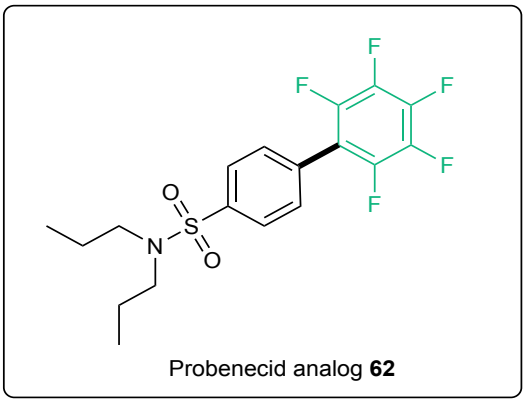


Probenecid analog **62**

^{13}C NMR







Probenecid analog **62**

^{19}F NMR