Electronic Supplementary Information

Trifluoromethylation of Arenediazonium Salts with Fluoroform-Derived $CuCF_3$ in Aqueous Media

Anton Lishchynskyi,[†] Guillaume Berthon,[‡] and Vladimir V. Grushin[†]*

Email: vgrushin@iciq.es

[†]*Institute of Chemical Research of Catalonia (ICIQ), Tarragona 43007, Spain*

[‡]*Syngenta Crop Protection, Münchwilen AG, Schaffhauserstrasse, Postfach 4332, Stein, Switzerland*

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I. General Information

Caution: Aqueous HF is toxic and corrosive. Inhalation and contact with skin and eyes must be avoided.

All chemicals, solvents, and deuterated solvents were purchased from Aldrich, Alfa Aesar, TCI, and Acros chemical companies. NMR spectra were recorded on a Bruker Avance Ultrashield 400 MHz spectrometer. An Agilent Technologies 7890A chromatograph equipped with a 5975C MSD unit was used for GC-MS analysis. Fluoroform-derived $CuCF_3$ reagents in DMF were prepared following the literature procedure.[1] Anhydrous DMF was stored over freshly calcined 4 Å molecular sieves in a glovebox. Quantitative ^{19}F NMR analysis was carried out with D1 = 5 s. Crude estimates of the yields of side products are provided on the basis of GC-MS data without calibration. Single-crystal X-ray diffraction studies were performed using a Bruker-Nonius diffractometer equipped with an APEX II 4K CCD area detector.

II. Optimization Experiments under Anhydrous Conditions

Trifluoromethylation of Para-Substituted Arenediazonium Tetrafluoroborates

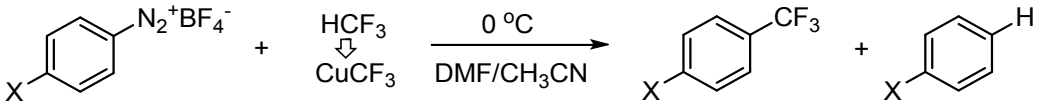


Table S1. Trifluoromethylation of 4-$XC_6H_4N_2BF_4$ in DMF or DMF/CH_3CN.

Entry[a]	X	$CuCF_3$, equiv	Yield,[b] %	Unreacted $CuCF_3$,[b] equiv	ArH / $ArCF_3$[c]
1[d]	NO_2	1.1	8	0.4	4.26
2[d]	Br	1.1	10	0.35	3.57
3[d]	OMe	1.1	17	0.35	1.53
4	NO_2	1.1	43	0.6	0.42
5[e]	NO_2	1.1	30	0.7	0.51
6	OMe	1.1	73	0.4	0.08
7[e]	OMe	1.1	68	0.4	0.08

8[f]	OMe	1.1	66	0.4	0.10
9[g]	OMe	1.1	67	0.35	0.08
10	OMe	0.55	52 (95)[h]	<0.01	0.09
11	OMe	1.1 ($Cu^{II}CF_3$)[i]	2	0.5	1.44
12	OMe	1 ($Cu^{I}CF_3$) + 0.5 ($Cu^{II}CF_3$)[i]	72	0.75	0.08

[a] Reactions were performed on a 0.32 mmol scale; a solution of ArN_2BF_4 in CH_3CN (2 mL) or DMF (1 mL; for entries 1-3) was added dropwise to $CuCF_3$ in DMF at 0 °C. [b] Determined by ^{19}F NMR. [c] Determined by GC-MS. [d] Solution of ArN_2BF_4 in DMF (1 mL) was used. [e] $CuCF_3$ in DMF was added to a solution of ArN_2BF_4 in CH_3CN (2 mL) at 0 ºC. [f] The reaction was performed at rt. [g] A solution of ArN_2BF_4 was added in one portion to $CuCF_3$ in DMF. [h] The yield in parentheses is calculated on the basis of the amount of $CuCF_3$ used. [i] $CuCF_3$ reagent was oxidized in air (stirring in an open flask for 10 min) prior to use.

General Procedure

Under argon, to fluoroform-derived $CuCF_3$ in DMF (0.35 M; 1 mL; 1.1 equiv) cooled to 0 ºC (ice bath) was added at stirring a solution of ArN_2BF_4 (0.32 mmol) and 4,4'-difluoro-1,1'-biphenyl (91 mg; 0.48 mmol; internal standard) in DMF (1 mL) or CH_3CN (2 mL) via a syringe pump over 1 h. The reaction mixture was stirred for 30 min at 0 ºC and then for 1 h at room temperature. The yields of the trifluoromethylated products and unreacted $CuCF_3$ were determined by ^{19}F NMR. Side products were identified by GC-MS analysis of the organic layer after dilution of the reaction mixture with ether (3 mL) and washing with water (10 mL).

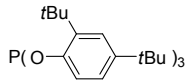
Table S2. Trifluoromethylation of 4-$MeOC_6H_4N_2BF_4$ in various solvents.

Entry[a]	$CuCF_3$, equiv	Solvent(s)	Yield, %[b]	Unreacted $CuCF_3$, equiv[b]	ArH / $ArCF_3$ / ArAr / ArN_2Ar[c]
1	1.1	EtCN	65	0.45	10 : 76 : 1 : 13
2[d]	1.1	PrCN[e]	58	0.50	21 : 76 : <1 : 3
3[d,f]	1.1	*t*-BuCN[e]	55	0.50	7 : 77 : 2 : 14
4[d]	1.1	PhCN[e]	40	0.65	10 : 88 : <1 : 2[g]

5	2	MeCN[h]	75	1.15	5 : 85 : 2 : 8
6	2	$(CF_3)_2CHOH$[h]	20[i]	-	15 : 41 : 23 : 21
7	2	CF_3CH_2OH[h]	28[i]	-	16 : 53 : 15 : 16
8[d]	1.1	*t*-BuOH[e]	7[i]	-	58 : 20 : 8 : 14[j]
9[d]	1.1	*t*-BuOH / MeCN (1:1)	60	0.5	10 : 78 : 1 : 11
10	1.1	Me_2CO	30	0.25	9 : 52 : 14 : 25
11	1.1	$HCONH_2$	45	-	31 : 33 : 11 : 25

[a] Reactions were performed on a 0.32 mmol scale; a solution of ArN_2BF_4 in a solvent (2 mL) was slowly added (over 10-30 min) to $CuCF_3$ in DMF at 0 ºC. [b] Determined by ^{19}F NMR. [c] Determined by GC-MS. [d] $CuCF_3$ in DMF was added to a solution of ArN_2BF_4 at 0 ºC. [e] The diazonium salt did not dissolve completely. [f] The reaction was performed at rt. [g] Isomeric products of radical arylation of PhCN (solvent) on the ring were detected. [h] $CuCF_3$ in DMA was used. [i] Cu metal was produced. [j] Other side products were detected.

Table S3. Trifluoromethylation of 4-$XC_6H_4N_2BF_4$ in the presence of various additives.

Entry[a]	**X**	**$CuCF_3$, equiv**	**$Et_3N{\cdot}3HF$, equiv**	**Additive**	**Yield, %**[b]	**$CuCF_3$ remained,**[b] **equiv**	**ArH / $ArCF_3$ / ArAr / ArN_2Ar**[c]
1	OMe	1.1	0.53[d]	phen (0.2 equiv)	47	0.35	19 : 76 : 3 : 2[e]
2[f]	OMe	1.1	0.33	TMEDA (1.2 equiv)	30	0.55	14 : 48 : 23 : 15[e]
3[f]	OMe	1.1	0.33	 (1.2 equiv)	72	0.45	6 : 84 : 1 : 9
4[f]	OMe	2	-[g]	HF[h] (2 equiv)	70	0.5	8 : 86 : 1 : 6
5[i]	OMe	1.1	0.33	HF[h] (9 equiv)	81	-	4 : 90 : <1 : 6
6[i]	OMe	2	0.33	HF[h] (9 equiv)	**85**	-	3 : 94 : <1 : 3
7[i]	Br	2	0.33	HF[h] (9 equiv)	78	-	4 : 87 : 9 : <1
8[i]	NO_2	2	0.33	HF[h] (9 equiv)	48	-	4 : 86 : 10 : -
9[i]	OMe	3	-[g]	HF[h] (43 equiv)	78	-	7 : 90 : <1 : 3
10[i]	OMe	3	0.33	HF[h] (43 equiv)	73	-	6 : 89 : <1 : 5
11	OMe	2	0.33	$Py(HF)_x$[j] (12 equiv)	73	-	4 : 94 : <1 : 2

12[f]	OMe	2	0.33	$Py(HF)_x$[j] (12 equiv)	66	<0.05	4 : 92 : <1 : 4

[a] Reactions were performed on a 0.32 mmol scale; $CuCF_3$ in DMF was slowly added (over 10-30 min) to a solution of ArN_2BF_4 in CH_3CN (2 mL) containing an additive at 0 ºC. [b] Determined by ^{19}F NMR. [c] Determined by GC-MS. [d] $CuCF_3$ reagent with 0.2 extra equiv of TREAT HF was used. [e] Other unidentified side-products were detected. [f] To $CuCF_3$ and the additive in DMF at 0 ºC was slowly added (10 min) a solution of ArN_2BF_4 in CH_3CN (2 mL). [g] The $CuCF_3$ reagent was prepared from $[K(DMF)][Cu(OBu^t)_2]$ and CHF_3 and used without stabilization immediately. [h] 48% aqueous HF. [i] The reaction was performed in a FEP flask. [j] HF/pyridine (70% HF).

Experimental Procedure (Entry 6)

Under argon, to a solution of *p*-methoxyphenyl diazonium tetrafluoroborate (purity 98%; 72 mg; 0.32 mmol) and 1,3-bis(trifluoromethyl)benzene (25 μL; 0.16 mmol; internal standard) in CH_3CN (2 mL) in a 50-mL FEP round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, was added at 0 ºC (ice bath) 48% aqueous HF (0.1 mL). To this solution still immersed in the ice bath, was added, at stirring, a solution of $CuCF_3$ in DMF (0.38 M; 1.7 mL; 2 equiv) via a syringe pump over 10 min. The reaction mixture was stirred for an additional 10 min at 0 ºC and allowed to warm to room temperature. Quantitative ^{19}F NMR analysis of the reaction mixture indicated that *p*-trifluoromethylanisole was produced in 85% yield. After stirring the reaction mixture with ether (3 mL) and aqueous K_2CO_3 (1M; 10 mL) in air, the organic layer was analyzed by GC-MS.

Solvent effect. Side Reduction in Various Amide Solvents

To confirm that the solvent is the main hydrogen source for the side-produced arene and rationalize the observed side-reduction suppression in the presence of CH_3CN, trifluoromethylation of 4-$MeOC_6H_4N_2BF_4$ was performed in various amide solvents and their mixtures with CH_3CN (Table S4).

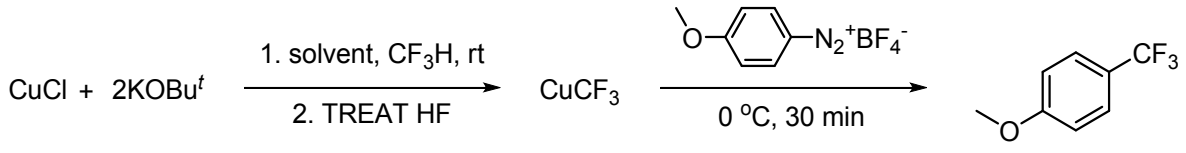


Table S4. Trifluoromethylation of 4-$MeOC_6H_4N_2BF_4$ in various amide solvents and their mixtures with CH_3CN.

Entry[a]	Solvent(s)	Yield, %[b]	$CuCF_3$ remained, equiv[b]	ArH(D) / $ArCF_3$[c]
1	DMF[d]	39	0.6	0.15
2	DMF-d_7[d]	51	0.5	0.04 (ArH/ArD = 1:1)
3	NMP[d]	43	0.7	0.34
4	DMA[d]	55	0.6	0.10
5	DMF/CH_3CN[e]	**72**	0.33	0.02
6	DMF/CH_3CN/H_2O[f]	69	-	0.05
7	DMF-d_7/CH_3CN[e]	70	0.35	0.02 (ArH/ArD = 10:1)
8	NMP/CH_3CN[e]	68	0.38	0.06
9	DMA/CH_3CN[e]	72	0.25	0.02

[a] A solution of ArN_2BF_4 (0.45 mmol) was slowly added (30 min) to $CuCF_3$ (1.1 equiv) in DMF at 0 ºC. [b] Determined by ^{19}F NMR. [c] Determined by GC-MS. [d] Volumes used: 1 mL for the preparation of $CuCF_3$, 0.1 mL for the preparation of the stabilizing TREAT HF solution, and 0.5 mL to dissolve the the diazonium salt. [e] A diazonium salt solution in CH_3CN (2 mL). [f] To a solution of 4-$MeOC_6H_4N_2BF_4$ in a mixture of CH_3CN (2 mL) and H_2O (2 mL) at 0 ºC, $CuCF_3$ in DMF (1.1 equiv; 1.1 mL) was added over 15 min.

The ArH/$ArCF_3$ (GC-MS) ratios determined for the reactions in DMF, DMF-d_7, NMP, and DMA under otherwise identical conditions, were 1:7, 1:25, 1:3, and 1:10, respectively (entries 1-4). These data point to hydrogen abstraction from both the formyl and NMe moieties. The secondary cyclic radical from NMP is more stable and forms faster, hence larger arene amounts. The arene side-product in the reaction mixture in DMF-d_7 was 1:1 ArH/ArD (GC-MS; entry 2), indicating that nondeuterated components of the mixture also served as H-sources, e.g., NEt_3 and/or *t*-BuOH. With CH_3CN cosolvent, the ArH to $ArCF_3$ ratio was almost solvent-independent (entries 5-9), the quantities of the formed arene being small (2% in DMF, DMF-d_7, and DMA, and 6% in NMP). The ArH/ArD ratio in the reaction in DMF-d_7/CH_3CN was 10:1 (entry 7), suggesting that both solvents served as the hydrogen source.

Experimental Procedure (Entry 5)

Under argon, to a mixture of CuCl (purity 99%; 50 mg; 0.5 mmol) and $KOBu^t$ (purity 97%; 120 mg; 1 mmol) in 10-mL flask was added DMF (1 mL) and the mixture was sonicated for 5 min. Then the argon was removed from the flask on the vacuum line and CF_3H (ca. 20 mL) was introduced via a syringe. The mixture was stirred for 10 min and the solution of TREAT HF in DMF (1.8 M; 0.1 mL) was added dropwise. To this mixture at 0 ºC was added the solution of *p*-methoxyphenyl diazonium tetrafluoroborate (purity 98%; 102 mg; 0.45 mmol) and 1,3-bis(trifluoromethyl)benzene (35 μL; 0.23 mmol; internal standard) in CH_3CN (2 mL) over 30 min via a syringe pump. The reaction mixture was stirred at 0 ºC for 10 min and heated to rt. Quantitative ^{19}F NMR analysis of the reaction mixture indicated that the desired product was produced in 72% yield (0.33 equiv of $CuCF_3$ remained

unreacted). After dilution of the reaction mixture with ether (2 mL) and washing with water (10 mL), the organic layer was analyzed by GC-MS.

Trifluoromethylation in the Presence of Radical Traps

In Table S5 the experiments of trifluoromethylation of para-methoxy benzenediazonium tetrafluoroborate using $CuCF_3$ in DMF in the presence of several radical traps in anhydrous conditions are presented.

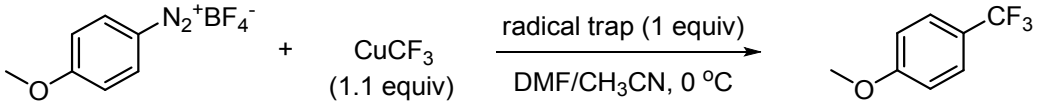


Table S5. Trifluoromethylation of 4-$MeOC_6H_4N_2BF_4$ in the presence of radical traps.

Entry[a]	Radical trap	Yield (15 min),[b] %	$CuCF_3$ remained,[b] equiv	Yield (3h),[b] %	Yield (after workup),[b] %	ArH / $ArCF_3$ / ArAr / ArN_2Ar[c]
1	BHT	63	0.5	63	62	7 : 68 : 3 : 22
2	DPPH	62	<0.05	62	62	11 : 89 : - : -
3	1,1-diphenyl-ethylene	61	0.5	61	60	5 : 90 : <1 : 5[d]
4	TEMPO	25	0.75	50	60	11 : 89 : <1 : -[e]

[a] Reaction conditions: a solution of ArN_2BF_4 (0.32 mmol) in CH_3CN (2 mL) was slowly added (10-15 min) to a mixture of $CuCF_3$ in DMF (1.1 equiv) and a radical scavenger (1 equiv) at 0 ºC. [b] Determined by ^{19}F NMR. [c] Determined by GC-MS. [d] 1,1-Diphenyl-2-(4-methoxyphenyl)ethylene (3-5%) was also detected. [e] Tetramethylpiperidine (10-15%) and ArOH (5-10%) were also detected.

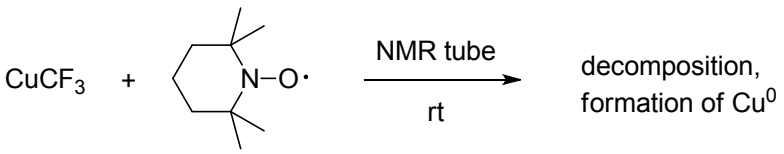
The stoichiometric amounts of butylated hydroxytoluene (BHT), 2,2-diphenyl-1-picrylhydrazyl (DPPH), and 1,1-diphenylethylene did not provide any significant effect on

the reaction yield and product distribution (entries 1-3). Only in case of 1,1-diphenylethylene the formation of somewhat diminished amounts of anisole (ca. 5% vs. 8% in the absence of the scavenger) was observed and also 1,1-diphenyl-2-(4-methoxyphenyl)ethylene (3-5 %), a product of the addition of the aryl radical, was detected (GC-MS). When performing the reaction in the presence of 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO) the trifluoromethylation was noticeably inhibited and only 25% yield was achieved in 15 min (entry 4). After the aqueous workup in air of a portion of the reaction mixture the yield of the trifluoromethylated product increased to ca. 60%.

Experimental Procedure (Entry 4)

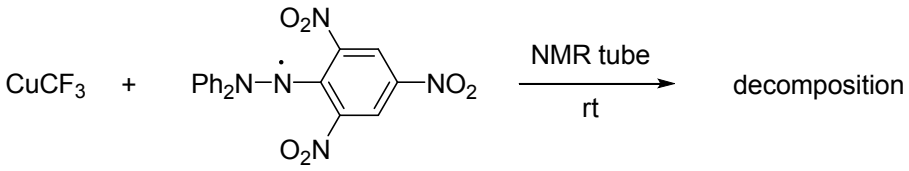
Under argon, to $CuCF_3$ in DMF (0.38M; 0.92 mL; 1.1 equiv) cooled to 0 ºC (ice bath), was added at stirring TEMPO (51 mg; 1 equiv) and then, via a syringe pump over 15 min, a solution of 4-$MeOC_6H_4N_2BF_4$ (purity 98%; 72 mg; 0.32 mmol) and 1,3-bis(trifluoromethyl)benzene (25 μL; 0.16 mmol; internal standard) in CH_3CN (2 mL). After the addition was complete the reaction mixture was stirred for an additional 10 min at 0 ºC and then for 15 min at room temperature. Quantitative ^{19}F NMR analysis of a ca. 0.5-mL aliquot of the reaction mixture indicated that *p*-trifluoromethylanisole was produced in 25% yield. This sample was then mixed with ether (1 mL) and distilled water (5 mL) in air and analyzed by ^{19}F NMR again to find that the yield of *p*-trifluoromethylanisole had increased to 60% yield. The originally produced reaction mixture was stirred at rt for 3 h and then analyzed as described above. The yield of *p*-trifluoromethylanisole was determined to be 50% and 60% before and after workup, respectively.

Decomposition of $CuCF_3$ in the presence of TEMPO (1 equiv):



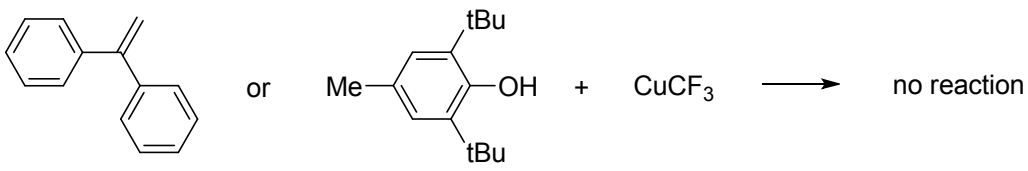
Time, h	$CuCF_3$ remained (^{19}F NMR), %
0.1	99
1	98
18	60

Decomposition of $CuCF_3$ in the presense of DPPH (1 equiv):



Time, h	$CuCF_3$ remained (^{19}F NMR), %
0.5	50
1.5	40
18	33

In contrast, 1,1-diphenylethylene and BHT did not decompose $CuCF_3$ at rt.



In Situ Preparation of Diazonium Salts. Varying the Order of Addition

The possibility of *in situ* trifluoromethylation of anilines by their diazotization and subsequent trifluoromethylation was explored. First, different mixing orders of the reagents ($MeC_6H_4NH_2$, *t*BuONO, and $CuCF_3$/DMF) were examined. The results of these experiments are summarized in Table S6.

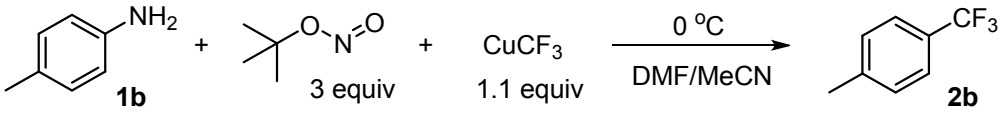


Table S6. Diazotization/trifluoromethylation of *p*-toluidine.

Conditions	$Et_3N{\cdot}3HF$, equiv	Yield (^{19}F NMR), %	$CuCF_3$ remained (^{19}F NMR), equiv[d]	ArH / $ArCF_3$ / ArNO / *t*-BuOAr / Ar_2NH (GC-MS)
A[a]	0.33	30	0.2	11 / 41 / 21 / 5 / 22
B[b]	0.53	35	<0.05	14 / 50 / 14 / 2 / 20
C[c]	0.53	40	<0.05	12 / 55 / 17 / - / 16

[a] $CuCF_3$ in DMF (0.35M; 1 mL) was added to a mixture of $ArNH_2$ (0.32 mmol) and *t*-BuONO (0.96 mmol) in MeCN (2 mL). [b] $ArNH_2$ (0.32 mmol) in MeCN (2 mL) was added to a mixture of $CuCF_3$ in DMF (0.35M; 1 mL) and *t*-BuONO (0.96 mmol). [c] *t*-BuONO (0.96 mmol) in MeCN (2 mL) was added to a mixture of $CuCF_3$ in DMF (0.35M; 1 mL) and $ArNH_2$ (0.32 mmol). [d] The reaction mixture was analyzed by ^{19}F NMR after stirring at rt for 10-15 min.

The low yields of 30-40% are rationalized by insufficiently efficient diazotization in the absence of an acid that is conventionally used to promote the reaction and decomposition of the $CuCF_3$ reagent by RONO and, to a minor extent, by $ArNH_2$ (Tables S7 and S8).

Stability of $CuCF_3$ toward $ArNH_2$ and RONO:

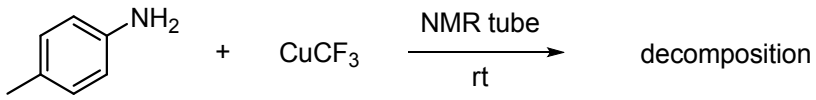


Table S7. Decomposition of $CuCF_3$ in the presense of *p*-toluidine.

Entry	Time, min	$CuCF_3$ remained (^{19}F NMR), %
1	15	99
2	85	97
3	180	90

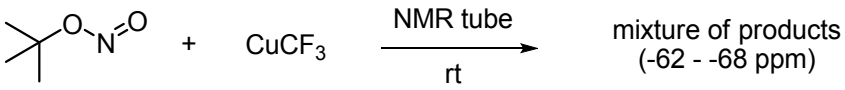


Table S8. Decomposition of $CuCF_3$ in the presense of *tert*-butyl nitrite.

Entry	Time, min	$CuCF_3$ remained (^{19}F NMR), %
1	15	82
2	85	66
3	180	47

Screening of Different Acids for *in situ* Generation of Diazonium Salts

Optimization of conditions for the two step sequence of *in situ* generation of diazonium salts in the presence of various acids and subsequent trifluoromethylation was performed on *p*-anisidine (Table S9).

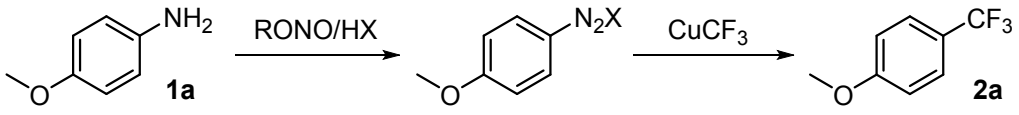


Table S9. Screening of acids for *in situ* generation of diazonium salts. The reaction of *p*-anisidine.

Entry[a]	R	RONO, equiv	HX (1.1 equiv)	T, °C	t, min	$CuCF_3$, equiv	$Et_3N{\cdot}3HF$, equiv	Yield,[b] %	$CuCF_3$ remained,[b] equiv	Products composition (GC-MS)
1	t-Bu	1.5	$BF_3{\cdot}Et_2O$	0 rt	30 10	1.1	0.53	53	0.25	ArH / $ArCF_3$ / ArAr / Ar_2NH / ArN=NAr 10% 79% 1% 1% 9%
2	i-Pent	1.5	$BF_3{\cdot}Et_2O$	0 rt	30 60	1.1	0.53	45	0.3	ArH / $ArCF_3$ / ArAr / Ar_2NH / ArN=NAr 15% 77% 1% 3% 4%
3	t-Bu	1.5	HCl[c]	0 rt	50 25	1.1	0.53	55	0.25	ArH / $ArCF_3$ / ArCl / $ArNO_2$ / ArAr / ArN=NAr 3% 71% 15% 5% 3% 3%
4[d]	t-Bu	1.5	HCl[c]	0	30	1.1	0.33	30	0.4	ArH / $ArCF_3$ / ArCl / $ArNO_2$ / ArAr / ArN=NAr 4% 43% 39% 9% 2% 3%
5	t-Bu	1.5	$MeSO_3H$	0 rt	60 15[e]	1.1	0.53	55	0.3	ArH / $ArCF_3$ / ArAr / Ar_2NH / ArN=NAr 9% 75% 3% 1% 12%
6	t-Bu	1.5	HOAc	0 rt	50 15[f]	1.1	0.53	22	0.2	ArH / $ArCF_3$ / $ArNH_2$ / Ar_2NH / ArN=NAr 17% 55% 14% 13% 1%
7	t-Bu	1.5	-	0 rt	30 15[f]	1.1	0.53	41	0.4	ArH / $ArCF_3$ / $ArNH_2$ / Ar_2NH / ArN=NAr 14% 69% 7% 9% 1%
8	t-Bu	1.5	-	0 rt	30 15[f]	1.1	0.33	35	0.7	ArH / $ArCF_3$ / $ArNH_2$ / Ar_2NH / ArN=NAr 8% 54% 6% 23% 9%
9	t-Bu	1.2	$MeSO_3H$	0 rt	60 15[e]	1.1	0.53	63	0.3	ArH / $ArCF_3$ / ArAr / Ar_2NH / ArN=NAr 6% 70% 2% 1% 21%
10	t-Bu	1.2	$MeSO_3H$	0 rt	30 30[e]	1.1	0.33	56	0.3	ArH / $ArCF_3$ / $ArCH_2CN$ / ArAr / ArN=NAr 10% 78% 2% 2% 8%
11	t-Bu	1.2	$MeSO_3H$	0 rt	30 30[e]	2.2	0.33	60	1.1	ArH / $ArCF_3$ / $ArCH_2CN$ / ArAr / ArN=NAr 8% 80% 2% 2% 8%

[a] Reaction conditions: a solution of *p*-anisidine (0.18 mmol), RONO (1.2-1.5 equiv), and HX (1.1 equiv) in CH_3CN (1 mL) was stirred first at 0 ºC and then at rt for a specified periods of time (TLC monitoring). The thus prepared solution of the diazonium salt was then added over 30 min (syringe pump) to $CuCF_3$ in DMF (0.35M; 1 mL; 1.1 equiv) premixed with CH_3CN (1 mL) at 0 ºC and stirred for an additional 10 min at 0 ºC. [b] ^{19}F NMR. [c] HCl in dioxane (4M). [d] Reversed addition: $CuCF_3$ in DMF to the diazonium solution at 0 ºC. [e] RNH_3SO_3Me completely dissolved. [f] The unreacted starting material was still present in the reaction mixture (TLC).

General Procedure:

Under argon, to a solution of *p*-anisidine (23 mg; 0.18 mmol) and 4,4'-difluoro-1,1'-biphenyl (52 mg; 0.27 mmol; internal standard) in CH_3CN (1 mL) at 0 ºC, was added HX (1.1 equiv) followed by RONO (1.2-1.5 equiv). The reaction mixture was stirred first at 0 ºC and then at rt (see Table S9 for specifics). The thus prepared solution of the diazonium salt was then added via a syringe pump over 30 min at 0 ºC to $CuCF_3$ in DMF (0.35M; 1.1-2.2 equiv) premixed with CH_3CN (1 mL) and stirred for an additional 10 min at 0 ºC. After quantitative ^{19}F NMR analysis, the reaction mixture was treated with ether (2 mL) and water (10 mL), and the organic layer was analyzed by GC-MS.

III. Trifluoromethylation of Arenediazonium Salts under Aqueous Conditions

Trifluoromethylation of *p*-Anisidine under Aqueous Conditions

Table S10 displays a summary of the results of optimization studies of the trifluoromethylation reaction of *p*-anisidine under aqueous conditions. Inorganic acids H_2SO_4 (96%), H_3PO_4 (85%), HNO_3 (65%), HBF_4 (48%) were used to generate the diazonium salt. The highest yields of *p*-trifluoromethylanisole were achieved using H_2SO_4 (2 equiv) and HBF_4 (2 equiv). A larger excess of H_2SO_4 (6 equiv) diminished the yield and larger quantities of the undesired reduction product (anisole) were produced (entry 13). The addition of 48% aqueous HF (10-14 equiv) to the preformed diazonium salt benefited the trifluoromethylation in terms of both selectivity and yield (Table S10, entries 14-18, 22, and 23).

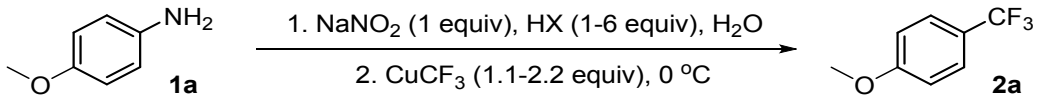


Table S10. ***In situ*** **diazotization of** ***p*****-anisidine with $NaNO_2$/HX in water and subsequent trifluoromethylation with $CuCF_3$.**

Entry[a]	**HX, equiv**	**$CuCF_3$, equiv**	**Additive(s)**	**Yield, %**[b]	**ArH / $ArCF_3$ / $ArCH_2CN$ / ArAr / ArNHAr / ArN_2Ar**[c]
1[d,e]	H_2SO_4 (96%; 1.8 equiv)	2.2[f]	-	32[g]	13 : 57 : <1 : 5 : <1: 25
2[d,e]	H_2SO_4 (96%; 1.8 equiv)	2.2[f]	-	33	14 : 56 : <1: 5 : <1: 25
3[d,e]	H_2SO_4 (96%; 1 equiv)	2.2[f]	-	33[g]	13 : 55 : <1: 8 : 1: 23
4[d]	H_2SO_4 (96%; 1 equiv)	2.2[f]	-	56	6 : 83 : 1: 1 : <1: 9
5[d]	H_2SO_4 (96%; 1 equiv)	2.2	-	60	6 : 79 : 1: 1 : 1: 12
6	H_2SO_4 (96%; 2 equiv)	2.2	-	70	11 : 77 : - : 1 : 1 : 10
7	H_2SO_4 (96%; 2 equiv)	2.2[h]	-	70	11 : 78 : 1 : 1 : 1 : 8
8	H_2SO_4 (96%; 2 equiv)	2.2[h]	pyrrolidine (2 equiv)	30	20 : 72 : 2 : 3 : - : 3[i]
9	H_2SO_4 (96%; 2 equiv)	1.5	-	70	11 : 77 : - : 1 : 3 : 8
10	H_2SO_4 (96%; 2 equiv)	1.1	-	69	10 : 77 : - : 1 : 3 : 9

11	H_2SO_4 (96%; 1.5 equiv)	1.5	-	61	15 : 70 : 2 : 3 : 1 : 9
12	H_2SO_4 (96%; 3 equiv)	1.5	-	62	13 : 76 : - : 1 : 5 : 5
13	H_2SO_4 (96%; 6 equiv)	1.5	-	38	32 : 59 : - : 1 : 4 : 4
14	H_2SO_4 (96%; 1.5 equiv)	2.2	HF (48%; 0.35 mL; 10 equiv), Na_2SO_4 (1 g)	80	9 : 87 : - : <1 : 1 : 3
15	H_2SO_4 (96%; 1.5 equiv)	2.2	HF (48%; 0.35 mL; 10 equiv)	77	9 : 85 : - : <1 : 1 : 4
16	H_2SO_4 (96%; 2 equiv)	2.2	HF (48%; 0.35 mL; 10 equiv)	76	11 : 84 : - : <1 : 1 : 4
17	H_2SO_4 (96%; 2 equiv)	2.2	HF (48%; 0.35 mL; 10 equiv), Na_2SO_4 (1 g)	75	11 : 82 : - : <1 : 1 : 6
18	H_2SO_4 (96%; 1 equiv)	2.2	HF (48%; 0.35 mL; 10 equiv)	69	10 : 82 : - : <1 : 2 : 6
19	H_3PO_4 (85%; 2 equiv)	2.2	-	45	19 : 58 : 3 : 1+9+2[j] : <1 : 8
20	HNO_3 (65%; 2 equiv)	2.2	-	60	9 : 70 : 4 : 2 : 2 : 13
21	HBF_4 (48%; 2 equiv)	2.2	-	66	8 : 78 : 2 : 1 : - : 11
22	HBF_4 (48%; 2 equiv)	2.2	HF (48%; 0.35 mL; 10 equiv)	75	4 : 84 : - : 1 : - : 11
23	HBF_4 (48%; 2 equiv)	2.2	HF (48%; 0.5 mL; 14 equiv)	77	5 : 86 : - : <1 : - : 9

[a] Reagents: *p*-anisidine (123 mg; 1 mmol) suspended in water (0.5 mL), HX (1.5-14 equiv), $NaNO_2$ in water (2 M; 0.5 mL; 1 equiv), CH_3CN (10 mL), 1,3-bis(trifluoromethyl)benzene (77 μL; 0.5 mmol; internal standard), $CuCF_3$ in DMF (1.1-2.2 equiv). [b] Determined by ^{19}F NMR. [c] Determined by GC-MS. [d] H_2SO_4 in water (2 mL) and $NaNO_2$ in water (1 mL) were used. [e] No CH_3CN was added to the reaction mixture. [f] $CuCF_3$ in DMF was added fast (10-15 sec) via syringe. [g] Reaction performed in air. [h] Freshly prepared unstabilized $CuCF_3$ was used. [i] Other side products were detected. [j] A mixture of isomers.

Experimental Procedure (Entry 7)

Under argon, to *p*-anisidine (123 mg; 1 mmol) were added water (0.5 mL) and H_2SO_4 (96%; 0.11 mL; 2 equiv) and the mixture was sonicated for 5-10 min to produce a white homogeneous suspension. To this vigorously stirred suspension at 0 ºC, a solution of $NaNO_2$ (2 M; 0.5 mL; 1 equiv) was added dropwise over ca. 5 min. The white solid of *p*-anisidinium hydrogen sulfate had completely dissolved toward the end of the addition. After CH_3CN (10 mL) and 1,3-bis(trifluoromethyl)benzene (77 μL; 0.5 mmol; internal standard) were added, the solution was treated at 0 ºC with $CuCF_3$ in DMF (ca. 0.4 M; 5.5 mL), which was added slowly (10 min) via a syringe pump. The reaction mixture was allowed to warm to room temperature and after dilution with ether (5 mL) and washing with water (25 mL) the organic layer was analyzed by ^{19}F NMR and GC-MS. The yield of *p*-trifluoromethylanisole was 70%.

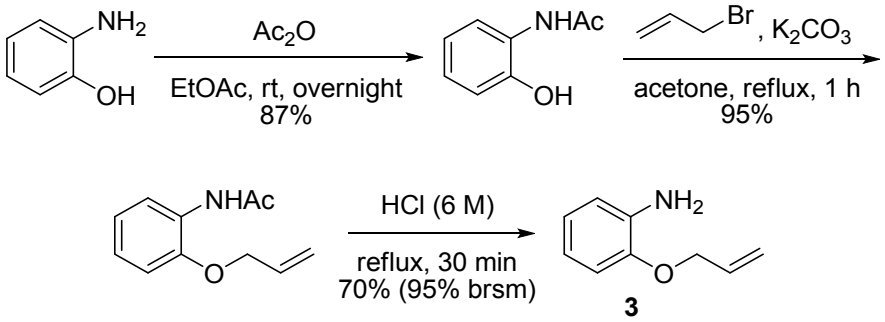
Experimental Procedure (Entry 15)

Under argon, a 50-mL FEP round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum was charged with *p*-anisidine (123 mg; 1 mmol) and water (0.5 mL). Sulfuric acid (96%; 83 μL; 1.5 equiv) was added and the reaction mixture was sonicated for 5-10 min to produce a white homogeneous suspension. To this vigorously stirred suspension at 0 ºC, was added dropwise a solution of $NaNO_2$ (2 M; 0.5 mL; 1 equiv) over ca. 5 min. Toward the end of the addition the white solid of *p*-anisidinium hydrogen sulfate had completely dissolved. To this solution were added aqueous HF (48%; 0.35 mL; 10 equiv), CH_3CN (10 mL) and 1,3-bis(trifluoromethyl)benzene (77 μL; 0.5 mmol; internal standard) and the resultant mixture was treated at 0 ºC with $CuCF_3$ in DMF (0.38 M; 5.8 mL; 2.2 equiv) that was added over 10 min via a syringe pump. The reaction mixture was allowed

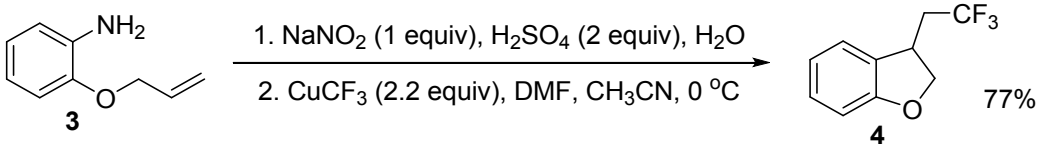
to warm to room temperature and after dilution with ether (5 mL) and washing with water (25 mL) the organic layer was analyzed by ^{19}F NMR and GC-MS. The yield of *p*-trifluoromethylanisole was 77%.

Radical Clock Experiment

The radical clock substrate (**3**) was prepared following the literature procedure, as shown below.[2]

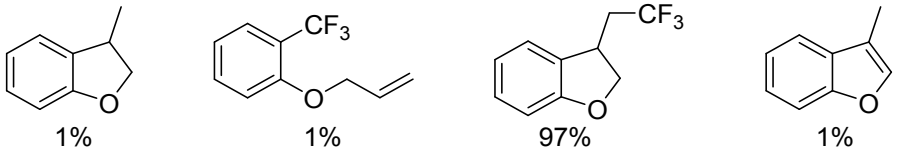


The trifluoromethylation of **3** was performed under the aqueous conditions previously used for the trifluoromethylation of *p*-anisidine (Table S10, entry 7):



The cyclic trifluoromethylated product **4** was obtained in 77% yield and only trace amounts of the corresponding acyclic product (ca. 1%) together with some other side products were detected (GC-MS and ^{19}F NMR).

Product Distribution (GC-MS):



1% 1% 97% 1%

Experimental Procedure:

Under argon, to 2-(allyloxy)aniline (**3**; 150 mg; 1 mmol) and water (0.5 mL) was added at 0 ºC at stirring H_2SO_4 (96%; 0.11 mL; 2 equiv), then a solution of $NaNO_2$ (2M; 0.5 mL) over 5 min (dropwise), CH_3CN (10 mL), and 1,3-bis(trifluoromethyl)benzene (77 μL; 0.5 mmol; internal standard). To the resultant solution at 0 ºC was added over a period of 10 min via a syringe pump freshly prepared unstabilized $CuCF_3$ in DMF (ca. 0.4 M; 5.5 mL; 2.2 equiv). The reaction mixture was allowed to warm to room temperature and after dilution with ether (5 mL) and washing with water (25 mL), the organic layer was analyzed by GC-MS and ^{19}F NMR. The determined product distribution is shown above.

Diazotization in Aqueous HF. Optimization and Substrate Scope

We found that superior results can be obtained by performing the reaction with aqueous HF in the absence of a stronger acid. A summary of optimization experiments with various aromatic amines is presented in Table S11.

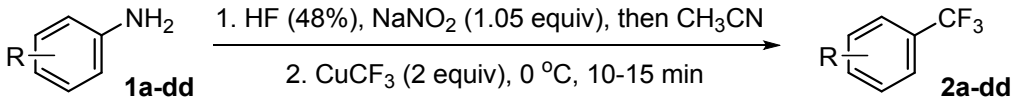
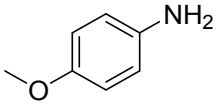
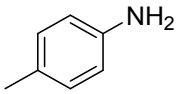
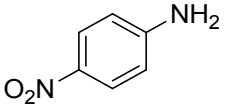
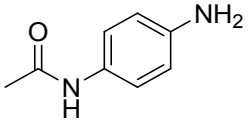
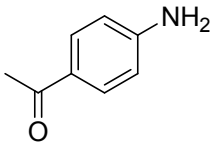
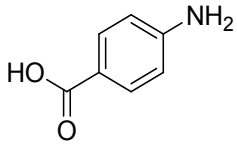
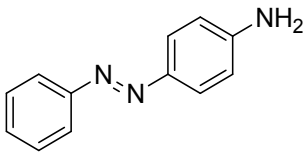
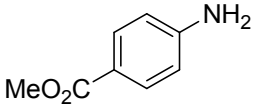
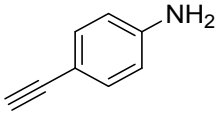
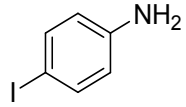
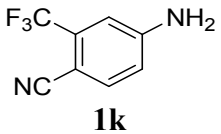
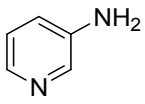
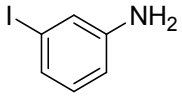
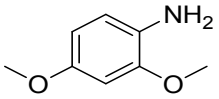
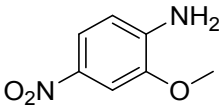
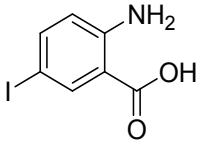
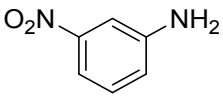
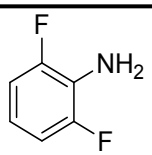
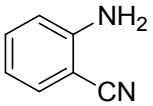
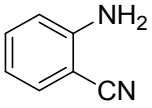
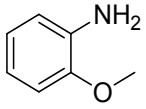
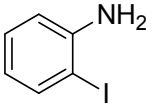
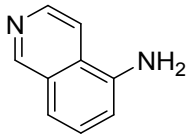
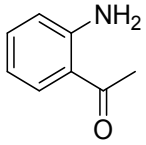


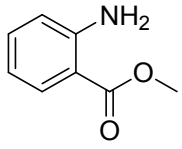
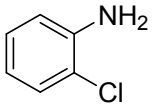
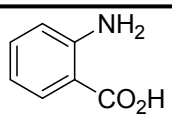
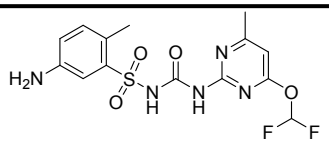
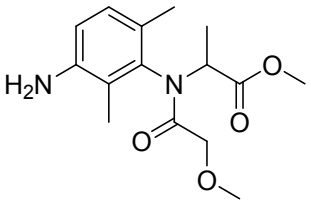
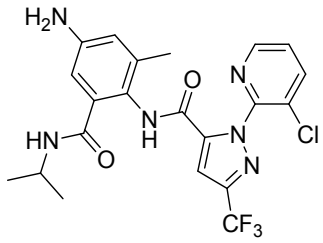
Table S11. Trifluoromethylation of arenediazonium salts generated with aqueous HF.

Entry[a]	Substrate	HF (48%), mL	MeCN, mL	Yield, %[b]	ArH / $ArCF_3$ / ArAr / ArN_2Ar[c]	ArH / $ArCF_3$
1	 **1a**	0.25	2	76	4 : 94 : <1 : 2	0.04
2		0.25	5	**81**	4 : 96 : <1 : <1	0.04
3		0.25	5	58[d]	11 : 89 : <1 : <1	0.12
4		0.25	8	75	5 : 95 : <1 : <1	0.05
5	 **1b**	0.25	2	72	4 : 82 : 11 : 3	0.05
6		0.25	3	80	3 : 91 : 3 : 3	0.03
7		0.25	5	**84**	3 : 97 : <1 : <1	0.03
8		0.25	8	84	3 : 97 : <1 : <1	0.03
9	 **1c**	0.25	5	50	7 : 93 : <1 : -	0.08
10		0.5	5[e]	55[f]	4 : 95 : 1 : -	0.04
11		0.5	10[e]	**70**[f]	3 : 97 : <1 : <1($ArNH_2$) : -	0.03
12		0.5	30[e]	42[f]	6 : 90 : <1 : 4($ArNH_2$) : -	0.07
13	 **1d**	0.25	5	80	--[g]	-
14		0.5	5[e]	78[f]	--[g]	-
15		0.5	10[e]	53[f]	--[g]	-
16		0.5	5	77	--[g]	-
17		0.5	5	78	1 : 99 : - : -	0.01
18		0.5	10	**80**	1 : 99 : - : -	0.01
19	 **1e**	0.25	5	66	4 : 90 : 6 : -	0.04
20		0.5	10[e]	**72**[f]	3 : 97 : - : -	0.03
21		0.5	20[e]	64[f]	5 : 95 : - : -	0.05

22	 **1f**	0.25	5	57	<1 : >99 : - : -	<0.01
23		0.5	10	**85**	<1 : >99 : - : -	<0.01
24		1	10	83	<1 : >99 : - : -	<0.01
25		1	15	82	<1 : >99 : - : -	<0.01
26	 **1g**	0.5	5	**71**	4 : 96 : - : -	0.04
27		0.5	10	60	3 : 97 : - : -	0.03
28		0.5	15	61	4 : 96 : - : -	0.04
29		1	15	71	3 : 97 : - : -	0.03
30	 **1h**	0.5	10	**85**	4 : 96 : <1 : -	0.04
31	 **1i**	0.25	5	**47**	2 : 97 : - : -	0.02
32		0.25	10	45	2 : 98 : - : -	0.02
33		0.25	10	20[h]	4 : 96 : - : -	0.04
34	 **1j**	0.25	5	54	5 : 93 : 2 : -[i]	0.05
35		0.5	1[e] + 9	**80**	2 : 98 : <1 : -[i]	0.02
36	 **1k**	0.5	10	46 (7:13:5)[j]	8 : 84 : 7 : 1($ArNH_2$) : -	0.10
37		1	20	51[j] (5:7:12)[j]	6 : 88 : 2 : 4($ArNH_2$) : -	0.07
38		1	1[e] + 19	**60** (6:12:-)[j]	6 : 78 : 16 : -	0.08
39		2	1[e] + 19	53 (5:16:-)[j]	4 : 74 : 22 : -	0.05
40	 **1l**	0.25	5	42	1 : 72 : 27 : -	0.01
41		0.25	10	50	1 : 93 : 6 : -	0.01
42		0.25	10[e]	<1	-	-
43		0.25	20	61	<1 : 97 : 3 : -	<0.01
44		0.25	20[e]	0	-	-
45		0.25	30	**65**	<1 : >99 : <1 : -	<0.01
46	 **1m**	0.25	5	47	6 : 94 : <1 : -[i]	0.06
47		0.5	1[e] + 9	**50**	2 : 98 : <1 : -[i]	0.02

48	 **1n**	0.25	5	64	14 : 86 : - : -	0.16
49		0.25	10	**70**	11 : 89 : - : -	0.13
50		0.25	10[e]	24[f]	17 : 76 : - : - : 1 ($ArNH_2$) : 6 (ArNCO)	0.22
51		0.5	10	55	24 : 76 : - : -	0.31
52		1	10	32	50 : 50 : - : -	1.02
53		2	10	8	85 : 15 : - : -	5.67
54		0.2[l]	10	56	23 : 75 : - : - : 2 ($ArCH_2CN$)	0.31
55		0.2[l]	20	55	24 : 71 : - : - : 5 ($ArCH_2CN$)	0.34
56	 **1o**	0.25	5	56	21 : 79 : - : -	0.27
57		0.5	10	70	6 : 94 : - : -	0.06
58		1	10	**75**	3 : 97 : - : -	0.03
59		1	15	74	4 : 96 : - : -	0.04
60	 **1p**	0.5	5	48	10 : 90 : - : -[m]	0.11
61		1	1[e] + 9	**64**	3 : 97 : - : -	0.03
62	 **1q**	0.25	5	48	9 : 88 : 3 : -	0.10
63		0.5	10	68	2 : 98 : - : -	0.02
64		0.5	15	**73**	2 : 98 : - : -	0.02
65		1	15	69	2 : 98 : - : -	0.02
66	 **1r**	0.25	5	8	61 : 19 : 7+13 : -[m]	3.21
67		2	20	**27**	43 : 41 : 16 : -	1.05
68	 **1s**	0.15	5	27	24 : 66 : 10 : -	0.36
69		0.25	5	39	21 : 63 : 16 : -	0.34
70		0.25	5	29[n]	21 : 58 : 21 : -	0.36
71		0.25	5	31[o]	31 : 63 : 6 : -	0.47
72		0.35	5	37	14 : 56 : 30 : -	0.25
73		1	5	35	8 : 56 : 36 : -	0.14
74		1	10	43	8 : 73 : 19 : -	0.11

75	 **1s**	1	10[e]	51	8 : 84 : 8 : -	0.09
76		1	5[e] + 5	48	12 : 82 : 6 : -	0.15
77		1	15[e]	49	8 : 90 : 2 : -	0.09
78		1	15[e]	59[p]	8 : 87 : 5 : -	0.09
79		1	15[e]	60[f]	6 : 90 : 4 : -	0.07
80		1	15[e]	**64**[f,k]	7 : 91 : 2 : -	0.08
81		1	20[e]	56	9 : 90 : 1 : -	0.10
82		1	20[e]	60[f]	7 : 91 : 2 : -	0.08
83		1	20[e]	64[f,k]	7 : 92 : 1 : -	0.07
84		1.5	15[e]	47	10 : 85 : 5 : -	0.12
85		2	15[e]	41	12 : 83 : 4 : -	0.15
86		2	20[e]	50	9 : 86 : 5 : -	0.10
87		2	30[e]	55	7 : 90 : 3 : -	0.08
88		2	30[e]	61[p]	8 : 91 : 1 : -	0.09
89		2	30[e]	61[f]	8 : 90 : 2 : -	0.09
90	 **1t**	0.25	5	**85**	3 : 97 : <1 : <1	0.03
91	 **1u**	0.25	5	36	17 : 75 : 8 : -[i]	0.22
92		1	10	**58**	9 : 90 : 1 : -[i]	0.10
93	 **1v**	0.5	10	**70** (16:3:-)[j]	10 : 85 : 5 : -	0.12
94	 **1w**	0.25	5	37	13 : 87 : - : -	0.15
95		1	10	**73**[k]	<1 : >99 : - : -	<0.01
96		10	100	**69**[q] (5 mmol)	<1 : >99 : - : - (- : 90 : 10 : -)[r]	<0.01
97	 **1x**	0.5	10	70	2 : 93 : 5 : -	0.02
98		1	15	**75**[k]	1 : 96 : 3 : -	0.01

99	 **1y**	0.5	10	60	10 : 85 : 5 : -	0.12
100		1	15	**63**	6 : 88 : 6 : -	0.06
101		2	20	51	14 : 76 : 10 : -	0.18
102	 **1z**	0.5	10	59	13 : 80 : 1($ArNH_2$) : 4 : 1(Ar_2NH) : 1	0.17
103		1	15	**69**	12 : 86 : 2 : -	0.14
104	 **1aa**	0.5	10	76	<1 : >99 : - : -	<0.01
105		1	10	**78**	<1 : >99 : - : -	<0.01
106	 **1bb**	0.5	10	**64**[s]	--	-
107		1	20	18 (**66**)[q] (1 mmol)	9 : 91 : - : -[r]	0.10
108	 **1cc**	0.5	10	75	8 : 92 : - : -	0.09
109		1	10	**82**[k]	3 : 97 : - : -	0.03
110		4	40	**78**[q] (2 mmol)	5 : 95 : - : -	0.05
111	 **1dd**	0.5	1[e] + 9	55[f]	12 : 60 : - : - : 28 ($ArNH_2$)[r]	0.20
112		0.5[t]	1[e] + 4	**70**[f]	15 : 85 : - : -[r]	0.17
113		1.5	1[e] + 14	41 (**69**)[q] (0.75 mmol)	14 : 86 : - : -[r]	0.16
114		1[t]	1[e] + 4	70[f]	14 : 86 : - : -[r]	0.16

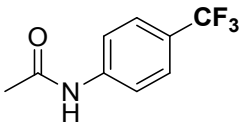
[a] Reactions were performed on a 0.5 mmol scale using 4,4'-difluoro-1,1'-biphenyl (35 mg; 0.19 mmol; 0.25 equiv) or 1,3-bis(trifluoromethyl)benzene (39 µL; 0.25 mmol; 1 equiv) as internal standards. [b] Determined by ^{19}F NMR. [c] Determined by GC-MS. [d] Both the diazotization and trifluoromethylation were performed at rt. [e] Volume of CH_3CN added before the addition of $NaNO_2$. [f] The diazonium salt solution was stirred for 10 min at 0 ºC. [g] ArH has the same retention time as the internal standard (4,4'-difluoro-1,1'-biphenyl) used in this particular run. [h] 1.2 equiv of $CuCF_3$ reagent. [i] Bis(trifluoromethyl)benzenes (2-5%) and diiodobenzenes (7-22%) were also detected. In the highest yielding reactions, the yields of side-produced bis(trifluoromethyl)benzenes and diiodobenzenes were 3% and 7% (entry 35), 3% and 7% (entry 47), and 5% and 10% (entry 92). [j] ArH/ArAr/$ArNH_2$ (^{19}F NMR ratio). [k] $CuCF_3$ in DMAc (0.38 M) was used. [l] The reaction was performed on a 1 mmol scale. [m] Other unidentified side product(s). [n] The diazonium salt solution was allowed to warm to rt (5 min). [o] 1.2 equiv of $NaNO_2$. [p] The diazonium salt solution was stirred for 30-40 min at 0 ºC. [q] Isolated yield of the clean product after purification with calculated overall yield (^1H NMR) in parentheses. [r] Determined by ^1H and/or ^{19}F NMR. [s] A CF_2H impurity (ca. 5%) in the starting material and consequently in the product detected by ^{19}F NMR. [t] 0.25 mmol scale.

General Procedure

A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

Under argon, to a substituted aniline (0.5 mmol) and 4,4'-difluoro-1,1'-biphenyl (35 mg; 0.19 mmol; 0.25 equiv; internal standard) or 1,3-bis(trifluoromethyl)benzene (39 μL; 0.25 mmol; 1 equiv; internal standard) in a 50-mL FEP flask, was added at 0 ºC 48% aqueous HF (0.15-2 mL) and then, dropwise, the stock solution of $NaNO_2$ (69 μL; 1.05 equiv). Acetonitrile (2-30 mL) was added slowly at stirring, to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.38 M; 2.6 mL; 2 equiv) was added at 0 ºC over a period of 10 min via a syringe pump. After the addition was finished the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room temperature. Quantitative ^{19}F NMR analysis of the reaction mixture allowed for the determination of the yield of the desired trifluoromethylated product and indicated that no unreacted $CuCF_3$ was left. After dilution of the reaction mixture with ether (5-10 mL) and washing with saturated aqueous solution of K_2CO_3 (15 mL; workup **A**) or water (10 mL; workup **B**) or aqueous ammonia (33%; 10 mL; workup **C**), the organic layer was analyzed by GC-MS. Workup procedure **A** was used in all cases, except for **1f**, **1p**, and **1aa** (procedure **B**) and **1l**, **1w**, and **1bb**-**1dd** (procedure **C**).

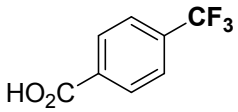
***N*-(4-(trifluoromethyl)phenyl)acetamide (2d):**



A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

Under argon, to *N*-(4-aminophenyl)acetamide (**1d**; purity 99%; 758 mg; 5 mmol) placed in a 500-mL PFA round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, were added at 0 ºC (ice bath), at agitation, 48% aqueous HF (5 mL) and then, dropwise, the stock solution of $NaNO_2$ (0.69 mL; 1.05 equiv). Acetonitrile (100 mL) was added slowly at stirring to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.38 M; 26 mL; 2 equiv) was added at 0 ºC over a period of 10 min via a syringe pump. After the addition was finished, the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room temperature. Ether (50 mL), water (250 mL), and aqueous ammonia (33%; 25 mL) were added to the reaction mixture in air. After agitation, the organic layer was separated and the aqueous layer washed with ether (3 × 50 mL). The combined ether solutions were washed with brine (3 × 50 mL), dried over $MgSO_4$, filtered, and evaporated. The residue was purified on a short silica gel plug with dichloromethane to give **2d** as a white solid (0.79 g; 78%). ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 7.63 (d, J = 8.6 Hz, 2H), 7.57 (d, J = 8.7 Hz, 2H), 7.33 (bs, 1H), 2.21 (s, 3H). ^{13}C NMR (methanol-d_4, 100 MHz): δ = 171.9, 143.5 (q, $^4J_{C–F}$ = 1.2 Hz), 125.7 (q, $^1J_{C–F}$ = 270.5 Hz), 126.9 (q, $^3J_{C–F}$ = 3.8 Hz), 126.5 (q, $^2J_{C–F}$ = 32.5 Hz), 120.6, 24.0. ^{19}F NMR ($CDCl_3$, 376 MHz): δ = -62.3 (s).[3]

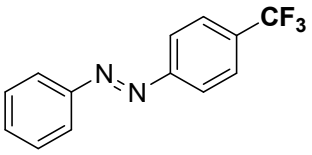
4-(Trifluoromethyl)benzoic acid (2f):



A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

Under argon, to 4-aminobenzoic acid (**1f**; purity 99%; 416 mg; 3 mmol) placed in a 500-mL PFA round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, were added at 0 ºC (ice bath), at agitation, 48% aqueous HF (3 mL) and then, dropwise, the stock solution of $NaNO_2$ (0.41 mL; 1.05 equiv). Acetonitrile (60 mL) was added slowly at stirring to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.38 M; 16 mL; 2 equiv) was added at 0 °C over a period of 10 min via a syringe pump. After the addition was finished, the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room temperature. Ether (50 mL) and water (150 mL) were added to the reaction mixture in air. After agitation, the organic layer was separated and the aqueous layer washed with ether (3 × 50 mL). The combined ether solutions were washed with brine (3 × 50 mL), dried over $MgSO_4$, filtered, and evaporated. Purification of the residue on a short silica gel plug with EtOAc/hexane (1:2 v/v) and subsequent recrystallization from water/MeOH (2:1 v/v) gave **2f** as a white solid (0.46 g; 80%). ^{1}H NMR (methanol-d_4, 400 MHz): δ = 8.24 – 8.16 (m, 2H), 7.82 – 7.76 (m, 2H). ^{13}C NMR (methanol-d_4, 100 MHz): δ = 168.2, 135.6, 135.2 (q, $^2J_{C–F}$ = 32.3 Hz), 131.3, 126.4 (q, $^3J_{C–F}$ = 3.8 Hz), 125.2 (q, $^1J_{C–F}$ = 271.8 Hz). ^{19}F NMR (methanol-d_4, 376 MHz): δ = -64.3 (s).[4]

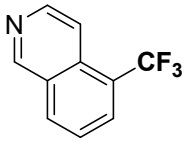
(*E*)-1-phenyl-2-(4-(trifluoromethyl)phenyl)diazene (2g):



A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

Under argon, to (*E*)-4-(phenyldiazenyl)aniline (**1g**; purity 98%; 805 mg; 4 mmol) placed in a 500-mL PFA round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, were added at 0 ºC (ice bath), at agitation, 48% aqueous HF (4 mL) and then, dropwise, the stock solution of $NaNO_2$ (0.55 mL; 1.05 equiv). Acetonitrile (40 mL) was added slowly at stirring to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.38 M; 21 mL; 2 equiv) was added at 0 ºC over a period of 10 min via a syringe pump. After the addition was finished the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room temperature. Ether (40 mL), water (200 mL), and aqueous ammonia (33%; 20 mL) were added to the reaction mixture in air. After agitation, the organic layer was separated and the aqueous layer washed with ether (3 × 40 mL). The combined ether solutions were washed with brine (3 × 50 mL), dried over $MgSO_4$, filtered, and evaporated. The residue was purified on a short silica gel plug with hexanes to give **2g** as an orange solid (0.68 g; 68%). ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 8.04 – 7.99 (m, 2H), 7.98 – 7.94 (m, 2H), 7.82 – 7.75 (m, 2H), 7.59 – 7.49 (m, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 154.6 (d, $^4J_{C–F}$ = 1.5 Hz), 152.6, 132.4 (q, $^2J_{C–F}$ = 32.5 Hz), 132.0, 129.4, 126.4 (q, $^3J_{C–F}$ = 3.8 Hz), 124.1 (q, $^1J_{C–F}$ = 272.4 Hz), 123.3, 123.2. ^{19}F NMR ($CDCl_3$, 376 MHz): δ = -62.7 (s).[5]

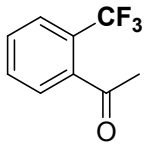
5-(Trifluoromethyl)isoquinoline (2w):



A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

Under argon, to 5-aminoisoquinoline (**1w**; purity 99%; 728 mg; 5 mmol) placed in a 500-mL PFA round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, were added at 0 ºC (ice bath), at agitation, 48% aqueous HF (10 mL) and then, dropwise, the stock solution of $NaNO_2$ (0.69 mL; 1.05 equiv). Acetonitrile (100 mL) was added slowly at stirring, to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.38 M; 26 mL; 2 equiv) was added at 0 ^oC over a period of 10 min via a syringe pump. After the addition was finished the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room temperature. Ether (50 mL), water (250 mL), and aqueous ammonia (33%; 50 mL) were added to the reaction mixture in air. After agitation, the organic layer was separated and the aqueous layer washed with ether (3 × 50 mL). The combined ether solutions were washed with brine (2 × 100 mL), dried over Na_2SO_4, filtered, and evaporated (25 °C; 50 mbar). A small amount of the residue (ca. 5 mg) was analyzed by ^1H NMR and GC-MS, and the rest was extracted with pentane (ca. 30 mL). The extract was filtered through a short silica gel plug and eluted with dichloromethane. Evaporation of the filtrate (25 °C; 10 mbar) gave **2w** as a yellowish oil (0.68 g; 69%) which crystallized on storage at room temperature. ^1H NMR ($CDCl_3$, 400 MHz): δ = 9.42 (bs, 1H), 8.74 (bs, 1H), 8.18 (d, J = 8.2 Hz, 1H), 8.08 (d, J = 7.3 Hz, 1H), 7.99 (bs, 1H), 7.68 (t, J = 7.8 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 153.1, 144.7, 132.4, 131.8, 129.3 (bs), 128.8 (q, $^3J_{C–F}$ = 5.5 Hz), 126.0, 125.6 (q, $^2J_{C–F}$ = 31.9 Hz), 124.1 (q, $^1J_{C–F}$ = 273.5 Hz), 117.5 (bs). ^{19}F NMR ($CDCl_3$, 376 MHz): δ = -60.4 (s). Anal. Calcd. for $C_{10}H_6F_3N$: C, 60.9; H, 3.1; N, 7.1. Found: C, 59.9; H, 3.1; N, 7.1. Although the C value was off by ca. 1%, the compound was spectroscopically (see Section V below) and GC-pure and did not contain insolubles.

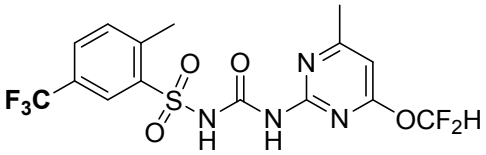
1-(2-(Trifluoromethyl)phenyl)ethanone (2x):



A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

Under argon, to a solution of 1-(2-aminophenyl)ethanone (**1x**; purity 98%; 405 mg; 3 mmol) in acetonitrile (5 mL) placed in a 500-mL PFA round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, were added at 0 ºC (ice bath), at agitation, 48% aqueous HF (6 mL) and then, dropwise, the stock solution of $NaNO_2$ (0.41 mL; 1.05 equiv). Acetonitrile (85 mL) was added slowly at stirring to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.38 M; 16 mL; 2 equiv) was added at 0 ºC over a period of 10 min via a syringe pump. After the addition was finished, the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room temperature. Ether (30 mL), water (150 mL), and aqueous ammonia (33%; 30 mL) were added to the reaction mixture in air. After agitation, the organic layer was separated and the aqueous layer washed with ether (3 × 50 mL). The combined ether solutions were washed with brine (3 × 50 mL), dried over $MgSO_4$, filtered, and evaporated (25 ºC; 10 mbar). The residue was purified on a short silica gel column with pentane/dichloromethane (3:1 v/v) to give **2x** as a yellowish oil (0.37 g; 65%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.74 – 7.69 (m, 1H), 7.64 – 7.58 (m, 1H), 7.58 – 7.53 (m, 1H), 7.48 – 7.43 (m, 1H), 2.58 (q, *J* = 0.5 Hz, 3H). ^{19}F NMR ($CDCl_3$, 376 MHz): δ = -58.3 (s).[6,7]

***N*-((4-(difluoromethoxy)-6-methylpyrimidin-2-yl)carbamoyl)-2-methyl-5-(trifluoromethyl)benzenesulfonamide (2bb):**

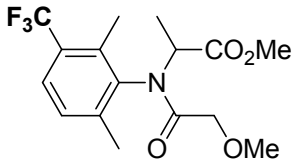


A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

Under argon, to **1bb** (387 mg; 1 mmol) placed in a 50-mL FEP round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, were added at 0 ºC (ice bath), at agitation, 48% aqueous HF (1 mL), CH_3CN (1 mL), and then, dropwise, the stock solution of $NaNO_2$ (0.14 mL; 1.05 equiv). Acetonitrile (19 mL) was added slowly at stirring, to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.37 M; 5.4 mL; 2 equiv) was added at 0 ºC over a period of 10 min via a syringe pump. After the addition was finished, the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room temperature. EtOAc (25 mL), water (50 mL), and aqueous ammonia (33%; 10 mL) were added to the reaction mixture in air. After agitation, the organic layer was separated and the aqueous layer washed with EtOAc (3 × 25 mL). The combined ethyl acetate solutions were washed with brine (20 mL), dried over Na_2SO_4, and filtered through a short silica gel plug. Evaporation of the filtrate gave crude **2bb** (containing ca. 9 mol % of the corresponding arene; ^{1}H NMR) as a tan solid (0.33 g; 66% yield of **2bb**). The pure product was obtained as a white solid (82 mg; 18%) after purification on a short silica gel column with EtOAc/hexane (2:1 v/v) and subsequent recrystallization from $CHCl_3$/hexane. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 8.44 (s, 1H), 7.74 (s, 1H), 7.73 (d, J = 6.9 Hz, 1H), 7.44 (d, J = 8.0 Hz, 1H), 7.34 (t, J = 71.1 Hz, 1H), 6.48 (s, 1H), 2.74 (s, 3H), 2.54 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 170.2, 166.6,

155.7, 148.8, 141.8, 138.1, 133.3, 130.4 (q, $^{3}J_{C–F}$ = 3.2 Hz), 129.2 (q, $^{2}J_{C–F}$ = 33.8 Hz), 128.4 (q, $^{3}J_{C–F}$ = 3.7 Hz), 123.4 (q, $^{1}J_{C–F}$ = 272.5 Hz), 113.2 (t, $^{1}J_{C–F}$ = 260.4 Hz), 102.3, 24.0, 20.3. ^{19}F NMR ($CDCl_3$, 376 MHz): δ = -62.8 (s, 3F), -90.1 (br d, *J* = ca. 70 Hz, 2F). Anal. Calcd. for $C_{15}H_{13}F_5N_4O_4S$: C, 40.9; H, 3.0; N, 12.7. Found: C, 40.9; H, 3.0; N, 12.7.

Methyl 2-(N-(2,6-dimethyl-3-(trifluoromethyl)phenyl)-2-methoxyacetamido)propanoate (2cc):

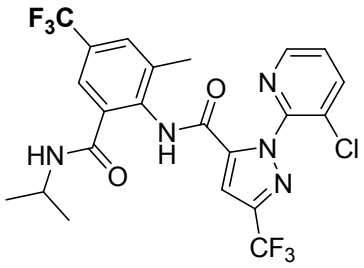


A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

Under argon, to **1cc** (589 mg; 2 mmol) placed in a 100-mL PP flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, were added at 0 ºC (ice bath), at agitation, 48% aqueous HF (4 mL), and then, dropwise, the stock solution of $NaNO_2$ (0.28 mL; 1.05 equiv). Acetonitrile (40 mL) was added slowly at stirring, to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.37 M; 11 mL; 2 equiv) was added at 0 ºC over a period of 10 min via a syringe pump. After the addition was finished, the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room temperature. Ether (25 mL), water (100 mL), and aqueous ammonia (33%; 15 mL) were added to the reaction mixture in air. After agitation, the organic layer was separated and the aqueous layer washed with ether (2 × 25 mL). The combined ether solutions were washed with brine (20 mL), dried over Na_2SO_4, and filtered through a short silica gel plug. Evaporation of the filtrate and subsequent crystallization of the residue from hexane gave pure **2cc** as a white solid (0.54 g; 78%). ^{1}H

NMR ($CDCl_3$, 400 MHz): δ = 7.61 (d, *J* = 8.1 Hz, 1H), 7.23 (d, *J* = 8.0 Hz, 1H), 4.53 (q, *J* = 7.4 Hz, 1H), 3.81 (s, 3H), 3.56 (d, *J* = 15.3 Hz, 1H), 3.46 (d, *J* = 15.3 Hz, 1H), 3.33 (s, 3H), 2.63 (q, *J* = 1.6 Hz, 3H), 2.22 (s, 3H), 0.98 (d, *J* = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 172.5, 169.9, 141.9, 138.1, 137.2, 128.9 (q, $^2J_{C–F}$ = 30.2 Hz), 128.5, 126.7 (q, $^3J_{C–F}$ = 5.7 Hz), 124.0 (q, $^1J_{C–F}$ = 273.6 Hz), 70.6, 59.3, 55.2, 52.3, 18.6, 14.6, 14.2 (q, $^5J_{C–F}$ = 2.2 Hz). ^{19}F NMR ($CDCl_3$, 376 MHz): δ = -61.7 (s). Anal. Calcd. for $C_{16}H_{20}F_3NO_4$: C, 55.3; H, 5.8; N, 4.0. Found: C, 55.2; H, 5.5; N, 4.2.

1-(3-Chloropyridin-2-yl)-*N*-(2-(isopropylcarbamoyl)-6-methyl-4-(trifluoromethyl)phenyl)-3-(trifluoromethyl)-1H-pyrazole-5-carboxamide (2dd):



A stock aqueous solution of $NaNO_2$ was prepared by dissolving $NaNO_2$ (98% purity; 704 mg; 10 mmol) in water (1 mL). Concentration: 41% or 7.6 M. Density: 1.3 g/mL.

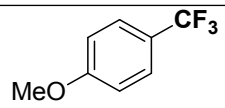
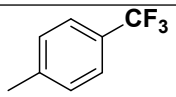
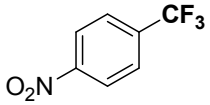
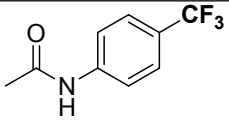
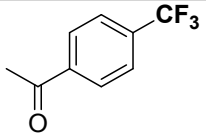
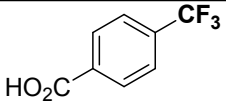
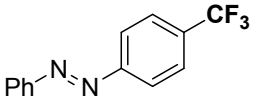
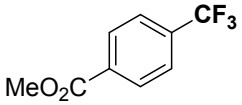
Under argon, to **1dd** (361 mg; 0.75 mmol) placed in a 50-mL FEP round-bottom flask equipped with a Teflon-coated magnetic stir-bar and sealed with a rubber septum, were added at 0 ºC (ice bath), at agitation, 48% aqueous HF (1.5 mL), CH_3CN (1 mL), and then, dropwise, the stock solution of $NaNO_2$ (104 μL; 1.05 equiv). Acetonitrile (14 mL) was added slowly at stirring, to maintain the temperature of the diazonium salt solution in the flask immersed in an ice bath. Then $CuCF_3$ in DMF (0.37 M; 4.1 mL; 2 equiv) was added at 0 ºC over a period of 10 min via a syringe pump. After the addition was finished, the reaction mixture was stirred for an additional 5 min at 0 ºC and then allowed to warm to room

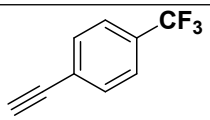
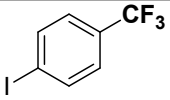
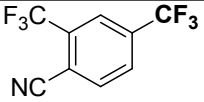
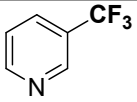
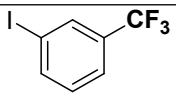
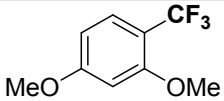
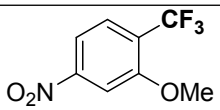
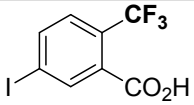
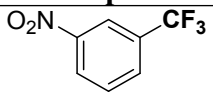
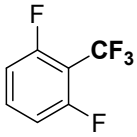
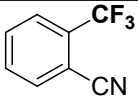
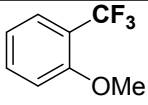
temperature. EtOAc (25 mL), water (50 mL), and aqueous ammonia (33%; 10 mL) were added to the reaction mixture in air. After agitation, the organic layer was separated and the aqueous layer washed with EtOAc (2 × 25 mL). The combined ethyl acetate solutions were washed with brine (20 mL), dried over Na_2SO_4, and filtered through a short silica gel plug. Evaporation of the filtrate gave crude **2dd** (containing ca. 14 mol % of the corresponding arene; ^{1}H NMR) as a yellowish solid (0.32 g; 69% yield of **2dd**). The pure product was obtained as a white solid (165 mg; 41%) after purification on a short silica gel column using EtOAc/hexane (1:2 v/v) and subsequent recrystallization from EtOAc. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.59 (s, 1H), 8.49 (d, J = 4.4 Hz, 1H), 7.88 (dd, J = 8.1, 1.5 Hz, 1H), 7.53 – 7.50 (m, 1H), 7.48 – 7.45 (m, 1H), 7.42 (dd, J = 8.1, 4.7 Hz, 1H), 7.37 (s, 1H), 5.97 (d, J = 7.6 Hz, 1H), 4.28 – 4.16 (m, 1H), 2.25 (s, 3H), 1.26 (d, J = 6.6 Hz, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 167.5, 156.5, 149.2, 147.1, 144.0 (q, $^2J_{C–F}$ = 39.5 Hz), 139.1, 138.5, 137.8, 136.4 (q, $^3J_{C–F}$ = 1.3 Hz), 131.9, 130.1 (q, $^3J_{C–F}$ = 3.5 Hz), 129.3, 128.8 (q, $^2J_{C–F}$ = 33.0 Hz), 126.2, 123.5 (q, $^1J_{C–F}$ = 272.5 Hz), 121.3 (q, $^3J_{C–F}$ = 3.7 Hz), 120.7 (q, $^1J_{C–F}$ = 269.5 Hz), 106.6 (q, $^3J_{C–F}$ = 2.0 Hz), 42.9, 22.5, 19.2. ^{13}C NMR (acetone-d_6, 100 MHz): δ = 167.3, 156.5, 149.8, 148.1, 143.7 (q, $^2J_{C–F}$ = 39.0 Hz), 140.2, 140.1, 138.2, 138.1 (q, $^3J_{C–F}$ = 1.4 Hz), 133.4, 129.9 (q, $^3J_{C–F}$ = 3.9 Hz), 129.3, 128.4 (q, $^2J_{C–F}$ = 32.6 Hz), 127.6, 124.8 (q, $^1J_{C–F}$ = 271.7 Hz), 123.2 (q, $^3J_{C–F}$ = 3.8 Hz), 121.9 (q, $^1J_{C–F}$ = 268.3 Hz), 107.1 (q, $^3J_{C–F}$ = 1.8 Hz), 42.9, 22.4, 19.0. ^{19}F NMR ($CDCl_3$, 376 MHz): δ = -62.5 (s, 3F), -62.8 (s, 3F). Anal. Calcd. for $C_{22}H_{18}ClF_6N_5O_2$: C, 49.5; H, 3.4; N, 13.1. Found: C, 49.1; H, 3.4; N, 13.0.

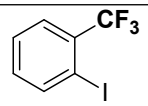
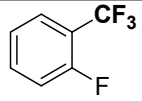
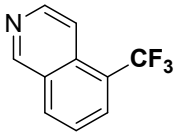
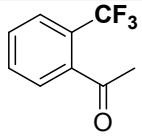
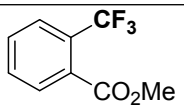
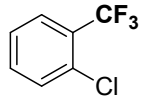
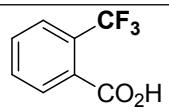
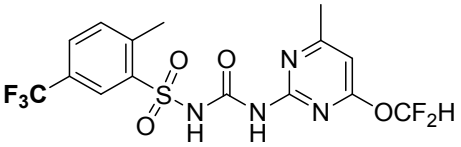
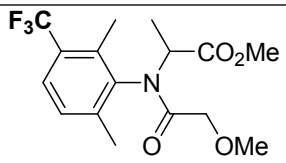
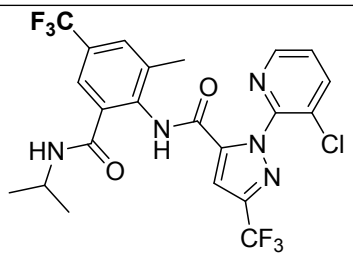
IV. ^{19}F NMR Data

Table S13 lists ^{19}F NMR chemical shifts of the trifluoromethylated products as measured directly for the organic solvent extracts used for the quantitative ^{19}F NMR yield determination with 1,3-bis(trifluoromethyl)benzene (δ = -62.1 ppm) or 4,4'-difluoro-1,1'-biphenyl (δ = -116.3 ppm) as internal standards.

Table S13. ^{19}F NMR shifts of trifluoromethylated products (unlocked).

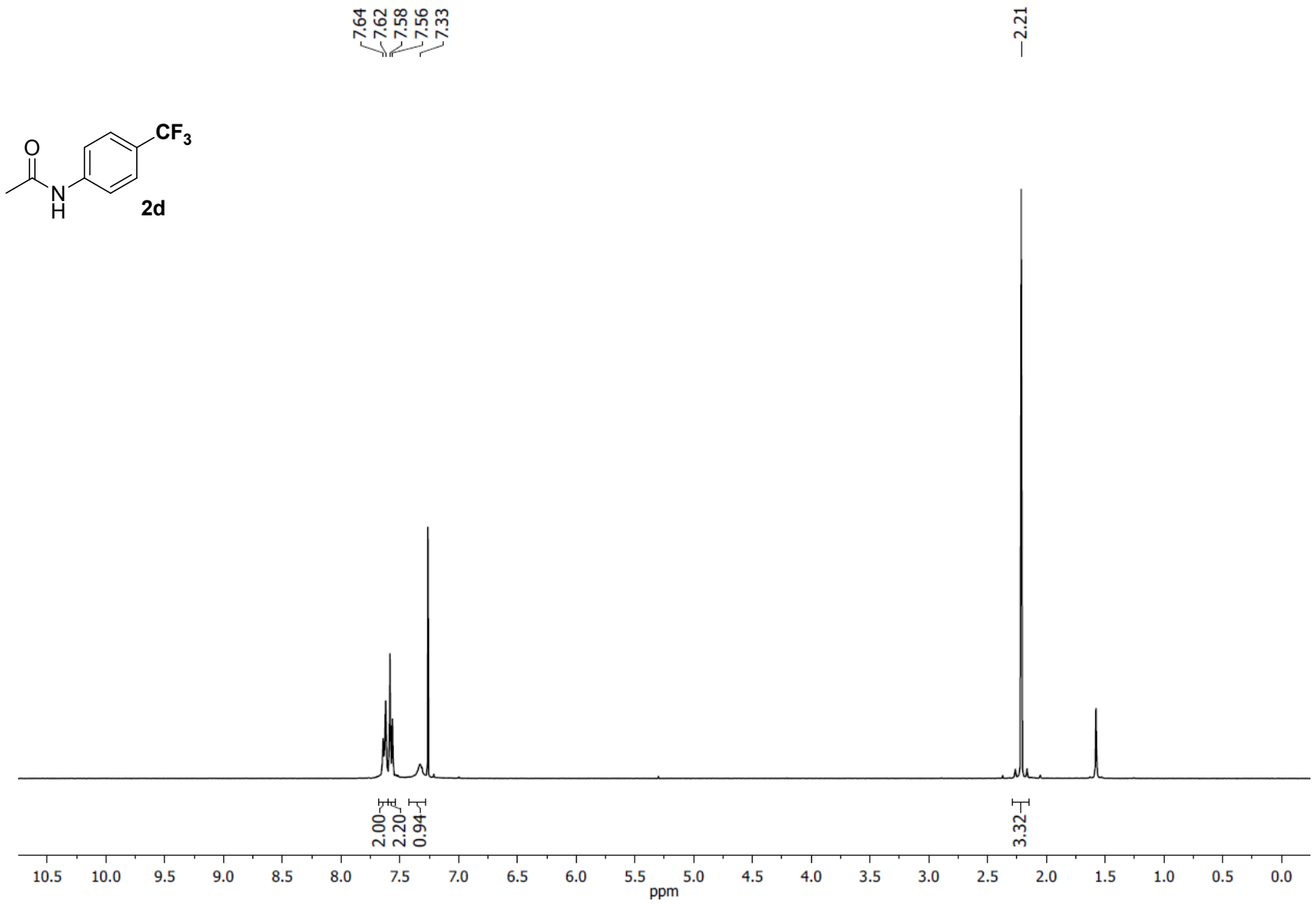
Compound	^{19}F NMR, ppm	Reference
 **2a**	-60.5 (s)	3
 **2b**	-61.4 (s)	8
 **2c**	-62.6 (s)	8
 **2d**	-61.1 (s)	3
 **2e**	-62.5 (s)	3
 **2f**	-62.2 (s)	4
 **2g**	-61.7 (s)	5
 **2h**	-62.3 (s)	8

 **2i**	-62.3 (s)	9
 **2j**	-62.4 (s)	10
 **2k**	-61.5 (s, 3F), -62.8 (s, 3F)	-
 **2l**	-62.1 (s)	8
 **2m**	-62.3 (s)	10
 **2n**	-60.1 (s)	11
 **2o**	-62.3 (s)	5
 **2p**	-59.1 (s)	-
 **2q**	-62.0 (s)	12
 **2r**	-55.6 (t, J = 22.4 Hz, 3F), -112.0 (m, 2F)	-
 **2s**	-61.5 (s)	6
 **2t**	-61.4 (s)	8

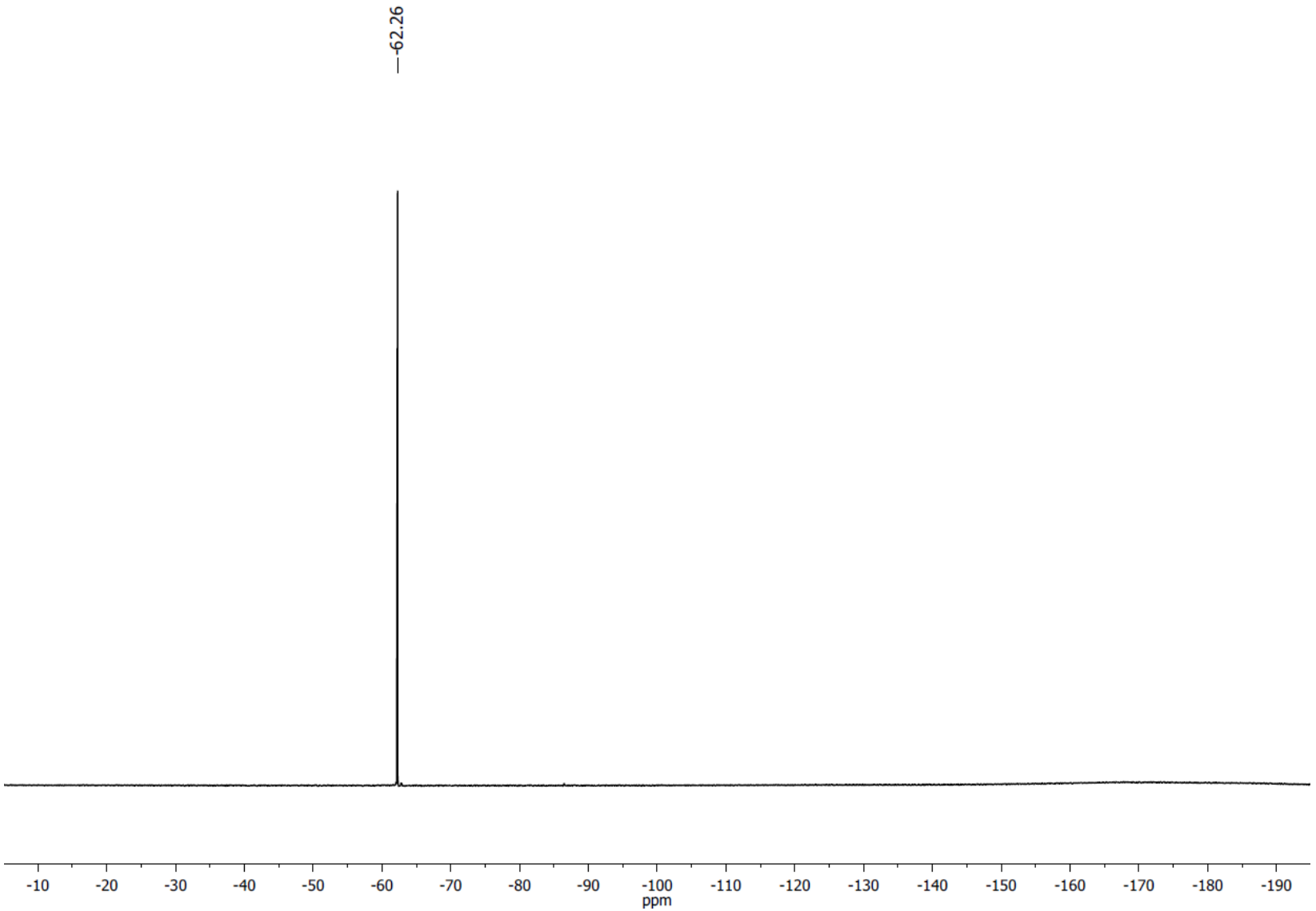
 **2u**	-62.0 (s)	10
 **2v**	-60.6 (t, *J* = 12.7 Hz, 3F), -115.7 (m, 1F)	10
 **2w**	-59.4 (s)	-
 **2x**	-57.4 (s)	6,7
 **2y**	-58.8 (s)	7
 **2z**	-61.7 (s)	10
 **2aa**	-58.5 (s)	6
 **2bb**	-61.6 (s, 3F), -89.4 (d, *J* = 70.7 Hz, 2F)	-
 **2cc**	-60.4 (s)	-
 **2dd**	-61.6 (s, 3F), -61.8 (s, 3F)	-

V. NMR Spectra

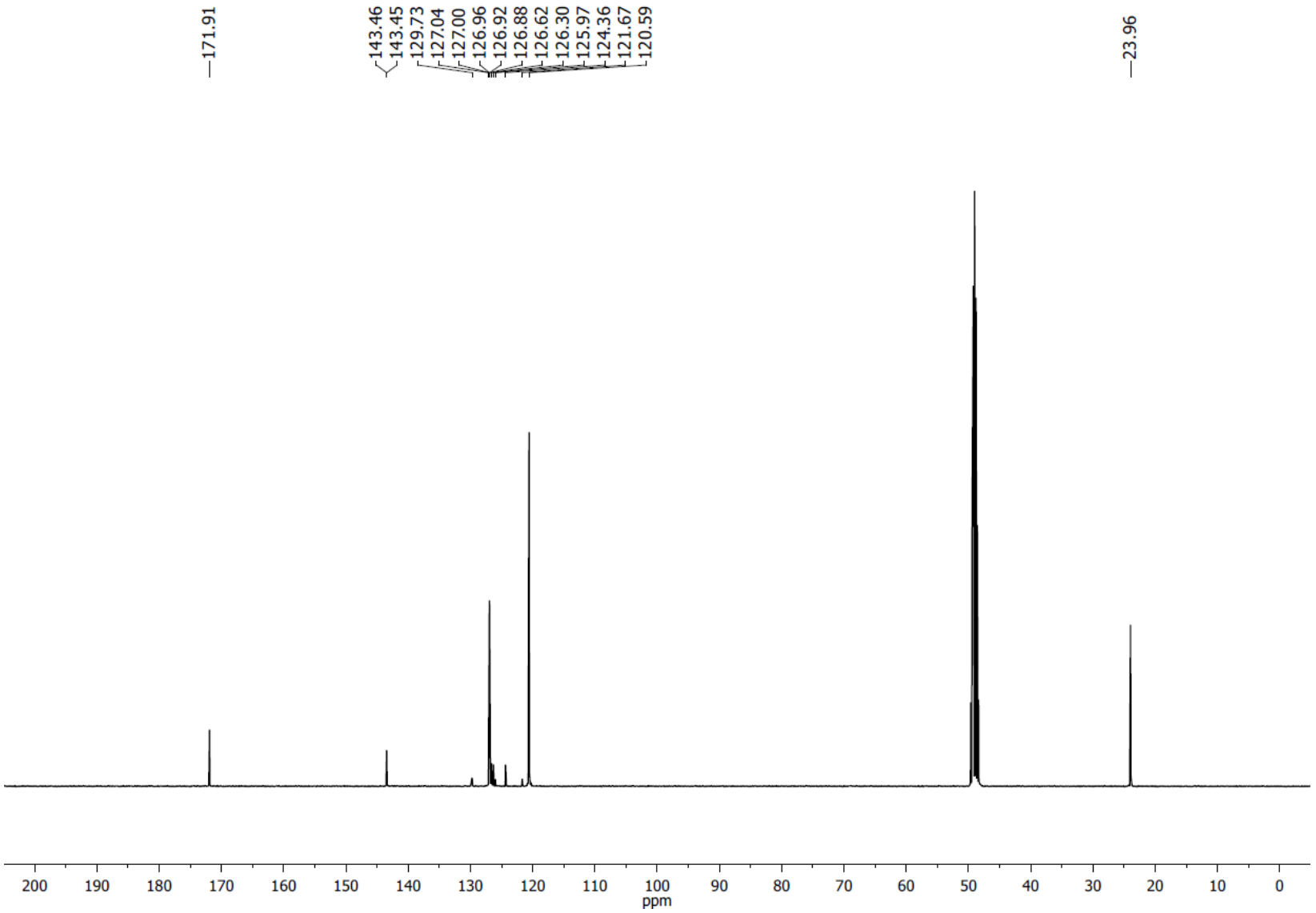
^{1}H NMR ($CDCl_3$, 400 MHz)



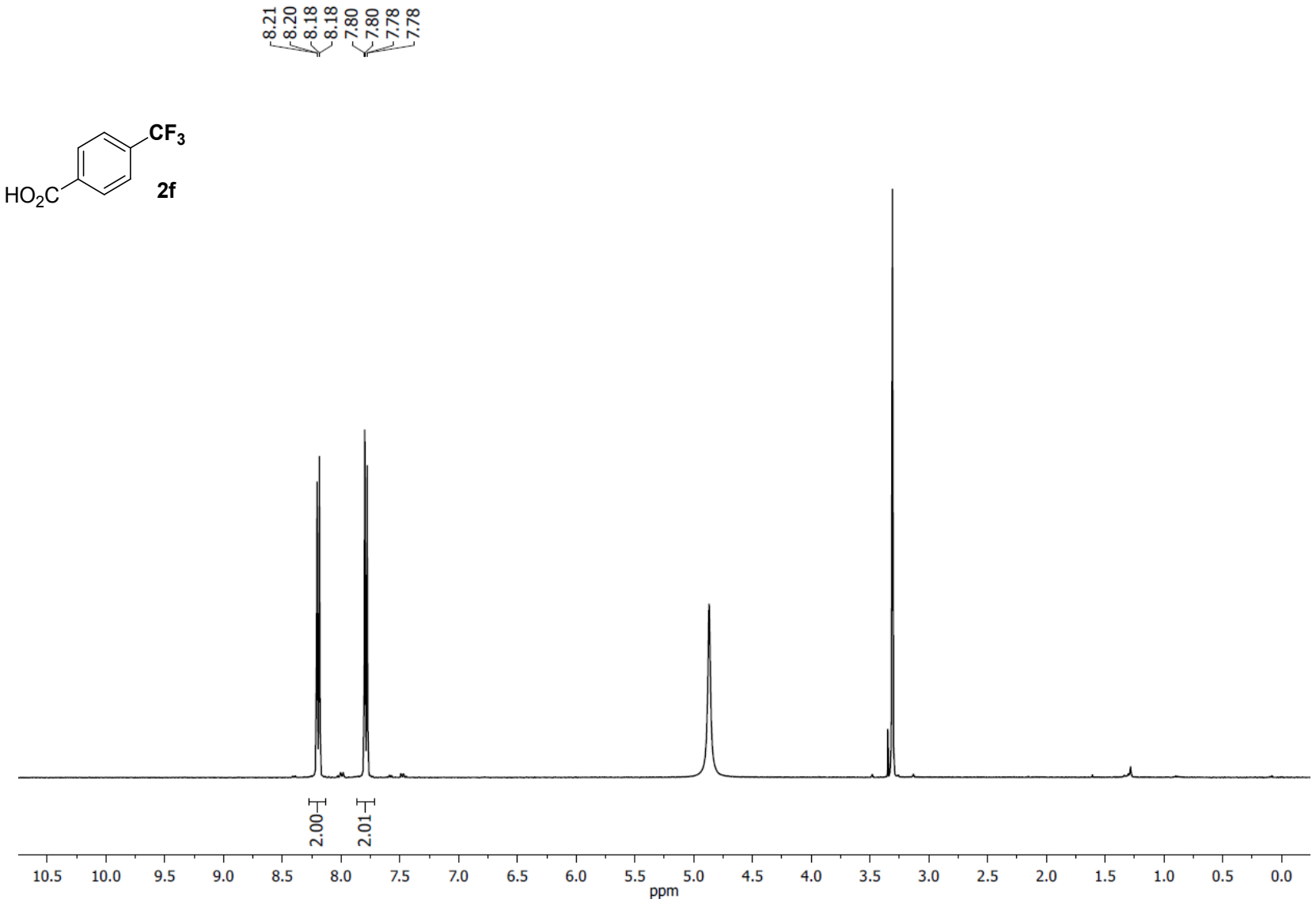
^{19}F NMR ($CDCl_3$, 376 MHz)



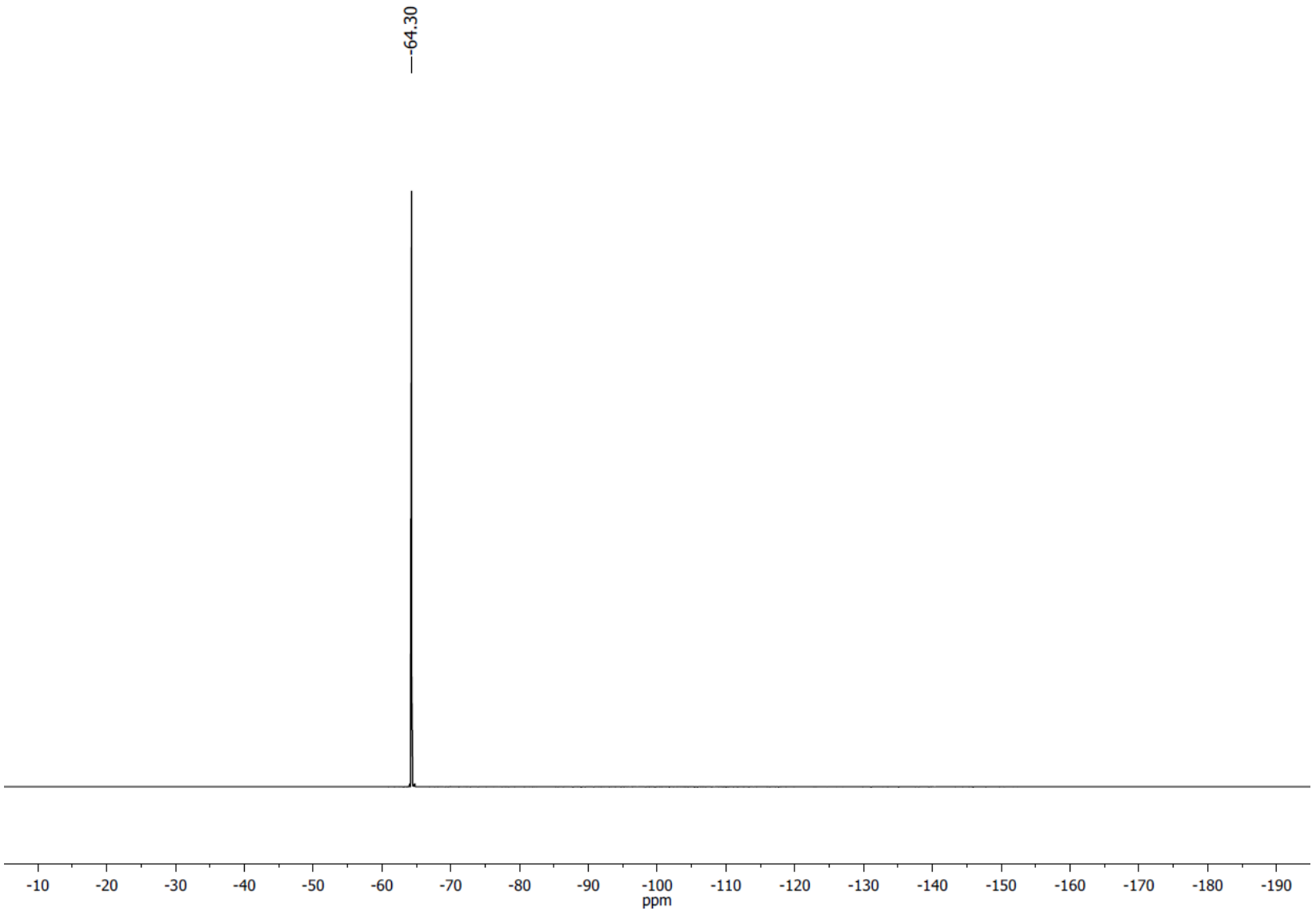
^{13}C NMR (methanol-d_4, 100 MHz)



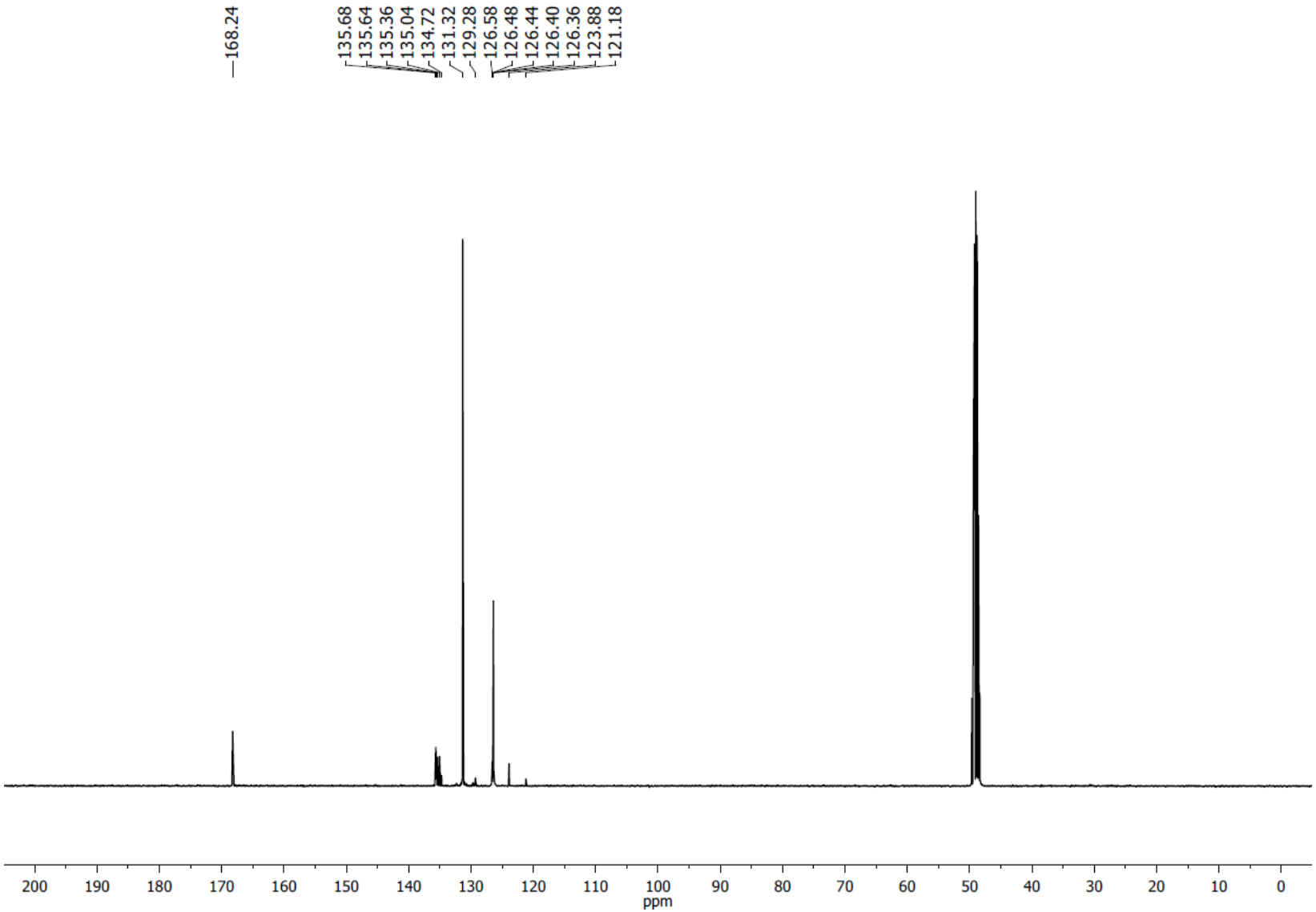
^{1}H NMR (methanol-d_4, 400 MHz)



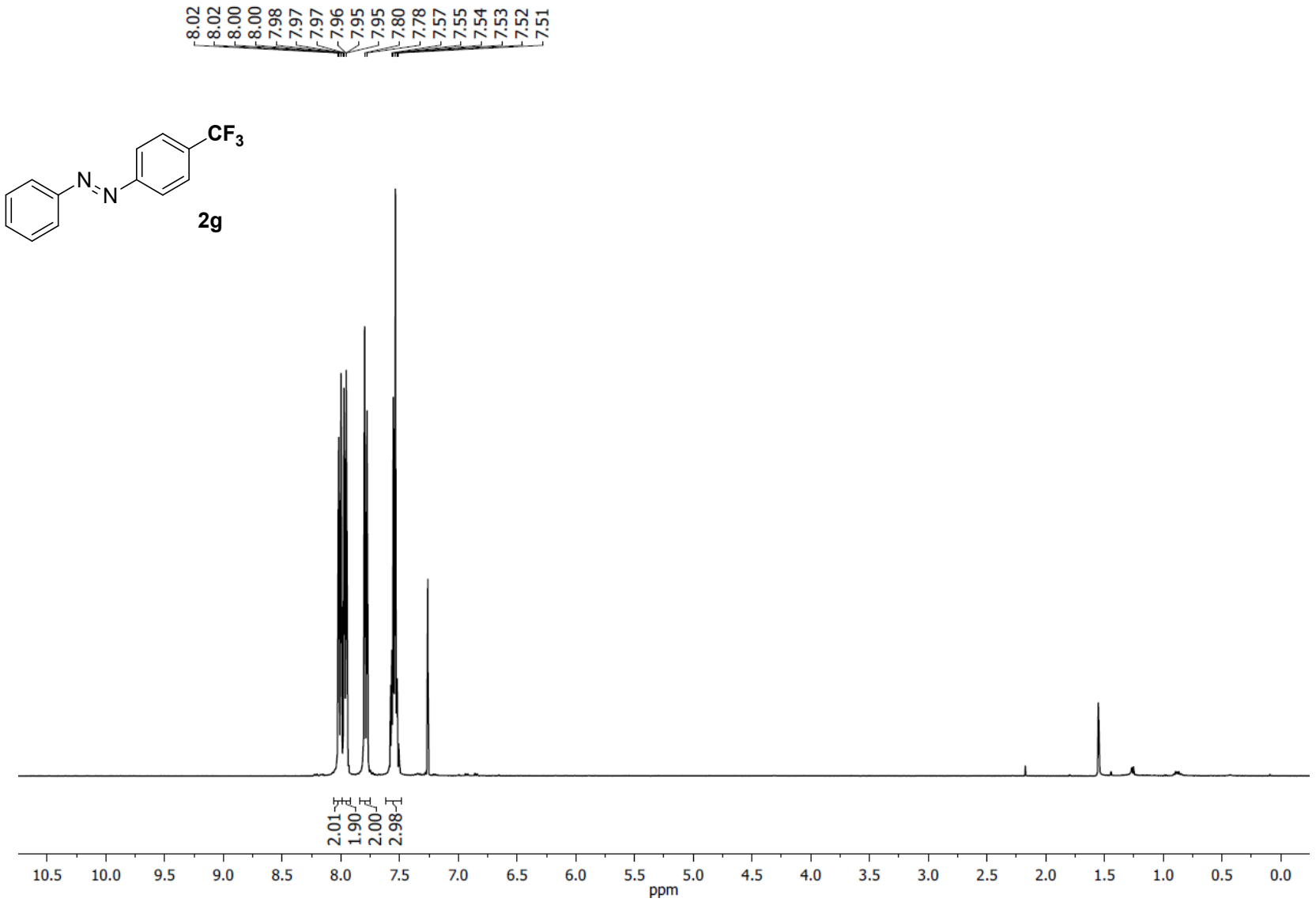
^{19}F NMR (methanol-d_4, 376 MHz)



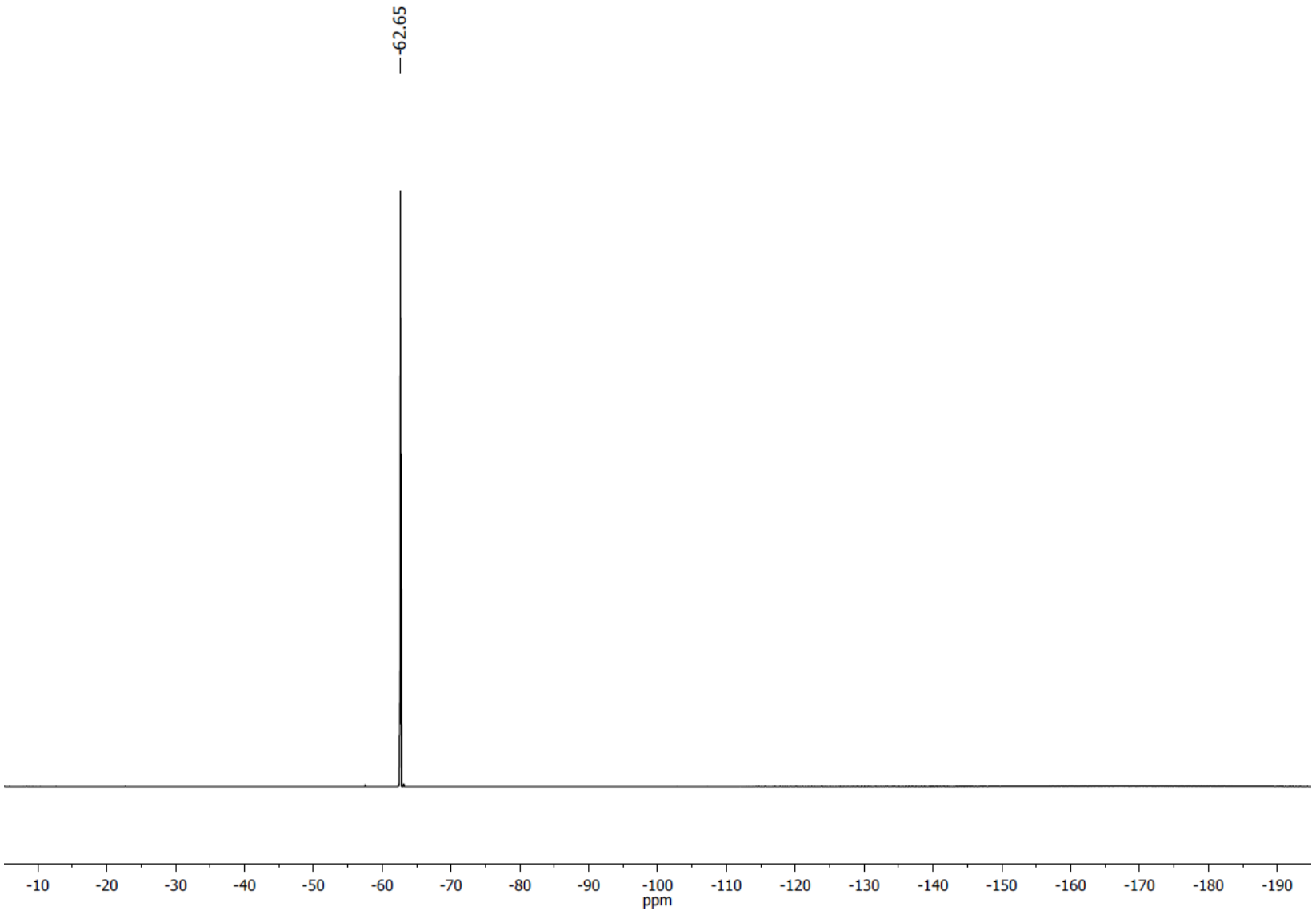
^{13}C NMR (methanol-d_4, 100 MHz)



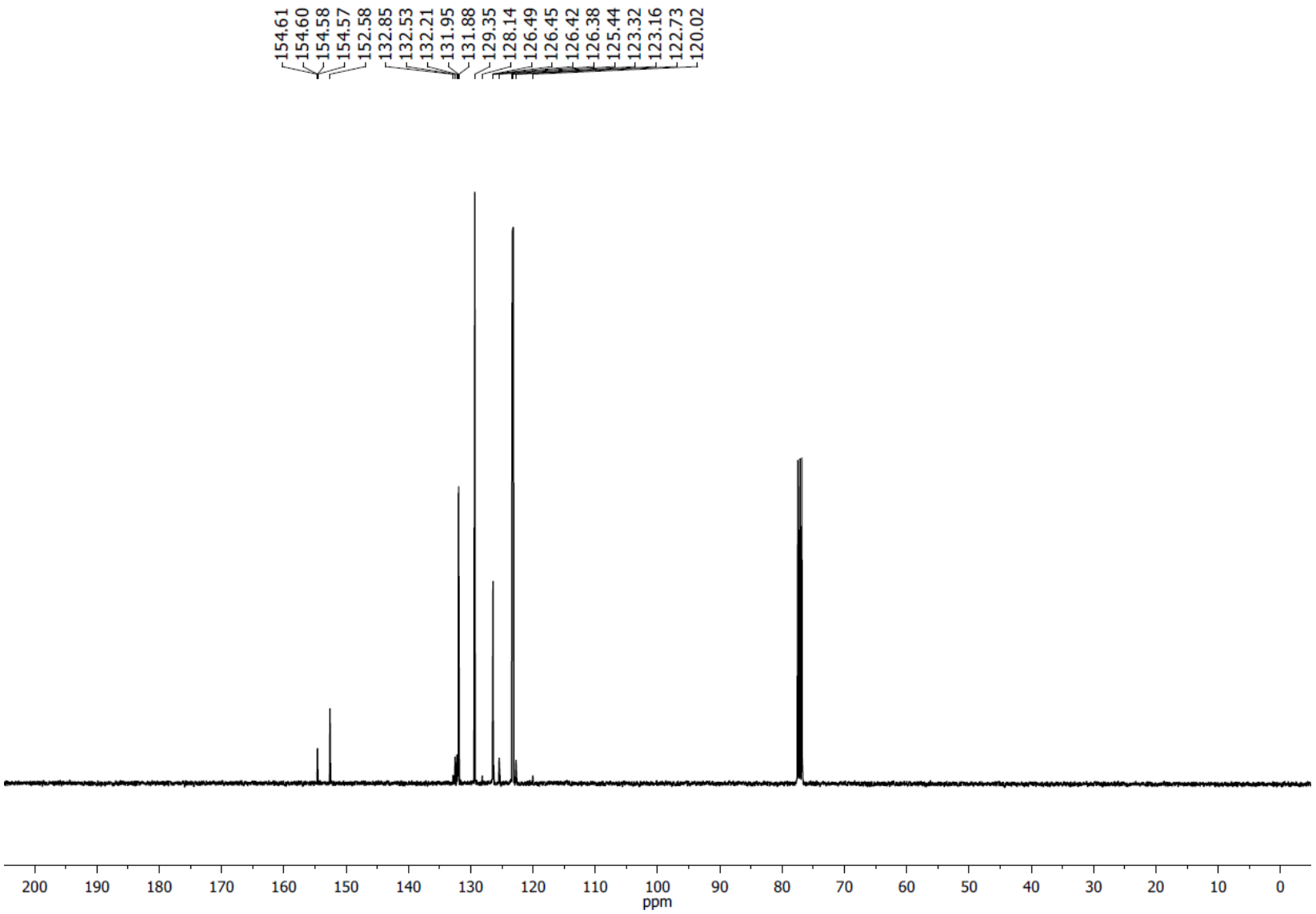
^{1}H NMR ($CDCl_3$, 400 MHz)



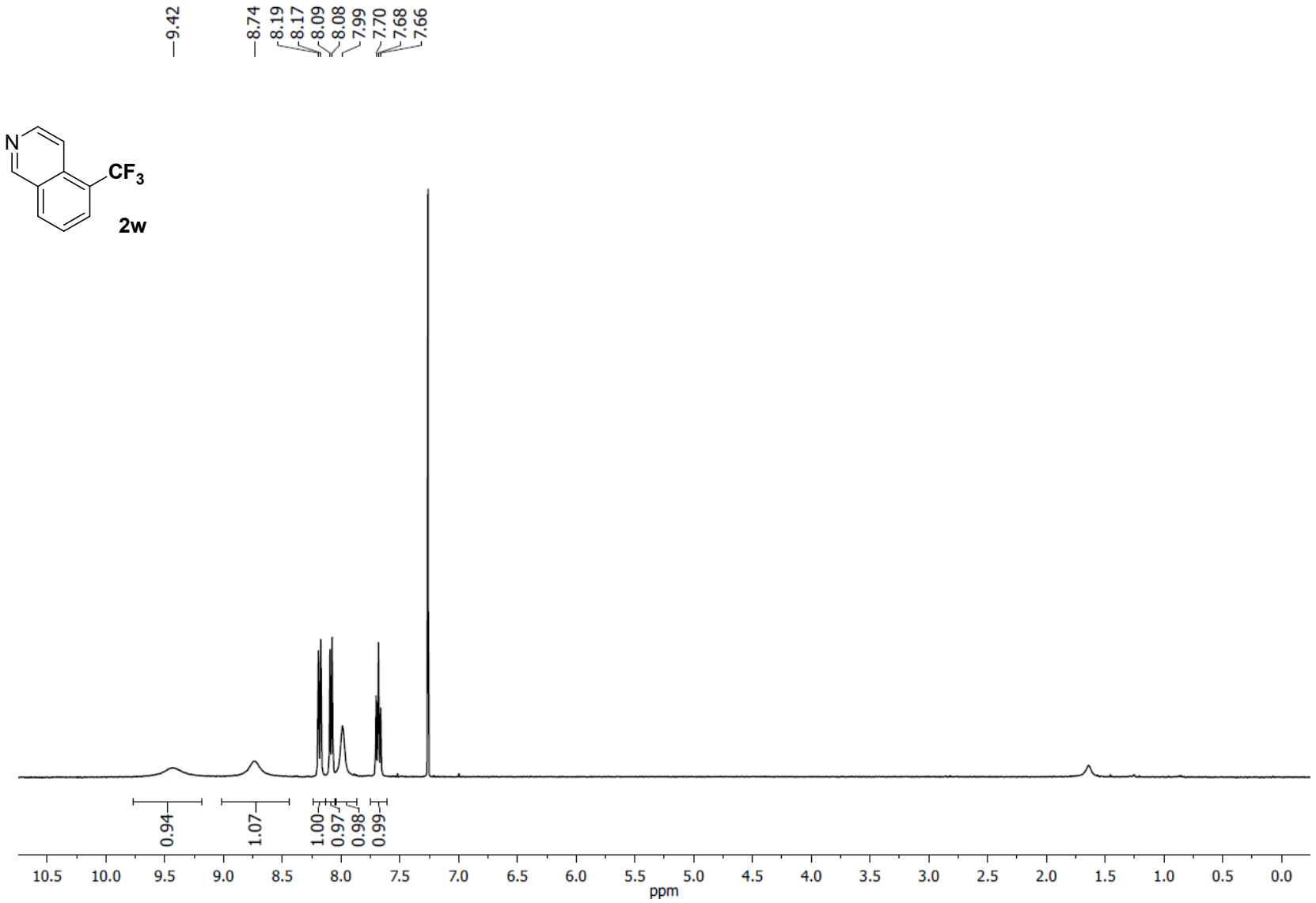
^{19}F NMR ($CDCl_3$, 376 MHz)



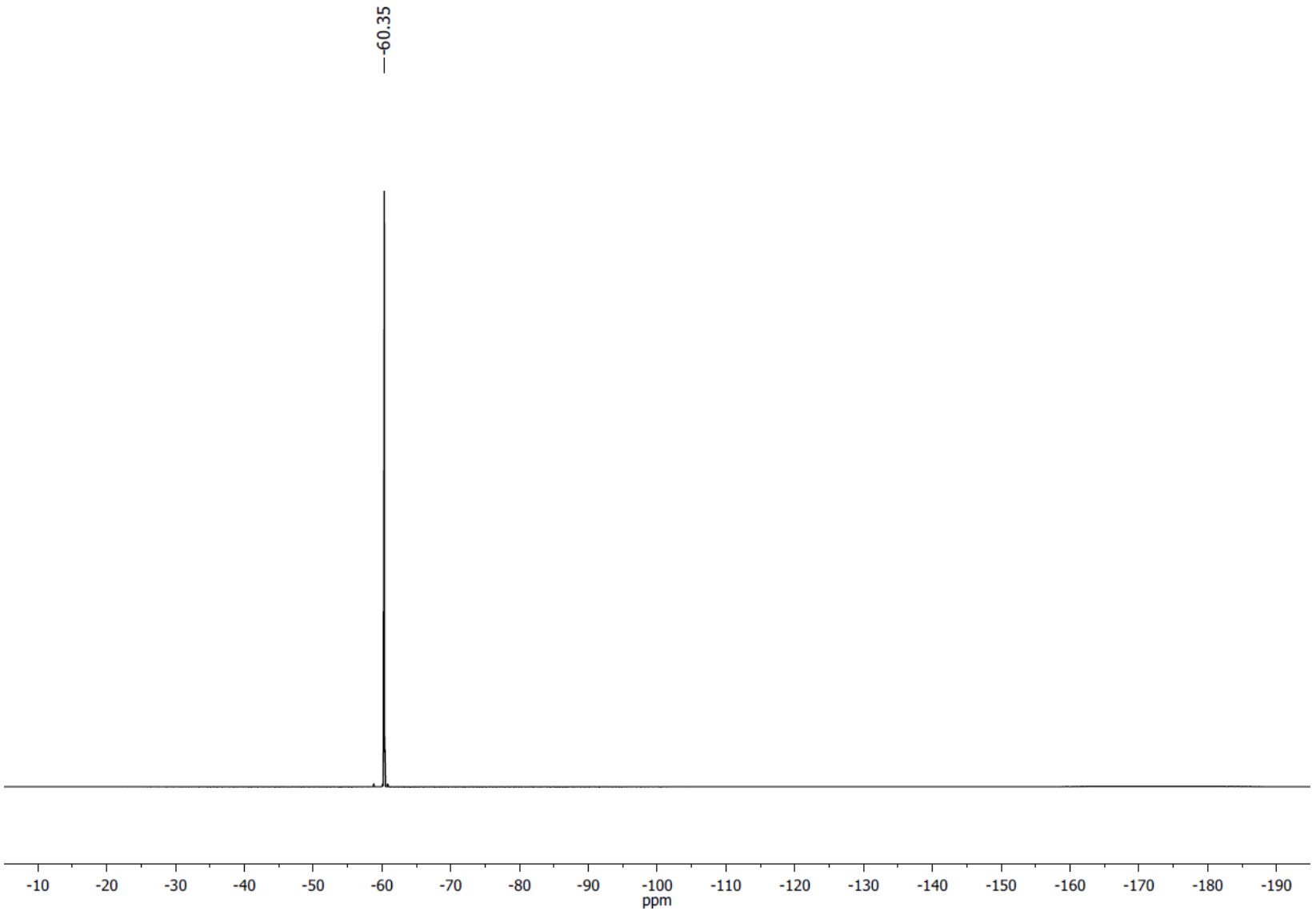
^{13}C NMR ($CDCl_3$, 100 MHz)



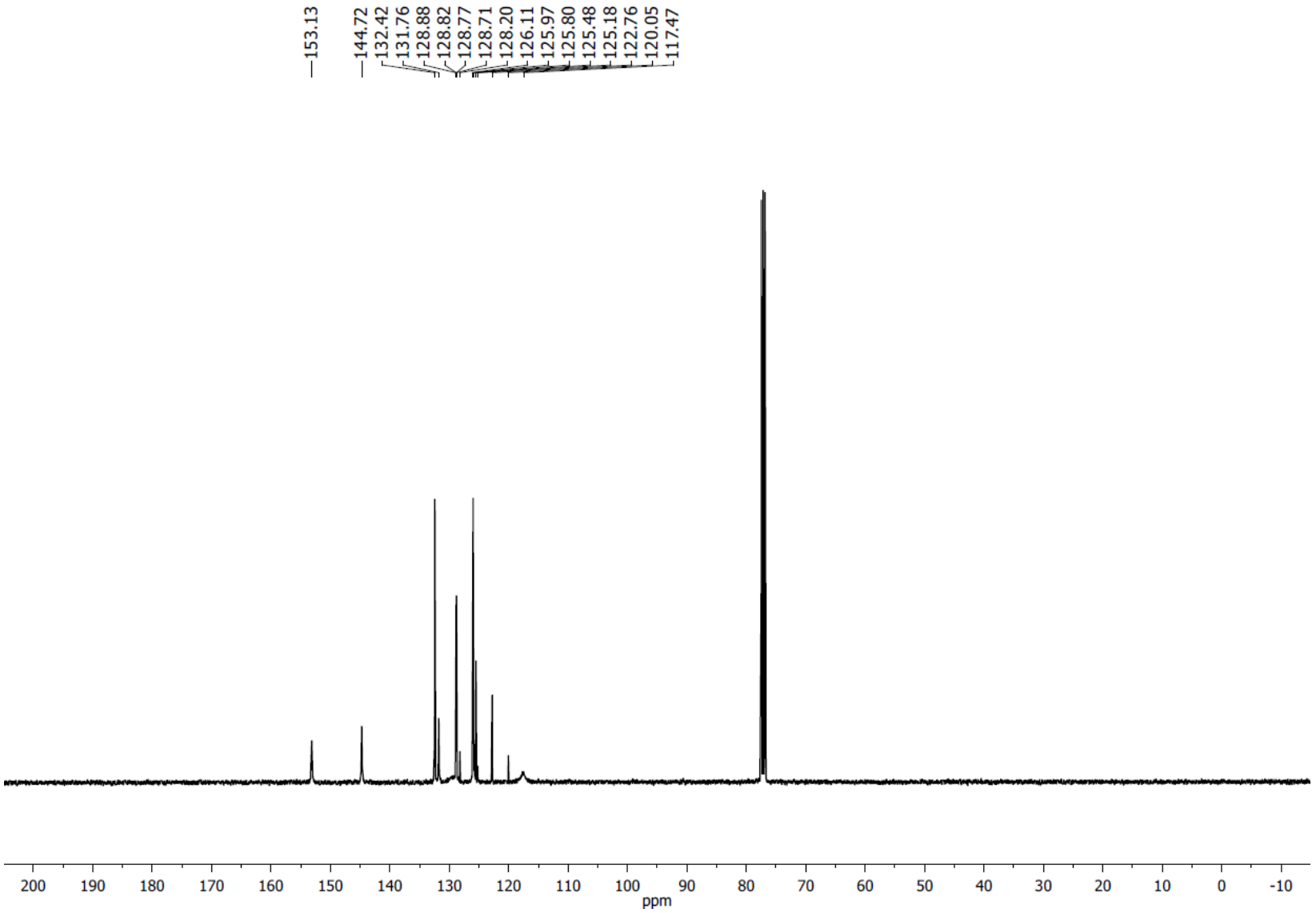
^{1}H NMR ($CDCl_3$, 400 MHz)



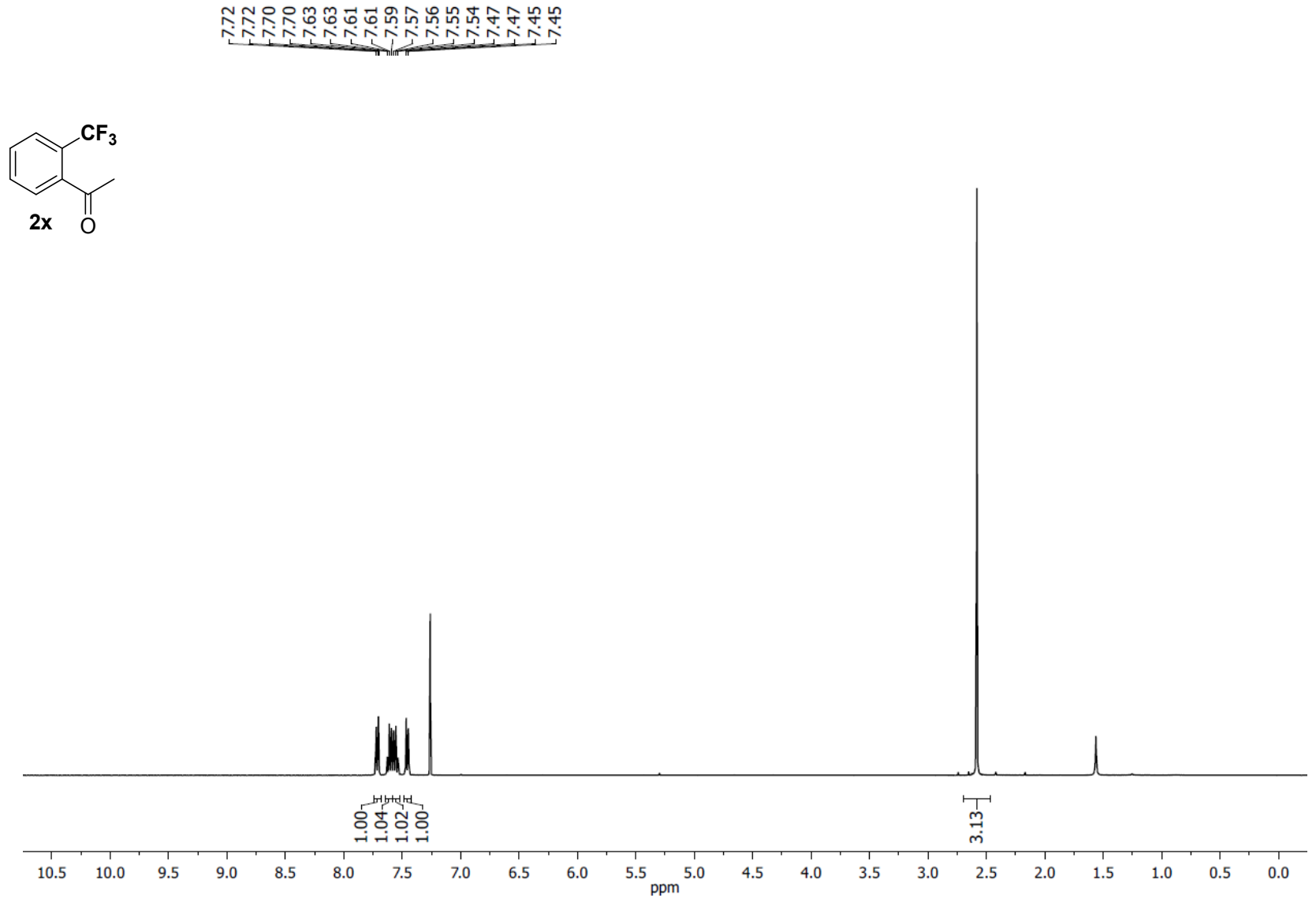
^{19}F NMR ($CDCl_3$, 376 MHz)



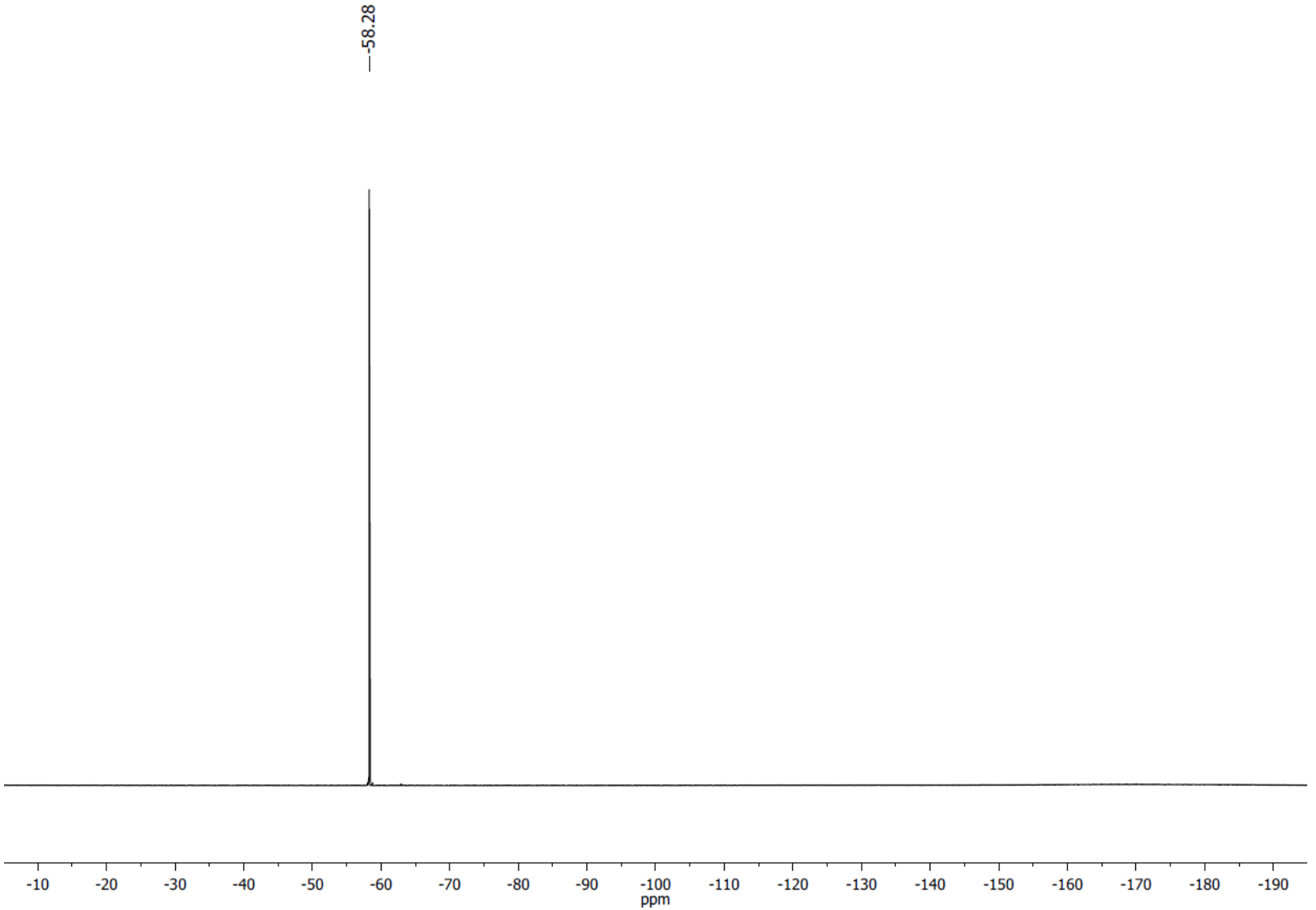
^{13}C NMR ($CDCl_3$, 100 MHz)



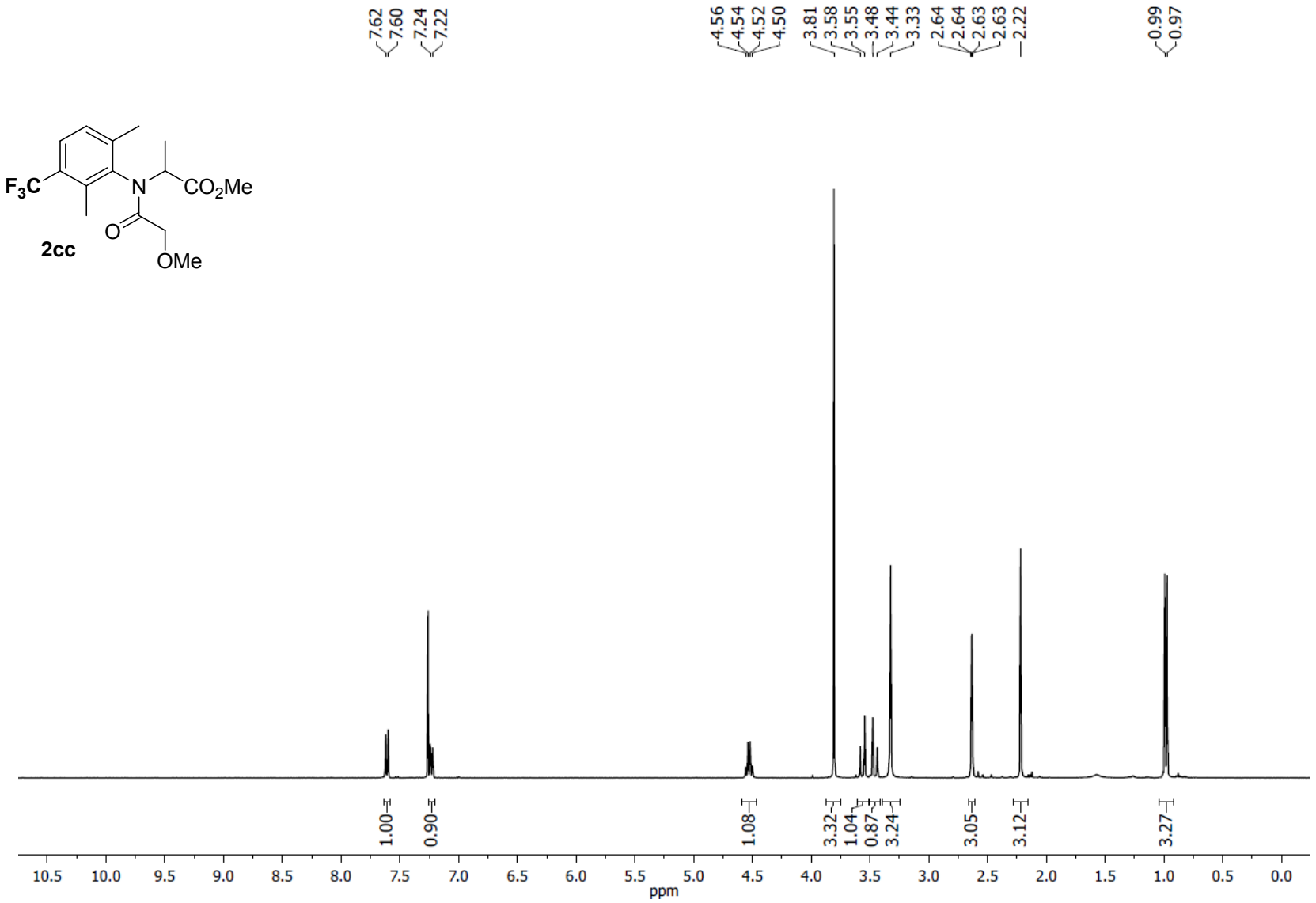
^{1}H NMR ($CDCl_3$, 400 MHz)



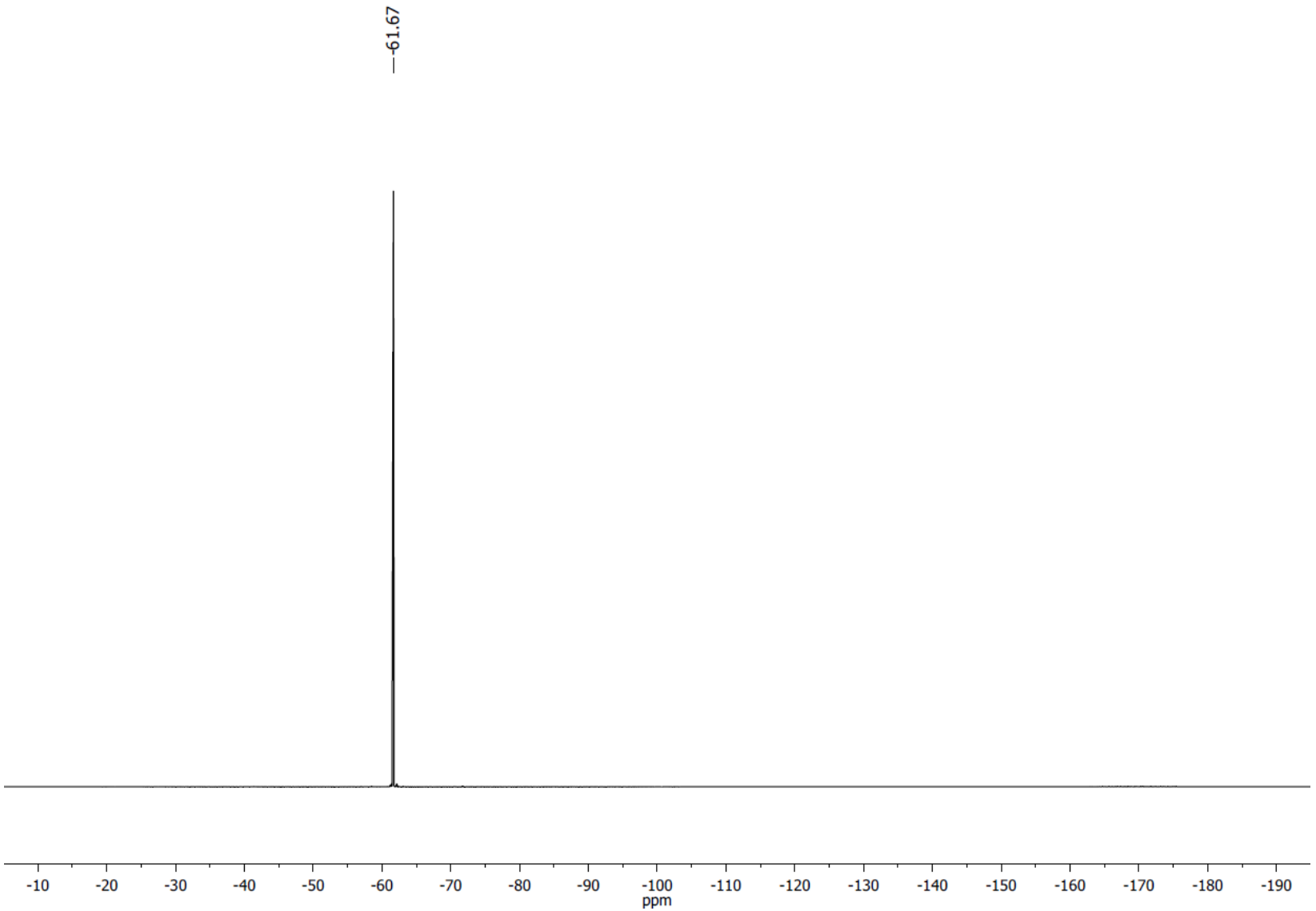
^{19}F NMR ($CDCl_3$, 376 MHz)



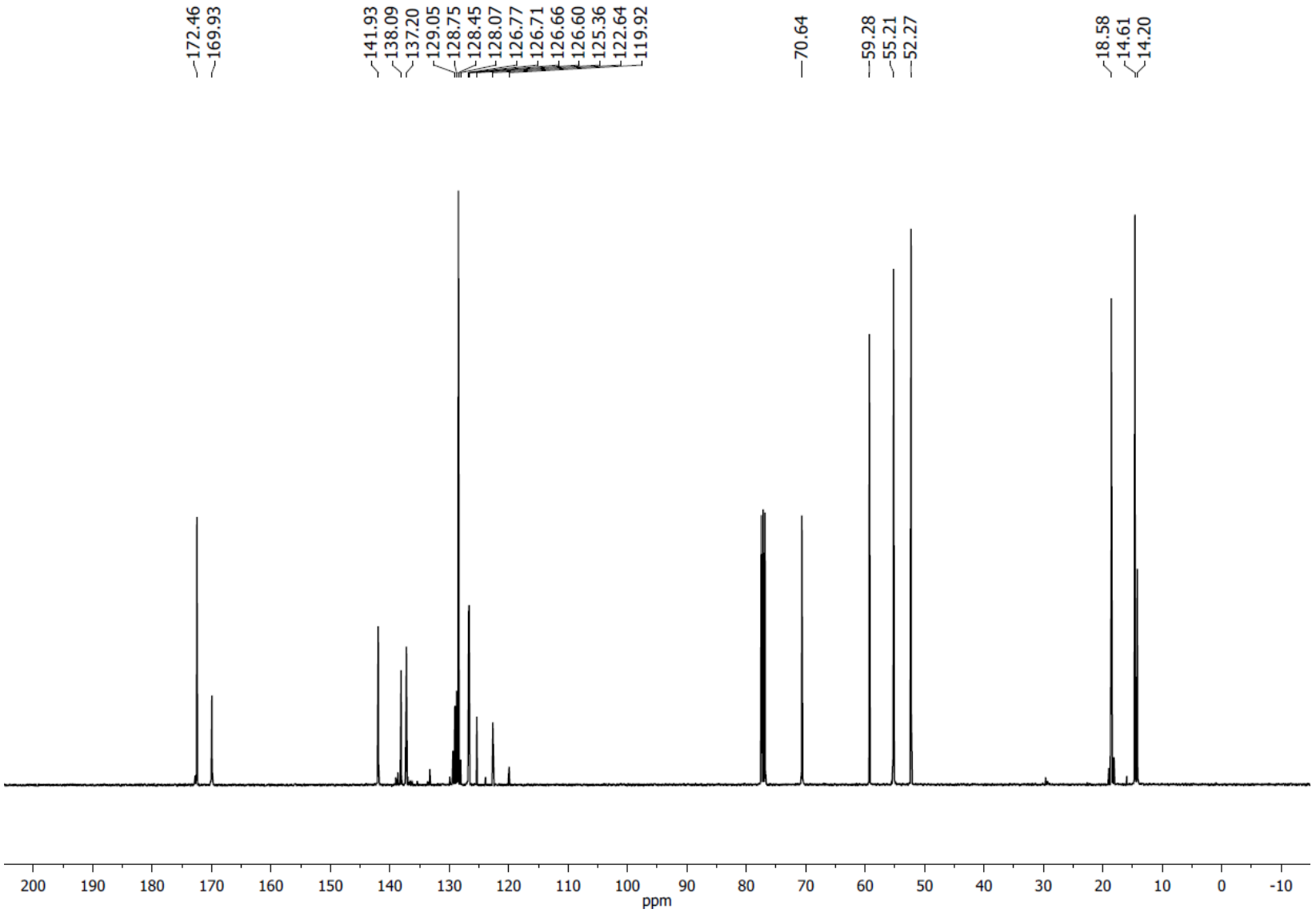
^{1}H NMR ($CDCl_3$, 400 MHz)



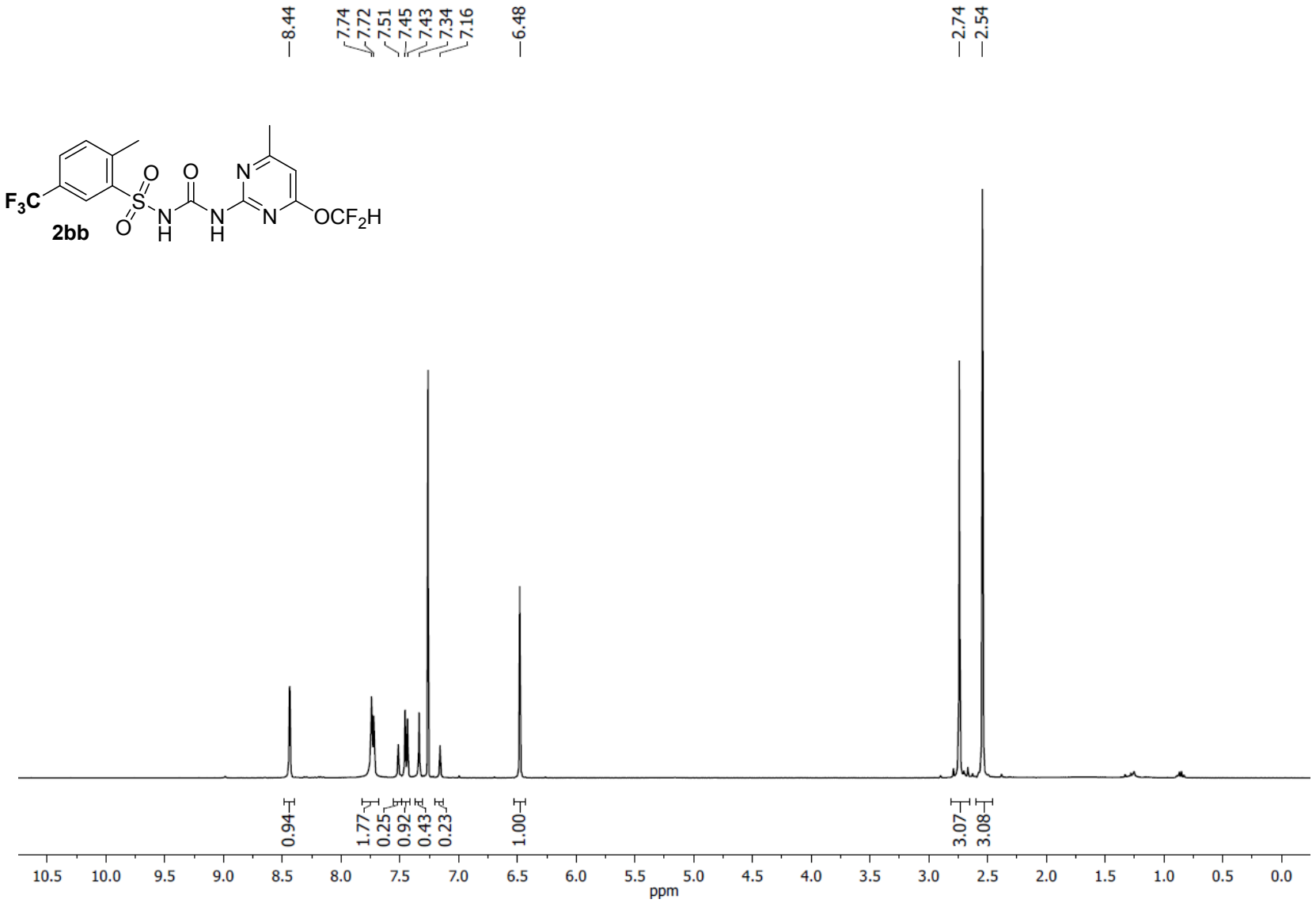
^{19}F NMR ($CDCl_3$, 376 MHz)



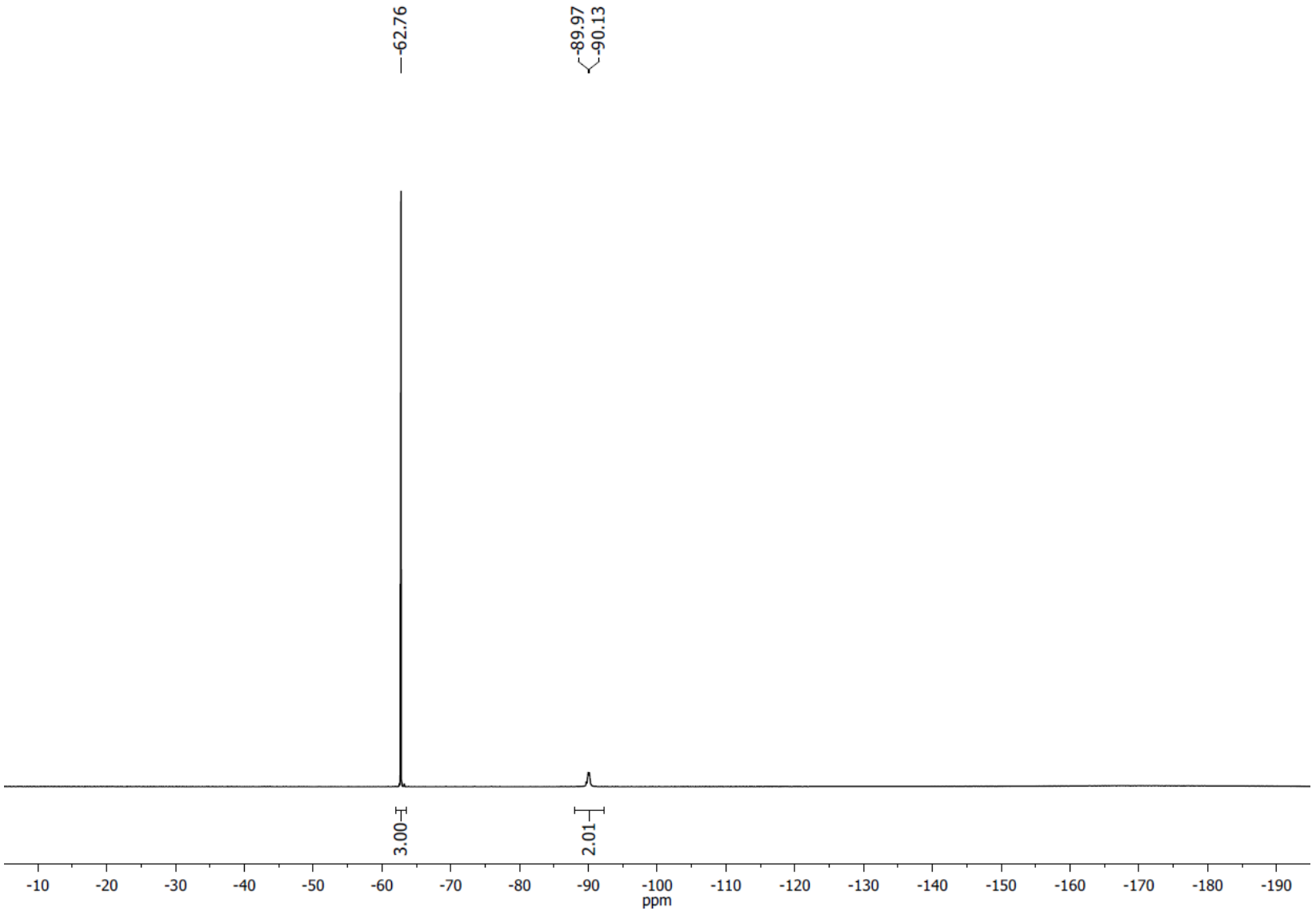
^{13}C NMR ($CDCl_3$, 100 MHz)



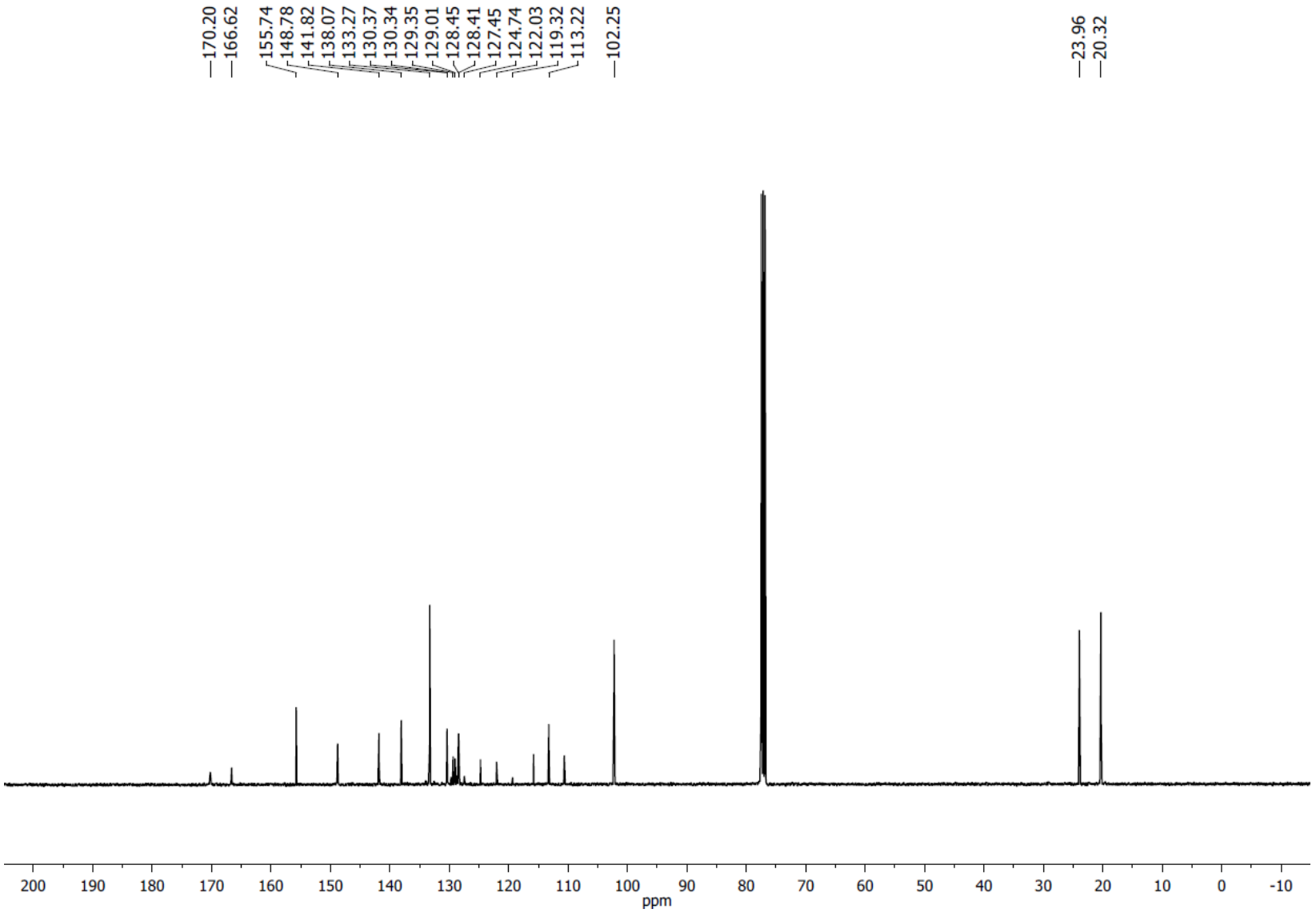
^{1}H NMR ($CDCl_3$, 400 MHz)



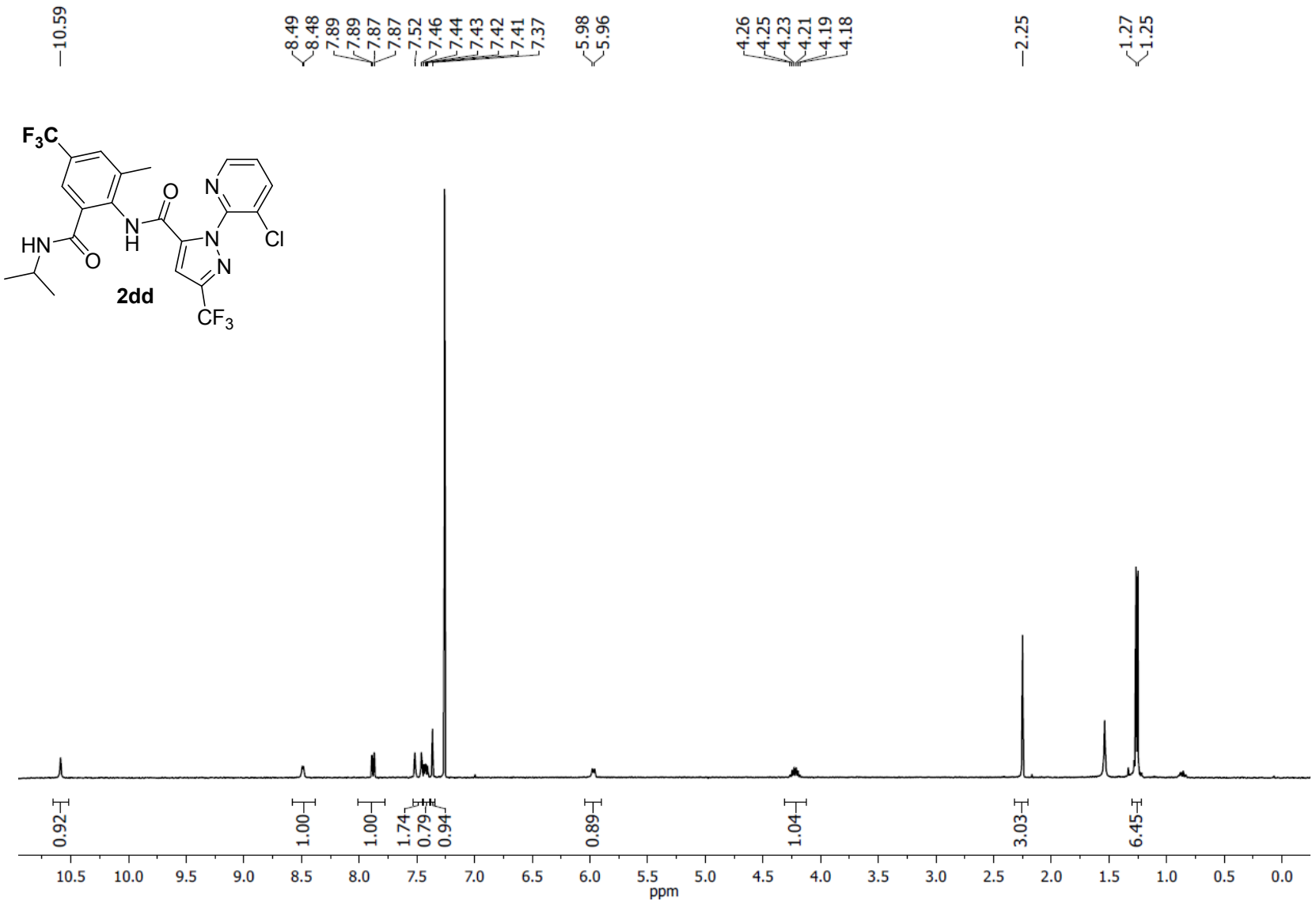
^{19}F NMR ($CDCl_3$, 376 MHz)



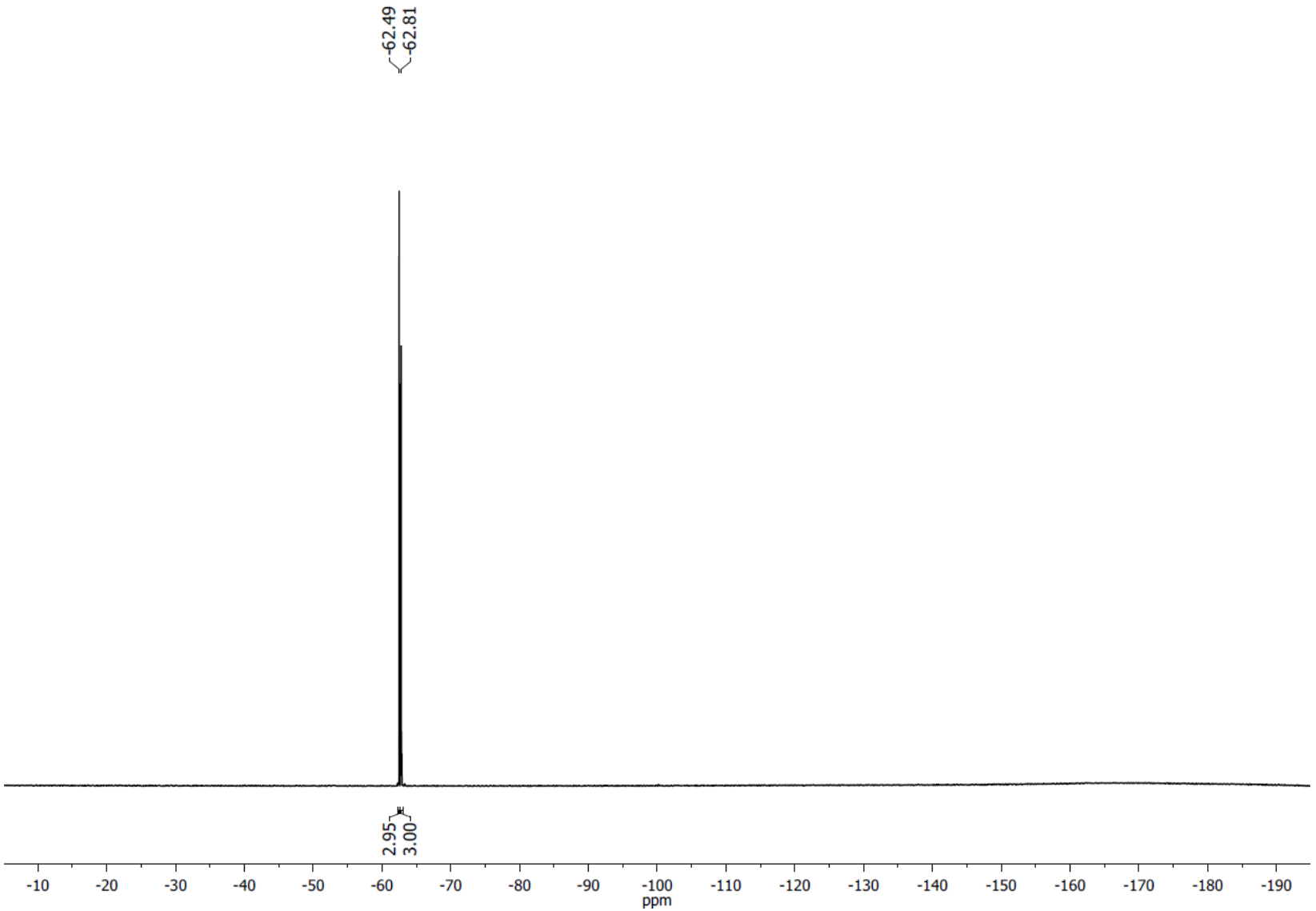
^{13}C NMR ($CDCl_3$, 100 MHz)



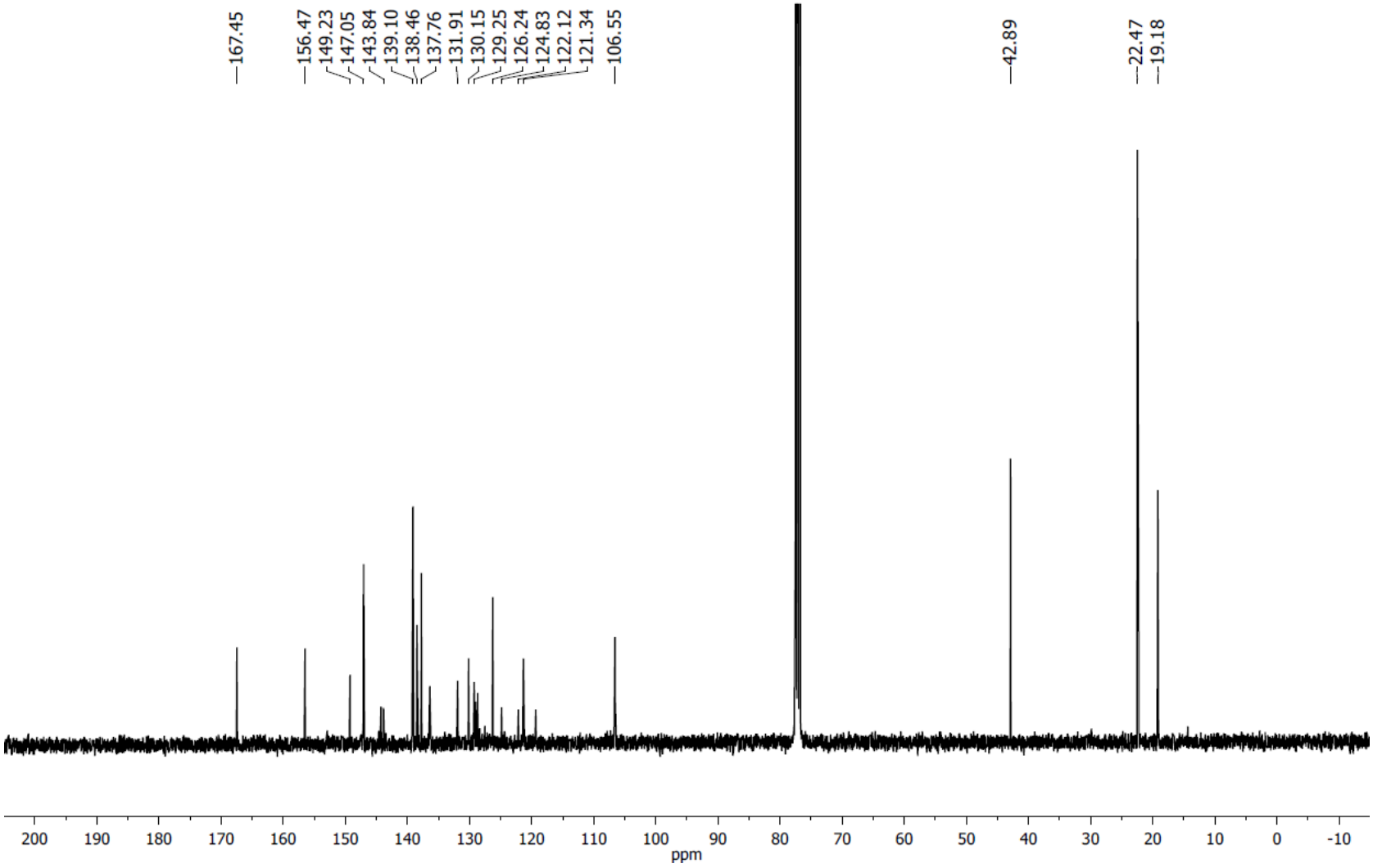
^{1}H NMR ($CDCl_3$, 400 MHz)



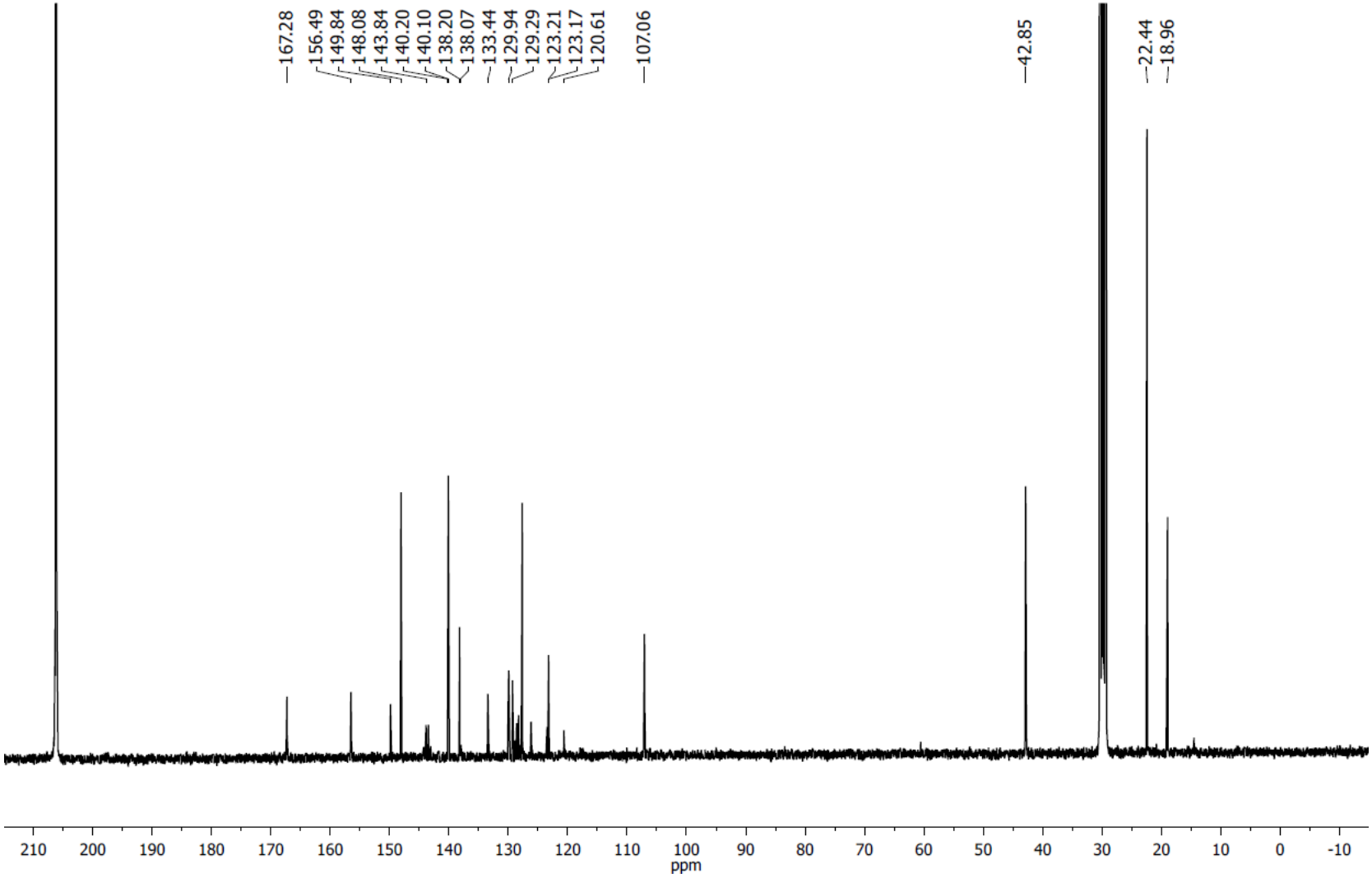
^{19}F NMR ($CDCl_3$, 376 MHz)



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



^{13}C NMR (acetone-d_6, 100 MHz)



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