Hypervalent iodine chemistry with a mechanochemical twist

Sayad Doobary,* Miguel M. de Vries Ibáñez and Berit Olofsson *

Berit.Olofsson@su.se

SUPPORTING INFORMATION

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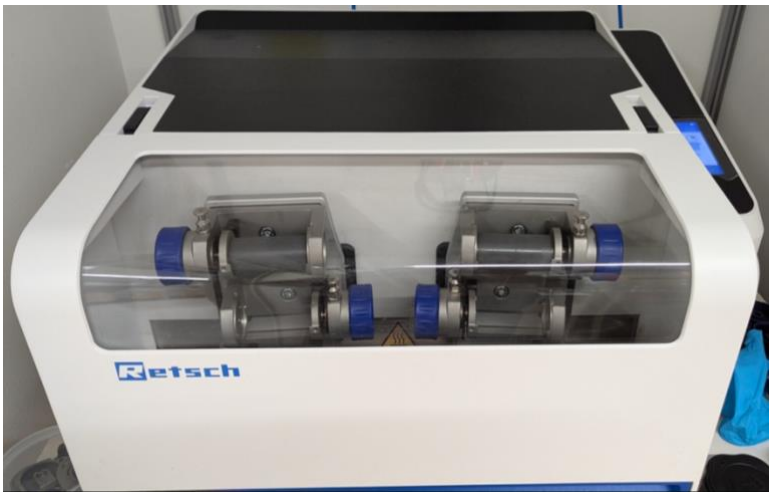
1. General experimental

The used reagents were bought from commercial suppliers and used as received, unless noted otherwise. Moisture and air sensitive reactions were carried out under argon or nitrogen environment using standard Schlenk techniques. Reactions performed above the boiling point of the solvent(s) were performed in pressure-stable microwave vials or using a standard condenser. Solvents were obtained as P.A. grade and dried using a VAC solvent purification system. *m*-CPBA (Aldrich, 77 % active oxidant) was dried under vacuum for 4 hours, after which the amount of active oxidant was determined through an iodometric titration.[1] Thin layer chromatography (TLC) was performed using TLC Silica gel 60 F254 plates (Merck) and visualized using UV-light and all TLC plates were stained with potassium permanganate stain. Purification of the products was conducted by flash column chromatography on SiO_2 purchased from Aldrich (technical grade, 60 Å pore size, 230-400 mesh). Melting points were measured using a STUART SMP3 and are reported uncorrected. NMR measurements were conducted using a 400 MHz Bruker AVANCE II with a BBO probe at 298 K unless otherwise stated. Chemical shifts (δ) are reported in parts per million (ppm) and referenced $CDCl_3$ (^{1}H: 7.26 ppm; ^{13}C: 77.0 ppm), DMSO-d_6 (^{1}H: 2.50 ppm; ^{13}C: 39.5 ppm) or MeOD-d_6 (^{1}H: 3.31 ppm; ^{13}C: 49.0 ppm). Coupling constants (*J)* are given in Hertz (Hz) and refer to apparent multiplicities (s = singlet, d = doublet, t = triplet, q = quartet, pent = pentet, m = multiplet, br = broad signal, and combinations thereof for example, dd = doublet of doublets.) HRMS spectra were measured on a Bruker microTOF with electron spray ionization (ESI). Retsch MM500 vario and Retsch MM2 were utilised for all ball milling reactions. Ball milling vessels were purchased as standard from Retsch. 1-Butyl-3-methylimidazolium tetrafluoroborate abbreviated to BMIM•BF_4. Petroleum ether (40-60) is abbreviated as PE throughout this supporting information.
The frequencies utilised under different protocols vary from 25 Hz to 35 Hz. This is because we aimed to use the lowest possible frequency to conduct our reactions in a timely manner to preserve the lifetime of the equipment.
Organic bases (e.g. DBU and TMG) can be utilised in most of the transformations, but it is established routine in our lab to avoid the use of liquid, organic bases due to the increased reactivity under mechanochemical conditions, often resulting in impure products and more difficult purifications.

Calculation of LAG amounts:
The amounts of LAG are calculated as μL/mg. This refers to the μL of LAG per mass of all other reagents added to the reaction.

Safety and hazard statement:
In general, care and attention must be considered when attempting to scale up mechanochemical transformations. There are a number of reports in the literature of large exotherms being produced during mechanochemical procedure.[2–5] Whilst this has certainly never been observed under our reaction conditions, it cannot be ruled out. A recent study by Waser and coworkers illustrates the utility of TGA and DSC measurements to characterise the probability of violent decomposition of many key hypervalent iodine intermediates.[6] Furthermore it is advised to carry out the safety protocol and procedure as described by Browne and coworkers.[7] HFIP is suspected of damaging fertility and can causes severe eye damage, so need to be used inside a ventilated fumehood.

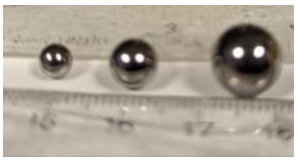
2. Mechanochemical setup



Retsch MM500 vario used as a ball milling device.

Retsch MM2 used as a ball milling device.

Retsch ball milling vessels. 1.5 mL (left) and 5 mL (right).



Retsch ball milling stainless steel balls. 5 mm (left), 7 mm (middle) and 10 mm (right).

3. Optimisation of different types of reactions

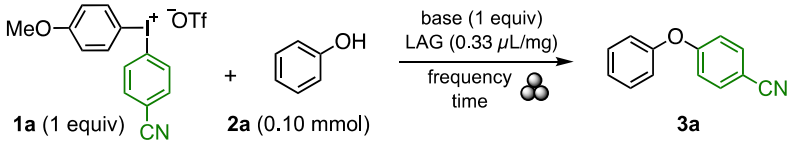
During the course of this optimisation, we found it was possible to carry this reaction out with a phenyl dummy ligand but chose to opt for the anisyl ligand due to consistency throughout the reported works.

3.1 *O*-Arylation optimisation

General procedure for the optimisation: Sodium carbonate (10.6 mg, 0.10 mmol, 1.0 equiv), phenol (**2a**, 9.4 mg, 0.10 mmol, 1.0 equiv), diaryliodonium salt **1a** (48.8 mg, 0.10 mmol, 1.0 equiv) and one 7 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for a given time at a given frequency. 1,3,5-Trimethoxybenzene (TMB, 1 equiv) was added to the vessel as internal standard, $CDCl_3$ was added and a crude NMR of the solution was recorded. The yield of **2a** was determined using TMB as the internal standard.

The optimisation details are given in Table S1. We found that the most important variable was the addition of the right liquid additive (LAG), which in general was used in 0.33 μL/mg = 20 μL. The most efficient process had EtOAc as the LAG, in combination with potassium carbonate as base (entry 25).

Table S1. Optimization of frequency and LAG.

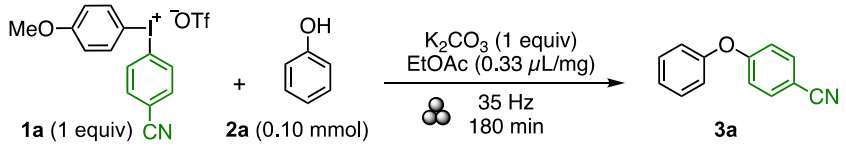


Entry	Time (min)	Frequency (Hz)	Base (1 equiv)	LAG (0.33 μL/mg)	NMR yield (%)
1	30	15	Na_2CO_3	/	4
2	30	25	NaO^tBu	/	5
3	30	25	NaOH	/	5
4	30	20	Na_2CO_3	/	6
5	30	25	Na_2CO_3	/	8
6	30	30	Na_2CO_3	/	10
7	30	35	Na_2CO_3	/	15
8	30	30	Na_2CO_3	THF	10
9	30	35	Na_2CO_3	THF	23
10	30	35	Na_2CO_3	Toluene	40
11	30	35	Na_2CO_3	MeCN	35
12	30	35	Na_2CO_3	EtOAc	40
13	30	35	Na_2CO_3	MeOH	39
14	30	35	Na_2CO_3	Cyclopentanone	28
15	30	35	Na_2CO_3	EtOAc (10 μL)	33
16	30	35	Na_2CO_3	EtOAc (30 μL)	41
17	30	35	Na_2CO_3	EtOAc (40 μL)	35
18	30	35	Na_2CO_3	EtOAc (50 μL)	20
19	180	35	Na_2CO_3	EtOAc	60
20	180	35	NaO^tBu	EtOAc	55
21	180	35	LiO^tBu	EtOAc	25
22	180	35	NaOH	EtOAc	44

23	180	35	KO^{t}Bu	EtOAc	69
24	180	35	NEt_3	EtOAc	40
25	**180**	**35**	**K_2CO_3**	**EtOAc**	**88**

The jar and ball size, and number of balls were then varied (Table S2). It was observed that the reaction was not very sensitive to either jar size or ball size. However, when two stainless steel balls were used with either 1.5 mL or 5 mL jars, the yields were markedly lower. This could be due to the balls becoming stuck inside the jars and effectively stopping the milling.

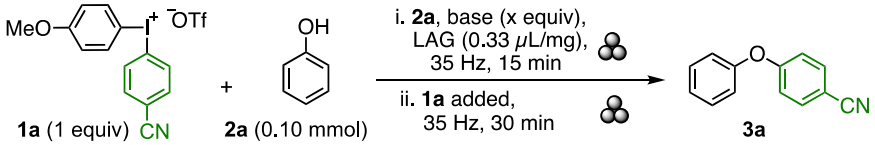
Table S2. Optimization of jar and ball size.



Entry	Jar size (mL)	Ball size (mm)	Number of balls	NMR yield (%)
1	1.5	7	1	88
2	1.5	5	1	87
3	1.5	5	2	63
4	5	10	1	90
5	5	7	1	89
6	5	5	1	90
7	5	5	2	85

In an effort to reduce the reaction time, a pre-mill of **2a** and base was performed to separate the deprotonation from the arylation step (Table S3). With 15 min deprotonation pre-mill and 30 min reaction time, the reaction time was reduced to just 45 min instead of 180 min (entry 1). An increase in the number of equivalents of base, does not increase the reaction yield (entry 2). To ascertain whether the 45 mins reaction time alone contributes to the reaction outcome, the reaction without pre-milling was carried out for 45 mins leading to a lower yield (entry 3). A scale-up from 0.1 mmol to 0.30 mmol resulted in a similarly high yield as previous (entry 4), which was then used as standard conditions in the reaction.

Table S3. Pre-milling of **2a** and base to reduce the reaction time.



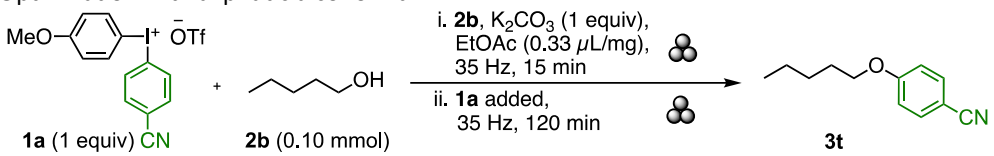
Entry	Base (x equiv)	NMR yield (%)	Isolated yield (%)
1	K_2CO_3 (1 equiv)	95	/
2	K_2CO_3 (2 equiv)	95	/
3 [a]	K_2CO_3 (1 equiv)	68	/
4 [b]	**K_2CO_3 (1 equiv)**	**/**	**91**

[a] 45 min reaction time without pre-milling of base and phenol; [b] 0.30 mmol scale.

Next, the arylation of 1-pentanol (**2b**) was performed (Table S4). Utilising the above conditions with 60 min milling time led to a yield of 43% (entry 1). By increasing the reaction time to 120 min, the yield increased to quantitative. Furthermore, changing the LAG to acetonitrile or adding everything at once produced similar yields. When the reaction was

increased to 0.3 mmol, a 91% isolated yield was acquired and these were used as standard conditions for the scope with aliphatic alcohols (entry 5).

Table S4. Optimization with aliphatic alcohol **2b**.



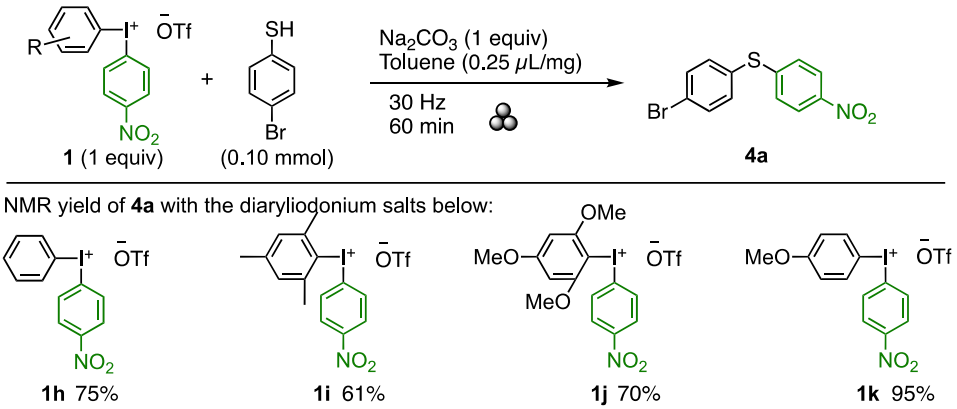
Entry	Changes to above conditions	NMR yield (%)	Isolated yield (%)
1	/	>95	/
2	60 mins milling with **1a**	43	/
3	MeCN instead of EtOAc	>95	/
4	Everything added at beginning	>95	/
5[a]	**/**	**/**	**91**

[a] Increase in scale from 0.1 mmol to 0.30 mmol.

3.2 *S*-Arylation optimisation

Early test reactions were carried out with a number of inorganic and organic bases and different types of diaryliodonium salts, which produced good yields. Sodium carbonate was ultimately chosen as a weak and functional group-tolerant base, which is also a solid and cheap to acquire.

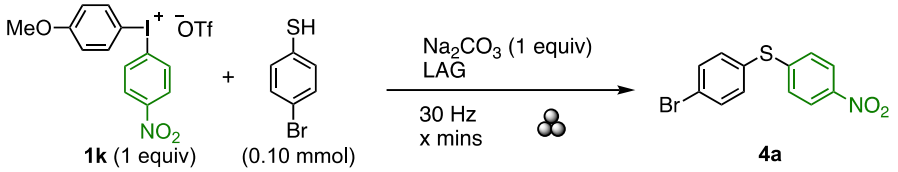
General procedure for the optimisation: Sodium carbonate (10.6 mg, 0.10 mmol, 1.0 equiv), 4-bromothiophenol (18.9 mg, 0.10 mmol, 1.0 equiv), diaryliodonium salt **1** (0.10 mmol, 1.0 equiv), toluene (20 μL) and one 7 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 60 min at 30 Hz. TMB (1 equiv) was added to the vessel, $CDCl_3$ was added and a crude NMR was recorded. The NMR yield of **4a** was determined using TMB as the internal standard.
A variety of "dummy" groups were evaluated to ensure complete chemoselectivity and good yields, and the anisyl group was found to be the best (Scheme S1).



Scheme S1. Evaluation of dummy groups for chemoselective and high-yielding *S*-arylation.

Then the toluene LAG was varied to find a more sustainable additive. Utilising the GSK solvent guide,[8] several more sustainable solvents were evaluated (Table S5). We found that green solvent additives such as cyclopentanone and dimethyl carbonate provided an efficient reaction environment for the reaction (entries 5, 6). Additionally, the amount of cyclopentanone additive could be reduced to 2 μL (0.025 μL/mg) and the reaction time was reduced to 30 minutes (entries 8, 9). The reaction could be scaled up to 0.30 mmol scale (entry 10) and these conditions were used as standard for the scope evaluation.

Table S5. Optimization of thiol arylation.



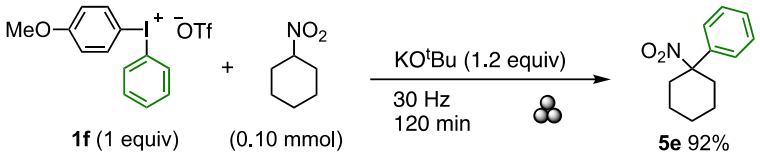
Entry	Time (min)	LAG (x µL/mg)	NMR yield (%)[a]
1	60	Toluene (0.25)	95
2	60	Anisole (0.25)	86
3	60	Ethyl acetate (0.25)	92
4	60	Isopropyl acetate (0.25)	>95
5	60	Dimethyl carbonate (0.25)	>95
6	60	Cyclopentanone (0.25)	>95
7	60	Cyclopentanone (0.125)	>95
8	60	Cyclopentanone (0.025)	>95
9	30	Cyclopentanone (0.025)	>95
10[a]	**30**	**Cyclopentanone (0.025)**	**(91)**

[a] 0.30 mmol scale, isolated yield.

3.4 *C*-Arylation optimisation

General procedure for the planned optimisation: Potassium *tert*-butoxide (11.9 mg, 0.12 mmol, 1.2 equiv), nitrocyclohexane (12.7 mg, 0.1 mmol, 1.0 equiv), and one 7 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 30 minutes at 30 Hz and then salt diaryliodonium **1f** (43.4 mg, 0.10 mmol, 1.0 equiv) was added. This mixture was milled for 120 minutes. TMB (1 equiv) was added to the vessel, $CDCl_3$ was added and a crude NMR was recorded. The NMR yield of **5e** was determined using TMB as the internal standard.

Conditions based on the standard solution phase reaction[9] produced a yield of 92% (Scheme S2). Based on the excellent reaction outcome, no optimization was performed.

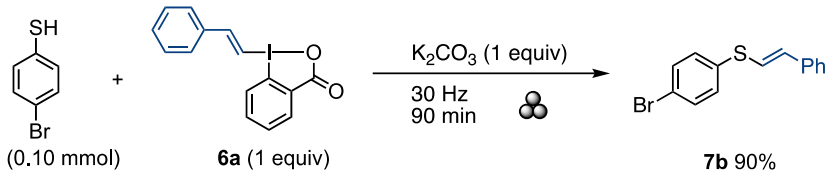


Scheme S2. C-vinylation conditions.

3.5 S-vinylation optimisation

General procedure for the planned optimisation: Potassium carbonate (13.2 mg, 0.1 mmol, 1.0 equiv), 4-bromothiophenol (18.9 mg, 0.1 mmol, 1.0 equiv), one 7 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the vessel was milled for 30 minutes at 30 Hz and VBX **6a** (43.4 mg, 0.10 mmol, 1.0 equiv) was added. This mixture was milled for 90 minutes. 1,3,5-Trimethoxybenzene (1 equiv) was added to the vessel, $CDCl_3$ was added and a crude NMR was recorded. The NMR yield of **7b** was determined using TMB as the internal standard.

Literature conditions from the standard solution phase reaction[10] produced a yield of 90% (Scheme S3). Based on the excellent reaction outcome, no optimization was performed.

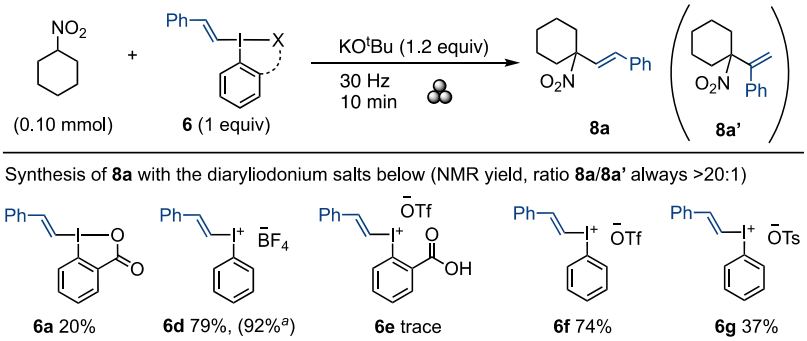


Scheme S3. C-vinylation conditions.

3.6 C-Vinylation optimisation

General procedure for the optimization: Potassium *tert*-butoxide (11.9 mg, 0.12 mmol, 1.2 equiv), nitrocyclohexane (12.7 mg, 0.1 mmol, 1.0 equiv), and one 7 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the vessel was milled for 15 minutes at 30 Hz and **6** (0.10 mmol, 1.0 equiv) was added. This mixture was milled for 10 minutes. TMB (1 equiv) was added to the vessel, $CDCl_3$ was added and a crude NMR was recorded. The NMR yield of **8a** was determined using TMB as the internal standard.

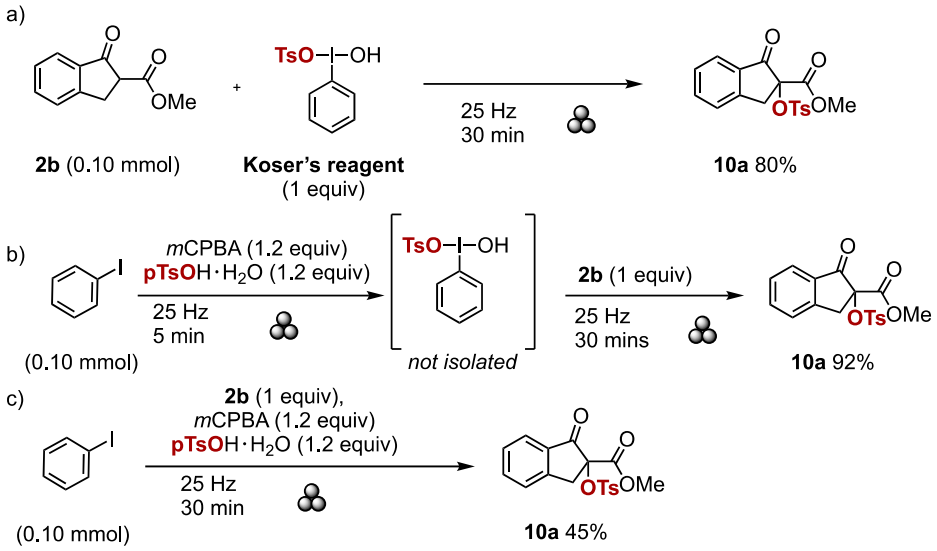
Optimisation began with using nitrocyclohexane as the model substrate since it was used previously by the Olofsson group. The reactions were milled for 10 minutes at 30 Hz. Utilising VBX reagent **6a** produced the internal alkene with excellent regioselectivity but only 20% yield (Scheme S4). Acyclic vinyliodonium salts **6d**-**6g** were then evaluated and reagent **6d** proved superior to the rest (92% yield). Different LAGs and excess equivalents of **6d** were utilised but did not produced higher yields. Further optimization was not performed.



Scheme S4. Evaluation of vinylating reagents for regioselective and high-yielding *C*-vinylation. [a] 0.30 mmol scale, isolated yield.

3.7 Catalytic tosyloxylation optimisation

Initial investigations used stoichiometric amounts of iodine(III) reagent. The synthesis of **10a** using Koser's reagent led to a yield of 80% (Scheme S5a). We then synthesized Koser's reagent from iodobenzene, followed by in-situ reaction with **2b** to form product **10a** in 92% yield (Scheme S5b). Finally, a true wone-pot reaction with all reagents added at once gave the product in the same yield (Scheme S5c). These reactions were the first examples of mechanochemical oxidation of iodine(I) to iodine(III), and quite promising for development of a catalytic reaction, which is discussed below.



Scheme S5. Reactions with stoichiometric amount of iodine(III) reagent.

General procedure for the optimization: 2b (19 mg, 0.1 mmol, 1.0 equiv), iodoarene (0.02 mmol, 0.2 equiv), *p*TsOH·H_2O (19 mg, 0.1 mmol, 1.0 equiv), *m*CPBA (20.8 mg, 0.1 mmol, 1.0 equiv) and one 10 mm stainless steel ball were added to a 5 mL stainless steel ball milling vessel. The vessel was closed and the vessel was milled for 15 minutes at 25 Hz for the tabulated time. TMB (1 equiv) was added to the vessel, $CDCl_3$ was added and a crude NMR was recorded. The NMR yields of **10a** and **10a'** were determined using TMB as the internal standard.

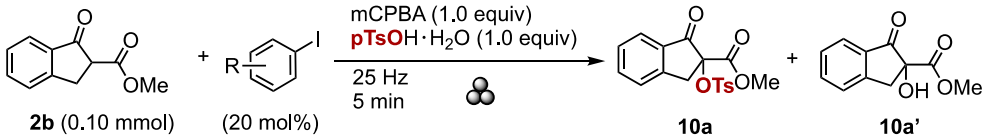
Optimisation began with iodobenzene as catalyst, which produced moderate yield of **10a** with considerable amount of the byproduct **10a'** (Table S6, entries 1-4). Next, a screen of iodoarene catalysts was conducted, which showed that strongly withdrawing and donating groups were unfavourable, and 4-iodotoluene was best (entries 5-9). Investigation of sterics on the iodoarene showed that substitution in the *ortho* position can be favourable (entry 5 vs 10), and 2,4-dimethyliodobenzene was chosen as the best catalyst with multiple substitutions (entries 13-16), giving **10a** in 84% yield, with 24% of **10a'**.

We then screened a range of LAGs (0.25 μL/mg), including water, EtOAc and isopropanol in order to avoid the formation of byproduct **10a'** (entries 15-23). However, we found that HFIP was the only LAG that suppressed the formation of **10a'** (entries 13 vs 24), and the optimal amount was found to be 0.5 μL/mg (entries 24-27).

Finally the amounts of iodoarene and *p*TsOH·H_2O were varied but the original amounts were the best (entry 26). The reaction was then scaled up to 0.3 mmol and these conditions were used as standard for the scope (entry 30).

While HFIP is not a great additive for sustainability reasons, it should be pointed out that only 0.5 µL/mg of HFIP is added, amounting to about 100 µL for each reaction in Scheme 4. As reactions without HFIP were difficult to purify due to **10a'**, the use of HFIP as LAG is motivated. Note that the synthesis of product **10c** was efficient in absence of HFIP.

Table S6. Optimization of the tosyloxylation.



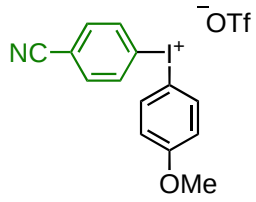
Entry	R	Time (min)	LAG (0.25 µL/mg)	Yield 10a (%)	Yield 10a' (%)
1	H	120	/	56	36
2	H	60	/	61	26
3	H	15	/	62	35
4	H	5	/	66	32
5	4-NO_2	5	/	0	88
6	4-OMe	5	/	70	22
7	4-Me	5	/	77	28
8	4-OH	5	/	19	20
9	4-$N(Me)_2$	5	/	7	65
10	2-NO_2	5	/	30	65
11	2-CF_3	5	/	17	70
12	2-Me	5	/	72	24
13	**2,4-Me**	**5**	**/**	**84**	**23**
14	2,4-OMe	5	/	46	26
15	2,4,6-Me	5	/	76	27
16	3,5-Me	5	/	82	27
17	2,4-Me	5	H_2O	40	38
18	2,4-Me	5	EtOAc	63	32
19	2,4-Me	5	Isopropanol	58	26
20	2,4-Me	5	MeCN	62	31
21	2,4-Me	5	CH_2Cl_2	65	23
22	2,4-Me	5	BMIM•BF_4	75	20
23	2,4-Me	5	TFE	76	19
24	2,4-Me	5	HFIP	81	14
25	2,4-Me	5	Anhydrous HFIP	82	11
26	**2,4-Me**	**5**	**HFIP (0.5 µL/mg)**	**83**	**11**
27	2,4-Me	5	HFIP (0.75 µL/mg)	76	7
28[a]	2,4-Me	5	HFIP (0.5 µL/mg)	76	23
29[b]	2,4-Me	5	HFIP (0.5 µL/mg)	2	11
30[c]	2,4-Me	5	HFIP (0.5 µL/mg)	(87)	Not isolated

1-Butyl-3-methylimidazolium tetrafluoroborate = BMIM BF_4. [a] 10 mol% ArI; [b] 1.2 equiv TsOH; [c] 0.30 mmol scale, isolated yield.

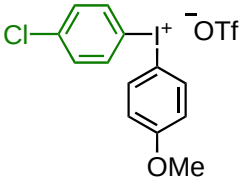
4. Substrates

4.1 Iodine(III) reagents

All of the iodine(III) reagents used in this manuscript have been reported previously. Thus, procedures data is not given for each salt, but can be found in the references provided.



1a, Ref [11]



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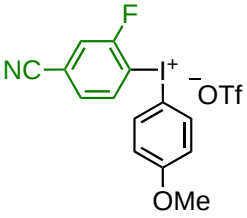

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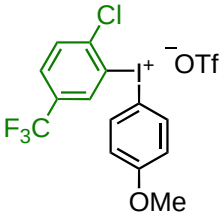

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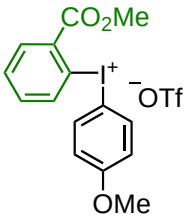

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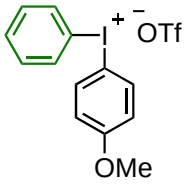
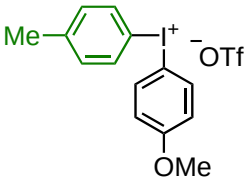
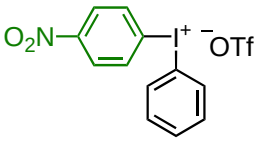


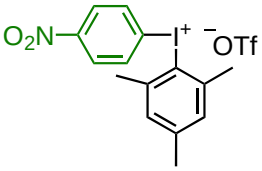
1f, Ref [11]



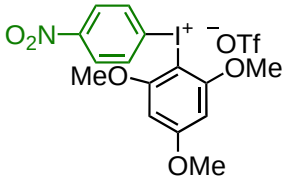
1g, Ref [11]



1h, Ref[11]



1i, Ref [11]



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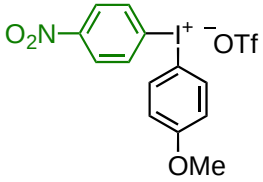

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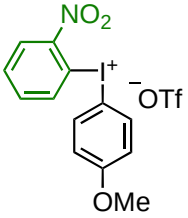

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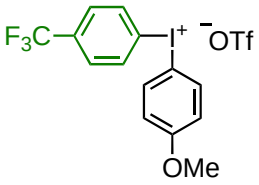

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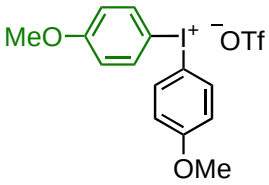
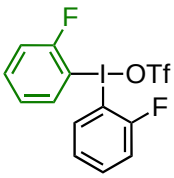


1n, Ref [9]



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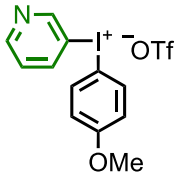
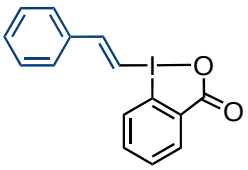
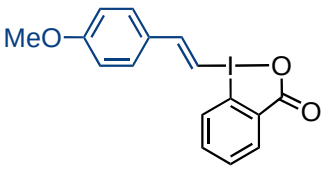


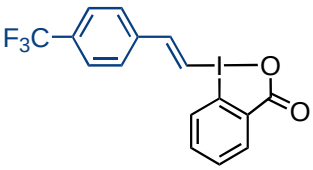
1p, Ref[13]



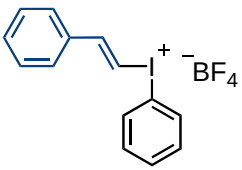
6a, Ref[14]



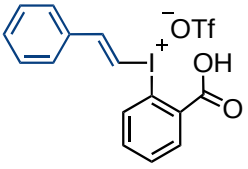
6b, Ref [15]



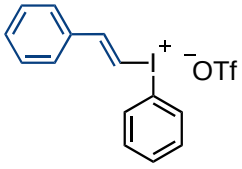
6c, Ref[15]



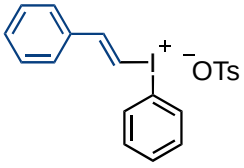
6d, Ref [14]



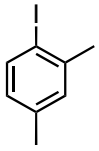
6e, Ref [14]



6f, Ref [16]



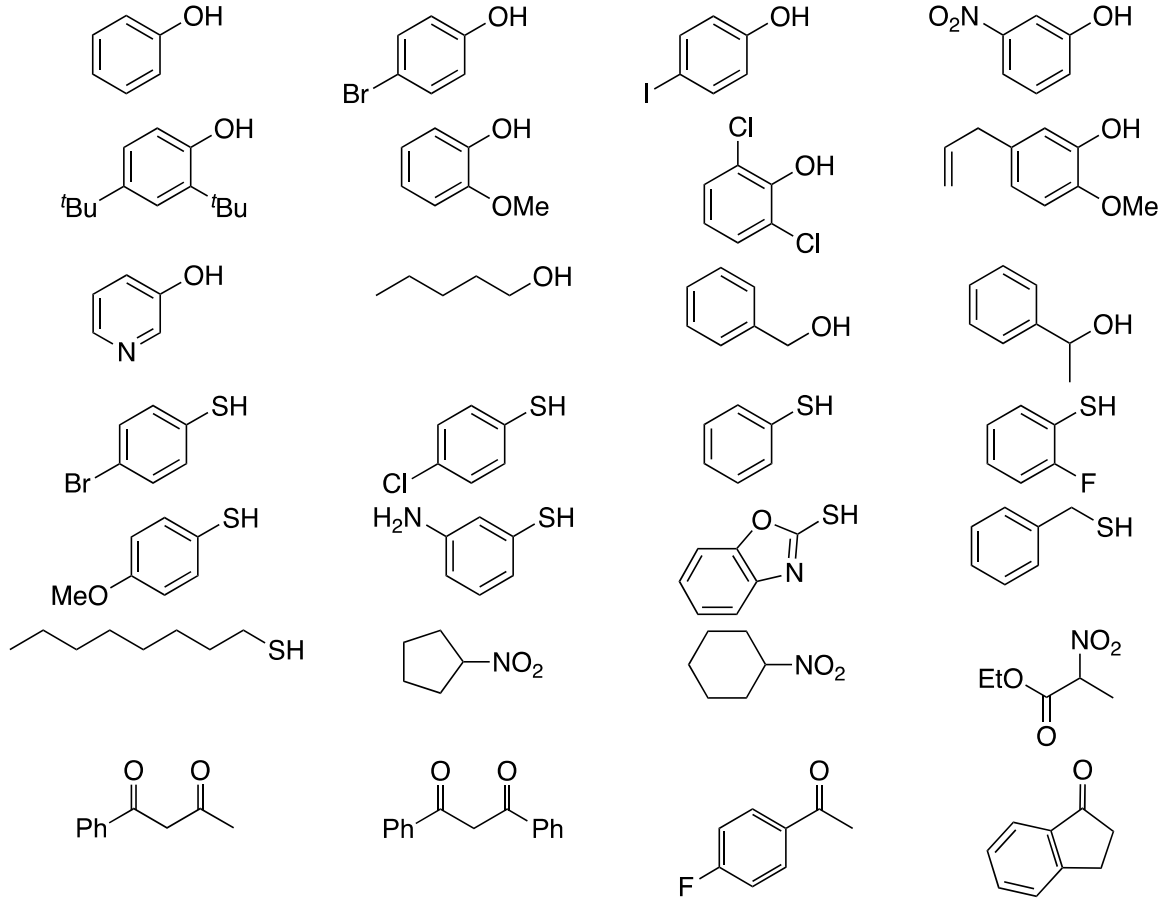
6g, Ref [17]



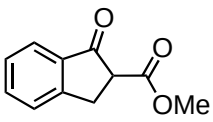
9, Ref [18]

4.2 Nucleophiles

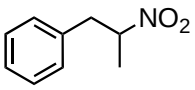
Commercially available nucleophiles:



The following were synthesised using the procedures indicated:



2b, Ref[11]

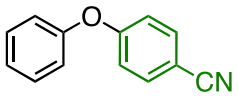


2c, Ref [19]

5. Products

5.1 Product compound table

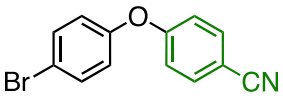
***O*-Arylation**



3a

Characterization

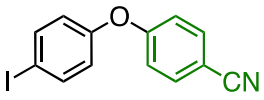
Spectra



3b

Characterization

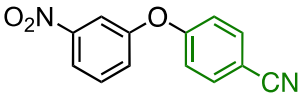
Spectra



3c

Characterization

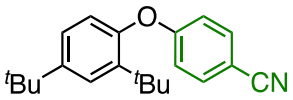
Spectra



3d

Characterization

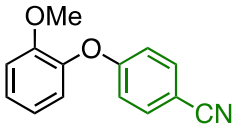
Spectra



3e

Characterization

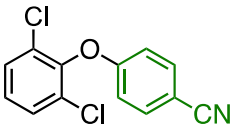
Spectra



3f

Characterization

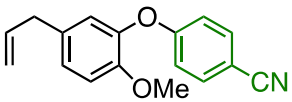
Spectra



3g

Characterization

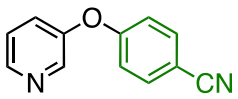
Spectra



3h

Characterization

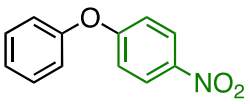
Spectra



3i

Characterization

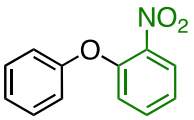
Spectra



3j

Characterization

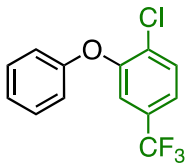
Spectra



3k

Characterization

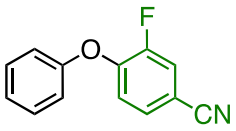
Spectra



3l

Characterization

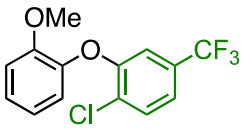
Spectra



3m

Characterization

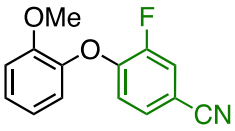
Spectra



3n

Characterization

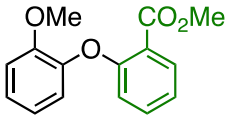
Spectra



3o

Characterization

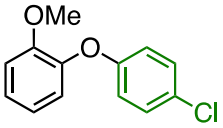
Spectra



3p

Characterization

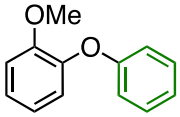
Spectra



3q

Characterization

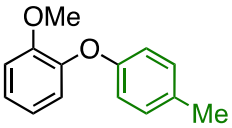
Spectra



3r

Characterization

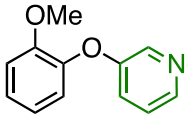
Spectra



3s

Characterization

Spectra



3t

Characterization

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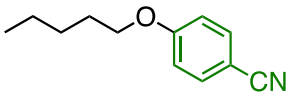
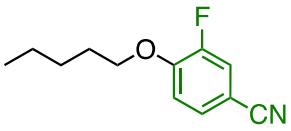


3u

Characterization

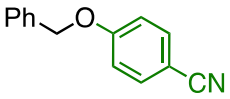
Spectra



3v

Characterization

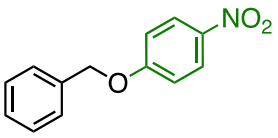
Spectra



3w

Characterization

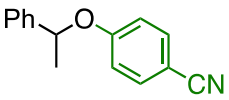
Spectra



3x

Characterization

Spectra

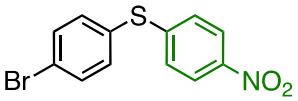


3y

Characterization

Spectra

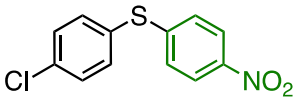
S-arylation



4a

Characterization

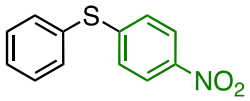
Spectra



4b

Characterization

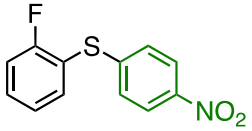
Spectra



4c

Characterization

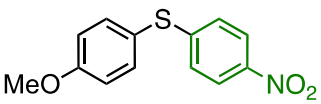
Spectra



4d

Characterization

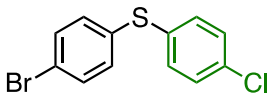
Spectra



4e

Characterization

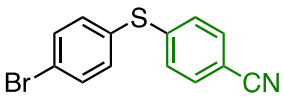
Spectra



4f

Characterization

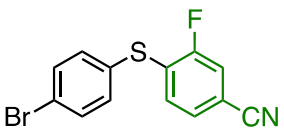
Spectra



4g

Characterization

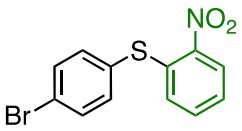
Spectra



4h

Characterization

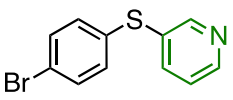
Spectra



4i

Characterization

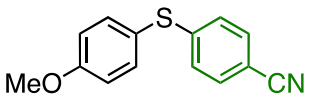
Spectra



4j

Characterization

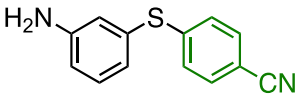
Spectra



4k

Characterization

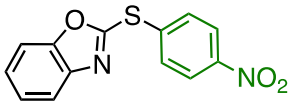
Spectra



4l

Characterization

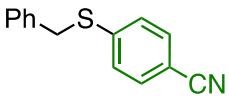
Spectra



4m

Characterization

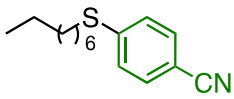
Spectra



4n

Characterization

Spectra

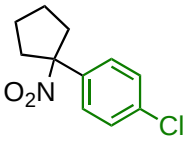


4o

Characterization

Spectra

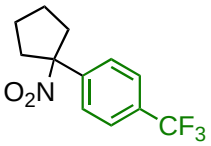
C-Arylation



5a

Characterization

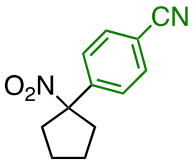
Spectra



5b

Characterization

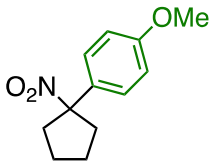
Spectra



5c

Characterization

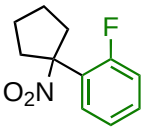
Spectra



5d

Characterization

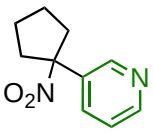
Spectra



5e

Characterization

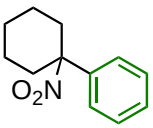
Spectra



5f

Characterization

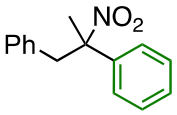
Spectra



5g

Characterization

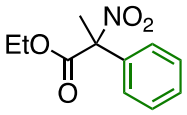
Spectra



5h

Characterization

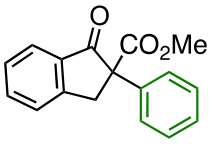
Spectra



5i

Characterization

Spectra

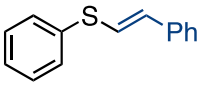


5j

Characterization

Spectra

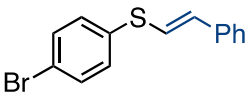
S-Vinylation



7a

Characterization

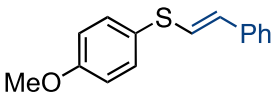
Spectra



7b

Characterization

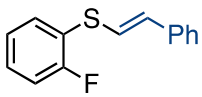
Spectra



7c

Characterization

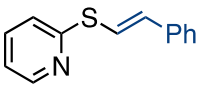
Spectra



7d

Characterization

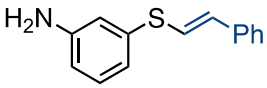
Spectra



7e

Characterization

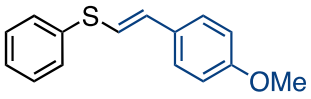
Spectra



7f

Characterization

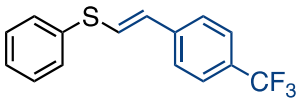
Spectra



7g

Characterization

Spectra

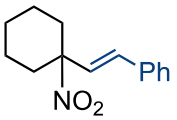


7h

Characterization

Spectra

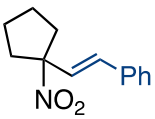
C-Vinylation



8a

Characterization

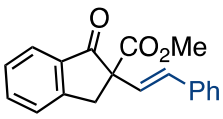
Spectra



8b

Characterization

Spectra

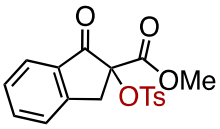


8c

Characterization

Spectra

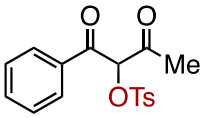
Catalytic tosyloxylation



10a

Characterization

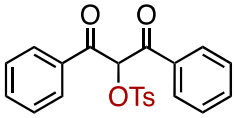
Spectra



10b

Characterization

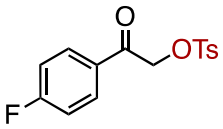
Spectra



10c

Characterisation

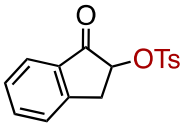
Spectra



10d

Characterization

Spectra



10e

Characterization

Spectra

5.2 *O*-Arylation

General procedure 1: *O*-arylation

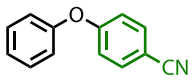
In prose:

Potassium carbonate (41.5 mg, 0.30 mmol, 1 equiv), the nucleophile (0.30 mmol), one 5 mm stainless steel ball and LAG (ethyl acetate or MeCN, 0.33 μL/mg) were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 15 minutes at 35 Hz and then diaryliodonium salt **1** (0.30 mmol, 1 equiv) was added. This mixture was milled for 30 minutes at 35 Hz. The contents of the vessel were washed out using EtOAc (5 x 0.75 mL) and concentrated *in vacuo*. This residue was purified using silica gel flash chromatography to provide product **3**.

In recipe style:

- Potassium carbonate (41.5 mg, 0.30 mmol, 1 equiv), nucleophile (0.30 mmol), one 5 mm stainless steel ball and LAG (ethyl acetate or MeCN, 0.33 μL/mg) were added to a 1.5 mL stainless steel ball milling vessel.
- Mill for 15 minutes at 35 Hz.
- Add diaryliodonium salt **1** (0.30 mmol, 1.0 equiv).
- Mill for 30 minutes at 35 Hz.
- Contents of vessel washed out with EtOAc (5 x 0.75 mL).
- Concentrate *in vacuo*.
- Purify residue using silica gel flash chromatography to provide product **3**.

4-Phenoxybenzonitrile (3a)



This compound was synthesised according to **general procedure 1** using phenol (28.2 mg, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3a** (53.0 mg, 91%) as a colourless solid;

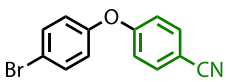
R_f (10% EtOAc/pentane) 0.3;

δ_H (400 MHz, $CDCl_3$) 7.64 – 7.56 (2H, m), 7.46 – 7.38 (2H, m), 7.26 – 7.20 (1H, m), 7.10 – 7.05 (2H, m), 7.03 – 6.98 (2H, m);

δ_C (101 MHz, $CDCl_3$) 161.8, 154.9, 134.3, 130.4, 125.3, 120.6, 119.0, 118.1, 106.0.

This data is consistent with literature precedent.[20]

4-(4-Bromophenoxy)benzonitrile (3b)



This compound was synthesised according to **general procedure 1** using 4-bromophenol (51.9 mg, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3b** (74.0 mg, 90%) as a colourless solid;

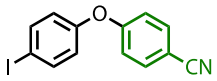
R_f (10% EtOAc/pentane) 0.3;

δ_H (400 MHz, $CDCl_3$) 7.64 – 7.59 (2H, m), 7.55 – 7.49 (2H, m), 7.03 – 6.97 (2H, m), 6.97 – 6.93 (2H, m);

δ_C (101 MHz, $CDCl_3$) 161.2, 154.2, 134.4, 133.4, 122.2, 118.8, 118.2, 118.0, 106.5.

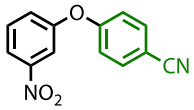
This data is consistent with literature precedent.[21]

4-(4-Iodophenoxy)benzonitrile (3c)



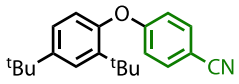
This compound was synthesised according to **general procedure X** using 4-iodophenol (66.0 mg, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (5% EtOAc/pentane) to give **3c** (70.30 mg, 73%) as a colourless solid;
R_f (10% EtOAc/pentane) 0.4;
δ_H (400 MHz, $CDCl_3$) 7.73 – 7.68 (2H, m), 7.64 – 7.59 (2H, m), 7.04 – 6.98 (2H, m), 6.87 – 6.80 (2H, m);
δ_C (101 MHz, $CDCl_3$) 161.1, 155.1, 139.4, 134.4, 122.5, 118.8, 118.3, 106.6, 88.6.
This data is consistent with literature precedent.[22]

4-(3-Nitrophenoxy)benzonitrile (3d)



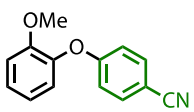
This compound was synthesised according to **general procedure 1** using 3-nitrophenol (41.7 mg, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3d** (60.0 mg, 83%) as a colourless solid;
R_f (10% EtOAc/pentane) 0.1;
δ_H (400 MHz, $CDCl_3$) 8.06 (1H, ddd, *J* = 8.2, 2.1, 1.0 Hz), 7.88 (1H, t, *J* = 2.3 Hz), 7.71 – 7.65 (2H, m), 7.59 (1H, t, *J* = 8.2 Hz), 7.40 (1H, ddd, *J* = 8.2, 2.3, 1.0 Hz), 7.11 – 7.07 (2H, m);
δ_C (101 MHz, $CDCl_3$) 160.0, 156.1, 149.5, 134.6, 131.0, 125.9, 119.6, 119.1, 118.4, 114.9, 107.8.
This data is consistent with literature precedent.[23]

4-(2,4-Di-tert-butylphenoxy)benzonitrile (3e)



This compound was synthesised according to **general procedure 1** using 2,4-bis(t-butyl)phenol (61.9 mg, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (2% EtOAc/pentane) to give **3e** (70.7 mg, 77%) as a colourless solid;
R_f (5% EtOAc/pentane) 0.3;
δ_H (400 MHz, $CDCl_3$) 7.62 – 7.56 (2H, m), 7.45 (1H, d, *J* = 2.4 Hz), 7.20 (1H, dd, *J* = 8.4, 2.4 Hz), 7.03 – 6.97 (2H, m), 6.78 (1H, d, *J* = 8.4 Hz), 1.36 (9H, s), 1.34 (9H, s);
δ_C (101 MHz, $CDCl_3$) 162.2, 151.2, 147.8, 141.0, 134.2, 124.8, 124.4, 121.1, 119.2, 118.1, 105.3, 35.0, 34.8, 31.7, 30.4;
HRMS (ESI) calculated for $C_{21}H_{25}NONa$ ($M+Na^+$): 330.1818; found: 330.1828
Mp 167.4 – 169.1 °C

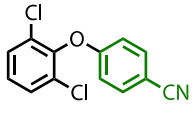
4-(2-Methoxyphenoxy)benzonitrile (3f)



This compound was synthesised according to **general procedure 1** using 2-methoxyphenol (37.2 mg, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3f** (60.1 mg, 89%) as a colourless solid;
R_f (10% EtOAc/pentane) 0.2;

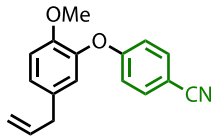
δ_H (400 MHz, $CDCl_3$) 7.59 – 7.53 (2H, m), 7.24 (1H, ddd, *J* = 9.2, 7.1, 1.4 Hz), 7.10 – 6.96 (3H, m), 6.95 – 6.89 (2H, m), 3.78 (3H, s);
δ_C (101 MHz, $CDCl_3$) 162.0, 151.8, 142.6, 134.0, 126.8, 122.7, 121.5, 119.1, 116.6, 113.2, 105.3, 55.9.
This data is consistent with literature precedent.[24]

4-(2,6-Dichlorophenoxy)benzonitrile (3g)



This compound was synthesised according to **general procedure 1** using 2,6-dichlorophenol (48.9 mg, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3g** (69.8 mg, 88%) as a colourless solid;
R_f (10% EtOAc/pentane) 0.3;
δ_H (400 MHz, $CDCl_3$) 7.64 – 7.58 (2H, m), 7.43 (2H, d, *J* = 8.2 Hz), 7.21 (1H, dd, *J* = 8.5, 7.8 Hz), 6.93 – 6.86 (2H, m);
δ_C (101 MHz, $CDCl_3$) 159.9, 146.2, 134.3, 129.8, 129.5, 127.3, 118.8, 116.0, 106.5;
HRMS (ESI) calculated for $C_{12}H_7{}^{35}Cl_2NONa$ ($M+Na^+$): 285.9790; found: 285.9797;
Mp 143.4 – 145.1 °C.

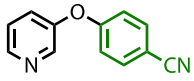
4-(5-Allyl-2-methoxyphenoxy)benzonitrile (3h)



This compound was synthesised according to **general procedure 1** using Eugenol (28.5 μL, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3h** (70.4 mg, 87%) as a colourless oil;
Large scale reaction: Potassium carbonate (414.6 mg, 3.00 mmol, 1 equiv), eugenol (0.467 mL, 3.00 mmol, 1 equiv), one 10 mm stainless steel ball and LAG (0.45 mL) were added to a 5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 15 minutes at 35 Hz and then diaryliodonium salt **1a** (1.455 g, 3.00 mmol, 1 equiv) was added. This mixture was milled for 30 minutes at 35 Hz. The contents of the vessel were washed out using EtOAc (5 x 4 mL) and concentrated *in vacuo*. This residue was purified using silica gel flash chromatography (10% EtOAc/pentane) to provide product **3h** (709.5 mg, 89%) as a colourless oil;

R_f (10% EtOAc/pentane) 0.23;
δ_H (400 MHz, $CDCl_3$) 7.57 – 7.52 (2H, m), 6.99 (1H, d, *J* = 8.0 Hz), 6.94 – 6.89 (2H, m), 6.85 (1H, d, *J* = 1.9 Hz), 6.81 (1H, dd, *J* = 8.0, 1.3 Hz), 5.99 (1H, ddt, 17.0, 10.2, 6.7 Hz), 5.18 – 5.09 (2H, m), 3.76 (3H, s), 3.41 (2H, dt, *J* = 6.7 Hz);
δ_C (101 MHz, $CDCl_3$) 162.2, 151.6, 140.8, 139.0, 137.0, 134.0, 122.5, 121.4, 119.2, 116.5, 116.4, 113.4, 105.1, 55.9, 40.1;
HRMS (ESI) calculated for $C_{17}H_{15}NO_2Na$ ($M+Na^+$): 288.0989; found: 288.0995

4-(Pyridin-3-yloxy)benzonitrile (3i)

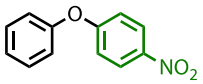


This compound was synthesised according to **general procedure 1** using 3-hydroxypyridine (28.5 mg, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv)

and EtOAc as LAG. The residue was purified by flash chromatography (80% EtOAc/pentane) to give **3i** (51.2 mg, 86%) as a colourless solid;
R_f (80% EtOAc/pentane) 0.3;
δ_H (400 MHz, $CDCl_3$) 8.48 (1H, dd, *J* = 4.4, 1.7 Hz), 8.44 (1H, d, *J* = 2.7 Hz), 7.66 – 7.61 (2H, m), 7.41 – 7.33 (2H, m), 7.05 – 7.00 (2H, m);
δ_C (101 MHz, $CDCl_3$) 160.8, 151.7, 146.4, 142.7, 134.5, 127.5, 124.6, 118.6, 118.3, 107.0.

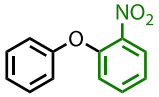
This data is consistent with literature precedent.[25]

1-Nitro-4-phenoxybenzene (3j)



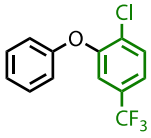
This compound was synthesised according to **general procedure 1** using Phenol (28.2 mg, 0.30 mmol), **1h** (151.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (5% -> 10% EtOAc/Pentane) to give **3j** (44.0 mg, 69%) as a colourless oil;
R_f (2% EtOAc/Pentane) 0.4;
δ_H (400 MHz, $CDCl_3$) 8.23 – 8.17 (2H, m), 7.48 – 7.40 (2H, m), 7.30 – 7.23 (1H, m), 7.12 – 7.07 (2H, m), 7.05 – 6.98 (2H, m);
δ_C (101 MHz, $CDCl_3$) 163.5, 154.8, 142.8, 130.4, 126.1, 125.5, 120.7, 117.2.
This data is consistent with literature precedent.[26]

1-Nitro-2-phenoxybenzene (3k)



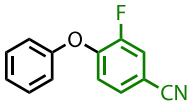
This compound was synthesised according to **general procedure 1** using phenol (18.8 mg, 0.2 mmol)), **1l** (101.0 mg, 0.20 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (5% -> 10% EtOAc/pentane) to give **3k** (21.0 mg, 48%) as an orange oil.
R_f (10% EtOAc/pentane) 0.25;
δ_H (400 MHz, $CDCl_3$) 7.95 (1H, dd, *J* = 8.2, 1.7 Hz), 7.50 (1H, ddd, *J* = 8.2, 7.4, 1.7 Hz), 7.41 – 7.36 (2H, m), 7.22 – 7.17 (2H, m), 7.08 – 6.98 (3H, m);
δ_C (101 MHz, $CDCl_3$) 155.9, 150.9, 141.5, 134.2, 130.2, 125.9, 124.7, 123.2, 120.6, 119.4.
This data is consistent with literature precedent.[27]

1-Chloro-2-phenoxy-4-(trifluoromethyl)benzene (3l)



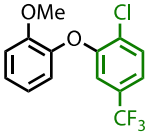
This compound was synthesised according to **general procedure 1** using phenol (28.2 mg, 0.30 mmol), **1d** (168.8 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (2% EtOAc/pentane) to give **3l** (65.5 mg, 80%) as a colourless oil;
R_f (2% EtOAc/pentane) 0.4;
δ_H (400 MHz, $CDCl_3$) 7.59 (1H, dd, *J* = 8.4, 1.0 Hz), 7.43 – 7.36 (2H, m), 7.33 (1H, ddd, *J* = 8.3, 2.1, 1.0 Hz), 7.22 – 7.16 (2H, m), 7.04 – 6.97 (2H, m);
δ_F (376 MHz, $CDCl_3$) -62.62 (s);
δ_C (101 MHz, $CDCl_3$) 156.1, 153.4, 131.5, 130.6 (q, *J* = 33.0 Hz), 130.3, 129.5 (q, *J* = 1.4 Hz), 124.5, 123.3 (q, *J* = 272.5 Hz), 121.0 (q, *J* = 4.3 Hz), 118.7, 116.9 (q, *J* = 3.75 Hz);
HRMS (ESI) calculated for $C_{13}H_9{}^{35}ClF_3O$ ($M+H^+$): 273.0452; found: 273.0473

3-Fluoro-4-phenoxybenzonitrile (3m)



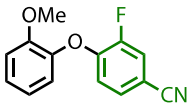
This compound was synthesised according to **general procedure 1** using phenol (28.2 mg, 0.30 mmol), **1c** (151.0 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3m** (44.0 mg, 88%) as a colourless oil;
R_f (10% EtOAc/pentane) 0.3;
δ_H (400 MHz, $CDCl_3$) 7.47 (1H, dd, *J* = 10.1, 2.0 Hz), 7.44 – 7.39 (2H, m), 7.37 (1H, ddd, *J* = 8.5, 2.0, 1.3 Hz), 7.26 – 7.20 (1H, m), 7.08 – 7.04 (2H, m), 6.96 (1H, t, *J* = 8.5 Hz);
δ_F (376 MHz, $CDCl_3$) -129.02 – -129.10 (m);
δ_C (101 MHz, $CDCl_3$) 155.0, 153.0 (d, *J* = 252.4 Hz), 149.8 (d, *J* = 10.9 Hz), 130.4, 129.5 (d, *J* = 4.0 Hz), 125.3, 120.9 (d, *J* = 21.3 Hz), 119.8, 119.5, 117.7 (d, *J* = 2.6 Hz), 106.8 (d, *J* = 8.2 Hz).
HRMS (ESI) calculated for $C_{13}H_8FNONa$ ($M+Na^+$): 236.0482; found: 236.0486.

1-Chloro-2-(2-methoxyphenoxy)-4-(trifluoromethyl)benzene (3n)



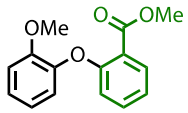
This compound was synthesised according to **general procedure 1** using 2-methoxyphenol (37.2 mg, 0.30 mmol), **1d** (168.8 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. After addition of iodonium salt, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (0% -> 5% EtOAc/PE) to give **3n** (56.7 mg, 63%) as a colourless oil;
R_f (5% EtOAc/PE) 0.45;
δ_H (400 MHz, $CDCl_3$) 7.55 (1H, dd, *J* = 10.3, 2.0 Hz), 7.26 – 7.19 (2H, m), 7.06 – 6.95 (3H, m), 6.91 (1H, d, *J* = 1.7 Hz), 3.81 (3H, s);
δ_F (376 MHz, $CDCl_3$) -62.58 (3H, s);
δ_C (101 MHz, $CDCl_3$) 154.2, 151.3, 143.5, 131.1, 130.2 (q, *J* = 33.4 Hz), 127.6 (q, *J* = 1.3 Hz), 126.3, 123.6 (q, *J* = 272.4 Hz), 121.5, 121.5, 119.8 (q, *J* = 3.8 Hz), 113.9 (q, *J* = 3.8 Hz), 113.3, 56.1.
HRMS calculated for $C_{14}H_{10}{}^{35}ClF_3O_2Na$ ($M+Na^+$): 325.0211; found: 325.0214.

3-Fluoro-4-(2-methoxyphenoxy)benzonitrile (3o)



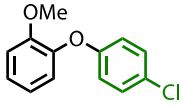
This compound was synthesised according to **general procedure 1** using 2-methoxyphenol (33 µL, 0.30 mmol), **1c** (151.0 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. After addition of iodonium salt, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (10% EtOAc/PE) to give **3o** (52.4 mg, 72%) as a colourless oil;
R_f (10% EtOAc/PE) 0.30;
δ_H (400 MHz, $CDCl_3$) 7.44 (1H, dd, *J* = 10.3, 2.0 Hz), 7.31 – 7.28 (1H, m), 7.25 (1H, ddd, *J* = 8.2, 7.4, 1.7 Hz), 7.10 (1H, dd, *J* = 7.9, 1.7 Hz), 7.03 (1H, dd, *J* = 8.3, 1.4 Hz), 6.99 (1H, td, *J* = 7.7, 1.4 Hz), 6.73 (1H, t, *J* = 8.4 Hz), 3.79 (3H, s);
δ_F (376 MHz, $CDCl_3$) -130.74 (dd, *J* = 10.1, 8.1 Hz);
δ_C (101 MHz, $CDCl_3$) 151.8 (d, *J* = 258.6 Hz), 151.4, 150.7 (d, *J* = 17.5 Hz), 142.5, 129.3 (d, *J* = 3.8 Hz), 127.0, 122.2, 121.5, 120.5 (d, *J* = 21.2 Hz), 118.0, (d, *J* = 2.6 Hz), 117.5 (d, *J* = 1.9 Hz), 113.2, 105.6 (d, *J* = 7.5 Hz), 56.0.
HRMS calculated for $C_{14}H_{10}FNO_2Na$ ($M+Na^+$): 266.0579; found: 266.0588.

Methyl 2-(2-methoxyphenoxy)benzoate (3p)



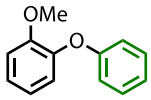
This compound was synthesised according to **general procedure 1** using 2-methoxyphenol (37.2 mg, 0.30 mmol), **1e** (155.5 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. After addition of iodonium salt, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (0% -> 5% EtOAc/PE) to give **3p** (47.9 mg, 62%) as a colourless oil;
R_f (5% EtOAc/PE) 0.30;
δ_H (400 MHz, $CDCl_3$) 7.90 (1H, dd, *J* = 7.8, 1.8 Hz), 7.39 (1H, ddd, *J* = 8.3, 7.3, 1.8 Hz), 7.15 – 7.07 (2H, m), 7.01 – 6.98 (1H, m), 6.91 – 6.87 (2H, m), 6.83 (1H, dd, *J* = 8.3, 1.1 Hz), 3.84 (3H, s), 3.84 (3H, s);
δ_C (101 MHz, $CDCl_3$) 166.5, 157.3, 151.2, 145.8, 133.5, 131.9, 124.8, 122.7, 121.9, 121.3, 120.3, 118.8, 113.1, 56.2, 52.3;
HRMS calculated for $C_{15}H_{14}O_4Na$ ($M+Na^+$): 281.0777; found: 281.0784.

1-(4-Chlorophenoxy)-2-methoxybenzene (3q)



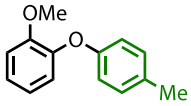
This compound was synthesised according to **general procedure 1** using 2-methoxyphenol (33.0 μL, 0.30 mmol), **1b** (155.0 mg, 0.30 mmol, 1.0 equiv) and MeCN as LAG. After addition of iodonium salt, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (PE) to give **3q** (54.7 mg, 81%) as a colourless oil;
R_f (PE) 0.45;
δ_H (400 MHz, $CDCl_3$) 7.60 – 7.55 (2H, m), 7.48 – 7.42 (2H, m), 7.39 – 7.32 (2H, m), 7.10 – 6.99 (2H, m), 3.84 (3H, s);
δ_C (101 MHz, $CDCl_3$) 156.6, 138.7, 131.0, 130.9, 129.7, 128.7, 128.1, 127.0, 121.0, 111.4, 55.7. This data is consistent with literature precedent.[28]

1-Methoxy-2-phenoxybenzene (3r)



This compound was synthesised according to **general procedure 1** using 2-methoxyphenol (33.0 μL, 0.30 mmol), **1f** (155.0 mg, 0.30 mmol, 1.0 equiv) and MeCN as LAG. After addition of iodonium salt, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (PE) to give **3r** (47.2 mg, 76%) as a colourless oil;
R_f (PE) 0.45;
δ_H (400 MHz, $CDCl_3$) 7.34 – 7.25 (2H, m), 7.14 (1H, ddd, *J* = 8.2, 7.2, 1.8 Hz), 7.08 – 6.90 (6H, m), 3.85 (3H, m);
δ_C (101 MHz, $CDCl_3$) 158.1, 151.6, 145.2, 129.6, 124.9, 122.6, 121.2, 121.2, 117.3, 113.0, 56.1. This data is consistent with literature precedent.[29]

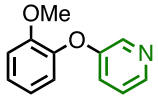
1-Methoxy-2-(p-tolyloxy)benzene (3s)



This compound was synthesised according to **general procedure 1** using 2-methoxyphenol (33.0 μL, 0.30 mmol), **1g** (155.0 mg, 0.30 mmol, 1.0 equiv) and MeCN as LAG. After addition of iodonium salt, the reaction was milled

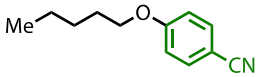
for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (PE) to give **3s** (26.9 mg, 47%) as a colourless oil;
R_f (PE) 0.45;
δ_H (400 MHz, $CDCl_3$) 7.14 – 7.08 (3H, m), 7.01 (1H, d, J = 8.7 Hz), 6.97 – 6.85 (4H, m), 3.86 (3H, s), 2.33 (3H, s).
δ_C (101 MHz, $CDCl_3$) 155.6, 151.3, 145.9, 131.2, 130.1, 124.4, 121.1, 120.5, 117.6, 112.8, 56.1, 20.7.
This data is consistent with literature precedent.[30]

3-(2-methoxyphenoxy)pyridine (3t)



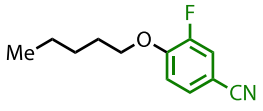
This compound was synthesised according to **general procedure 1** using 2-methoxyphenol (33.0 μL, 0.30 mmol), **1p** (138.4 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (30% EtOAc/pentane) to give **3t** (63.1 mg, 79%) as a colourless oil;
R_f (30% EtOAc/pentane) 0.4;
δ_H (400 MHz, $CDCl_3$) 8.34 (1H, dd, *J* = 2.7, 0.9 Hz), 8.29 (1H, dd, *J* = 4.3, 1.7 Hz), 7.23 – 7.14 (3H, m), 7.02 (2H, ddd, *J* = 7.9, 5.9, 1.7Hz), 6.99 – 6.92 (1H, m), 3.81 (3H, s);
δ_C (101 MHz, $CDCl_3$) 154.7, 151.6, 143.9, 143.6, 139.9, 125.9, 123.9, 123.5, 121.6, 121.4, 113.0, 56.0.;
HRMS (ESI) calculated for $C_{12}H_{12}NO_2$ ($M+H^+$): 202.0863; found: 202.0849.

4-(Pentyloxy)benzonitrile (3u)



This compound was synthesised according to **general procedure 1** using 1-pentanol (33.0 μL, 0.30 mmol) and **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and MeCN as LAG. After addition of iodonium salt, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3u** (51.7 mg, 91%) as a colourless oil;
R_f (10% EtOAc/pentane) 0.40;
δ_H (400 MHz, $CDCl_3$) 7.59 – 7.54 (2H, m), 6.96 – 6.89 (2H, m), 3.99 (2H, t, *J* = 6.6 Hz), 1.80 (2H, dq, *J* = 8.0, 6.5, Hz), 1.50 – 1.32 (4H, m), 0.93 (3H, t, *J* = 7.1 Hz);
δ_C (101 MHz, $CDCl_3$) 162.6, 134.1, 119.5, 115.3, 103.8, 68.5, 28.8, 28.2, 22.5, 14.1.
This data is consistent with literature precedent.[31]

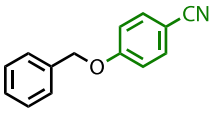
3-Fluoro-4-(pentyloxy)benzonitrile (3v)



This compound was synthesised according to **general procedure 1** using 1-pentanol (33.0 μL, 0.30 mmol), **1c** (151.0 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. After addition of iodonium salt, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (5% EtOAc/pentane) to give **3v** (34.1 mg, 55%) as a colourless oil;
R_f (10% EtOAc/pentane) 0.45;
δ_H (400 MHz, $CDCl_3$) 7.40 (1H, ddd, *J* = 8.5, 2.0, 1.3 Hz), 7.35 (1H, dd, *J* = 10.6, 2.0 Hz), 6.99 (1H, t, *J* = 8.5 Hz), 4.08 (2H, t, *J* = 6.6 Hz), 1.85 (2H, dq, *J* = 8.1, 6.6 Hz), 1.52 – 1.33 (4H, m), 0.94 (3H, t, *J* = 7.1 Hz);

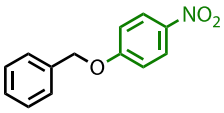
δ_F (376 MHz, $CDCl_3$) -131.47 – -131.57 (m);
δ_C (101 MHz, $CDCl_3$) 152.1 (d, *J* = 248.4 Hz), 151.6 (d, *J* = 10.2 Hz), 129.8 (d, *J* = 3.9 Hz), 119.7 (d, *J* = 21.4 Hz), 118.3 (d, *J* = 2.5 Hz), 114.6 (d, *J* = 2.4 Hz), 103.7 (d, *J* = 7.9 Hz), 68.5, 28.8, 28.2, 22.5, 14.1.
HRMS (ESI) calculated for $C_{12}H_{14}FNNa$ ($M+Na^+$): 230.0952; found: 230.0945.

4-(Benzyloxy)benzonitrile (3w)



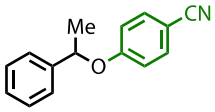
This compound was synthesised according to **general procedure 1** using benzyl alcohol (31.0 μL, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3w** (55.0 mg, 88%) as a colourless oil;
R_f (10% EtOAc/pentane) 0.20;
δ_H (400 MHz, $CDCl_3$) 7.62 – 7.56 (2H, m), 7.45 – 7.32 (5H, m), 7.05 – 6.99 (2H, m), 5.12 (2H, s);
δ_C (101 MHz, $CDCl_3$) 162.1, 135.8, 134.1, 128.9, 128.5, 127.6, 119.3, 115.7, 104.3, 70.4.
This data is consistent with literature precedent.[32]

1-(Benzyloxy)-4-nitrobenzene (3x)



This compound was synthesised according to **general procedure 1** using benzyl alcohol (31.0 μL, 0.30 mmol), **1h** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (5% EtOAc/pentane) to give **3x** (50.3 mg, 80%) as a colourless oil;
R_f (10% EtOAc/pentane) 0.4;
δ_H (400 MHz, $CDCl_3$) 8.24 – 8.17 (2H, m), 7.47 – 7.34 (5H, m), 7.06 – 7.00 (2H, m), 5.17 (2H, s);
δ_C (101 MHz, $CDCl_3$) 163.8, 141.8, 135.6, 128.9, 128.6, 127.6, 126.1, 115.0, 70.8.
This data is consistent with literature precedent.[33]

4-(1-Phenylethoxy)benzonitrile (3y)



This compound was synthesised according to **general procedure 1** using 1-phenyl ethanol (36.0 μL, 0.30 mmol), **1a** (145.6 mg, 0.30 mmol, 1.0 equiv) and EtOAc as LAG. The residue was purified by flash chromatography (10% EtOAc/pentane) to give **3y** (39.8 mg, 59%) as a colourless oil;
R_f (10% EtOAc/pentane) 0.2;
δ_H (400 MHz, $CDCl_3$) 7.51 – 7.45 (2H, m), 7.38 – 7.27 (5H, m), 6.92 – 6.87 (2H, m), 5.35 (1H, q, *J* = 6.4 Hz), 1.66 (3H, d, *J* = 6.4 Hz);
δ_C (101 MHz, $CDCl_3$) 161.4, 142.0, 134.0, 129.0, 128.0, 125.5, 119.3, 116.6, 103.9, 76.7, 24.5.
This data is consistent with literature precedent.[34]

5.3 S-Arylation

General procedure 2: *S*-arylation

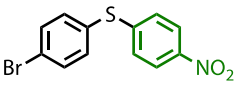
In prose:

Sodium carbonate (31.8 mg, 0.30 mmol, 1 equiv), nucleophile (0.30 mmol), diaryliodonium salt **1** (0.30 mmol, 1 equiv), cyclopentanone (0.025 μL/mg) and one 5 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 30 minutes at 30 Hz. The contents of the vessel were washed out using EtOAc (5 x 0.75 mL) and concentrated *in vacuo*. This residue was purified using silica gel flash chromatography to provide product **4**.

In recipe style:

- Sodium carbonate (31.8 mg, 0.30 mmol, 1 equiv), nucleophile (0.30 mmol), diaryliodonium salt **1** (0.30 mmol, 1 equiv), cyclopentanone (0.025 μL/mg), and one 5 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel.
- Mill for 30 minutes at 30 Hz.
- Contents of vessel washed out with EtOAc (5 x 0.75 mL).
- Concentrate *in vacuo*.
- Purify residue using silica gel flash chromatography to provide products **5**.

(4-bromophenyl)(4-nitrophenyl)sulfane (4a)



This compound was synthesised according to **general procedure 2** using 4-bromothiophenol (56.7 mg, 0.30 mmol) and **1h** (151.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash column chromatography (2% EtOAc/pentane) to give **4a** (84.0 mg, 91%) as a yellow solid;

Large scale reaction: Sodium carbonate (318 mg, 3.00 mmol, 1 equiv), 4-bromothiophenol (567 mg, 3.00 mmol, 1 equiv), one 10 mm stainless steel ball and cyclopentanone (0.06 mL), **1h** (1.516 g, 3.00 mmol, 1 equiv) were added to a 5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 30 minutes at 30 Hz. The contents of the vessel were washed out using EtOAc (5 x 4 mL) and concentrated *in vacuo*. This residue was purified using silica gel flash chromatography (2% EtOAc/pentane) to provide product **4a** (724 mg, 78%) as a yellow solid;

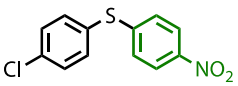
R_f (2% EtOAc/pentane) 0.33;

δ_H (400 MHz, $CDCl_3$) 8.11 – 8.06 (2H, m), 7.60 – 7.55 (2H, m), 7.42 – 7.37 (2H, m), 7.22 – 7.18 (2H, m);

δ_C (101 MHz, $CDCl_3$) 147.5, 145.8, 138.3, 136.1, 133.4, 130.1, 127.3, 124.3.

This data is consistent with literature precedent.[35]

(4-Chlorophenyl)(4-nitrophenyl)sulfane (4b)

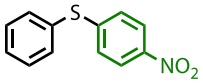


This compound was synthesised according to **general procedure 2** using 4-chlorothiophenol (43.4 mg, 0.30 mmol) and **1h** (151.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **4g** (70.4 mg, 88%) as a yellow solid.

R_f (2% EtOAc/pentane) 0.35;

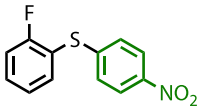
δ_H (400 MHz, $CDCl_3$) 8.12 – 8.06 (2H, m), 7.50 – 7.40 (4H, m), 7.22 – 7.16 (2H, m);
δ_C (101 MHz, $CDCl_3$) 147.7, 145.8, 136.2, 136.0, 130.4, 129.3, 127.1, 124.3.
This data is consistent with literature precedent.[35]

(4-Nitrophenyl)(phenyl)sulfane (4c)



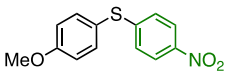
This compound was synthesised according to **general procedure 2** using thiophenol (33.1 mg, 0.30 mmol) and **1h** (151.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **4c** (51.9 mg, 75%) as a yellow solid.
R_f (2% EtOAc/pentane) 0.55;
δ_H (400 MHz, $CDCl_3$) 8.10 – 8.03 (2H, m), 7.57 – 7.52 (2H, m), 7.49 – 7.43 (3H, m), 7.21 – 7.15 (2H, m);
δ_C (101 MHz, $CDCl_3$) 148.7, 145.5, 134.9, 130.6, 130.2, 129.8, 126.9, 124.2.
This data is consistent with literature precedent.[36]

(2-Fluorophenyl)(4-nitrophenyl)sulfane (4d)



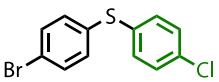
This compound was synthesised according to **general procedure 2** using 2-fluoro thiophenol (38.4 mg, 0.30 mmol) and **1h** (151.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **4d** (61.3 mg, 82%) as a yellow solid;
R_f (2% EtOAc/pentane) 0.45;
δ_H (400 MHz, $CDCl_3$) 8.11 – 8.07 (2H, m), 7.57 (1H, ddd, *J* = 7.8, 7.1, 1.9 Hz), 7.50 (1H, dddd, *J* = 8.3, 7.8, 5.1, 1.9 Hz), 7.27 – 7.17 (4H, m);
δ_F (376 MHz, $CDCl_3$) -105.59 – -105.70 (m);
δ_C (101 MHz, $CDCl_3$) 162.7 (d, *J* = 251.0 Hz), 146.5, 145.8, 137.0, 132.5 (d, *J* = 7.8 Hz), 126.8, 125.6 (d, *J* = 3.9 Hz), 124.3, 117.8 (d, *J* = 18.1 Hz), 117.0 (d, *J* = 22.7 Hz).
This data is consistent with literature precedent.[37]

(4-Methoxyphenyl)(4-nitrophenyl)sulfane (4e)



This compound was synthesised according to **general procedure 2** using 4-methoxythiophenol (42.1 mg, 0.30 mmol) and **1h** (151.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **4e** (64.4 mg, 82%) as a yellow solid;
R_f (5% EtOAc/pentane) 0.35;
δ_H (400 MHz, $CDCl_3$) 8.04 – 8.00 (2H, m), 7.51 – 7.45 (2H, m), 7.09 – 7.06 (2H, m), 7.01 – 6.97 (2H, m), 3.87 (3H, s);
δ_C (101 MHz, $CDCl_3$) 161.2, 150.2, 137.3, 132.8, 125.7, 124.1, 120.2, 115.8, 55.6.
This data is consistent with literature precedent.[38]

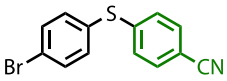
(4-Bromophenyl)(4-chlorophenyl)sulfane (4f)



This compound was synthesised according to **general procedure 2** using 4-bromothiophenol (56.7 mg, 0.30 mmol) and **1b** (148.4 mg, 0.30 mmol, 1.0

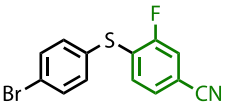
equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **4f** (75.4 mg, 84%) as a colourless solid.
R_f (2% EtOAc/pentane) 0.40;
δ_H (400 MHz, $CDCl_3$) 7.47 – 7.43 (2H, m), 7.33 – 7.27 (4H, m), 7.22 – 6.17 (2H, m);
δ_C (101 MHz, $CDCl_3$) 134.9, 133.8, 133.7, 132.7, 132.5, 132.5, 129.7, 121.5.
This data is consistent with literature precedent.[39]

4-((4-Bromophenyl)thio)benzonitrile (4g)



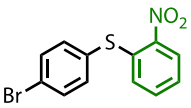
This compound was synthesised according to **general procedure 2** using 4-bromothiophenol (56.7 mg, 0.30 mmol) and **1a** (145.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **4g** (72.2 mg, 83%) as a colourless solid.
R_f (2% EtOAc/pentane) 0.25;
δ_H (400 MHz, $CDCl_3$) 7.57 – 7.53 (2H, m), 7.52 – 7.47 (2H, m), 7.38 – 7.33 (2H, m), 7.21 – 7.16 (2H, m);
δ_C (101 MHz, $CDCl_3$) 144.8, 135.8, 133.2, 132.6, 130.5, 127.8, 124.0, 118.7, 109.4.
This data is consistent with literature precedent.[40]

4-((4-Bromophenyl)thio)-3-fluorobenzonitrile (4h)



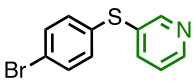
This compound was synthesised according to **general procedure 2** using 4-bromothiophenol (56.7 mg, 0.30 mmol) and **1c** (157.0 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (5% EtOAc/pentane) to give **4h** (91.2 mg, 92%) as a colourless solid;
R_f (5% EtOAcpPentane) 0.35;
δ_H (400 MHz, $CDCl_3$) 7.60 – 7.54 (2H, m), 7.39 – 7.25 (4H, m), 6.95 (1H, dd, *J* = 8.2, 7.3 Hz);
δ_F (376 MHz, $CDCl_3$) -108.09 (dd, *J* = 9.1, 7.2 Hz);
δ_C (101 MHz, $CDCl_3$) 158.6 (d, *J* = 249.1 Hz), 136.0, 133.4, 132.9 (d, *J* = 16.9 Hz), 129.8 (d, *J* = 2.7 Hz), 128.7 (d, *J* = 1.8 Hz), 128.6 (d, *J* = 3.9 Hz), 124.4, 118.9 (d, *J* = 24.8 Hz), 117.6 (d, *J* = 2.8 Hz), 110.7 (d, *J* = 9.0 Hz).
This data is consistent with literature precedent.[40]

(4-Bromophenyl)(2-nitrophenyl)sulfane (4i)



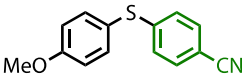
This compound was synthesised according to **general procedure 2** using 4-bromothiophenol (56.7 mg, 0.30 mmol) and **1l** (151.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **4i** (70.7 mg, 76%) as a colourless solid.
R_f (2% EtOAc/pentane) 0.3;
δ_H (400 MHz, $CDCl_3$) 8.22 (1H, dd, *J* = 8.2, 1.5 Hz), 7.63 – 7.59 (2H, m), 7.47 – 7.42 (2H, m), 7.37 (1H, ddd, *J* = 8.2, 7.2, 1.5 Hz), 7.24 (1H, dd, *J* = 8.2, 7.2, 1.3 Hz), 6.86 (1H, dd, *J* = 8.2, 1.5 Hz);
δ_C (101 MHz, $CDCl_3$) 145.3, 138.7, 137.4, 133.7, 133.5, 130.4, 128.4, 125.9, 125.4, 124.9.
This data is consistent with literature precedent.[41]

3-((4-Bromophenyl)thio)pyridine (4j)



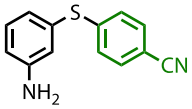
This compound was synthesised according to **general procedure 2** using 4-bromothiophenol (56.7 μL, 0.30 mmol) and **1p** (138.4 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (20% -> 30% EtOAc/pentane) to give **4j** (69.7 mg, 87%) as a colourless oil.
R_f (30% EtOAc/ pentane) 0.33;
δ_H (400 MHz, $CDCl_3$) 8.57 (1H, d, *J* = 2.4 Hz), 8.49 (1H, dd, *J* = 4.8, 1.6 Hz), 7.61 (1H, dt, *J* = 8.0, 2.0 Hz), 7.48 – 7.41 (2H, m), 7.25 – 7.16 (3H, m);
δ_C (101 MHz, $CDCl_3$) 151.6, 148.5, 138.5, 133.7, 133.0, 132.8, 132.7, 124.2, 122.0.
This data is consistent with literature precedent.[42]

4-((4-Methoxyphenyl)thio)benzonitrile (4k)



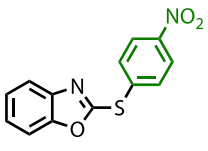
This compound was synthesised according to **general procedure 2** using 4-methoxythiophenol (37 μL, 0.30 mmol) and **1a** (145.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (5% EtOAc/pentane) to give **4k** (51.0 mg, 70%) as a colourless solid;
R_f (5% EtOAc/pentane) 0.20;
δ_H (400 MHz, $CDCl_3$) 7.51 – 7.41 (4H, m), 7.10 – 7.04 (2H, m), 7.00 – 6.94 (2H, m), 3.86 (3H, s);
δ_C (101 MHz, $CDCl_3$) 161.1, 147.5, 137.2, 132.4, 126.2, 120.5, 119.1, 115.7, 108.2, 55.6.
This data is consistent with literature precedent.[36]

4-((3-Aminophenyl)thio)benzonitrile (4l)



This compound was synthesised according to **general procedure 2** using 3-aminothiophenol (37.6 mg, 0.30 mmol) and **1a** (145.6 mg, 0.30 mmol, 1.0 equiv). Additionally, instead of cyclopentanone, ethyl acetate (60 μL) was used as LAG. The residue was purified by flash chromatography (35% EtOAc/pentane) to give **4l** (45.4 mg, 67%) as a colourless solid;
R_f (35% EtOAc/pentane) 0.45;
δ_H (400 MHz, $CDCl_3$) 7.49 – 7.43 (2H, m), 7.22 – 7.16 (3H, m), 6.87 (1H, ddd, *J* = 7.6, 1.7, 1.0 Hz), 6.82 (1H, t, *J* = 2.4 Hz), 6.72 (1H, ddd, *J* = 7.6, 2.4, 1.0 Hz), 3.78 (2H, s);
δ_C (101 MHz, $CDCl_3$) 147.9, 146.1, 132.4, 131.4, 130.8, 127.4, 124.3, 120.4, 119.0, 116.1, 108.6.
This data is consistent with literature precedent.[43]

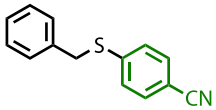
2-((4-Nitrophenyl)thio)benzo[*d*]oxazole (4m)



This compound was synthesised according to **general procedure 2** using 2-mercaptobenzoxazole (45.4 mg, 0.30 mmol) and **1h** (151.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **4m** (62.6 mg, 76%) as a colourless solid;
R_f (2% EtOAc/pentane) 0.20;
δ_H (400 MHz, $CDCl_3$) 8.31 – 8.25 (2H, m), 7.88 – 7.83 (2H, m), 7.69 – 7.63 (1H, m), 7.50 – 7.45 (1H, m), 7.36 – 7.30 (2H, m);

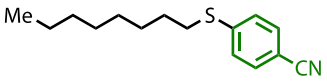
δ_C (101 MHz, $CDCl_3$) 160.5, 152.0, 148.2, 141.7, 136.8, 133.2, 125.3, 125.0, 124.6, 119.6, 110.4.
This data is consistent with literature precedent.[44]

4-(Benzylthio)benzonitrile (4n)



This compound was synthesised according to **general procedure 2** using benzylmercaptan (37.3 mg, 0.30 mmol) and **1a** (145.6 mg, 0.30 mmol, 1.0 equiv). After addition of **1a**, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (5% -> 10% EtOAc/ pentane) to give **4n** (33.0 mg, 49%) as a yellow oil.
R_f (10% EtOAc/ pentane) 0.4;
δ_H (400 MHz, $CDCl_3$) 7.52 – 7.48 (2H, m), 7.38 – 7.27 (7H, m), 4.20 (2H, s);
δ_C (101 MHz, $CDCl_3$) 144.6, 135.9, 132.4, 128.9, 128.8, 127.8, 127.5, 118.9, 108.7, 37.2.
This data is consistent with literature precedent.[45]

4-(Octylthio)benzonitrile (4o)



This compound was synthesised according to **general procedure 2** using octanethiol (52.0 μL, 0.30 mmol) and **1a** (145.6 mg, 0.30 mmol, 1.0 equiv). After addition of **1a**, the reaction was milled for 120 minutes instead of 30 minutes. The residue was purified by flash chromatography (2% -> 5% EtOAc/pentane) to give **4p** (37.5 mg, 51%) as a colourless oil.
R_f (5% EtOAc/ pentane) 0.6;
δ_H (400 MHz, $CDCl_3$) 7.54 – 7.49 (2H, m), 7.31 – 7.27 (2H, m), 2.97 (2H, t, *J* = 7.1 Hz), 1.69 (2H, p, *J* = 7.6 Hz), 1.49 – 1.40 (m, 2H), 1.36 – 1.22 (m, 8H), (3H, t, *J* = 7.1 Hz);
δ_C (101 MHz, $CDCl_3$) 145.5, 132.3, 126.8, 119.1, 108.0, 32.0, 31.9, 29.3, 29.2, 29.0, 28.7, 22.8, 14.2.
This data is consistent with literature precedent.[46]

5.4 *C*-Arylation

General procedure 3: *C*-arylation

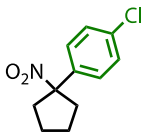
In prose:

Potassium *tert*-butoxide (43.0 mg, 0.36 mmol, 1.2 equiv), nucleophile (0.30 mmol), and one 5 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 30 minutes at 30 Hz. Then diaryliodonium salt **1** (0.30 mmol, 1 equiv) was added. This mixture was milled for 120 minutes. The contents of the vessel were washed out using EtOAc (5 x 0.75 mL) and concentrated *in vacuo*. This residue was purified using silica gel flash chromatography to provide products **5**.

In recipe style:

- Potassium *tert*-butoxide (43.0 mg, 0.36 mmol, 1.2 equiv), nucleophile (0.30 mmol), and one 5 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel.
- Mill for 30 minutes at 30 Hz.
- Add diaryliodonium salt **1** (0.30 mmol, 1.0 equiv).
- Mill for 120 minutes at 30 Hz.
- Contents of vessel washed out with EtOAc (5 x 0.75 mL).
- Concentrate *in vacuo*.
- Purify residue using silica gel flash chromatography to provide products **5**.

1-Chloro-4-(1-nitrocyclopentyl)benzene (5a)



This compound was synthesised according to **general procedure 3** using nitrocyclopentane (32.0 µL, 0.30 mmol) and **1b** (148.4 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (1% Et_2O/pentane) to give **5a** (62.1 mg, 99%) as a colourless oil;

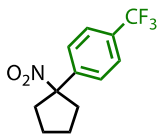
R_f (1% Et_2O/pentane) 0.40;

δ_H (400 MHz, $CDCl_3$) 7.47 – 7.41 (2H, m), 7.37 – 7.32 (2H, m), 3.24 – 3.13 (2H, m), 2.21 – 2.07 (2H, m), 1.94 – 1.77 (4H, m);

δ_C (101 MHz, $CDCl_3$) 137.2, 135.4, 129.0, 128.5, 101.5, 37.0, 22.9.

This data is consistent with literature precedent. [9]

1-(1-Nitrocyclopentyl)-4-(trifluoromethyl)benzene (5b)



This compound was synthesised according to **general procedure 3** using nitrocyclopentane (32.0 µL, 0.30 mmol) and **1m** (158.5 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (1% Et_2O/pentane) to give **5b** (75.2 mg, 96%) as a colourless oil;

R_f (1% EtOAc/pentane) 0.50;

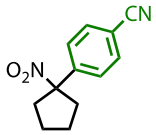
δ_H (400 MHz, $CDCl_3$) 7.68 – 7.59 (4H, m), 3.27 – 3.18 (2H, m), 2.25 – 2.12 (2H, m), 1.94 – 1.83 (4H, m);

δ_F (376 MHz, $CDCl_3$) -62.88;

δ_C (101 MHz, $CDCl_3$) 142.3, 131.5 (q, *J* = 32.3 Hz), 127.9, 125.8 (q, *J* = 3.3 Hz), 123.8 (q, *J* = 270.6 Hz), 101.6, 37.1, 22.9.

This data is consistent with literature precedent.[9]

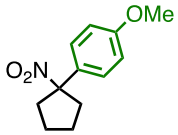
4-(1-Nitrocyclopentyl)benzonitrile (5c)



This compound was synthesised according to **general procedure 3** using nitrocyclopentane (32.0 μL, 0.30 mmol) and **1a** (145.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (5% EtOAc/pentane) to give **5c** (62.0 mg, 96%) as a colourless oil.

R_f (5% EtOAc/pentane) 0.30;
δ_H (400 MHz, $CDCl_3$) 7.74 – 7.66 (2H, m), 7.63 – 7.58 (2H, m), 3.22 – 3.15 (2H, m), 2.22 – 2.11 (2H, m), 1.97 – 1.80 (4H, m);
δ_C (101 MHz, $CDCl_3$) 143.2, 132.6, 127.8, 118.2, 113.3, 101.5, 37.1, 22.9;
HRMS (ESI) calculated for $C_{12}H_{12}N_2O$ ($M+Na^+$): 239.0815; found: 239.0791.

1-methoxy-4-(1-nitrocyclopentyl)benzene (5d)



This compound was synthesised according to **general procedure 3** using nitrocyclopentane (32.0 μL, 0.30 mmol) and **1n** (153.4 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane → 5% EtOAc/pentane) to give **5d** (55.0 mg, 83%) as a colourless oil.

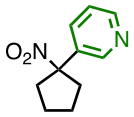
R_f (2% EtOAc/pentane) 0.30;
δ_H (400 MHz, $CDCl_3$) 7.48 – 7.42 (2H, m), 6.91 – 6.84 (2H, m), 3.80 (3H, s), 3.24 – 3.15 (2H, m), 2.19 – 2.09 (2H, m), 1.92 – 1.75 (4H, m);
δ_C (101 MHz, $CDCl_3$) 159.9, 130.7, 128.1, 113.7, 101.5, 55.1, 36.6, 22.6;
This data is consistent with literature precedent.[9]

1-Fluoro-2-(1-nitrocyclopentyl)benzene (5e)

This compound was synthesised according to **general procedure 1** using nitrocyclopentane (32 μL, 0.30 mmol) and **1o** (139.8 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (1% Et_2O/pentane) to give **5e** (46.8 mg, 76%) as a colourless oil;

R_f (1% EtOAc/pentane) 0.45;
δ_H (400 MHz, $CDCl_3$) 7.47 (1H, td, *J* = 7.8, 1.7 Hz), 7.37 (1H, tdd, *J* = 7.8, 5.1, 1.7 Hz), 7.18 (1H, td, *J* = 7.6, 1.7 Hz), 7.08 (1H, ddd, *J* = 11.4, 7.8, 1.7 Hz), 3.12 – 3.02 (2H, m), 2.33 – 2.20 (2H, m), 2.00 – 1.81 (4H, m);
δ_F (376 MHz, $CDCl_3$) -110.55 - -110.66 (m);
δ_C (101 MHz, $CDCl_3$) 160.9 (d, *J* = 249.6 Hz), 131.0 (d, *J* = 8.7 Hz), 128.3 (d, *J* = 3.7 Hz), 126.8 (d, *J* = 13.5 Hz), 124.3 (d, *J* = 3.5 Hz), 116.5 (d, *J* = 22.4 Hz), 98.9, 37.6 (d, *J* = 2.1 Hz), 23.4.
This data is consistent with literature precedent. [9]

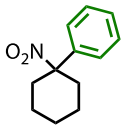
3-(1-nitrocyclopentyl)pyridine (5f)



This compound was synthesised according to **general procedure 3** using nitrocyclopentane (32.0 μL, 0.30 mmol) and **1p** (138.4 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (40% EtOAc/pentane) to give **5f** (53.1 mg, 92%) as a colourless oil.

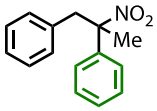
R_f (40% EtOAc/pentane) 0.25;
δ_H (400 MHz, $CDCl_3$) 8.77 (1H, dd, *J* = 2.5, 0.9 Hz), 8.60 (1H, dd, *J* = 4.8, 1.6 Hz), 7.80 (1H, ddd, *J* = 8.0, 2.5, 1.6 Hz), 7.30 (1H, ddd, *J* = 8.1, 4.8, 0.9 Hz), 3.34 – 3.12 (2H, m), 2.27 – 2.10 (2H, m), 1.93 – 1.67 (4H, m);
δ_C (101 MHz, $CDCl_3$) 150.4, 148.4, 134.8, 134.3, 123.5, 100.3, 36.8, 22.8.
This data is consistent with literature precedent.[9]

(1-Nitrocyclohexyl)benzene (5g)



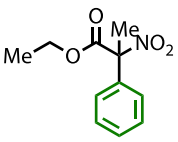
This compound was synthesised according to **general procedure 3** using nitrocyclohexane (38.7 mg, 0.30 mmol) and **1f** (145.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (0% → 5% EtOAc/pentane) to give **5g** (57.3 mg, 92%) as a colourless oil;
R_f (5% EtOAc/pentane) 0.60;
δ_H (400 MHz, $CDCl_3$) 7.52 – 7.46 (2H, m), 7.41 – 7.32 (3H, m), 2.89 – 2.80 (2H, m), 2.12 (2H, ddd, *J* = 14.6, 10.9, 3.9 Hz), 1.78 – 1.49 (5H, m), 1.42 – 1.31 (1H, m);
δ_C (101 MHz, $CDCl_3$) 139.6, 129.1, 129.0, 125.5, 92.8, 35.0, 24.7, 22.9.
This data is consistent with literature precedent. [9]

(2-Nitropropane-1,2-diyl)dibenzene (5h)



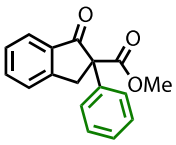
This compound was synthesised according to **general procedure 3** using (2-nitropropyl)benzene **2c** (49.6 mg, 0.30 mmol) and **1f** (145.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (0% → 5% EtOAc/pentane) to give **5h** (66.9 mg, 95%) as a colourless oil;
R_f (5% EtOAc/pentane) 0.60;
δ_H (400 MHz, $CDCl_3$) 7.42 – 4.38 (5H, m), 7.25 – 7.19 (3H, m), 6.98 – 6.93 (2H, m), 3.87 (1H, d, *J* = 13.8 Hz), 3.52 (1H, d, *J* = 13.8 Hz), 1.86 (3H, s);
δ_C (101 MHz, $CDCl_3$) 139.8, 134.8, 130.6, 129.1, 128.9, 128.5, 127.5, 125.8, 93.7, 45.7, 23.6.
This data is consistent with literature precedent.[9]

Ethyl 2-nitro-2-phenylpropanoate (5i)



This compound was synthesised according to **general procedure 3** using ethyl 2-nitropropionate (44.1 mg, 0.30 mmol) and **1f** (145.6 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (0% → 10% EtOAc/pentane) to give **5i** (24.8 mg, 39%) as a yellow oil;
R_f (5% EtOAc/pentane) 0.40;
δ_H (400 MHz, $CDCl_3$) 7.48 – 7.40 (5H, m), 4.34 (2H, q, *J* = 7.1 Hz), 2.26 (3H, s), 1.31 (3H, t, *J* = 7.1 Hz);
δ_C (101 MHz, $CDCl_3$) 167.3, 134.2, 130.0, 128.7, 127.6, 95.2, 63.4, 23.3, 14.0.
This data is consistent with literature precedent.[9]

Methyl 1-oxo-2-phenyl-2,3-dihydro-1H-indene-2-carboxylate (5j)



This compound was synthesised according to **general procedure 3** using methyl 1-oxo-2,3-dihydro-1H-indene-2-carboxylate (**2b**, 57.1 mg, 0.30 mmol) and **1j** (138 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (5% → 10% EtOAc/pentane) to give **5i** (60.1 mg, 78%) as a colourless oil;

R_f (10% EtOAc/pentane) 0.30;

δ_H (400 MHz, $CDCl_3$) 7.87 – 7.82 (1H, m), 7.65 (1H, td, *J* = 7.6, 1.1 Hz), 7.49 (1H, dp, *J* = 7.6, 0.9 Hz), 7.45 – 7.24 (6H, m), 4.23 (1H, d, *J* = 17.2 Hz), 3.75 (3H, s), 3.57 (1H, d, *J* = 17.2 Hz);

δ_C (101 MHz, $CDCl_3$) 200.3, 171.2, 152.2, 138.8, 135.8, 135.2, 128.8, 128.1, 127.7, 127.4, 126.3, 125.2, 65.5, 53.4, 41.0.

This data is consistent with literature precedent.[47]

5.5 *S*-Vinylation

General procedure 4

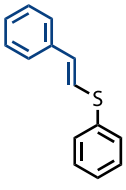
In prose:

Thiol (0.30 mmol) and potassium carbonate (41.5 mg, 0.30 mmol, 1.0 equiv), and one 5 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 30 minutes at 30 Hz. Then VBX reagent **6** (0.30 mmol, 1.0 equiv) was added. This mixture was milled for 90 minutes at 30 Hz. The contents of the vessel were washed out using EtOAc (5 x 0.75 mL) and concentrated *in vacuo*. This residue was purified using silica gel flash chromatography to provide product **7** as the only regioisomer according to NMR analysis.

In recipe style:

- Thiol (0.30 mmol) and potassium carbonate (41.5 mg, 0.30 mmol, 1.0 equiv), and one 5 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel.
- Mill for 30 minutes at 30 Hz.
- Then reagent **6** (0.30 mmol, 1.0 equiv) was added.
- Mill for 90 minutes at 30 Hz.
- Contents of vessel washed out with EtOAc (5 x 0.75 mL).
- Concentrate *in vacuo*.
- Purify residue using silica gel flash chromatography to provide products **7**.

(*E*)-Phenyl(styryl)sulfane (7a)



This compound was synthesised according to **general procedure 4** using thiophenol (31.0 µL, 0.30 mmol) and **6a** (105 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (0% -> 5% EtOAc/pentane) to give **7a** (49.1 mg, 77%) as a colourless oil;

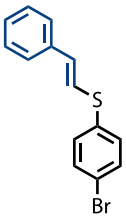
R_f (2% EtOAc/pentane) 0.35;

δ_H (400 MHz, $CDCl_3$) 7.45 – 7.40 (2H, m), 7.38 – 7.21 (8H, m), 6.90 (1H, d, *J* = 15.2 Hz), 6.74 (1H, d, *J* = 15.2 Hz);

δ_C (101 MHz, $CDCl_3$) 136.7, 135.4, 131.9, 130.0, 129.3, 128.8, 127.7, 127.1, 126.2, 123.5.

This data is consistent with literature precedent.[48]

(*E*)-(4-Bromophenyl)(styryl)sulfane (7b)



This compound was synthesised according to **general procedure 4** using 4-bromothiophenol (56.7 mg, 0.30 mmol) and **6a** (105 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **7b** (53.2 mg, 90%) as a colourless oil.

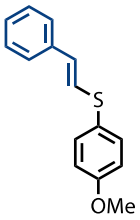
R_f (2% EtOAc/pentane) 0.40;

δ_H (400 MHz, $CDCl_3$) 7.52 – 7.21 (9H, m), 6.80 (1H, d, *J* = 16.3 Hz), 6.75 (1H, d, *J* = 16.3 Hz);

δ_C (101 MHz, $CDCl_3$) 136.4, 134.8, 133.2, 132.4, 131.3, 128.9, 128.0, 126.3, 122.4, 121.0.

This data is consistent with literature precedent.[48]

(*E*)-(4-Methoxyphenyl)(styryl)sulfane (7c)



This compound was synthesised according to **general procedure 4** using 4-methoxythiophenol (38.0 µL, 0.30 mmol) and **6a** (105 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **7c** (53.7 mg, 73%) as a colourless oil;

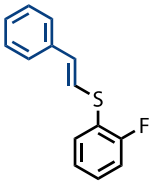
R_f (2% EtOAc/pentane) 0.34;

δ_H (400 MHz, $CDCl_3$) 7.44 – 7.39 (2H, m), 7.32 – 7.17 (5H, m), 6.94 – 6.88 (2H, m), 6.84 (1H, d, *J* = 16.1 Hz), 6.51 (1H, d, *J* = 16.1 Hz), 3.83 (3H, s);

δ_C (101 MHz, $CDCl_3$) 159.7, 136.9, 133.6, 129.1, 128.8, 127.3, 125.9, 125.8, 124.6, 115.0, 55.5.

This data is consistent with literature precedent.[48]

(*E*)-(2-Fluorophenyl)(styryl)sulfane (7d)



This compound was synthesised according to **general procedure 4** using 2-fluorothiophenol (38.4 mg, 0.30 mmol) and **6a** (105 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (2% EtOAc/pentane) to give **7d** (49.1 mg, 90%) as a colourless oil.

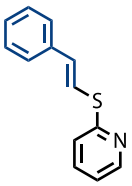
R_f (2% EtOAc/pentane) 0.33;

δ_H (400 MHz, $CDCl_3$) 7.46 (1H, td, *J* = 7.5, 1.7 Hz), 7.40 – 7.25 (4H, m), 7.20 – 7.03 (3H, m), 6.84 (1H, d, *J* = 15.8 Hz), 6.77 (1H, d, *J* = 15.8 Hz);

δ_C (101 MHz, $CDCl_3$) 160.9 (d, *J* = 247.6 Hz), 136.5, 132.8, 132.2 (d, *J* = 1.4 Hz), 131.4, 129.2 (d, *J* = 8.0 Hz), 128.8, 127.9, 126.2, 124.9 (d, *J* = 4.1 Hz), 121.7 (d, *J* = 1.9 Hz), 116.0 (d, *J* = 21.9 Hz).

This data is consistent with literature precedent.[48]

(*E*)-3-(Styrylthio)pyridine (7e)

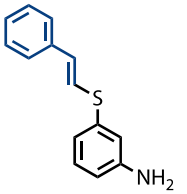


This compound was synthesised according to **general procedure 4** using 2-mercaptopyridine (33.3 mg, 0.30 mmol) and **6a** (105 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (0 -> 20% EtOAc/Pentane) to give **7e** (50.7 mg, 77%, E/Z 12:1) as a colourless oil;

R_f (10% EtOAc/Pentane) 0.45;

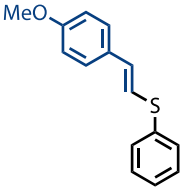
δ_H (400 MHz, $CDCl_3$) 8.49 (1H, ddd, *J* = 4.9, 1.9, 0.9 Hz), 7.55 (1H, ddd, *J* = 8.1, 7.4, 1.9 Hz), 7.50 – 7.42 (3H, m), 7.38 – 7.30 (2H, m), 7.28 - 7.23 (2H, m), 7.06 (1H, ddd, *J* = 7.4, 4.9, 1.9 Hz), 6.89 (1H, d, *J* = 15.8 Hz);
δ_C (101 MHz, $CDCl_3$) 158.1, 150.0, 136.7, 136.6, 132.1, 128.8, 127.9, 126.4, 122.2, 120.4, 119.8.
This data is consistent with literature precedent.[48]

(*E*)-3-(Styrylthio)aniline (7f)



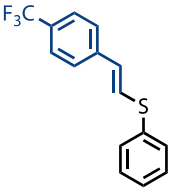
This compound was synthesised according to **general procedure 4** using 3-aminothiophenol (32.0 µL, 0.30 mmol) and **6a** (105 mg, 0.30 mmol, 1.0 equiv). The residue was purified by flash chromatography (40% EtOAc/Pentane) to give **7f** (58.0 mg, 85%) as a yellow oil;
R_f (30% EtOAc/Pentane) 0.25;
δ_H (400 MHz, $CDCl_3$) 7.39 – 7.30 (4H, m), 7.28 – 7.21 (1H, m), 7.13 (1H, t, *J* = 7.3 Hz), 6.91 (1H, d, *J* = 16.1 Hz), 6.81 (1H, ddd, *J* = 7.7, 1.8, 1.0 Hz), 6.79 – 6.71 (2H, m), 6.58 (1H, ddd, *J* = 8.0, 2.3, 1.0 Hz), 3.71 (2H, br.s);
δ_C (101 MHz, $CDCl_3$) 147.2, 136.7, 136.3, 131.8, 130.1, 128.8, 127.7, 126.1, 123.6, 119.8, 115.9, 113.9.
This data is consistent with literature precedent.[48]

(*E*)-(4-Methoxystyryl)(phenyl)sulfane (7g)



This compound was synthesised according to **general procedure 4** using thiophenol (20.0 µL, 0.20 mmol), potassium *tert*-butoxide (33.7 mg, 0.20 mmol, 1.0 equiv) and THF (50 µL). This was initially milled for 15 minutes. then **6b** (76.0 mg, 0.20 mmol, 1.0 equiv) was added and the mixture was milled for 120 minutes. The residue in the ball milling vessel was washed with Et_2O:PE (1:1, 6 mL) and this organic extract was concentrated *in vacuo* to produce **7g** as a colourless solid (40.9 mg, 85%).
R_f (PE) 0.40;
δ_H (400 MHz, $CDCl_3$) 7.41 – 7.38 (2H, m), 7.36 – 7.28 (4H, m), 7.26 – 7.21 (1H, m), 6.88 – 6.84 (2H, m), 6.76 (1H, d, *J* = 15.4 Hz), 6.71 (1H, d, *J* = 15.4 Hz), 3.82 (3H, s);
δ_C (101 MHz, $CDCl_3$) 159.5, 136.1, 132.9, 129.5, 129.4, 129.2, 127.5, 126.7, 120.2, 114.3, 55.5.
This data is consistent with literature precedent.[10]

(E)-Phenyl(4-(trifluoromethyl)styryl)sulfane (7h)



This compound was synthesised according to **general procedure 4** using thiophenol (20.0 µL, 0.20 mmol), potassium *tert*-butoxide (33.7 mg, 0.20 mmol, 1.0 equiv) and THF (50 µL). This was initially milled for 15 minutes, then **6c** (83.6 mg, 0.20 mmol, 1.0 equiv) was added and the mixture was milled for 120 minutes. The residue in the ball milling vessel was washed with Et_2O:PE (1:1, 6 mL) and this organic extract was concentrated *en vacuo* to produce **7h** as a colourless solid (52.3 mg, 93%);
R_f (PE) 0.45;
δ_H (400 MHz, $CDCl_3$) 7.58 – 7.53 (2H, m), 7.48 – 7.28 (7H, m), 7.03 (1H, d, *J* = 15.4 Hz), 6.65 (1H, d, *J* = 15.4 Hz);

δ_F (376 MHz, $CDCl_3$) -62.45;
δ_C (101 MHz, $CDCl_3$) 140.1, 134.1, 130.9, 129.5, 129.2 (q, *J* = 31.7 Hz), 128.5, 127.8, 127.8, 127.7, 126.1, 125.8 (q, *J* = 3.9 Hz), 124.6 (q, *J* = 271.2 Hz).
This data is consistent with literature precedent.[10]

5.6 *C*-Vinylation

General procedure 5: *C*-vinylation

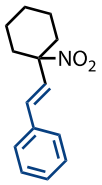
In prose:

Potassium *tert*-butoxide (40.3 mg, 0.36 mmol, 1.2 equiv), the nucleophile (0.30 mmol), and one 5 mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 15 minutes at 30 Hz and then vinyliodonium salt **6d** (118 mg, 0.30 mmol, 1 equiv) was added. This mixture was milled for 10 minutes at 30 Hz. The contents of the vessel were washed out using EtOAc (5 x 0.75 mL) and concentrated *in vacuo* to provide product **8** as the only regioisomer according to NMR analysis.
No flash chromatography needed.

In recipe style:

- Potassium *tert*-butoxide (43.2 mg, 0.36 mmol, 1.2 equiv), nucleophile (0.30 mmol), and one 5mm stainless steel ball were added to a 1.5 mL stainless steel ball milling vessel.
- Mill for 15 minutes at 30 Hz.
- Add vinyliodonium salt **6d** (0.30 mmol, 1.0 equiv).
- Mill for 10 minutes at 30 Hz.
- Wash out the contents of vessel with EtOAc (5 x 0.75 mL).
- Concentrate *in vacuo* to provide products **8**. *No flash chromatography needed.*

(*E*)-(2-(1-nitrocyclohexyl)vinyl)benzene (8a)



This compound was synthesised according to **general procedure 5** using nitrocyclohexane (35.6 µL, 0.30 mmol). After evaporation of the organic extract *in* vacuo, a yellow oil **8a** (65 mg, 92%) was isolated;

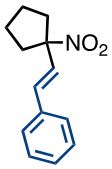
Large scale reaction: Potassium *tert*-butoxide (403 mg, 3.6 mmol, 1.2 equiv), nitrocyclohexane, and one 10 mm stainless steel ball were added to a 5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 15 minutes at 30 Hz and then vinyliodonium salt **6d** (1.181 g, 3.00 mmol, 1.0 equiv) was added. This mixture was milled for 10 minutes at 30 Hz. The contents of the vessel were washed out using EtOAc (5 x 4 mL) and concentrated *in vacuo***.** The residue was purified by flash chromatography (10% EtOAc/Pentane) to give **8a** (492 mg, 71%) as a yellow oil;

δ_H (400 MHz, $CDCl_3$) 7.41 – 7.27 (5H, m), 6.71 (1H, d, *J* = 16.3 Hz), 6.26 (1H, d, *J* = 16.3 Hz), 2.61 – 2.48 (2H, m), 2.06 – 1.95 (2H, m), 1.72 – 1.61 (2H, m), 1.60 – 1.47 (3H, m), 1.46 – 1.35 (1H, m);

δ_C (101 MHz, $CDCl_3$) 135.6, 133.2, 129.2, 128.9, 128.8, 127.0, 91.1, 34.6, 24.8, 22.7.

This data is consistent with literature precedent.[49]

(*E*)-(2-(1-nitrocyclopentyl)vinyl)benzene (8b)



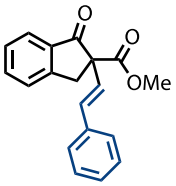
This compound was synthesised according to **general procedure 5** using nitrocyclopentane (32.0 µL, 0.30 mmol). After evaporation of the organic extract *in* vacuo, a yellow oil **8b** (58.0 mg, 89%) was isolated.

δ_H (400 MHz, $CDCl_3$) 7.44 – 7.25 (5H, m), 6.68 (1H, d, *J* = 15.9 Hz), 6.55 (1H, d, *J* = 15.9 Hz), 2.85 – 2.76 (2H, m), 2.17 – 2.03 (2H, m), 1.86 – 1.79 (4H, m);

δ_C (101 MHz, $CDCl_3$) 135.6, 132.4, 128.8, 128.8, 128.7, 127.6, 126.9, 99.7, 37.0, 23.4;

HRMS calculated for $C_{13}H_{15}NO_2$ ($M+Na^+$): 240.0995; found: 240.0986.

Methyl (*E*)-1-oxo-2-styryl-2,3-dihydro-1H-indene-2-carboxylate (8c)



This compound was synthesised according to **general procedure 5** using **1b** (57.1 mg, 0.30 mmol). After addition of iodonium salt **6d**, the mixture was milled for 30 minutes instead of 10 minutes. The residue was purified by flash chromatography (20% EtOAc/pentane) to give **8c** (55.0 mg, 55%) as a yellow oil.

R_f (20% EtOAc/pentane) 0.33;

δ_H (400 MHz, $CDCl_3$) 7.83 – 7.80 (1H, m), 7.65 (1H, dt, *J* = 7.5, 1.2 Hz), 7.55 – 7.52 (1H, m), 7.45 – 7.35 (3H, m), 7.32 – 7.19 (3H, m), 6.76 (1H, d, *J* = 16.7 Hz), 6.52 (1H, d, *J* = 16.7 Hz), 3.95 (1H, d, *J* = 17.1 Hz), 3.76 (3H, s), 3.49 (1H, d, *J* = 17.1 Hz);

δ_C (101 MHz, $CDCl_3$) 200.1, 170.9, 152.6, 136.5, 135.7, 134.4, 131.2, 128.9 128.7, 128.1, 128.1, 126.7, 126.5, 125.5, 63.0, 53.3, 37.9.

This data is consistent with literature precedent.[50]

5.7 Catalytic tosyloxylation

Meta-chloroperbenzoic acid is known to be explosive when completely pure, and is hence used as a commercial mixture with *m*-chlorobenzoic acid. However, care should be taken when upscaling this reaction. HFIP is suspected of damaging fertility and can causes severe eye damage, so need to be used inside a ventilated fumehood.

General procedure 6

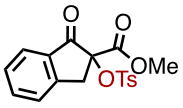
In prose:

The nucleophile (0.30 mmol, 1 equiv), 4-iodo-m-xylene (**9**, 9 μL, 0.30 mmol, 0.2 equiv), *m*CPBA (92% purity) (62.4 mg, 0.30 mmol, 1 equiv), *p*TsOH·H_2O (57.1 mg, 0.30 mmol, 1 equiv), HFIP (0.5 µL/mg) and one 10 mm stainless steel ball were added to a 5 mL stainless steel ball milling vessel. The vessel was closed and the mixture was milled for 5-30 minutes at 25 Hz. The contents of the vessel were washed out using EtOAc (5 x 0.75 mL) and washed with a saturated aqueous solution of $NaHCO_3$. The aqueous layer was washed with more EtOAc (3 x 5 mL). The organic layers were collected and dried over Na_2SO_4. The residue was purified by silica gel column chromatography to provide products **10**.

In recipe style:

- Add nucleophile (0.30 mmol, 1 equiv), 4-iodo-m-xylene (**9**, 9 μL, 0.30 mmol, 0.2 equiv), *m*CPBA (62.4 mg, 0.30 mmol, 1 equiv), *p*TsOH·H_2O (57.1 mg, 0.30 mmol, 1 equiv), HFIP (0.5 µL/mg) and one 10 mm stainless steel ball to a 5 mL stainless steel ball milling vessel.
- Mill for 15 minutes at 35 Hz.
- Wash out the contents of the vessel using EtOAc (5 x 0.75 mL) and wash with a saturated aqueous solution of $NaHCO_3$.
- Wash the aqueous layer with more EtOAc (3 x 5 mL).
- Collect the organic layers and dry over Na_2SO_4.
- Purify the residue by silica gel column chromatography to provide products **10**.

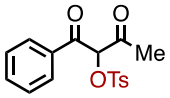
Methyl 1-oxo-2-(tosyloxy)-2,3-dihydro-1H-indene-2-carboxylate (10a)



This compound was synthesised according to **general procedure 6** using **2b** (57.1 mg, 0.3 mmol). The residue was purified by flash chromatography (10% EtOAc/PE) to give **10a** (94 mg, 87%) as a white solid;

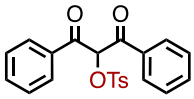
R_f (10% EtOAc/pentane) 0.15;
δ_H (400 MHz, $CDCl_3$) δ 7.91 (2H, d, *J* = 8.2 Hz), 7.80 (1H, d, *J* = 7.7 Hz), 7.69 (1H, tt, *J* = 7.7, 1.2 Hz), 7.52 (1H, d *J* = 7.7 Hz), 7.44 (1H, t, *J* = 7.5 Hz), 7.36 (2H, d, *J* = 8.2 Hz), 4.16 (1H, d, *J* = 17.6 Hz), 3.89 (1H, d, *J* = 17.6 Hz), 3.74 (3H, s), 2.45 (3H, s).
δ_C (101 MHz, $CDCl_3$) δ 193.8, 167.0, 151.8, 145.7, 137.2, 134.8, 133.1, 130.2, 128.9, 128.6, 126.9, 126.1, 87.7, 54.1, 39.0, 22.2.
This data is consistent with literature precedent.[51]

1,3-Dioxo-1-phenylbutan-2-yl 4-methylbenzenesulfonate (10b)



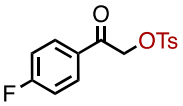
This compound was synthesised according to **general procedure 6** using 1-phenyl-1,3-propandione (48.7 mg, 0.3 mmol) and the reaction was milled for 15 minutes. The residue was purified by flash chromatography (10% EtOAc/PE) to give **10b** (69 mg, 69%) as a white solid;
R_f (10% EtOAc/pentane) 0.2;
δ_H (400 MHz, $CDCl_3$) 15.17 (1H, s), 7.44 – 7.41 (2H, m), 7.36 – 7.32 (3H, m), 7.22 – 7.18 (2H, m), 6.95 (2H, d, *J* = 8.0 Hz), 2.39 (3H, s), 2.32 (3H, s).
δ_C (101 MHz, $CDCl_3$) δ 192.0, 180.2, 145.8, 133.8, 131.9, 131.5, 129.9, 129.2, 129.0, 128.5, 128.3, 23.1, 22.0.
This data is consistent with literature precedent.[52]

Tosyloxydibenzoylmethane (10c):



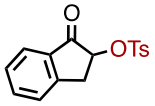
This compound was synthesised according to **general procedure 6** using 1,3-diphenyl-1,3-propandione (67.3 mg, 0.3 mmol, 1.0 equiv) but no HFIP was used. The reaction was milled for 15 minutes. The residue was purified by flash chromatography (10% EtOAc/PE) to give **10c** (90.7 mg, 77%) as a white solid;
R_f (10% EtOAc/pentane) 0.2;
δ_H (400 MHz, $CDCl_3$) δ 15.62 (1H, s), 7.97 – 7.94 (4H, m), 7.79 – 7.76 (4H, m), 7.69 (2H, d, *J* = 8.1 Hz), 7.59 – 7.55 (2H, m), 7.49 – 7.35 (10H, m), 7.27 – 7.24 (2H, m), 7.20 (2H, d, *J* = 8.4 Hz), 6.87 (2H, d, *J* = 8.1 Hz), 6.67 (1H, s), 2.39 (3H, s), 2.29 (3H, s).
δ_C (101 MHz, $CDCl_3$) δ 190.1, 183.6, 145.7, 145.2, 134.5, 134.2, 133.8, 132.6, 132.1, 131.0, 129.9, 129.8, 129.5 129.3, 128.8, 128.6, 128.4, 127.1, 84.0, 21.8, 21.7.
This data is consistent with literature precedent.[52]

1-(4-fluorophenyl)-2-(p-tolylsulfonyloxy)ethanone (10d)



This compound was synthesised according to **general procedure 6** with modifications: 4-fluoroacetophenone (36 *μL,* 0.3 mmol), *m*CPBA (93.6 mg, 0.45 mmol, 1.5 equiv) and *p*TsOH·H_2O (85.6 mg, 0.45 mmol, 1.5 equiv) were added to a vessel which had been warmed in a 60 °C oven overnight. The residue was purified by flash chromatography (10% EtOAc/PE) to give **10d** (68 mg, 74%) as a white solid;
R_f (10% EtOAc/pentane) 0.2;
δ_H (400 MHz, $CDCl_3$) δ 7.91 – 7.87 (2H, m), 7.84 (2H, d, J = 8.4 Hz), 7.35 (2H, d, J = 8.2 Hz), 7.18 – 7.12 (2H, m), 5.21 (2H, s), 2.45 (3H, s).
δ_C (101 MHz, $CDCl_3$) δ 189.0, 167.6, 165.0, 145.4, 132.6, 130.9, 130.8, 130.3, 130.3, 129.9, 128.2, 116.3, 116.1, 69.8, 21.7.
δ_F (377 MHz, $CDCl_3$) δ -102.43 – -102.61 (m).
This data is consistent with literature precedent.[53]

1-oxo-2,3-dihydro-1H-inden-2-yl 4-methylbenzenesulfonate (10e)



This compound was synthesised according to **general procedure 6** with modifications: 1-indanone (39.6 mg, 0.3 mmol), *m*CPBA (93.6 mg, 0.45 mmol, 1.5 equiv) and *p*TsOH·H_2O (85.6 mg, 0.45 mmol, 1.5 equiv) were added to a vessel which had been warmed in a 60°C oven overnight. The residue was purified by flash chromatography (10% EtOAc/PE) to give **10e** (37 mg, 41%) as a white solid;

R_f (10% EtOAc/pentane) 0.2;

δ_H (400 MHz, $CDCl_3$) δ 7.92 (2H, d, *J* = 8.3 Hz), 7.72 (1H, d, *J* = 7.7 Hz), 7.64 (1H, td, *J* = 7.5, 1.2 Hz), 7.43 (1H, dq, *J* = 7.9, 1.0 Hz), 7.40 – 7.37 (3H, m), 5.12 (1H, dd, *J* = 8.0, 4.8 Hz), 3.65 (1H, dd, *J* = 17.2, 8.0 Hz), 3.26 (1H, ddt, *J* = 17.3, 4.7, 1.1 Hz), 2.46 (3H, s).

δ_C (101 MHz, $CDCl_3$) δ 197.7, 150.1, 145.3, 136.5, 133.8, 133.4, 130.0, 128.6, 128.4, 126.8, 124.8, 78.4, 34.0, 21.9.

This data is consistent with literature precedent.[54]

6. Benchmarking studies

6.1 Solution-phase reactions

Literature methods for solution phase arylation with diaryliodonium salts **1**, vinylation with vinylating reagents **6** and tosyloxylations with **9** were performed to evaluate the reaction efficiency compared to the mechanochemical reactions. The methods are described below, and the results are given in Table S7.

BM1: *O*-arylation using KO^{t}Bu as base[55]

To a solution of KO^t*B*u (37.0 mg, 0.33 mmol, 1.1 equiv) in dry THF (1.5 mL) under nitrogen atmosphere, was added the alcohol (0.30 mmol, 1 equiv). This mixture was stirred for 5 min at room temperature. Salt **1** (0.30 mmol) was added at 0 °C, and the solution was stirred for 1 h at 40 °C. The reaction mixture was quenched with H_2O (10 mL) and extracted with EtOAc, dried over Na_2SO_4 and concentrated *in vacuo*. The crude material was purified with flash chromatography, to yield ether **3.**

BM2: *O*-arylation using NaOH as base[56]

To a solution of NaOH (24 mg, 0.6 mmol, 2 equiv) in distilled water (0.75 mL) was added alcohol (0.30 mmol) at rt and the mixture was stirred for a few minutes. Diaryliodonium salt **1** (0.36 mmol, 1.2 equiv) was added in one portion and the reaction was vigorously stirred at 60 °C for 3 h. The reaction was cooled to room temperature and extracted with EtOAc, dried over Na_2SO_4 and concentrated *in vacuo*. The crude material was purified with flash chromatography, to yield ether **3.**

BM3: *S*-arylation[57]

To a solution of thiol (0.3 mmol) and diaryliodonium salt **1** (0.3 mmol, 1 equiv) was added MeCN (3 mL) and DBU (43 μL, 0.33 mmol, 1.1 equiv). This mixture was then stirred at 80 °C for 1.5 h. The reaction was extracted with EtOAc (3 x 5mL), then the organic layer was washed with brine (5 x 10 mL), dried over Na_2SO_4 and concentrated *in vacuo*. The crude material was purified with flash chromatography, to yield ether **4.**

BM3: C-vinylation[49]

To an oven-dried microwave vial was added KO^t*B*u (37.0 mg, 0.33 mmol, 1.1 equiv). After evacuating the vial and back-filling with nitrogen, anhydrous THF (12.5) was added, followed by addition of the carbon nucleophile (57.1 mg, 0.3 mmol). This mixture was allowed to stir for one hour at room temperature, then vinyliodonium salt **6d** and additional anhydrous THF (7.5 mL) were added. The mixture was allowed to stir for 18 h and then the reaction was quenched with water (10 mL), extracted with CH_2Cl_2, dried over Na_2SO_4 and concentrated *in vacuo*. The crude material was purified with flash chromatography, to yield alkane **8.** THF (0.024 M

The C-arylation, S-vinylation, C-vinylation and tosyloxylation data were taken from literature.

6.2 Solution-phase reaction conditions higher solvent concentration

The following reactions were conducted using solution-phase conditions with the exception of using the same amount of solvent as the LAG in the mechanochemical reactions. This allows for a conclusion on whether solution-phase reactions can just be conducted at a much higher concentration in order to optimise further. The conditions are described below, and the results are given in Table S7.

BM5: O-arylation using KO^{t}Bu as base [55]
The same as BM1 but with THF (60 μL).

BM6: O-arylation using NaOH as base[56]
The same as BM2 but with distilled water (60 μL).

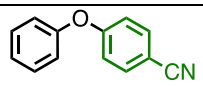
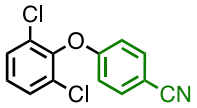
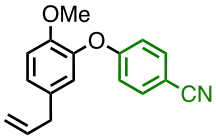
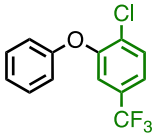
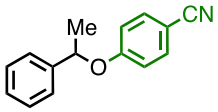
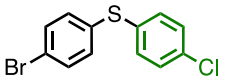
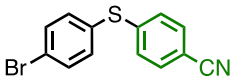
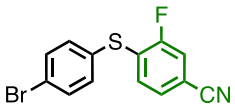
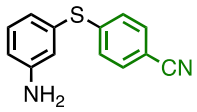
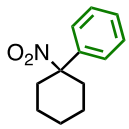
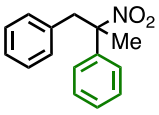
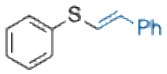
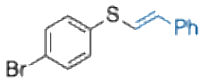
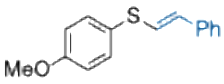
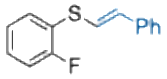
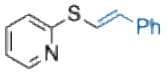
BM7: S-arylation [57]
The same as BM2 but with MeCN (6 μL).

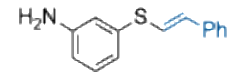
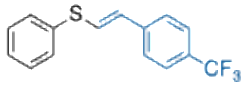
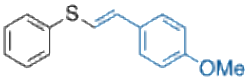
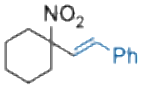
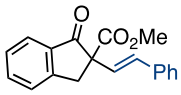
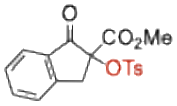
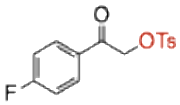
BM8: C-vinylation[49]
To an oven-dried microwave vial was added KO^{t}Bu (37.0 mg, 0.33 mmol, 1.1 equiv). After evacuating the vial and back-filling with nitrogen, anhydrous THF (30 μL) was added, followed by addition of the carbon nucleophile (57.1 mg, 0.3 mmol). This mixture was allowed to stir for one hour at room temperature, then vinyliodonium salt **6d** and additional anhydrous THF (7.5 mL) were added. The mixture was allowed to stir for 18 h and then the reaction was quenched with water (10 mL), extracted with CH_2Cl_2, dried over Na_2SO_4 and concentrated *in vacuo*. The crude material was purified with flash chromatography, to yield alkane **8.**

6.3 Mechanochemical reaction conditions with microwave vials

Several mechanochemical reactions were performed with the exact same experimental procedures as the aforementioned mechanochemical conditions, apart from that the reagents were added to a small microwave vial with stirring bar and stirred on a stirrer plate, instead of being added to a ball milling vessel and then milled in a ball miller.
This was done to ascertain whether the ball milling vessel/ ball miller itself was required for activation of the reactions. The results are given in Table S7.

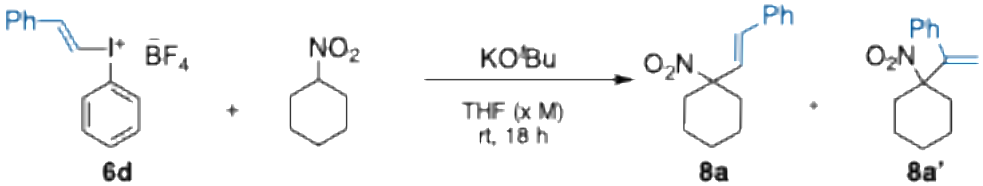
Table S7. Comparison of mechanochemical and solution-based methods.

Product		Yield obtained with various methods (%)			
		In solution	Higher conc	Microwave vials	Ball-milling
	**3a**	BM1: 95 BM2: 69	BM5: 85	28	91
	**3g**	BM1: 80 BM2: 37	BM5: 39	51	88
	**3h**	BM1: 87 BM2: 25	BM5: 41	18	87
	**3l**	BM1: 79 BM2: 63	BM5: 58	16	80
	**3y**	BM1: 63 BM2: 37	BM6: 42	Trace	59
	**4f**	BM3: 71	BM7: 41	28	84
	**4g**	BM3: 74	BM7: 39	22	83
	**4h**	BM3: 71	BM7: 37	39	92
	**4l**	BM3: 50	BM7: 43	49	67
	**5d**	Ref[9]: 91	-	-	76
	**5g**	Ref[9]: 89	-	-	92
	**5h**	Ref[9]: 73	-	-	95
	**7a**	Ref[48]: 81 (*E*:*Z* >20:1)	-	-	77 (*E*:*Z* >20:1)
	**7b**	Ref [15]: 75 (*E*:*Z* >20:1)	-	-	90 (*E*:*Z* >20:1)
	**7c**	Ref [15]: 73 (*E*:*Z* >20:1)	-	-	73 (*E*:*Z* >20:1)
	**7d**	Ref [15]: 52 (*E*:*Z* >20:1)	-	-	90 (*E*:*Z* >20:1)
	**7e**	Ref [15]: 60 (*E*:*Z* 5:1)	-	-	77 (*E*:*Z* 12:1)

	**7f**	Ref [15]: 37 (*E*:*Z* >20:1)	-	-	85 (*E*:*Z* >20:1)
	**7h**	Ref [15]: 72 (*E*:*Z* >20:1)	-	-	93 (*E*:*Z* >20:1)
	**7g**	Ref [15]: 51 (*E*:*Z* 4:1)	-	-	85 (*E*:*Z* >20:1)
	**8a**	Ref [14]: 67 (regiosel 4:1)	BM8: 33 (regiosel >20:1)	33 (regiosel >20:1)	92 (regiosel >20:1)
	**8c**	BM4: 11 (regiosel >20:1)	-	-	55 (regiosel >20:1)
	**10a**	59	-	-	87
	**10d**	Ref [53]: 85	-	-	74

The different regioselectivities observed in vinylation to **8a** are interesting. While high concentration is sufficient to reach excellent regioselectivity, the yields are low in absence of ball milling (Table S8).

Table S8. Regioselectivity investigation.

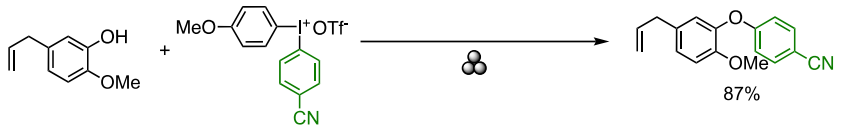


concentration (M)	NMR yield 8a (%)	NMR yield 8a' (%)	Ratio
0.024	55	12	5:1
0.05	59	10	6:1
0.2	59	6	10:1
1	48	trace	>20:1
10	36	trace	>20:1

7. E-factor calculations

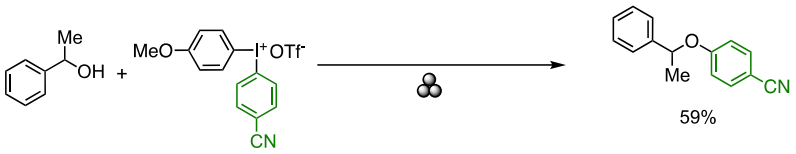
$$E-factor = \frac{waste\ mass\ (g)}{product\ (g)} = \frac{total\ mass\ of\ everything\ used\ (g) - product\ (g)}{product\ (g)}$$

NOTE on purification techniques: At the 0.3 mmol scale, the same amount of silica and column solvents was always used. In the case for reactions whose yields come directly from the literature, purification techniques are taken from their respective experimental and the same amount of silica and column solvents are used as in our experimental.

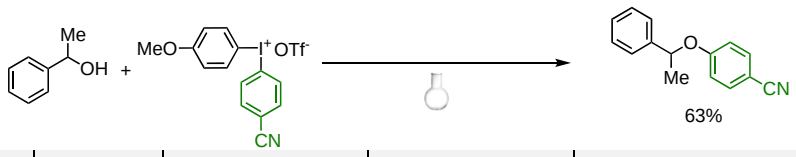


Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{11}INF_3O_4S$	485	0.3	1	/	0.145
$C_{10}H_{12}O_2$	164	0.3	1	1.06	0.052
K_2CO_3	138	0.3	1	/	0.042
$C_4H_8O_2$		0.61	2	0.902	0.054
Total mass of all substrates (g)					0.293
$C_{17}H_{15}NO_2$	265	0.27		/	0.070
Waste mass (g)					0.223
E-factor					3.2
E-factor including purification below					
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	18
Pentane: column	/	/	/	0.604	108
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					185.2
E-factor including purification					2646

Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{11}INF_3O_4S$	485	0.30	1	/	0.146
$C_{10}H_{12}O_2$	164	0.3	1	/	0.049
KOC_4H_9	112	0.33	1.1	/	0.037
C_4H_8O	/	/	/	0.867	1.730
Total mass of all substrates (g)					1.962
$C_{17}H_{15}NO_2$	265	0.168		/	0.069
Waste mass (g)					1.893
E-factor					27.4
E-factor including purification below					
EtOAc: column	/	/	/	0.902	18
Pentane: column	/	/	/	0.604	108
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					177.893
E-factor including purification					2578.2



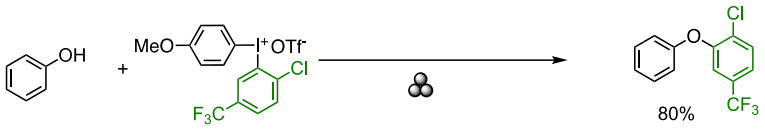
Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{11}INF_3O_4S$	485	0.3	1	/	0.145
$C_8H_{10}O$	122	0.3	1	1.102	0.036
K_2CO_3	138	0.3	1	/	0.042
$C_4H_8O_2$		0.61	2	0.902	0.054
Total mass of all substrates (g)					0.277
$C_{15}H_{13}NO$	223	0.18		/	0.040
Waste mass (g)					0.237
E-factor					5.9
E-factor including purification below					
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	18
Pentane: column	/	/	/	0.604	108
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					185.237
E-factor including purification					4630.9



Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{11}INF_3O_4S$	485	0.3	1	/	0.146
$C_8H_{10}O$	122	0.3	1	/	0.036
KOC_4H_9	96	0.33	1.1	/	0.037
C_4H_8O	/	/	/	0.867	1.730
Total mass of all substrates (g)					1.949
$C_{15}H_{13}NO$	223	0.042		/	0.042
Waste mass (g)					1.907
E-factor					45.4

E-factor including purification below

EtOAc: column	/	/	/	0.902	18
Pentane: column	/	/	/	0.604	108
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					177.907
E-factor including purification					4235.9

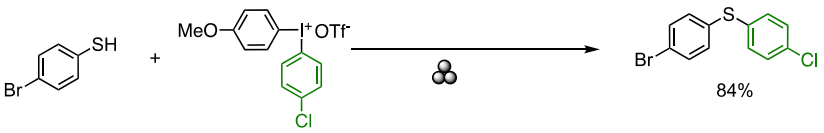


Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{10}ClF_6IO_4S$	562	0.3	1	/	0.169
C_6H_6O	94	0.3	1	/	0.028
K_2CO_3	138	0.3	1	/	0.042
$C_4H_8O_2$		0.61	2	0.902	0.054
Total mass of all substrates (g)					0.293
$C_{13}H_7ClF_3O_2$	272	0.24		/	0.066
Waste mass (g)					0.227
E-factor					3.4
E-factor including purification below					
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	18
Pentane: column	/	/	/	0.604	108
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					185.227
E-factor including purification					2806.5

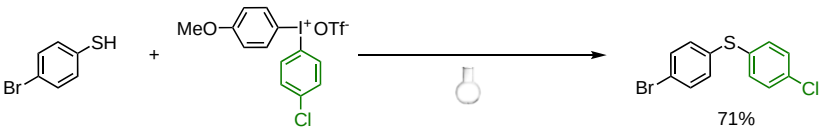
Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{10}ClF_6IO_4S$	562	0.3	1	/	0.168
C_6H_6O	94	0.3	1	1.129	0.028
KOC_4H_9	96	0.33	1.1	/	0.037
C_4H_8O	/	/	/	0.867	1.730
Total mass of all substrates (g)					1.963
$C_{14}H_{10}ClF_3O_2$	272	0.27		/	0.064
Waste mass (g)					1.899
E-factor					29.7

E-factor including purification below

EtOAc: column	/	/	/	0.902	18
Pentane: column	/	/	/	0.604	108
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					177.899
E-factor including purification					2779.7



Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{14}H_{11}ICIF_3O_4S$	494	0.3	1	/	0.148
C_6H_5BrS	189	0.3	1	/	0.057
Na_2CO_3	105	0.3	1	/	0.032
C_5H_8O		0.068	0.226	0.951	0.006
Total mass of all substrates (g)					0.243
$C_{12}H_8BrClS$	224	0.25	/	/	0.075
Waste mass (g)					0.168
E-factor					2.2
E-factor including purification below					
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	3.6
Pentane: column	/	/	/	0.604	118.3
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					181.1
E-factor including purification					2417

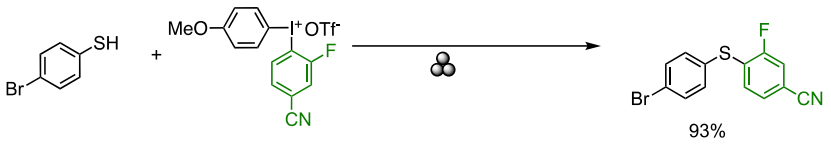


Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{14}H_{11}ICIF_3O_4S$	494	0.3	1	/	0.148
C_6H_5BrS	189	0.3	1	/	0.057
$C_9H_{16}N_2$	24	0.33	1.1	/	0.050
C_2H_3N		/	/	0.782	3.836
Total mass of all substrates (g)					4.091
$C_{12}H_8BrClS$	224	0.024	/	/	0.064
Waste mass (g)					4.027

E-factor					62.9

E-factor including purification below

H_2O wash	/	/	/	1	25
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	3.6
Pentane: column	/	/	/	0.604	118.3
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					209.927
E-factor including purification					3280.1

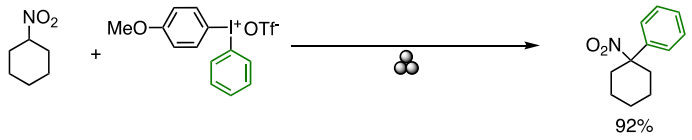


Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{10}IF_4O_4SN$	503	0.3	1	/	0.157
C_6H_5BrS	189	0.3	1	/	0.057
Na_2CO_3	105	0.3	1.2	/	0.032
C_5H_8O		0.068	0.226	0.951	0.006
Total mass of all substrates (g)					0.252
$C_{13}H_7BrFNS$	308	0.28	/	/	0.091
Waste mass (g)					0.161
E-factor					1.8
E-factor including purification below					
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	9
Pentane: column	/	/	/	0.604	114.8
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					183.0
E-factor including purification					2010.6

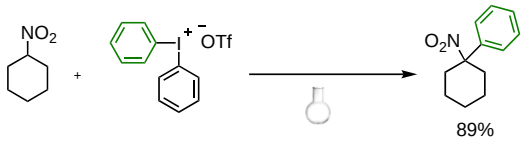
Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{10}IF_4O_4SN$	503	0.3	1	/	0.151
C_6H_5BrS	189	0.3	1	/	0.057
$C_9H_{16}N_2$	24	0.33	1.1	/	0.050
C_2H_3N		/	/	0.782	3.836
Total mass of all substrates (g)					4.094
$C_{13}H_7BrFNS$	308	0.020	/	/	0.066
Waste mass (g)					4.028
E-factor					61.0

E-factor including purification below

H_2O wash	/	/	/	1	25
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	3.6
Pentane: column	/	/	/	0.604	118.3
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					209.928
E-factor including purification					3180.7



Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{14}H_{12}IF_3O_4S$	460	0.3	1	/	0.138
$C_6H_{11}NO_2$	129	0.3	1	1.06	0.038
KOC_4H_9	112	0.33	1.1	/	0.032
Total mass of all substrates (g)					0.208
$C_{12}H_{15}NO_2$	205	0.27	/	/	0.055
Waste mass (g)					0.153
E-factor					2.8
E-factor including purification below					
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	9
Pentane: column	/	/	/	0.604	114.8
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					183.0
E-factor including purification					3326.4

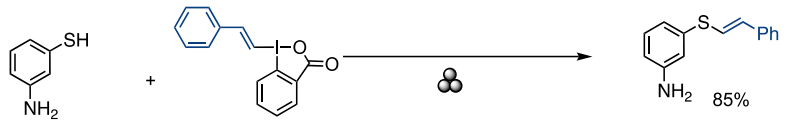


NOTE: this data was taken from the literature. [9]

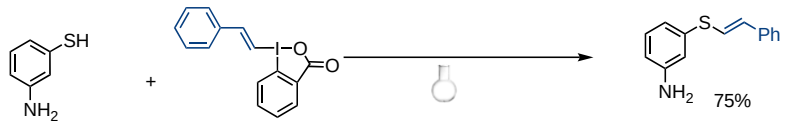
Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{14}H_{12}IF_3O_4S$	460	0.4	1	/	0.138
$C_6H_{11}NO_2$	129	0.4	1	1.06	0.038
KOC_4H_9	112	0.48	1.2	/	0.032
$C_4H_{10}O_2$	/	/	/	0.867	2.601
Total mass of all substrates (g)					2.809
$C_{12}H_{15}NO_2$	205	0.36	/	/	0.072
Waste mass (g)					2.737
E-factor					38.0

E-factor including purification below

Brine quench	/	/	/	/	7
EtOAc wash	/	/	/	0.902	34.1
EtOAc: column	/	/	/	0.902	11.7
Petroleum/Ether: column	/	/	/	0.604	152.8
Silica	/	/	/	/	75
Total waste of all substrates including purification (g)					283.3
E-factor including purification					3935.2



Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{11}IO_2$	350	0.3	1	/	0.105
C_6H_7NS	125	0.3	1	1.17	0.037
K_2CO_3	138	0.3	1	/	0.042
Total mass of all substrates (g)					0.184
$C_{14}H_{13}NS$	227	0.26	/	/	0.058
Waste mass (g)					0.126
E-factor					2.2
E-factor including purification below					
EtOAc wash	/	/	/	0.902	9
EtOAc: column	/	/	/	0.902	72
Pentane: column	/	/	/	0.604	72
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					203.1
E-factor including purification					3502.2

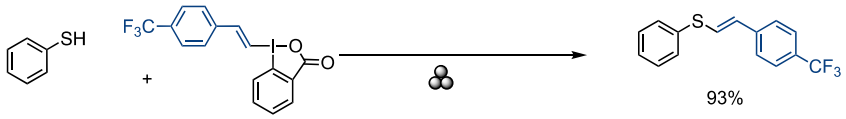


NOTE: this data was taken from the literature. [15]

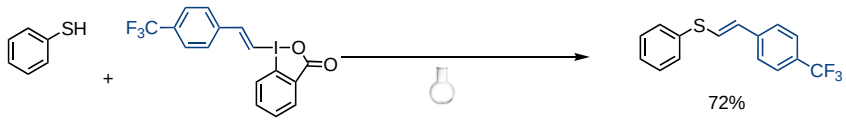
Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{15}H_{11}IO_2$	350	0.36	1.2	/	0.126
C_6H_7NS	125	0.3	1	1.17	0.038
KOC_4H_9	112	0.3	1	/	0.034
C_4H_8O	/	/	/	0.88	2.67
Total mass of all substrates (g)					2.868
$C_{14}H_{13}NS$	227	0.11	/	/	0.022
Waste mass (g)					2.846
E-factor					129.4

E-factor including purification below

Water quench	/	/	/	1	2
DCM extraction	/	/	/	0.902	26
EtOAc: column	/	/	/	0.902	14
Pentane: column	/	/	/	0.604	112
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					206.846
E-factor including purification					9402.1



Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{16}H_{10}IO_2F_3$	418	0.2	1	/	0.084
C_6H_6S	110	0.2	1	1.08	0.022
KOC_4H_9	112	0.2	1	/	0.022
C_4H_8O	72	0.62	2.1	0.88	0.044
Total mass of all substrates (g)					0.172
$C_{15}H_{11}F_3S$	280	0.18	/	/	0.052
Waste mass (g)					0.120
E-factor					2.3
E-factor including purification below					
Et_2O wash	/	/	/	0.713	2.1
Pentane wash	/	/	/	0.604	1.8
Total waste of all substrates including purification (g)					4.020
E-factor including purification					77.3

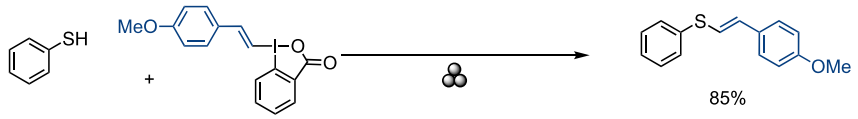


NOTE: this data was taken from the literature. [15]

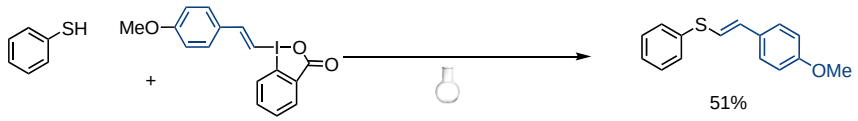
Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{16}H_{10}IO_2F_3$	418	0.11	1.1	/	0.046
C_6H_6S	110	0.1	1	1.08	0.011
KOC_4H_9	112	0.1	1	/	0.011
C_4H_8O	/	/	/	0.88	2.667
Total mass of all substrates (g)					2.735
$C_{15}H_{11}F_3S$	280	0.07	/	/	0.015
Waste mass (g)					2.72
E-factor					181.3

E-factor including purification below

Water quench	/	/	/	1	2
DCM extraction	/	/	/	0.902	26
Pentane:	/	/	/	0.626	125.2
column					
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					205.9
E-factor including purification					13728



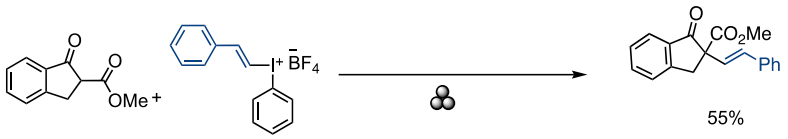
Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{16}H_{13}IO_3$	380	0.2	1	/	0.076
C_6H_6S	110	0.2	1	1.08	0.022
KOC_4H_9	112	0.2	1	/	0.022
C_4H_8O	72	0.62	2.1	0.88	0.044
Total mass of all substrates (g)					0.164
$C_{15}H_{11}F_3S$	280	0.18	/	/	0.041
Waste mass (g)					0.123
E-factor					3.0
E-factor including purification below					
Et_2O wash	/	/	/	0.713	2.1
Pentane wash	/	/	/	0.604	1.8
Total waste of all substrates including purification (g)					4.023
E-factor including purification					98.1



NOTE: this data was taken from the literature. [15]

Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{16}H_{13}IO_3$	380	0.11	1.1	/	0.039
C_6H_6S	110	0.1	1	1.08	0.011
KOC_4H_9	112	0.1	1	/	0.011
C_4H_8O	/	/	/	0.88	2.667
Total mass of all substrates (g)					2.728
$C_{15}H_{11}F_3S$	280	0.07	/	/	0.012
Waste mass (g)					2.716
E-factor					226.3
E-factor including purification below					

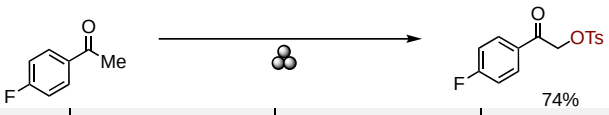
Water quench	/	/	/	1	2
DCM extraction	/	/	/	0.902	26
Pentane:	/	/	/	0.626	125.2
column					
Silica	/	/	/	/	50
Total waste of all substrates including purification (g)					205.9
E-factor including purification					17159.7



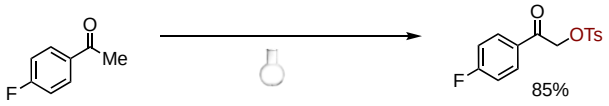
Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{14}H_{12}IBF4$	394	0.3	1	/	0.118
$C_{11}H_{14}O_3$	190	0.3	1	/	0.057
KOC_4H_9	112	0.33	1.1	/	0.040
Total mass of all substrates (g)					0.215
$C_{19}H_{21}O_3$	291	0.19	/	/	0.055
Waste mass (g)					0.160
E-factor					2.9
E-factor including purification below					
EtOAc wash	/	/	/	0.713	27
Pentane wash	/	/	/	0.604	102
Total waste of all substrates including purification (g)					129.160
E-factor including purification					2348.4

Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
$C_{14}H_{12}IBF4$	394	0.33	1.1	/	0.129
$C_{11}H_{14}O_3$	190	0.3	1	/	0.057
KOC_4H_9	112	0.33	1.1	/	0.037
C_4H_8O	/	/	/	0.88	11.11
Total mass of all substrates (g)					11.33
$C_{19}H_{21}O_3$	291	0.19	/	/	0.010
Waste mass (g)					11.32
E-factor					1132.0
E-factor including purification below					
Water wash	/	/	/	1	20

Brine wash	/	/	/	1	20
EtOAc: column	/	/	/	0.902	26.6
Pentane: column	/	/	/	0.604	102.7
Silica	/	/	/		50
Total waste of all substrates including purification (g)					230.6
E-factor including purification					23062



Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
C_6H_7FO	138	0.3	1	/	0.041
C_8H_9I	232	0.06	0.2	/	0.014
$C_7H_5ClO_3$	172	0.45	1.5	/	0.094
$C_7H_{10}SO_4$	190	0.45	1.5	/	0.086
$C_3H_2OF_6$	168	0.83	2.7	1.596	0.139
Total mass of all substrates (g)					0.374
$C_{15}H_{13}FO_4S$	308	0.22	/	/	0.068
Waste mass (g)					0.306
E-factor					4.5
E-factor including purification below					
$NaHCO_3$ quench	/	/	/	3.66	18.3
EtOAc: extraction	/	/	/	0.902	13.5
EtOAc: column	/	/	/	0.902	27.1
Pentane: column	/	/	/	0.604	102.7
Total waste of all substrates including purification (g)					161.906
E-factor including purification					2381.0



NOTE: this data was taken from the literature. [53]

Compound	M_r (g/mol)	mmol	equiv	density (g/mL)	mass (g)
E-factor not including purifications below					
C_6H_7FO	138	0.3	1	/	0.041
C_6H_5I	232	0.03	0.1	/	0.007
$C_7H_5ClO_3$	172	0.33	1.1	/	0.069
$C_7H_{10}SO_4$	190	0.33	1.1	/	0.063
C_2H_3N	/	/	/	0.786	1.179
Total mass of all substrates (g)					1.359

$C_{15}H_{13}FO_4S$	308	0.28	/	/	0.082
Waste mass (g)					1.277
E-factor					15.6

E-factor including purification below

$NaHCO_3$ quench	/	/	/	3.66	18.3
$CHCl_3$: extraction	/	/	/	1.49	44.7
EtOAc: column	/	/	/	0.902	27.06
Pentane: column	/	/	/	0.604	102.68
Total waste of all substrates including purification (g)					194.016
E-factor including purification					2366.1

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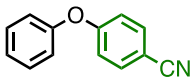
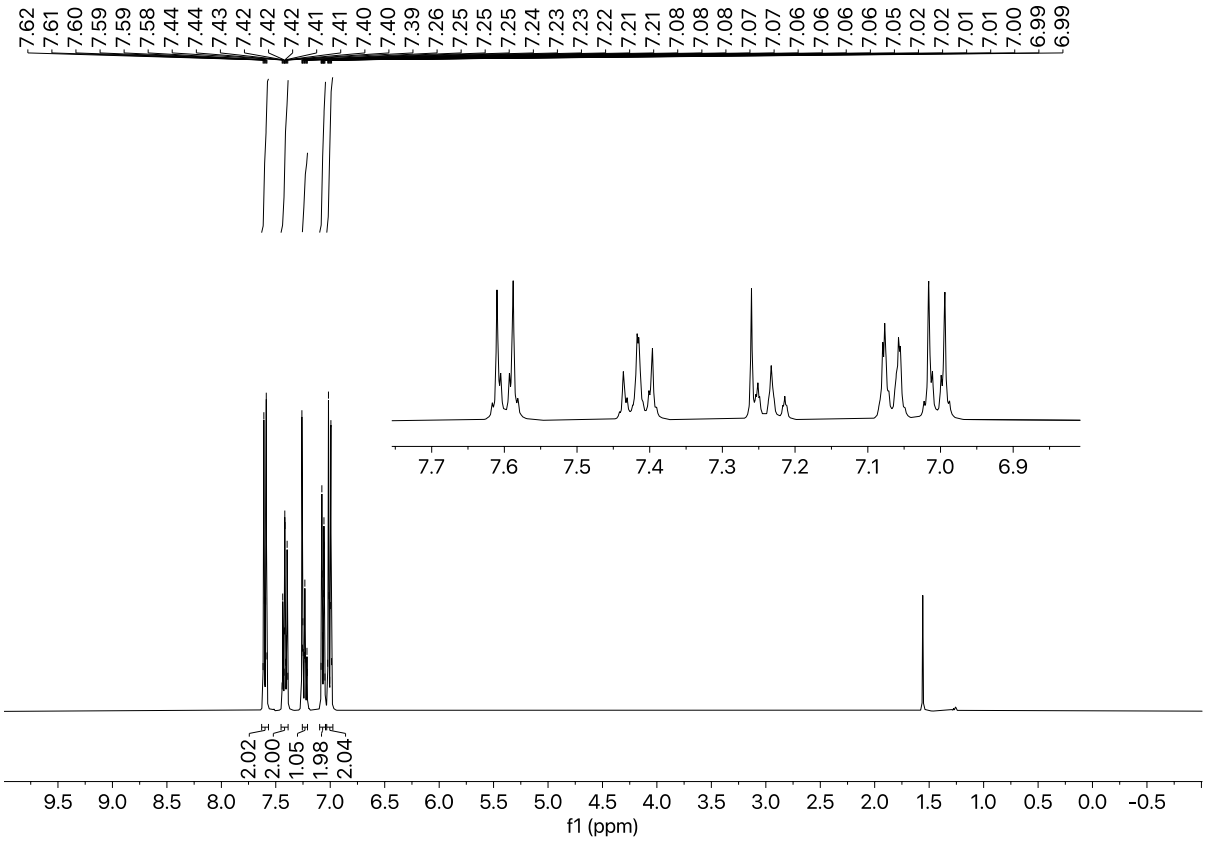
9. NMR Spectra

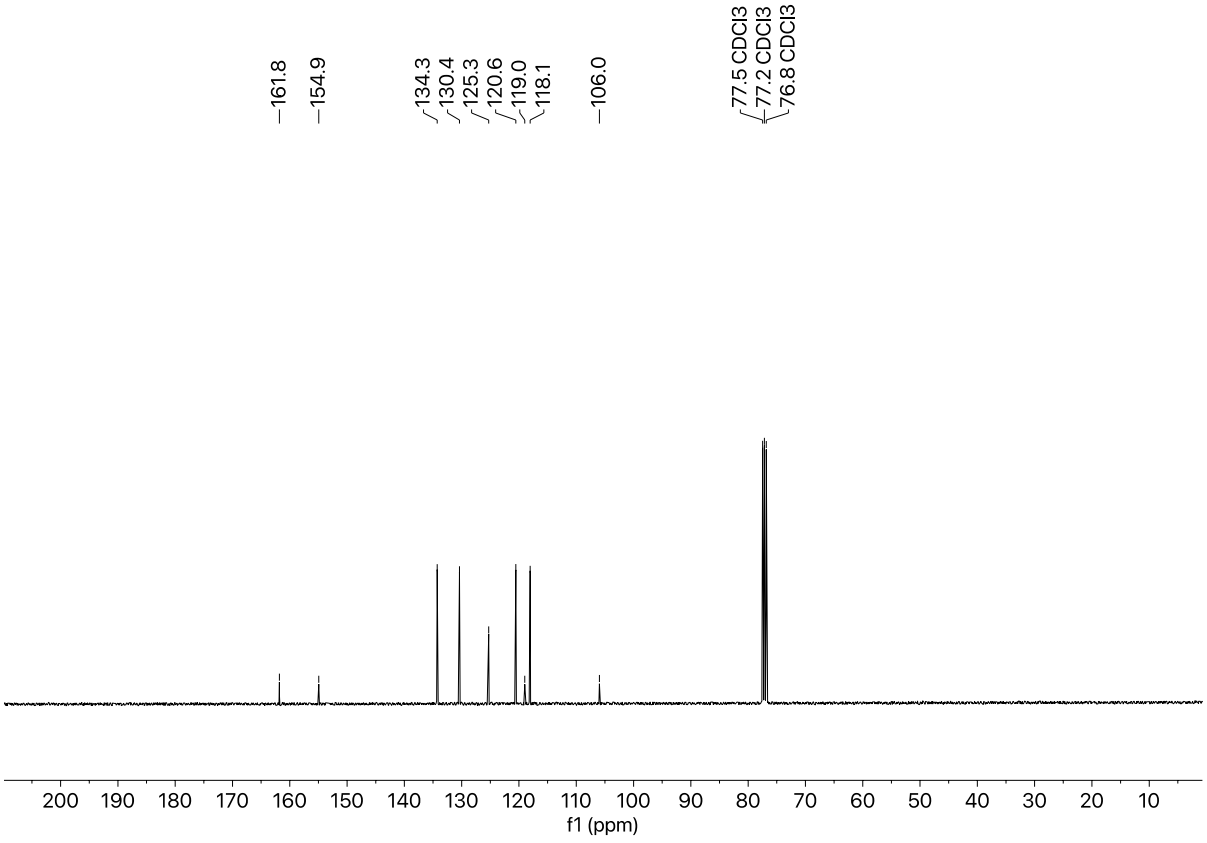
4-Phenoxybenzonitrile (3a)



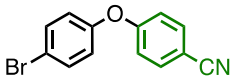
δ_H (400 MHz, $CDCl_3$)



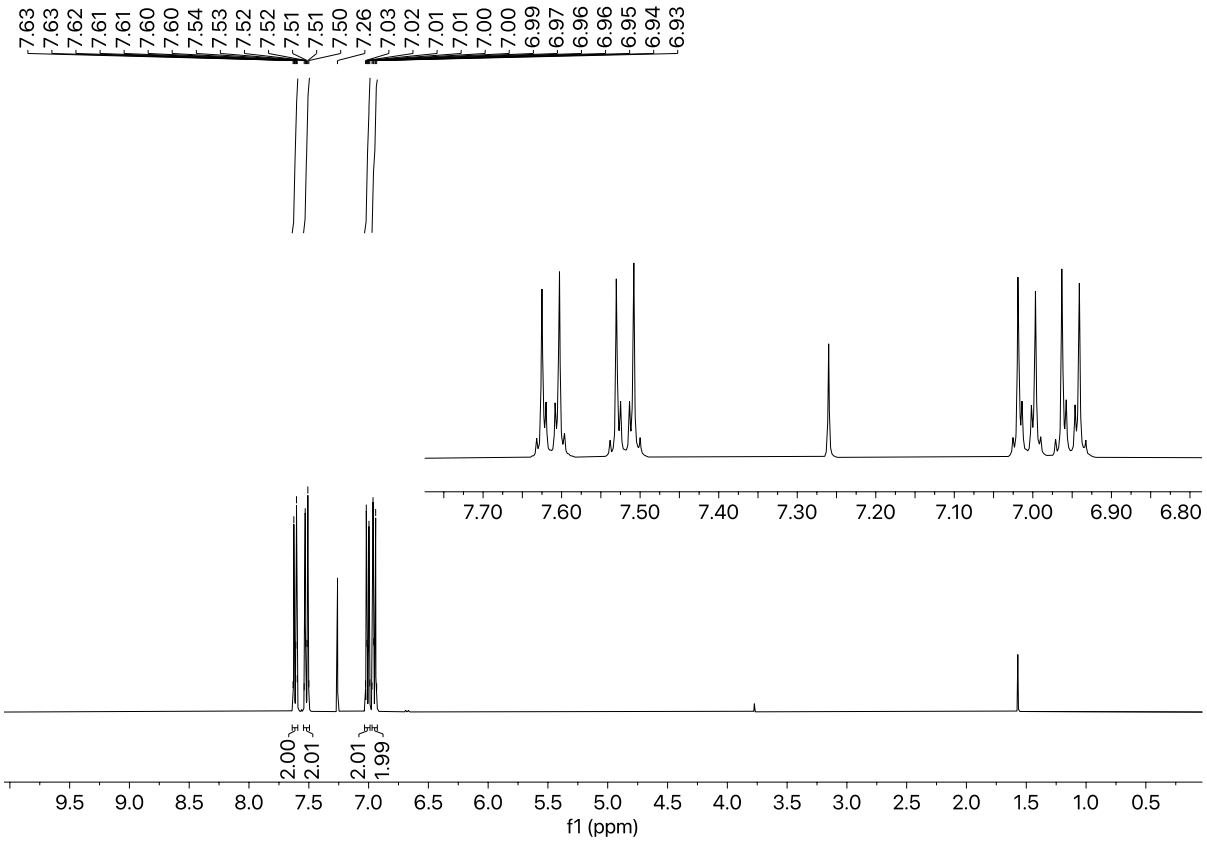
δ_C (101 MHz, $CDCl_3$)



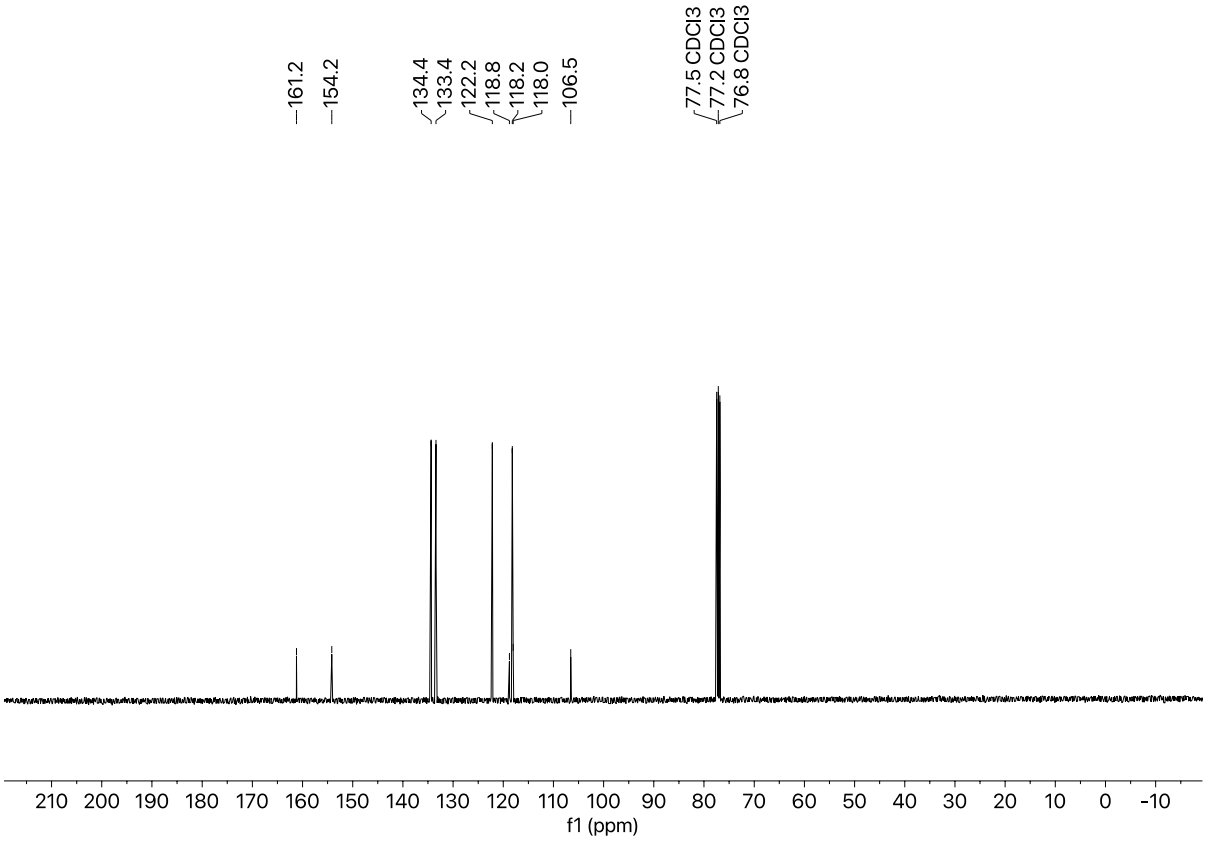
4-(4-Bromophenoxy)benzonitrile (3b)



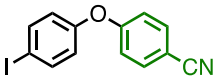
δ_H (400 MHz, $CDCl_3$)



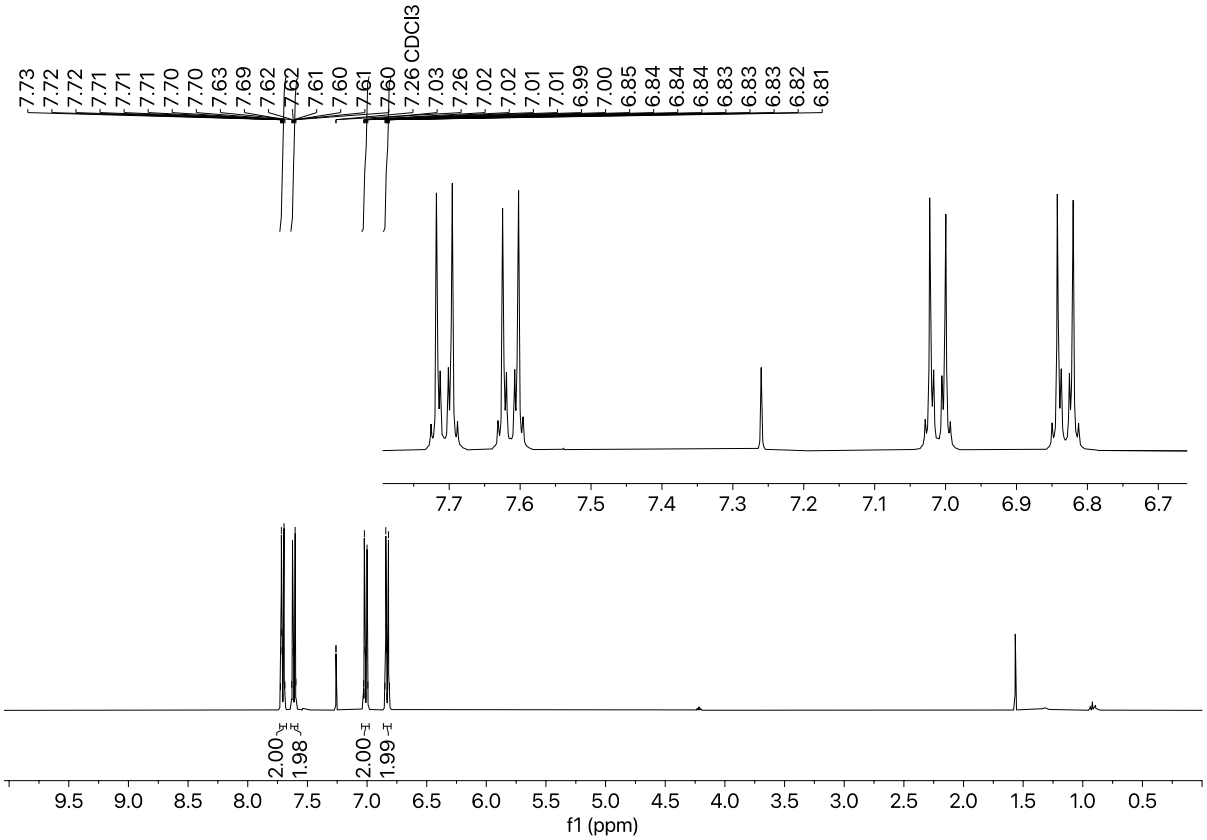
δ_C (101 MHz, $CDCl_3$)



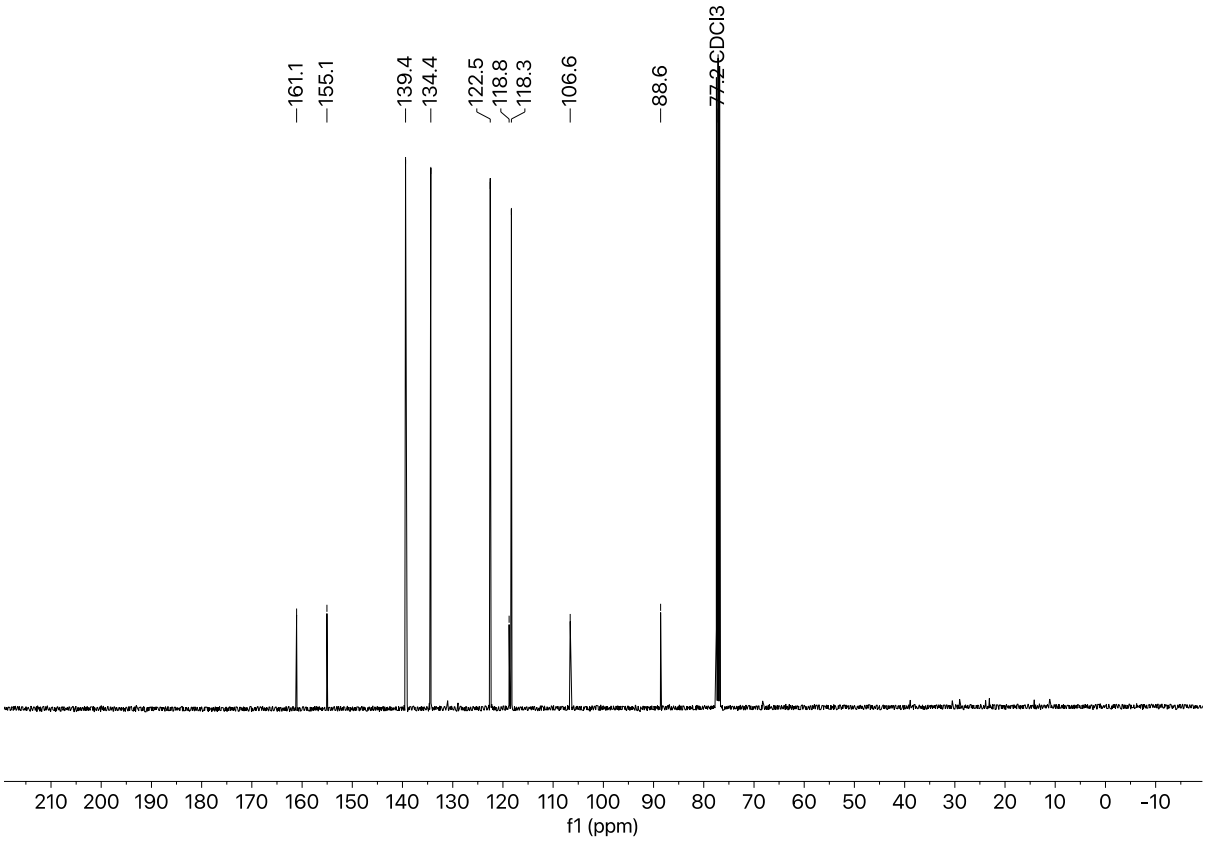
4-(4-Iodophenoxy)benzonitrile (3c)



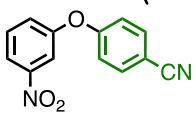
δ_H (400 MHz, $CDCl_3$)



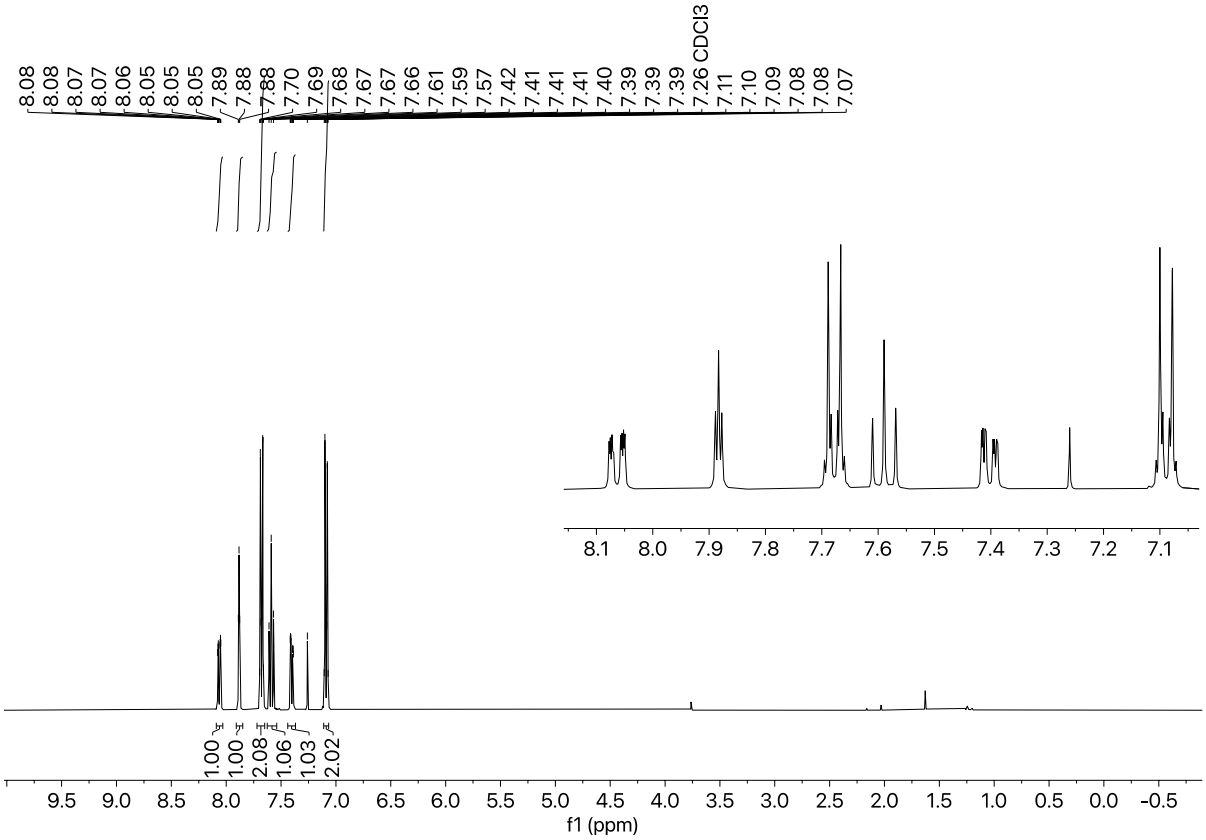
δ_C (101 MHz, $CDCl_3$)



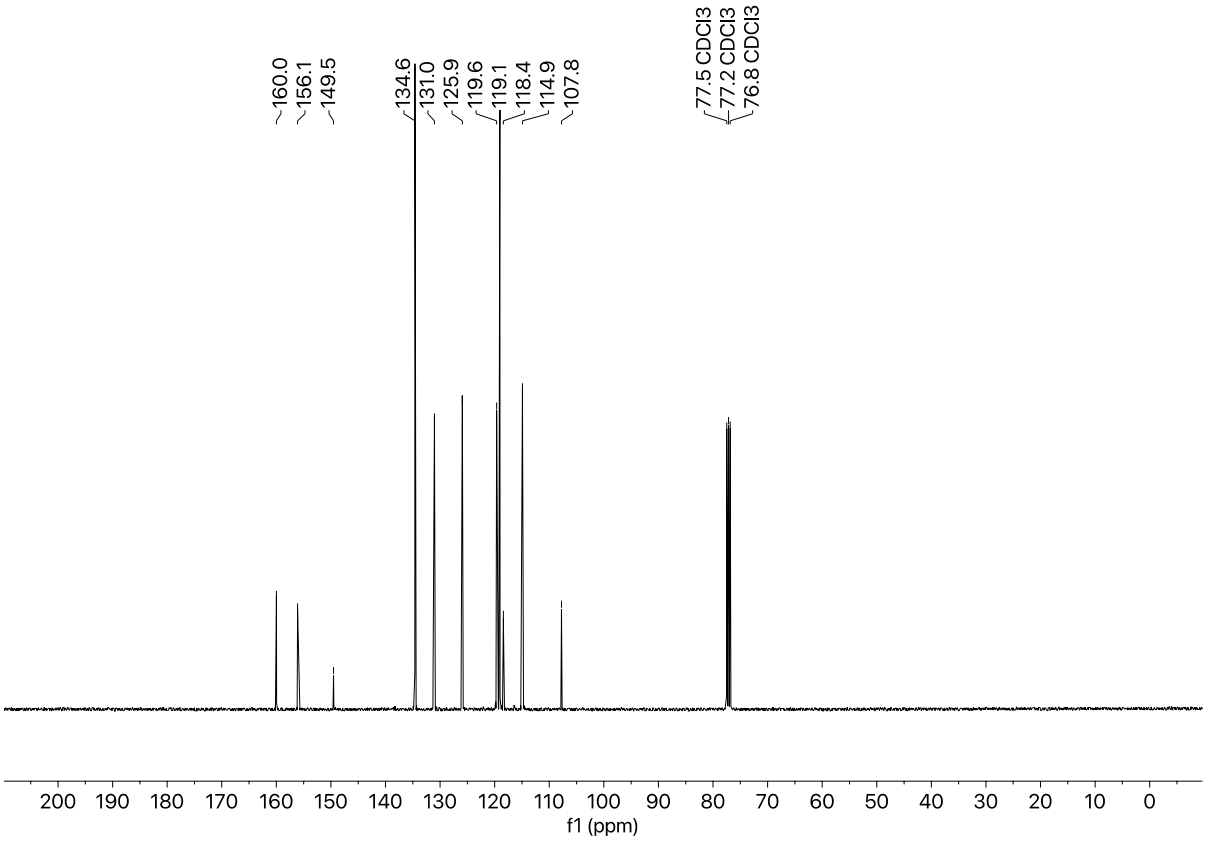
4-(3-Nitrophenoxy)benzonitrile (3d)



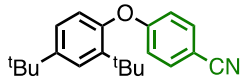
δ_H (400 MHz, $CDCl_3$)



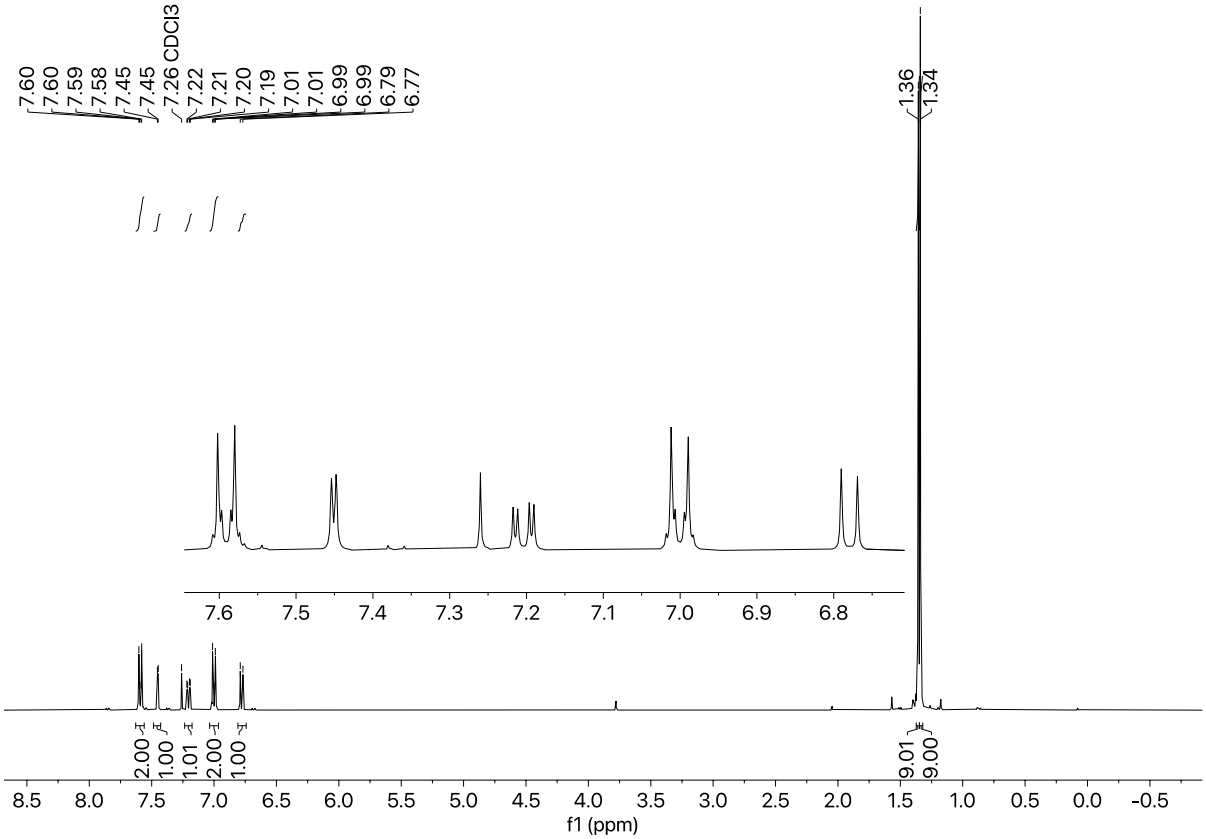
δ_C (101 MHz, $CDCl_3$)



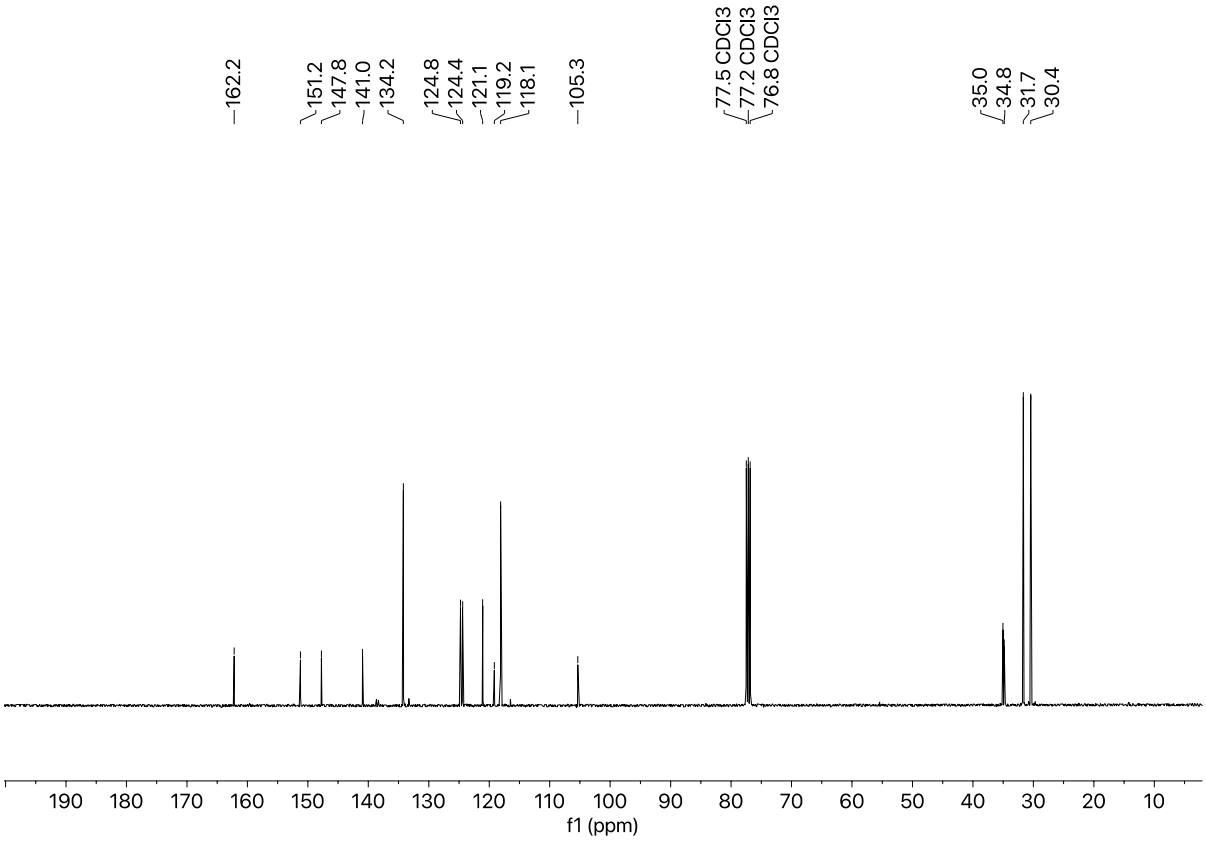
4-(2,4-Di-*tert*-butylphenoxy)benzonitrile. (3e)



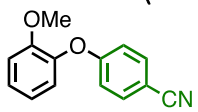
δ_H (400 MHz, $CDCl_3$)



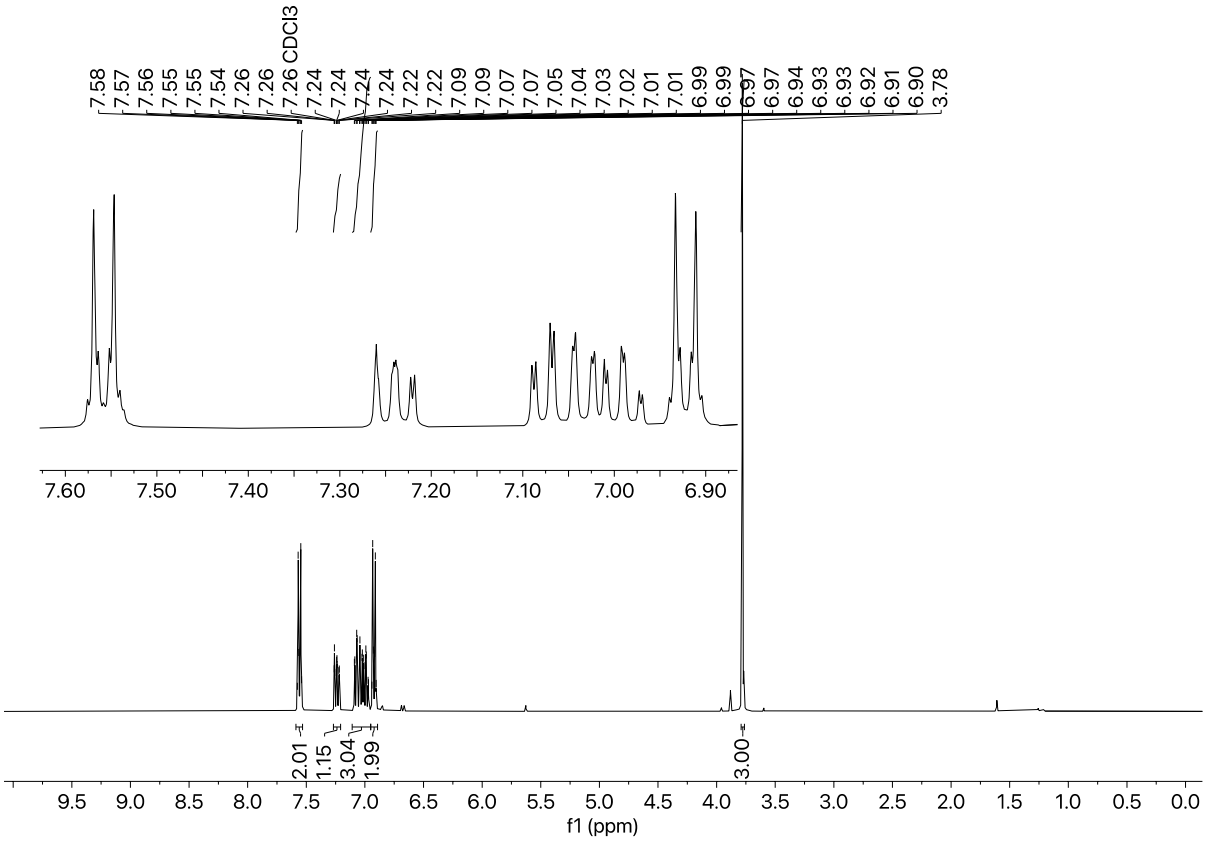
δ_C (101 MHz, $CDCl_3$)



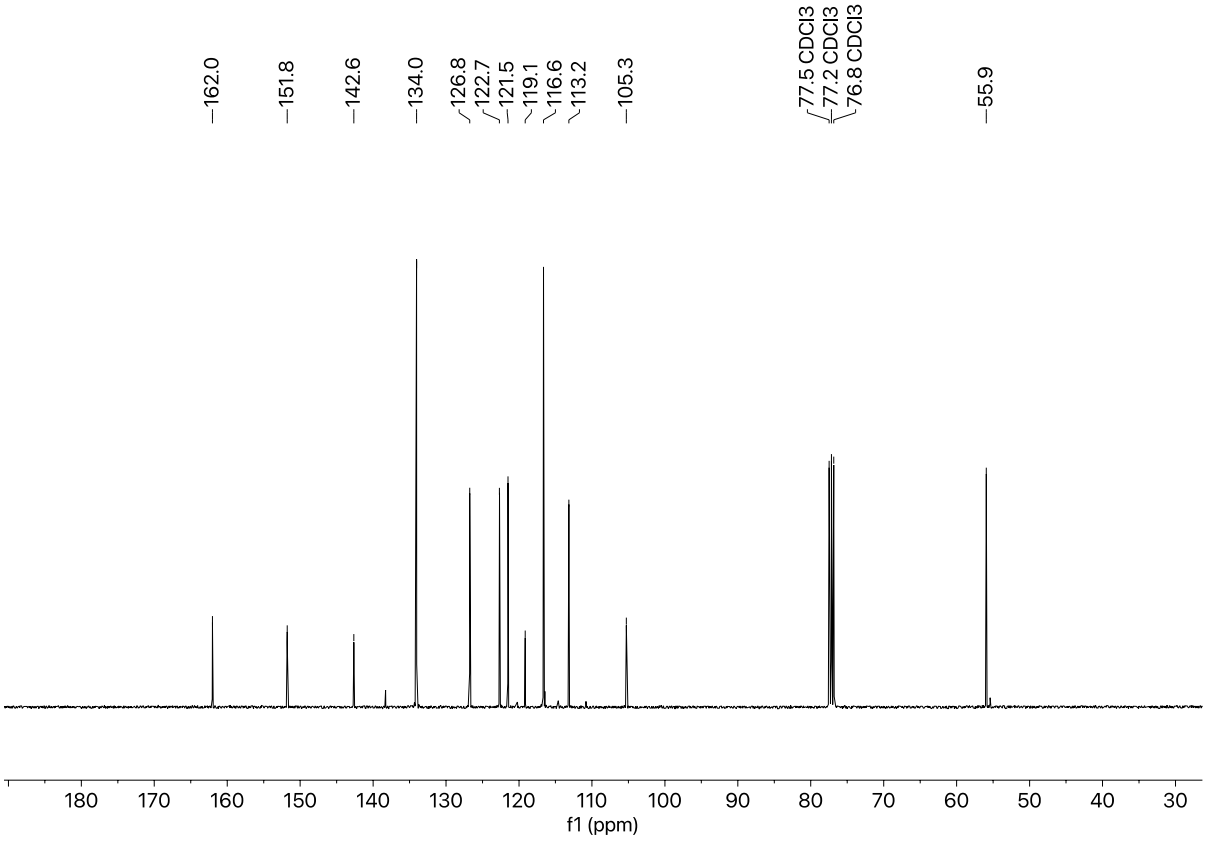
4-(2-Methoxyphenoxy)benzonitrile (3f)



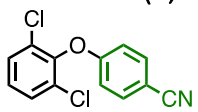
δ_H (400 MHz, $CDCl_3$)



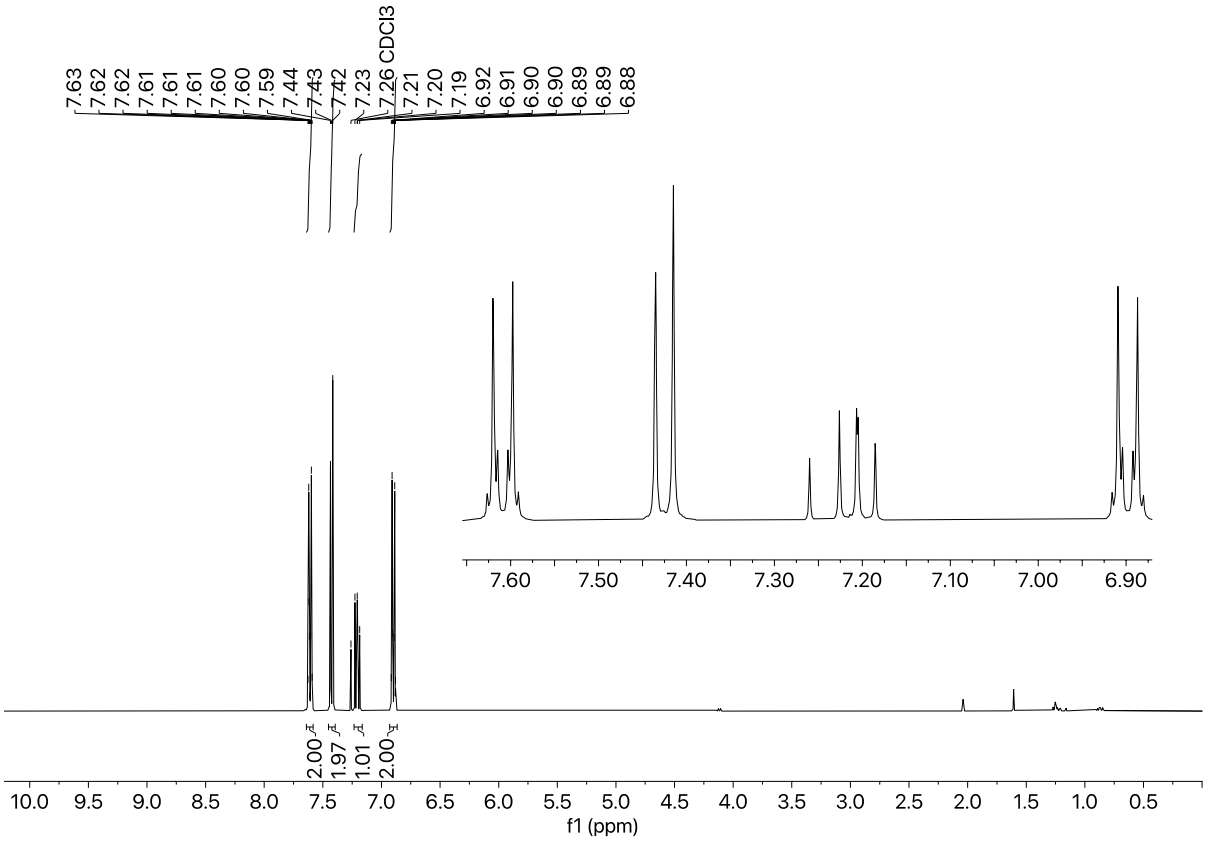
δ_C (101 MHz, $CDCl_3$)



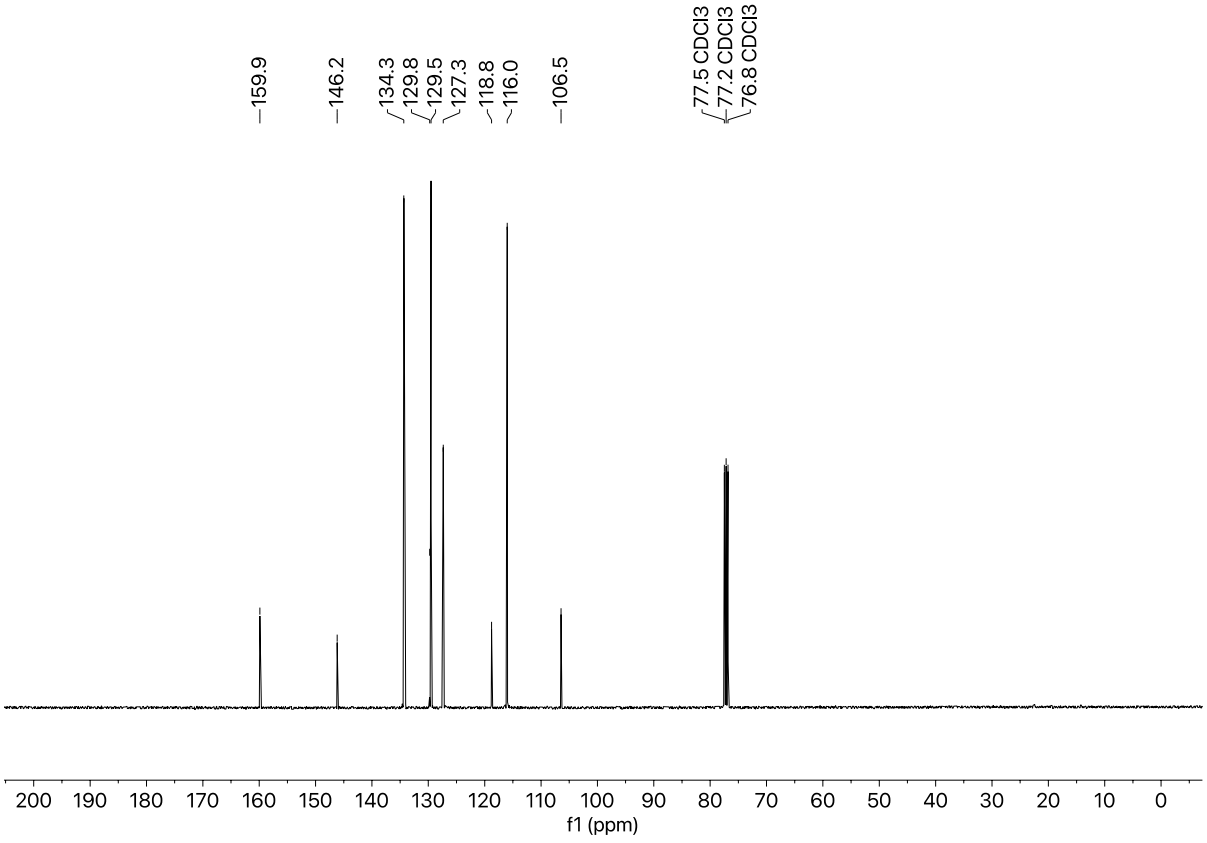
4-(2,6-Dichlorophenoxy)benzonitrile. (3g)



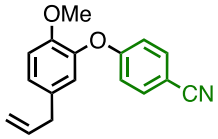
δ_H (400 MHz, $CDCl_3$)



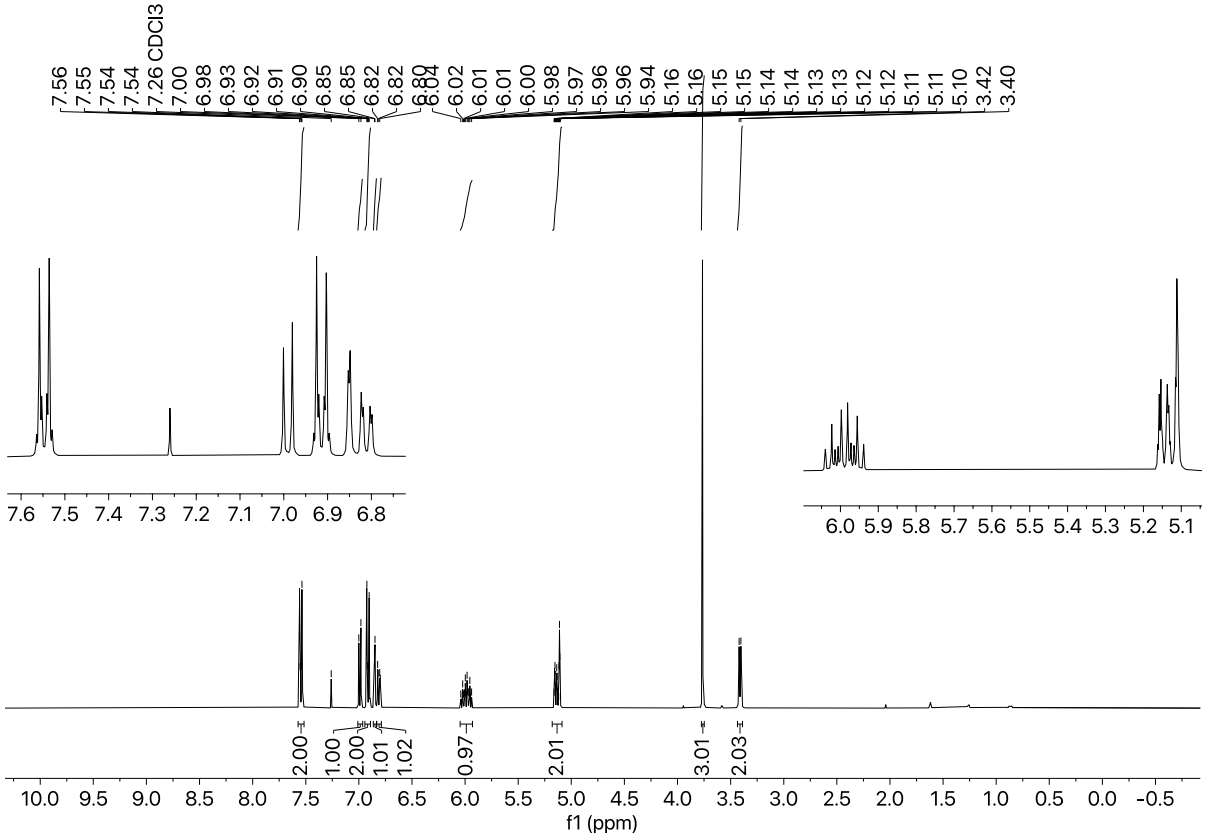
δ_C (101 MHz, $CDCl_3$)



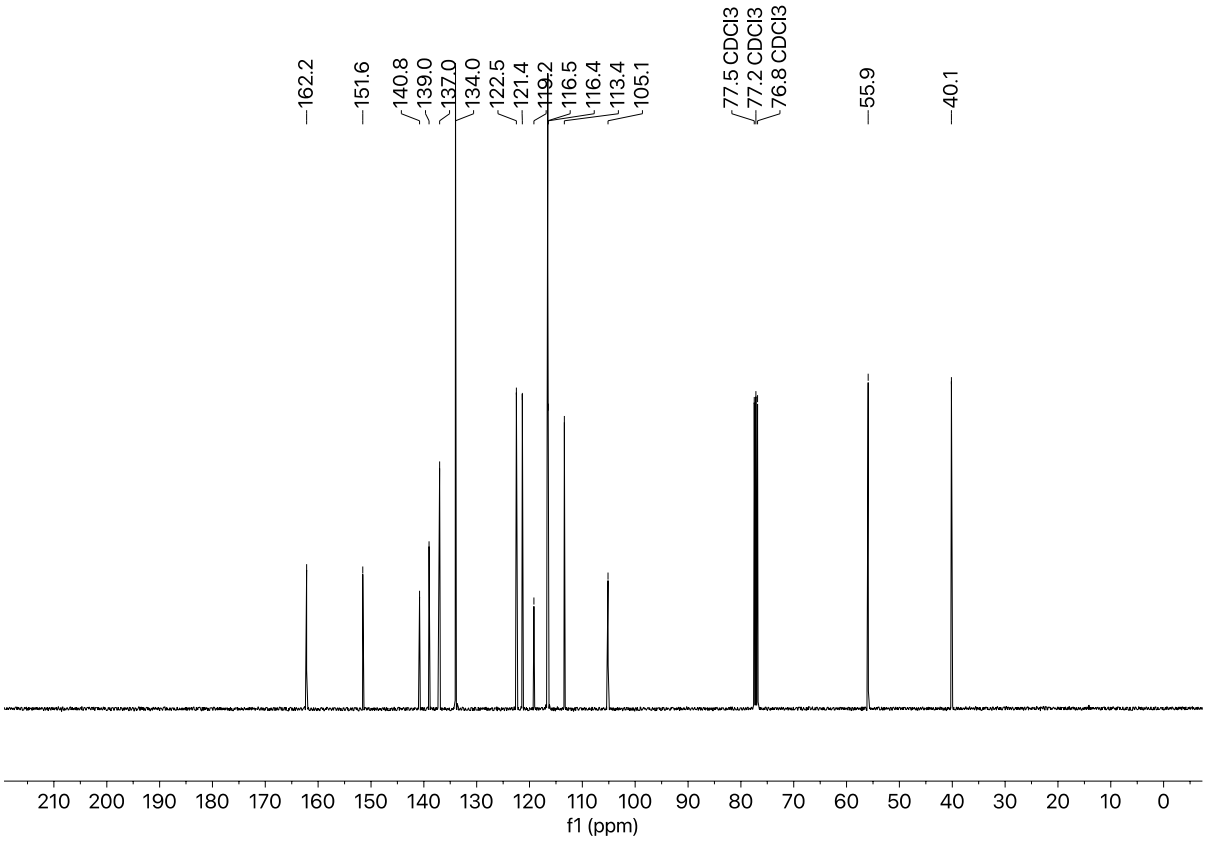
4-(5-Allyl-2-methoxyphenoxy)benzonitrile (3h)



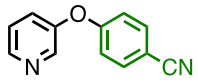
δ_H (400 MHz, $CDCl_3$)



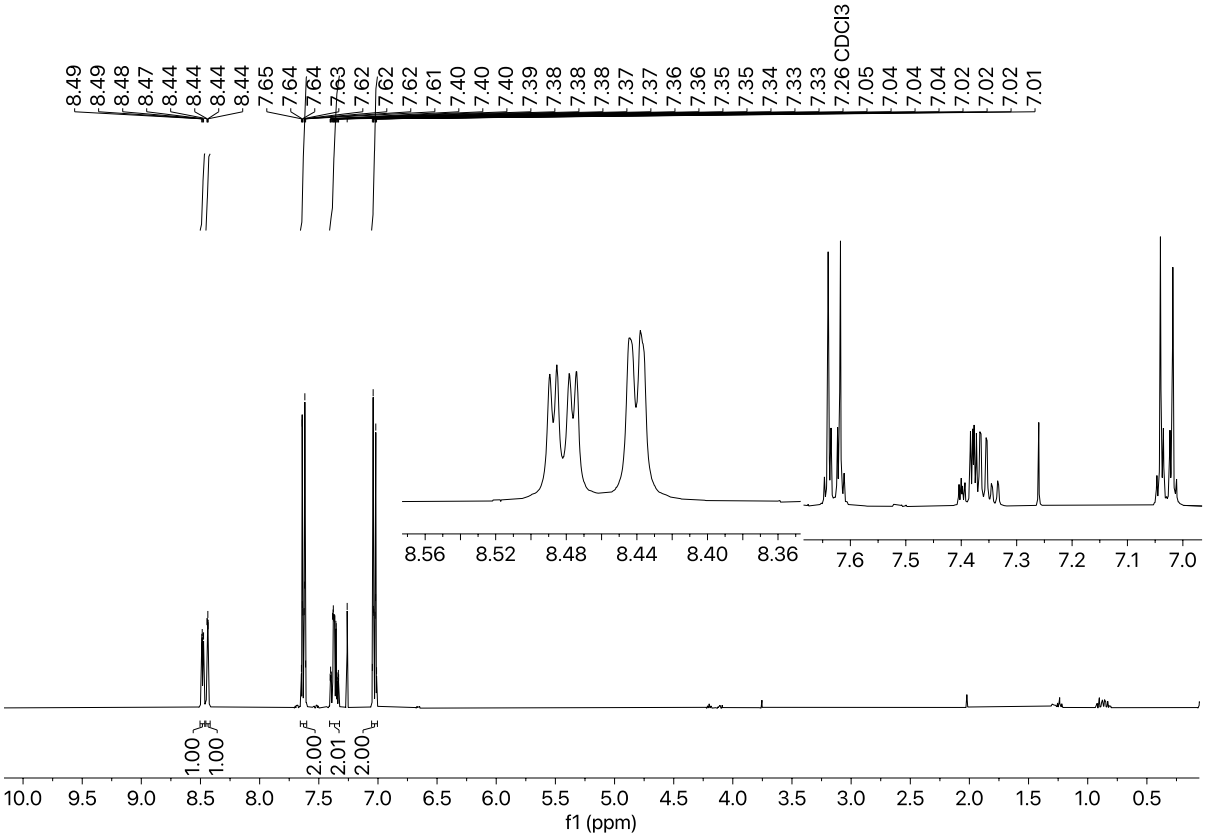
δ_C (101 MHz, $CDCl_3$)



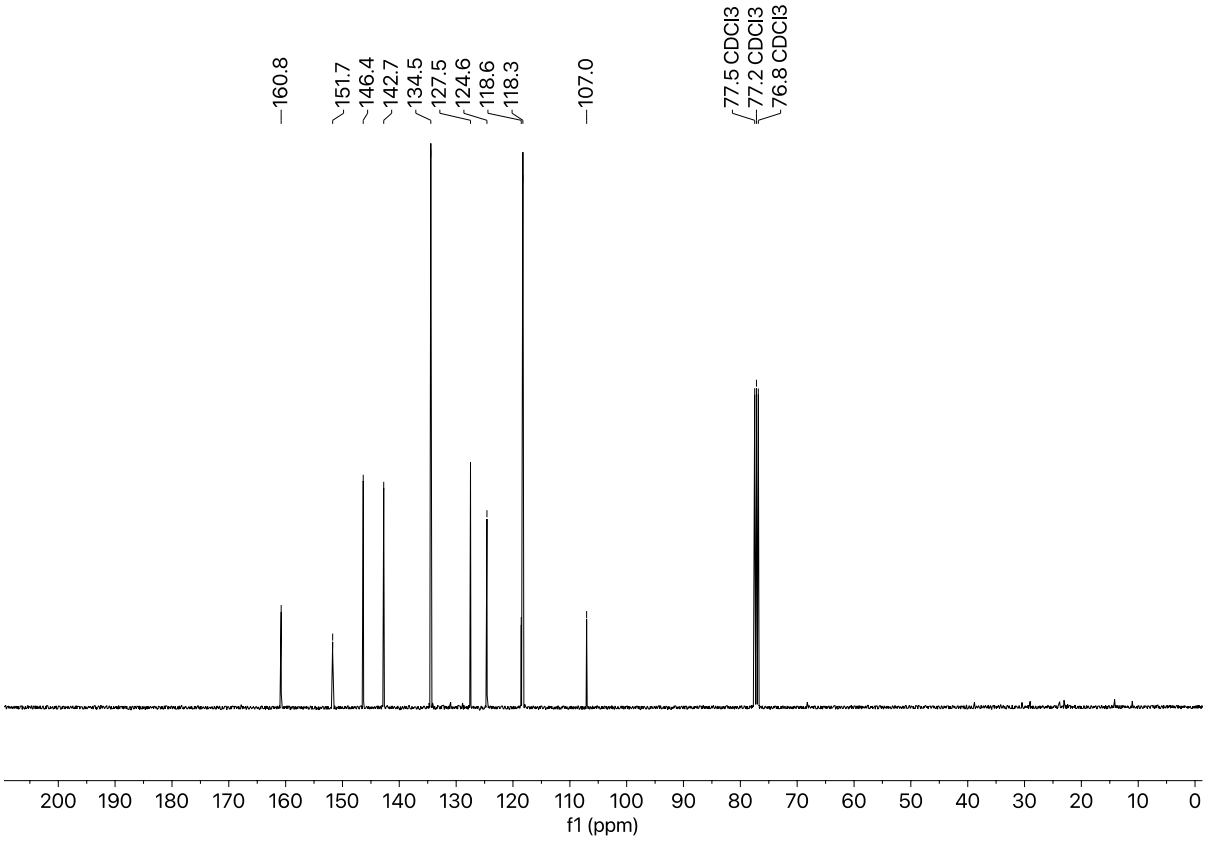
4-(Pyridin-3-yloxy)benzonitrile (3i)



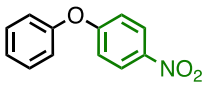
δ_H (400 MHz, $CDCl_3$)



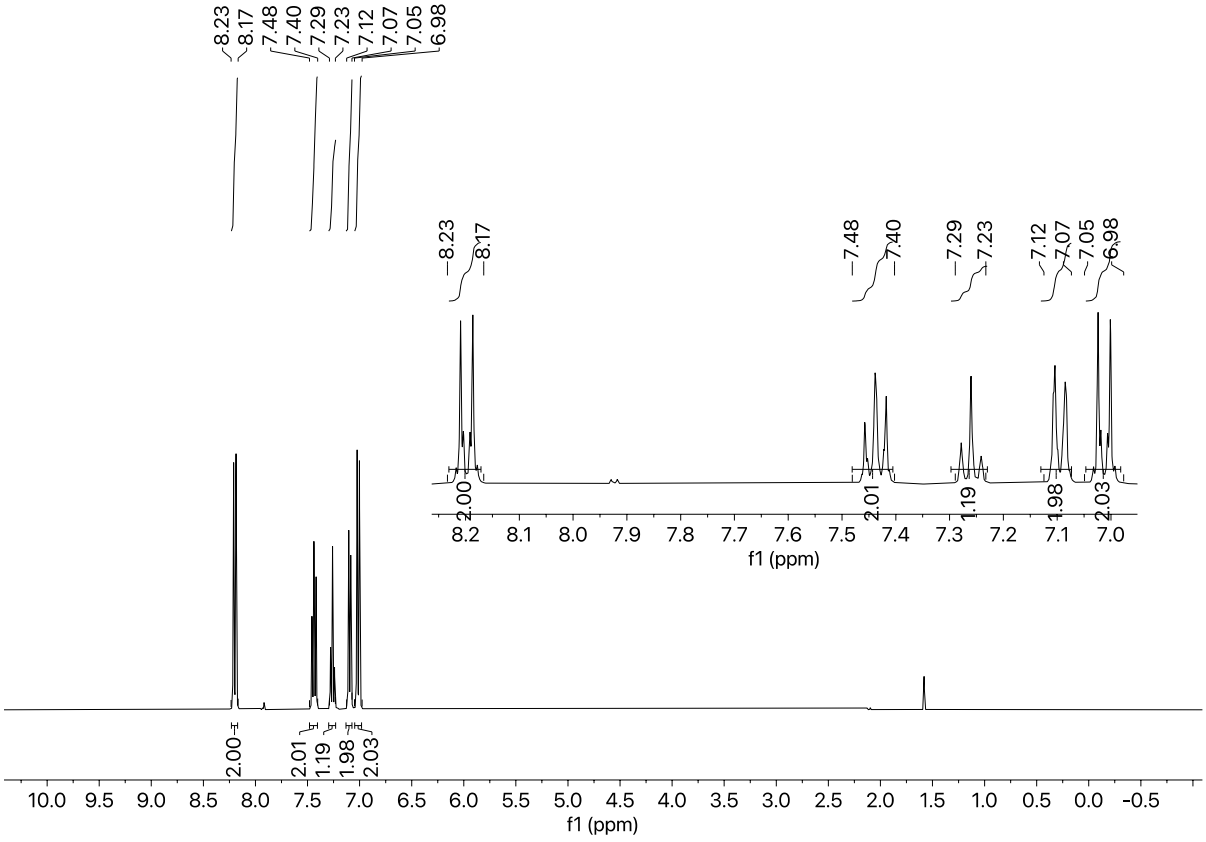
δ_C (101 MHz, $CDCl_3$)



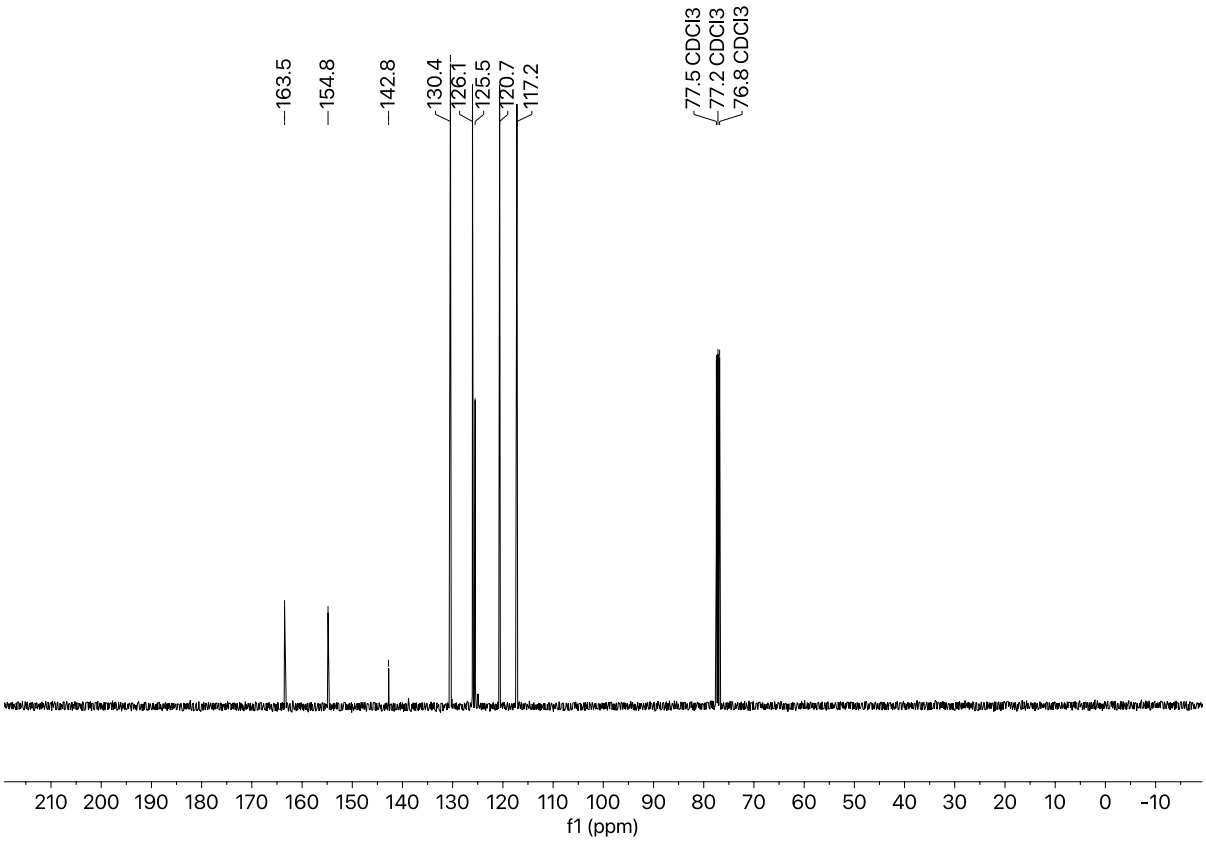
1-Nitro-4-phenoxybenzene (3j)



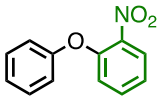
δ_H (400 MHz, $CDCl_3$)



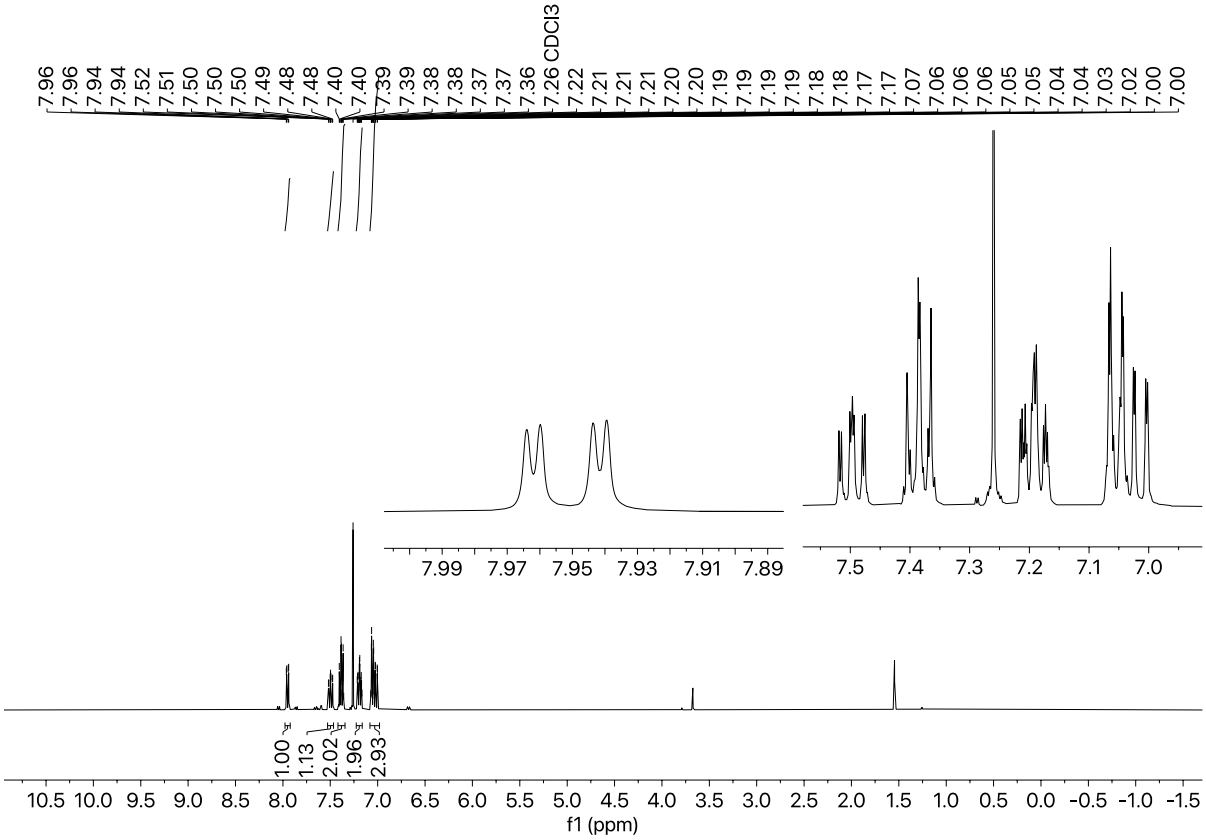
δ_C (101 MHz, $CDCl_3$)



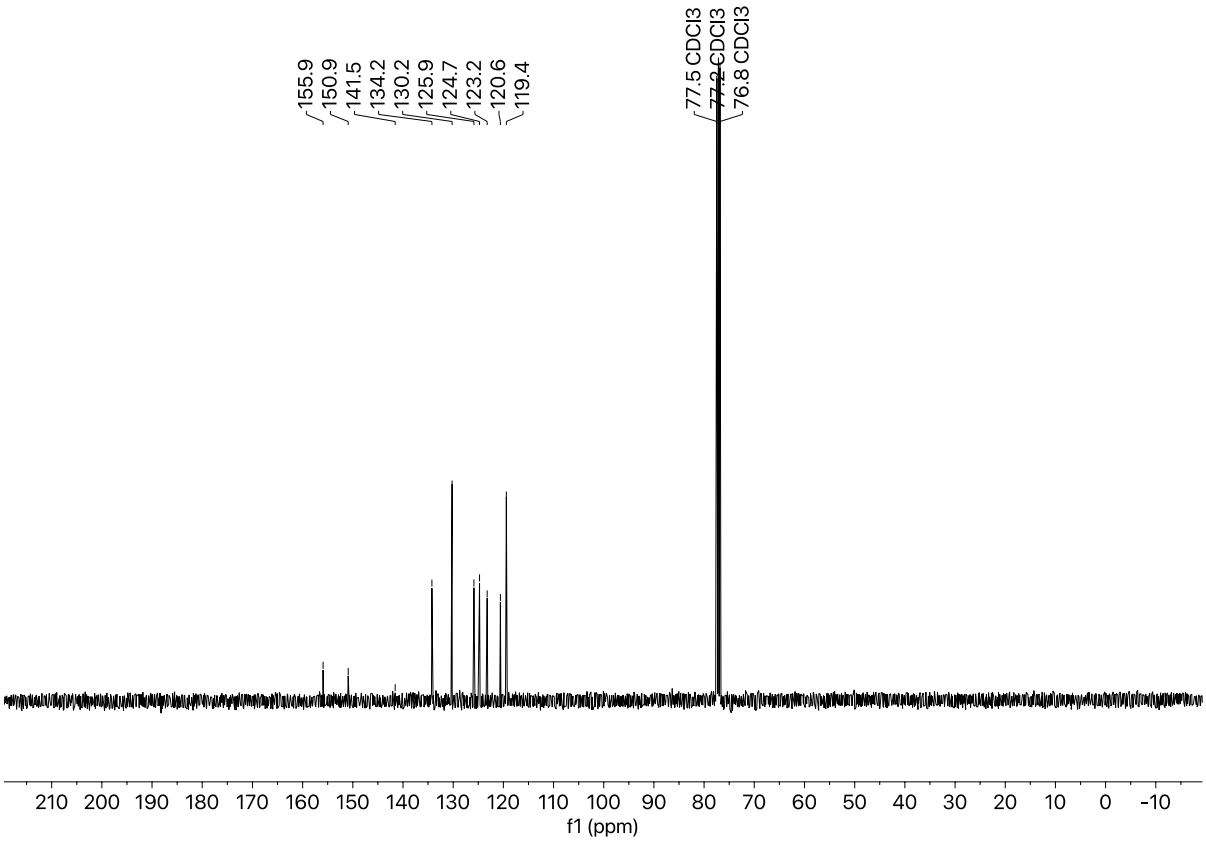
1-Nitro-2-phenoxybenzene (3k)



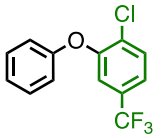
δ_H (400 MHz, $CDCl_3$)



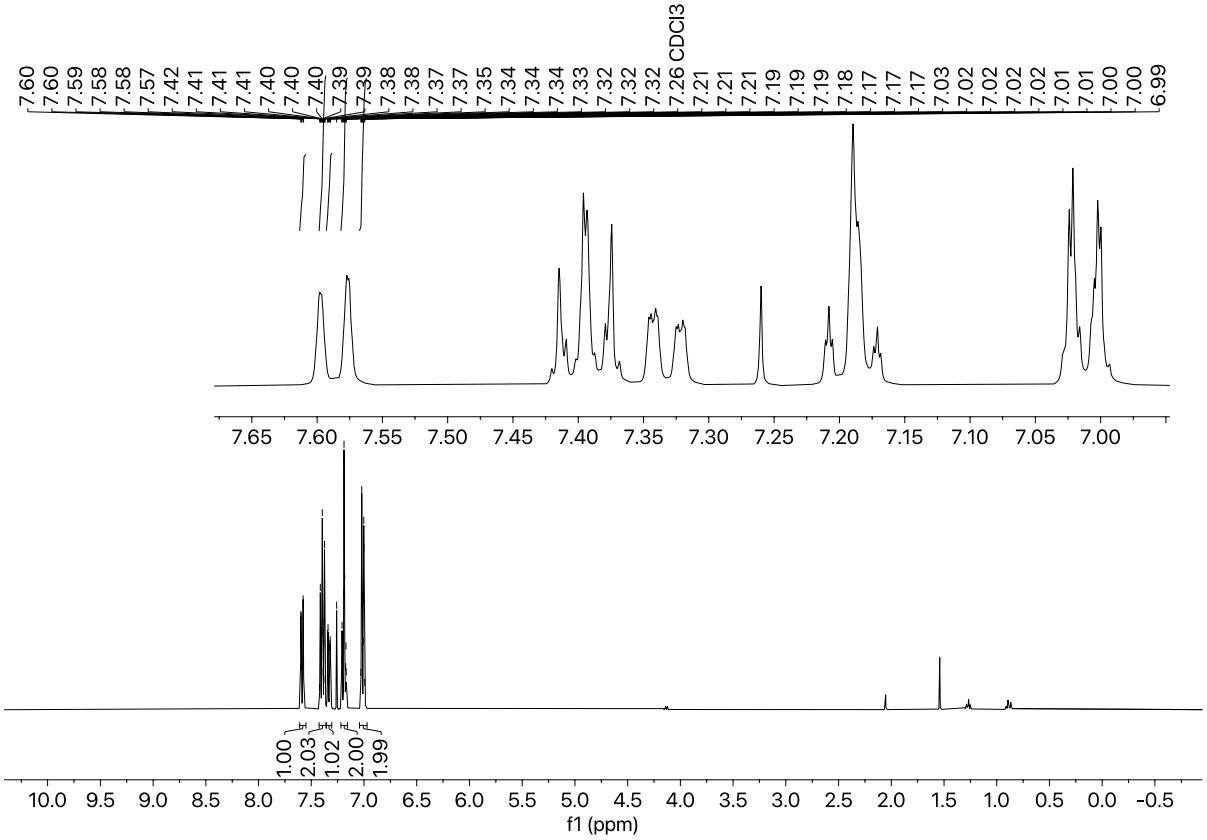
δ_C (101 MHz, $CDCl_3$)



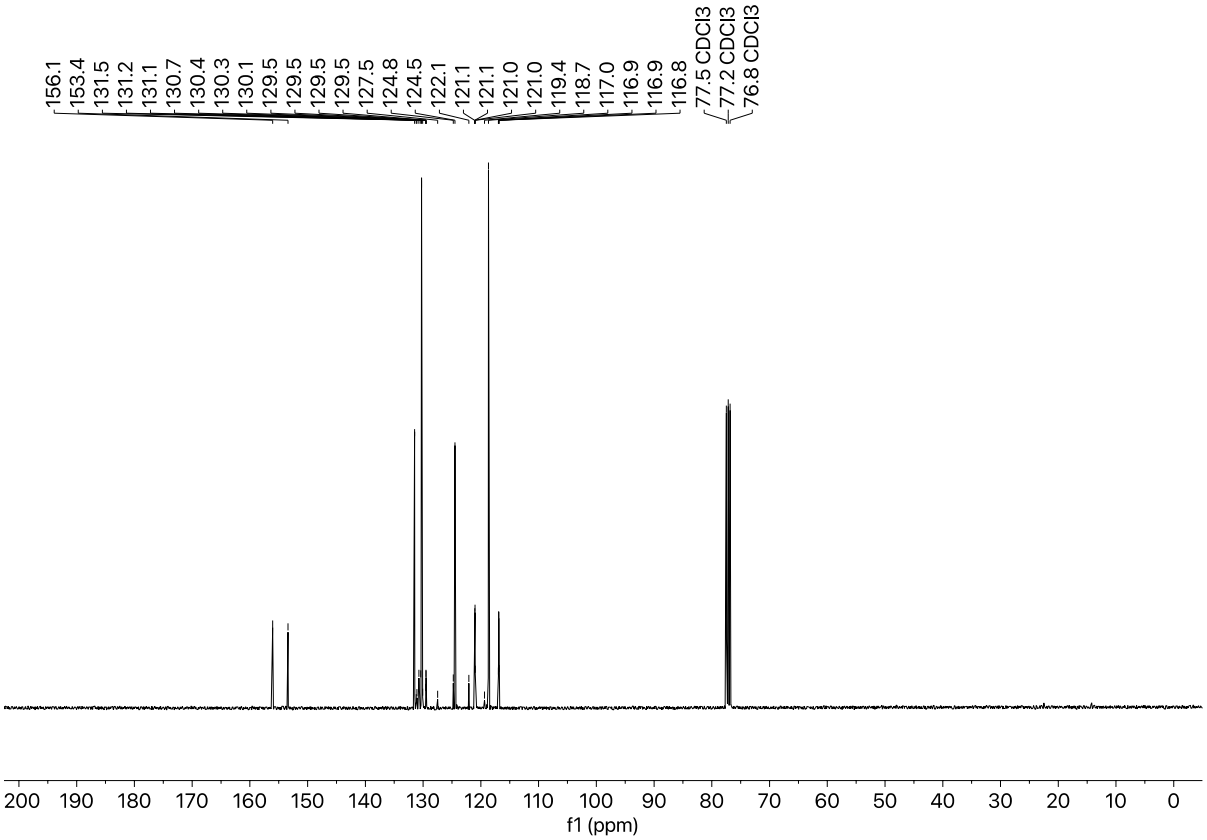
1-Chloro-2-phenoxy-4-(trifluoromethyl)benzene (3l)



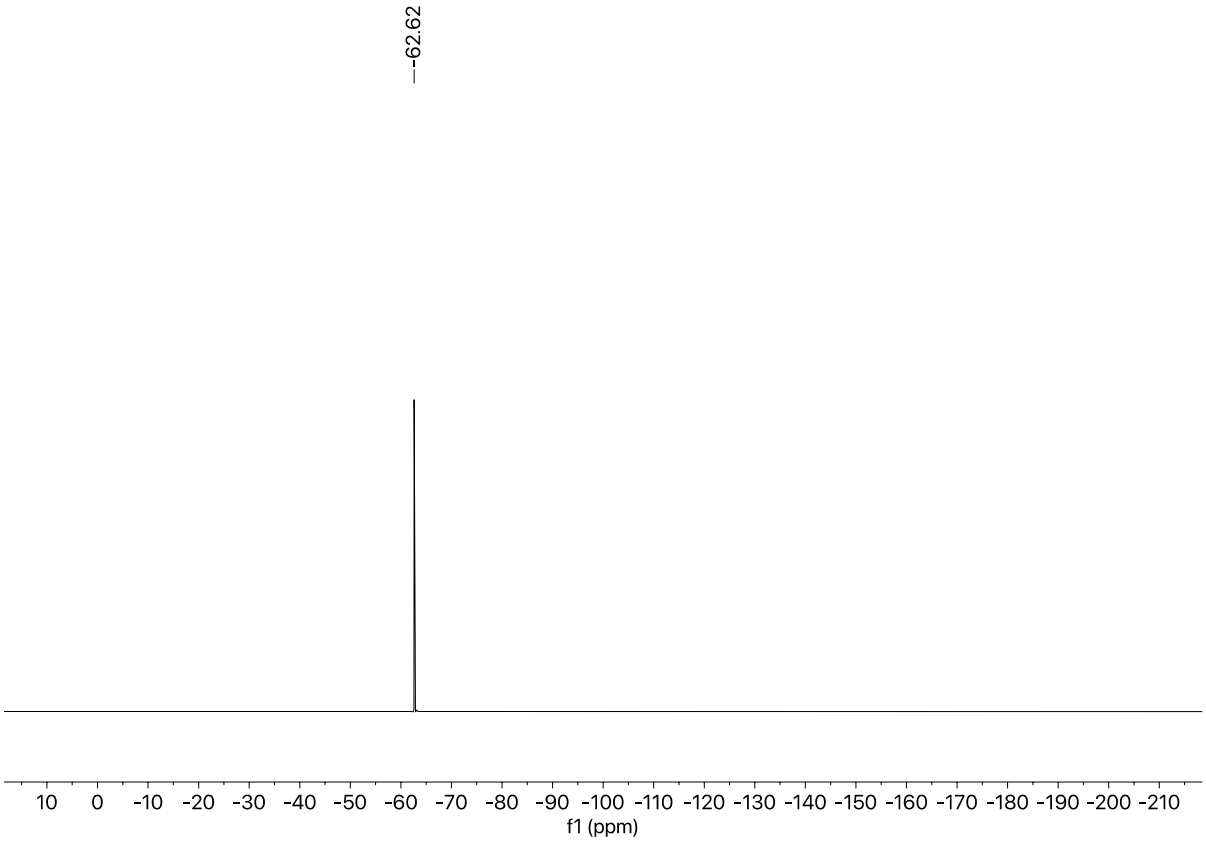
δ_H (400 MHz, $CDCl_3$)



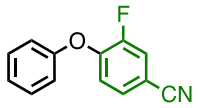
δ_C (101 MHz, $CDCl_3$)



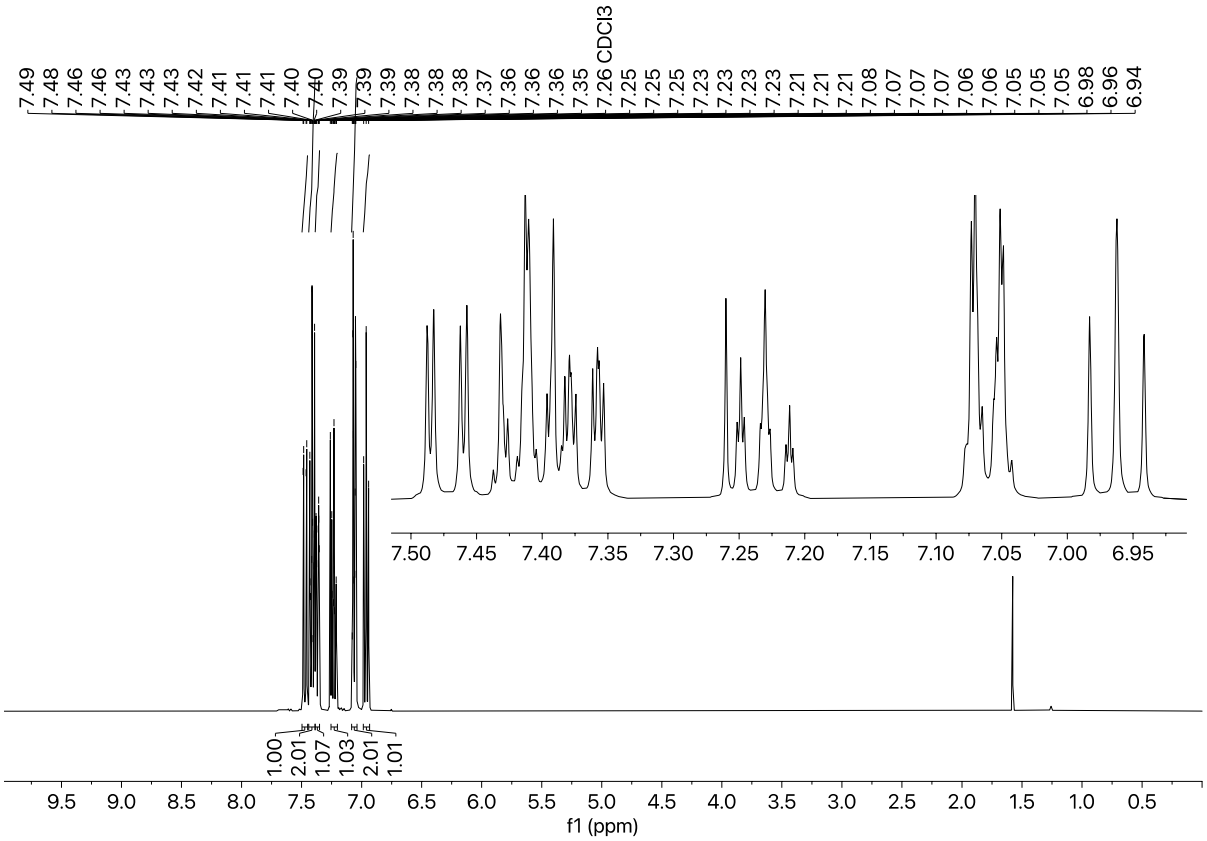
δ_F (376 MHz, $CDCl_3$)



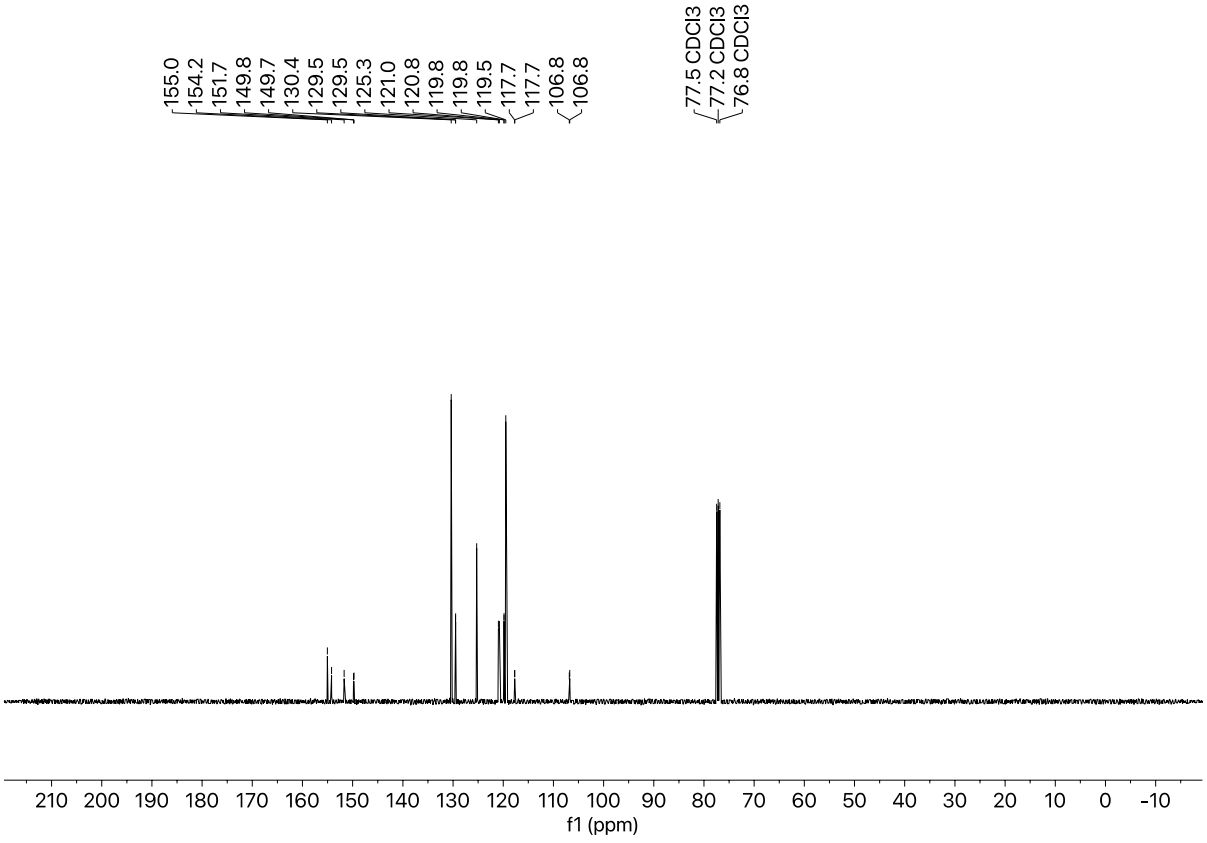
3-Fluoro-4-phenoxybenzonitrile (3m)



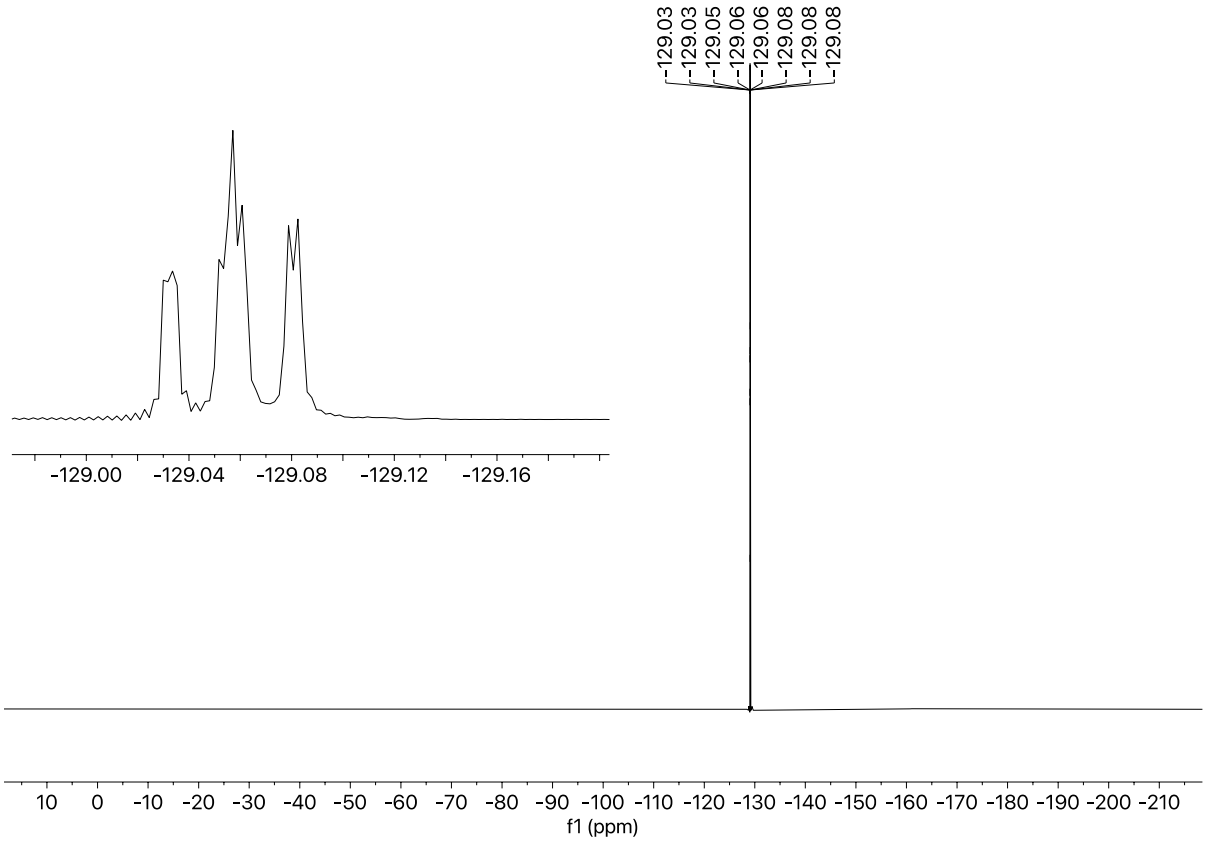
δ_H (400 MHz, $CDCl_3$)



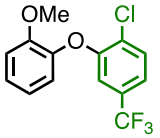
δ_C (101 MHz, $CDCl_3$)



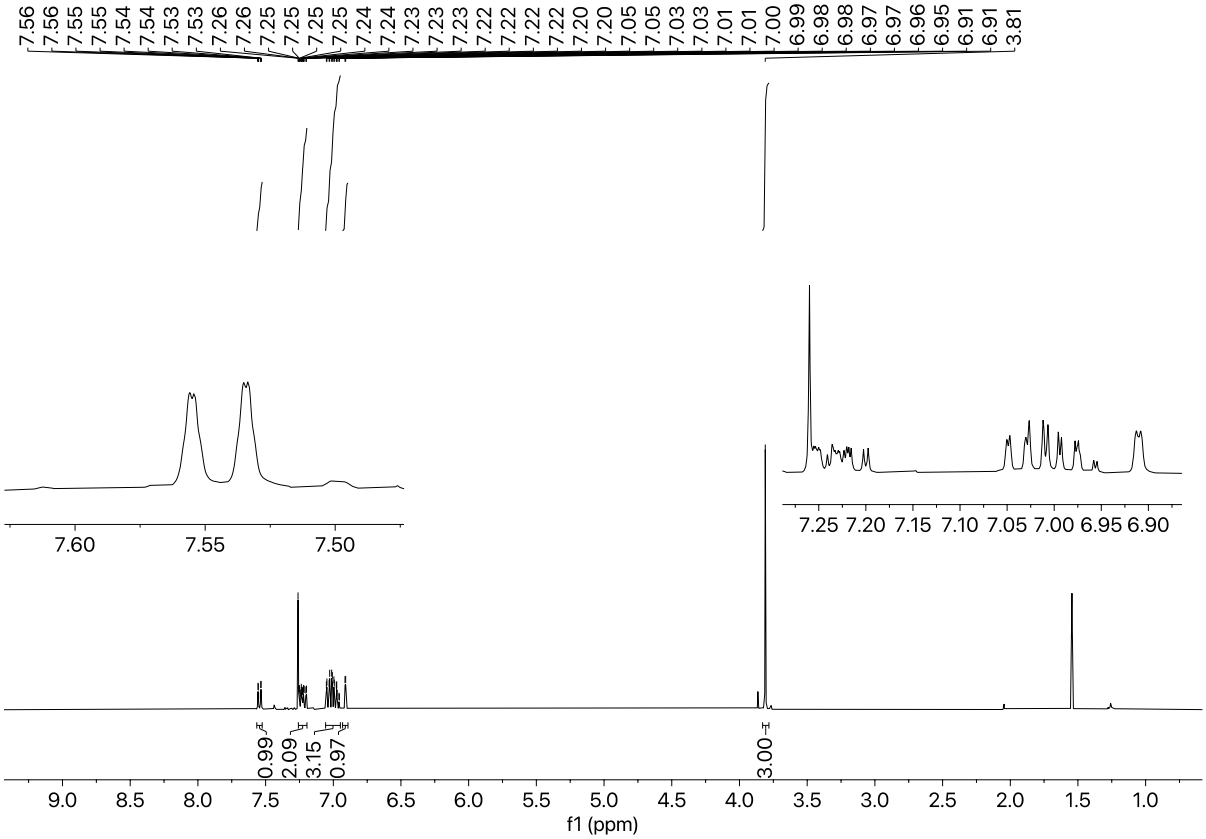
δ_F (376 MHz, $CDCl_3$)



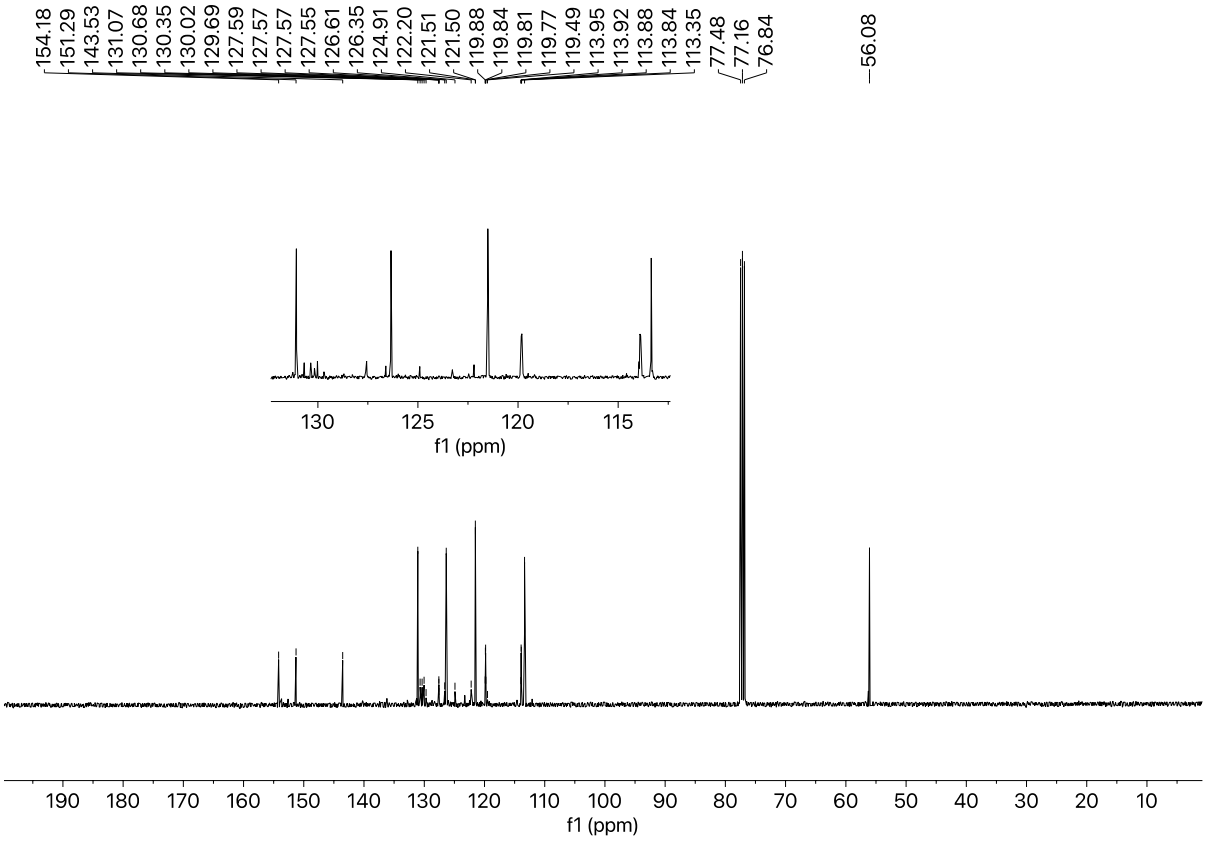
1-Chloro-2-(2-methoxyphenoxy)-4-(trifluoromethyl)benzene (3n)



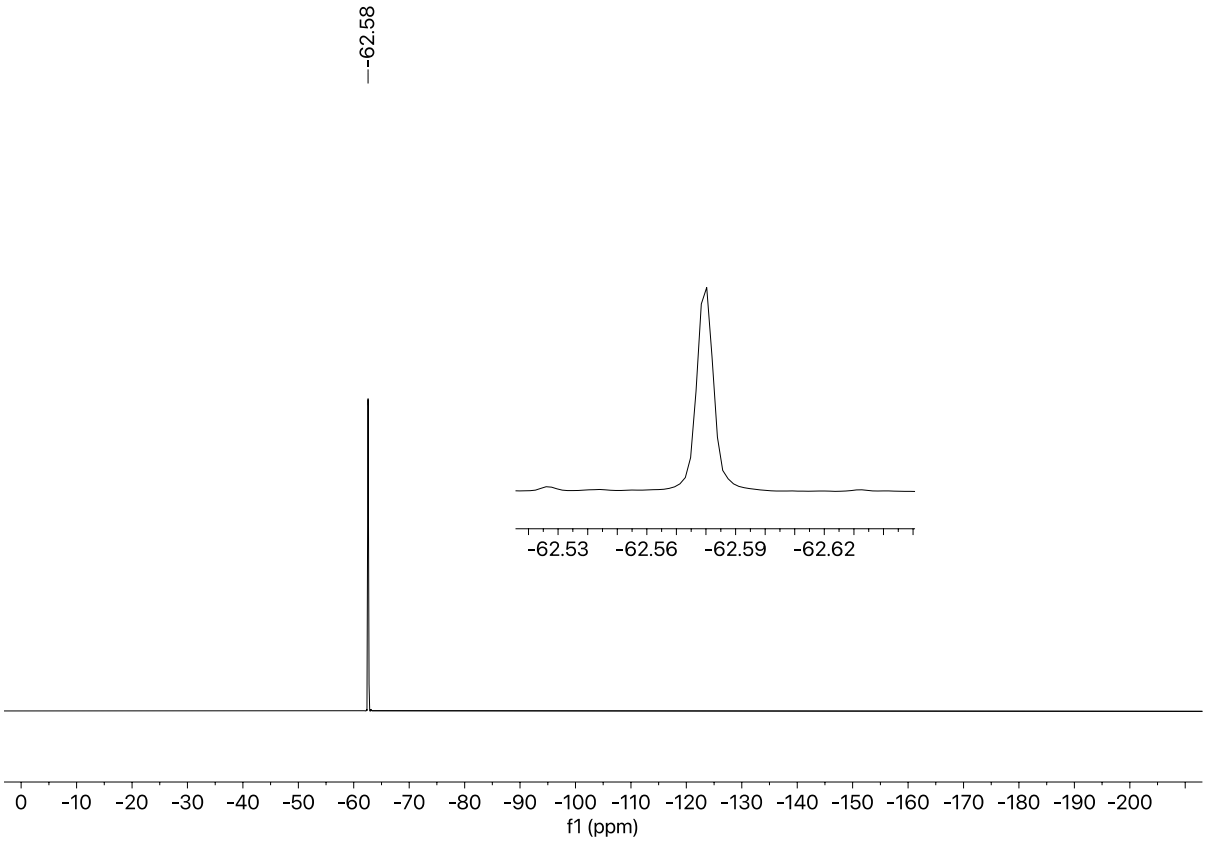
δ_H (400 MHz, $CDCl_3$)



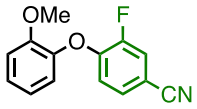
δ_C (101 MHz, $CDCl_3$)



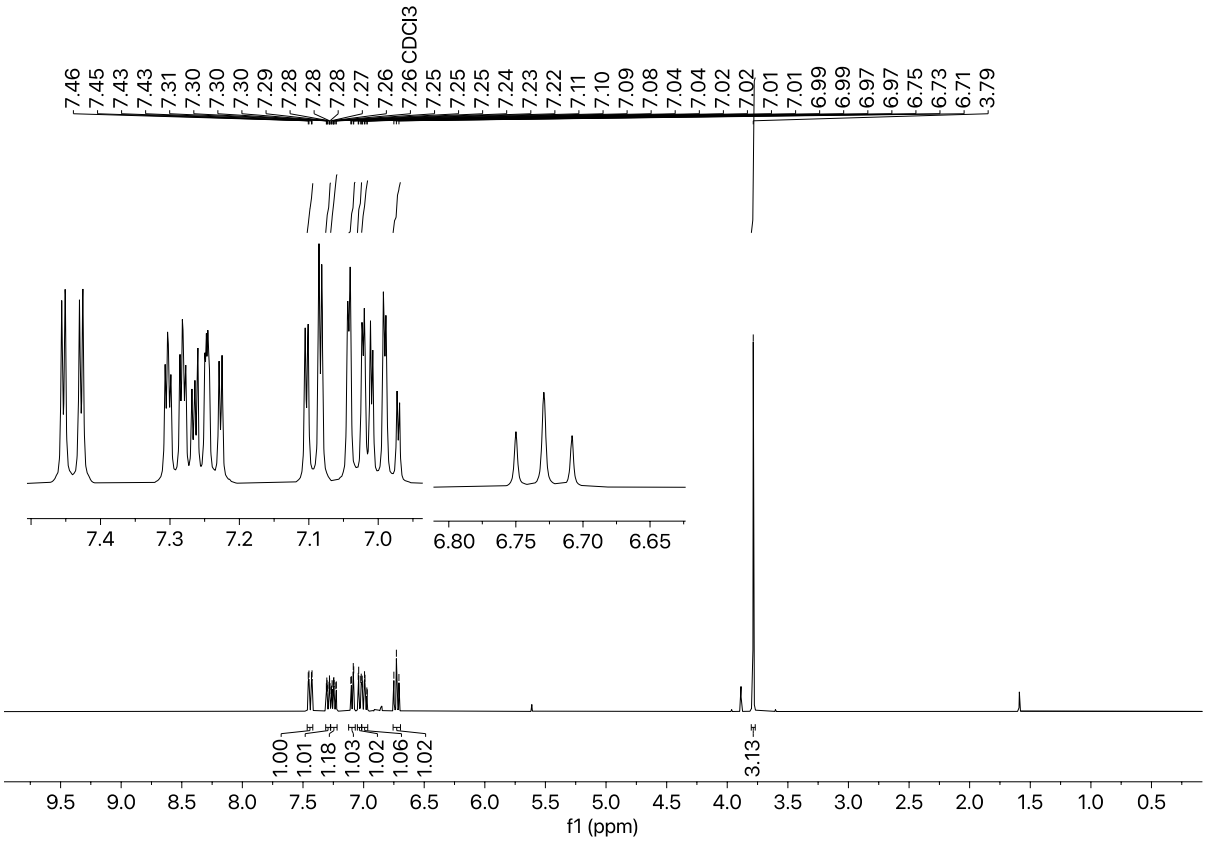
δ_F (376 MHz, $CDCl_3$)



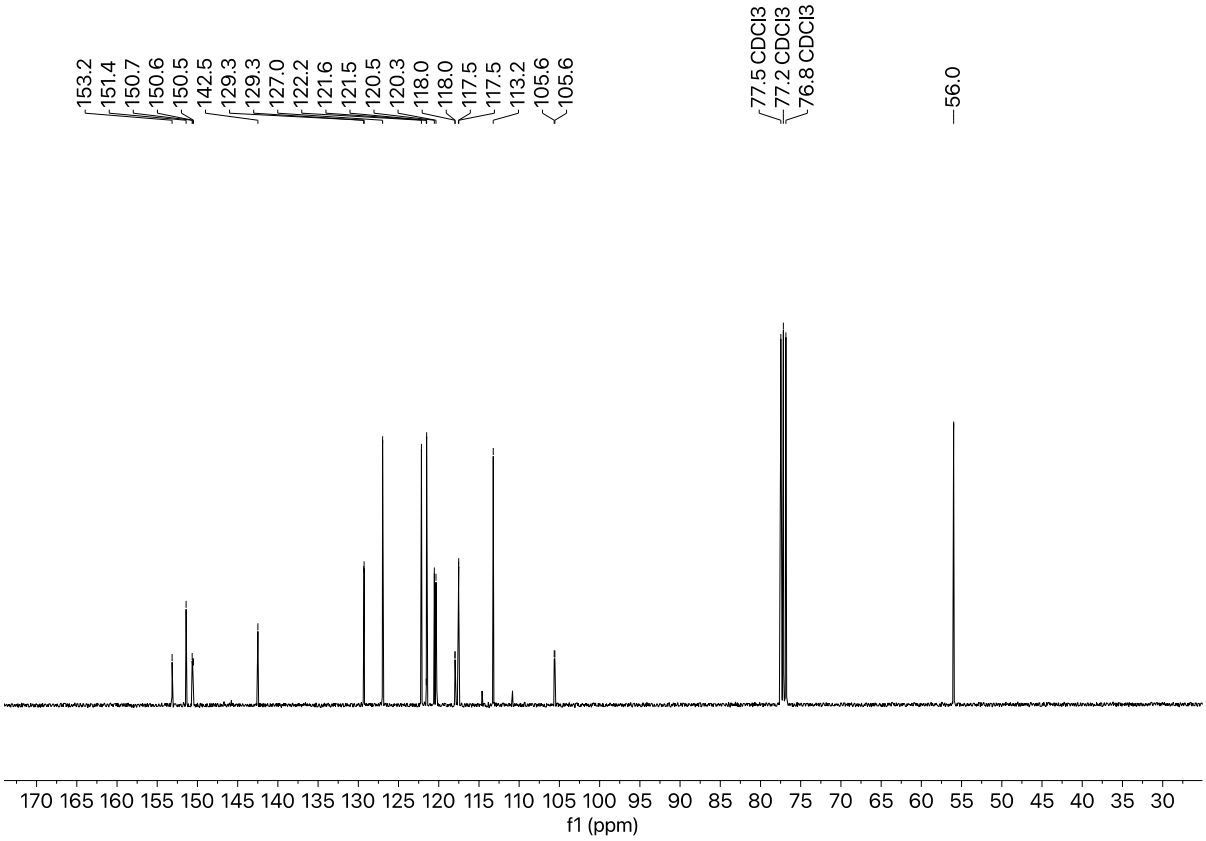
3-Fluoro-4-(2-methoxyphenoxy)benzonitrile (3o)



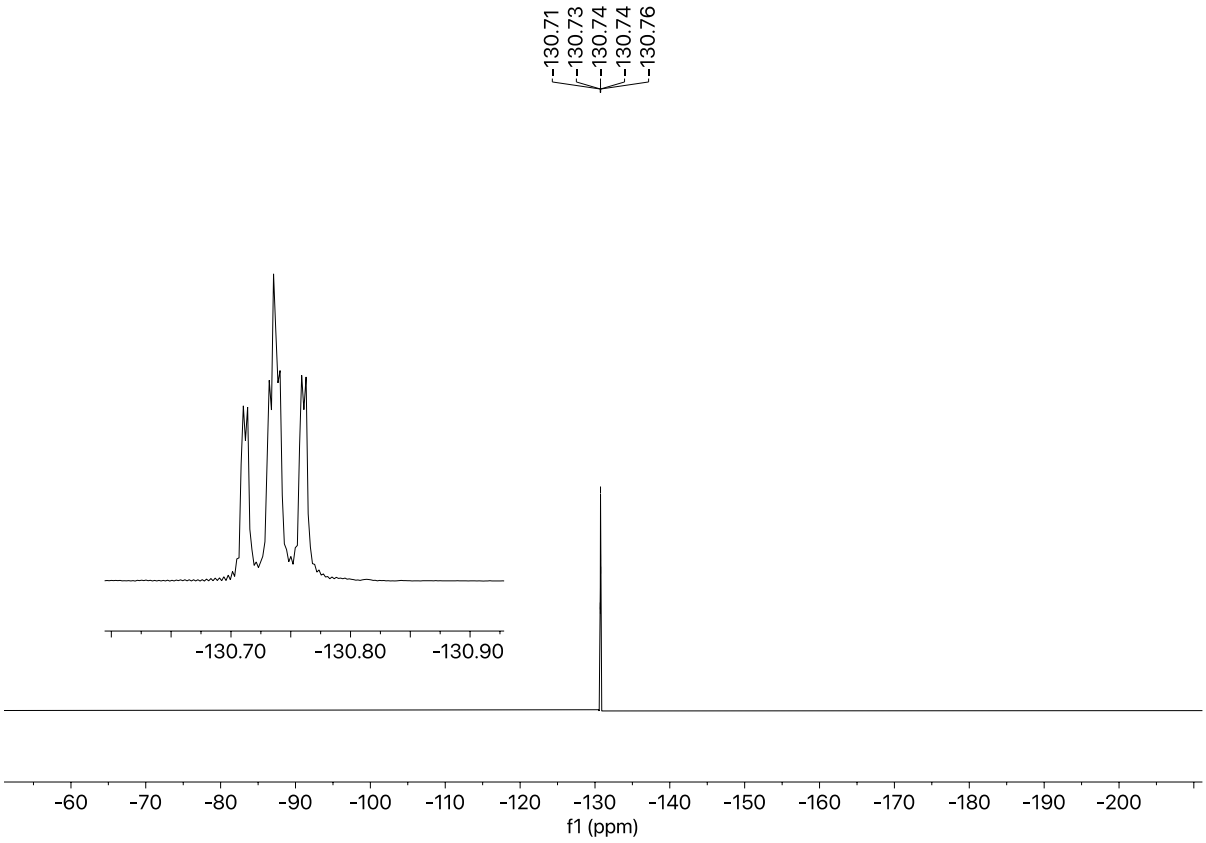
δ_H (400 MHz, $CDCl_3$)



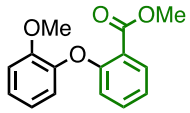
δ_C (101 MHz, $CDCl_3$)



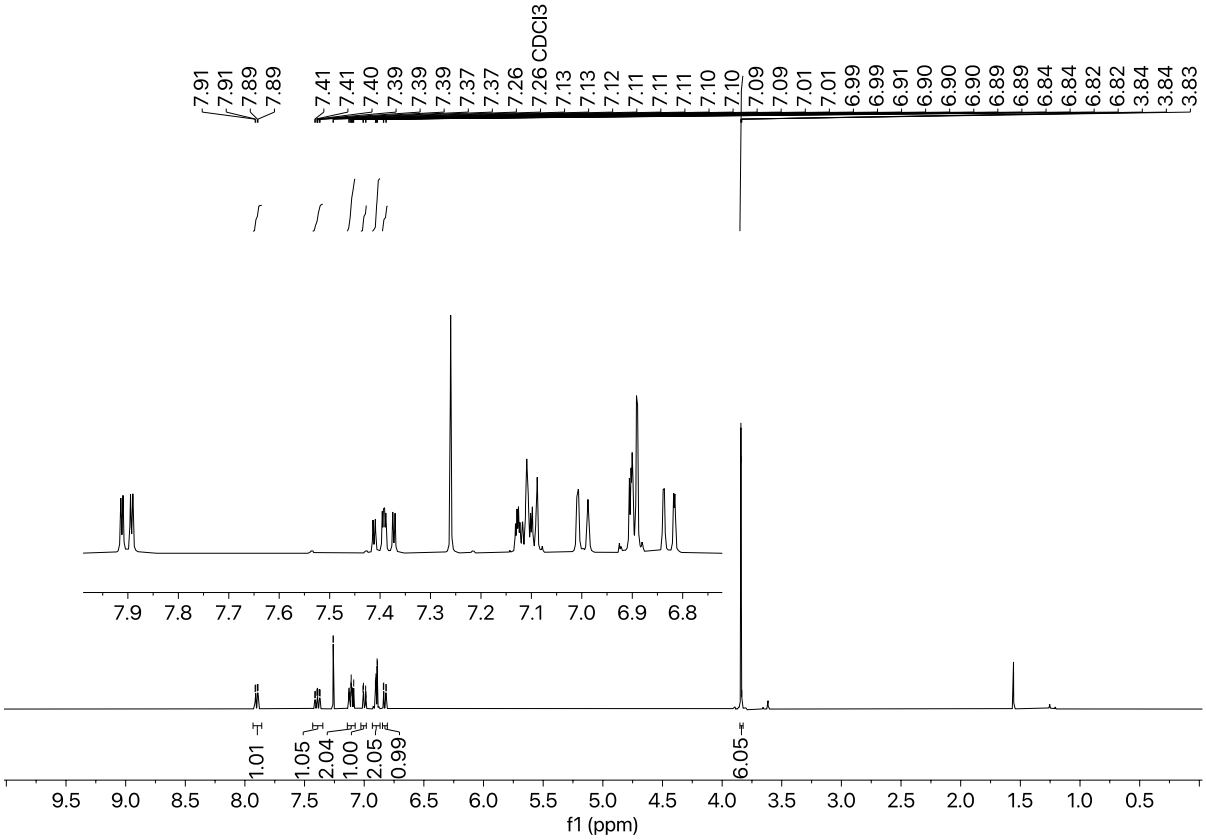
δ_F (376 MHz, $CDCl_3$)



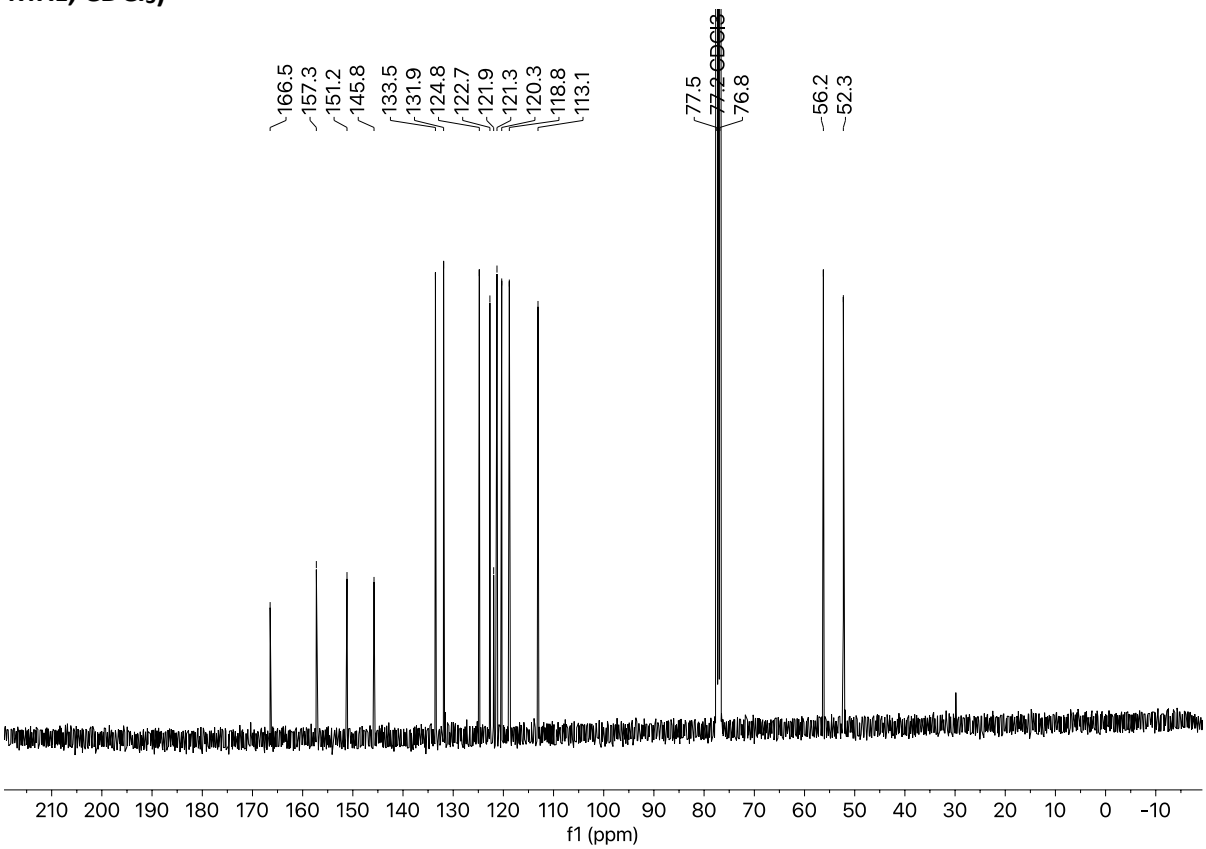
Methyl 2-(2-methoxyphenoxy)benzoate (3p)



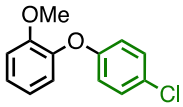
δ_H (400 MHz, $CDCl_3$)



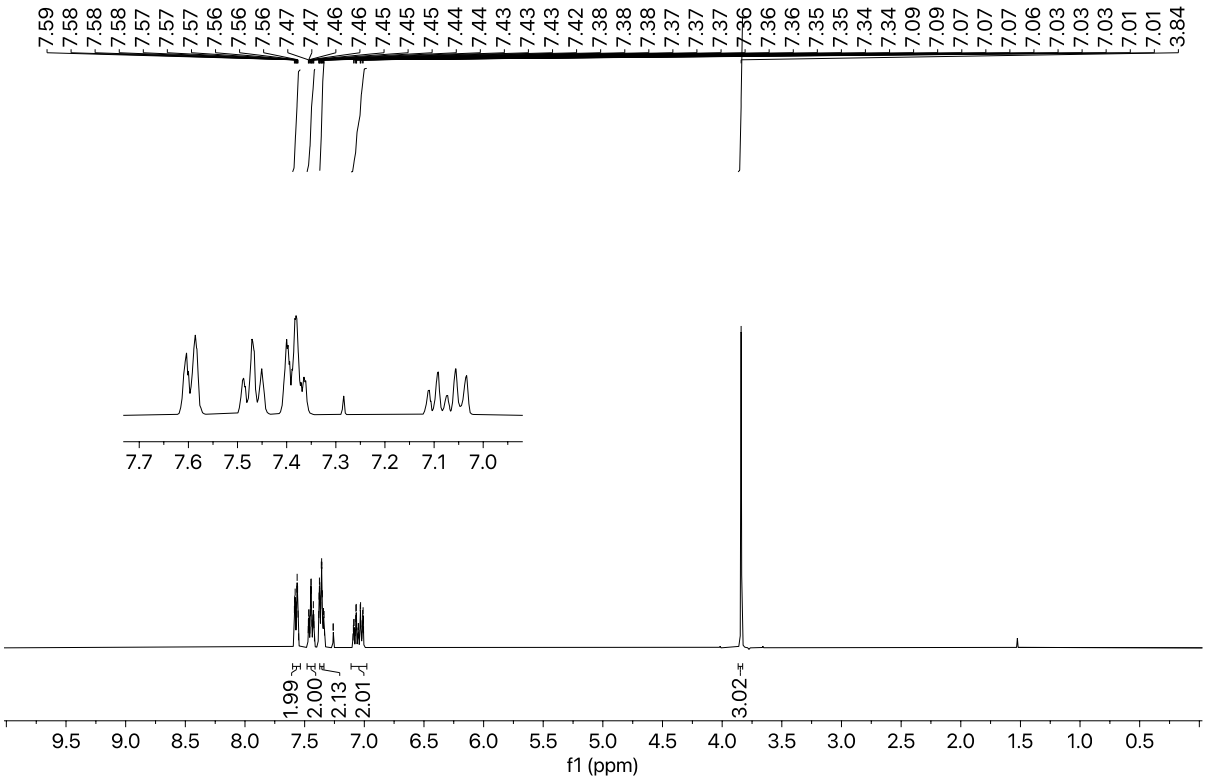
δ_C (101 MHz, $CDCl_3$)



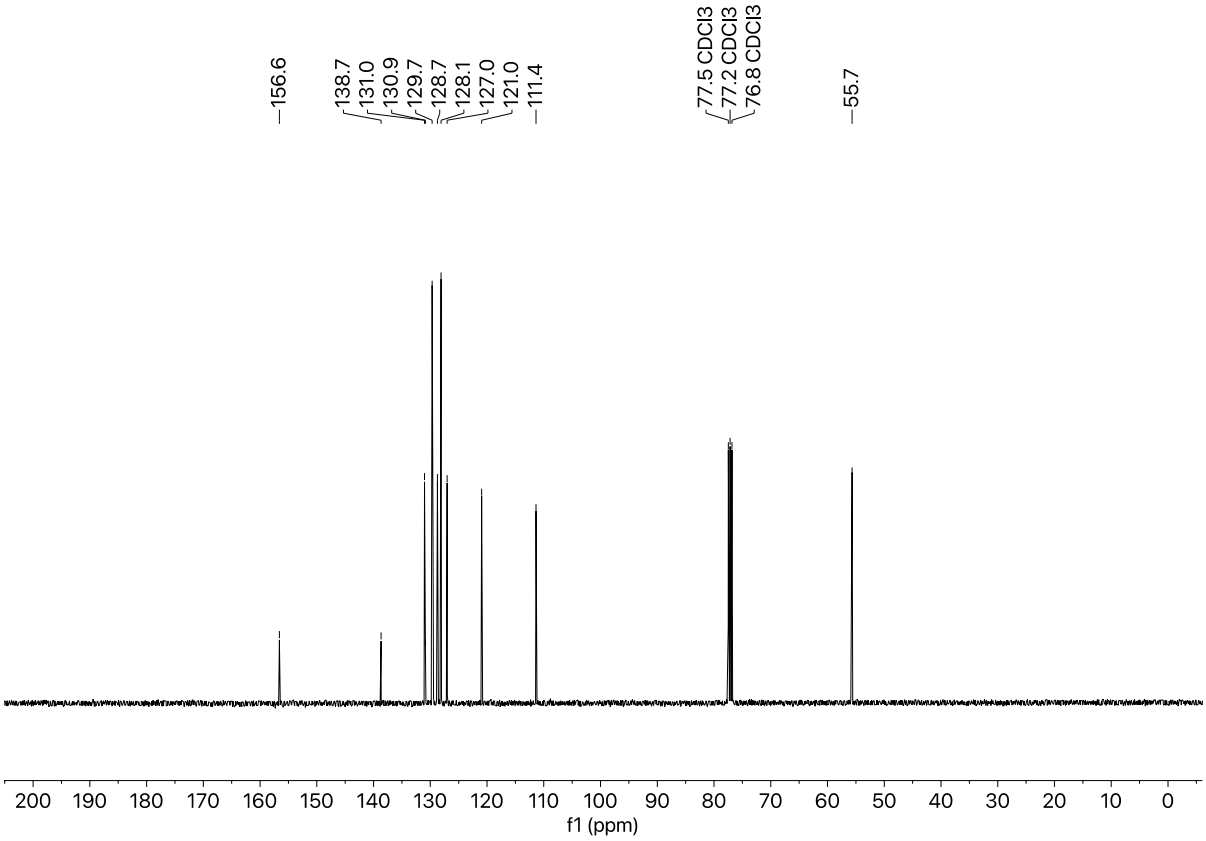
1-(4-Chlorophenoxy)-2-methoxybenzene (3q)



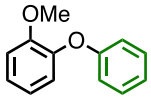
δ_H (400 MHz, $CDCl_3$)



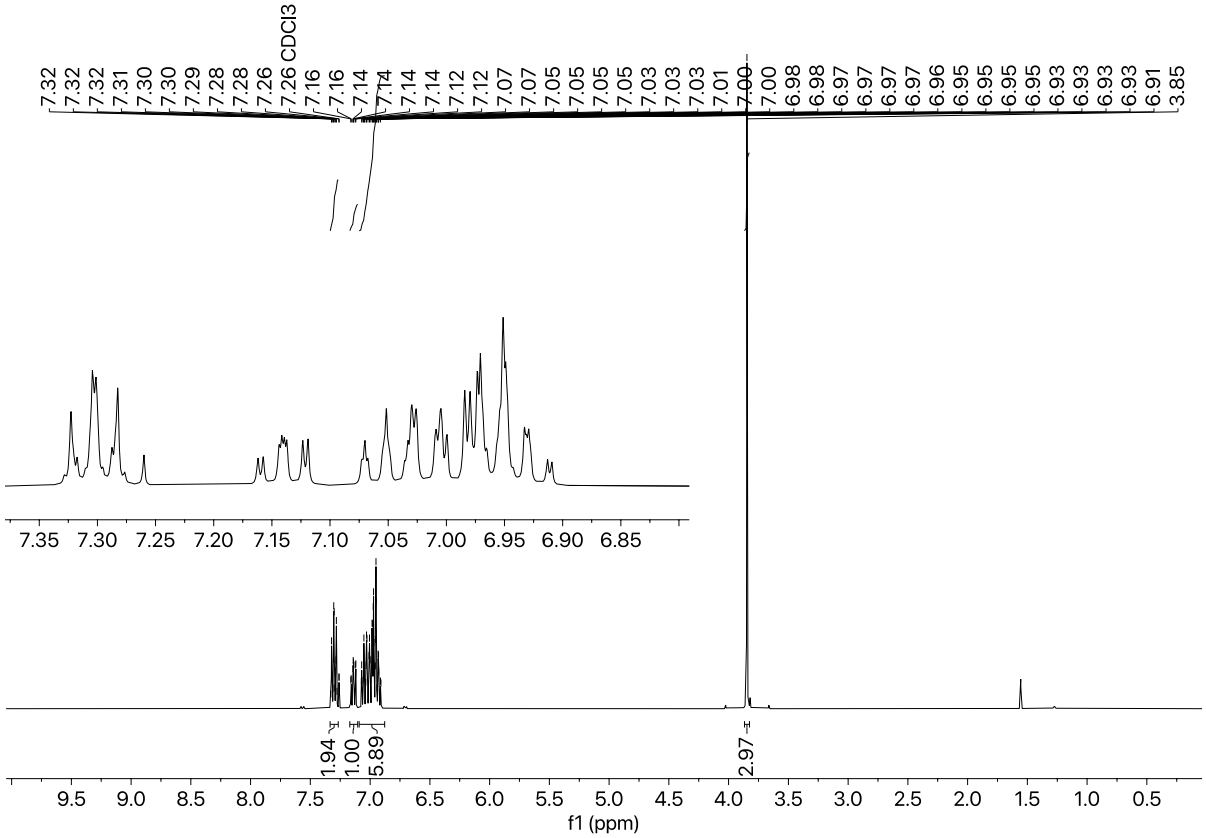
δ_C (101 MHz, $CDCl_3$)



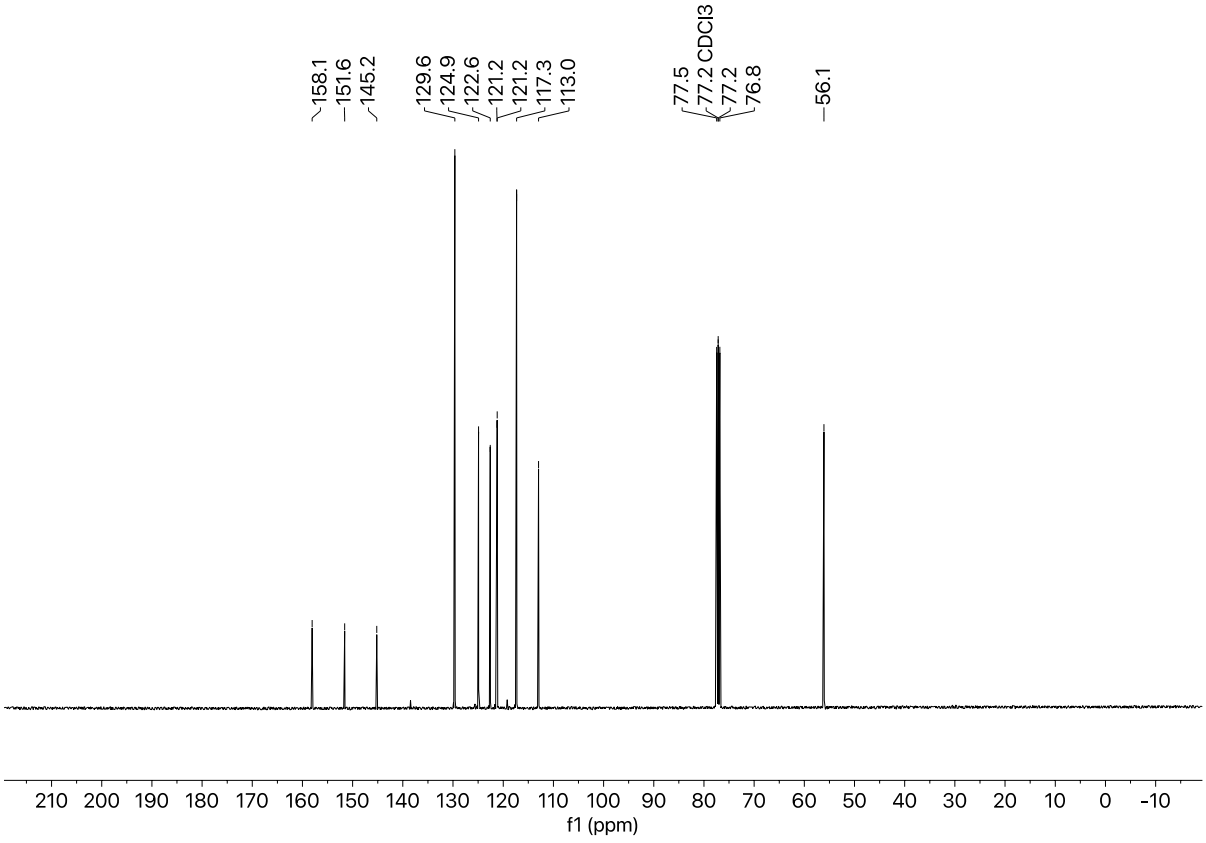
1-Methoxy-2-phenoxybenzene (3r)



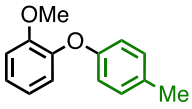
δ_H (400 MHz, $CDCl_3$)



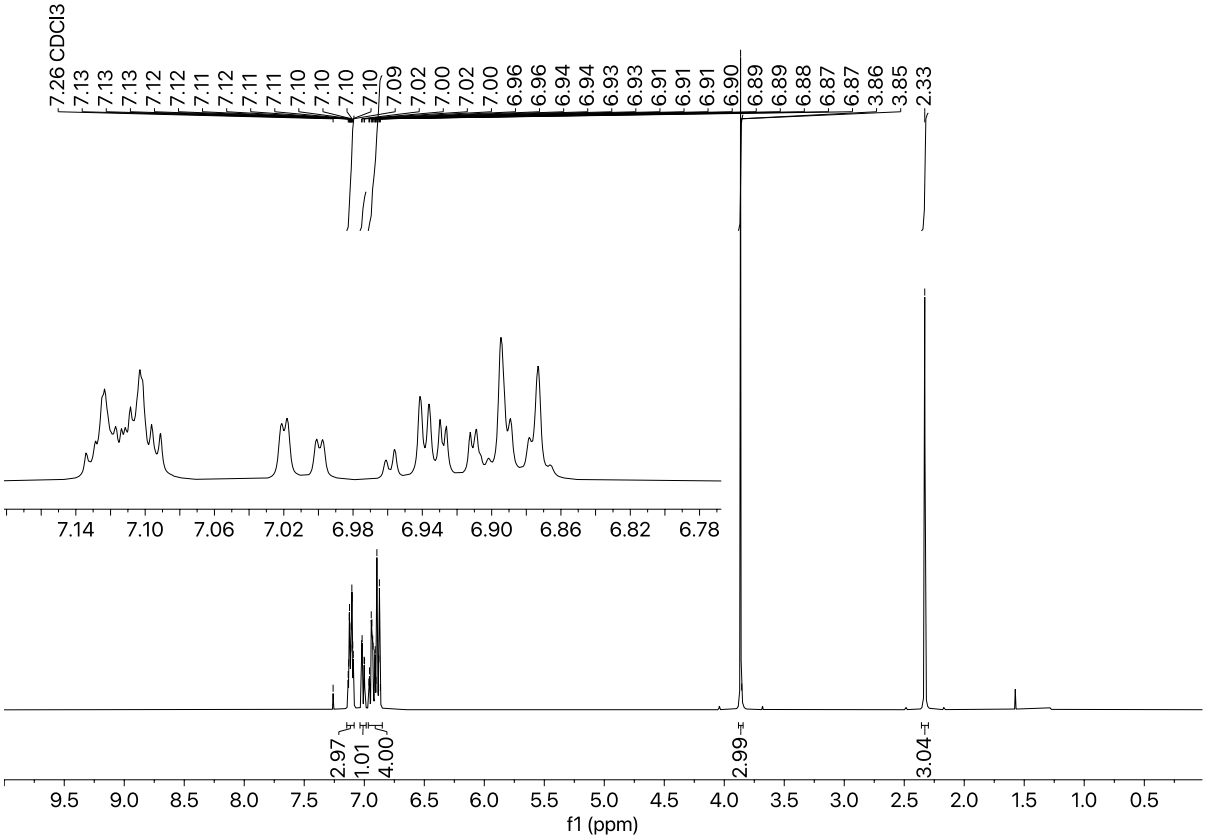
δ_C (101 MHz, $CDCl_3$)



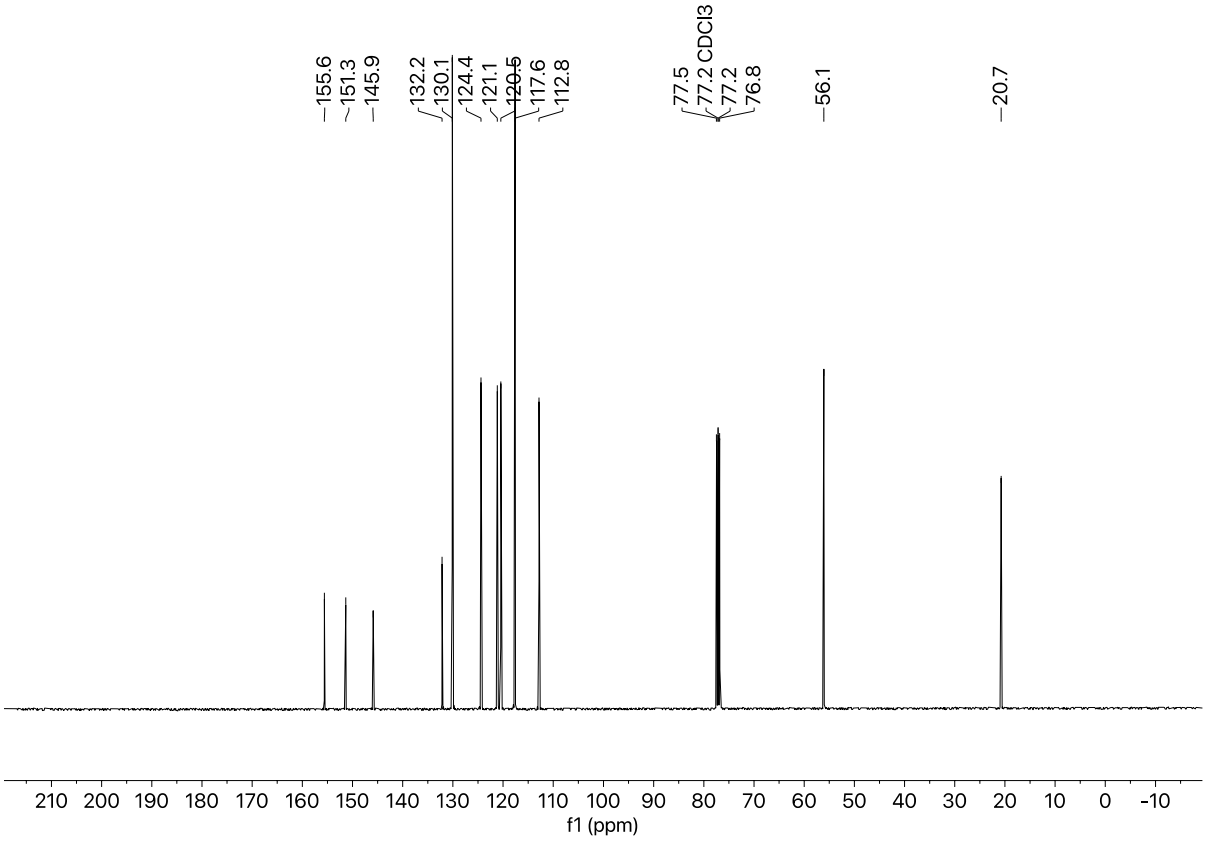
1-Methoxy-2-(*p*-tolyloxy)benzene (3s)



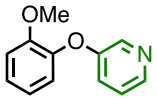
δ_H (400 MHz, $CDCl_3$)



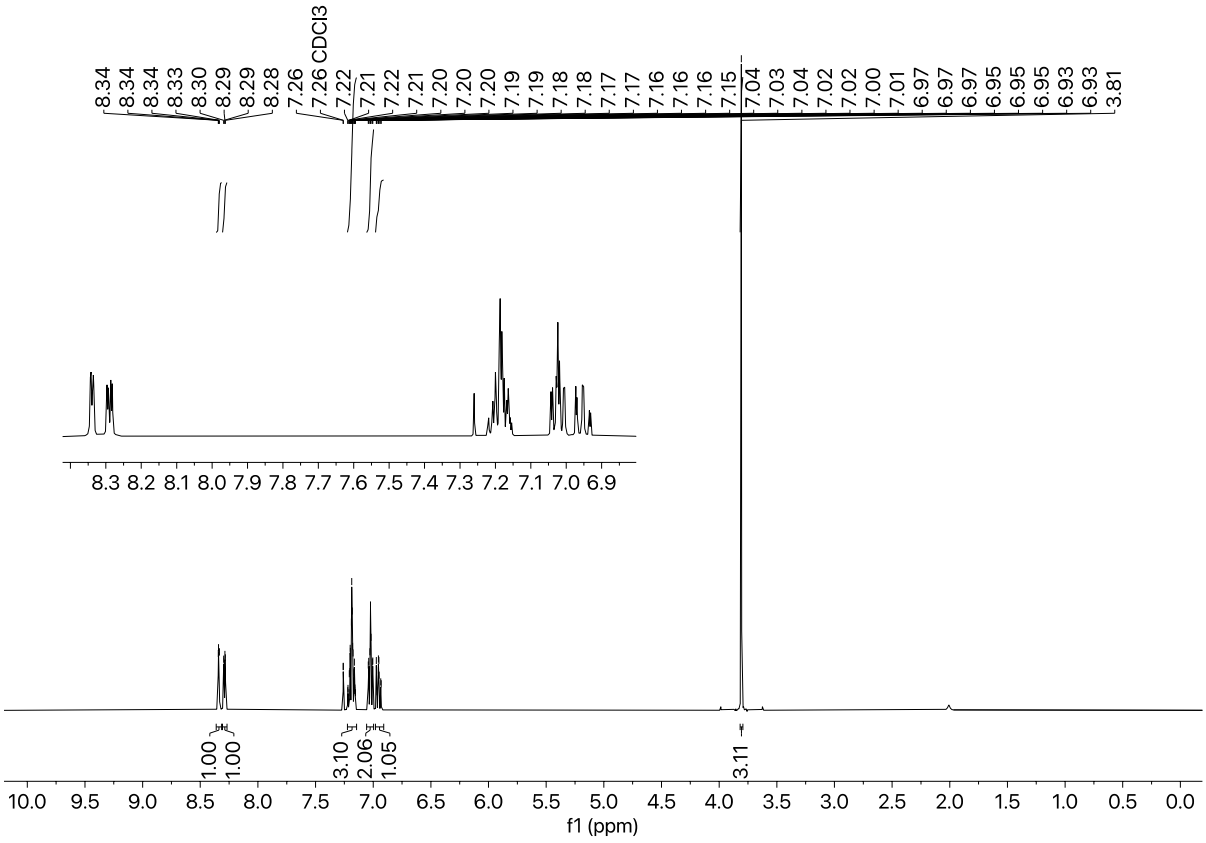
δ_C (101 MHz, $CDCl_3$)



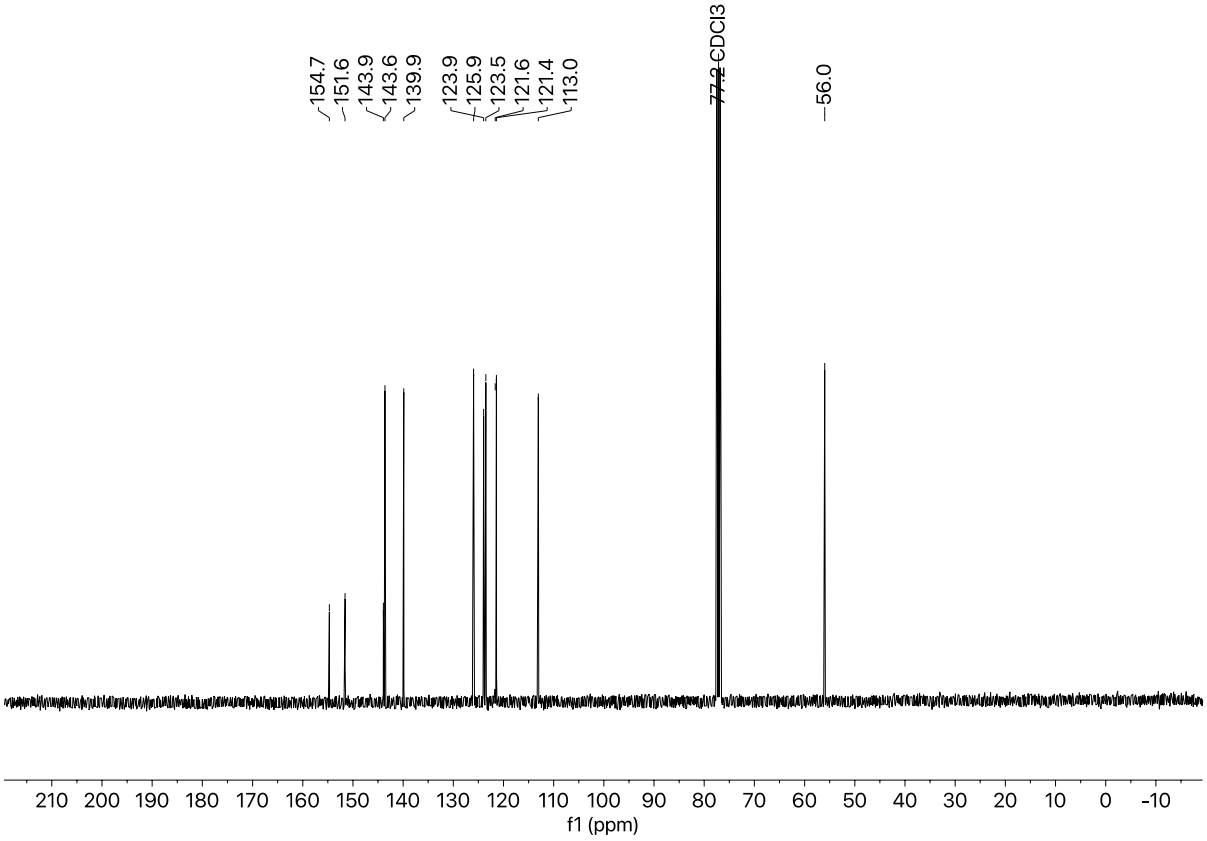
3-(2-methoxyphenoxy)pyridine (3t)



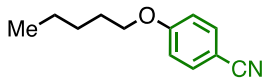
δ_H (400 MHz, $CDCl_3$)



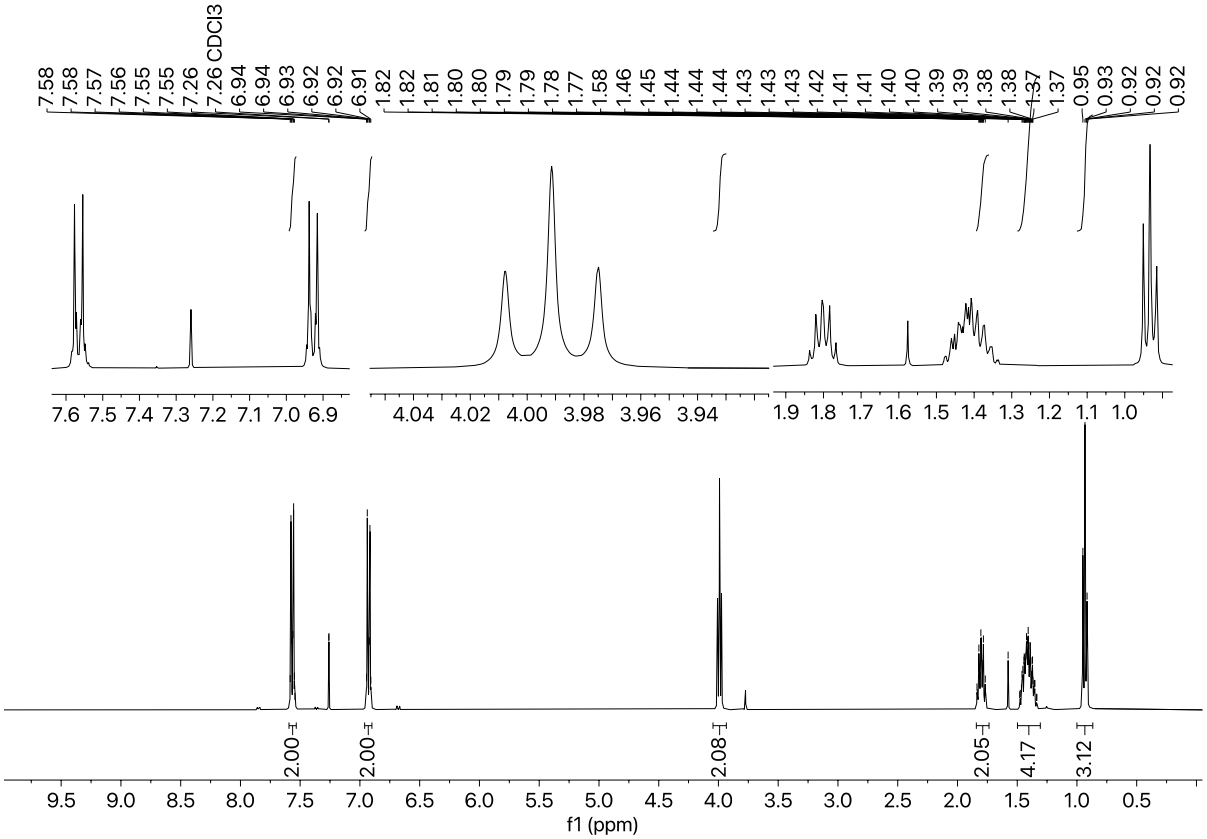
δ_C (101 MHz, $CDCl_3$)



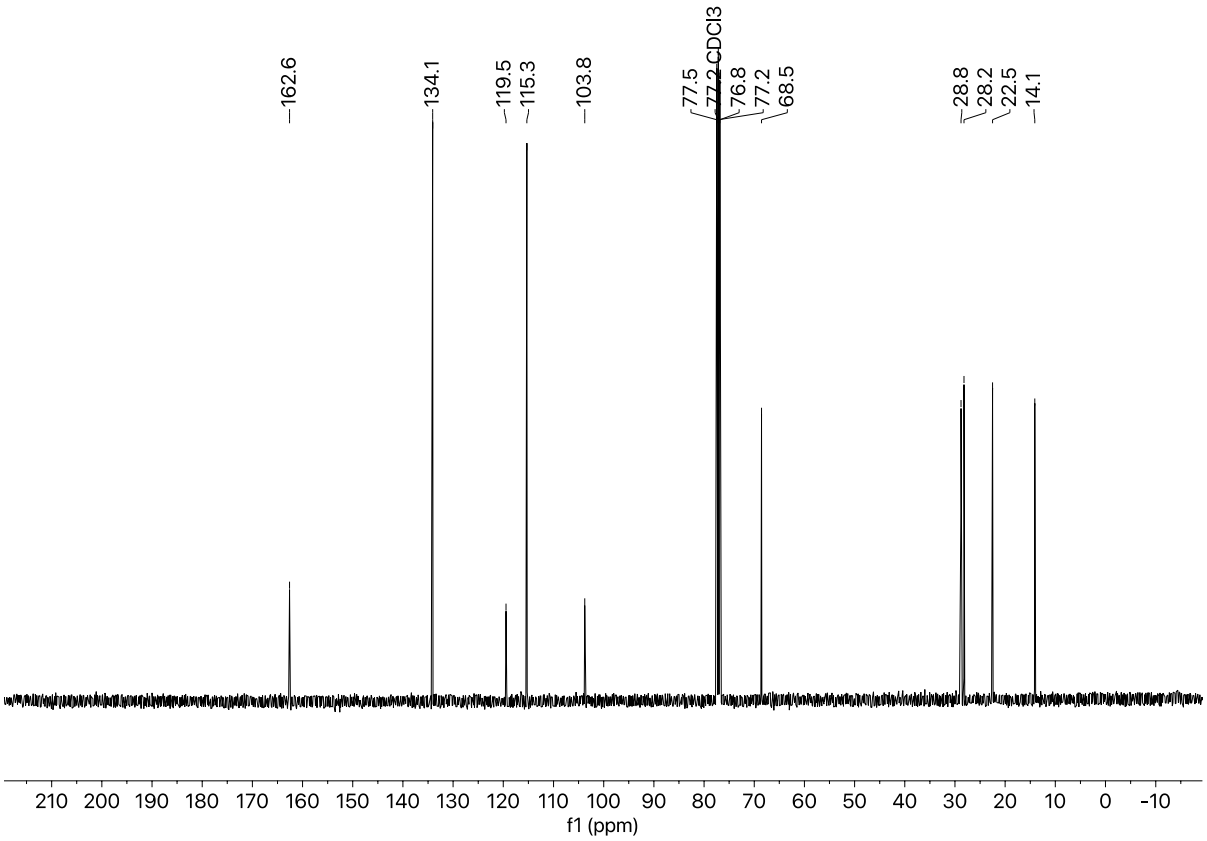
4-(Pentyloxy)benzonitrile (3u)



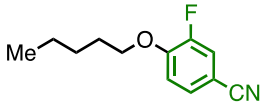
δ_H (400 MHz, $CDCl_3$)



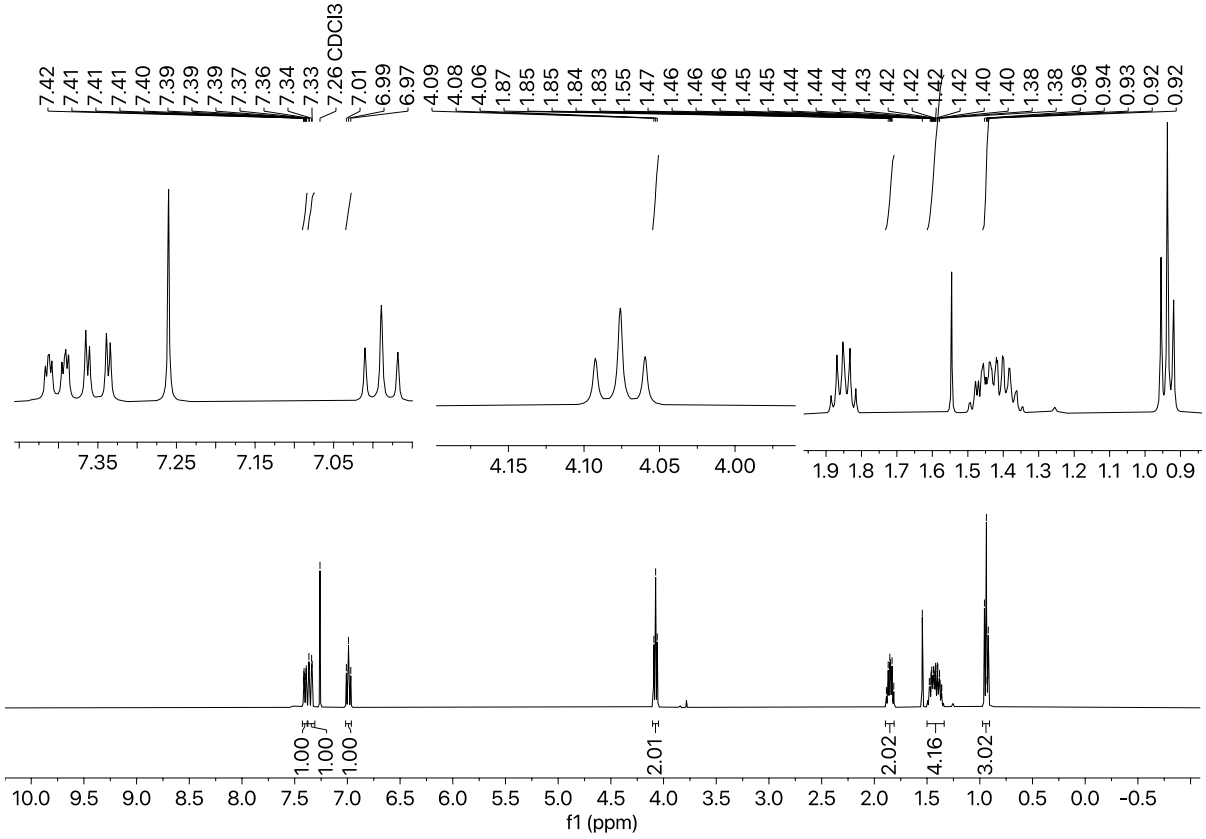
δ_C (101 MHz, $CDCl_3$)



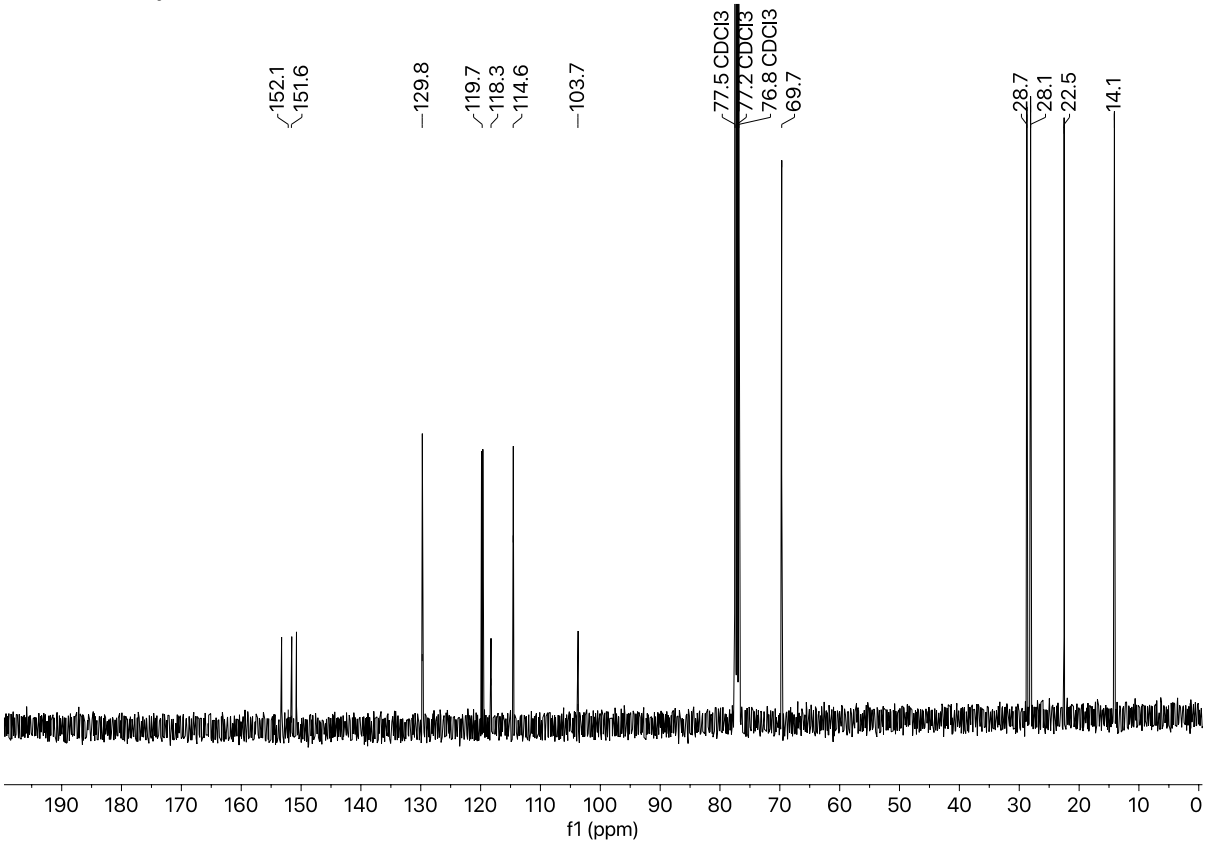
3-Fluoro-4-(pentyloxy)benzonitrile (3v)



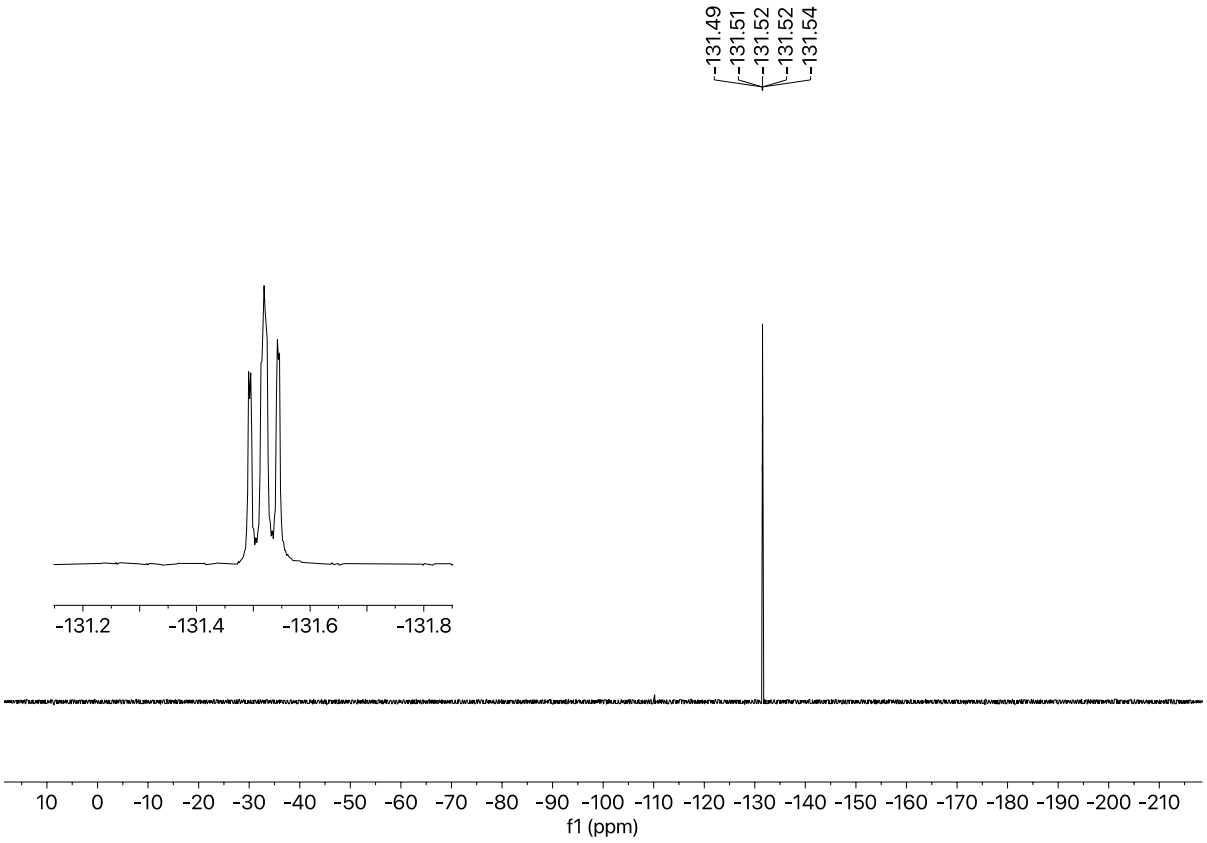
δ_H (400 MHz, $CDCl_3$)



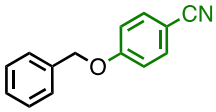
δ_C (101 MHz, $CDCl_3$)



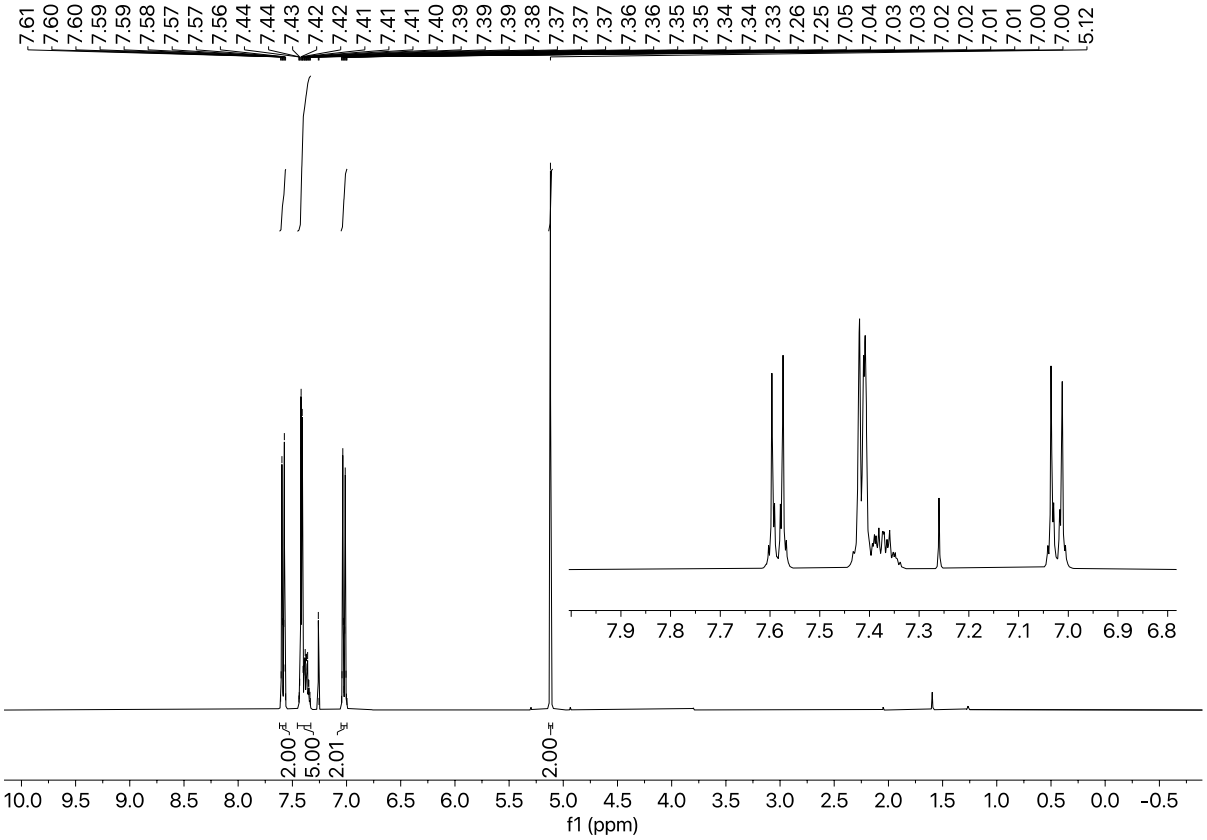
δ_F (376 MHz, $CDCl_3$)



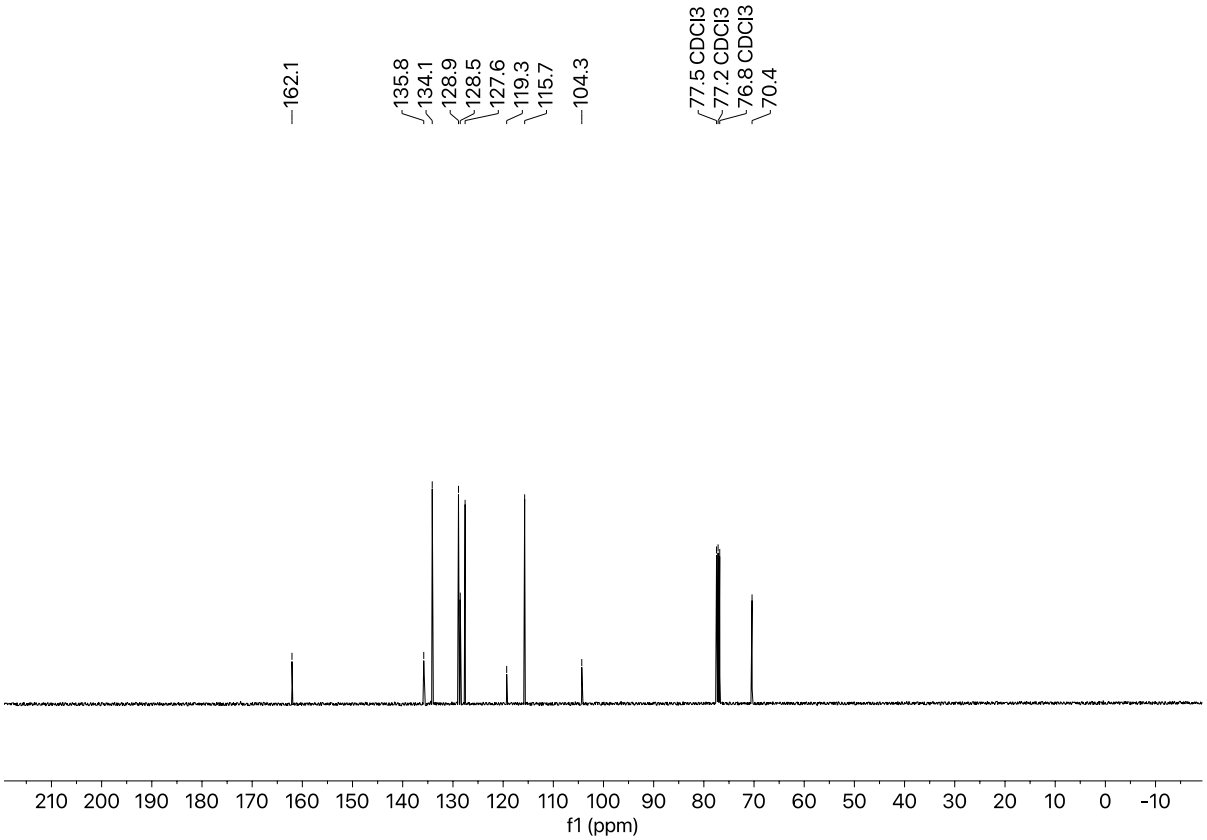
4-(Benzyloxy)benzonitrile (3w)



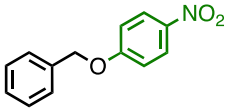
δ_H (400 MHz, $CDCl_3$)



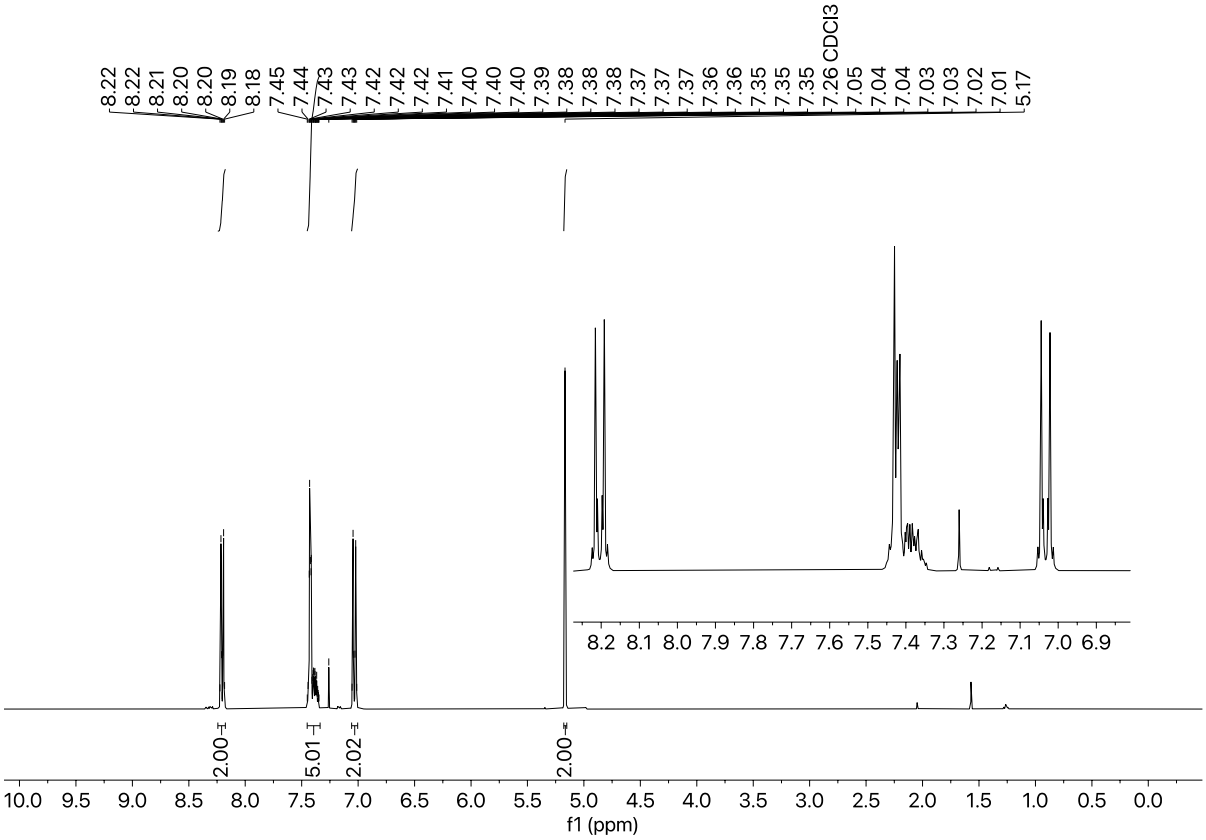
δ_C (101 MHz, $CDCl_3$)



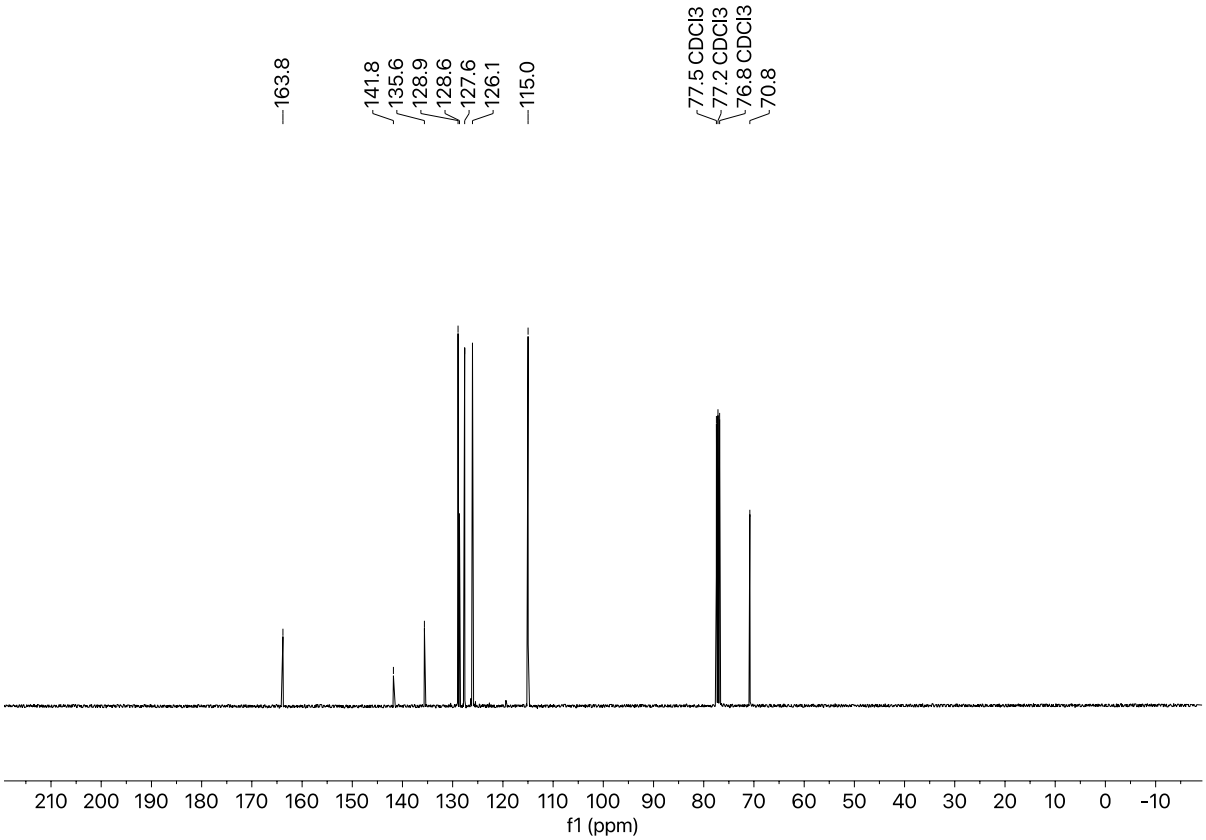
1-(Benzyloxy)-4-nitrobenzene (3x)



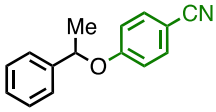
δ_H (400 MHz, $CDCl_3$)



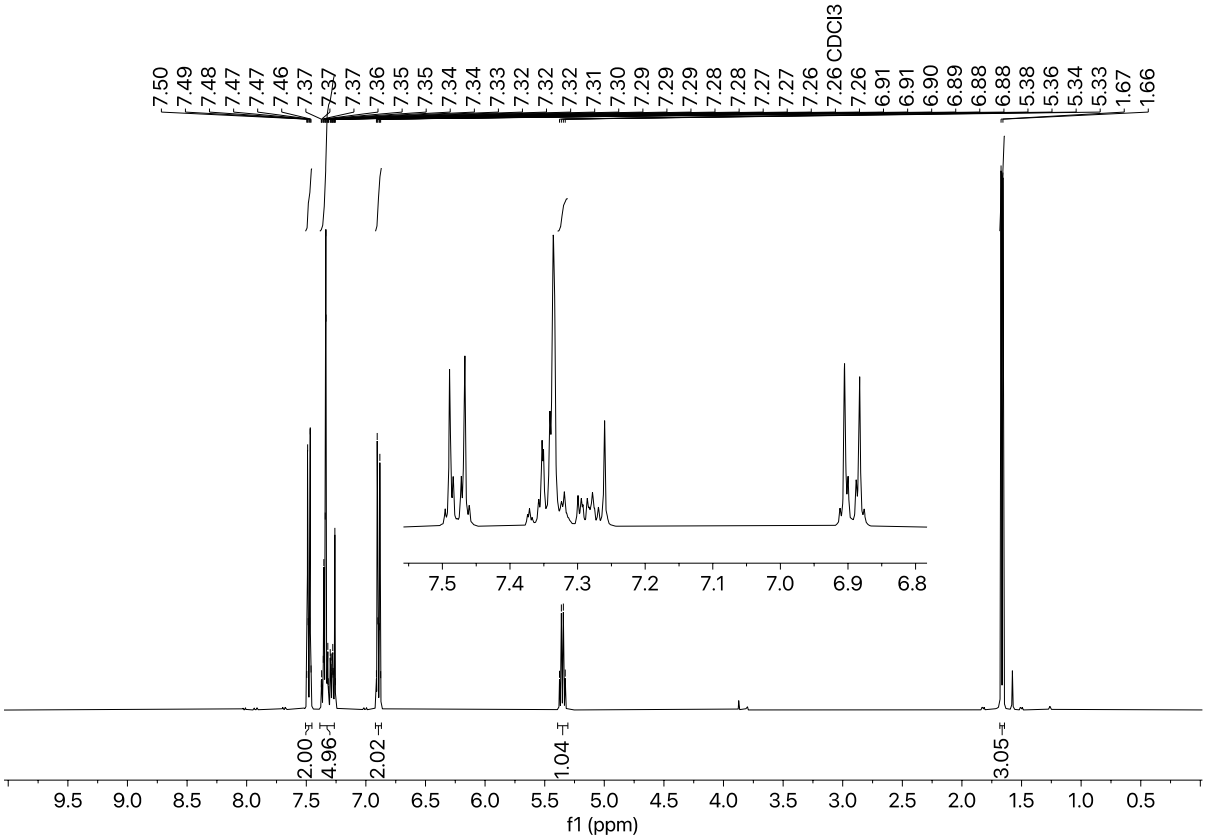
δ_C (101 MHz, $CDCl_3$)



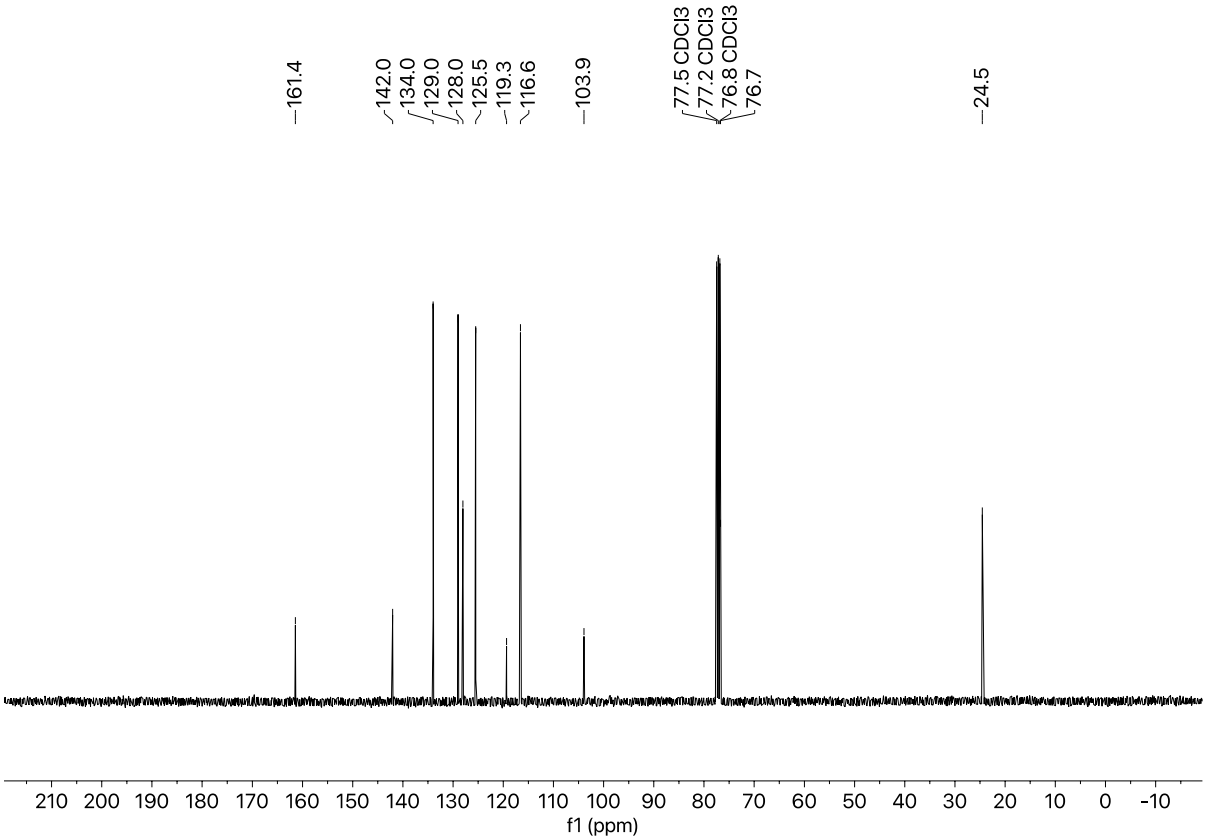
4-(1-Phenylethoxy)benzonitrile (3y)



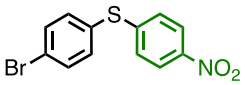
δ_H (400 MHz, $CDCl_3$)



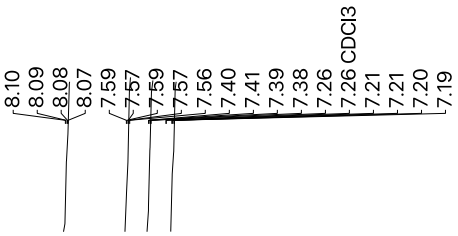
δ_C (101 MHz, $CDCl_3$)

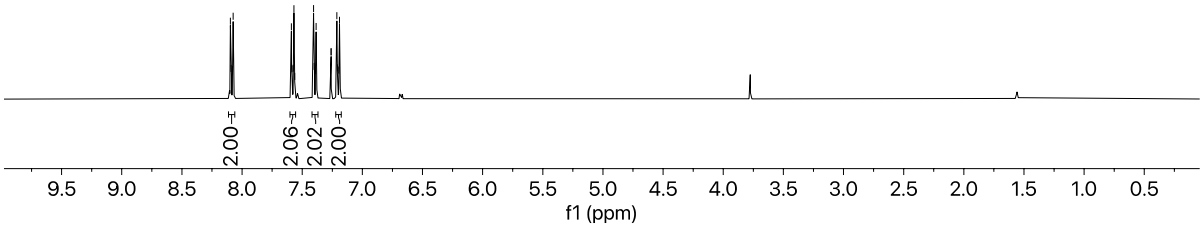


(4-Bromophenyl)(4-nitrophenyl)sulfane (4a)

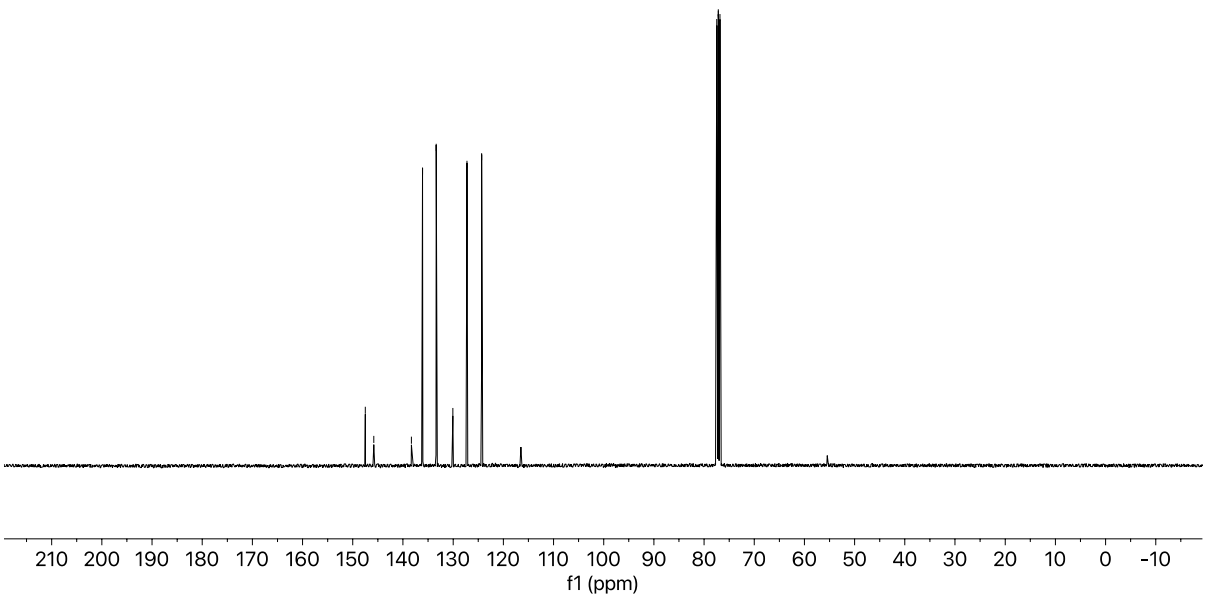


δ_H (400 MHz, $CDCl_3$)

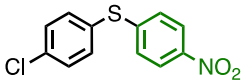




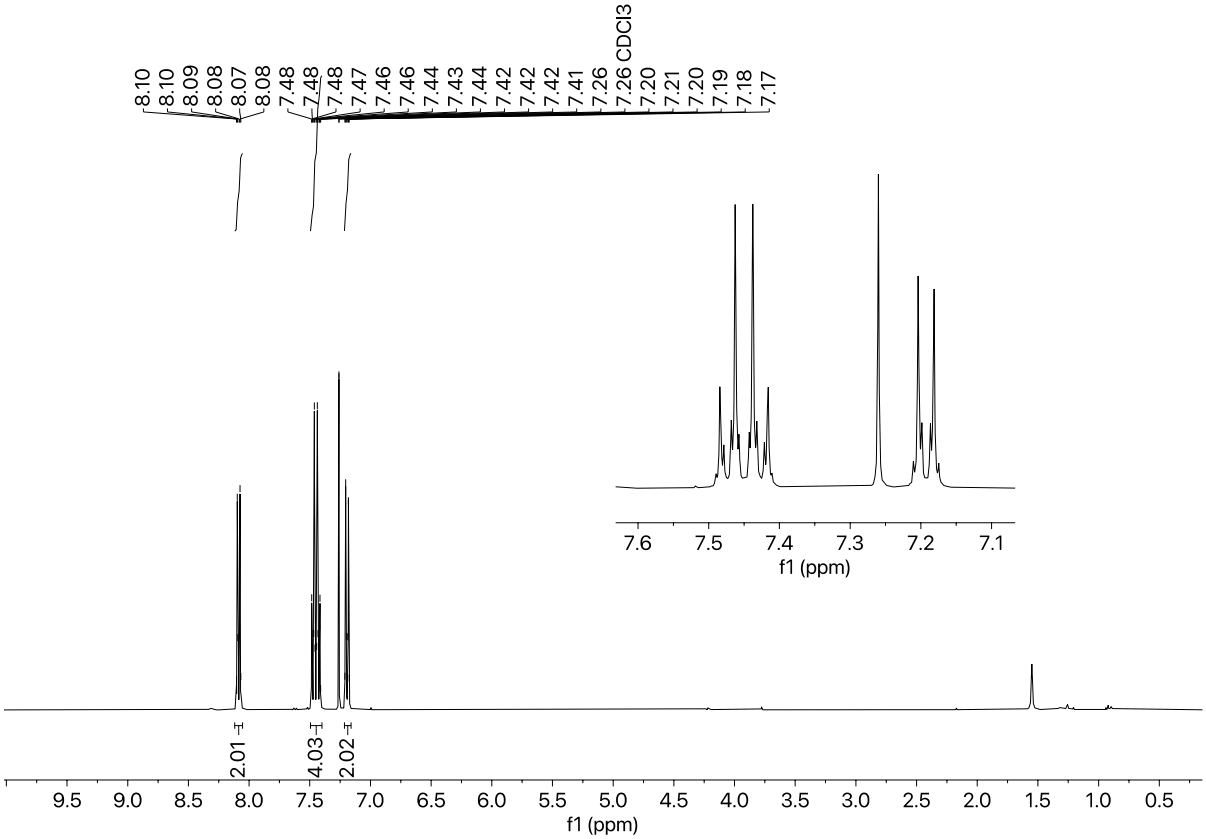
δ_C (101 MHz, $CDCl_3$)



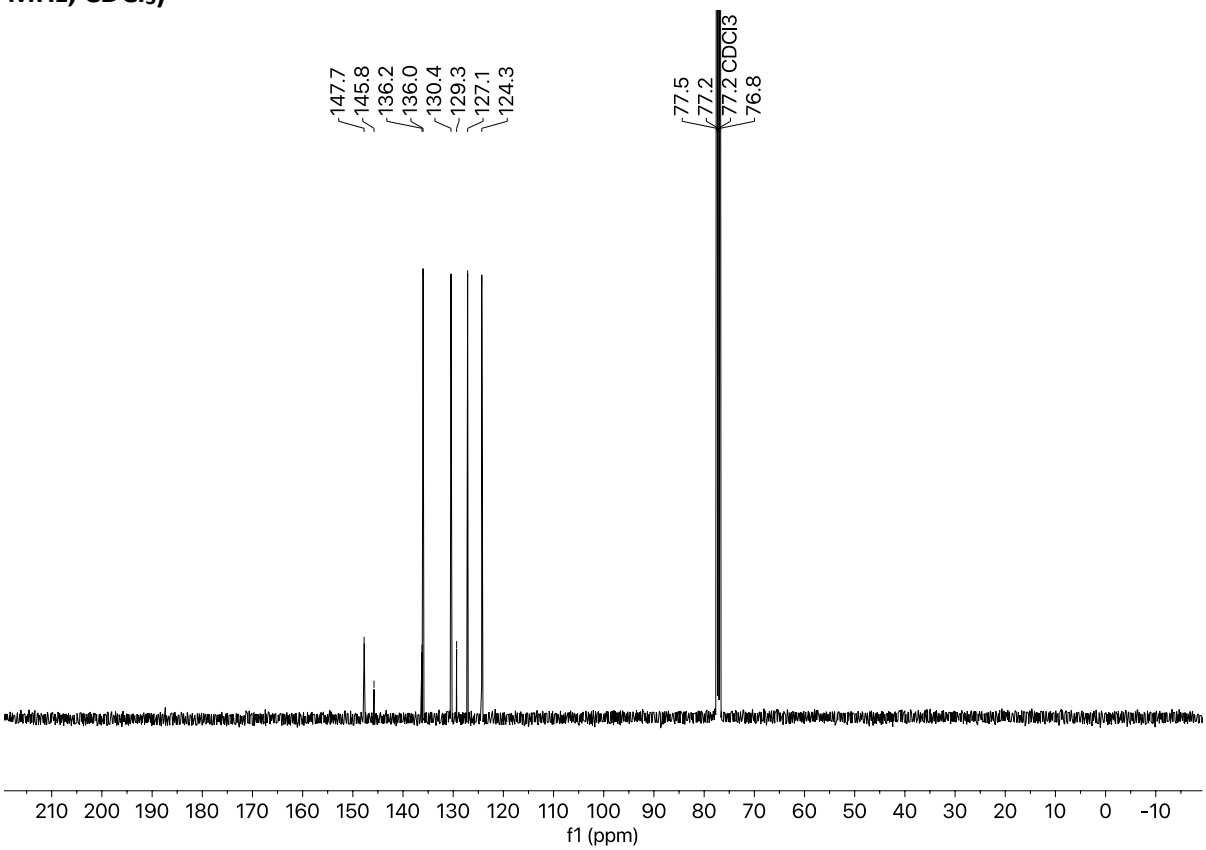
(4-Chlorophenyl)(4-nitrophenyl)sulfane (4b)



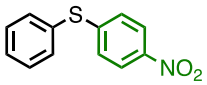
δ_H (400 MHz, $CDCl_3$)



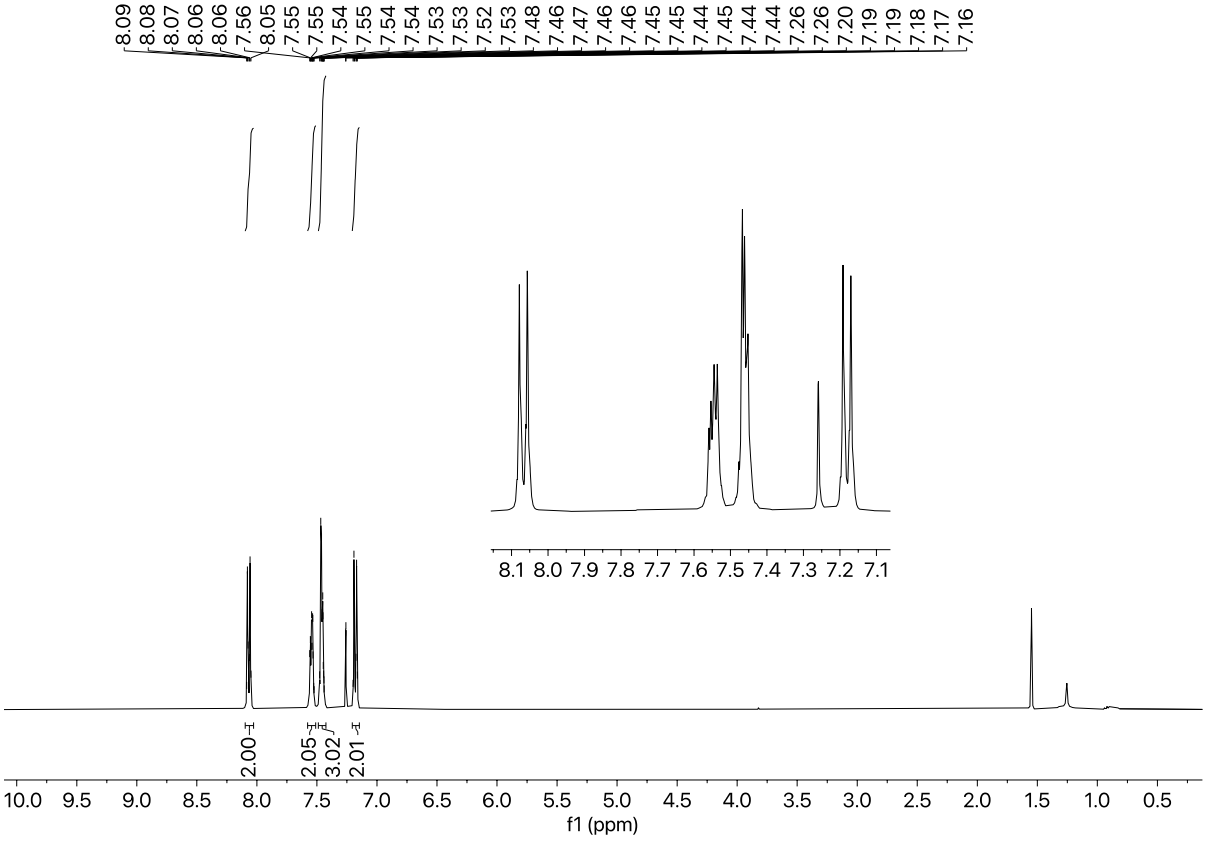
δ_C (101 MHz, $CDCl_3$)



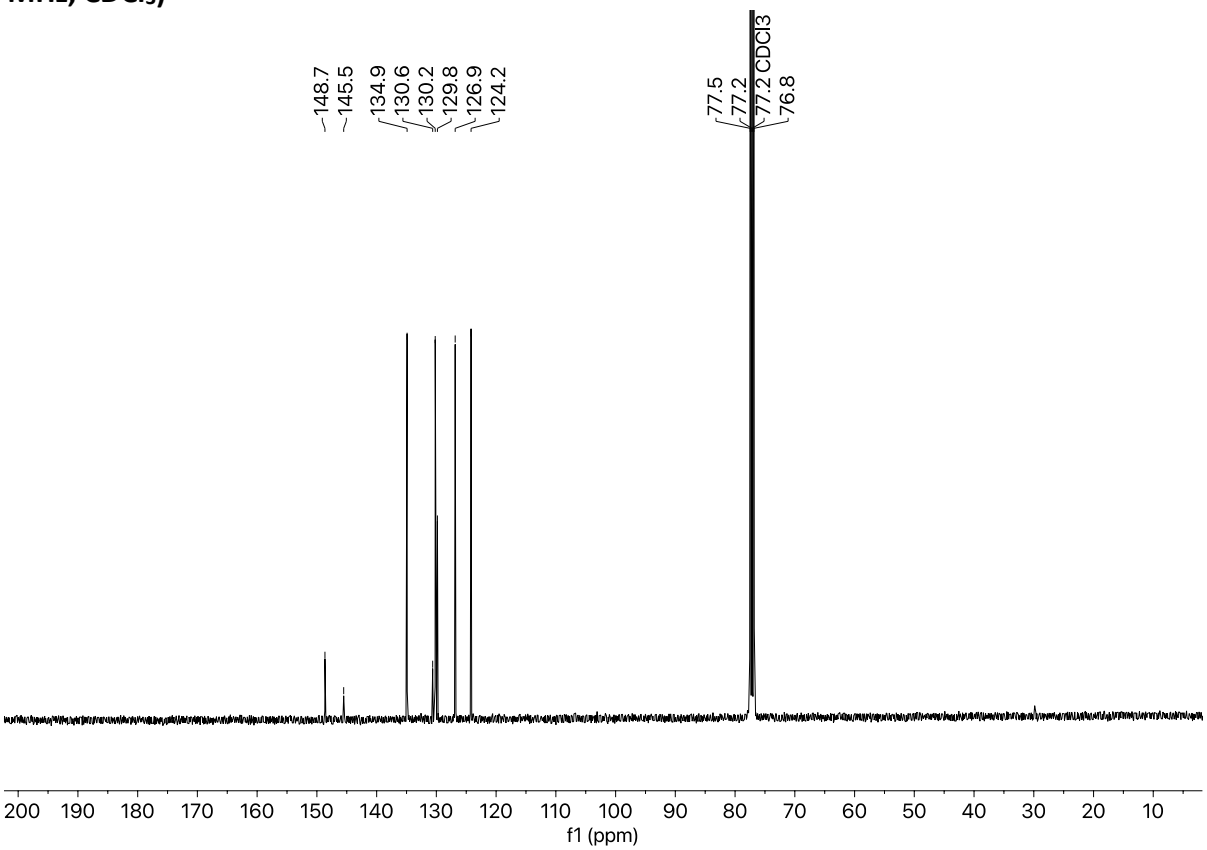
(4-Nitrophenyl)(phenyl)sulfane (4c)



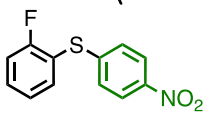
δ_H (400 MHz, $CDCl_3$)



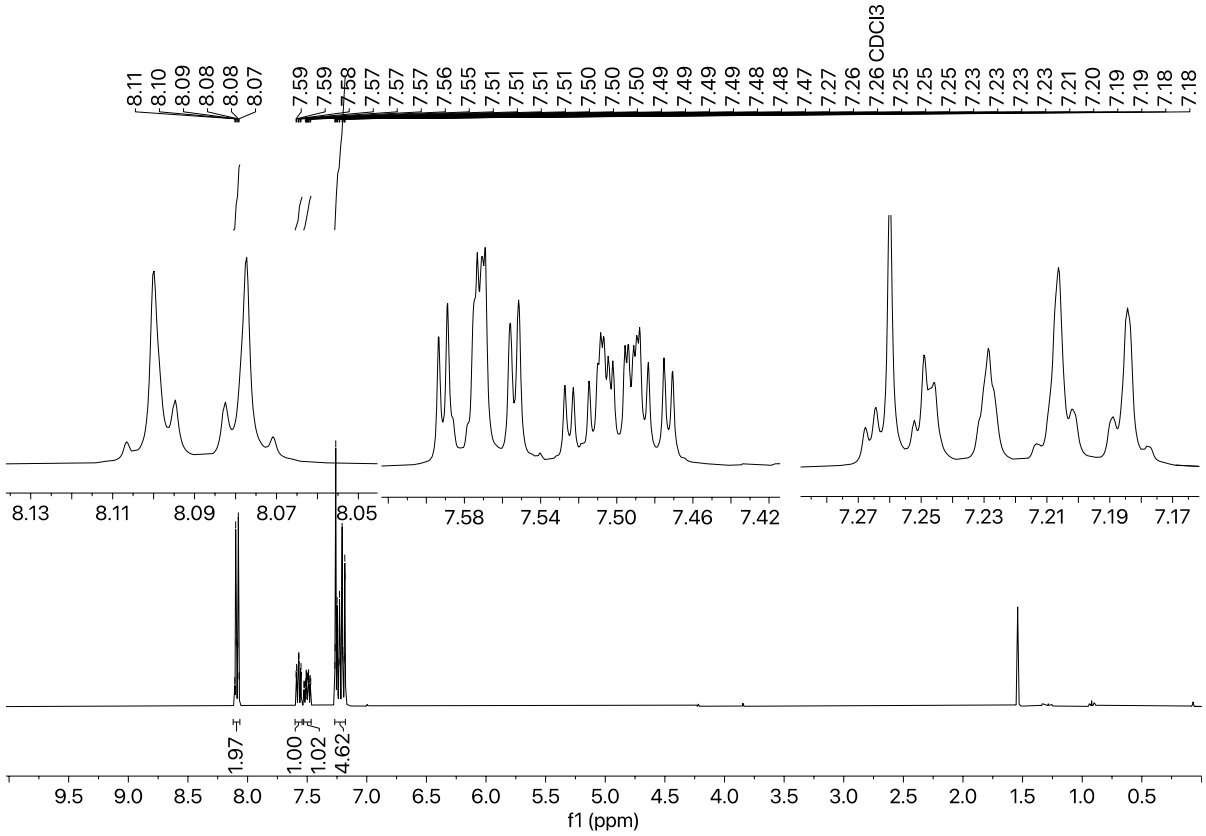
δ_C (101 MHz, $CDCl_3$)



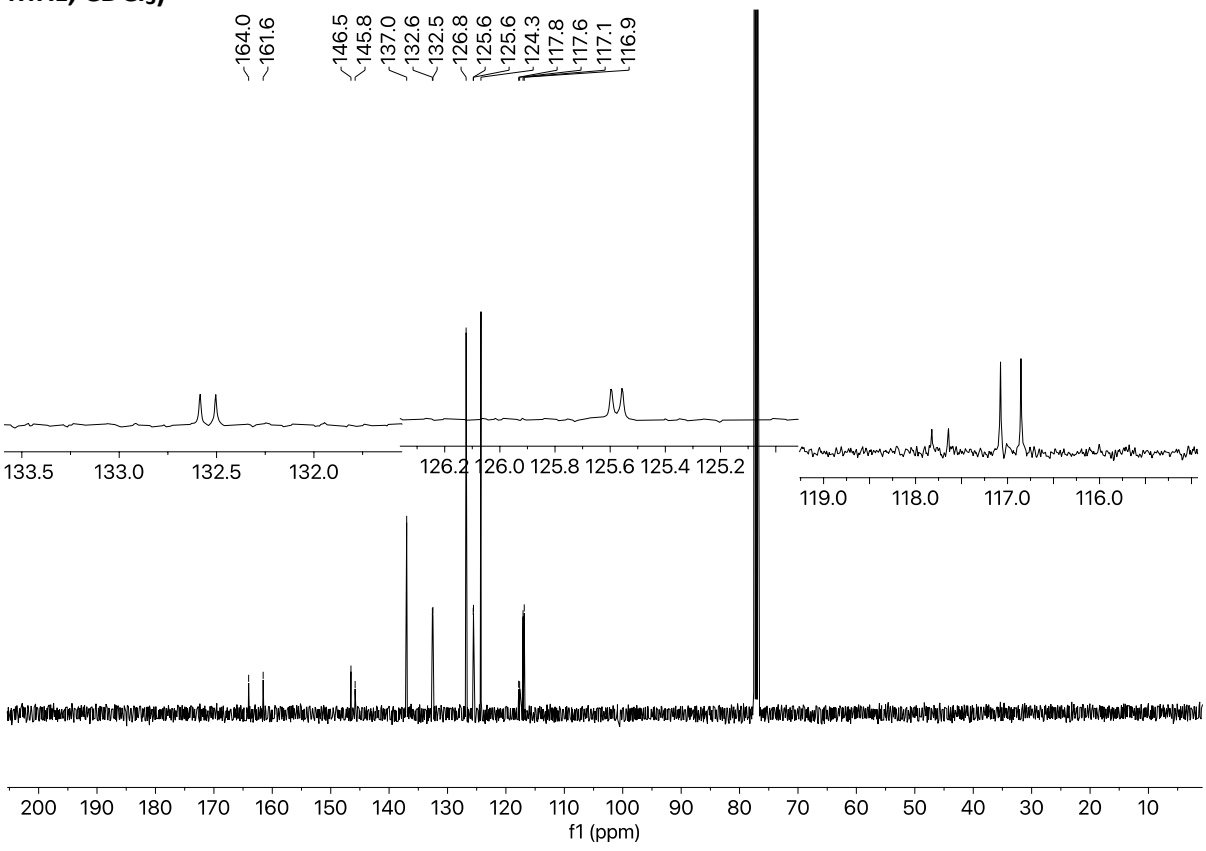
(2-Fluorophenyl)(4-nitrophenyl)sulfane (4d)



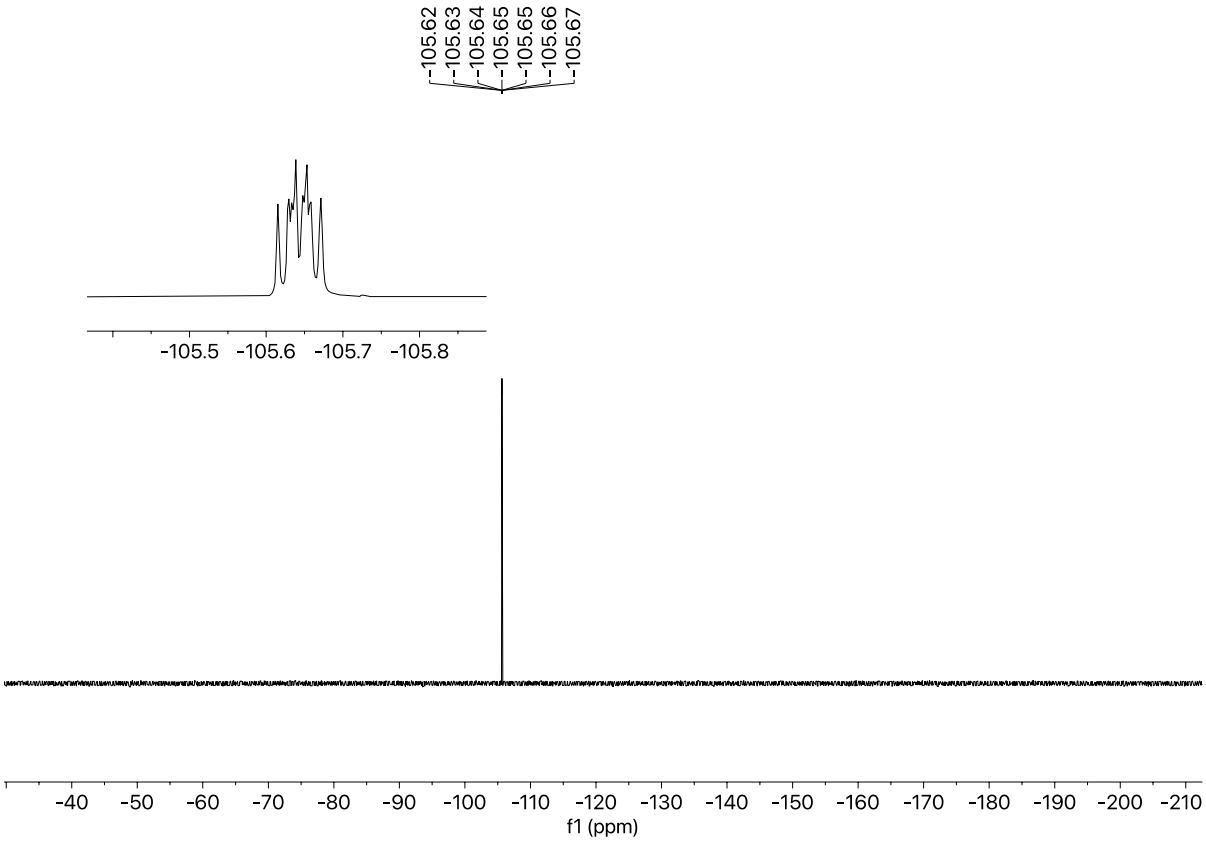
δ_H (400 MHz, $CDCl_3$)



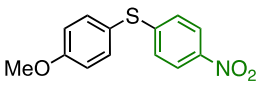
δ_C (101 MHz, $CDCl_3$)



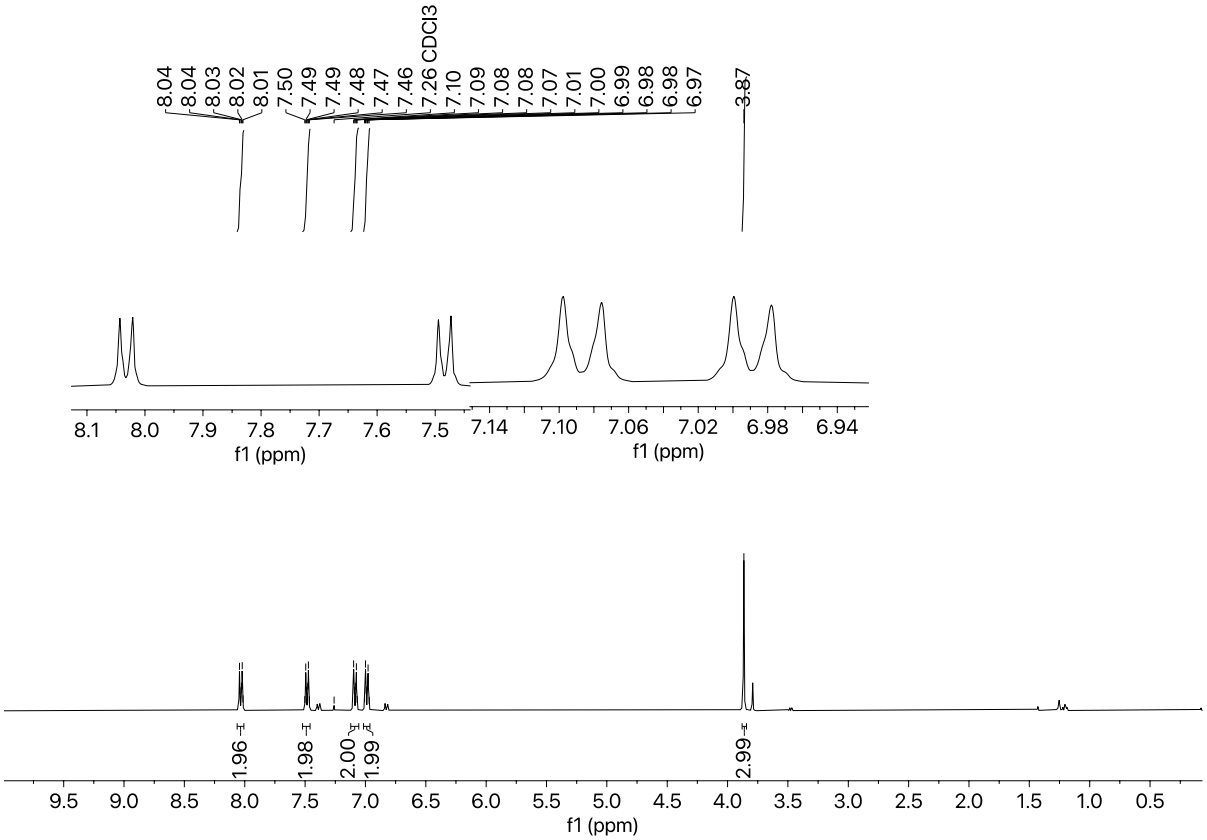
δ_F (376 MHz, $CDCl_3$)



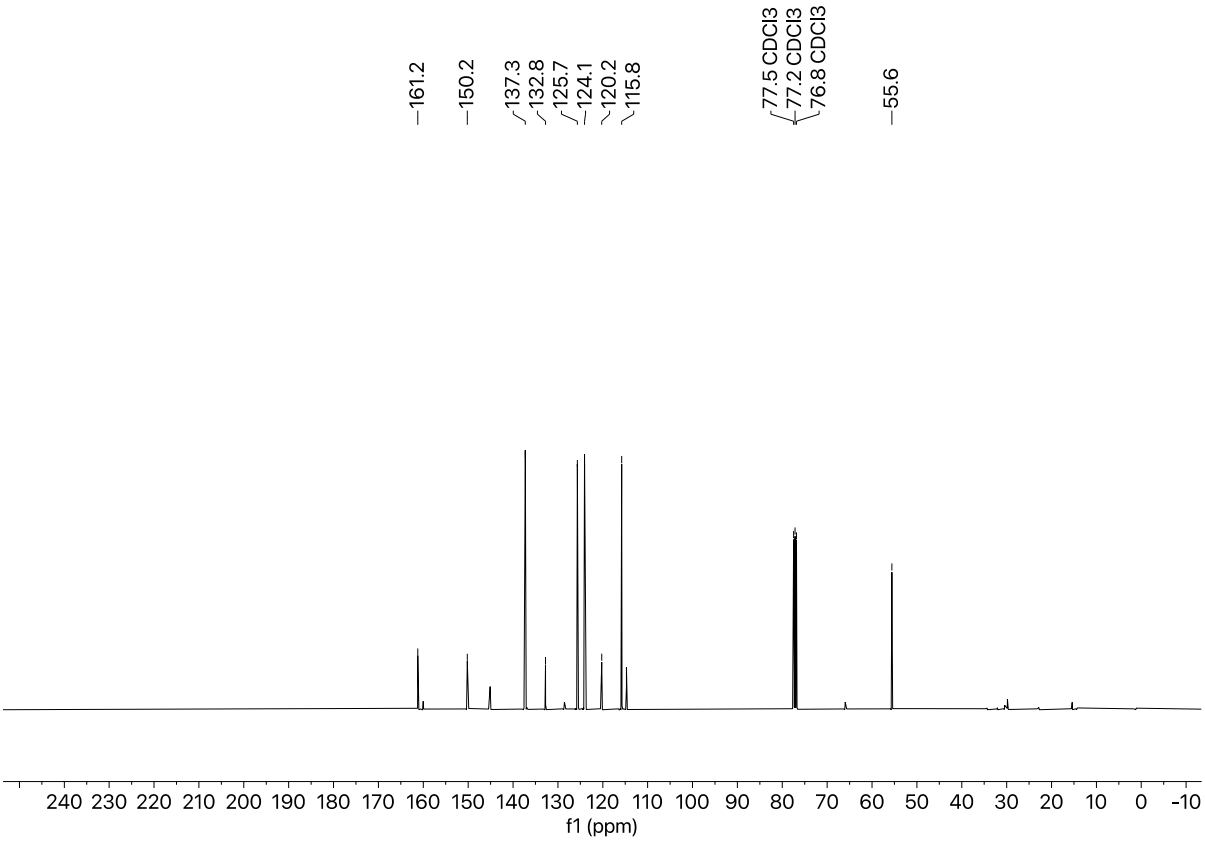
(4-Methoxyphenyl)(4-nitrophenyl)sulfane (4e)



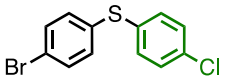
δ_H (400 MHz, $CDCl_3$)



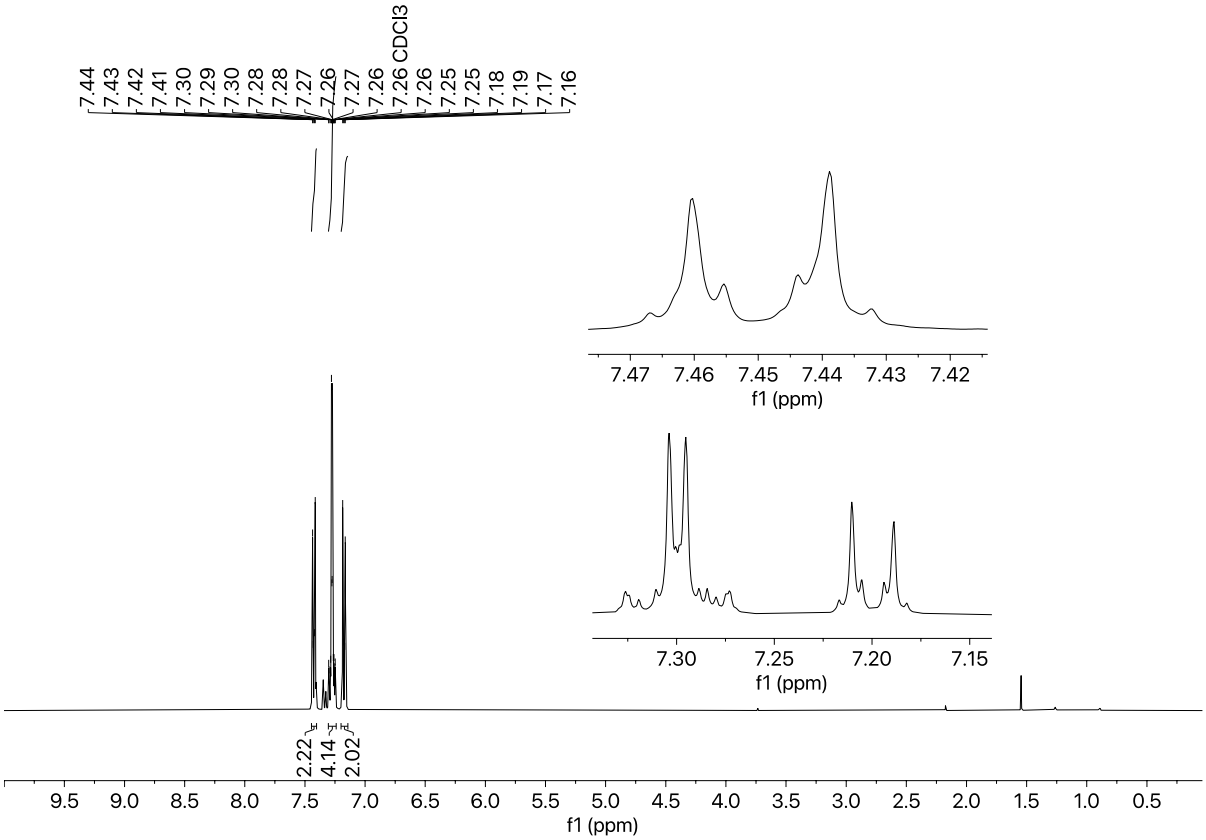
δ_C (101 MHz, $CDCl_3$)



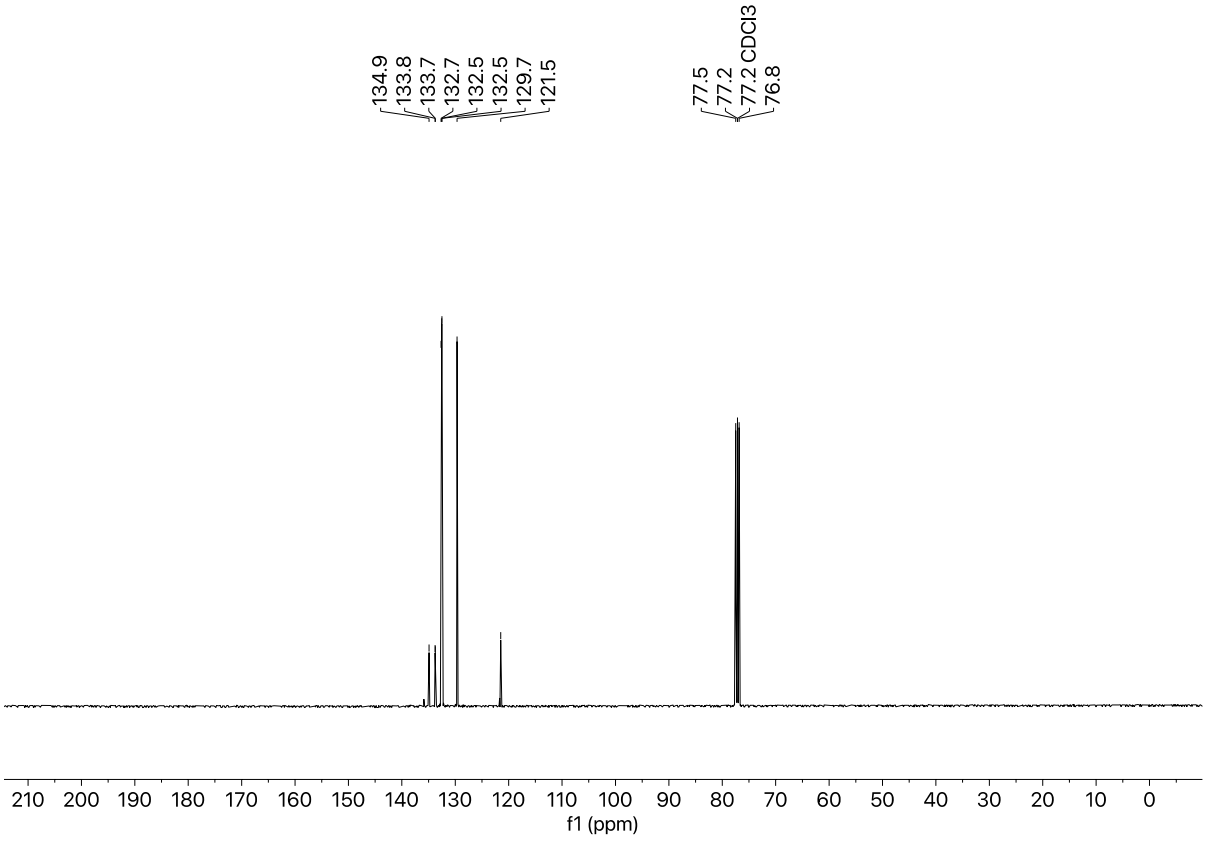
(4-Bromophenyl)(4-chlorophenyl)sulfane (4f)



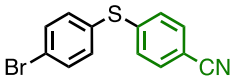
δ_H (400 MHz, $CDCl_3$)



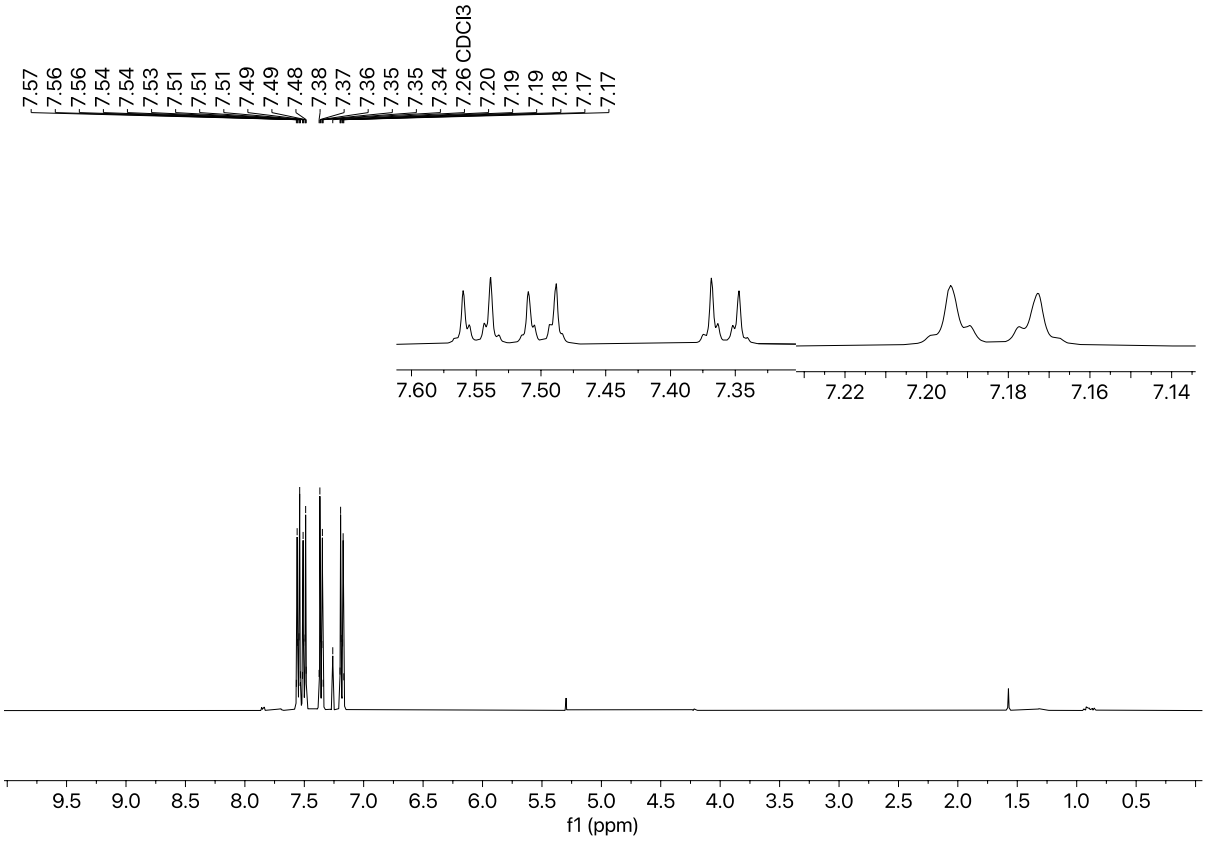
δ_C (101 MHz, $CDCl_3$)



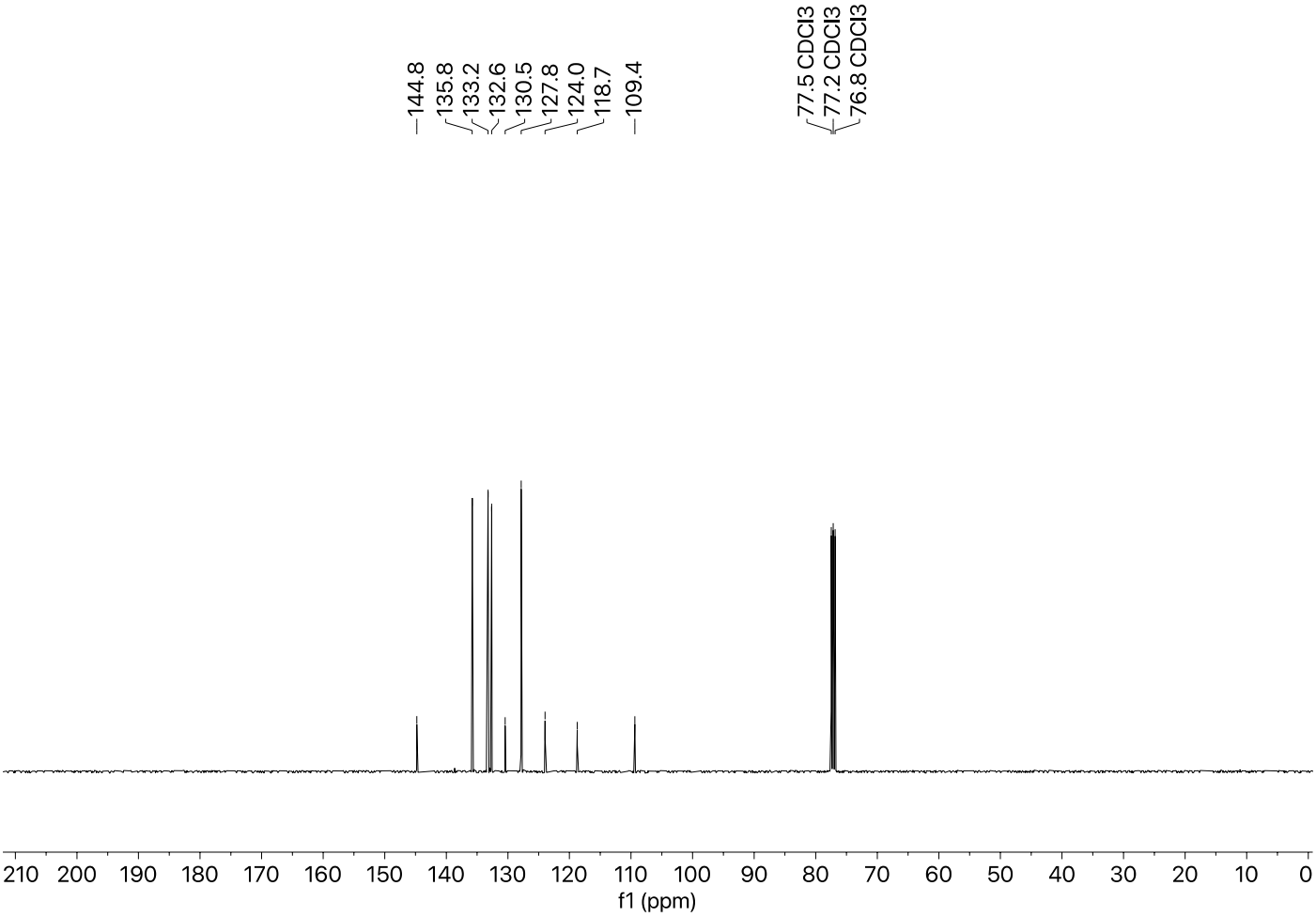
4-((4-Bromophenyl)thio)benzonitrile (4g)



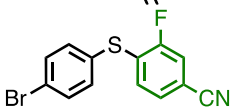
δ_H (400 MHz, $CDCl_3$)



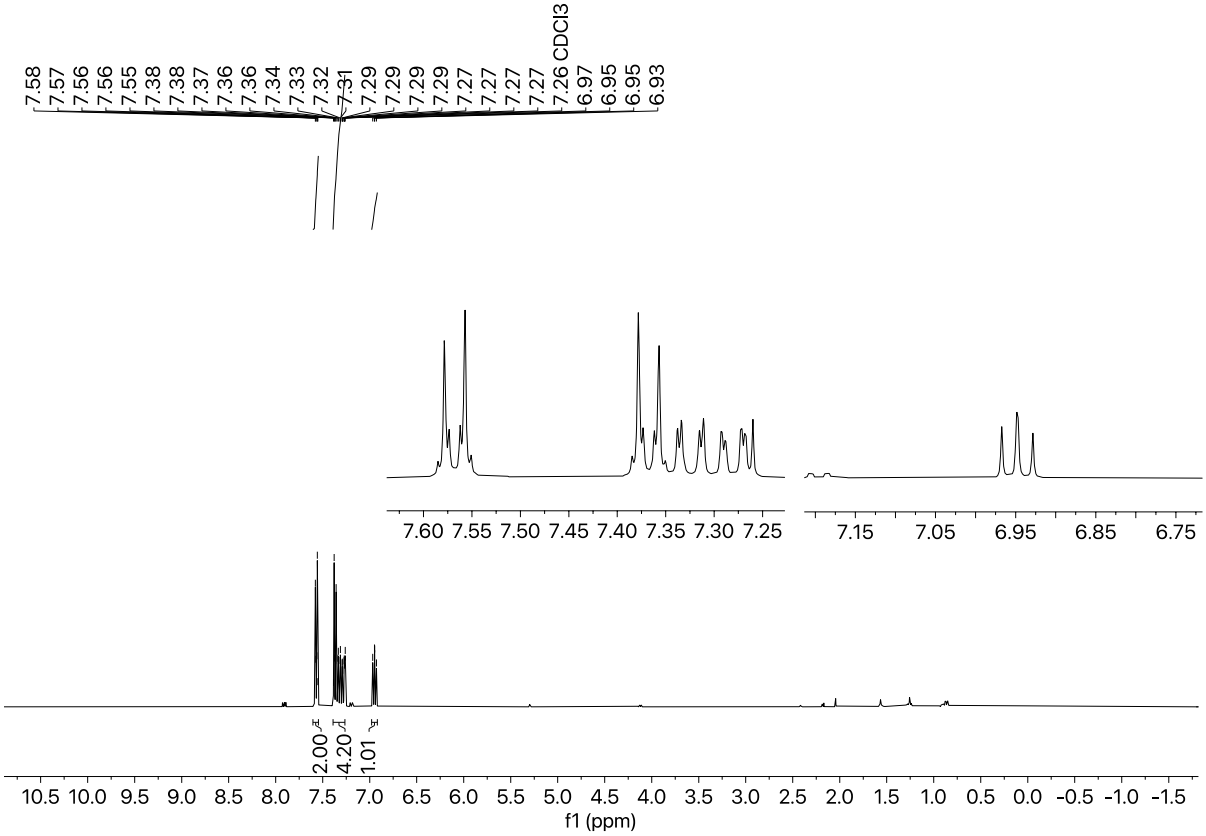
δ_C (101 MHz, $CDCl_3$)



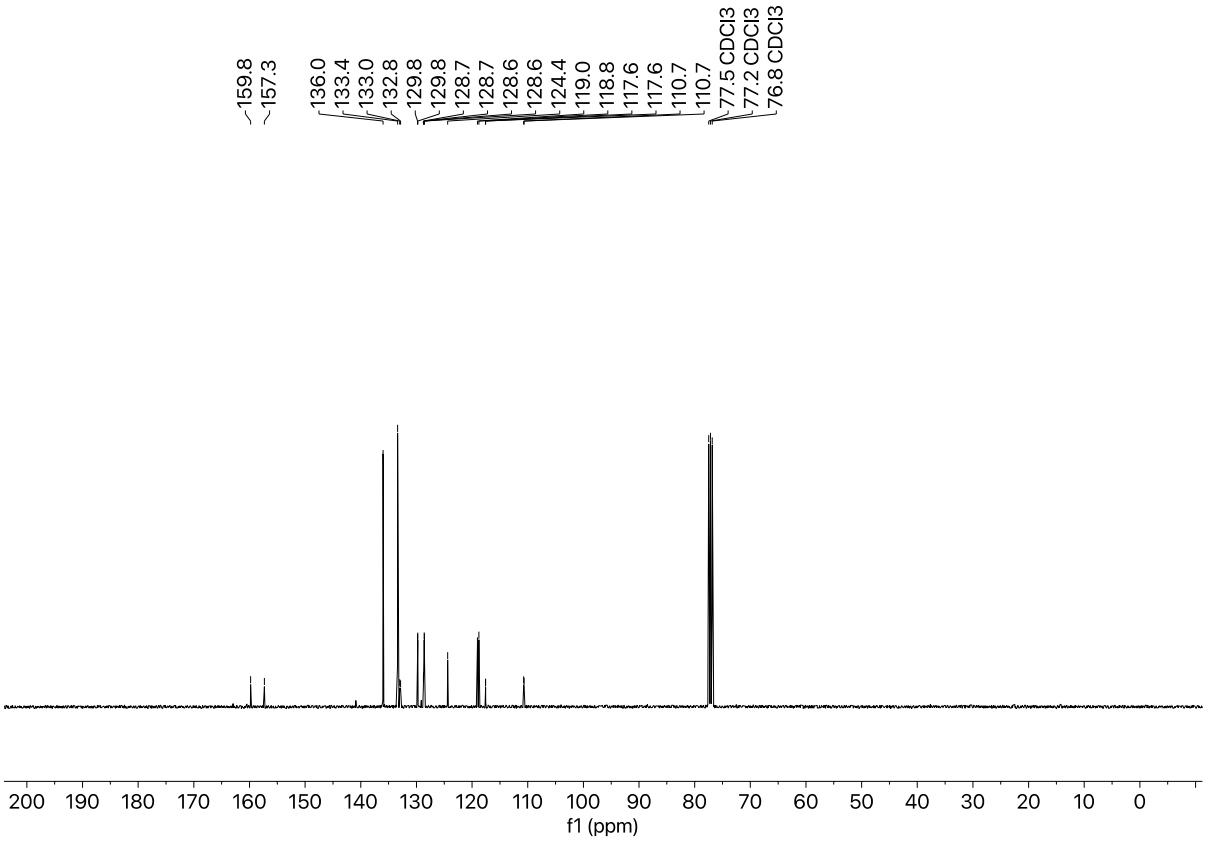
4-((4-Bromophenyl)thio)-3-fluorobenzonitrile (4h)



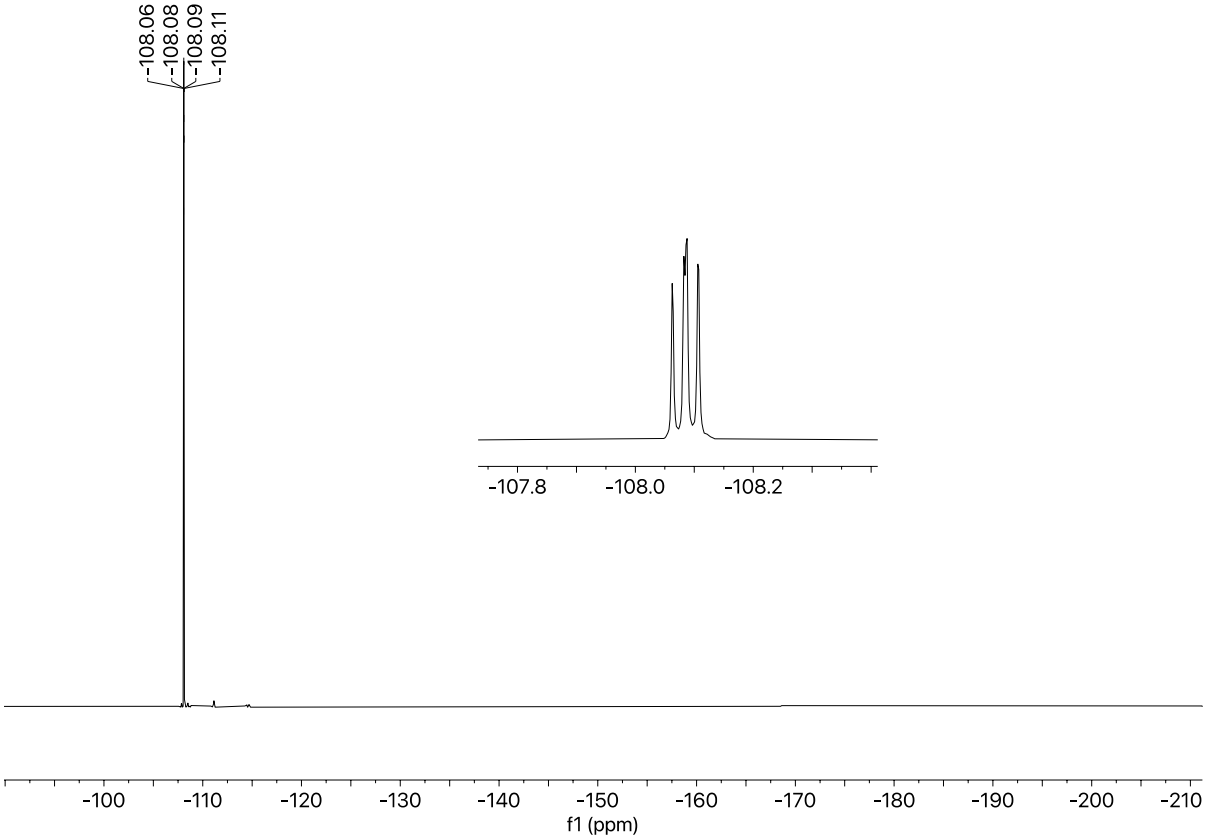
δ_H (400 MHz, $CDCl_3$)



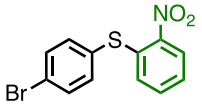
δ_C (101 MHz, $CDCl_3$)



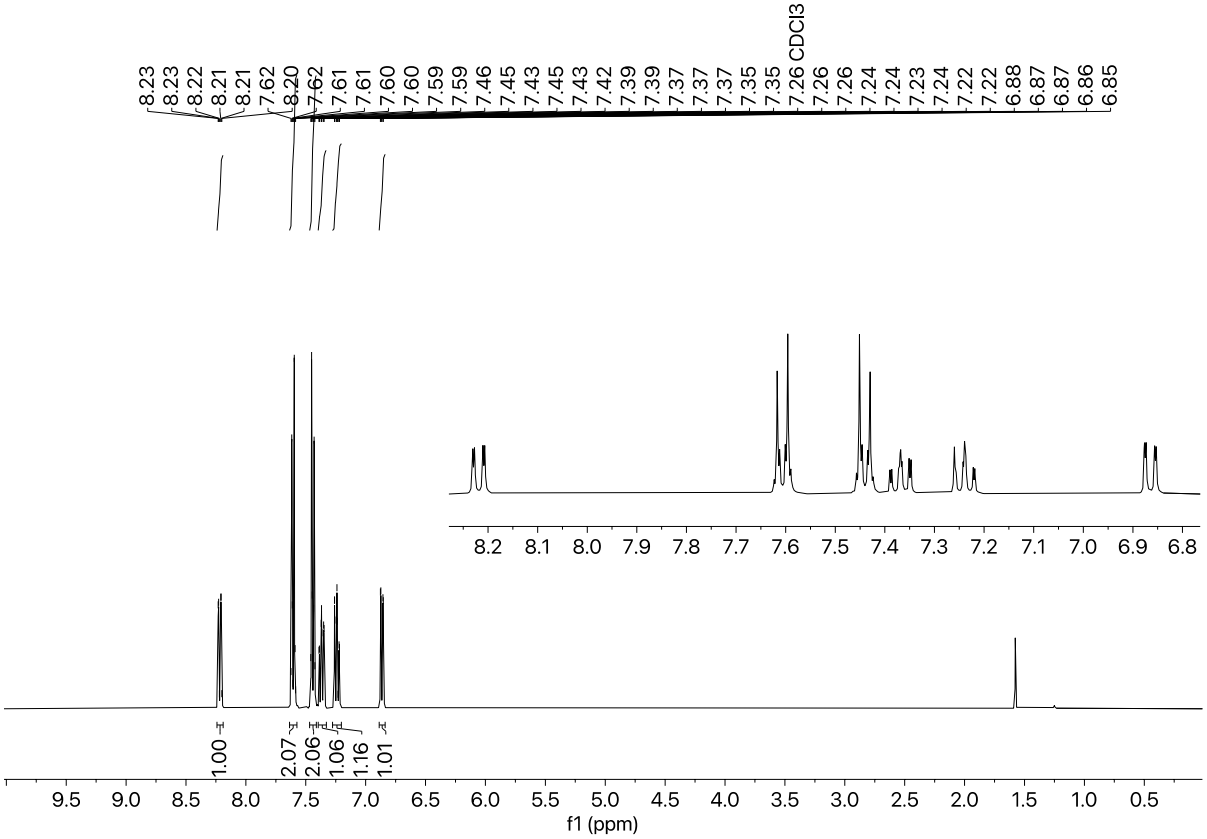
δ_F (376 MHz, $CDCl_3$)



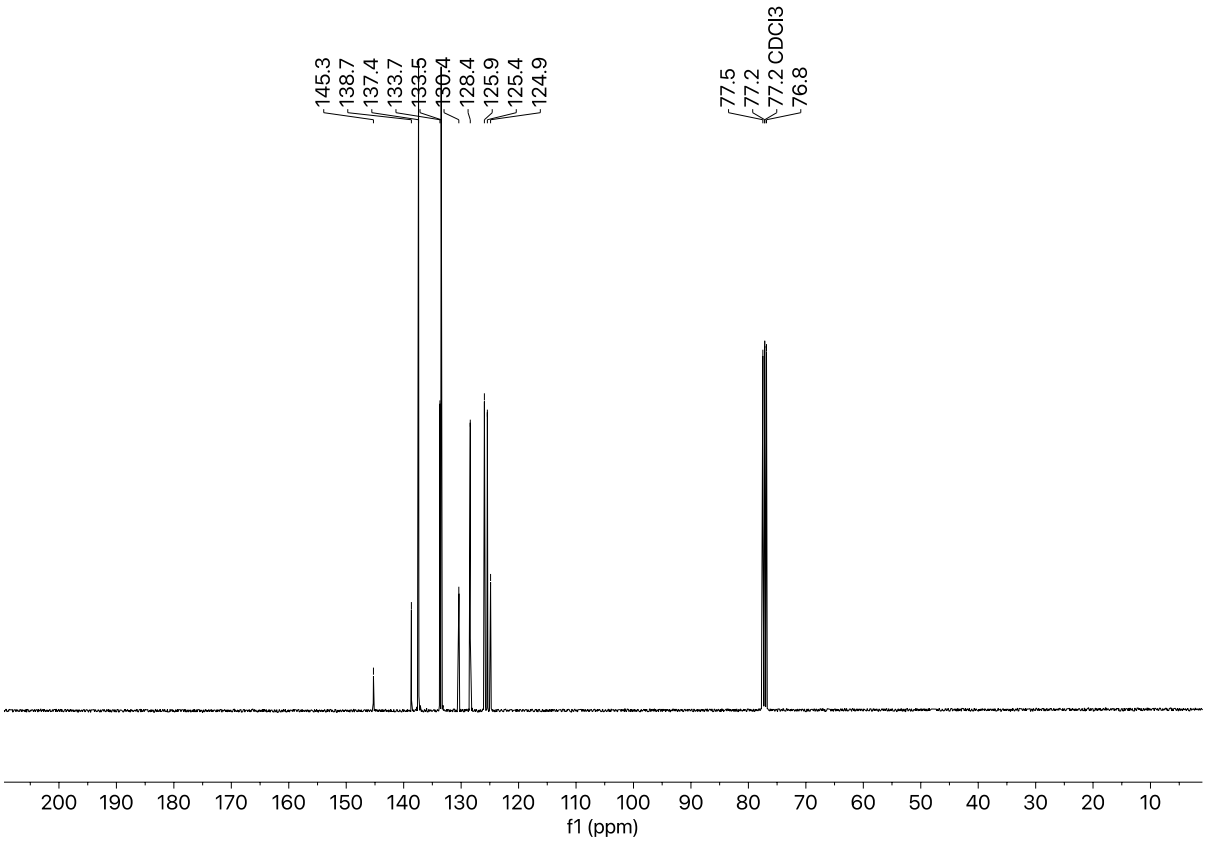
(4-Bromophenyl)(2-nitrophenyl)sulfane (4i)



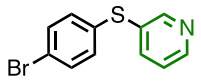
δ_H (400 MHz, $CDCl_3$)



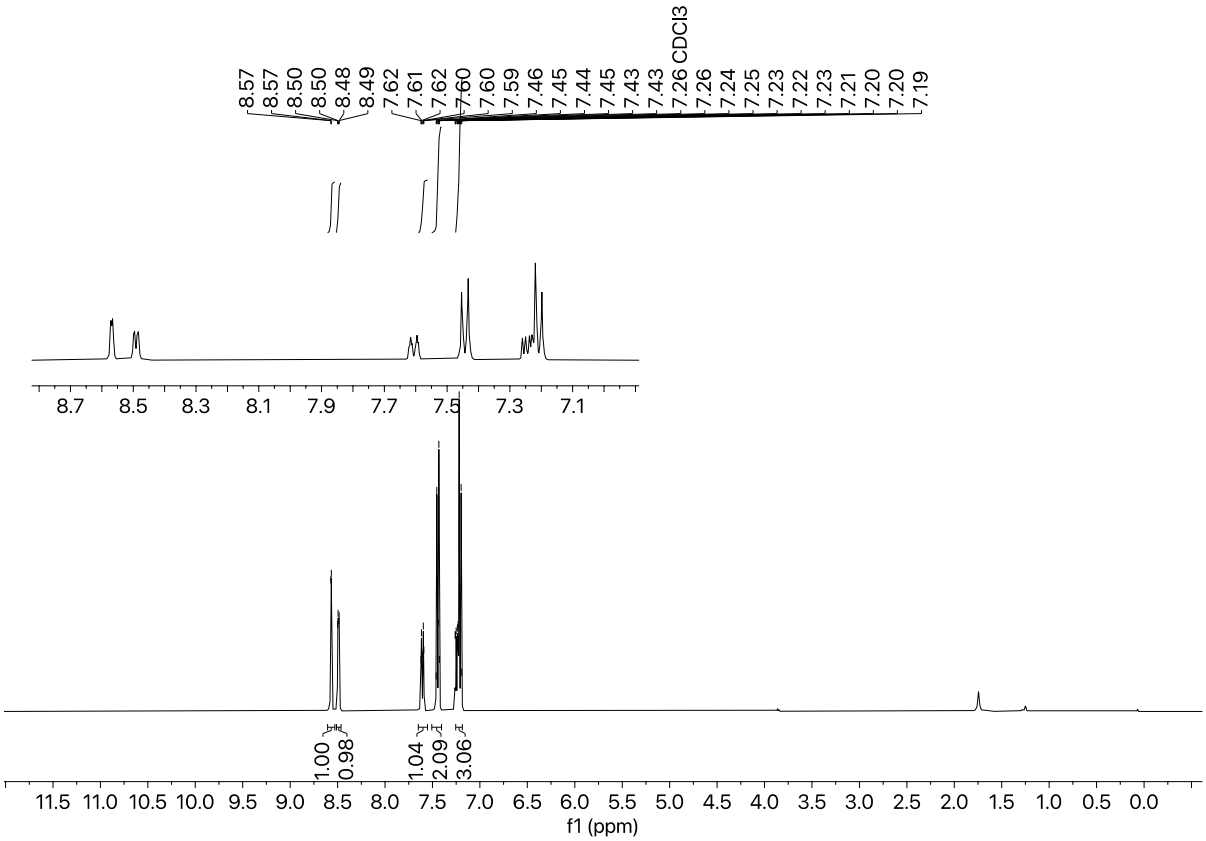
δ_C (101 MHz, $CDCl_3$)



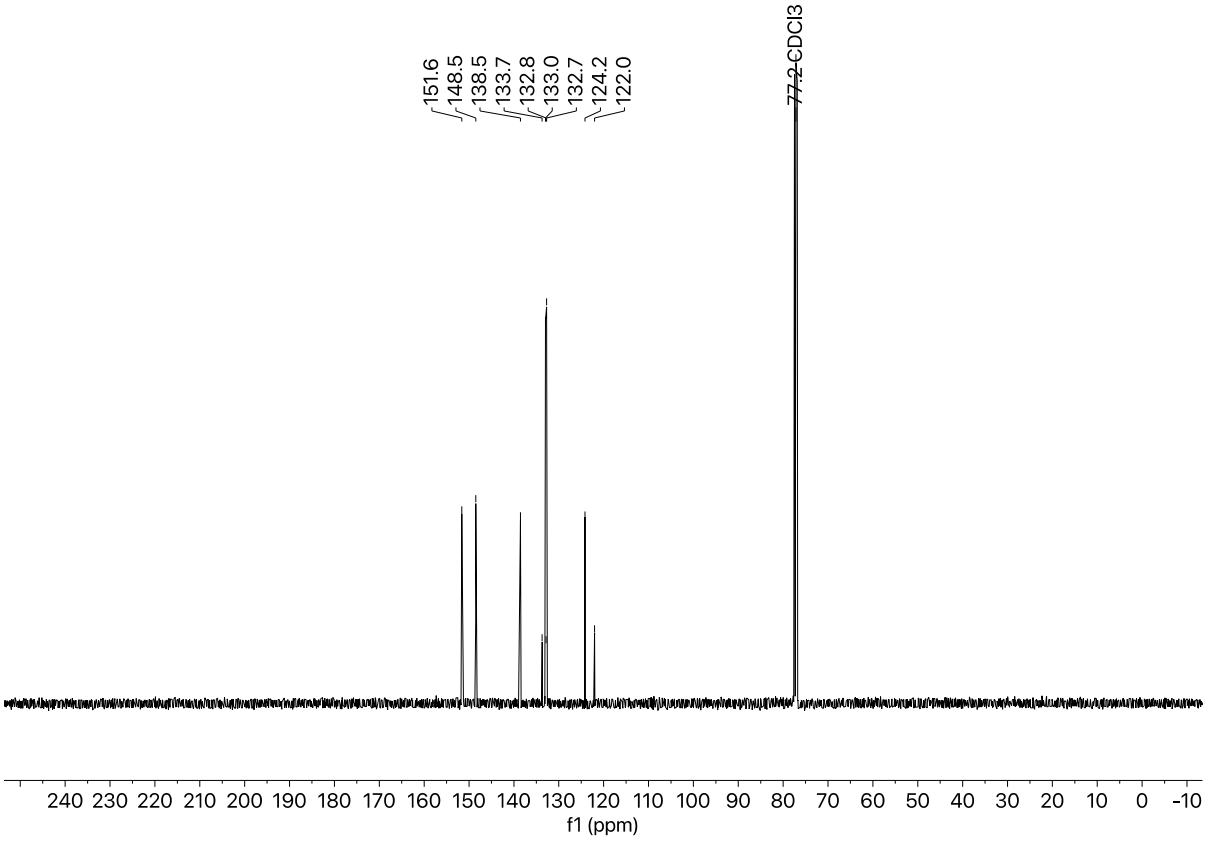
3-((4-Bromophenyl)thio)pyridine (4j)



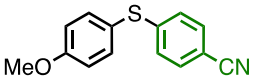
δ_H (400 MHz, $CDCl_3$)



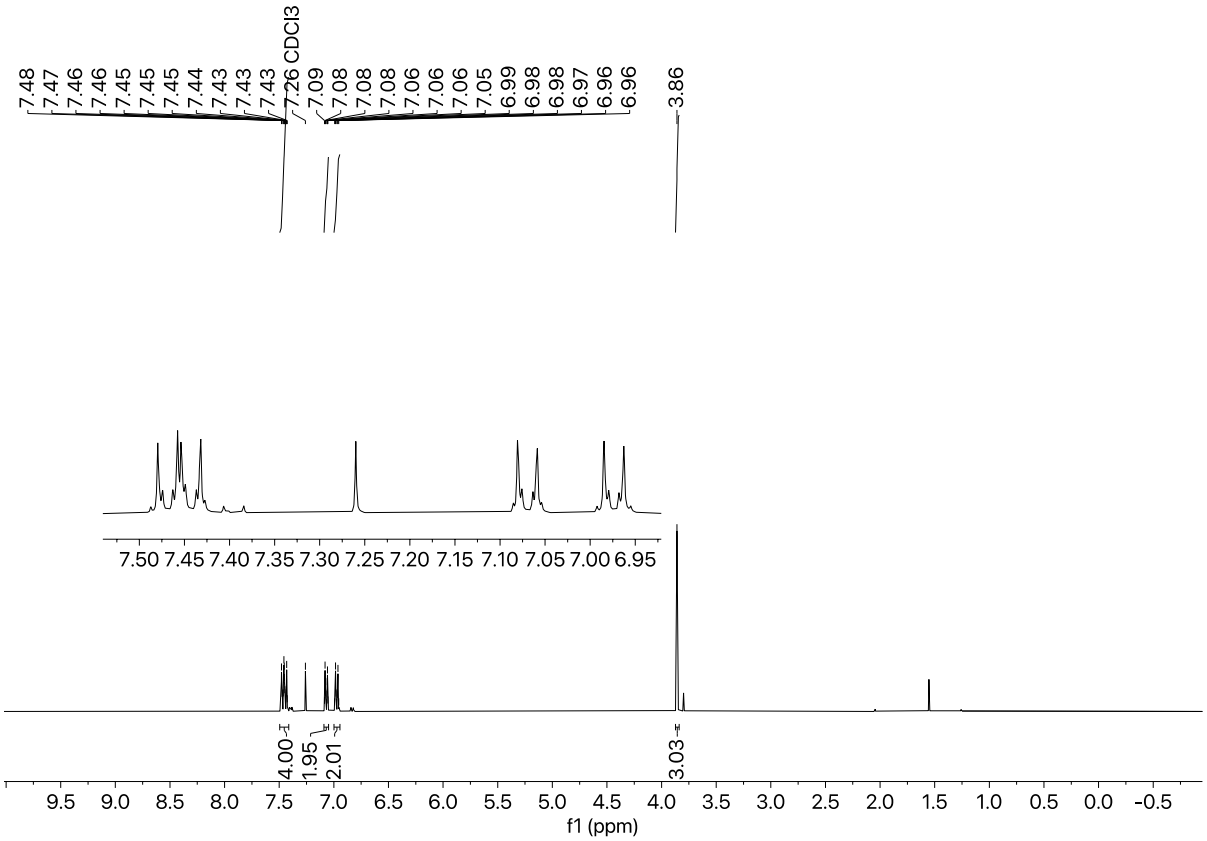
δ_C (101 MHz, $CDCl_3$)



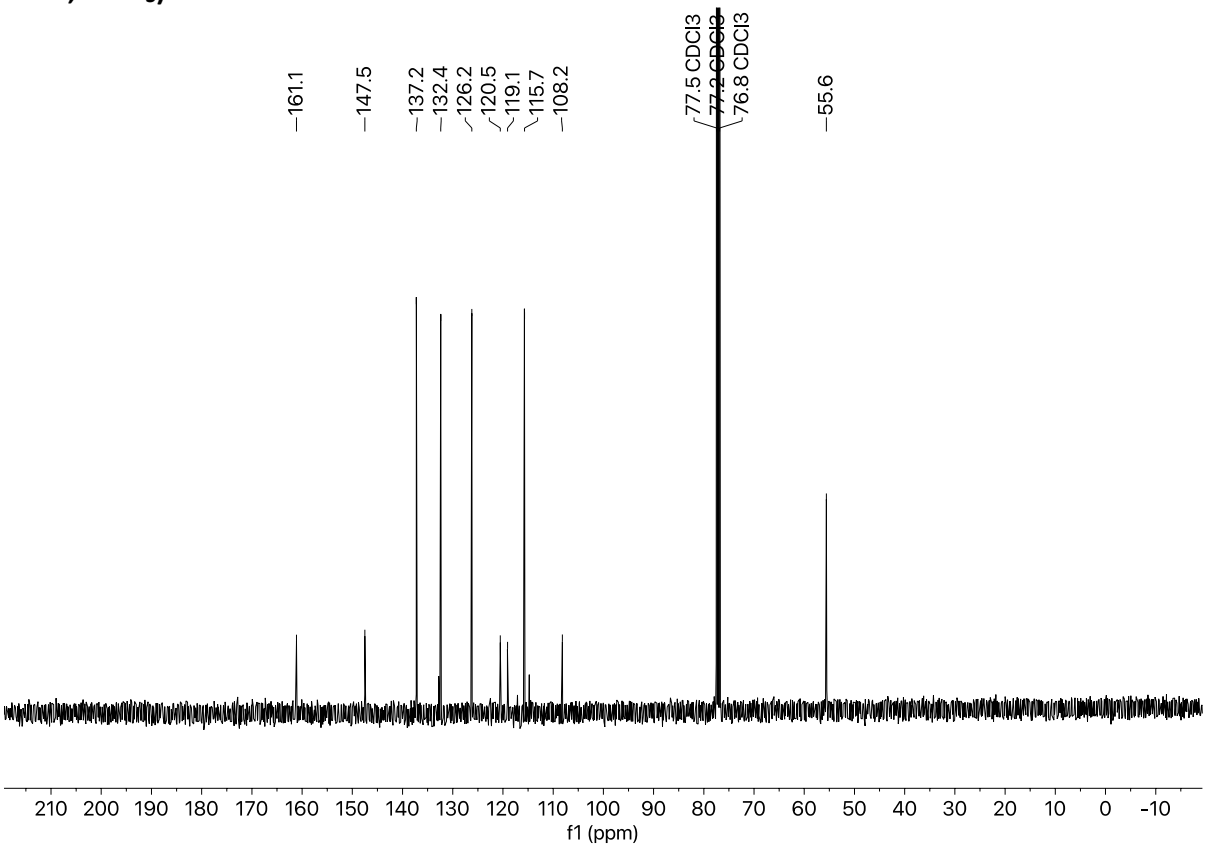
4-((4-Methoxyphenyl)thio)benzonitrile (4k)



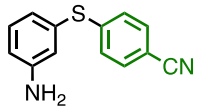
δ_H (400 MHz, $CDCl_3$)



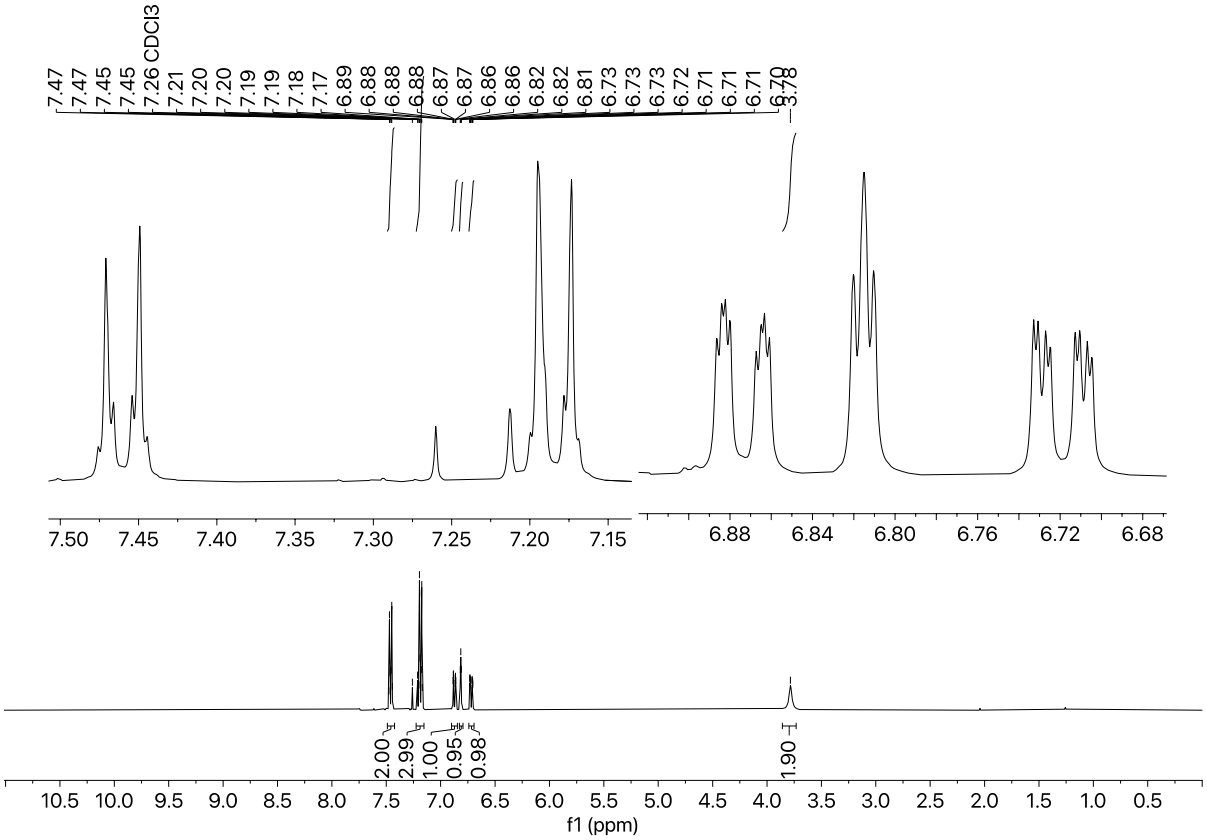
δ_C (101 MHz, $CDCl_3$)



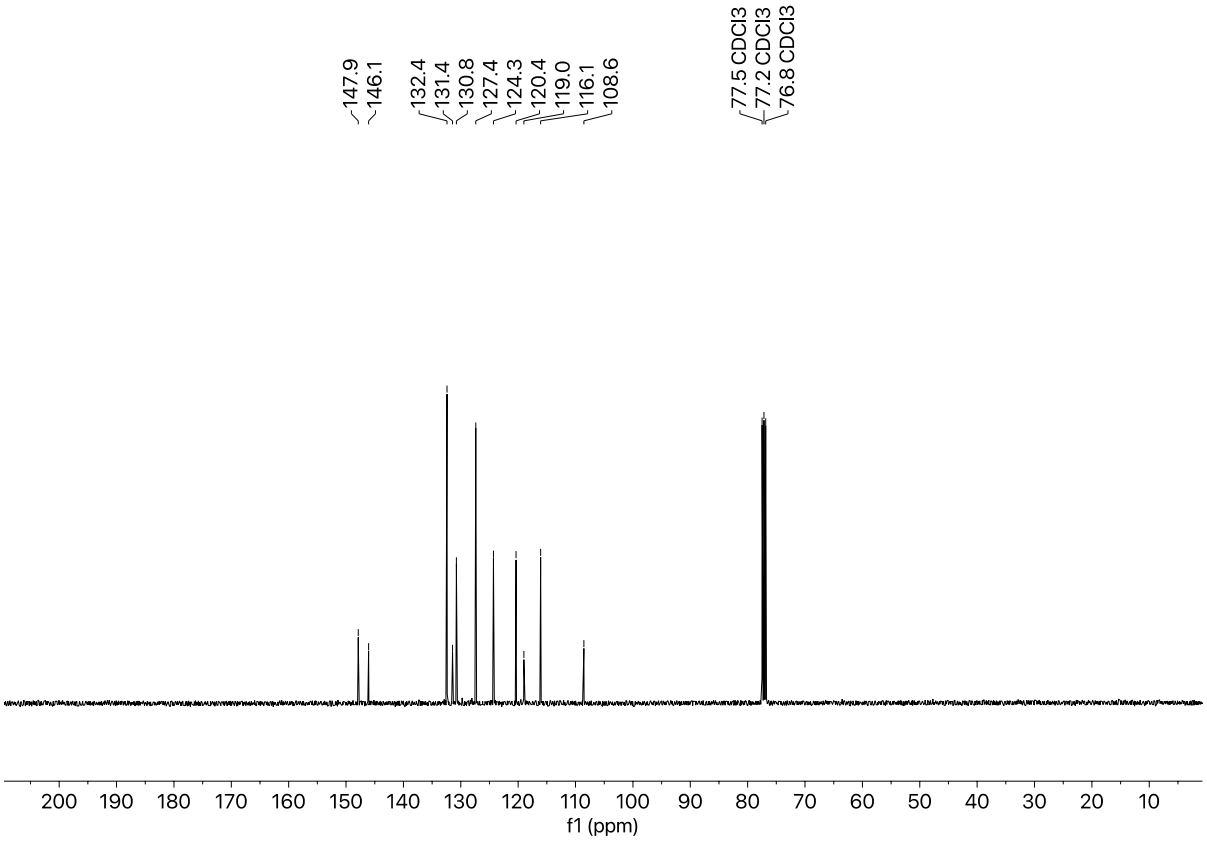
4-((3-Aminophenyl)thio)benzonitrile (4l)



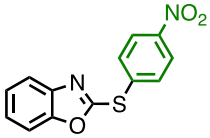
δ_H (400 MHz, $CDCl_3$)



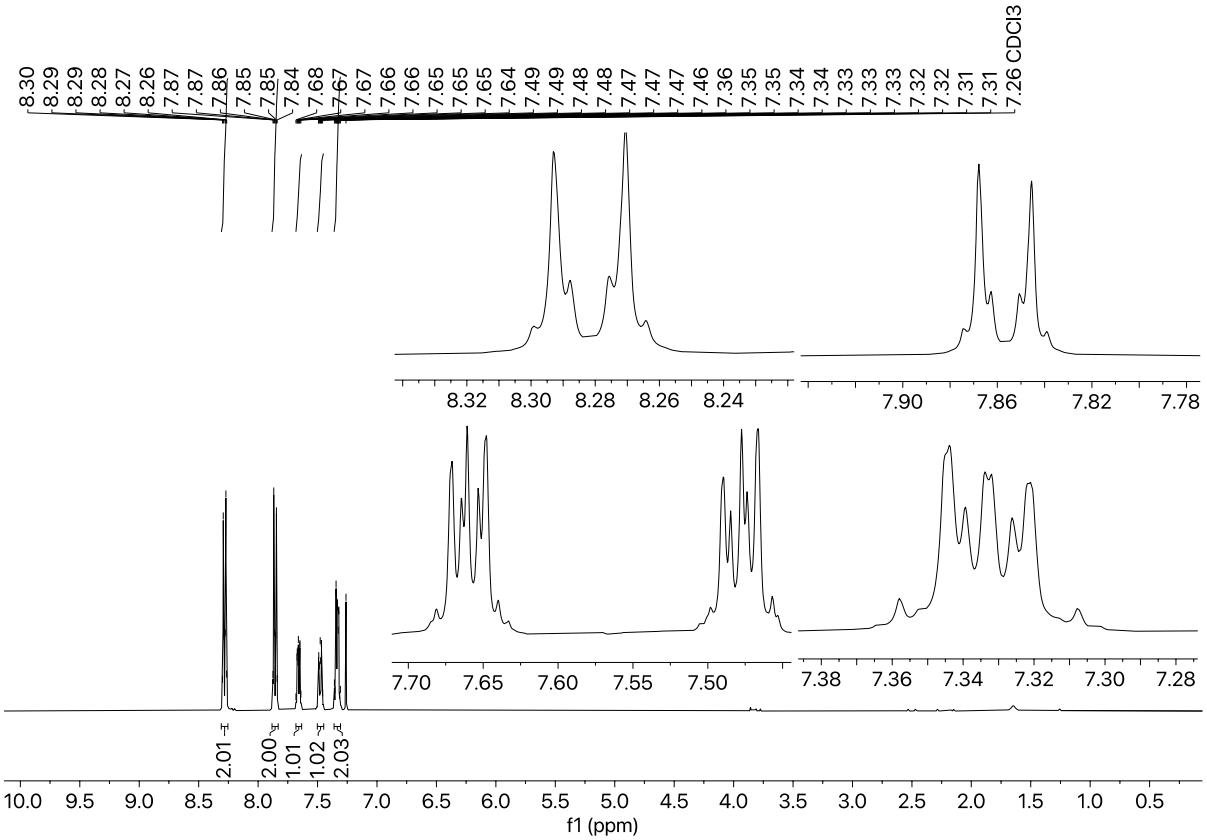
δ_C (101 MHz, $CDCl_3$)



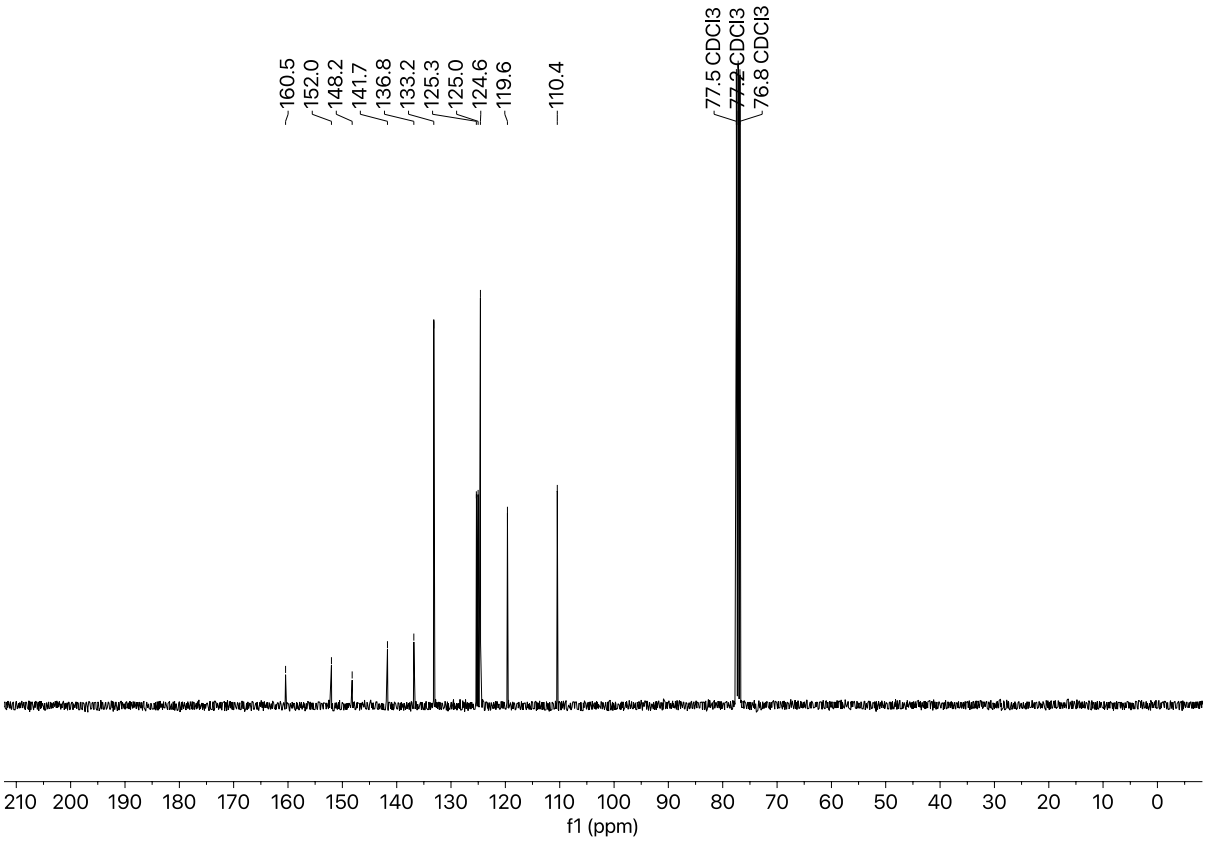
2-((4-Nitrophenyl)thio)benzo[*d*]oxazole (4m)



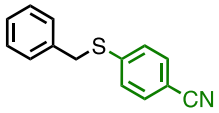
δ_H (400 MHz, $CDCl_3$)



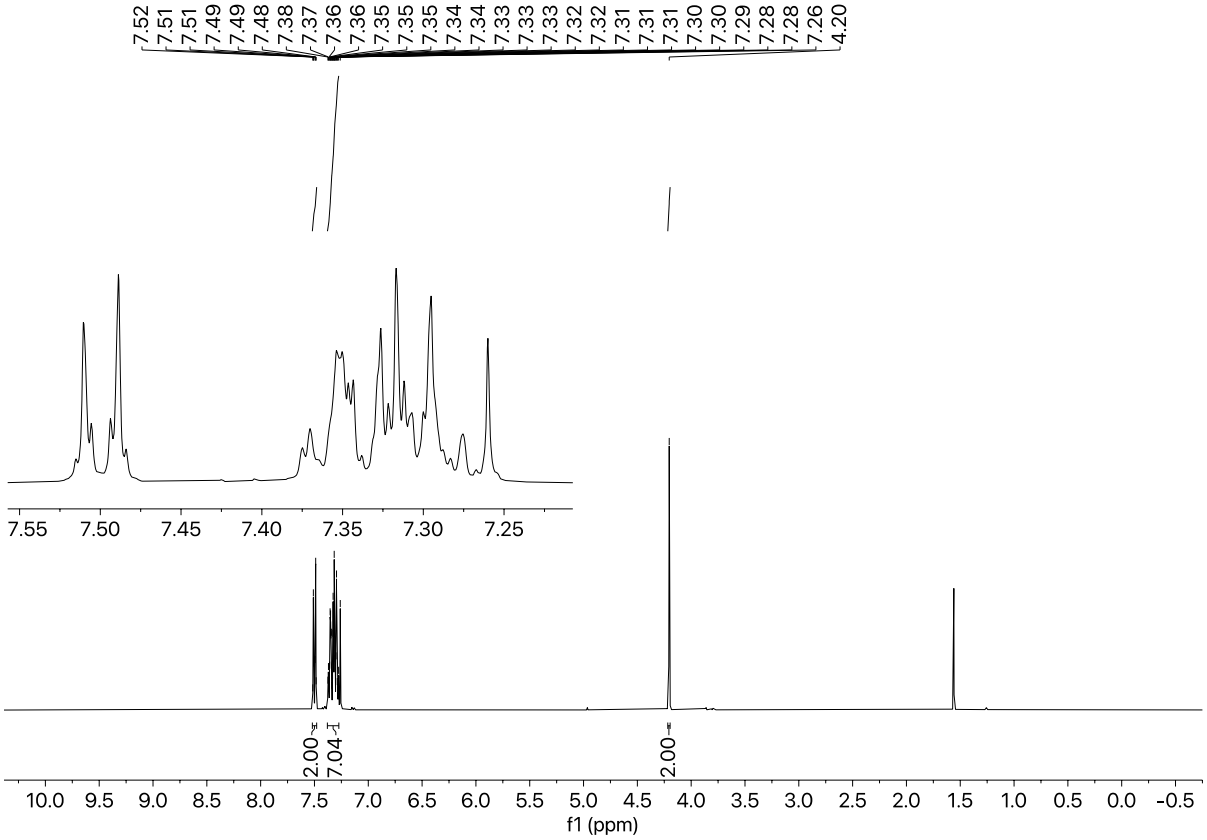
δ_C (101 MHz, $CDCl_3$)



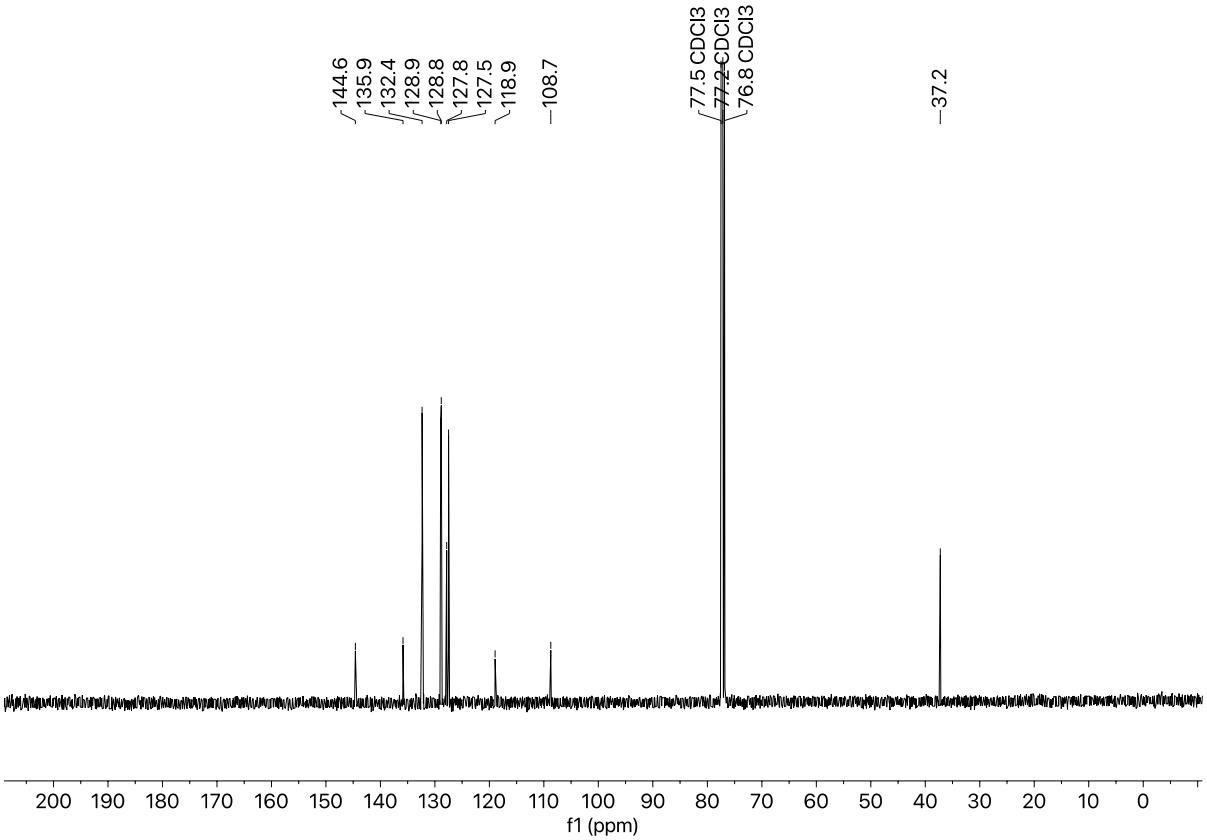
4-(Benzylthio)benzonitrile (4n)



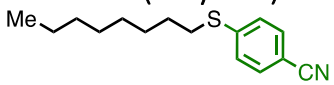
δ_H (400 MHz, $CDCl_3$)



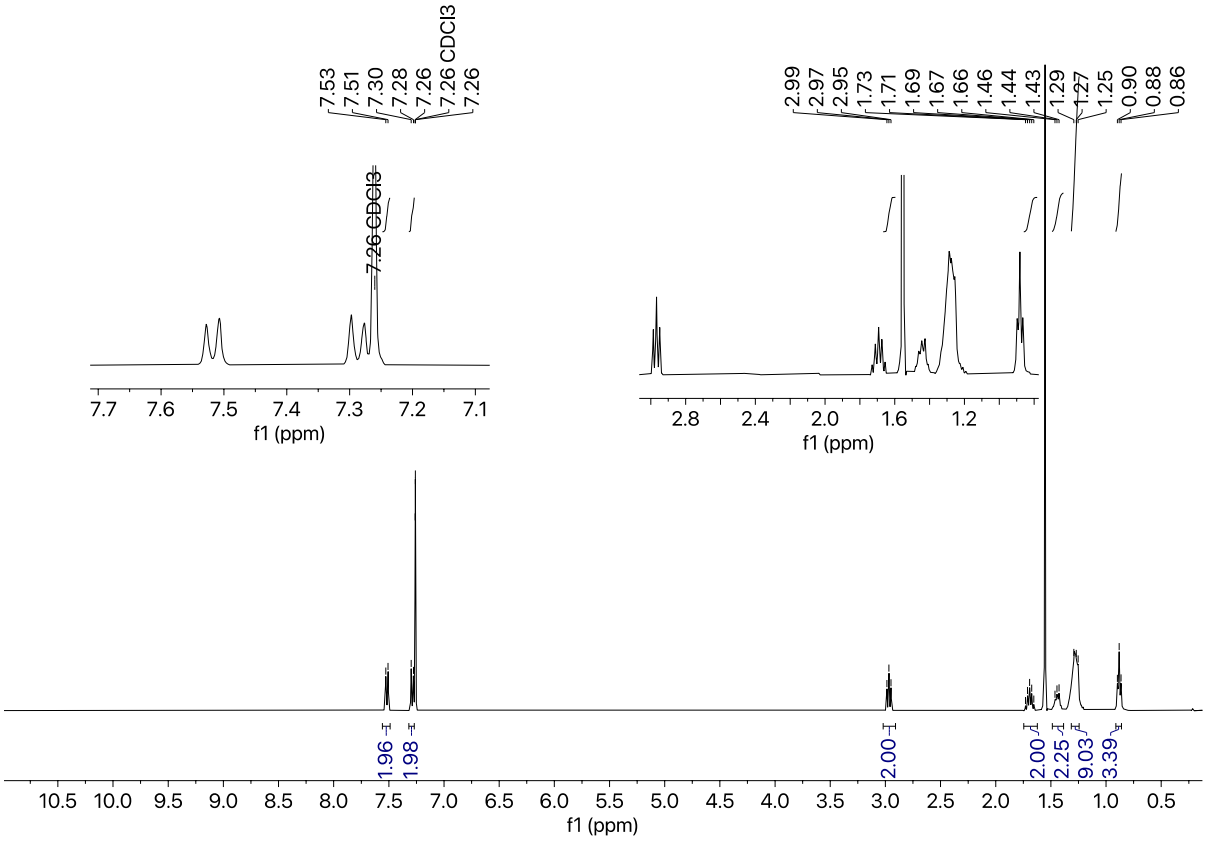
δ_C (101 MHz, $CDCl_3$)



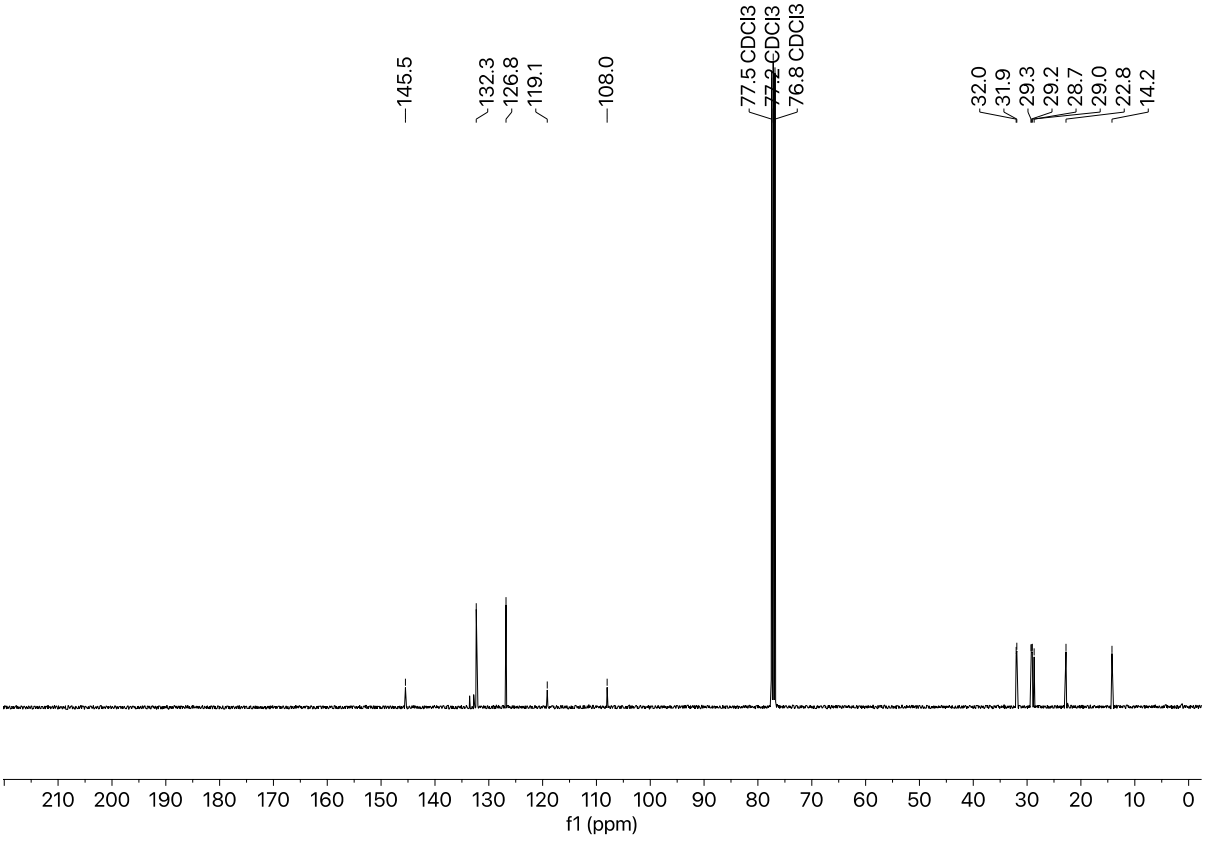
4-(Octylthio)benzonitrile (4o)



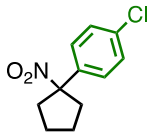
δ_H (400 MHz, $CDCl_3$)



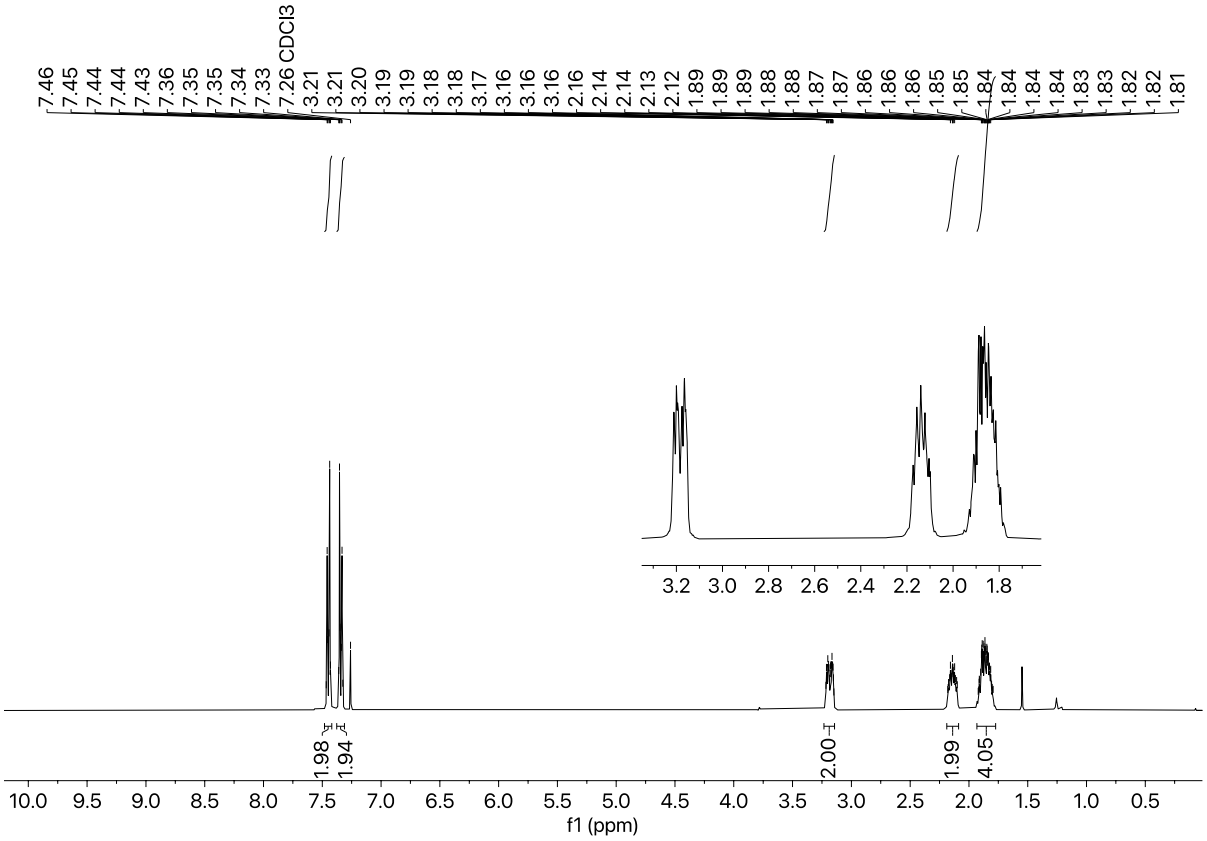
δ_C (101 MHz, $CDCl_3$)



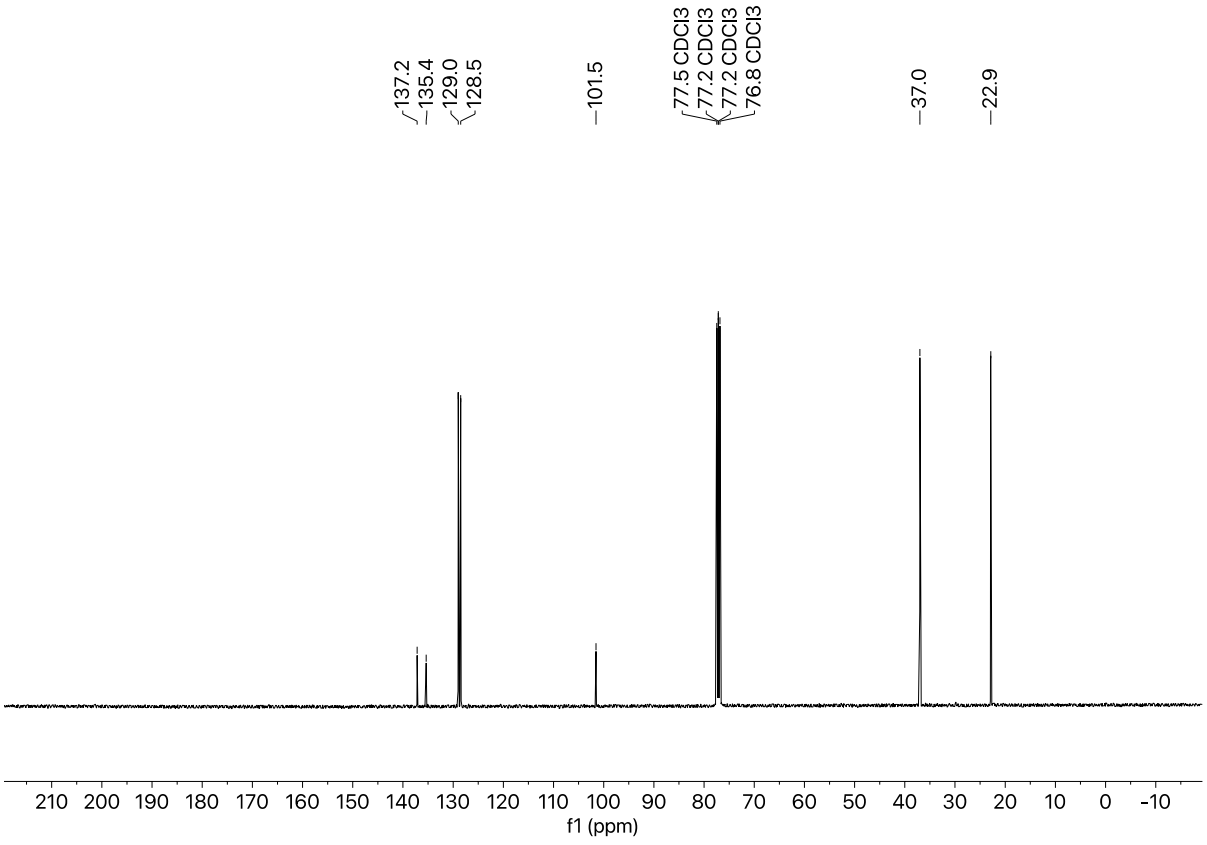
1-Chloro-4-(1-nitrocyclopentyl)benzene (5a)



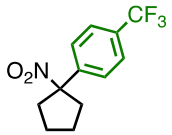
δ_H (400 MHz, $CDCl_3$)



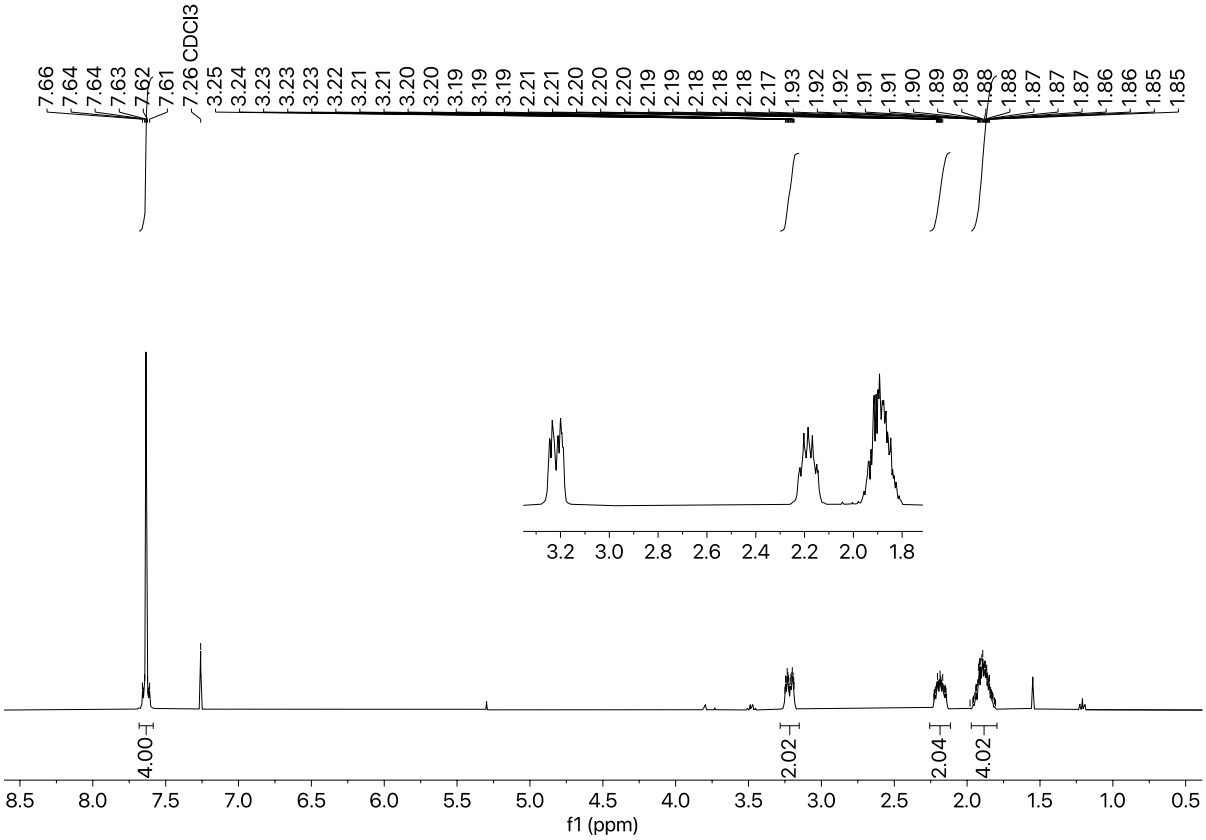
δ_C (101 MHz, $CDCl_3$)



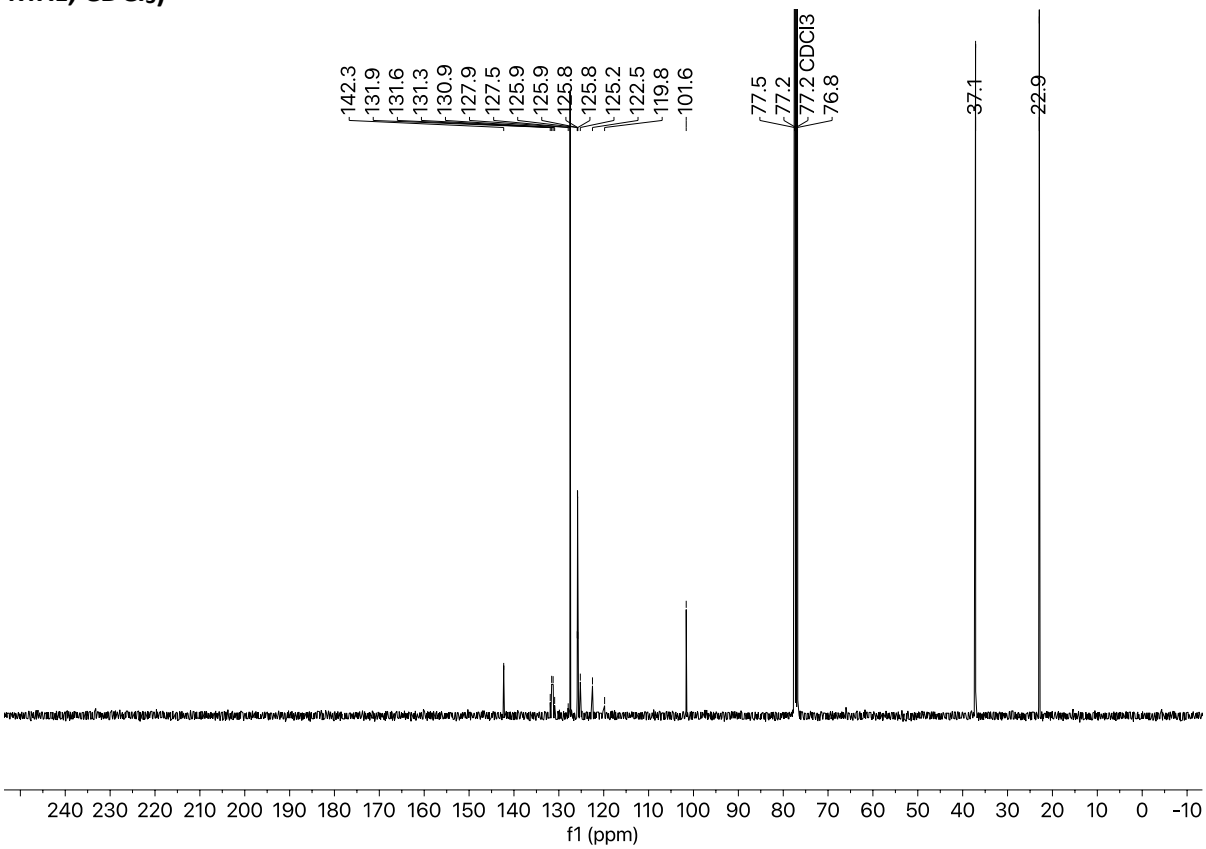
1-Trifluoromethyl-4-(1-nitrocyclopentyl)benzene (5b)



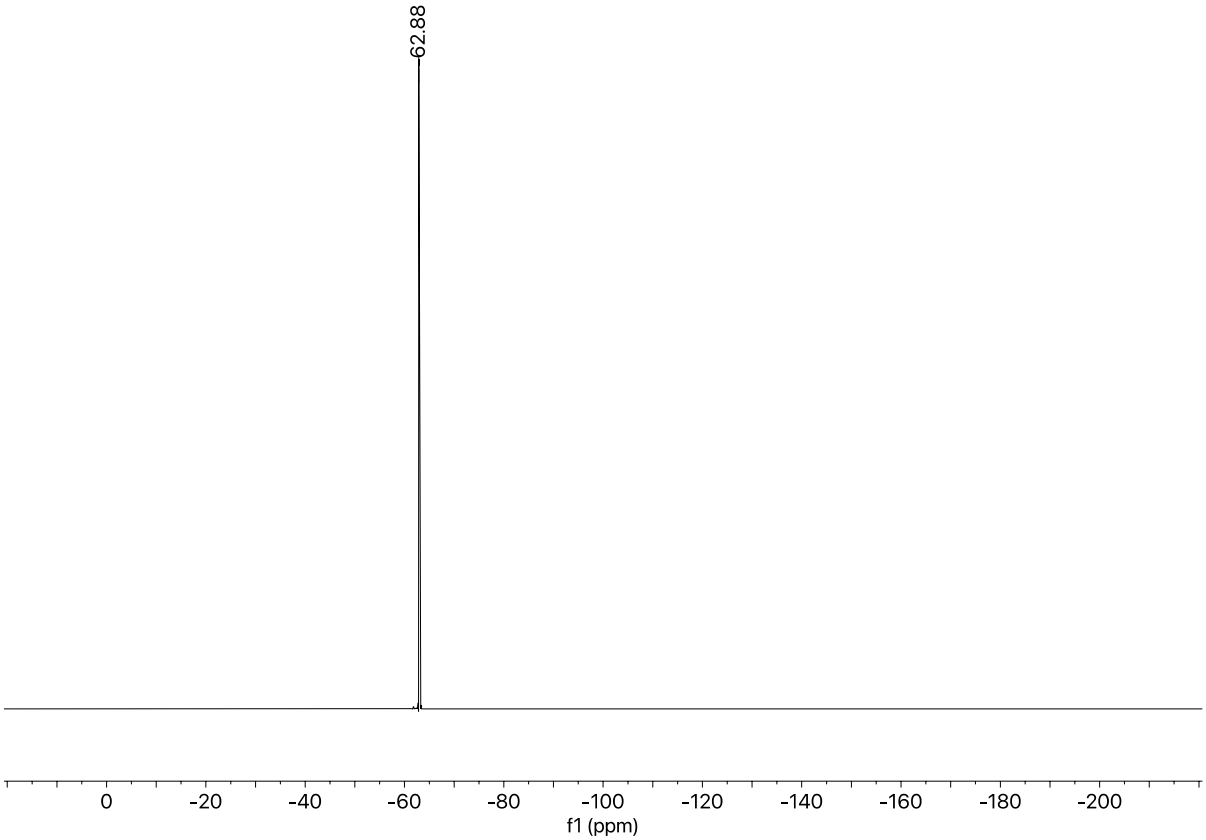
δ_H (400 MHz, $CDCl_3$)



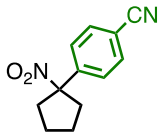
δ_C (101 MHz, $CDCl_3$)



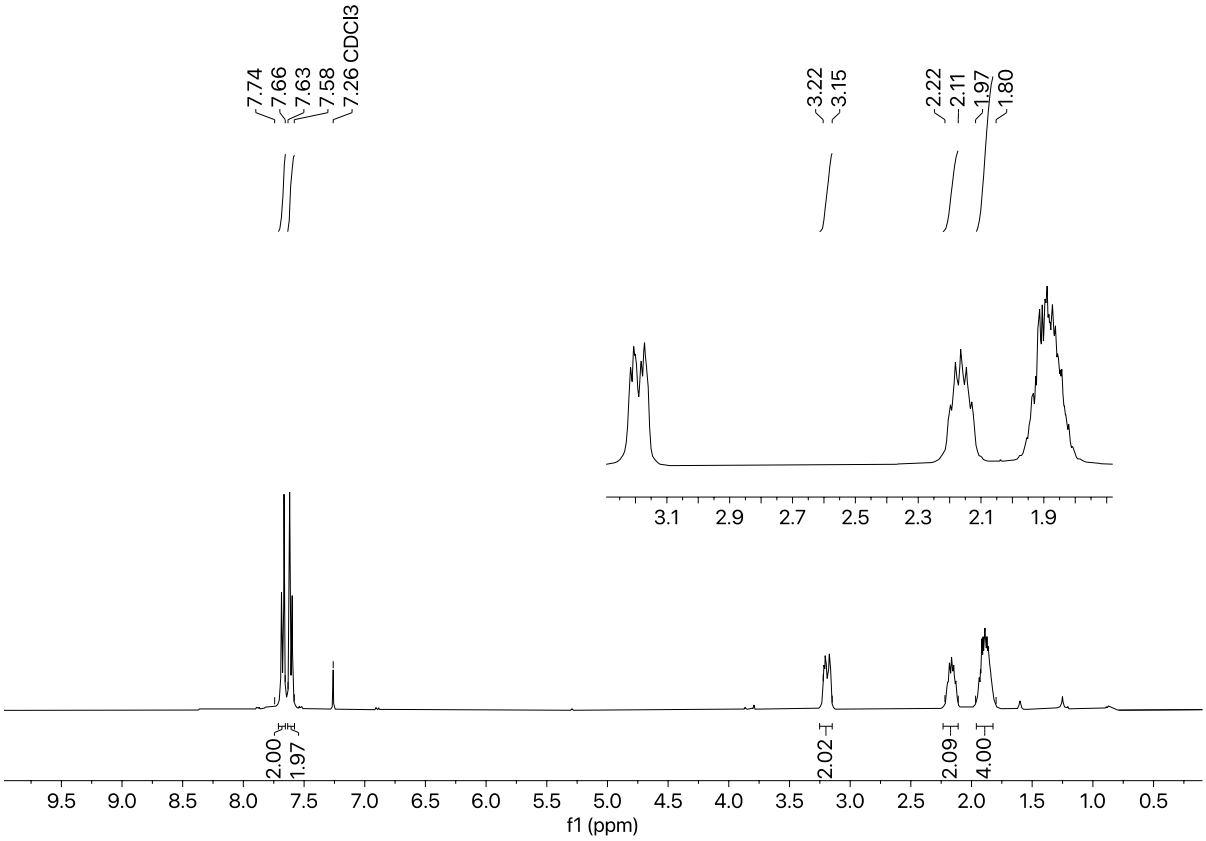
δ_F (376 MHz, $CDCl_3$)



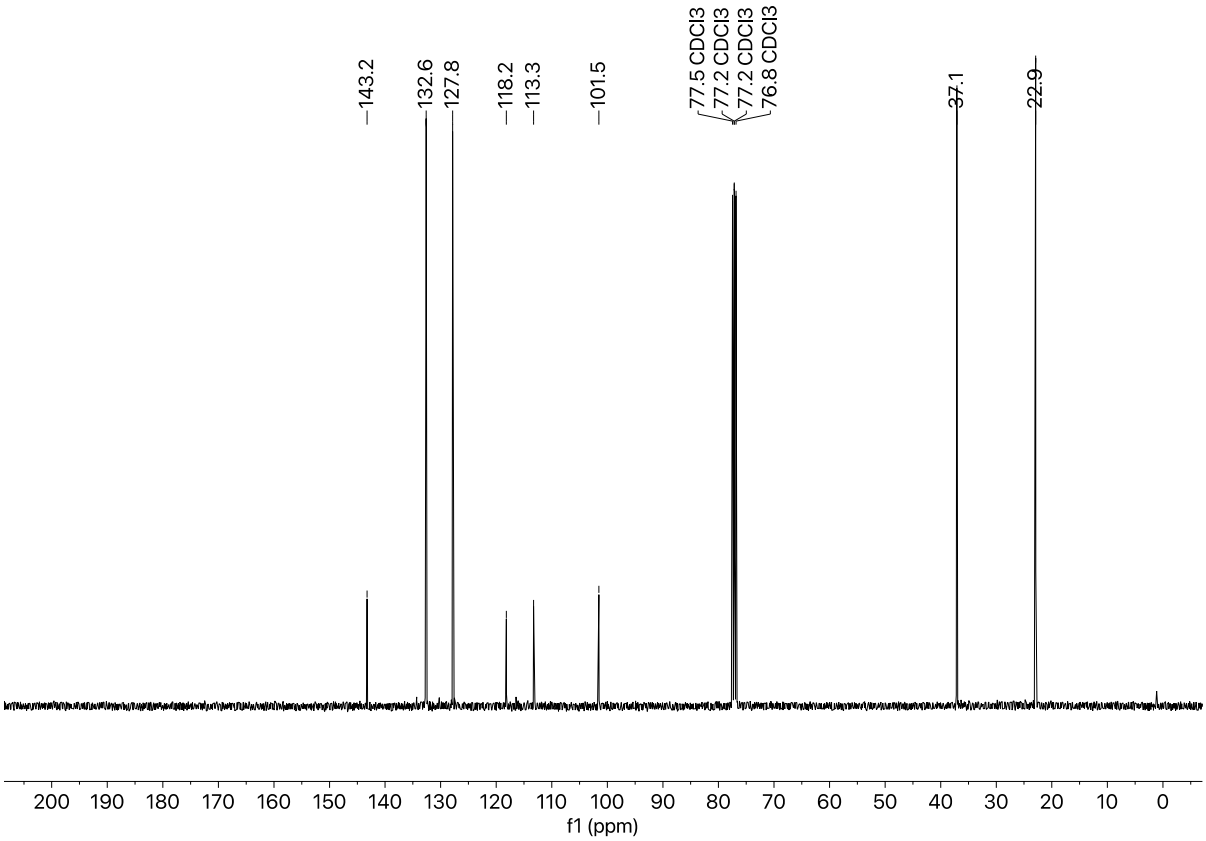
4-(1-Nitrocyclopentyl)benzonitrile (5c)



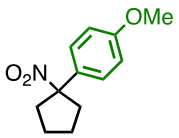
δ_H (400 MHz, $CDCl_3$)



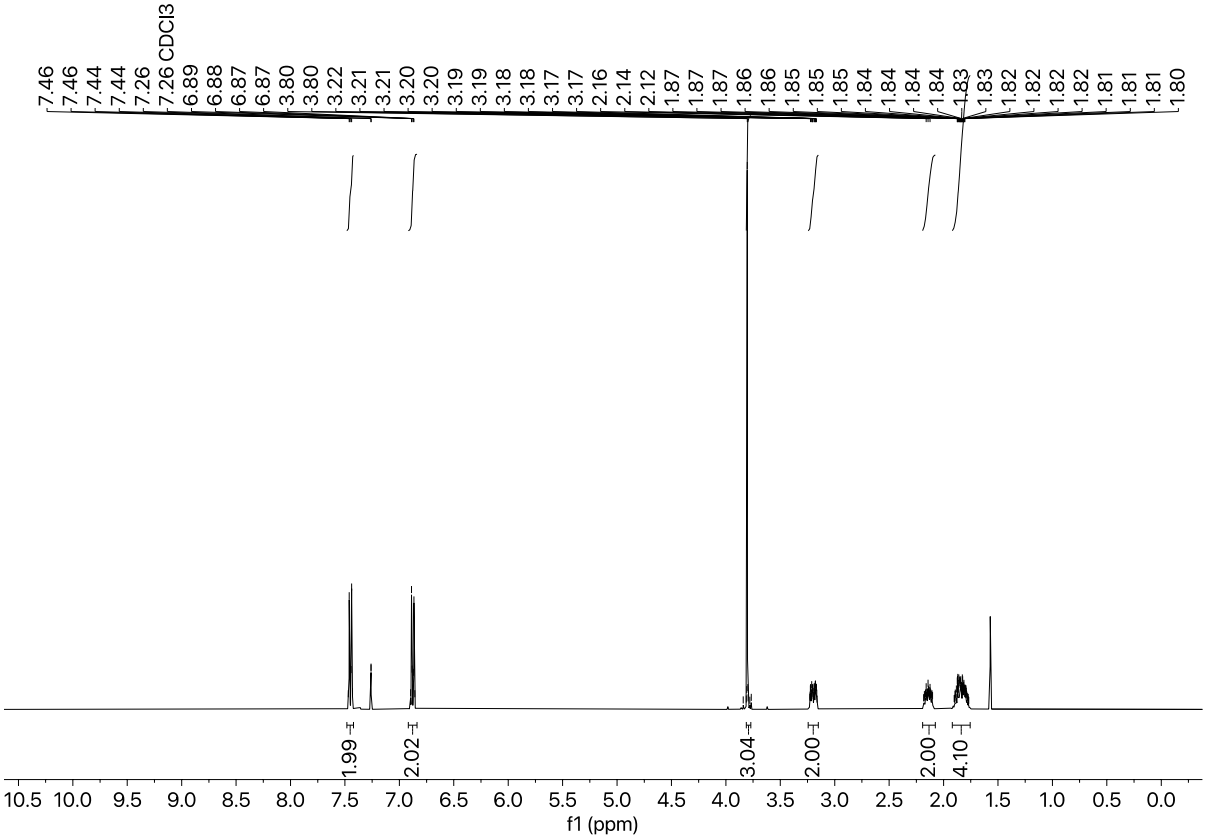
δ_C (101 MHz, $CDCl_3$)



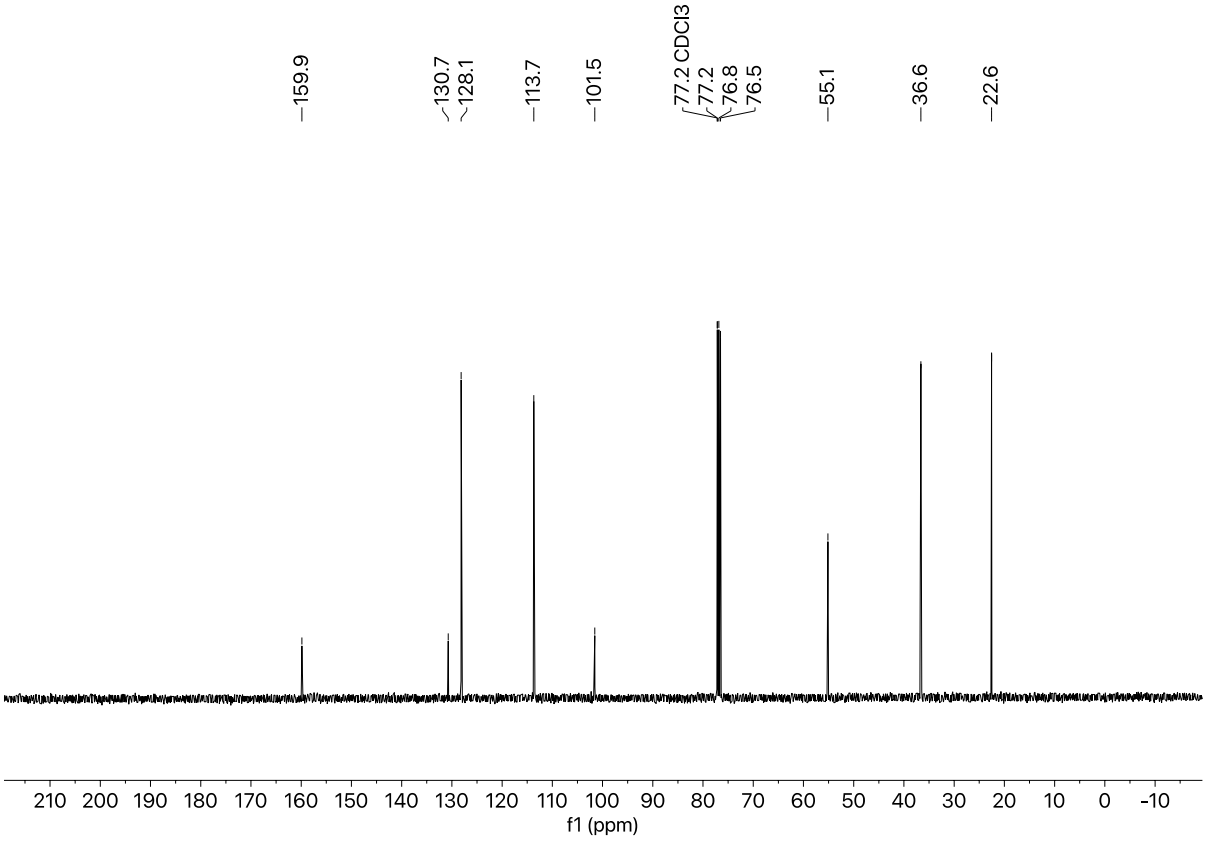
1-methoxy-4-(1-nitrocyclopentyl)benzene (5d)



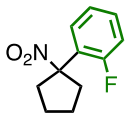
δ_H (400 MHz, $CDCl_3$)



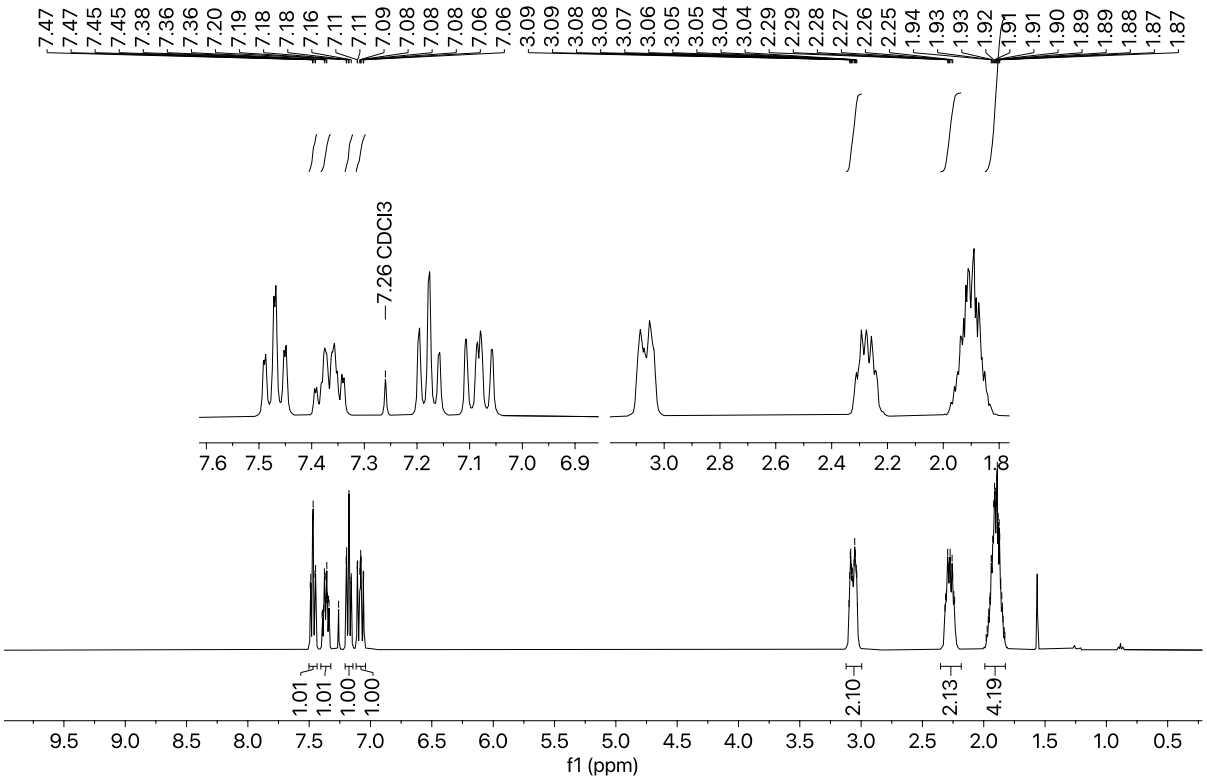
δ_C (101 MHz, $CDCl_3$)



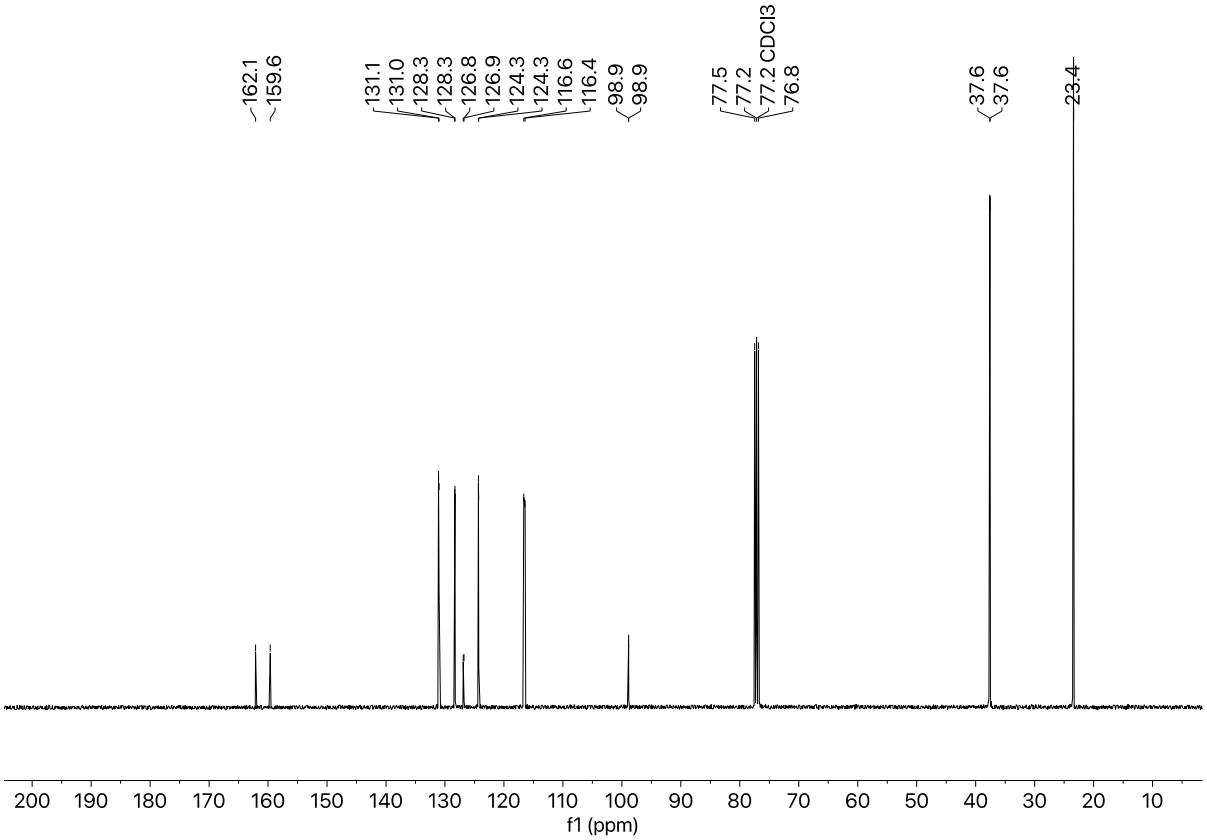
1-Fluoro-2-(1-nitrocyclopentyl)benzene (5e)



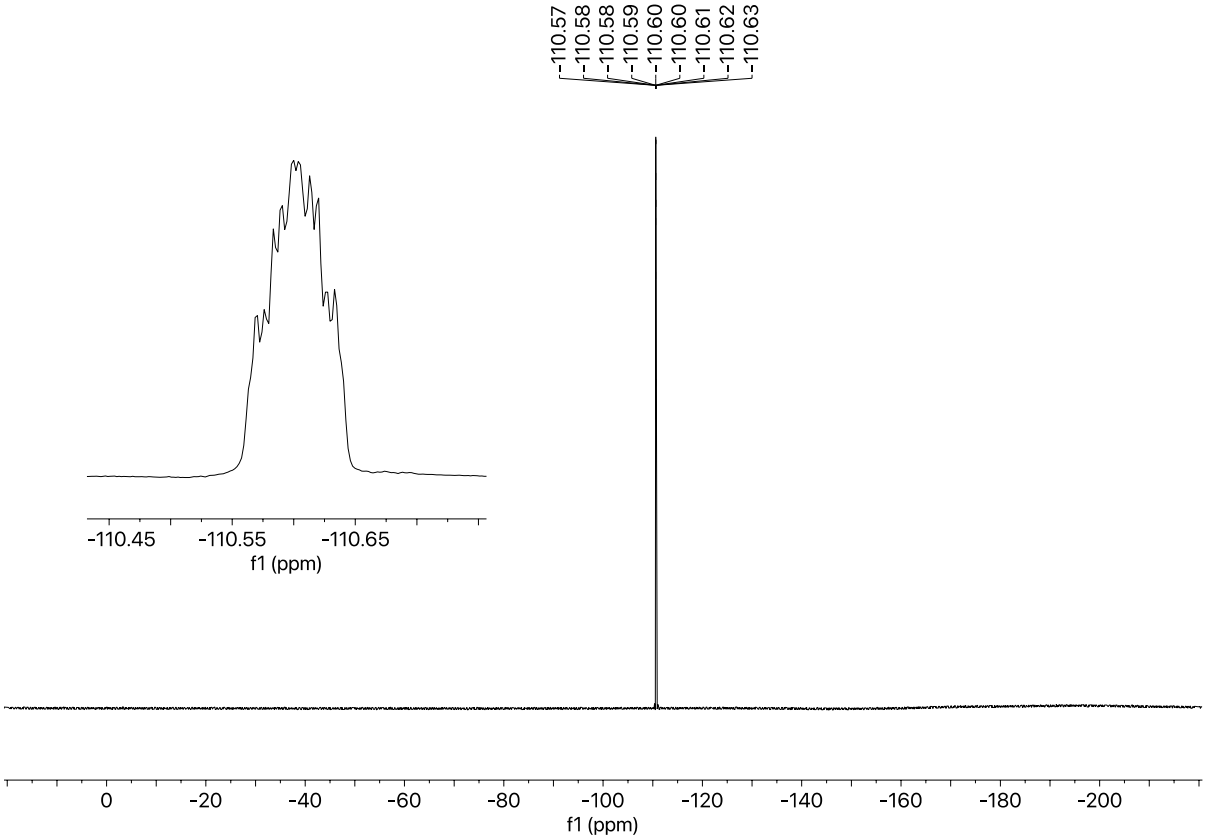
δ_H (400 MHz, $CDCl_3$)



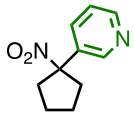
δ_C (101 MHz, $CDCl_3$)



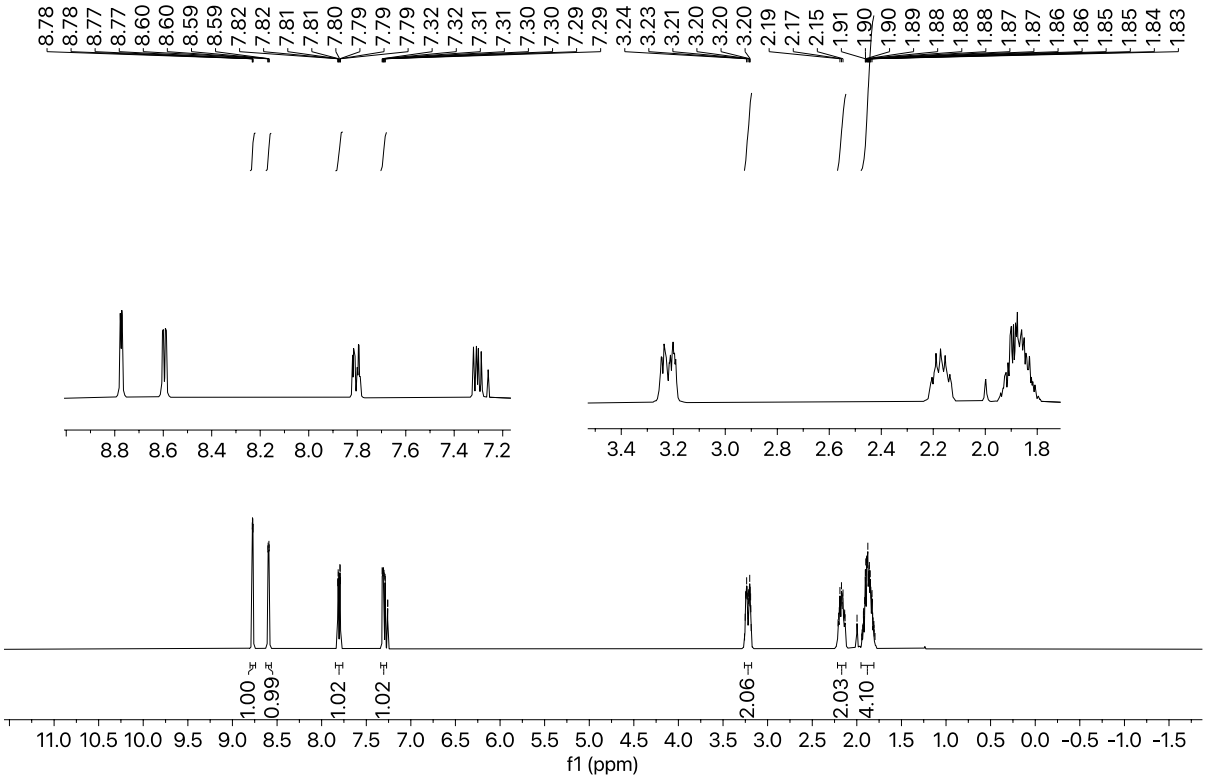
δ_F (376 MHz, $CDCl_3$)



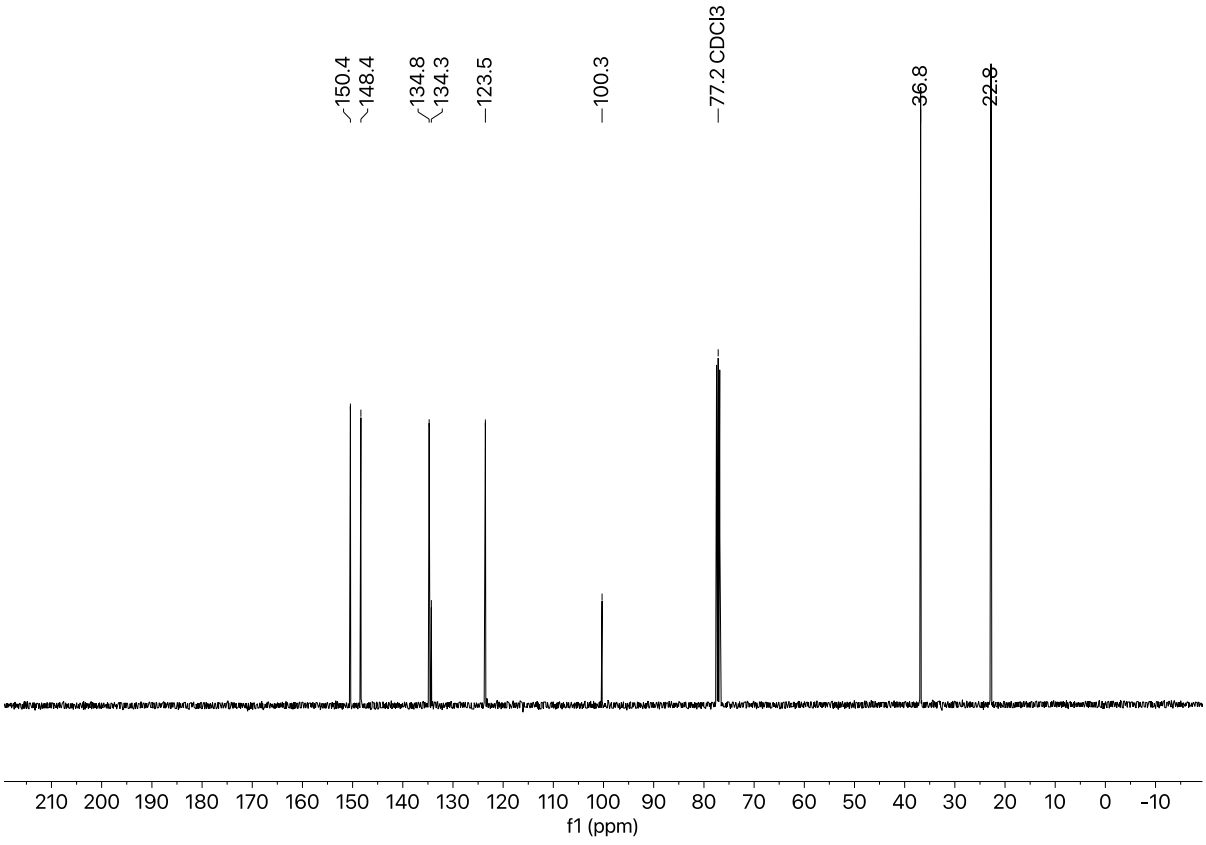
3-(1-nitrocyclopentyl)pyridine (5f)



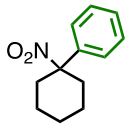
δ_H (400 MHz, $CDCl_3$)



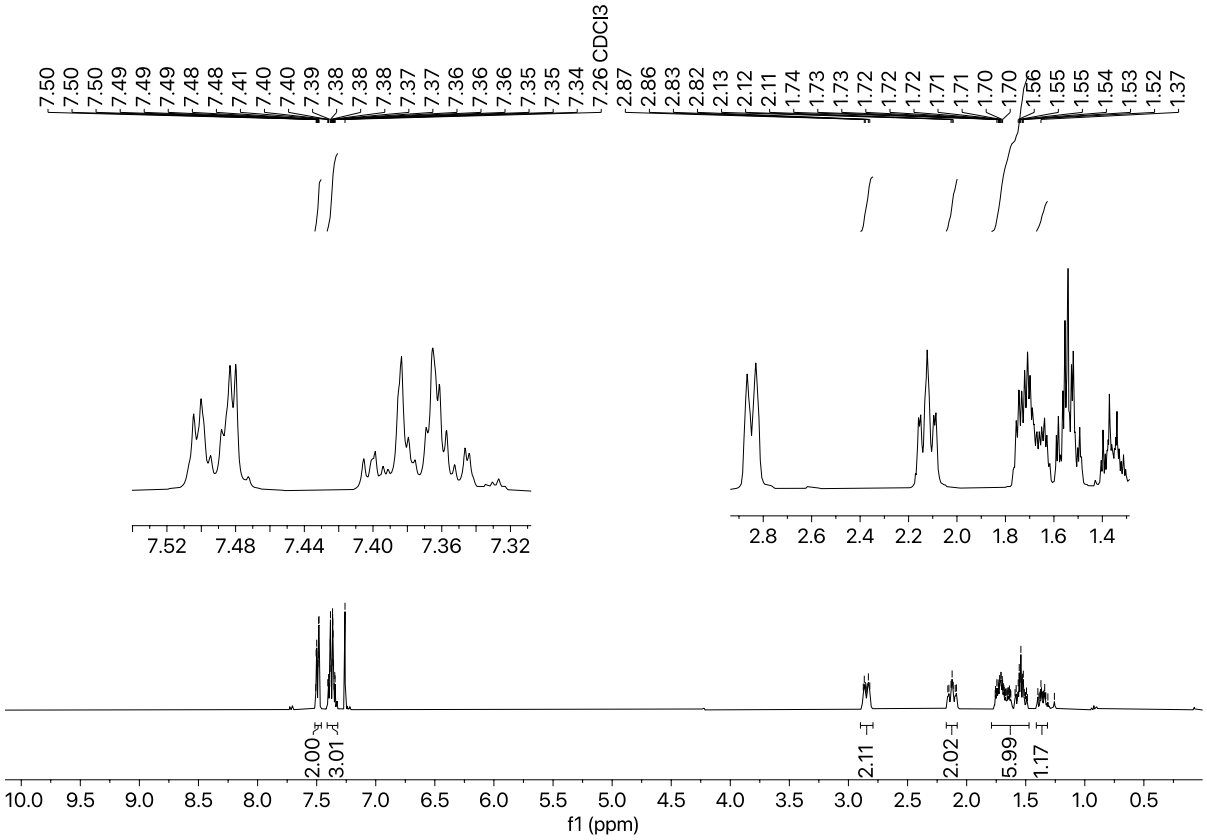
δ_C (101 MHz, $CDCl_3$)



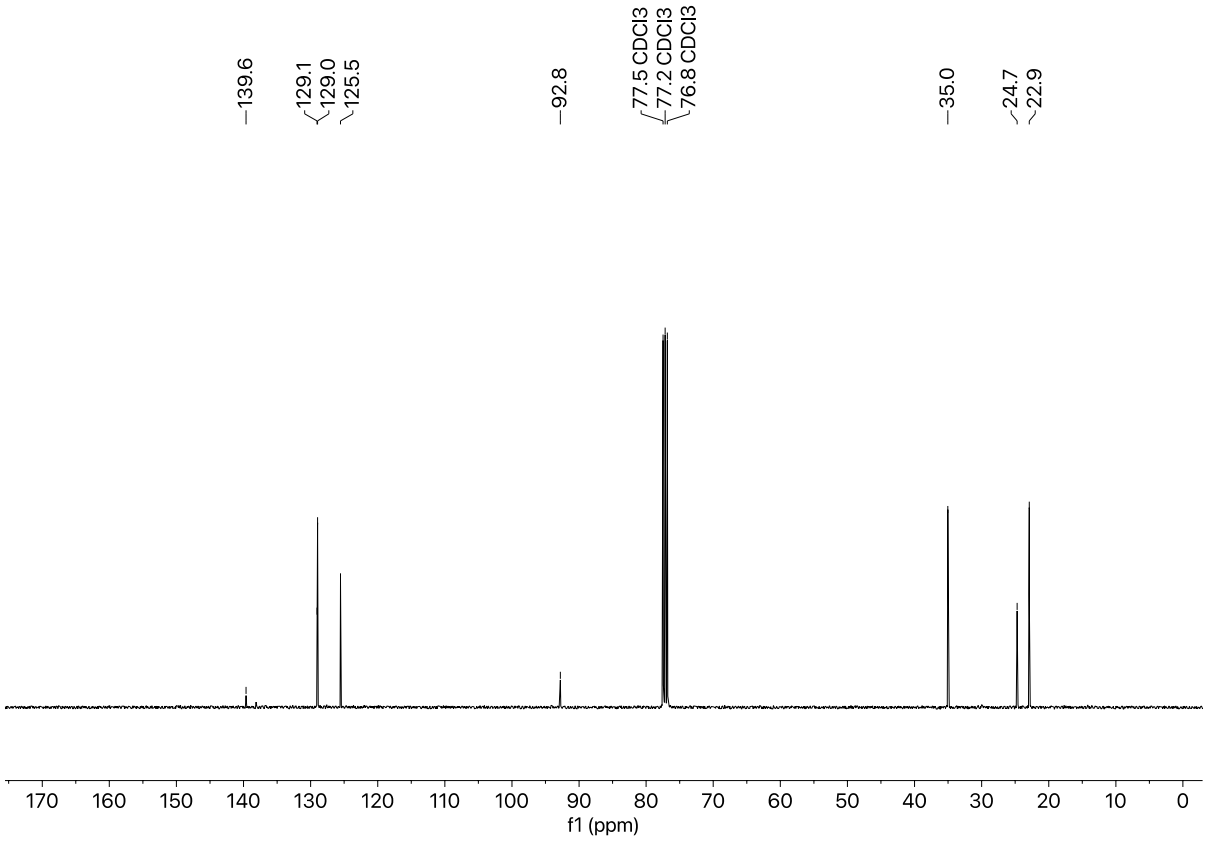
(1-Nitrocyclohexyl)benzene (5g)



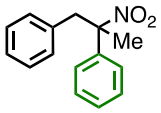
δ_H (400 MHz, $CDCl_3$)



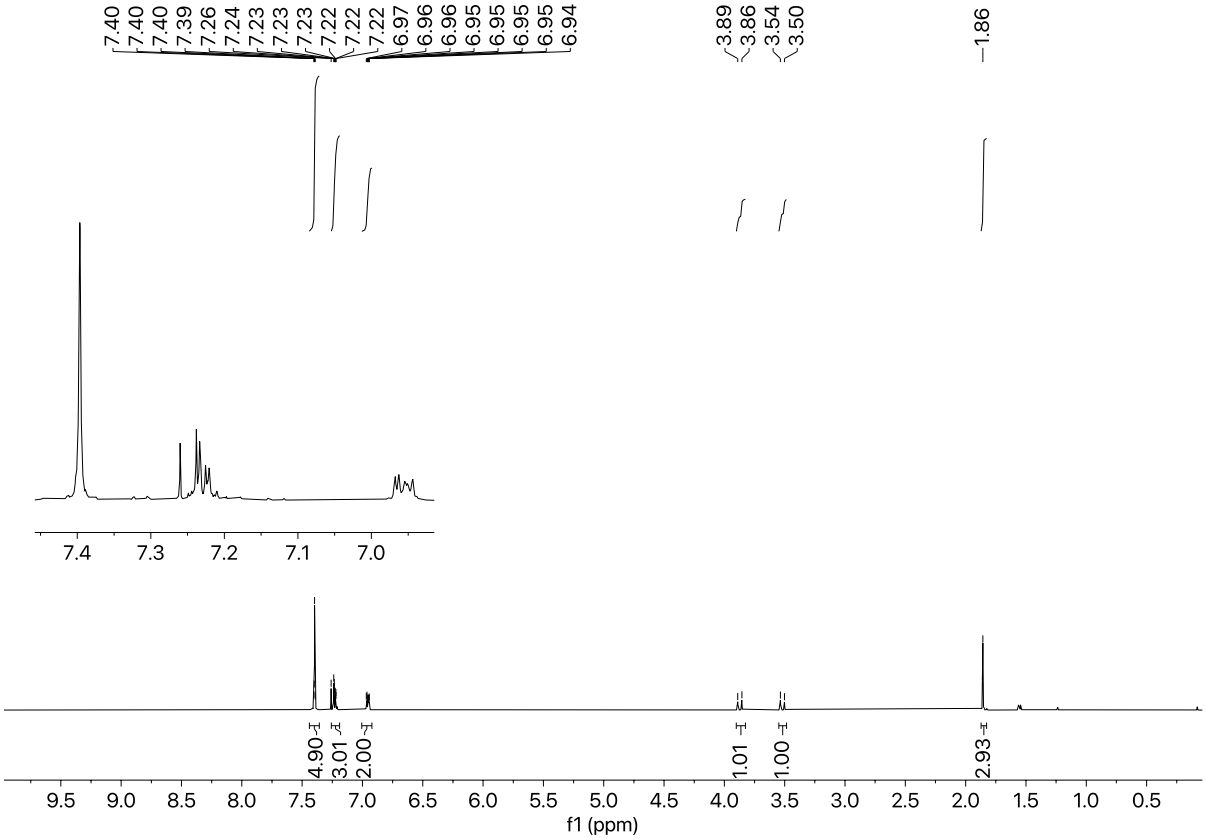
δ_C (101 MHz, $CDCl_3$)



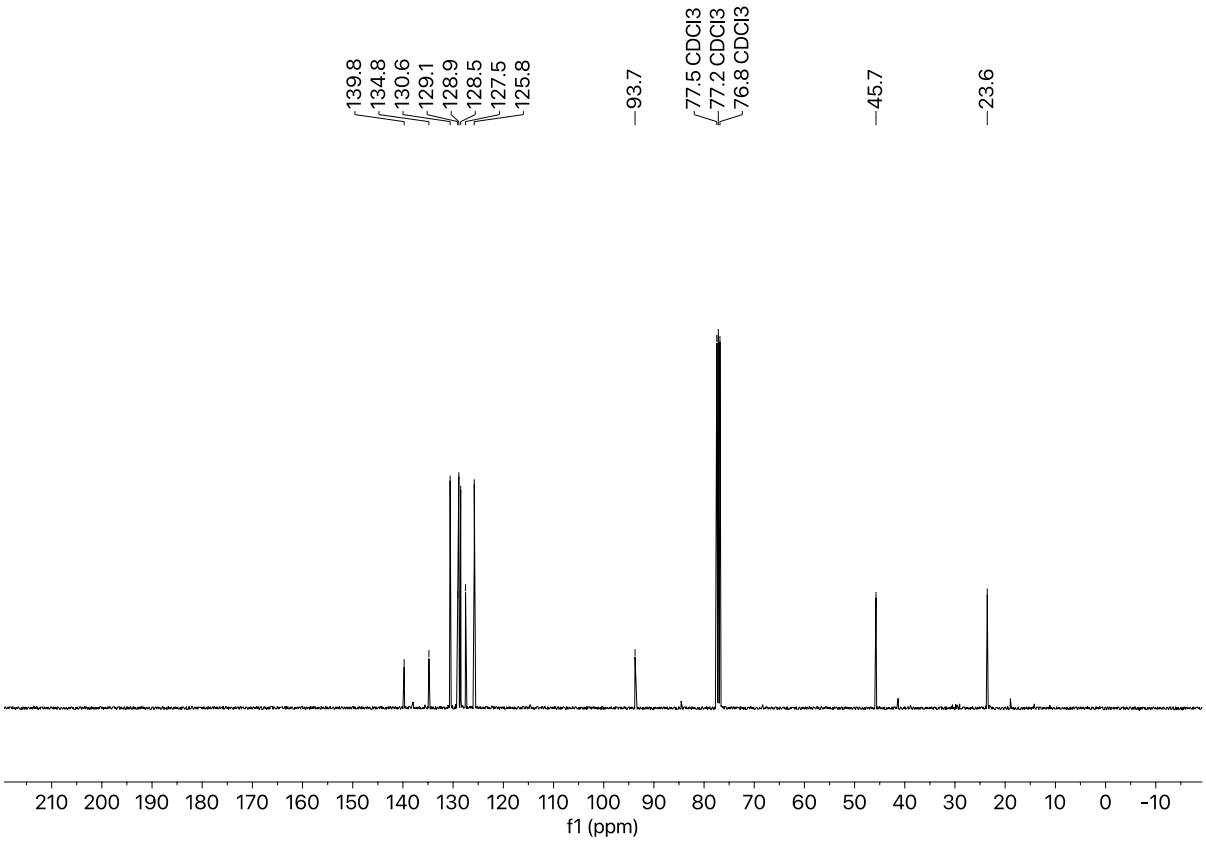
(2-nitropropane-1,2-diyl)dibenzene (5h)



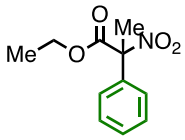
δ_H (400 MHz, $CDCl_3$)



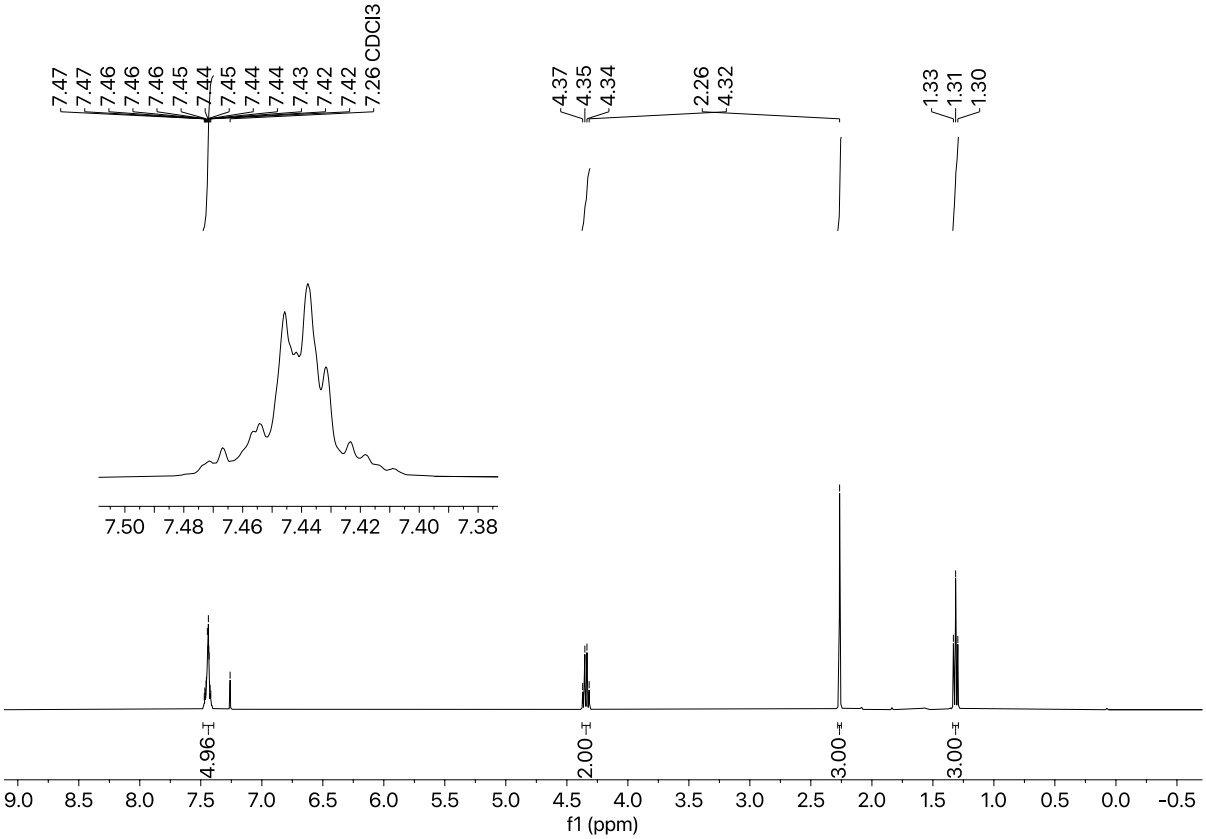
δ_C (101 MHz, $CDCl_3$)



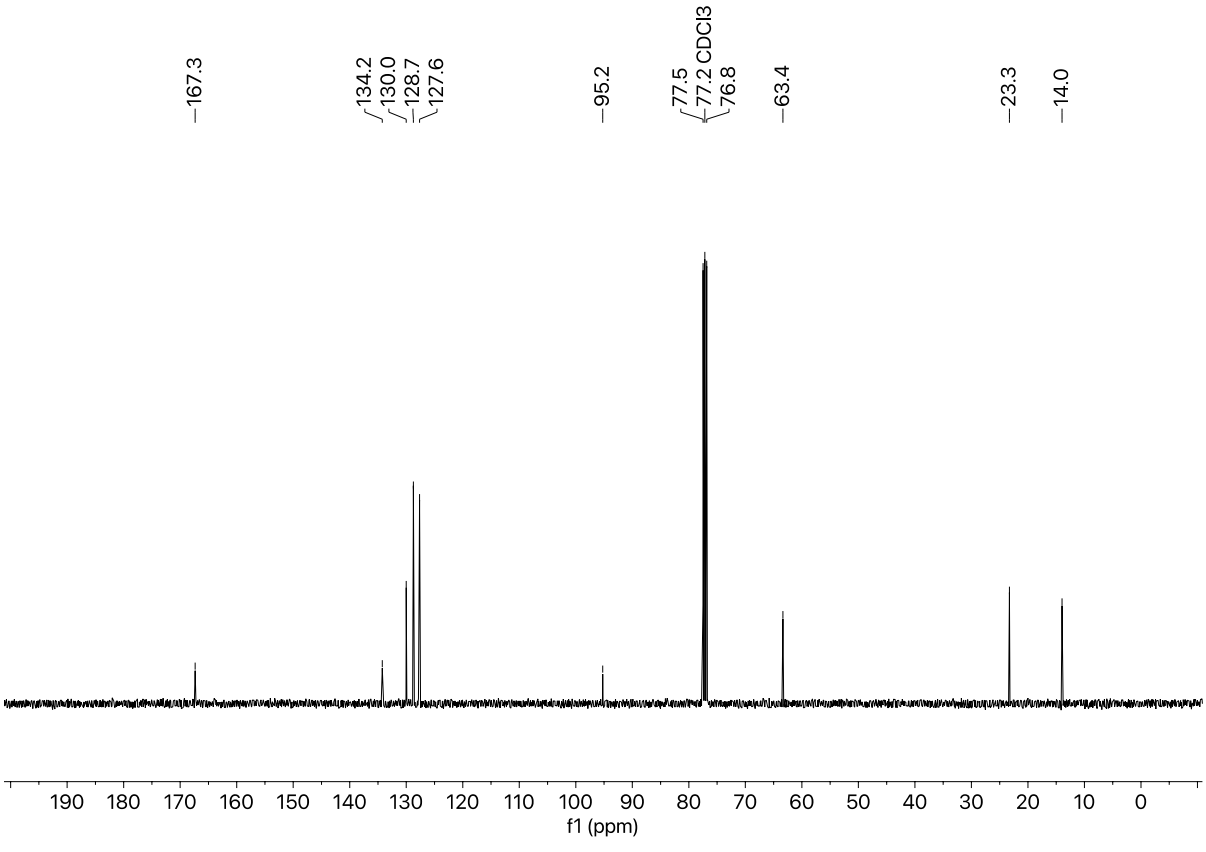
Ethyl 2-nitro-2-phenylpropanoate (5i)



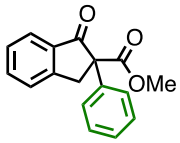
δ_H (400 MHz, $CDCl_3$)



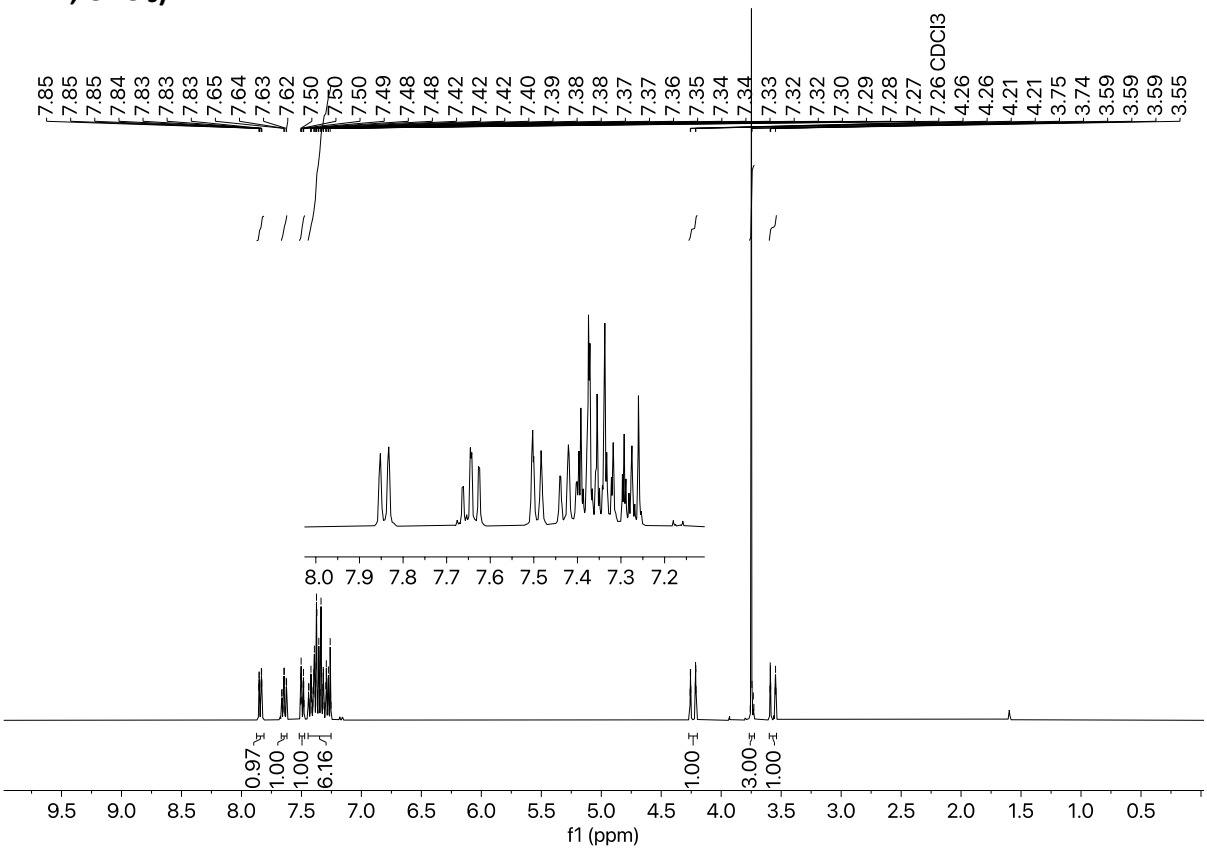
δ_C (101 MHz, $CDCl_3$)



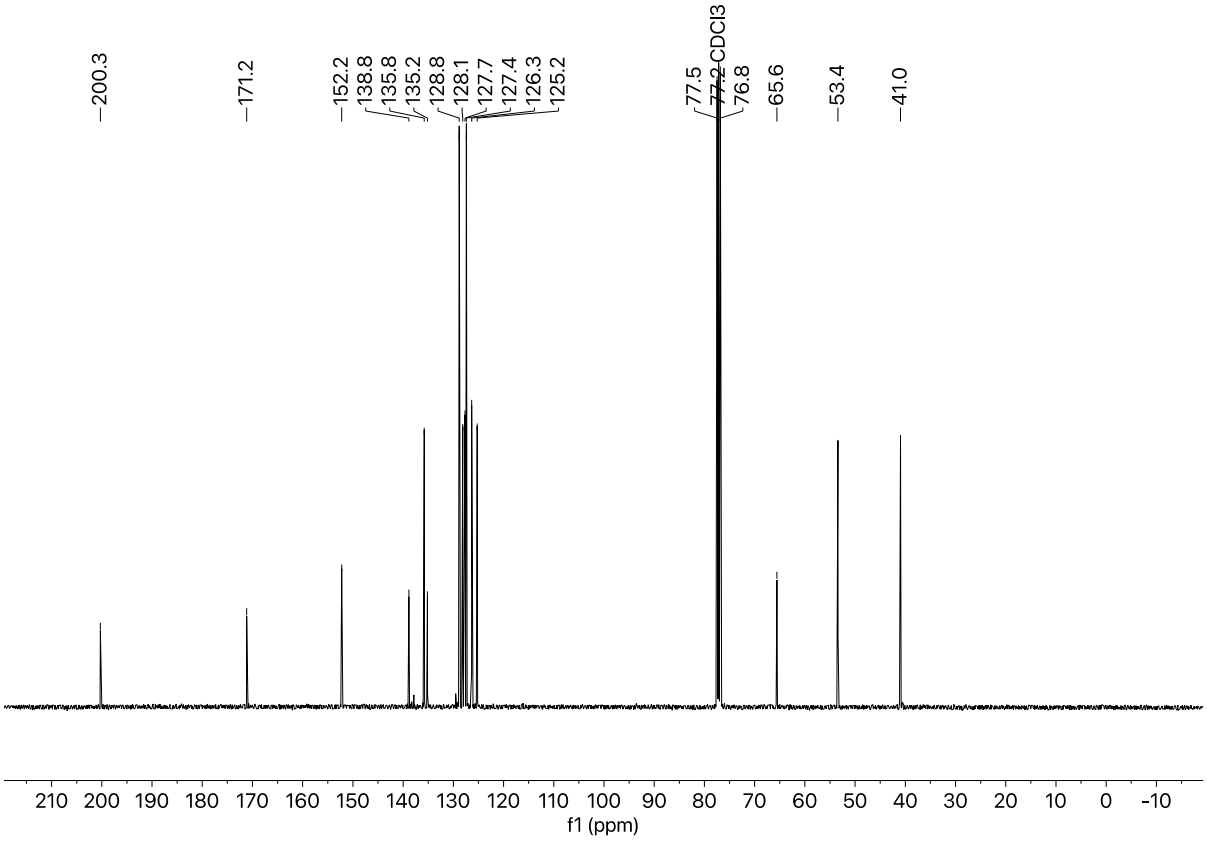
Methyl 1-oxo-2-phenyl-2,3-dihydro-1*H*-indene-2-carboxylate (5j)



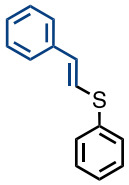
δ_H (400 MHz, $CDCl_3$)



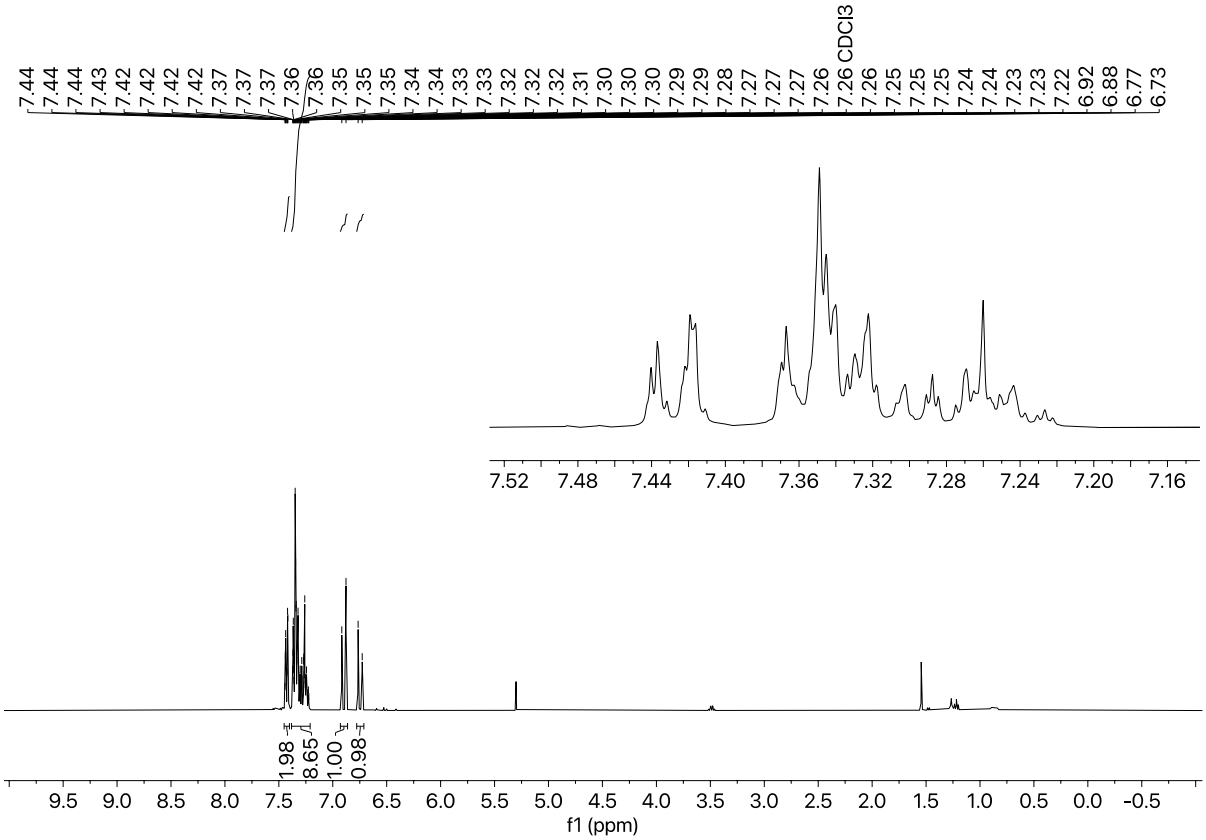
δ_C (101 MHz, $CDCl_3$)



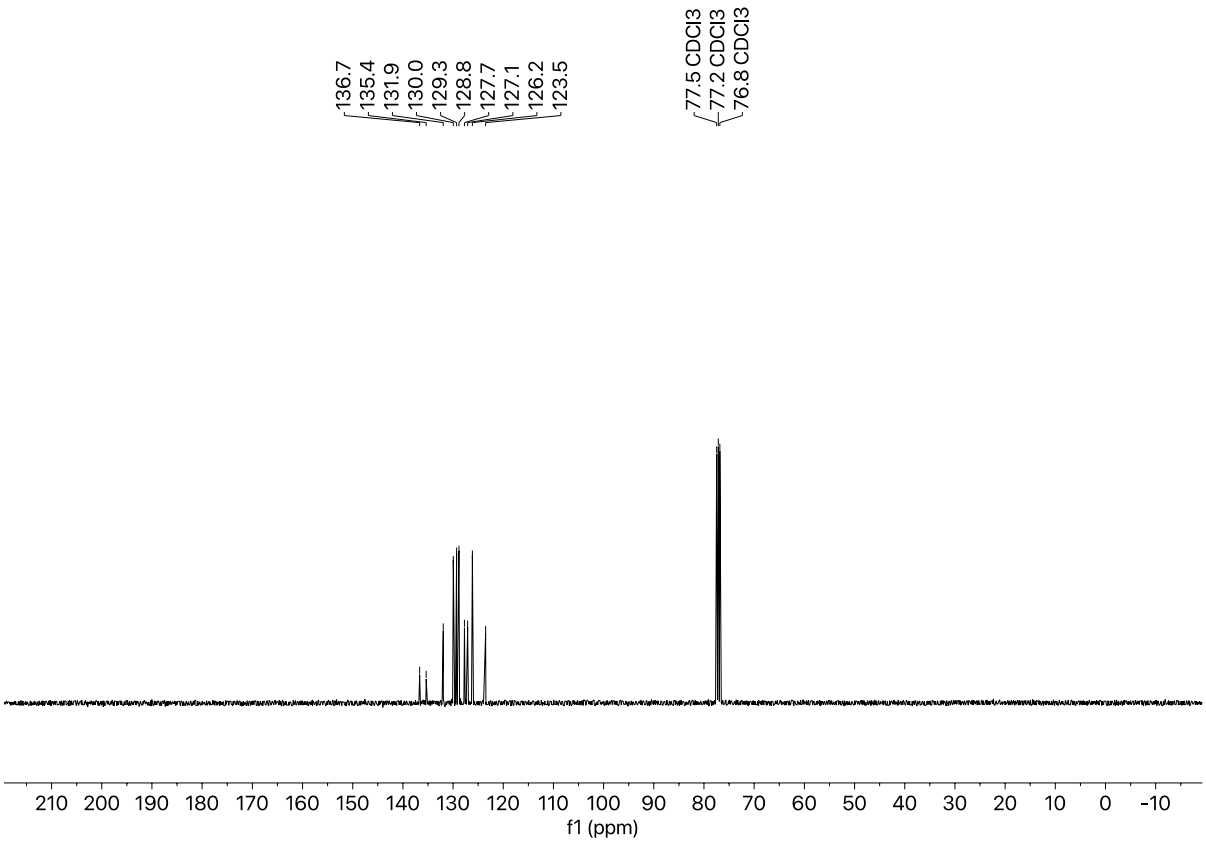
(*E*)-Phenyl(styryl)sulfane (7a)



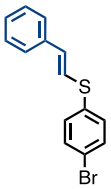
δ_H (400 MHz, $CDCl_3$)



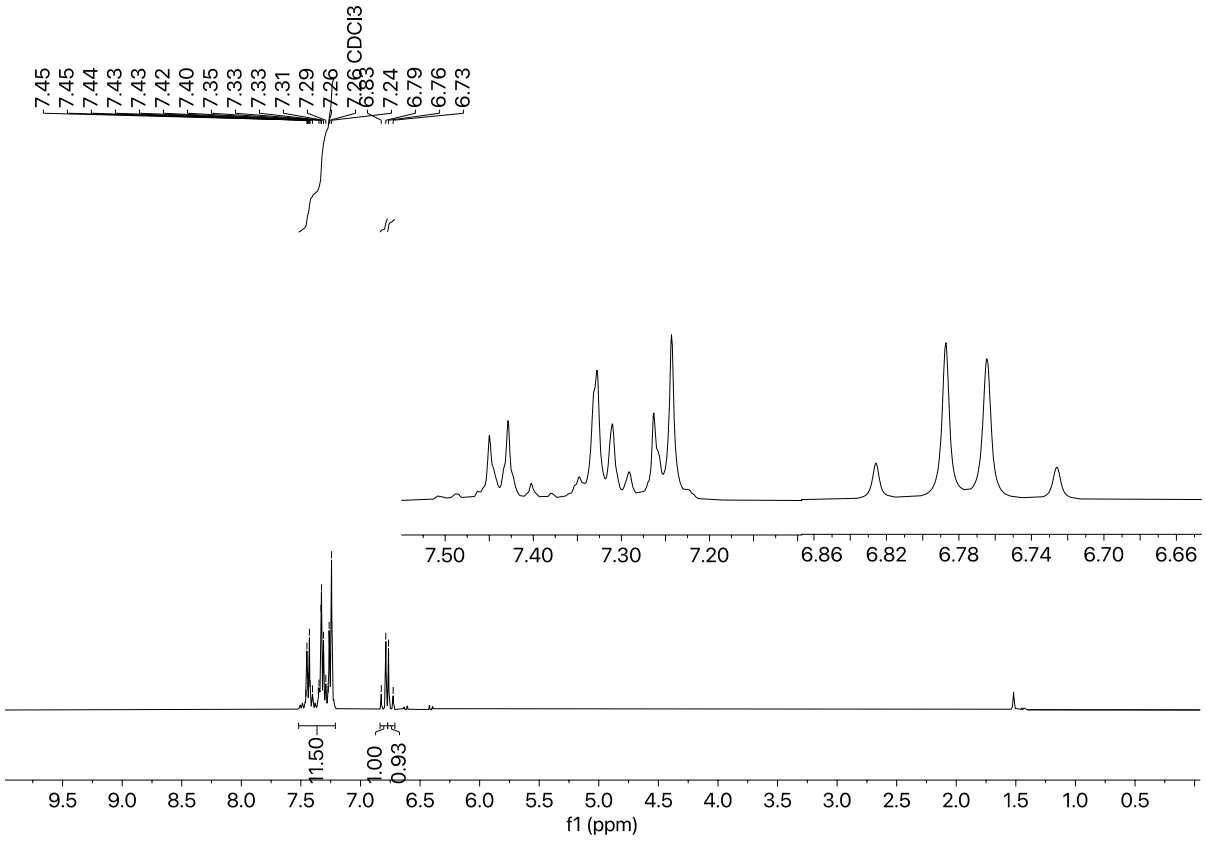
δ_C (101 MHz, $CDCl_3$)


136.7
135.4
131.9
130.0
129.3
128.8
127.7
127.1
126.2
123.5
77.5 CDCl3
77.2 CDCl3
76.8 CDCl3
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)

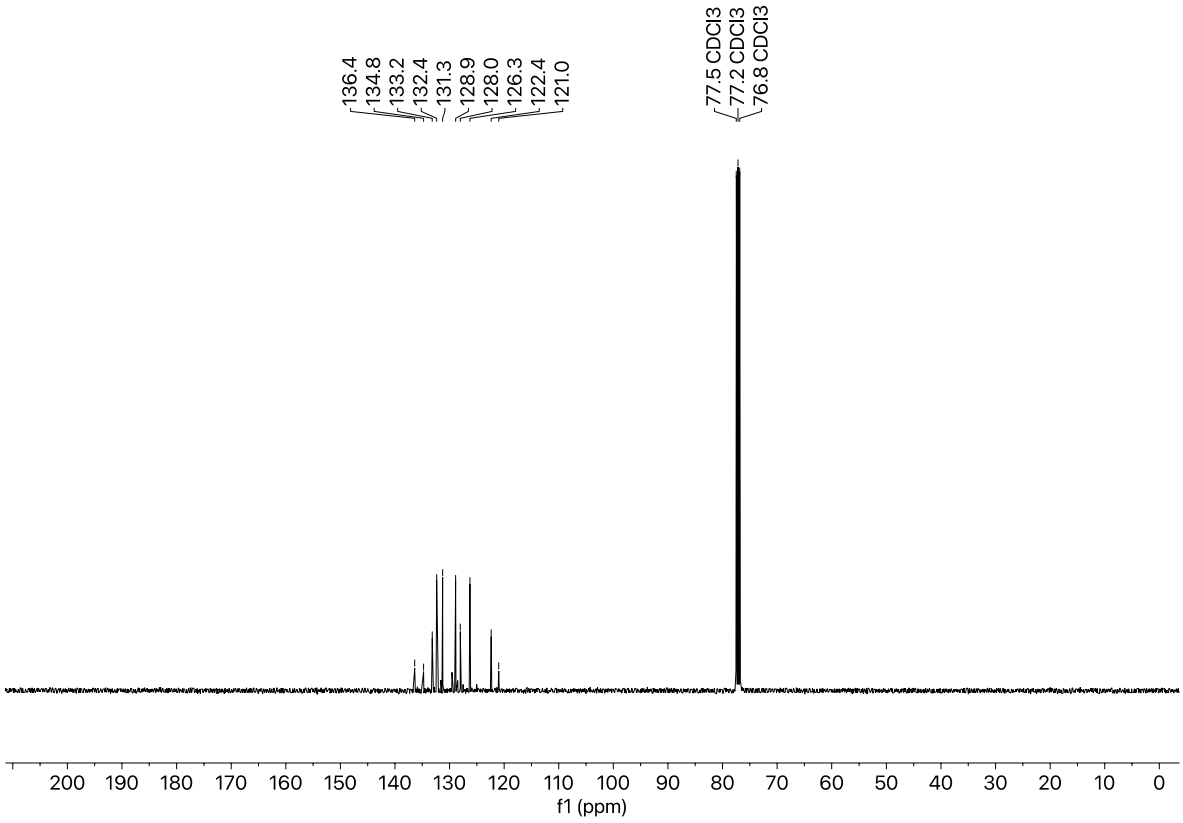
(*E*)-(4-Bromophenyl)(styryl)sulfane (7b)



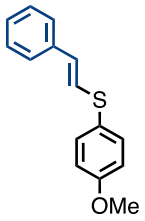
δ_H (400 MHz, $CDCl_3$)



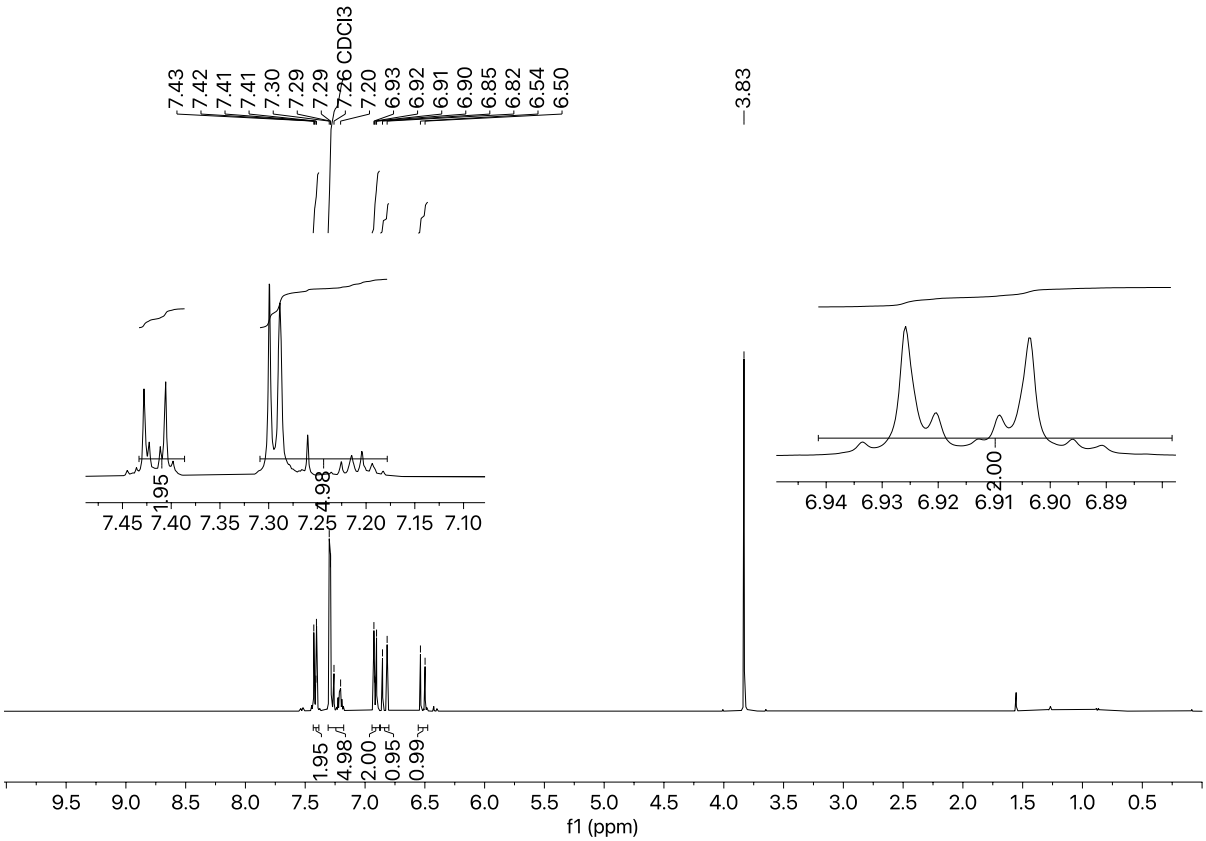
δ_C (101 MHz, $CDCl_3$)



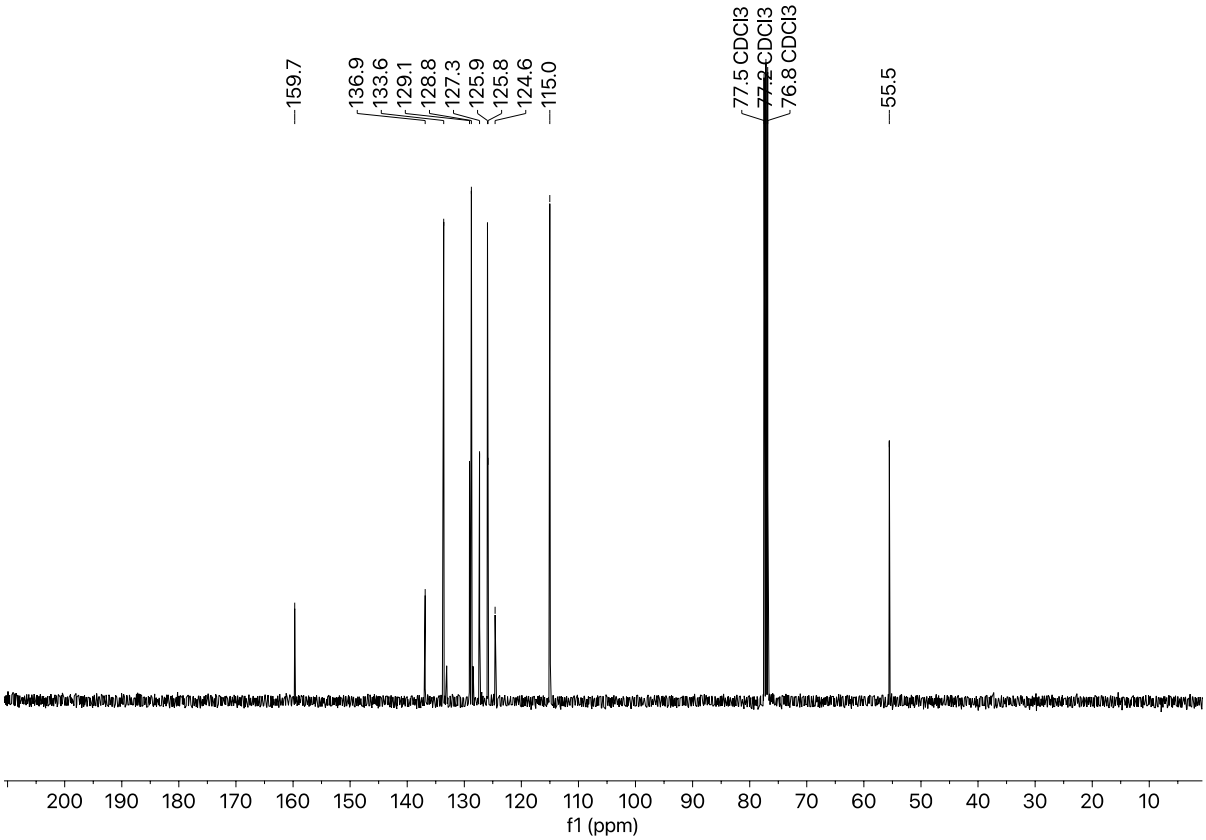
(*E*)-(4-Methoxyphenyl)(styryl)sulfane (7c)



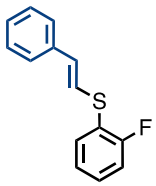
δ_H (400 MHz, $CDCl_3$)



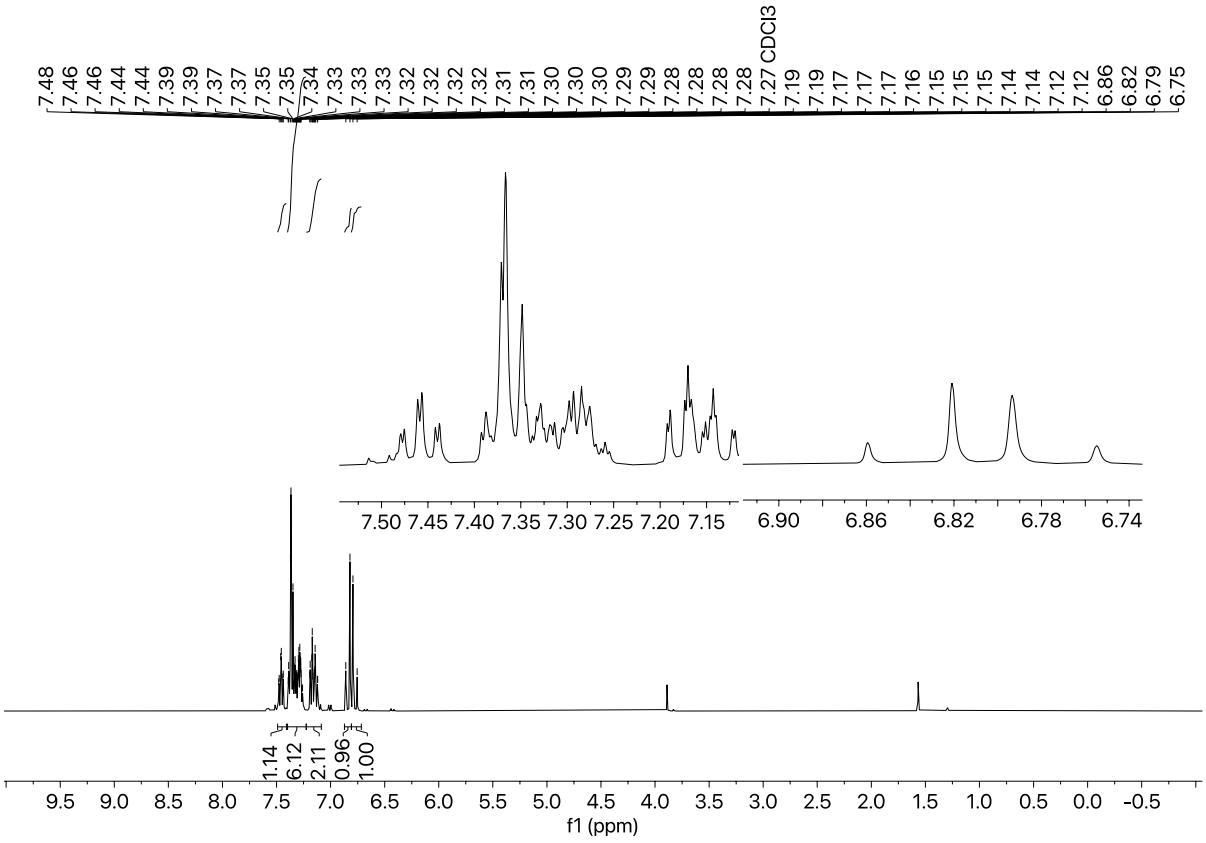
δ_C (101 MHz, $CDCl_3$)



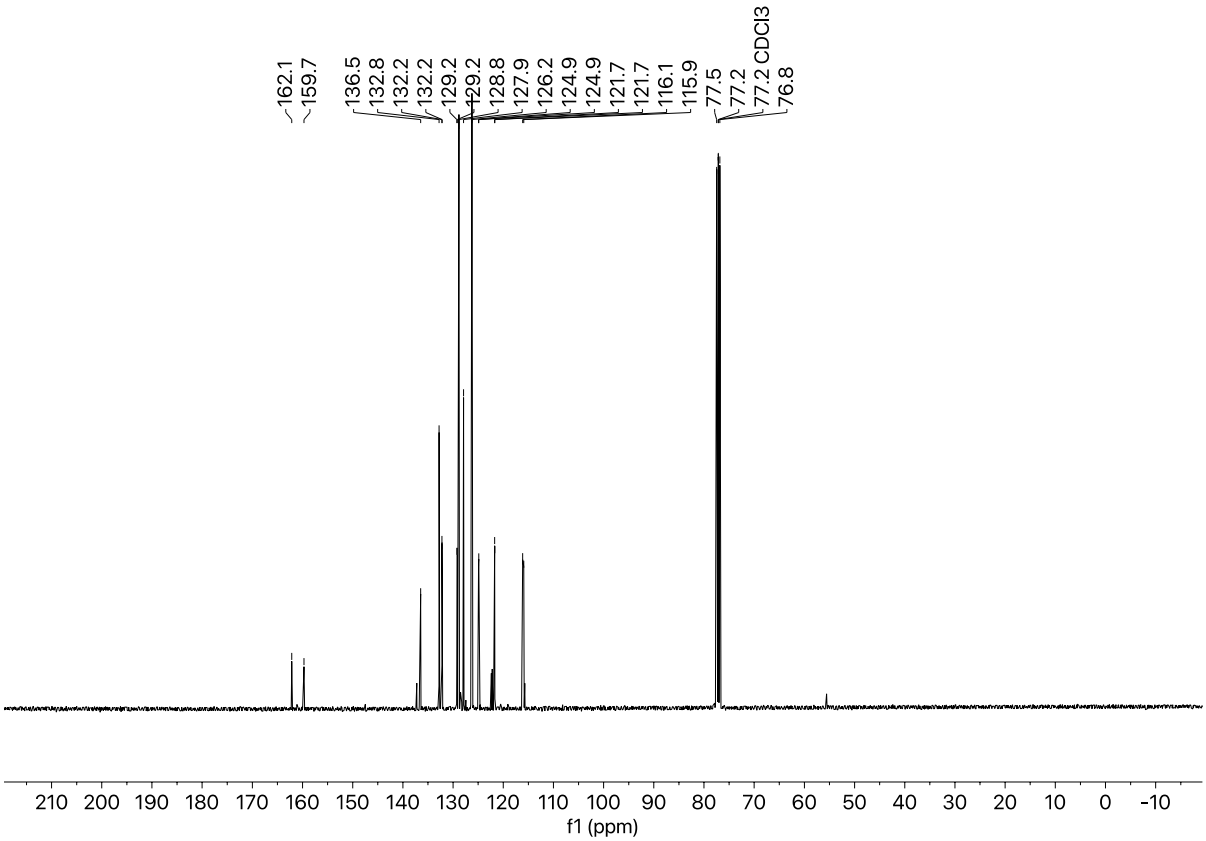
(*E*)-(2-Fluorophenyl)(styryl)sulfane (7d)



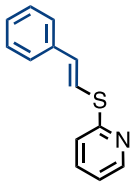
δ_H (400 MHz, $CDCl_3$)



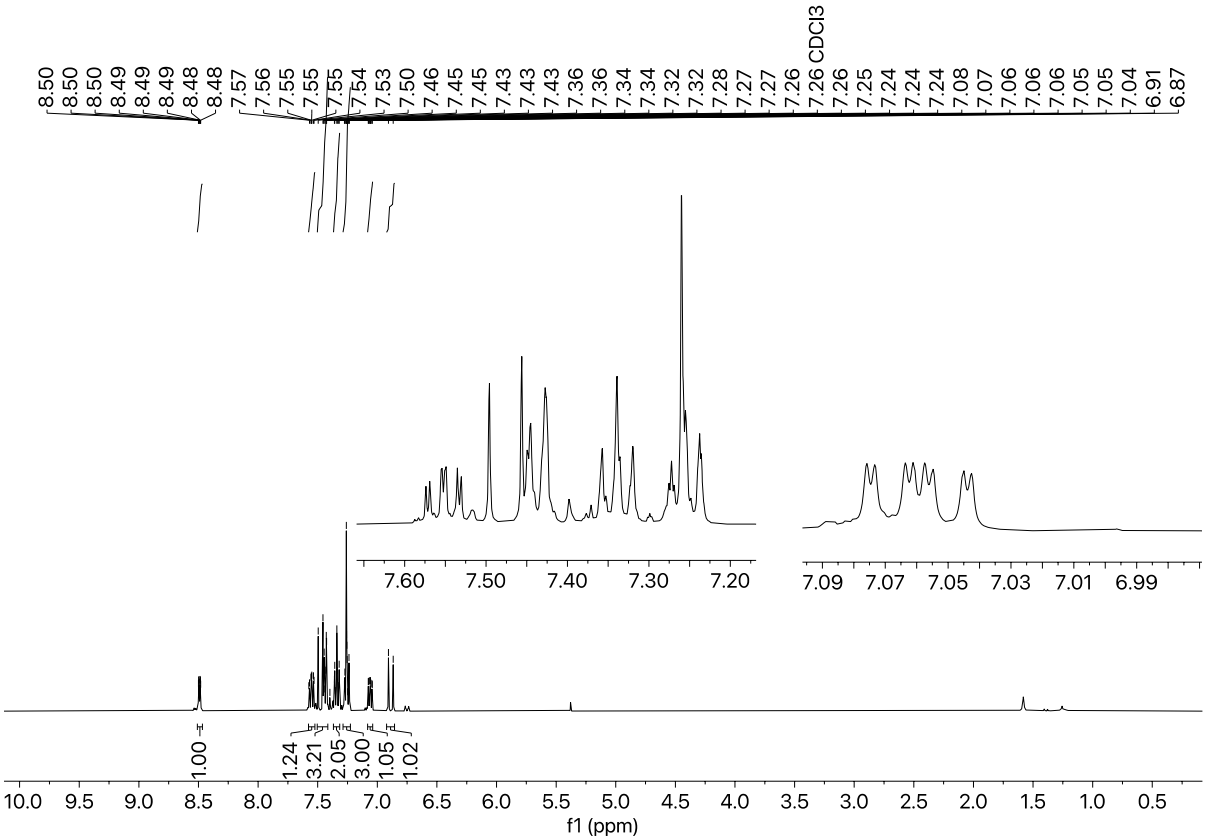
δ_C (101 MHz, $CDCl_3$)



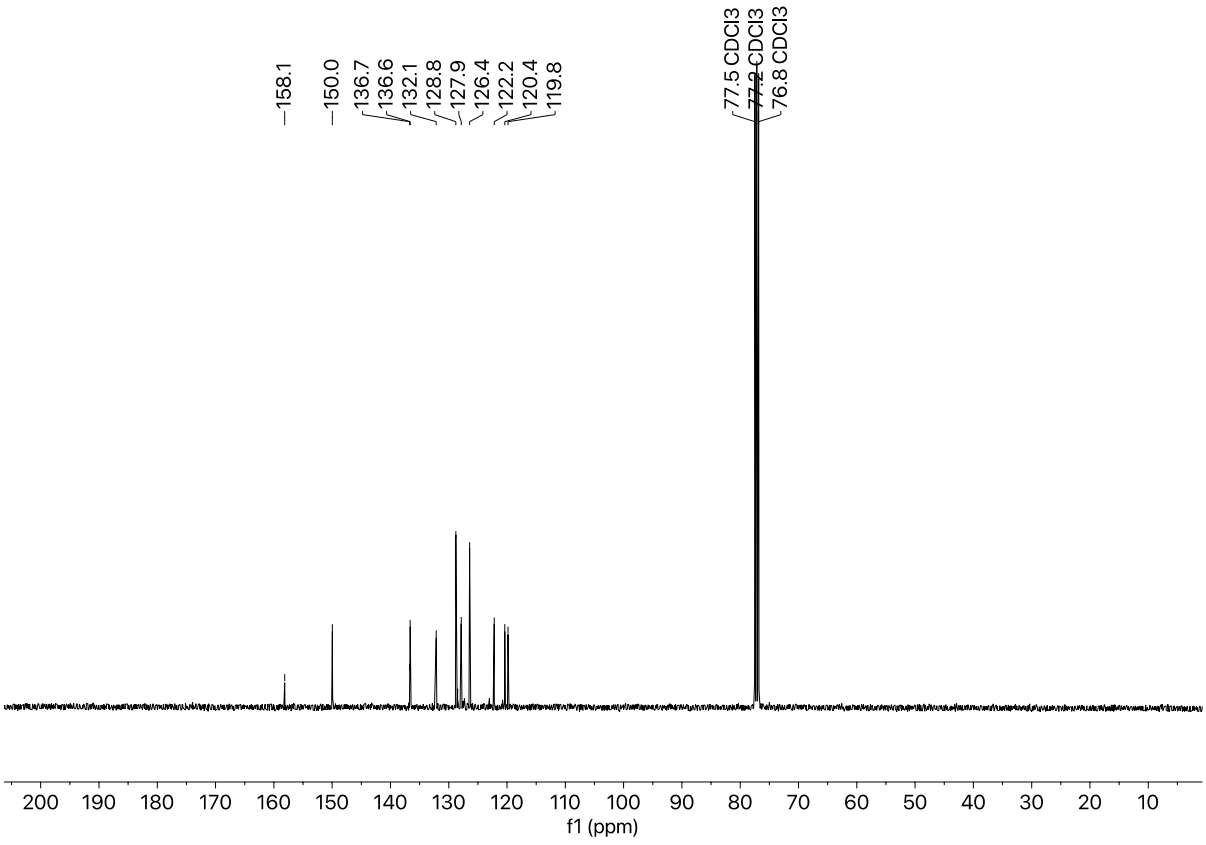
(*E*)-2-(Styrylthio)pyridine (7e)



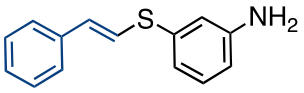
δ_H (400 MHz, $CDCl_3$)



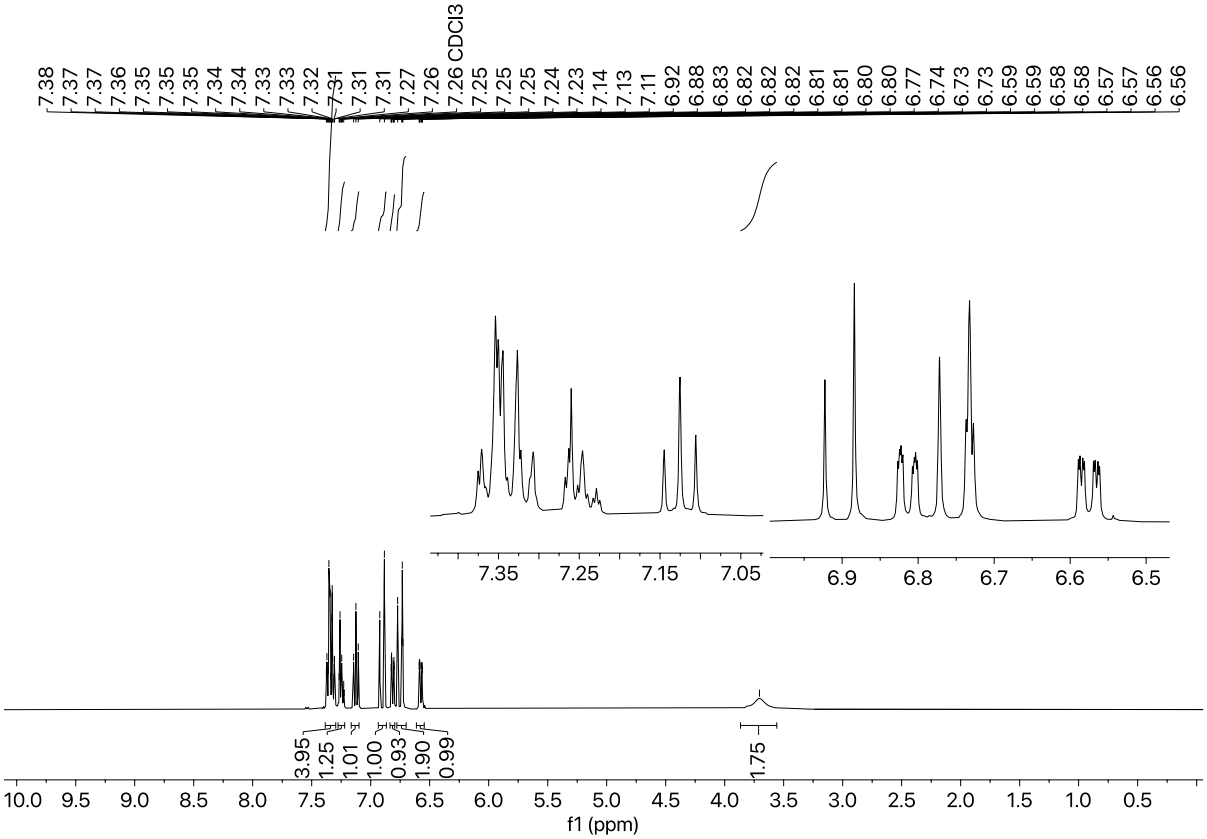
δ_C (101 MHz, $CDCl_3$)



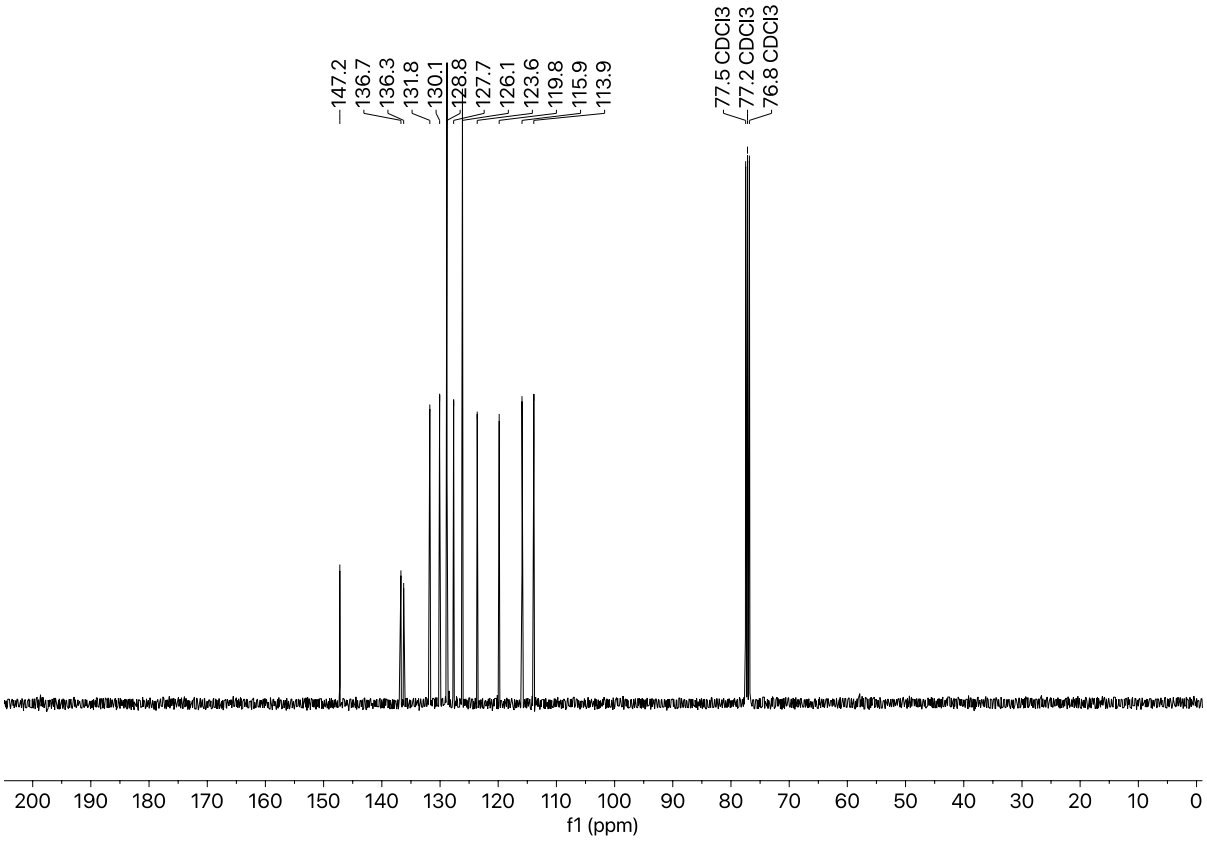
(*E*)-3-(styrylthio)aniline (7f)



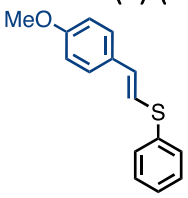
δ_H (400 MHz, $CDCl_3$)



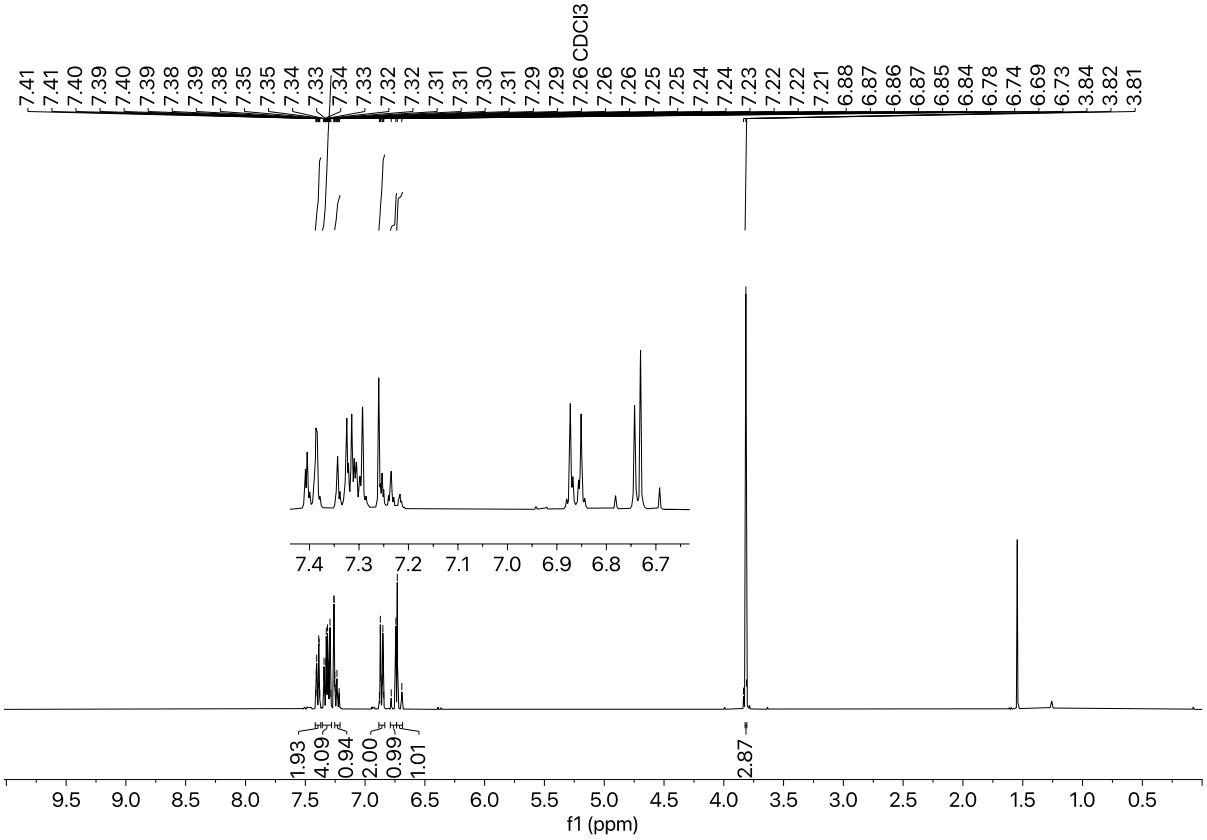
δ_C (101 MHz, $CDCl_3$)



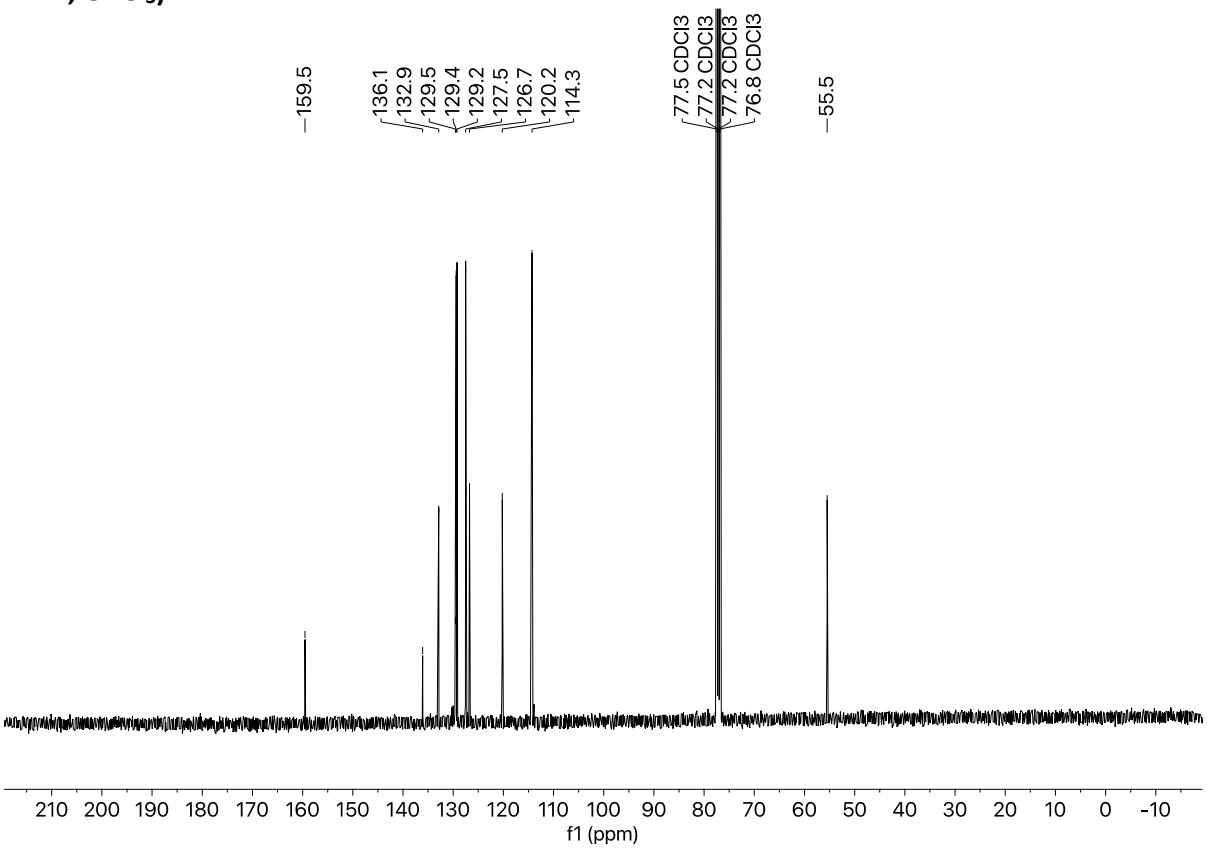
(*E*)-(4-Methoxystyryl)(phenyl)sulfane (7g)



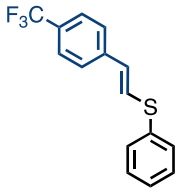
δ_H (400 MHz, $CDCl_3$)



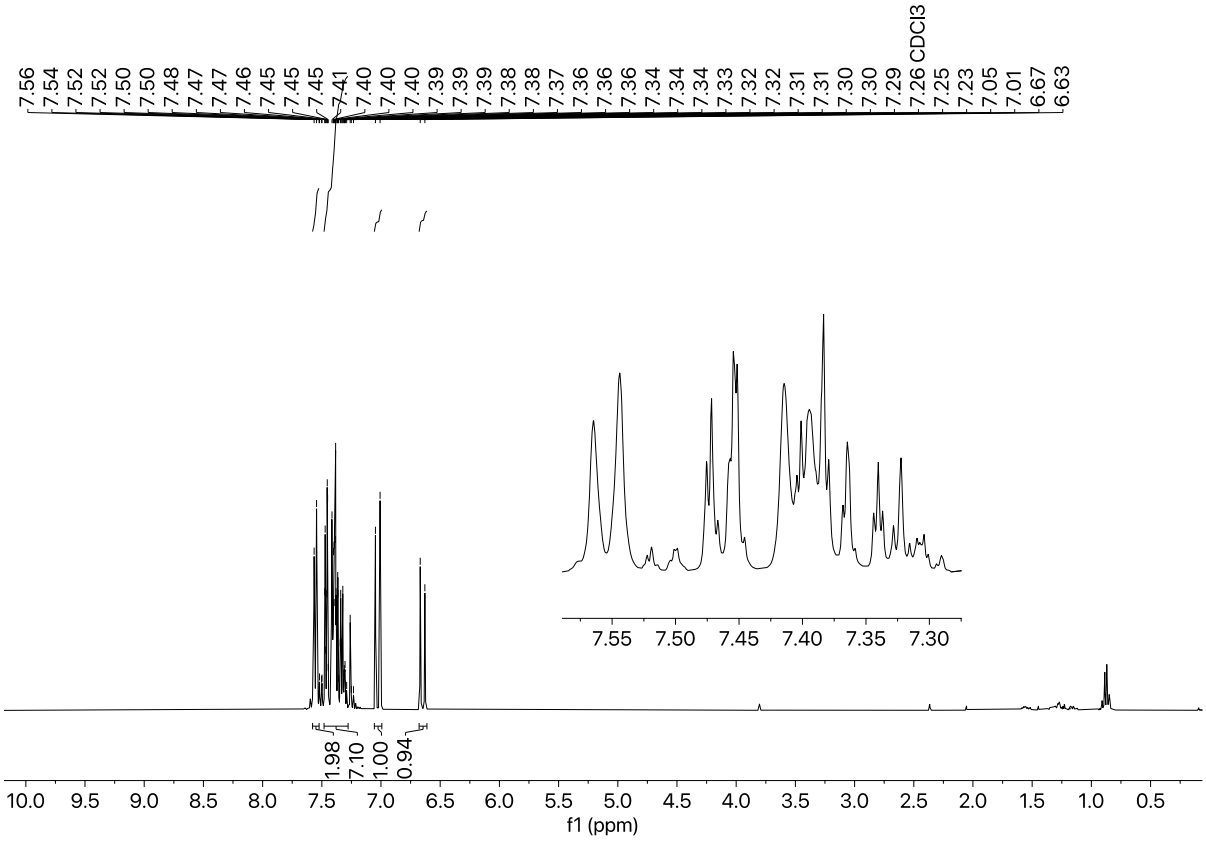
δ_C (101 MHz, $CDCl_3$)



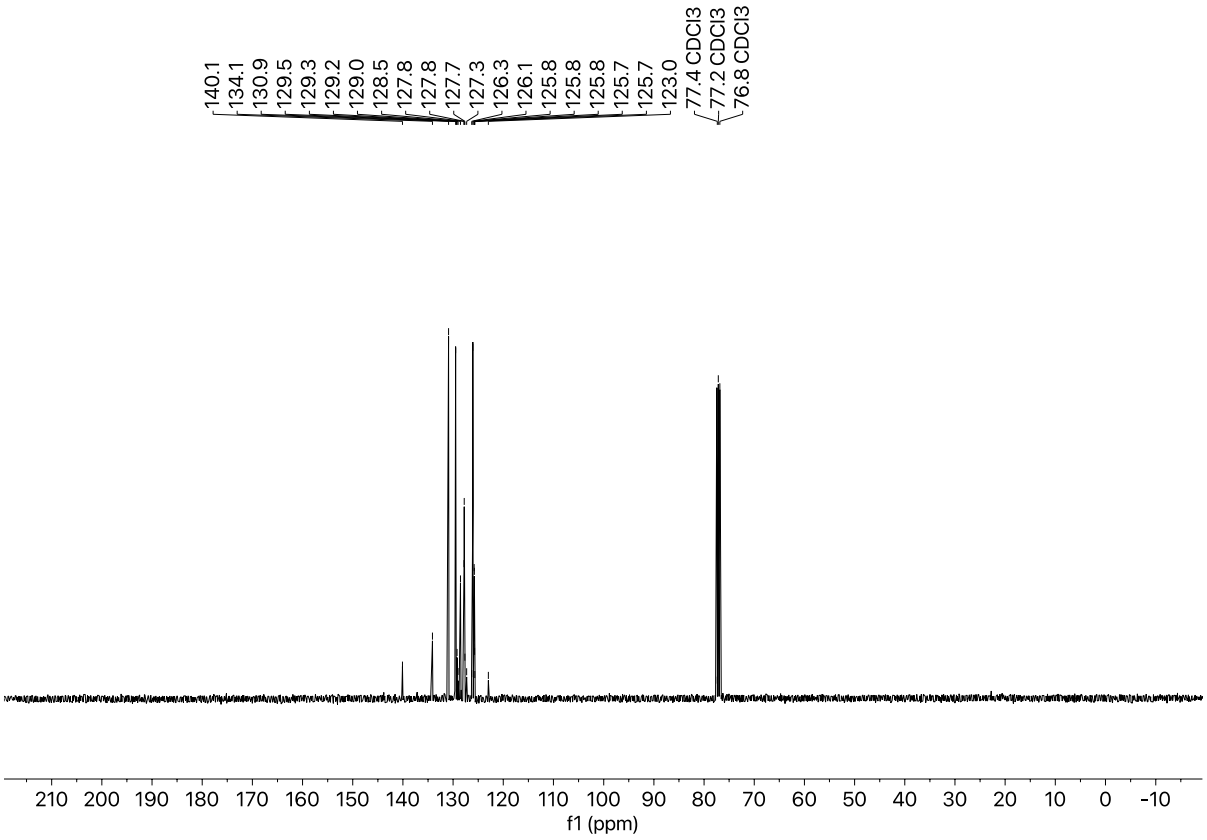
(*E*)-Phenyl(4-(trifluoromethyl)styryl)sulfane (7h)



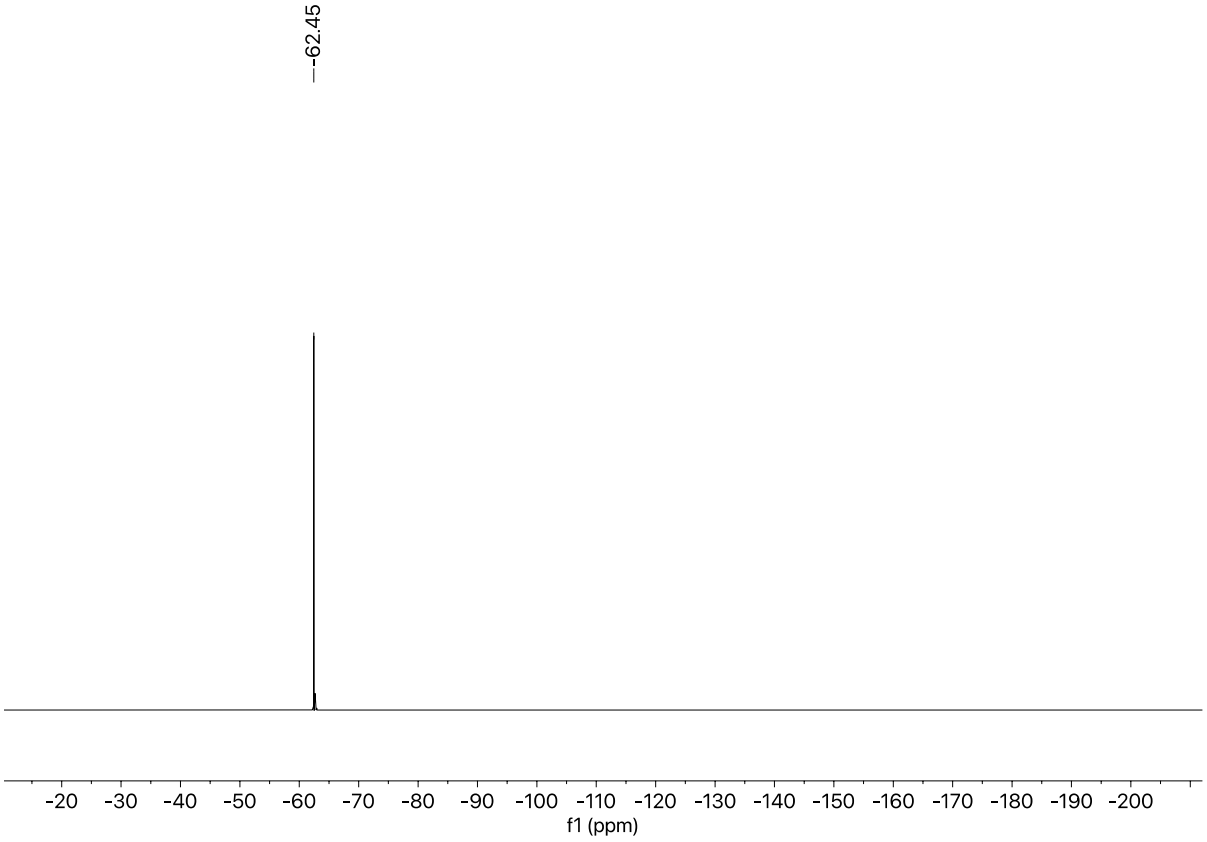
δ_H (400 MHz, $CDCl_3$)



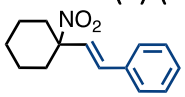
δ_C (101 MHz, $CDCl_3$)



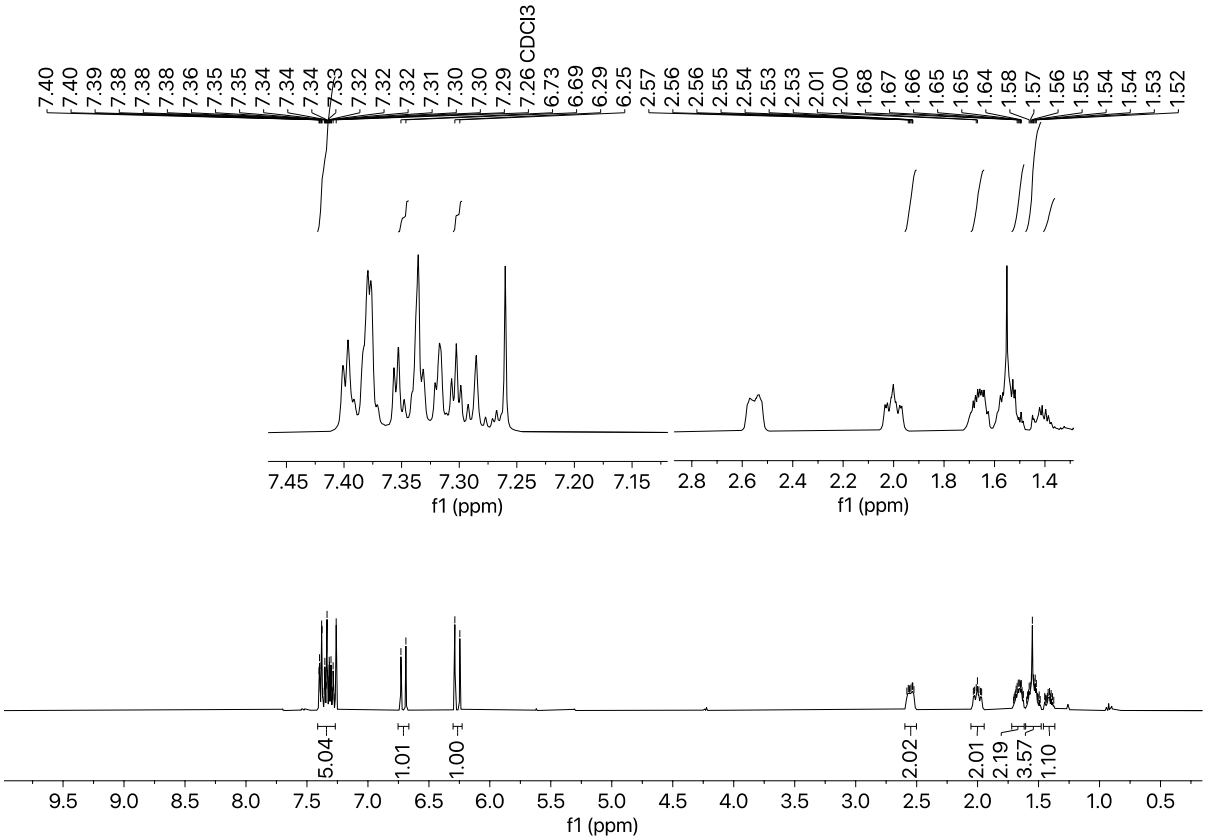
δ_F (376 MHz, $CDCl_3$)



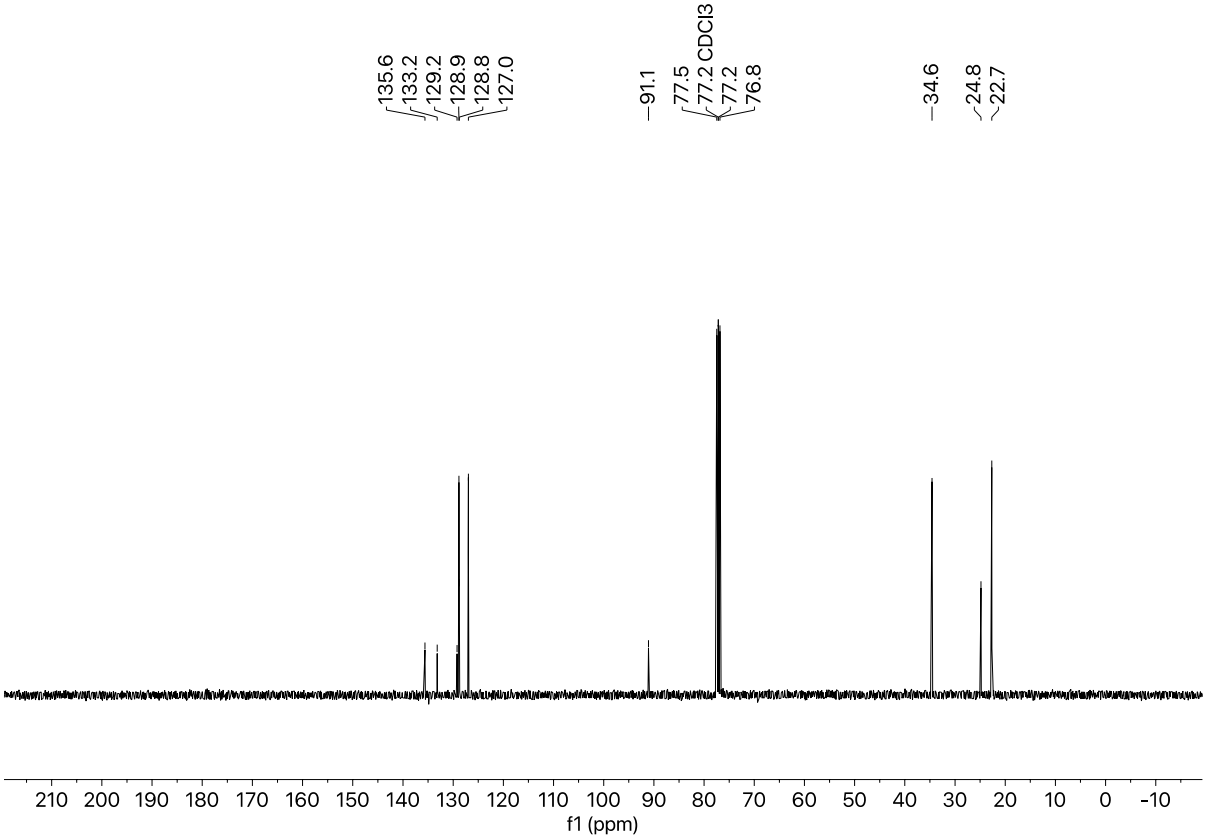
(*E*)-(2-(1-nitrocyclohexyl)vinyl)benzene (8a)



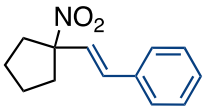
δ_H (400 MHz, $CDCl_3$)



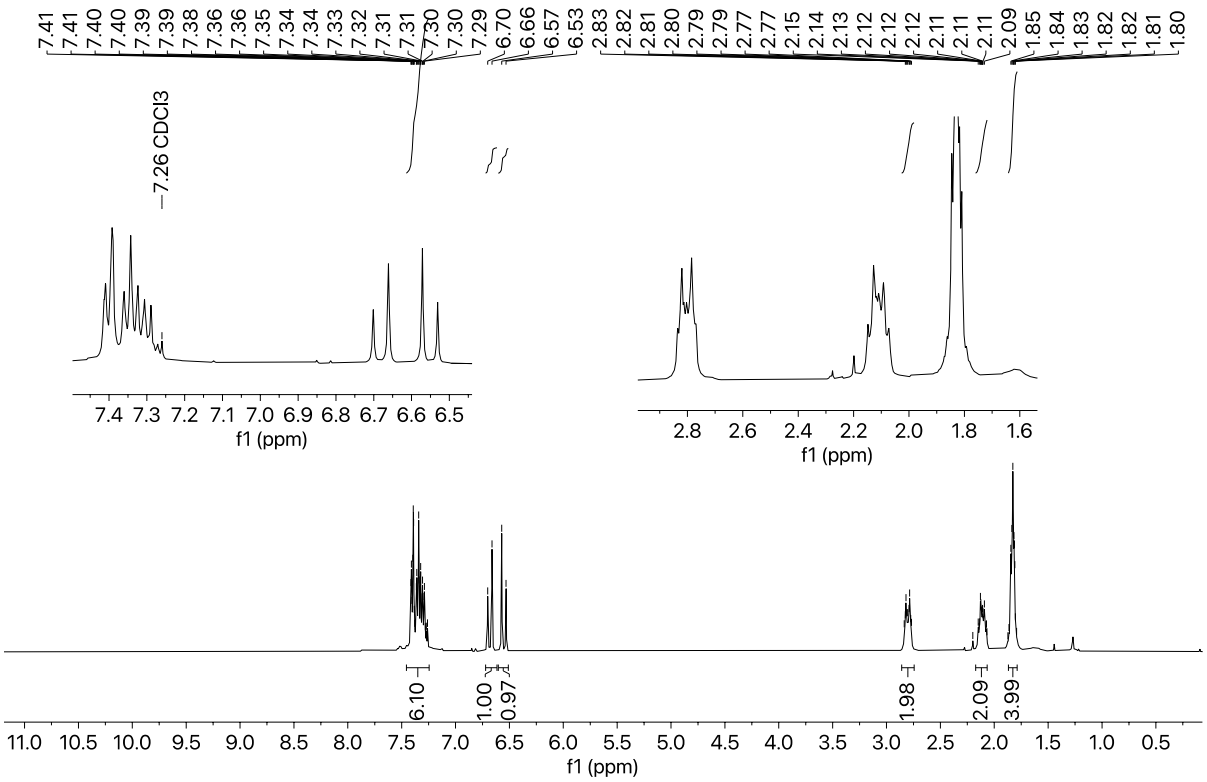
δ_C (101 MHz, $CDCl_3$)



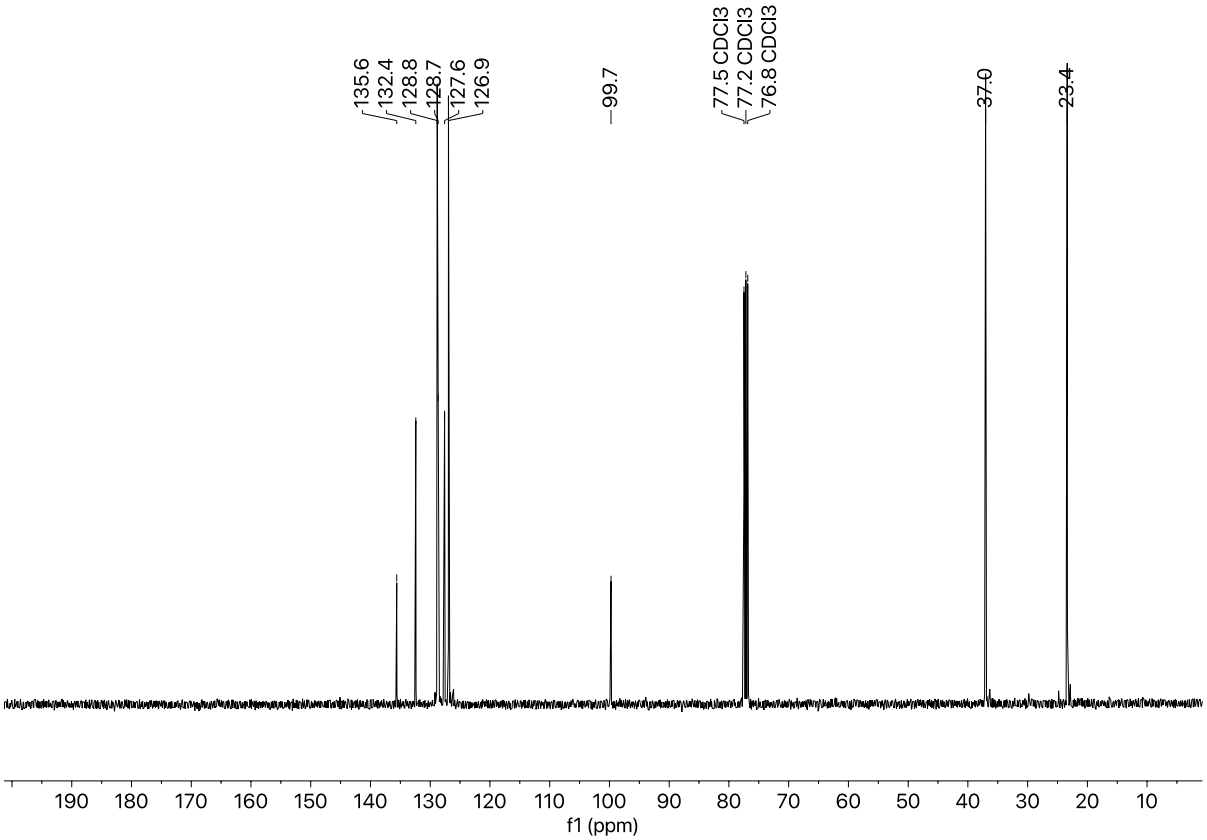
(*E*)-(2-(1-nitrocyclopentyl)vinyl)benzene (8b)



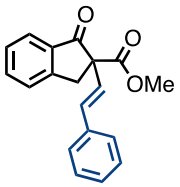
δ_H (400 MHz, $CDCl_3$)



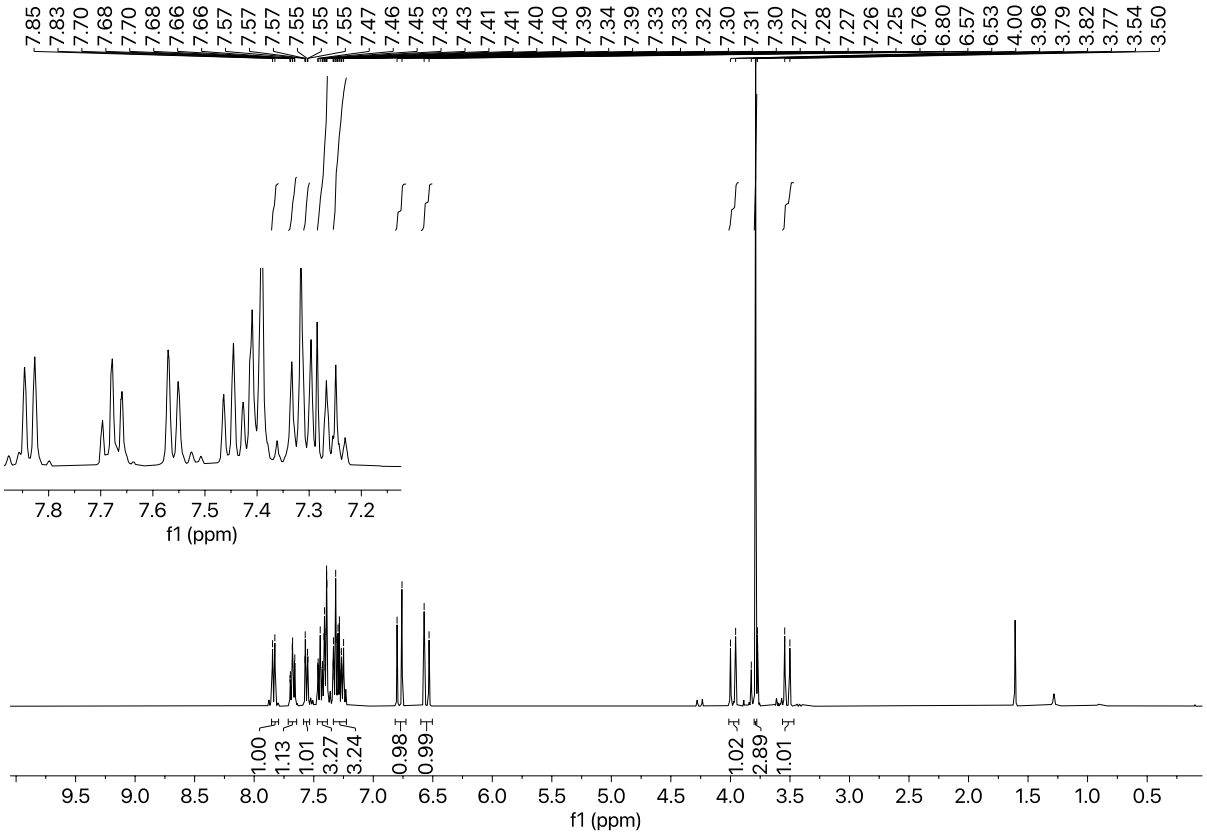
δ_C (101 MHz, $CDCl_3$)



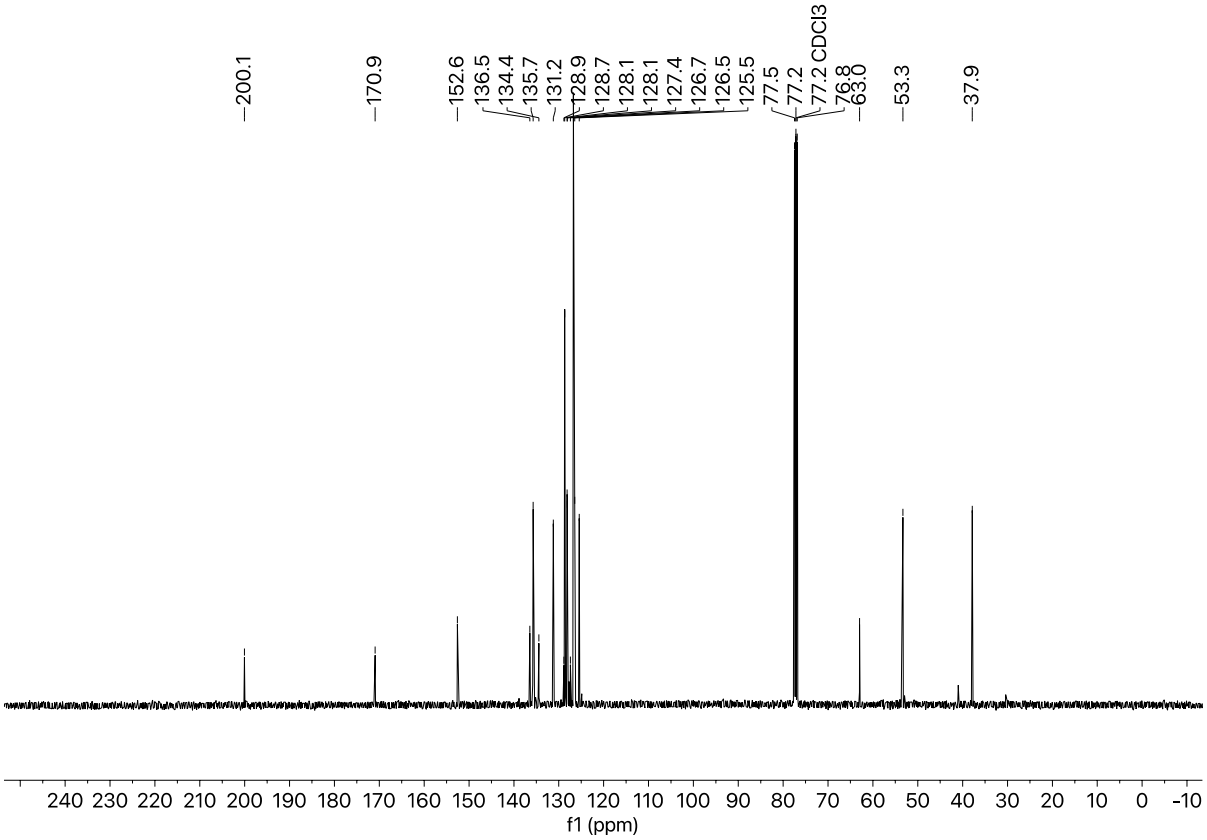
Methyl (*E*)-1-oxo-2-styryl-2,3-dihydro-1*H*-indene-2-carboxylate (8c)



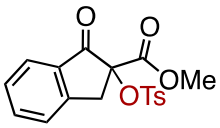
δ_H (400 MHz, $CDCl_3$)



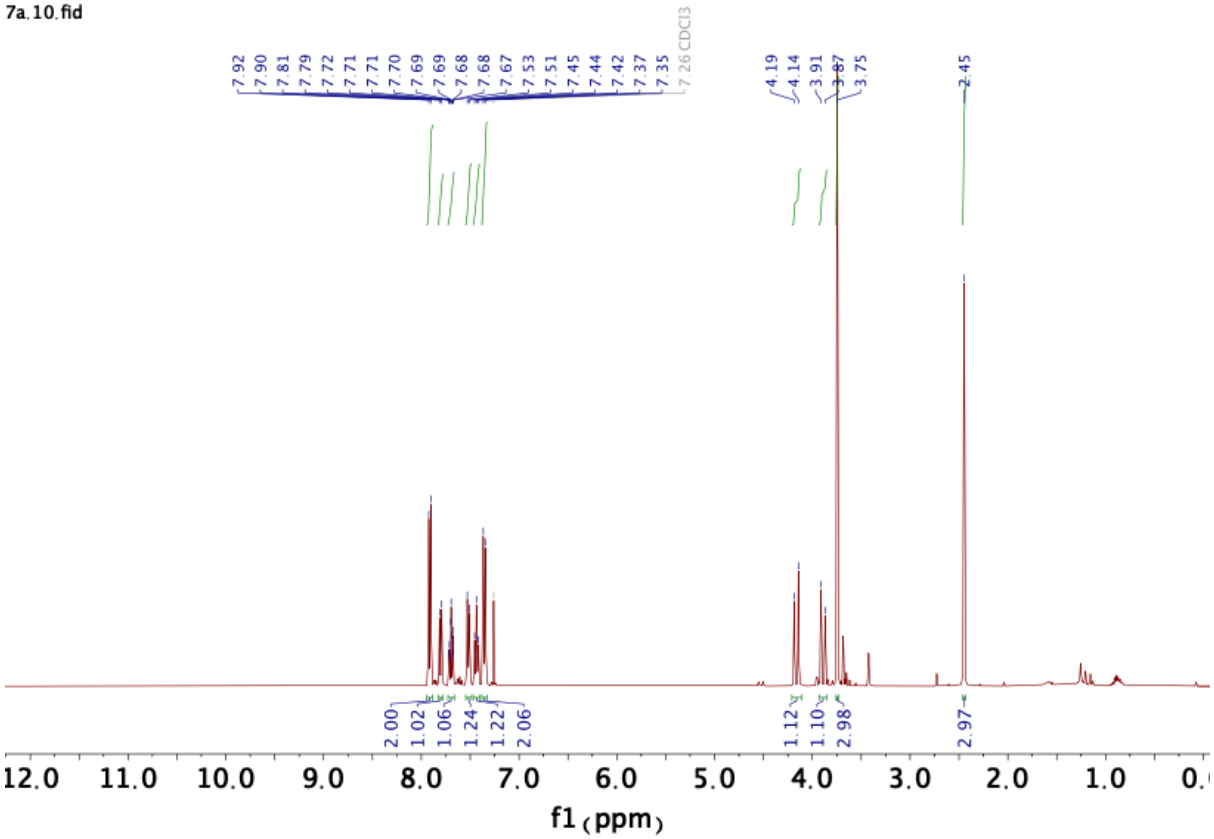
δ_C (101 MHz, $CDCl_3$)



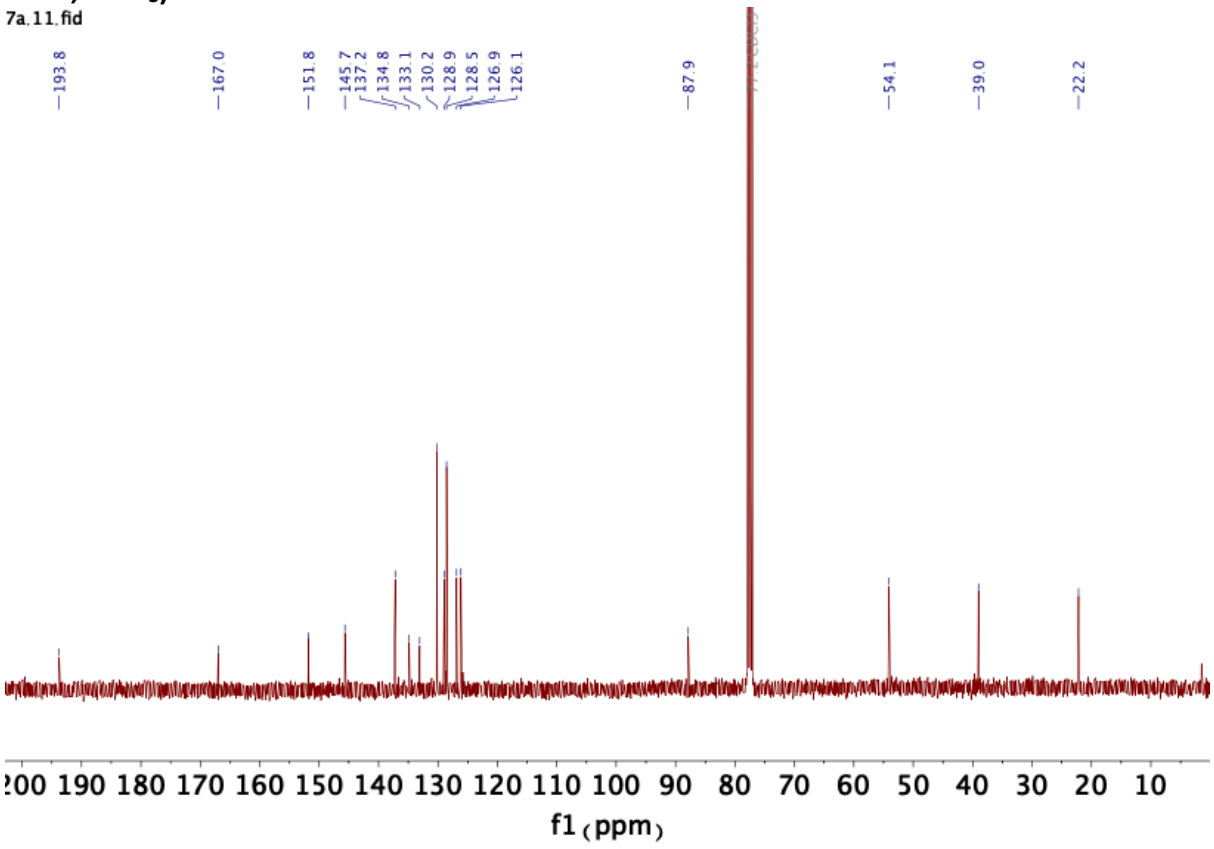
Methyl 1-oxo-2-(tosyloxy)-2,3-dihydro-1H-indene-2-carboxylate (10a)



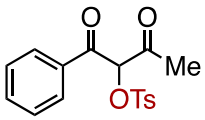
δ_H (400 MHz, $CDCl_3$)



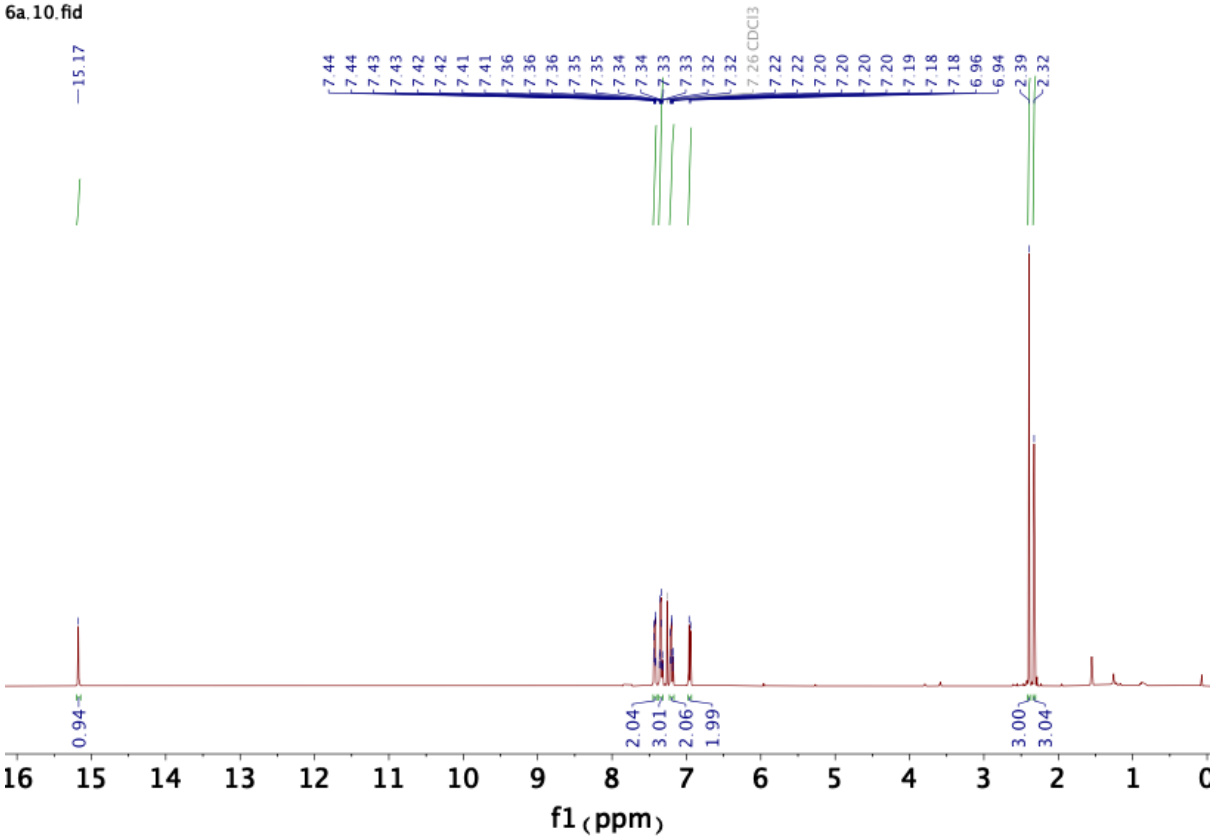
δ_C (101 MHz, $CDCl_3$)



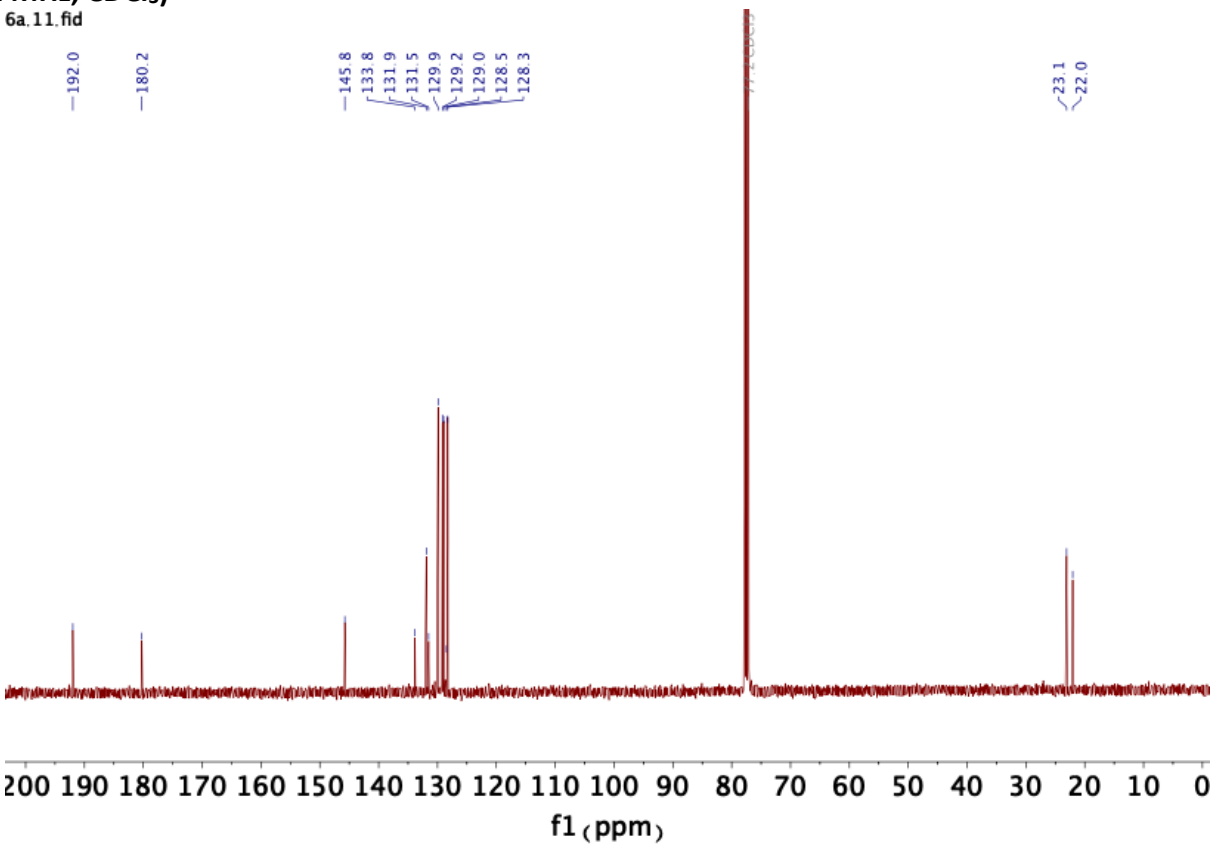
1,3-Dioxo-1-phenylbutan-2-yl 4-methylbenzenesulfonate (10b)



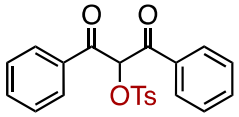
δ_H (400 MHz, $CDCl_3$)



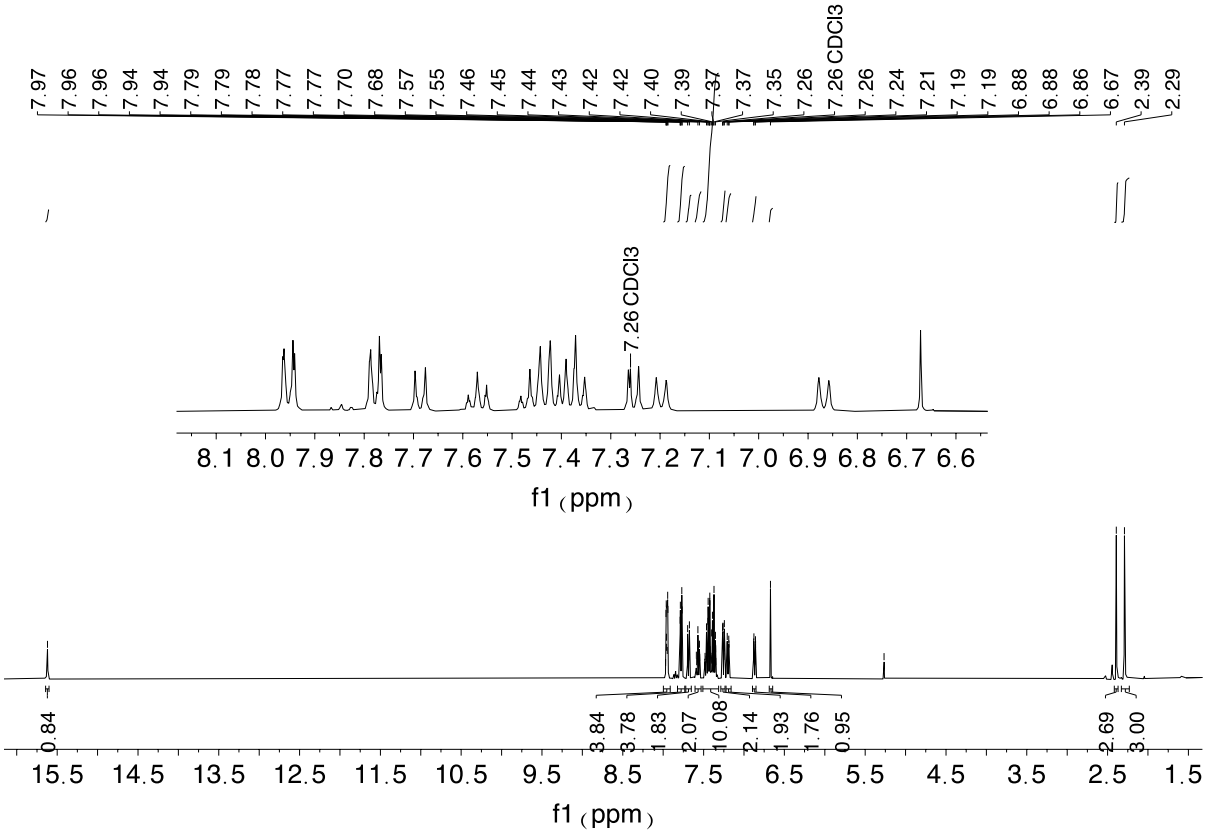
δ_C (101 MHz, $CDCl_3$)



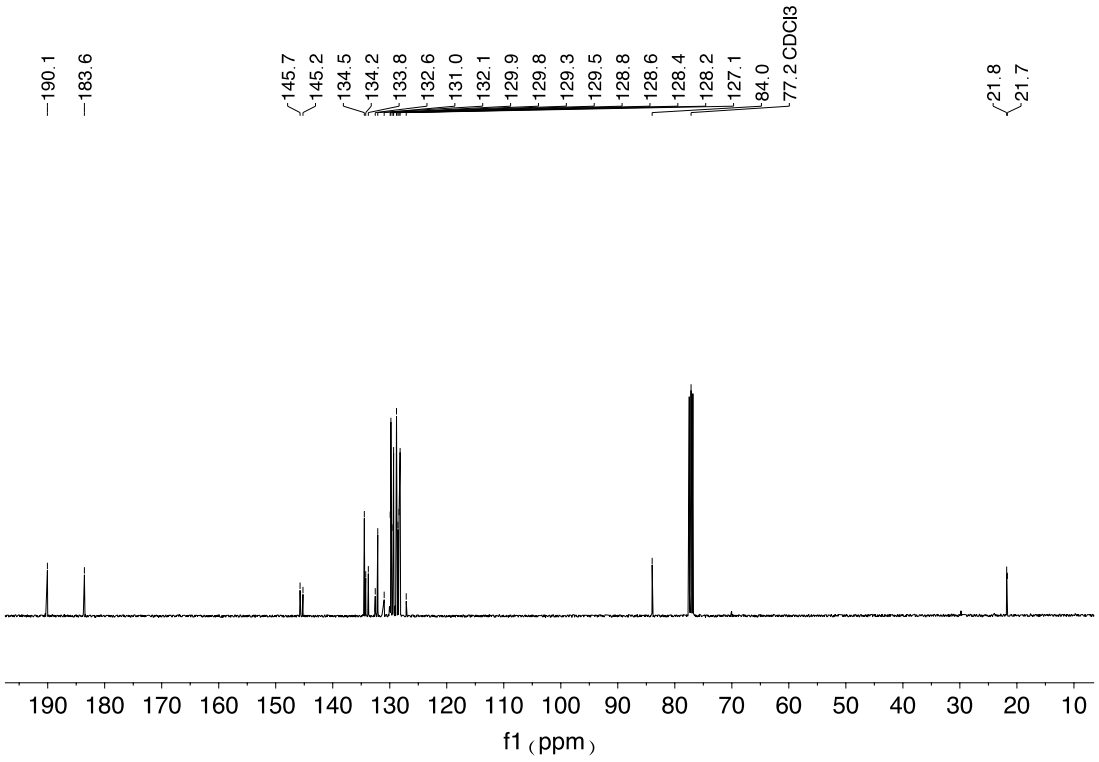
Tosyloxydibenzoylmethane (10c)



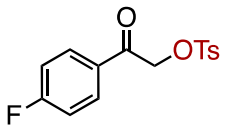
δ_H (400 MHz, $CDCl_3$)



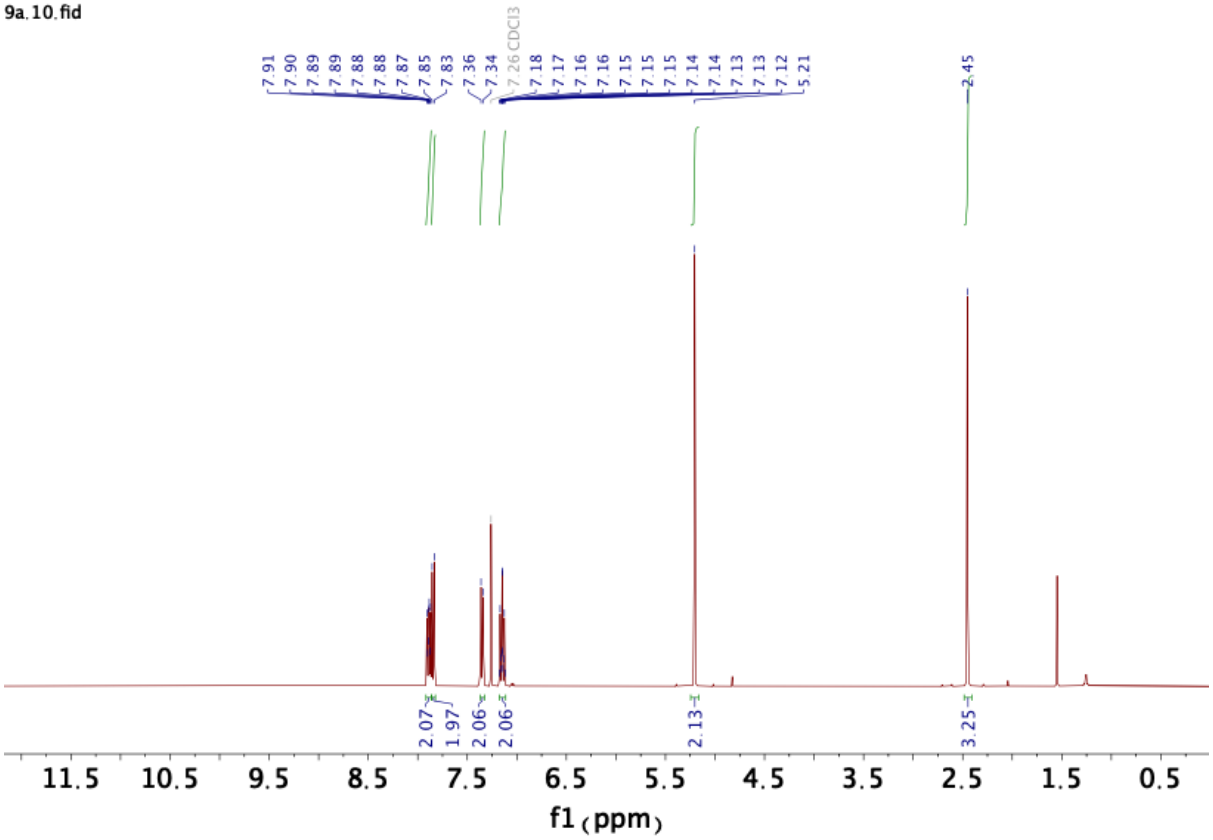
δ_C (101 MHz, $CDCl_3$)



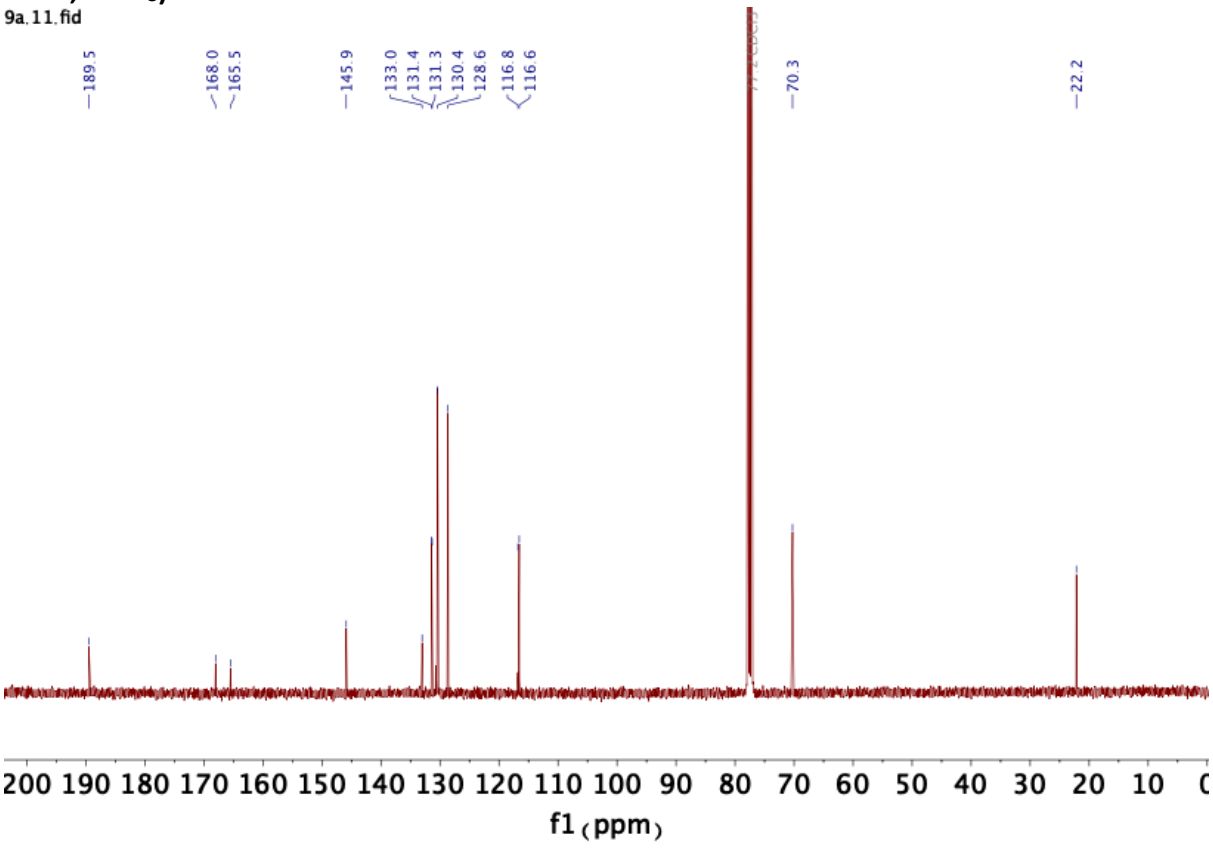
1-(4-fluorophenyl)-2-(p-tolylsulfonyloxy)ethanone (10d)



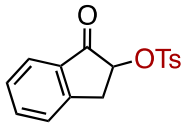
δ_H (400 MHz, $CDCl_3$)



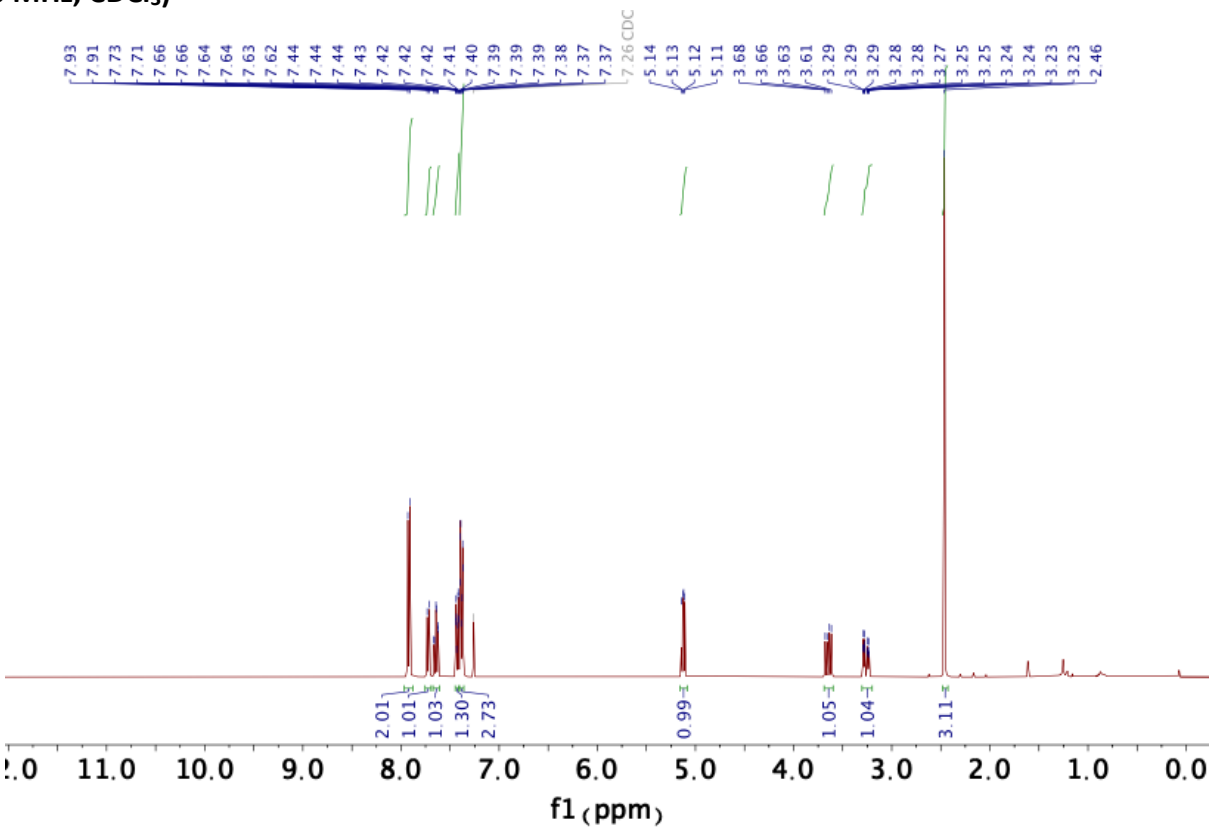
δ_C (101 MHz, $CDCl_3$)



1-oxo-2,3-dihydro-1H-inden-2-yl 4-methylbenzenesulfonate (10e)



δ_H (400 MHz, $CDCl_3$)



δ_C (101 MHz, $CDCl_3$)