BEILSTEIN JOURNAL OF ORGANIC CHEMISTRY

Supporting Information

for

Simple synthesis of multi-halogenated alkenes from 2-bromo-2-chloro-1,1,1-trifluoroethane (halothane)

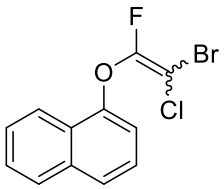
Yukiko Karuo, Atsushi Tarui, Kazuyuki Sato, Kentaro Kawai and Masaaki Omote

Beilstein J. Org. Chem. **2022,** *18,* 1567–1574. doi:10.3762/bjoc.18.167

Characterization data for 2b–p and copies of ^{1}H, ^{13}C, and ^{19}F NMR spectra

Spectroscopic data:

2-Bromo-2-chloro-1-fluoroethenyl 1-naphthyl ether (2b)

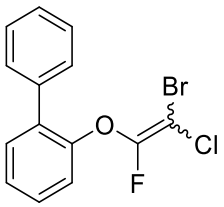


Reaction condition: **3b** (1.05 equiv) was used.

The title product (**2b**) was purified by column chromatography and preparative TLC (hexane only). **2b** was obtained in 70% yield (209.9 mg).

A pale yellow oil.; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.09-7.15 (1H, m), 7.43 (1H, dd, *J* = 7.9, 7.9 Hz), 7.53-7.61 (2H, m), 7.69 (1H, d, *J* = 8.3 Hz), 7.84-7.92 (1H, m), 8.17-8.26 (1H, m); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 80.7 (d, *J* = 60.6 Hz), 81.0 (d, *J* = 52.1 Hz), 109.6, 109.7, 121.38, 121.41, 124.9, 125.01, 125.03, 125.4, 126.7, 127.2, 127.9, 134.9, 149.6 (d, *J* = 3.8 Hz), 149.7 (d, *J* = 3.8 Hz), 152.5 (d, *J* = 287.6 Hz), 152.9 (d, *J* = 282.7 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.70 (1F, d, *J* = 2.2 Hz), -80.72 (1F, d, *J* = 2.2 Hz); MS (EI) *m/z*: 300, 302 (M^+); HRMS (EI) Calcd. for $C_{12}H_7BrClFO$: 299.9353, 301.9332 (M^+), Found: 299.9350, 301.9330.

2-Bromo-2-chloro-1-fluoroetheyl *o*-phenylphenyl ether (2c)

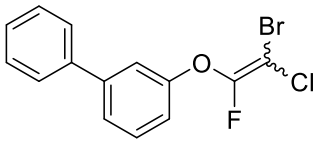


Reaction condition: **3c** (1.05 equiv) was used.

The title product (**2c**) was purified by column chromatography and preparative TLC (hexane only). **2c** was obtained in 85% yield (278.9 mg).

A pale yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.09-7.16 (1H, m), 7.27 (1H, t, *J* = 7.5 Hz), 7.33-7.47 (5H, m), 7.48-7.55 (2H, m); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 80.1 (d, *J* = 60.8 Hz), 80.5 (d, *J* = 51.8 Hz), 115.5, 115.6, 125.4, 127.8, 128.4, 128.9, 129.5, 129.6, 131.9, 132.1, 136.7, 150.4, 152.0 (d, *J* = 287.9 Hz), 152.5 (d, *J* = 282.6 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.8 (1F, d, *J* = 2.1 Hz), -80.9 (1F, d, *J* = 2.1 Hz); MS (EI) *m/z*: 326, 328 (M^+); HRMS (EI) Calcd. for $C_{14}H_9BrClFO$: 325.9509, 327.9489 (M^+), Found: 325.9510, 327.9485.

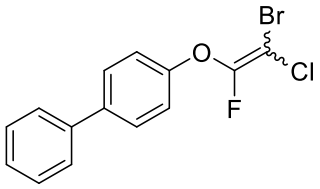
2-Bromo-2-chloro-1-fluoroethenyl *m*-phenylphenyl ether (2d)



The title product (**2d**) was purified by column chromatography and preparative TLC (hexane only). **2d** was obtained in 68% yield (221.8 mg).

A colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.07 (1H, d, *J* = 7.3 Hz), 7.29 (1H, s), 7.35-7.52 (5H, m), 7.58 (2H, d, *J* = 7.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 80.7 (d, *J* = 58.7 Hz), 80.9 (d, *J* = 52.9 Hz), 115.1, 115.3, 124.0, 127.3, 128.1, 129.1, 130.4, 140.0, 143.7, 152.2 (d, *J* = 287.7 Hz), 152.7 (d, *J* = 283.5 Hz), 154.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.45, -80.52; MS (EI) *m/z*: 326, 328 (M^+); HRMS (EI) Calcd. for $C_{14}H_9BrClFO$: 325.9509, 327.9489 (M^+), Found: 325.9507, 327.9489.

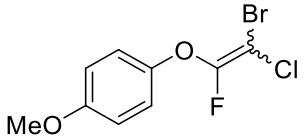
2-Bromo-2-chloro-1-fluoroethenyl *p*-phenylphenyl ether (2e)



The title product (**2e**) was purified by column chromatography and preparative TLC (hexane only). **2e** was obtained in 63% yield (205.2 mg).

A white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.16 (2H, d, *J* = 8.2 Hz), 7.36 (1H, tt, *J* = 7.3, 1.1 Hz), 7.44 (2H, dd, *J* = 7.3, 7.3 Hz), 7.55 (2H, d, *J* = 7.3 Hz), 7.59 (2H, d, *J* = 8.2 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 80.7 (d, *J* = 61.1 Hz), 80.9 (d, *J* = 52.7 Hz), 116.82, 116.84, 127.2, 127.6, 128.8, 129.0, 138.5, 140.1, 152.2 (d, *J* = 287.8 Hz), 152.6 (d, *J* = 282.4 Hz), 153.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.56 (1F, s), -80.61 (1F, s); MS (EI) *m/z*: 326, 328 (M^+); HRMS (EI) Calcd. for $C_{14}H_9BrClFO$: 325.9509, 327.9489 (M^+), Found: 325.9501, 327.9488.

2-Bromo-2-chloro-1-fluoroethenyl *p*-methoxyphenyl ether (2f)

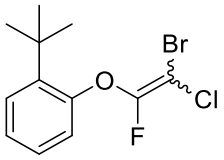


Reaction condition: **3f** (1.05 mmol) was used.

The title product (**2f**) was purified by column chromatography (hexane only to hexane/AcOEt = 12:1) and was obtained in 76% yield (213.9 mg).

A yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 3.80 (3H, s), 6.88 (2H, d, *J* = 8.6 Hz), 7.04 (2H, d, *J* = 8.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 55.8, 79.6 (d, *J* = 62.3 Hz), 79.8 (d, *J* = 53.4 Hz), 115.0, 118.0, 118.1, 147.59, 147.62, 152.8 (d, *J* = 287.8 Hz), 153.2 (d, *J* = 282.7 Hz), 157.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.58 (1F, s), -80.60 (1F, s); MS (EI) *m/z*: 280, 282 (M^+); HRMS (EI) Calcd. for $C_9H_7BrClFO_2$: 279.9302, 281.9282 (M^+), Found: 279.9307, 281.9278.

2-Bromo-2-chloro-1-fluoroethenyl *o-tert*-butylphenyl ether (2g)

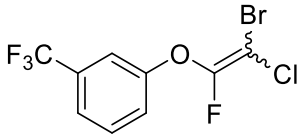


Reaction condition: **3g** (1.05 mmol) was used.

The title product (**2g**) was purified by column chromatography and preparative TLC (hexane only). **2g** was obtained in 43% yield (131.0 mg).

A colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.41 (9H, s), 6.91-6.98 (1H, m), 7.12 (1H, ddd, *J* = 7.6, 7.6, 2.3 Hz), 7.22 (1H, ddd, *J* = 7.6, 7.6, 2.7 Hz), 7.39 (1H, dd, *J* = 7.6, 2.3 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 30.1, 34.9, 80.4 (d, *J* = 60.9 Hz), 80.8 (d, *J* = 52.3 Hz), 114.8, 114.9, 124.79, 124.81, 127.5, 127.9, 138.8, 151.5 (d, *J* = 288.5 Hz), 151.9 (d, *J* = 282.8Hz), 152.27 (d, *J* = 2.8 Hz), 152.33 (d, *J* = 2.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ: -81.4 (1F, d, *J* = 2.7 Hz), -81.7 (1F, d, *J* = 2.7 Hz); MS (EI) *m/z*: 306, 308 (M^+); HRMS (EI) Calcd. for $C_{12}H_{13}BrClFO$: 305.9822, 307.9802 (M^+), Found: 305.9825, 307.9792.

2-Bromo-2-chloro-1-fluoroethenyl *m*-trifluoromethylphenyl ether (2h)

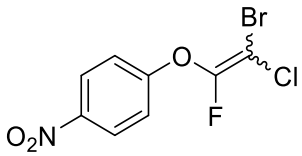


Reaction condition: **3h** (1.05 mmol) and DME (2.5 mL) was used.

The title product (**2h**) was purified by column chromatography and preparative TLC (hexane only). **2h** was obtained in 39% yield (125.4 mg).

A colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.27 (1H, d, *J* = 7.9 Hz), 7.34 (1H, s), 7.48 (1H, d, *J* = 7.6 Hz), 7.53 (1H, dd, *J* = 7.9, 7.6 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 81.5 (d, *J* = 59.8 Hz), 81.8 (d, *J* = 51.0 Hz), 113.9, 119.7, 122.0, 123.4 (q, *J* = 272.6 Hz), 130.9, 132.9 (q, *J* = 33.3 Hz), 151.7 (d, *J* = 288.2 Hz), 152.1 (d, *J* = 283.4 Hz), 153.82 (d, *J* = 3.6 Hz), 153.85 (d, *J* = 3.6 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ: -62.7 (3F, s), -81.4 (1F, s), -81.5 (1F, s); MS (EI) *m/z*: 318 (M^+); HRMS (EI) Calcd. for $C_9H_4BrClF_4O$: 317.9070 (M^+), Found: 317.9064.

2-Bromo-2-chloro-1-fluoroethenyl *p*-nitrophenyl ether (2i)



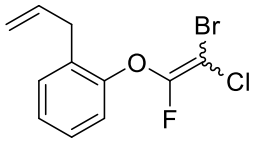
Reaction condition: **3i** (1.05 mmol) and DME (2.5 mL) was used.

The title product (**2i**) was purified by column chromatography and preparative TLC (hexane only). **2i**

was obtained in 18% yield (54.0 mg).

A pale yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.21 (2H, d, *J* = 8.5 Hz), 8.30 (2H, d, *J* = 8.5 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 82.5 (d, *J* = 58.1 Hz), 82.9 (d, *J* = 49.6 Hz), 116.7, 126.3, 144.9, 151.2 (d, *J* = 289.1 Hz), 151.5 (d, *J* = 283.6 Hz), 157.96 (d, *J* = 4.1 Hz), 158.03 (d, *J* = 4.1 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ: -81.6 (1F, s), -81.8 (1F, s); MS (EI) *m/z*: 295, 297 (M^+); HRMS (EI) Calcd. for $C_8H_4BrClFNO_3$: 294.9047, 296.9027 (M^+), Found: 294.9055, 296.9023.

<u>*o*-Allylphenyl 2-bromo-2-chloro-1-fluoroethenyl ether (2j)</u>

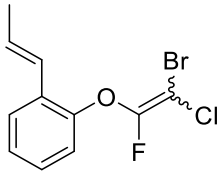


Reaction condition: **3j** (1.05 eq.) was used.

The title product (**2j**) was purified by column chromatography and preparative TLC (hexane only). **2j** was obtained in 75% yield (217.8 mg).

A colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 3.45 (2H, d, *J* = 6.7 Hz), 5.03-5.12 (2H, m), 5.89-6.03 (1H, m), 6.97-7.03 (1H, m), 7.13 (1H, t, *J* = 7.3 Hz), 7.20-7.27 (2H, m); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 34.1, 80.0 (d, *J* = 61.9 Hz), 80.4 (d, *J* = 51.9 Hz), 114.8, 115.0, 116.5, 125.3, 127.8, 129.7, 131.1, 135.8, 151.7, 152.4 (d, *J* = 288.1 Hz), 152.7 (d, *J* = 282.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.3 (1F, d, *J* = 2.1 Hz), -80.4 (1F, d, *J* = 2.1 Hz); MS (EI) *m/z*: 290, 292 (M^+); HRMS (EI) Calcd. for $C_{11}H_9BrClFO$: 289.9509, 291.9489 (M^+), Found: 289.9509, 291.9489.

<u>2-Bromo-2-chloro-1,1-fluoroethenyl *o*-propenylphenyl ether (2k)</u>

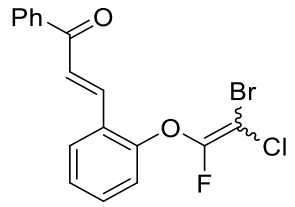


The title product (**2k**) was purified by column chromatography (hexane only) and was obtained as an inseparable mixture of *cis*-*trans* isomers (1:4) in 54% yield (157.9 mg).

A pale yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.81 (ddd, *J* = 7.1, 2.2, 1.1 Hz, *cis*-isomer) and 1.92 (dd, *J* = 6.8, 1.5 Hz, *trans*-isomer) (3H), 5.92 (dq, *J* = 11.3, 7.1 Hz, *cis*-isomer) and 6.23 (dq, *J* = 15.8, 6.7 Hz, *trans*-isomer) (1H), 6.50 (d, *J* = 11.3 Hz, *cis*-isomer) and 6.68 (dq, *J* = 15.8, 1.5 Hz, *trans*-isomer) (1H), 6.99 (dq, *J* = 8.1, 1.5 Hz, *trans*-isomer) and 7.04 (dq, *J* = 8.1, 1.1 Hz, *cis*-isomer) (1H), 7.09-7.29 (2H, m), 7.33 (d, *J* = 7.6 Hz, *cis*-isomer) and 7.49 (d, *J* = 7.6 Hz, *trans*-isomer) (1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 14.8 (*cis*-isomer), 19.0 (*trans*-isomer), 79.6 (d, *J* = 61.4 Hz, *cis*-isomer), 79.8 (d, *J* = 61.4 Hz, *trans*-isomer), 80.0 (d, *J* = 52.9 Hz, *cis*-isomer), 80.2 (d, *J* = 52.4 Hz, *trans*-isomer), 115.4, 115.6, 123.5 (*cis*-isomer), 123.6 (*cis*-isomer), 123.9 (*trans*-isomer), 124.0 (*trans*-isomer), 124.8 (*cis*-isomer), 125.3 (*trans*-isomer), 127.2 (*trans*-isomer), 127.78 (*cis*-isomer), 127.80 (*cis*-isomer), 128.0 (*trans*-isomer), 128.3 (*cis*-isomer), 128.38 (*trans*-isomer), 128.40 (*trans*-isomer),

128.86 (*trans*-isomer), 128.89 (*trans*-isomer), 129.28 (*cis*-isomer), 129.32 (*cis*-isomer), 131.1 (*cis*-isomer), 150.3 (*trans*-isomer), 151.1 (*cis*-isomer), 152.4 (d, J = 287.2 Hz), 152.8 (d, J = 282.3 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.21 (1F, s, *cis*-isomer), -80.22 (1F, s, *cis*-isomer), -80.22 (1F, d, J = 1.5 Hz, *trans*-isomer), -80.23 (1F, d, J = 1.5 Hz, *trans*-isomer); MS (EI) *m/z*: 290, 292 (M^+); HRMS (EI) Calcd. for $C_{11}H_9BrClFO$: 289.9509, 291.9489 (M^+), Found: 289.9505, 291.9493.

(*E*)-2'-(2-Bromo-2-chloro-1-fluoroethenyloxy)-chalcone (2l)

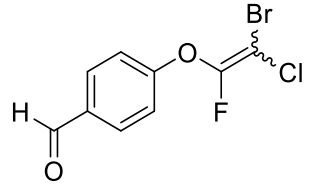


Reaction condition: **3l** (1.05 equiv) was used.

The title product (**2l**) was purified by column chromatography (hexane/AcOEt = 14:1) and was obtained in 51% yield (191.4 mg).

An orange oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.07-7.13 (1H, m), 7.26 (1H, dd, J = 7.5, 7.5 Hz), 7.40-7.47 (1H, m), 7.52 (2H, dd, J = 7.5, 7.5 Hz), 7.56-7.64 (2H, m), 7.52 (1H, dd, J = 7.8, 1.5 Hz), 8.00-8.04 (2H, m), 8.07 (1H, d, J = 16.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 81.2 (d, J = 60.0 Hz), 81.6 (d, J = 51.1 Hz), 115.4, 115.5, 124.8, 125.3, 125.4, 128.75, 128.83, 129.1, 129.2, 131.8, 133.1, 137.75, 137.79, 138.1, 151.9 (d, J = 288.1 Hz), 152.1 (d, J = 282.7 Hz), 152.5 (d, J = 3.3 Hz), 152.6 (d, J = 3.7 Hz), 190.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.5 (1F, d, J = 2.4 Hz), -80.6 (1F, d, J = 2.3 Hz); MS (EI) *m/z*: 380 (M^+); HRMS (EI) Calcd. for $C_{17}H_{11}BrClFO_2$: 379.9615 (M^+), Found: 379.9615.

2-Bromo-2-chloro-1-fluoroethenyl *p*-formylphenyl ether (2m)

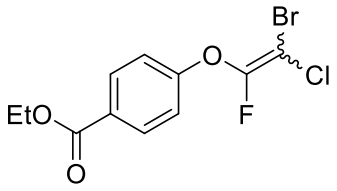


Reaction condition: **3m** (1.05 mmol) was used.

The title product (**2m**) was purified by column chromatography and preparative TLC (hexane/AcOEt = 14:1). **2m** was obtained in 9% yield (25.7 mg).

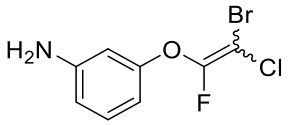
A yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.23 (2H, d, J = 8.4 Hz), 7.94 (2H, d, J = 8.5 Hz), 9.99 (1H, s); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 82.0 (d, J = 59.5 Hz), 82.4 (d, J = 51.0 Hz), 116.7, 132.2, 133.5, 151.4 (d, J = 288.6 Hz), 151.8 (d, J = 283.3 Hz), 158.06 (d, J = 5.0 Hz), 158.11 (d, J = 5.0 Hz), 190.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -81.1 (1F, s), -81.3 (1F, s); MS (EI) *m/z*: 278, 280 (M^+); HRMS (EI) Calcd. for $C_9H_5BrClFO_2$: 277.9145, 279.9125 (M^+), Found: 277.9141, 279.9125.

2-Bromo-2-chloro-1-fluoroethenyl *p*-ethoxycarbonylphenyl ether (2n)



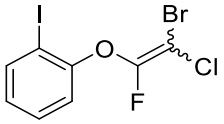
Reaction condition: **3n** (1.05 mmol) and THF was used.
The title product (**2n**) was purified by column chromatography (hexane/AcOEt = 19:1) and preparative TLC (hexane/AcOEt = 29:1). **2n** was obtained in 32% yield (102.7 mg).
A yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.39 (3H, t, *J* = 7.0 Hz), 4.38 (2H, q, *J* = 7.0 Hz), 7.12 (2H, d, *J* = 8.5 Hz), 8.08 (2H, d, *J* = 8.5 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 14.5, 61.3, 81.6 (d, *J* = 59.9 Hz), 81.9 (d, *J* = 51.2 Hz), 116.0, 127.5, 132.0, 151.7 (d, *J* = 288.0 Hz), 152.0 (d, *J* = 283.2 Hz), 157.0 (d, *J* = 4.3 Hz), 157.1 (d, *J* = 4.3 Hz), 165.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.9 (1F, s), -81.0 (1F, s); MS (EI) *m/z*: 322, 324 (M^+); HRMS (EI) Calcd. for $C_{11}H_9BrClFO_3$: 321.9408, 323.9387 (M^+), Found: 321.9401, 323.9377.

***m*-Aminophenyl 2-bromo-2-chloro-1-fluoroethenyl ether (2o)**



Reaction condition: **3o** (1.2 eq.) was used.
The title product (**2o**) was purified by column chromatography (hexane/AcOEt = 4:1) and was obtained in 66% yield (174.9 mg).
A yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 3.79 (2H, br s), 6.39 (1H, s), 6.43-6.53 (2H, m), 7.12 (1H, dd, *J* = 8.1, 8.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 80.4 (d, *J* = 61.5 Hz), 80.7 (d, *J* = 53.8 Hz), 103.02, 103.04, 106.07, 106.10, 111.8, 130.7, 148.3, 152.2 (d, *J* = 288.1 Hz), 152.7 (d, *J* = 282.9 Hz), 154.95, 154.98; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.03 (1F, s), -80.04 (1F, s); MS (EI) *m/z*: 265 (M^+); HRMS (EI) Calcd. for $C_8H_6BrClFNO$: 264.9305 (M^+), Found: 264.9300.

2-Bromo-2-chloro-1-fluoroethenyl *o*-iodophenyl ether (2p)



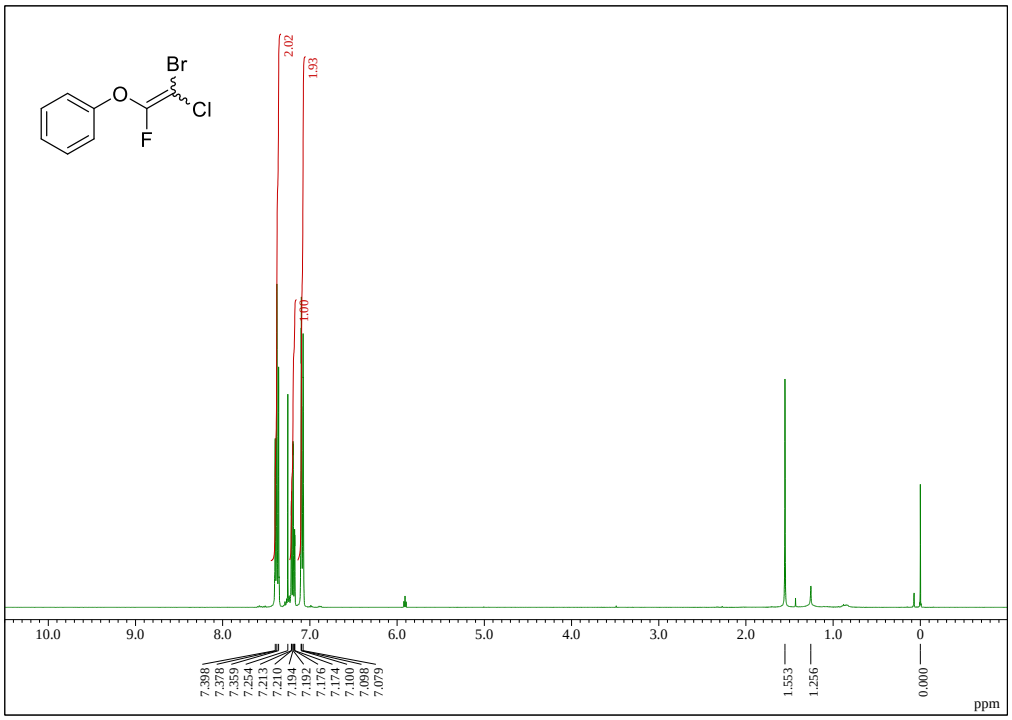
Reaction condition: Halothane (1.5 eq.) was used.
The title product (**2p**) was purified by column chromatography and preparative TLC (hexane only). **2p** was obtained in 69% yield (262.0 mg).
A yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.94 (1H, ddd, *J* = 8.0, 7.7, 1.5 Hz), 7.00-7.05 (1H, m), 7.34 (1H, ddd, *J* = 8.0, 7.7, 1.8 Hz), 7.84 (1H, dd, *J* = 8.0, 1.5 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ:

81.1 (d, J = 59.5 Hz), 81.5 (d, J = 50.5 Hz), 85.3, 115.3, 115.5, 126.8, 129.9, 140.4, 152.0 (d, J = 288.6 Hz), 152.4 (d, J = 283.1 Hz), 153.1 (d, J = 3.5 Hz), 153.2 (d, J = 3.5 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ: -80.8 (1F, d, J = 2.1 Hz), -81.0 (1F, d, J = 2.1 Hz); MS (EI) m/z: 376, 378 (M^+); HRMS (EI) Calcd. for $C_8H_4BrClFIO$: 375.8163, 377.8142 (M^+), Found: 375.8171, 377.8135.

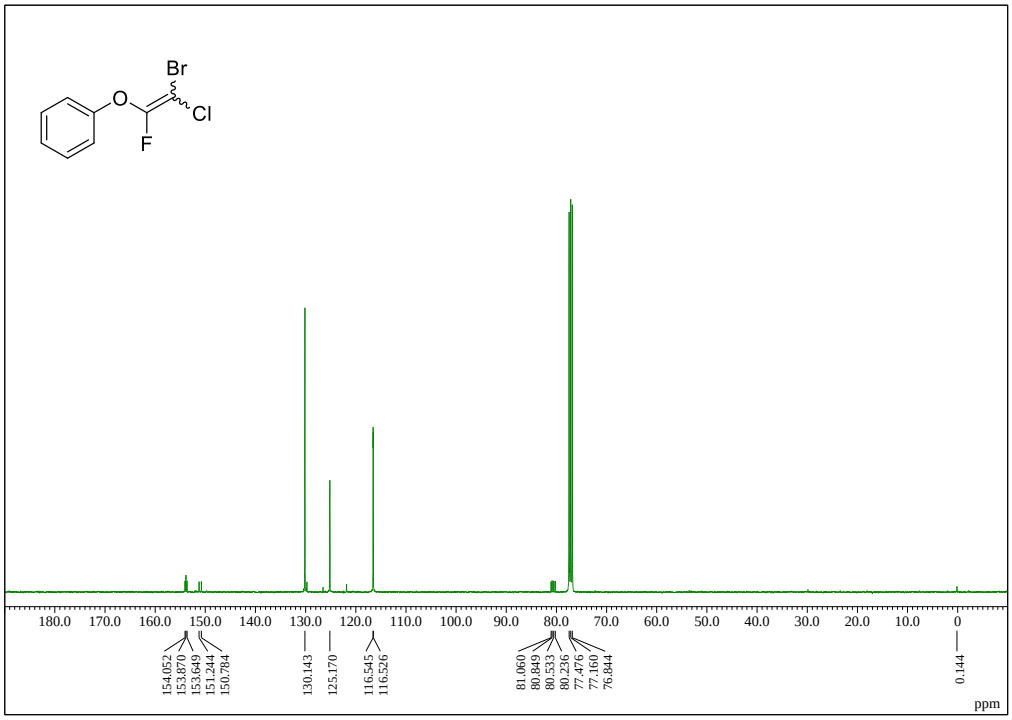
^{1}H and ^{13}C NMR Charts

2-Bromo-2-chloro-1-fluoroethenyl phenyl ether (2a)

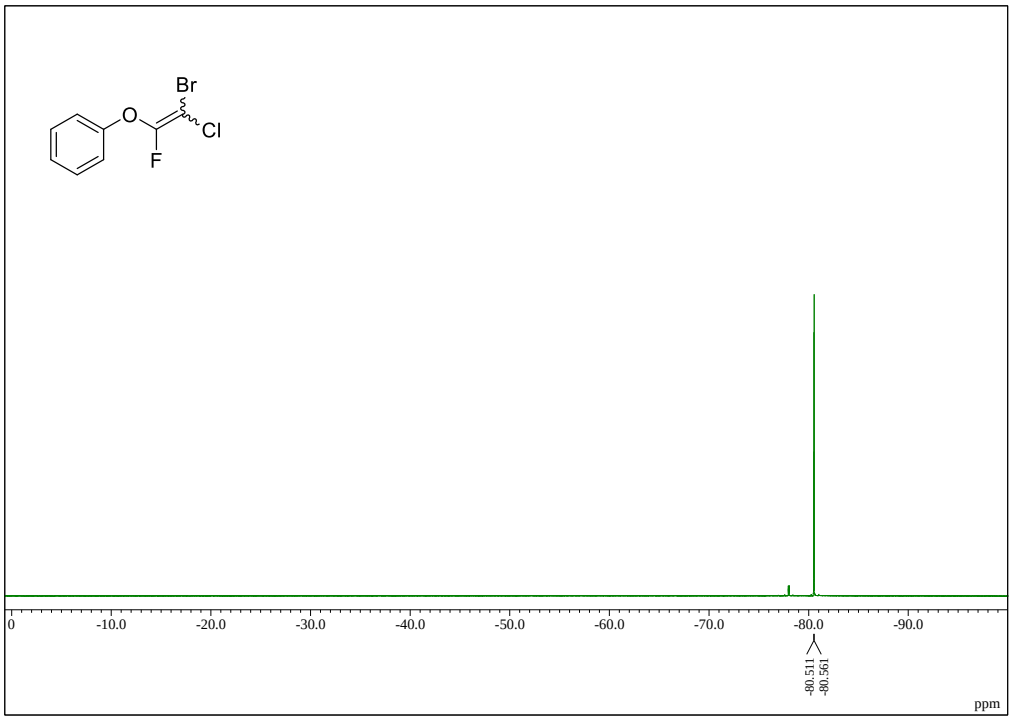
^{1}H NMR of **2a**



^{13}C NMR of **2a**

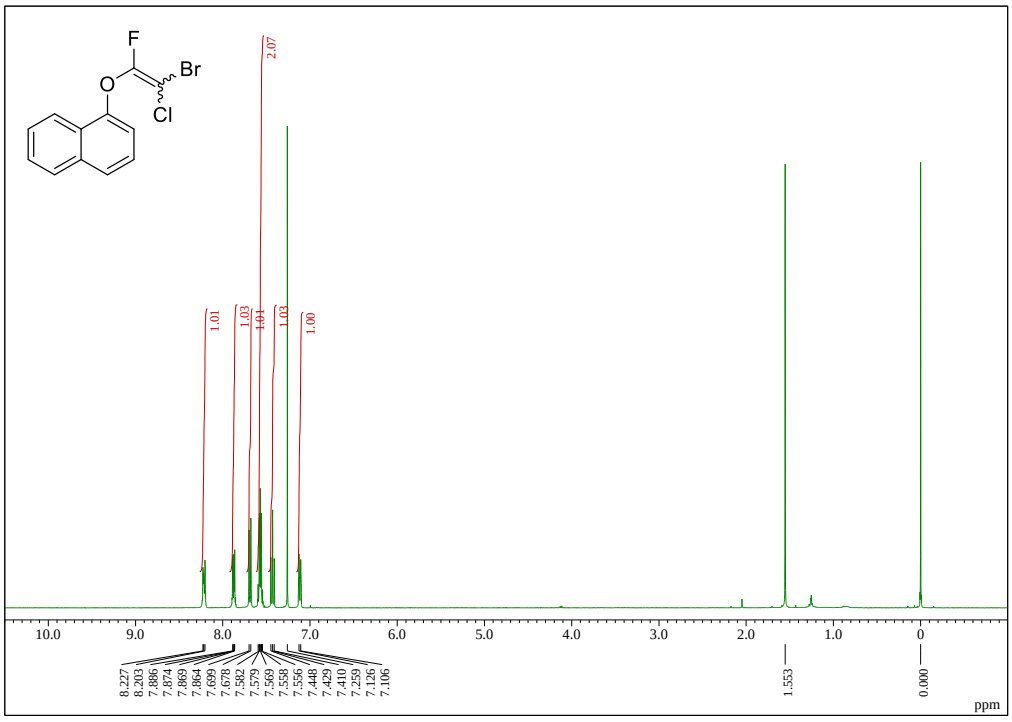


^{19}F NMR of **2a**

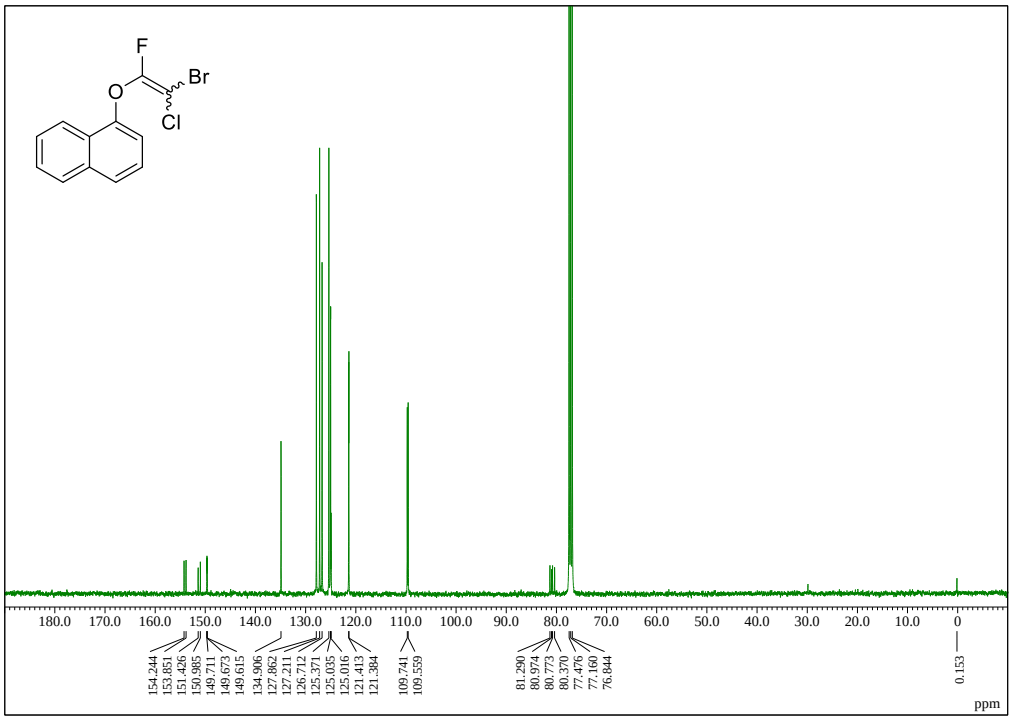


2-Bromo-2-chloro-1-fluoroethenyl 1-naphthyl ether (2b)

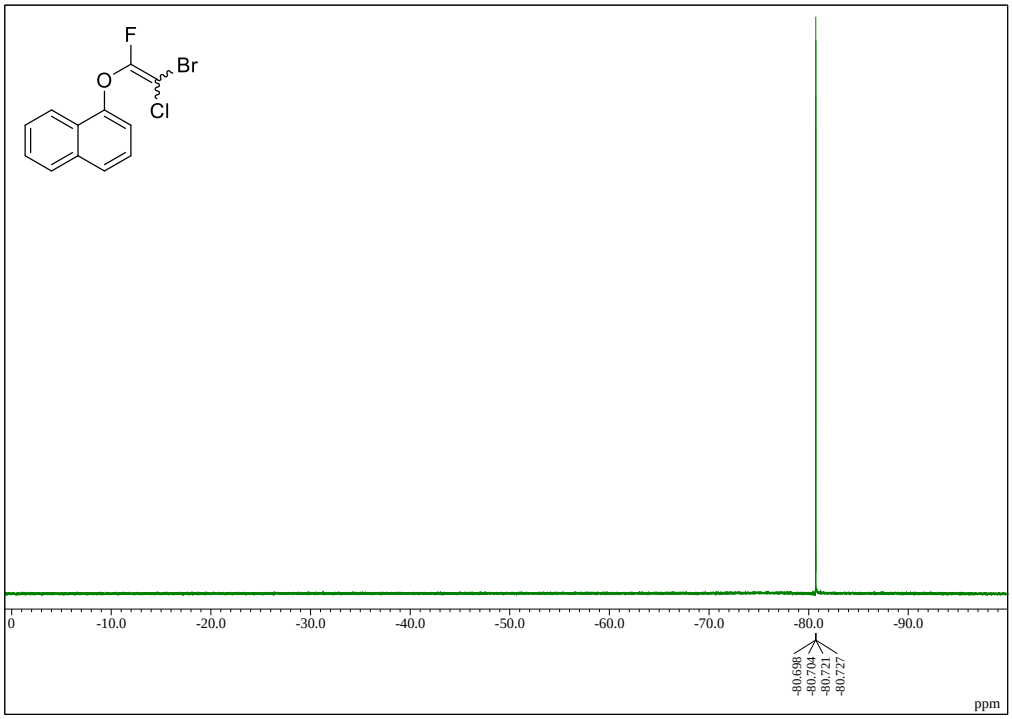
^{1}H NMR of **2b**



^{13}C NMR of **2b**

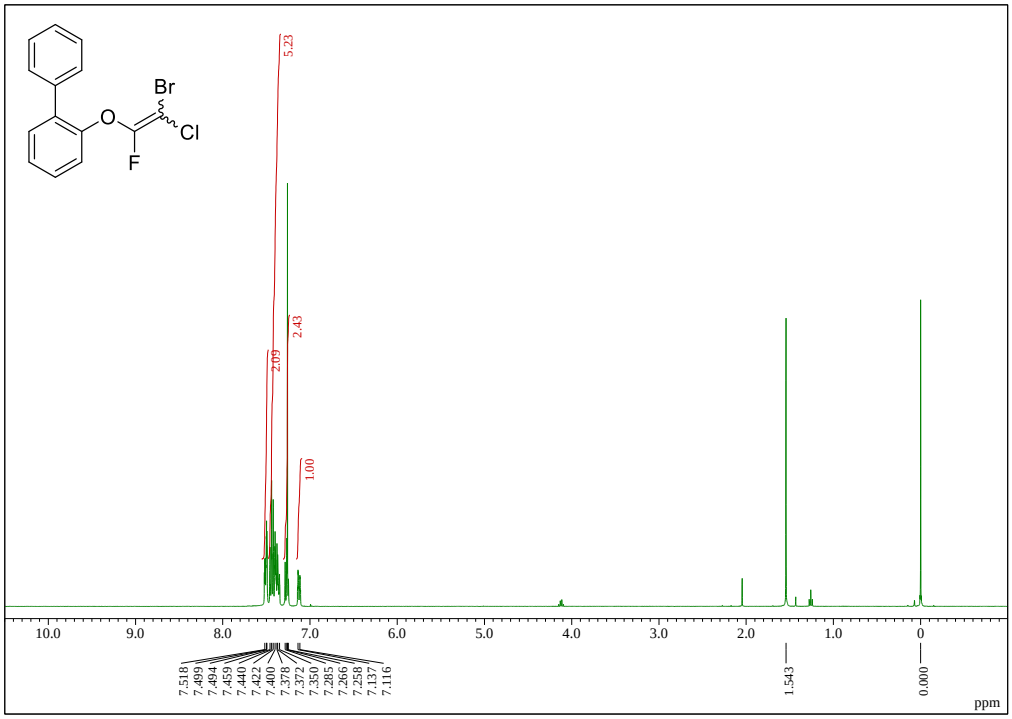


^{19}F NMR of **2b**

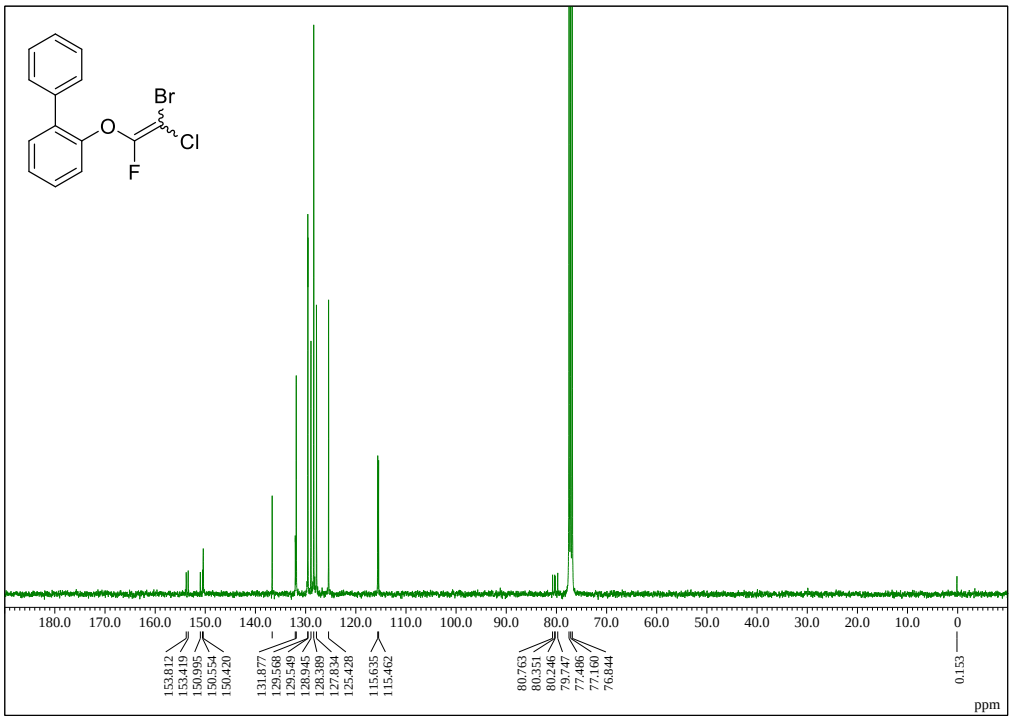


2-Bromo-2-chloro-1-fluoroethenyl *o*-phenylphenyl ether (2c)

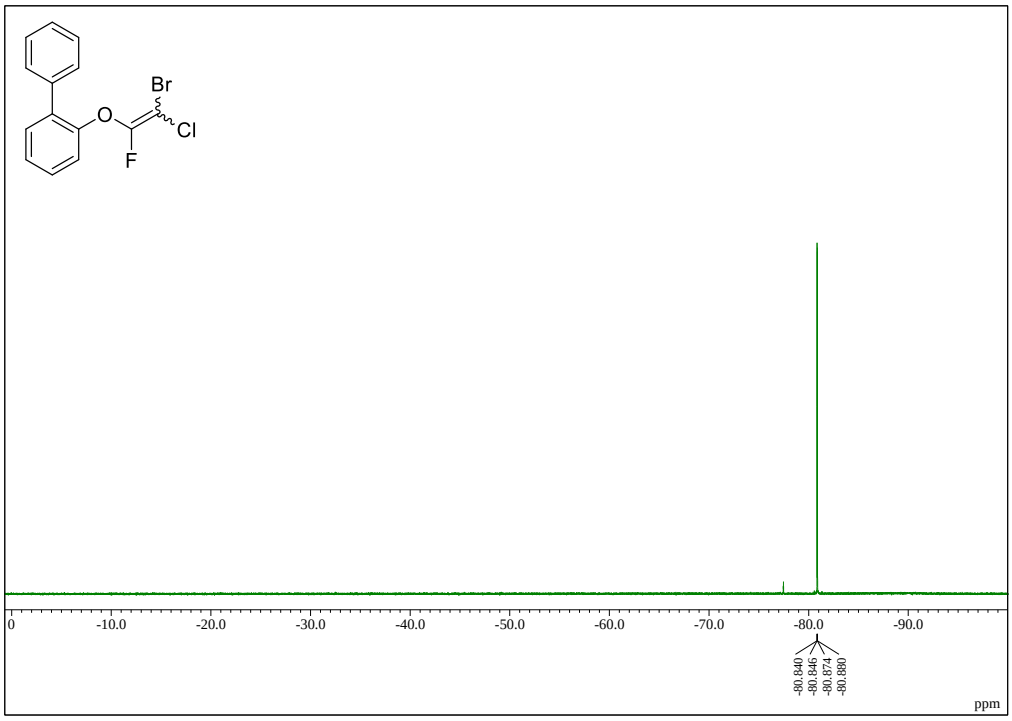
^{1}H NMR of **2c**



^{13}C NMR of **2c**

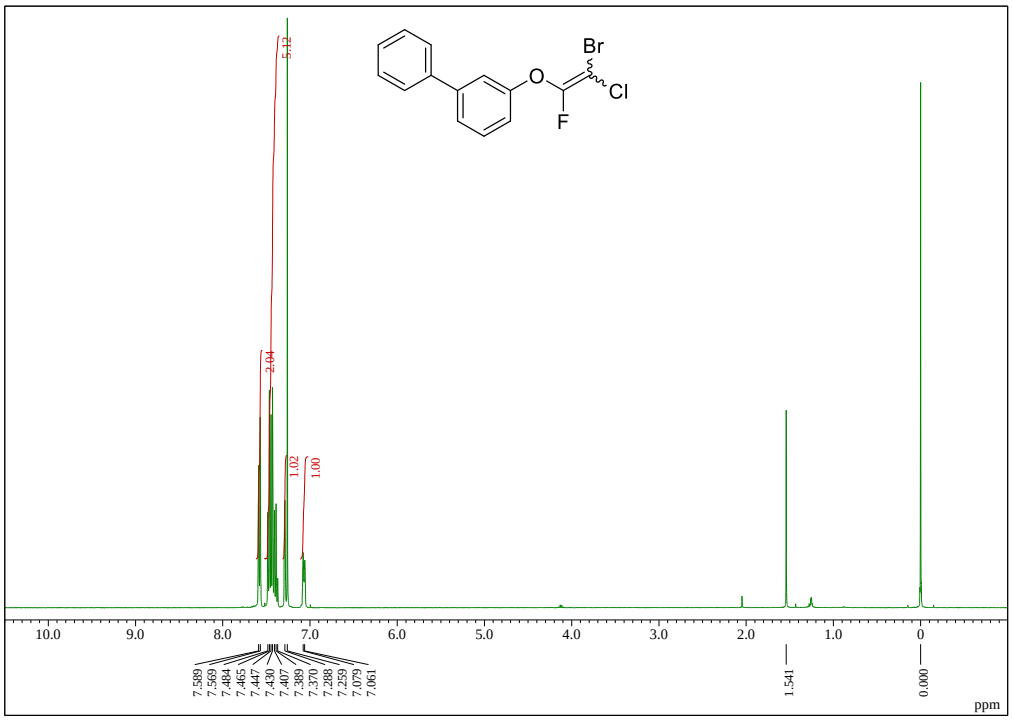


^{19}F NMR of **2c**

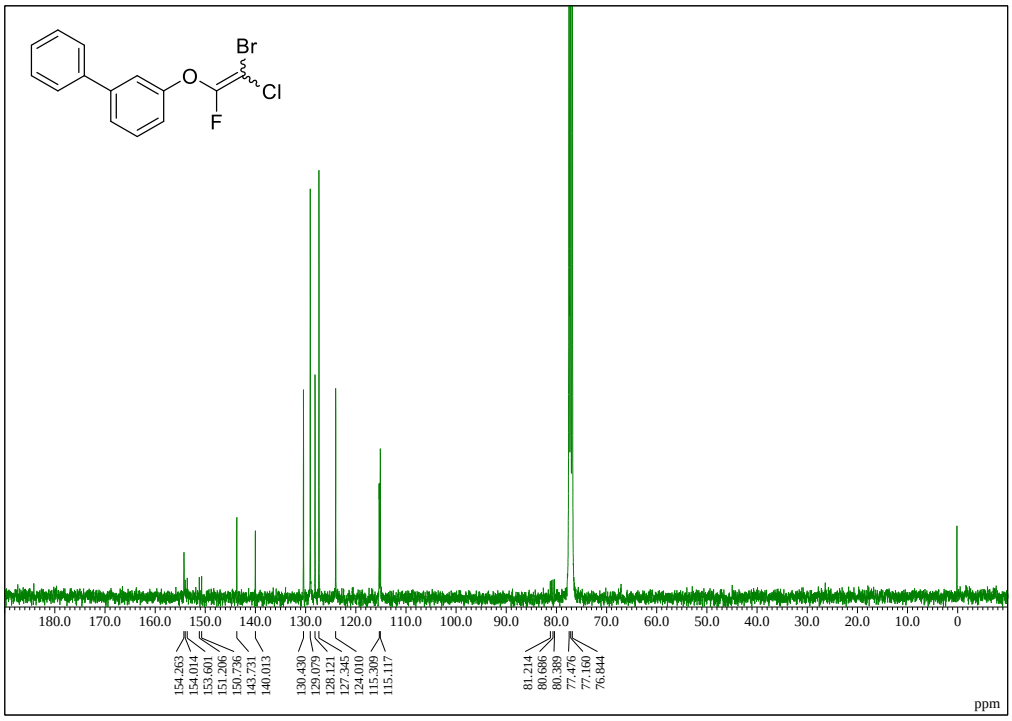


2-Bromo-2-chloro-1-fluoroetheyl *m*-phenylphenyl ether (2d)

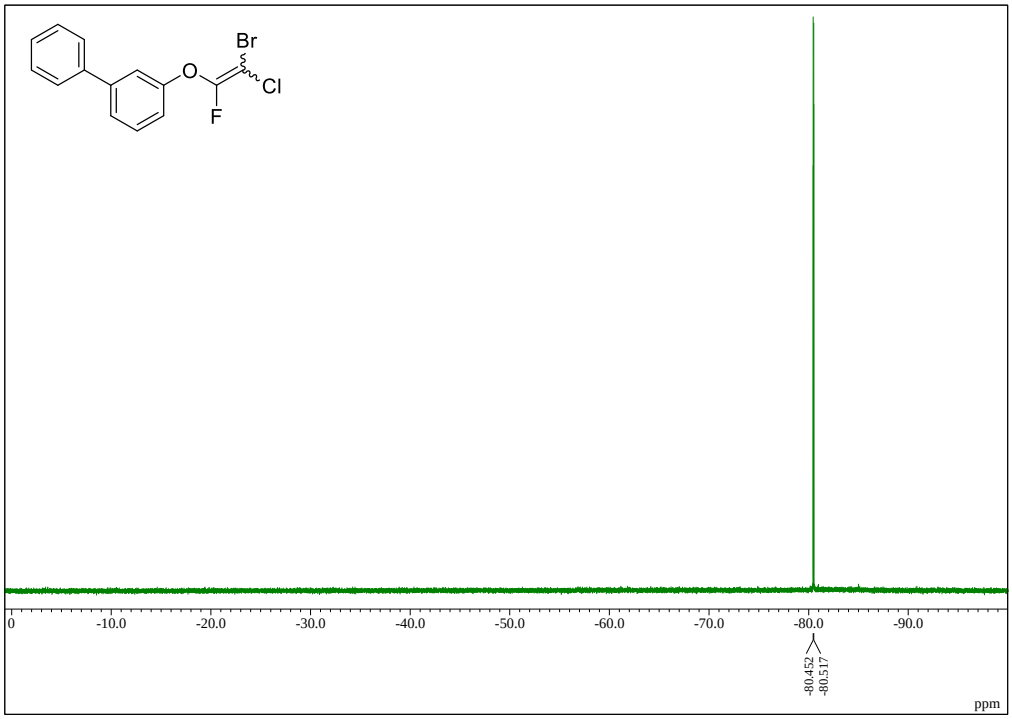
^{1}H NMR of **2d**



^{13}C NMR of **2d**

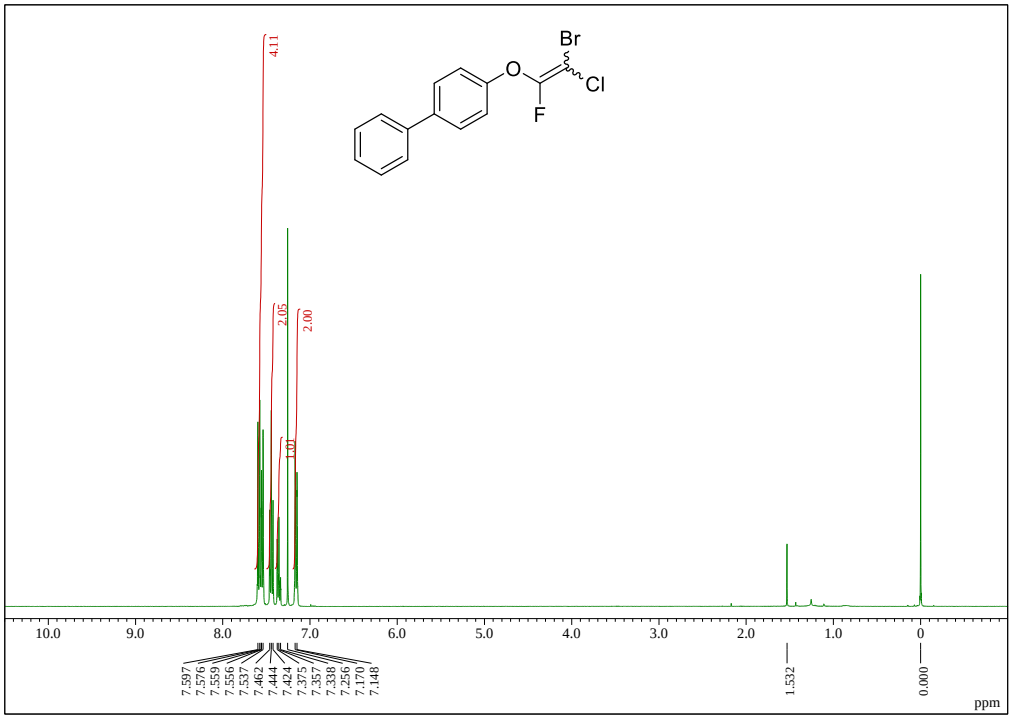


^{19}F NMR of **2d**

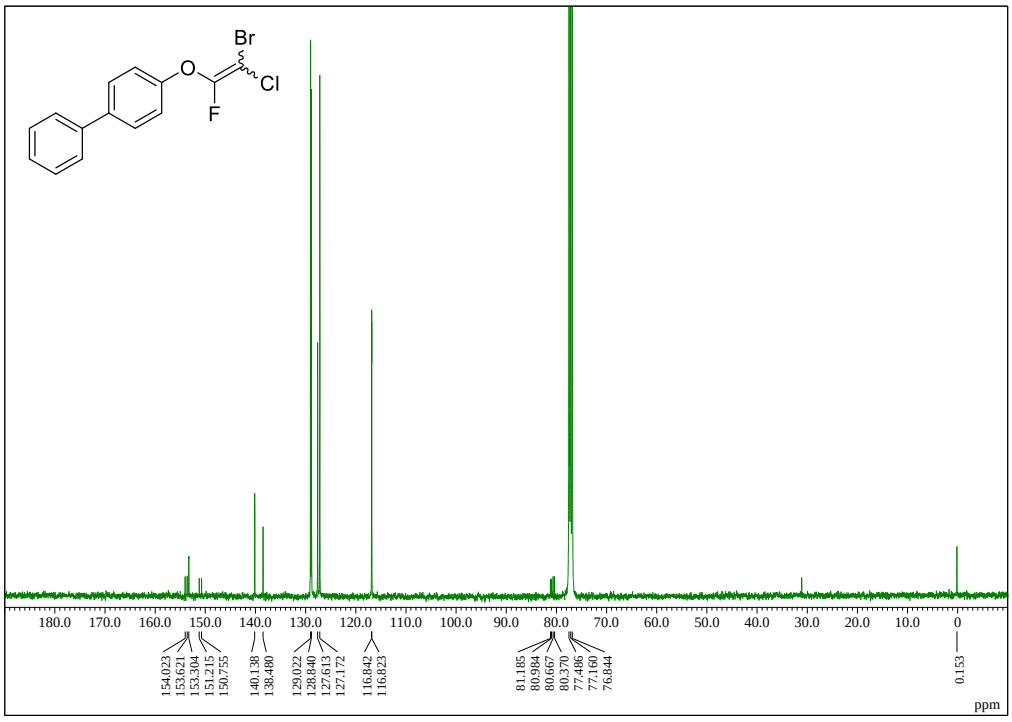


2-Bromo-2-chloro-1-fluoroethenyl *p*-phenylphenyl ether (2e)

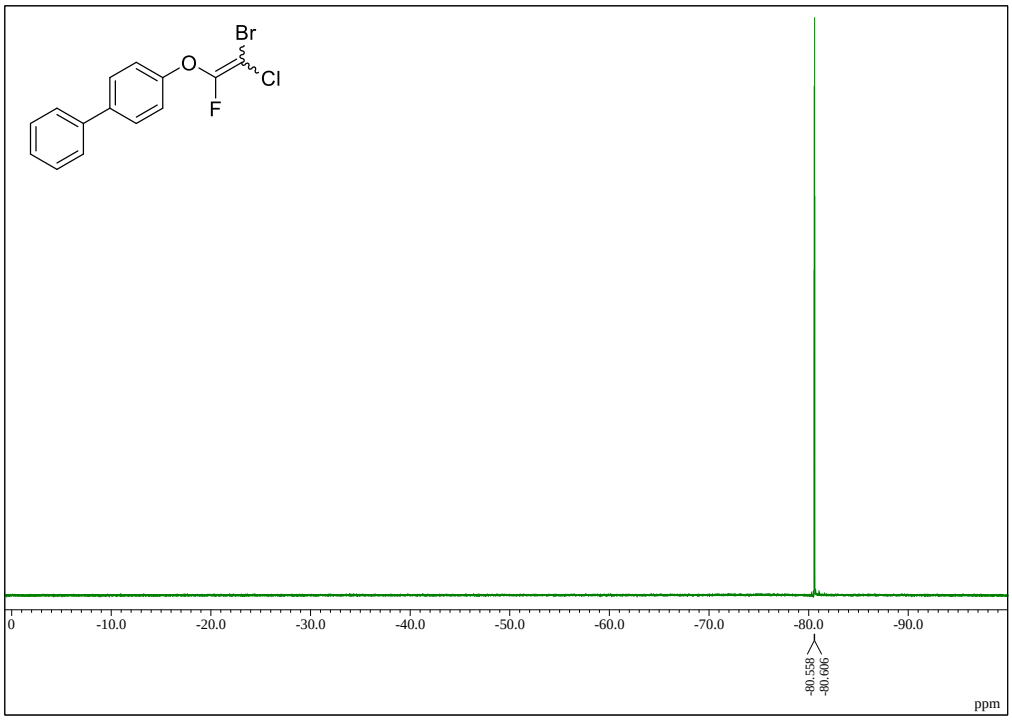
^{1}H NMR of **2e**



^{13}C NMR of **2e**

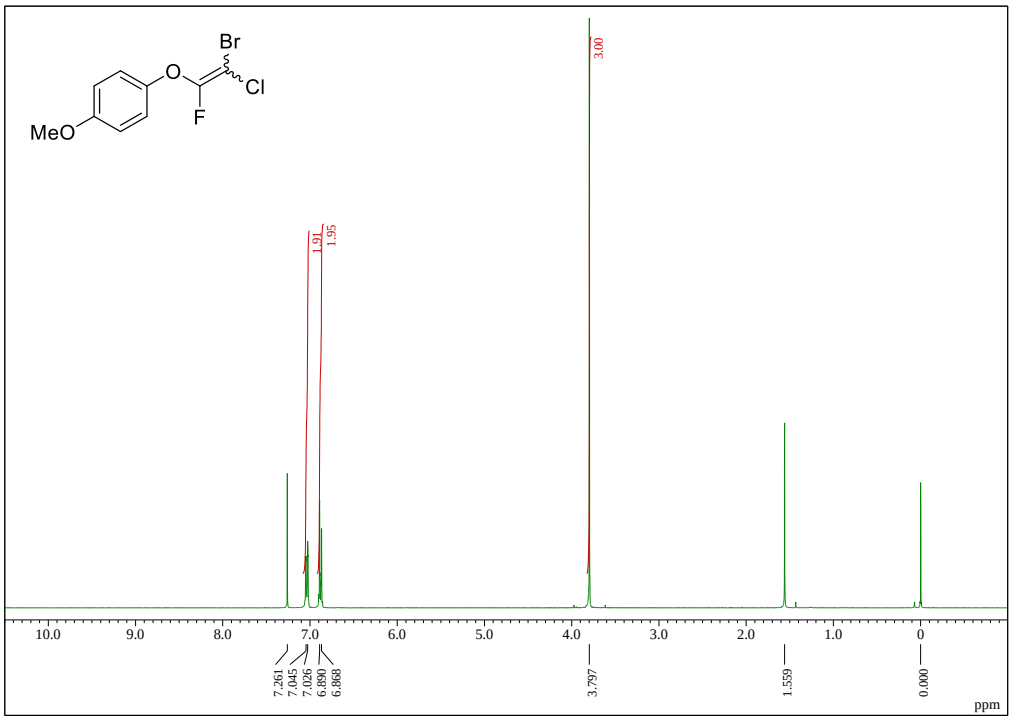


^{19}F NMR of **2e**

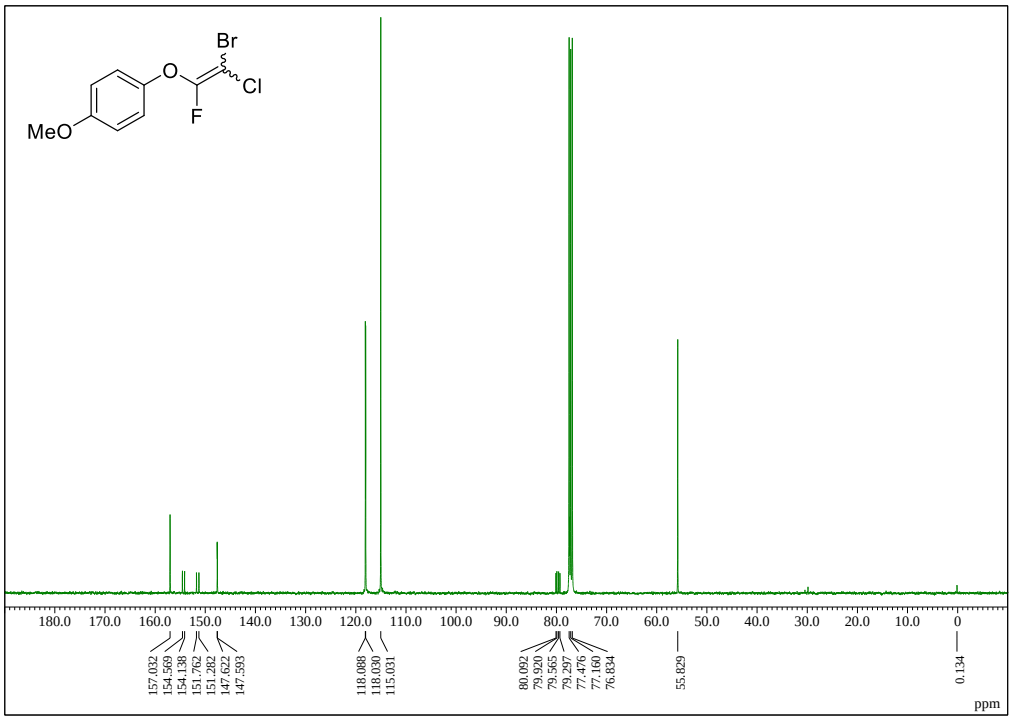


2-Bromo-2-chloro-1-fluoroetheyl *p*-methoxyphenyl ether (2f)

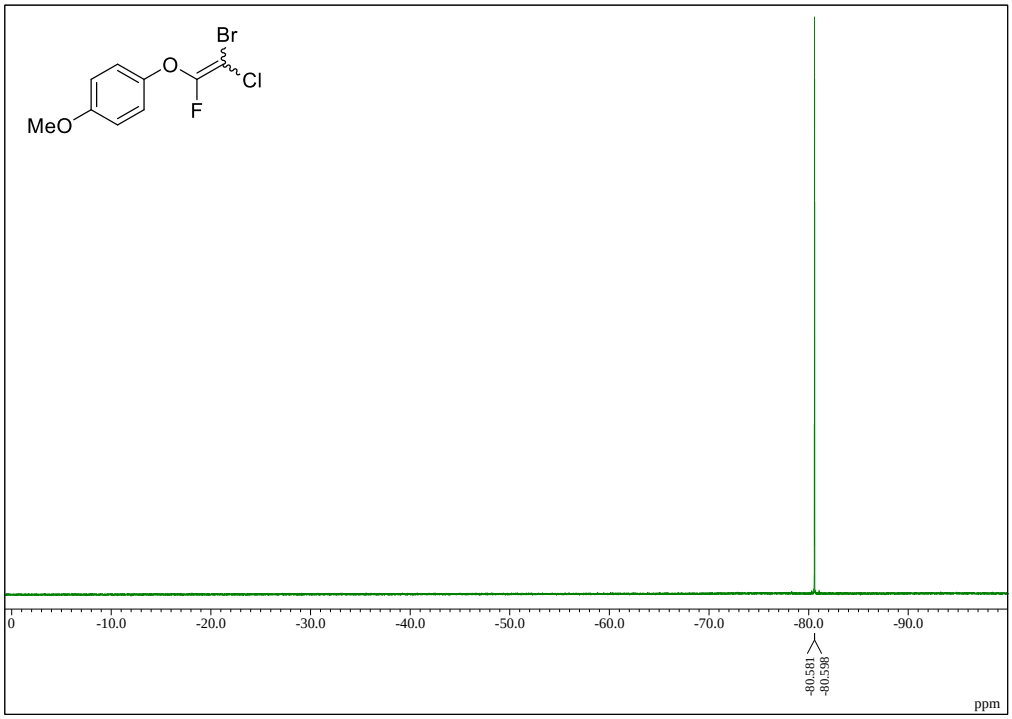
^{1}H NMR of **2f**



^{13}C NMR of **2f**

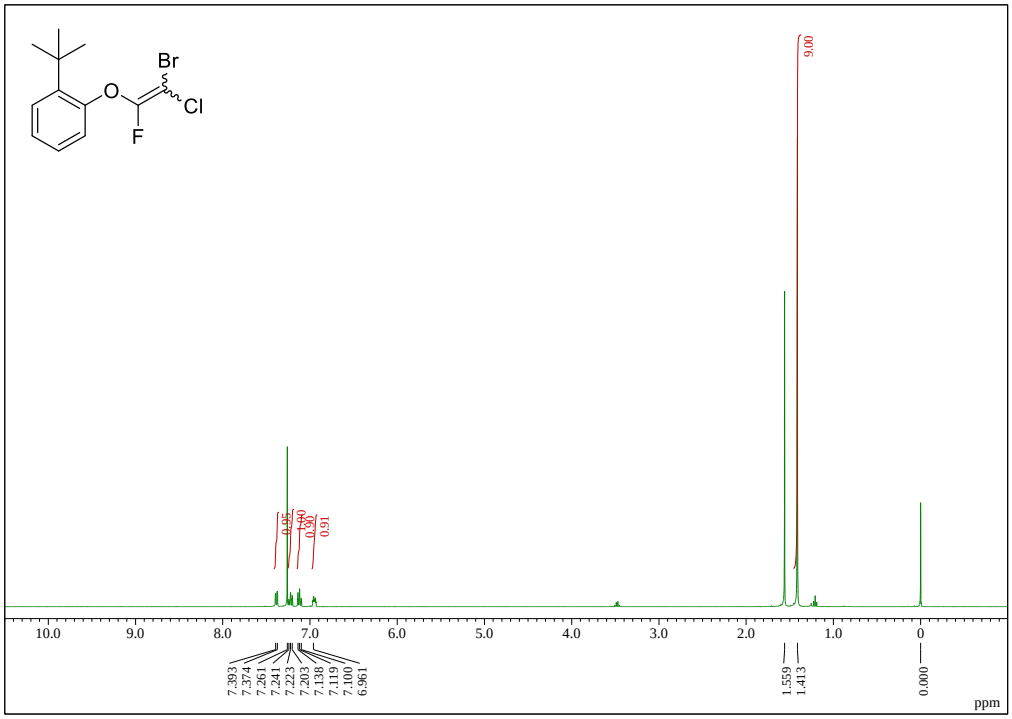


^{19}F NMR of **2f**

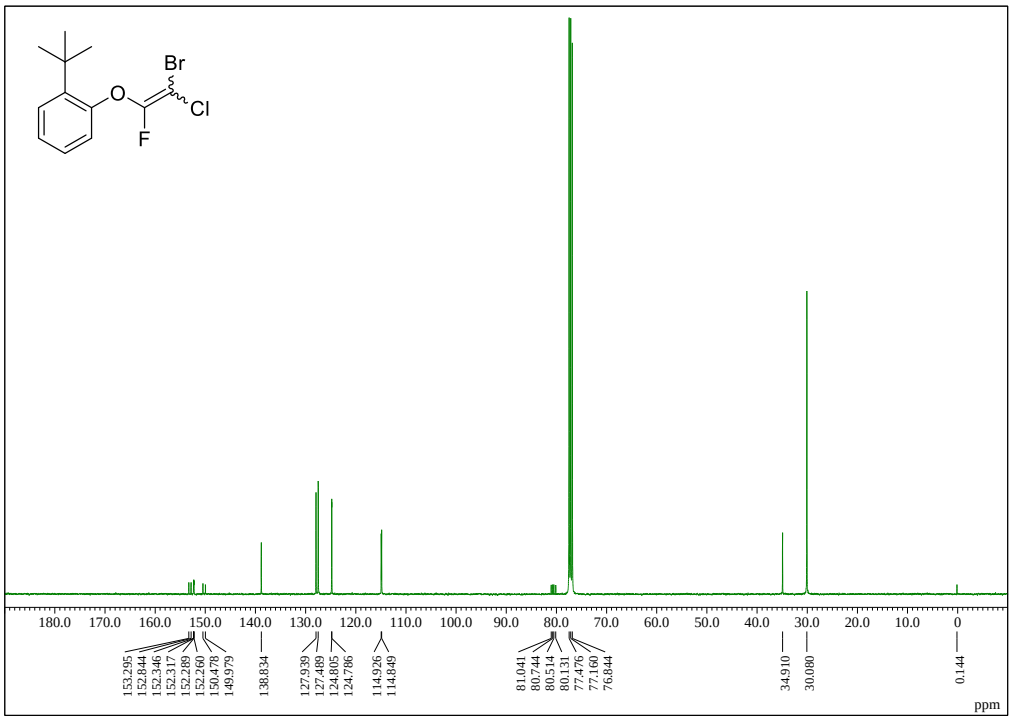


2-Bromo-2-chloro-1-fluoroethenyl *o-tert*-butylphenyl ether (2g)

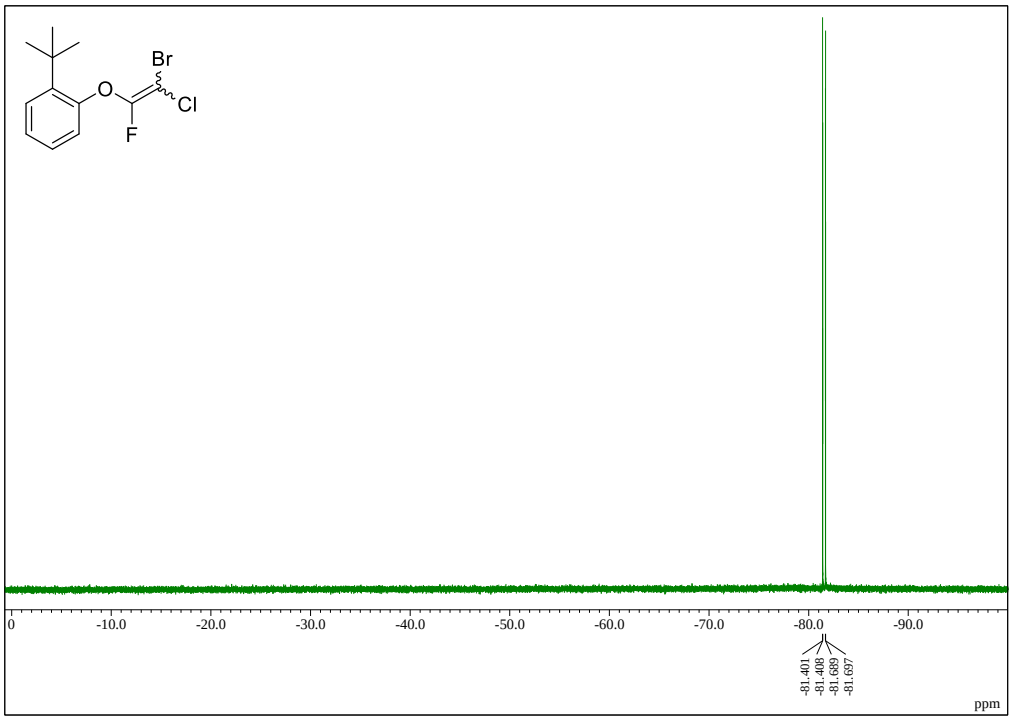
^{1}H NMR of **2g**



^{13}C NMR of **2g**

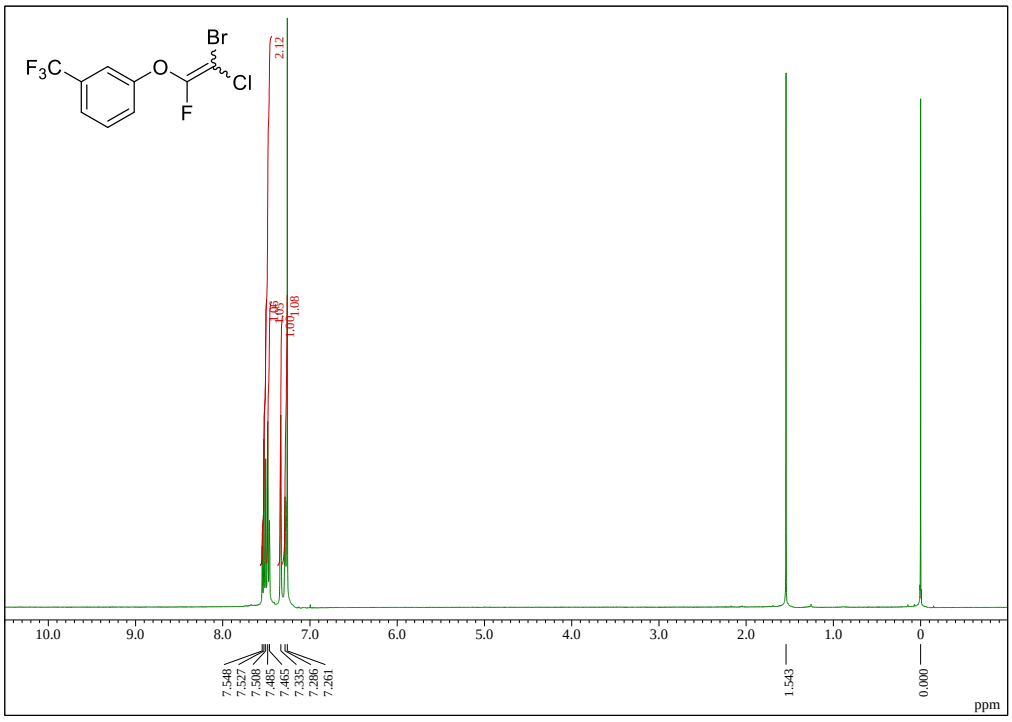


^{19}F NMR of **2g**

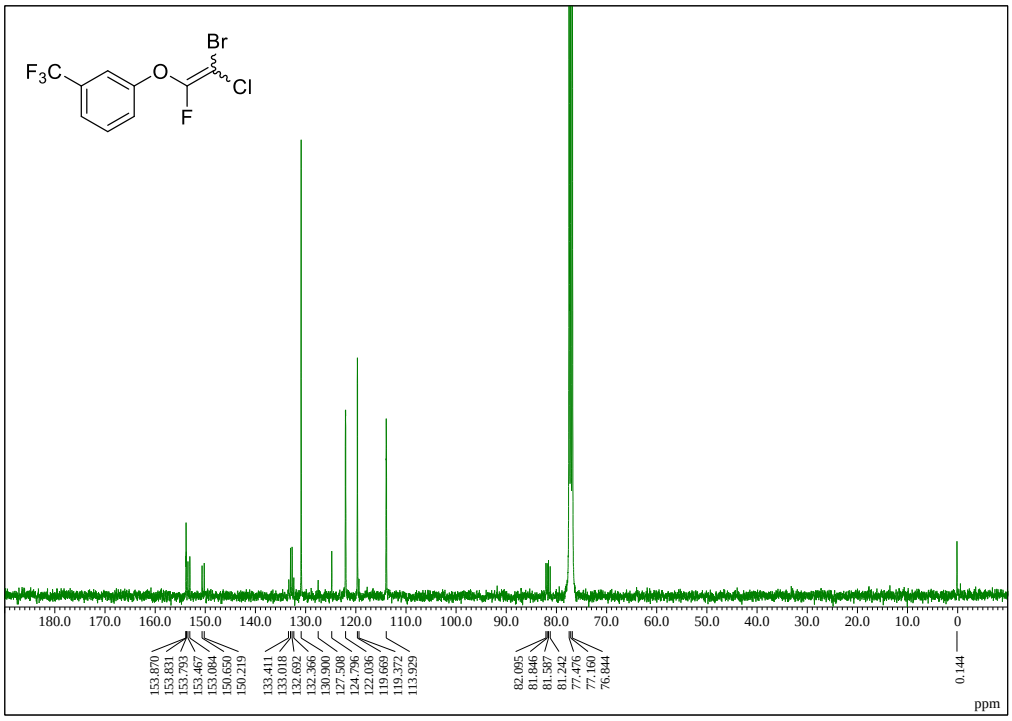


2-Bromo-2-chloro-1-fluoroethenyl *m*-trifluoromethylphenyl ether (2h)

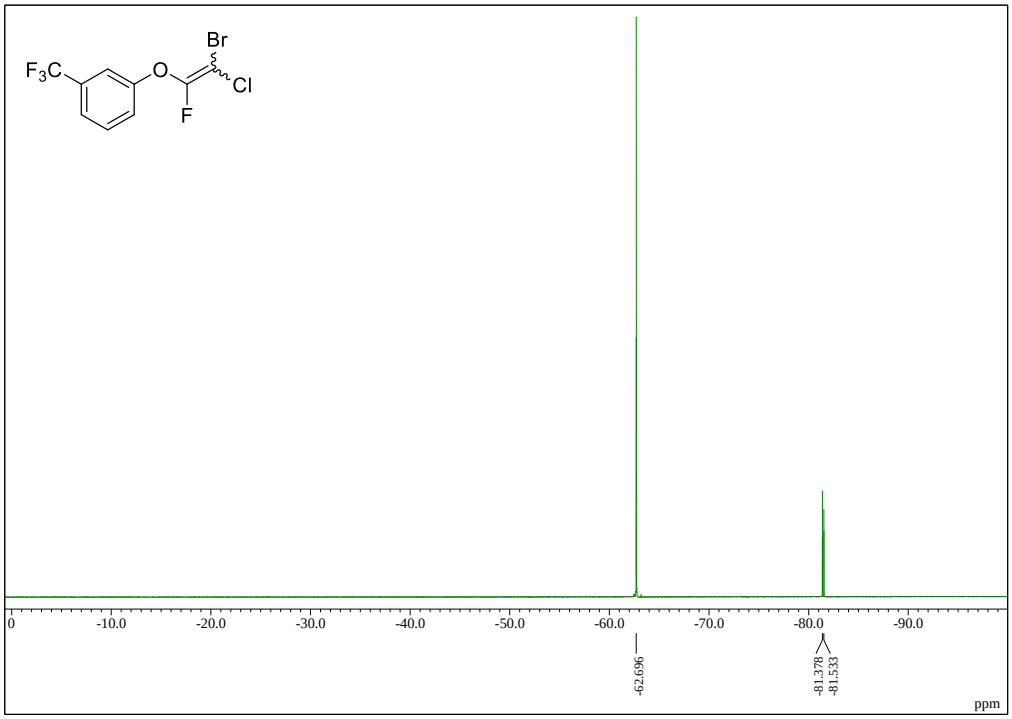
^{1}H NMR of **2h**



^{13}C NMR of **2h**

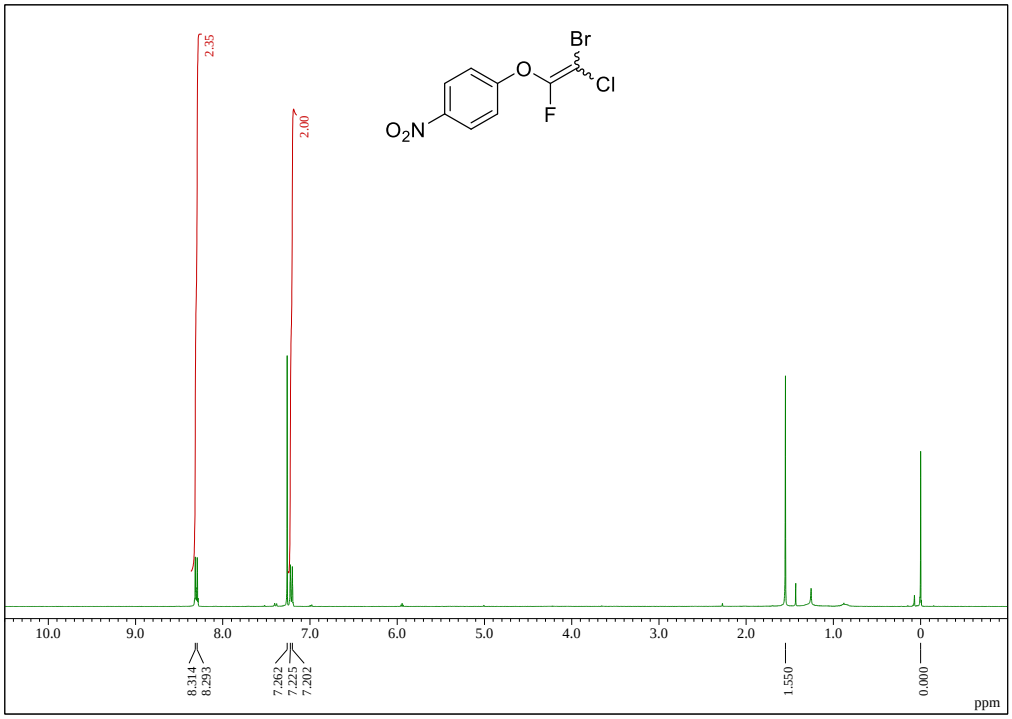


^{19}F NMR of **2h**

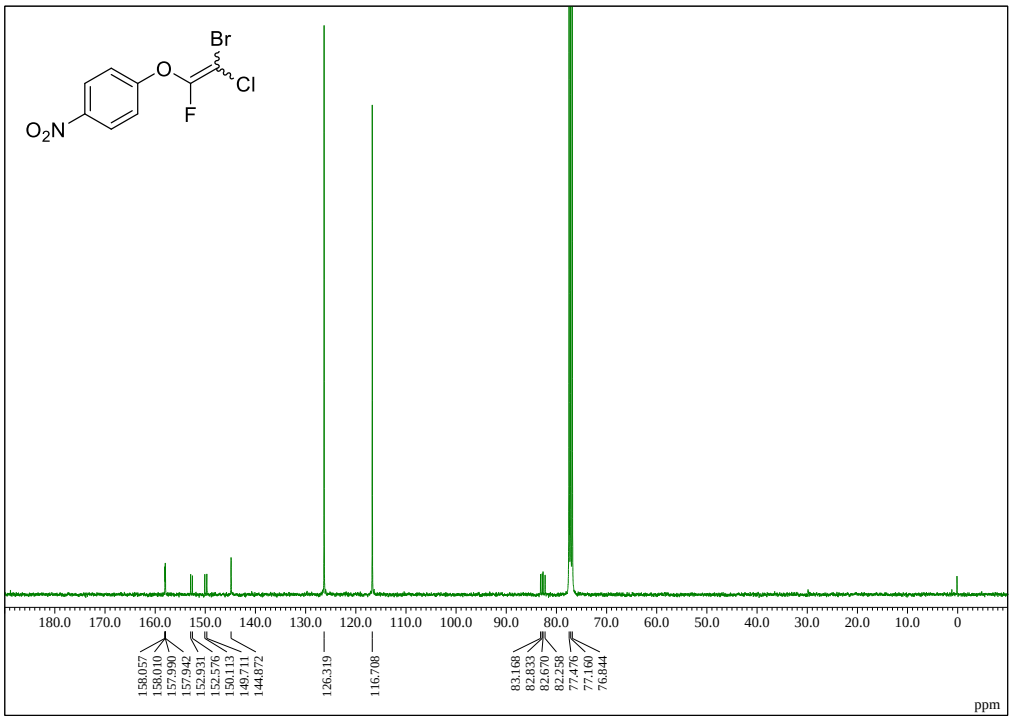


2-Bromo-2-chloro-1-fluoroethenyl *p*-nitrophenyl ether (2i)

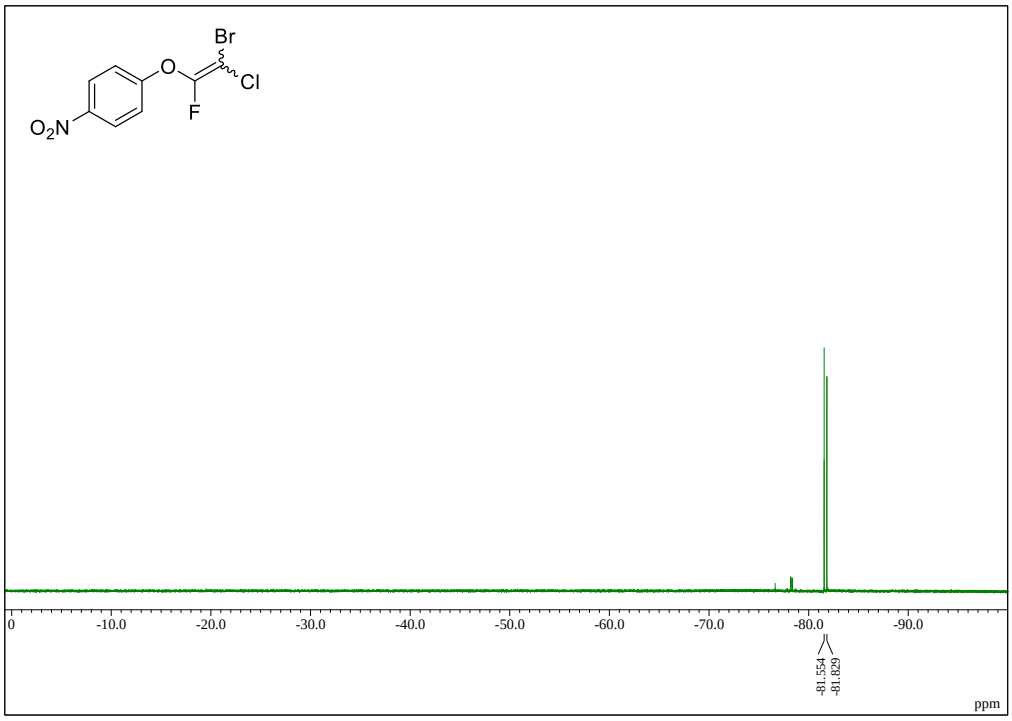
^{1}H NMR of **2i**



^{13}C NMR of **2i**

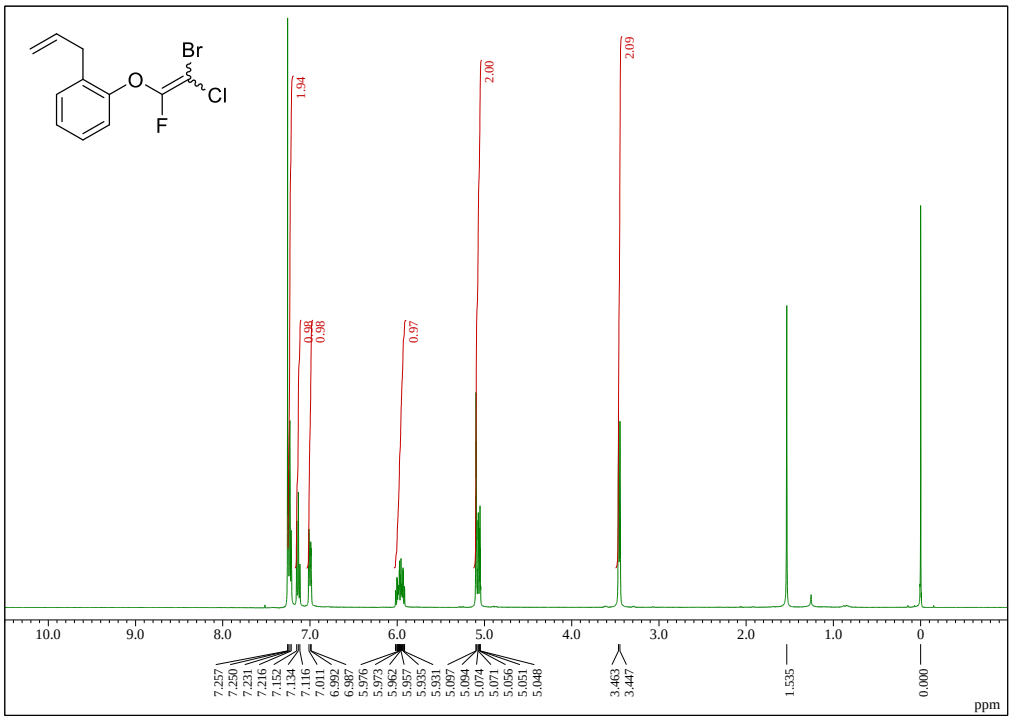


^{19}F NMR of **2i**

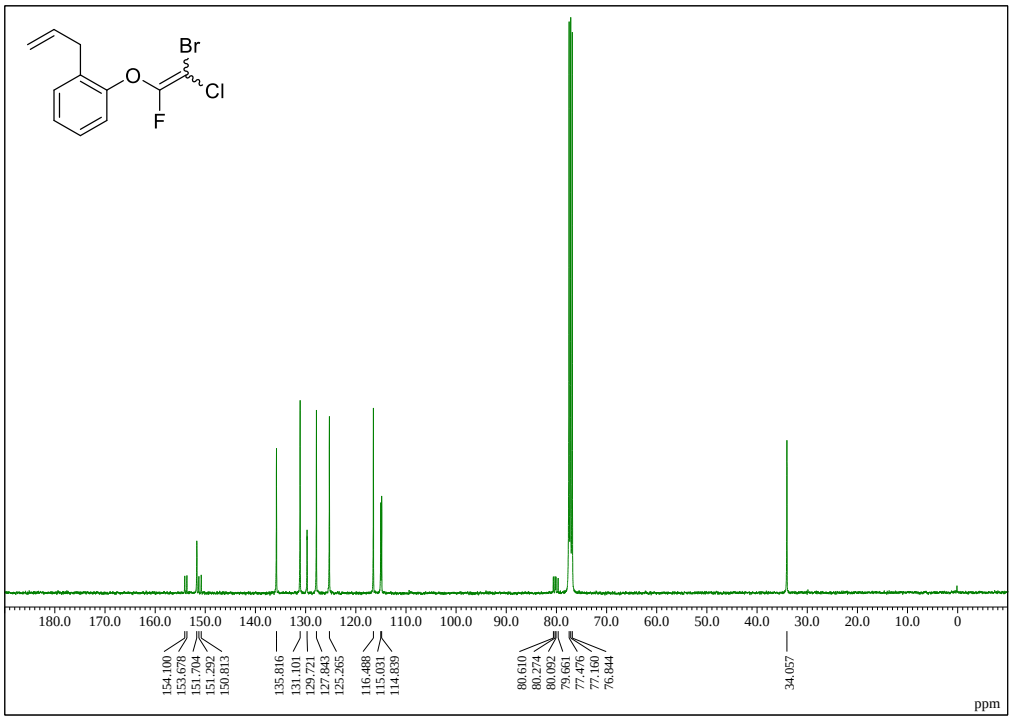


***o*-Allylphenyl 2-bromo-2-chloro-1-fluoroethenyl ether (2j)**

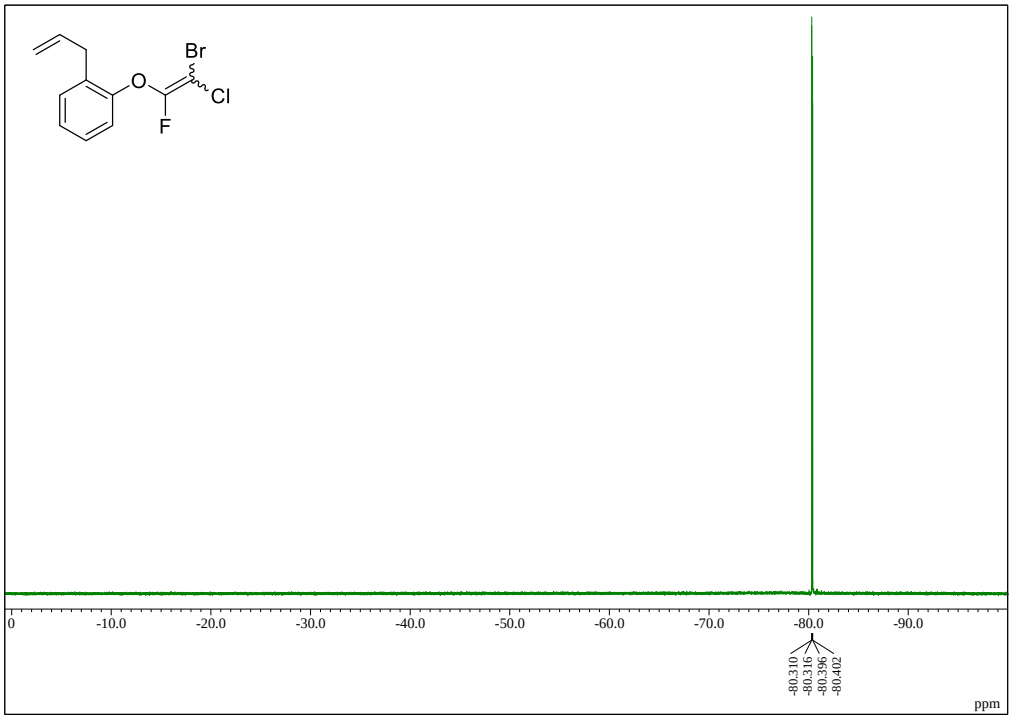
^{1}H NMR of **2j**



^{13}C NMR of **2j**

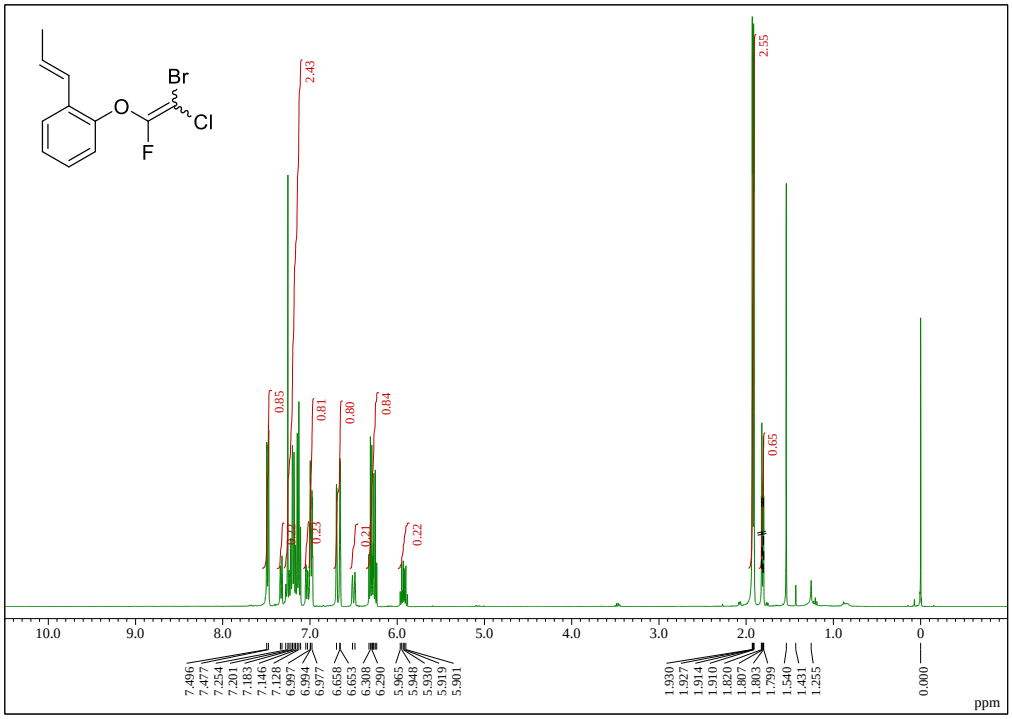


^{19}F NMR of **2j**

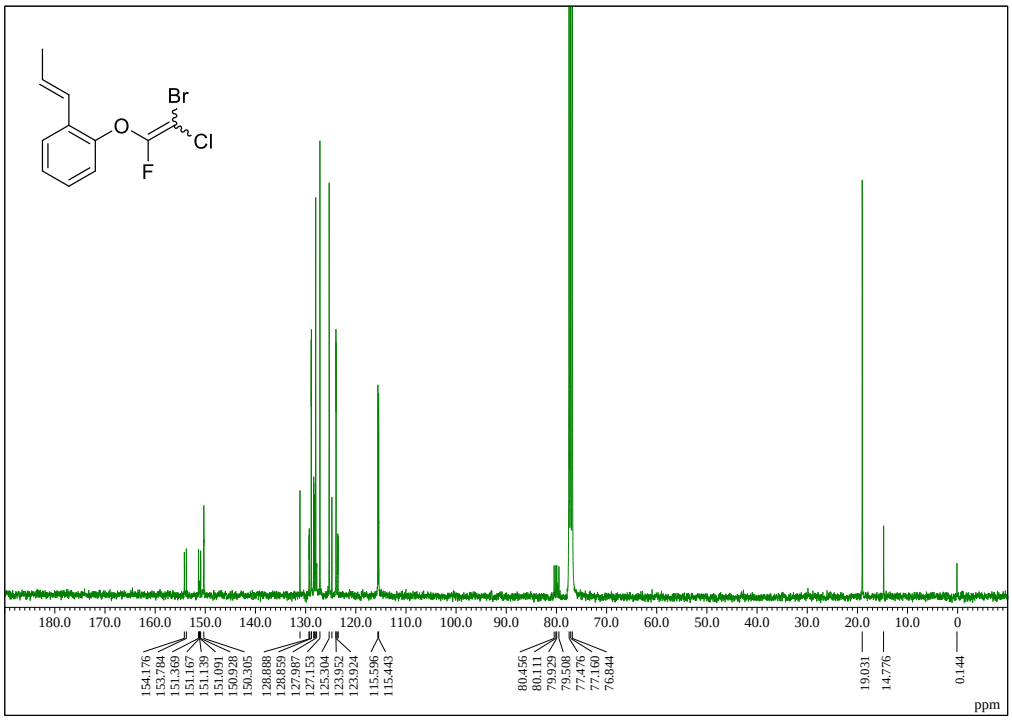


2-Bromo-2-chloro-1,1-difluoroethyl *o*-propenylphenyl ether (2k)

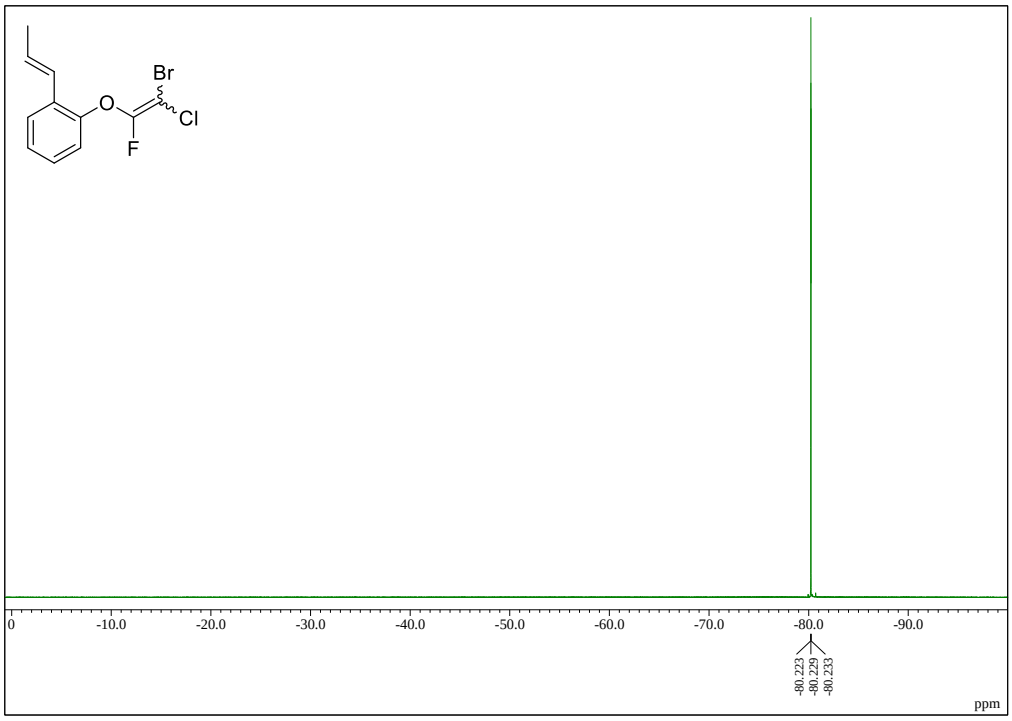
^{1}H NMR of **2k**



^{13}C NMR of **2k**

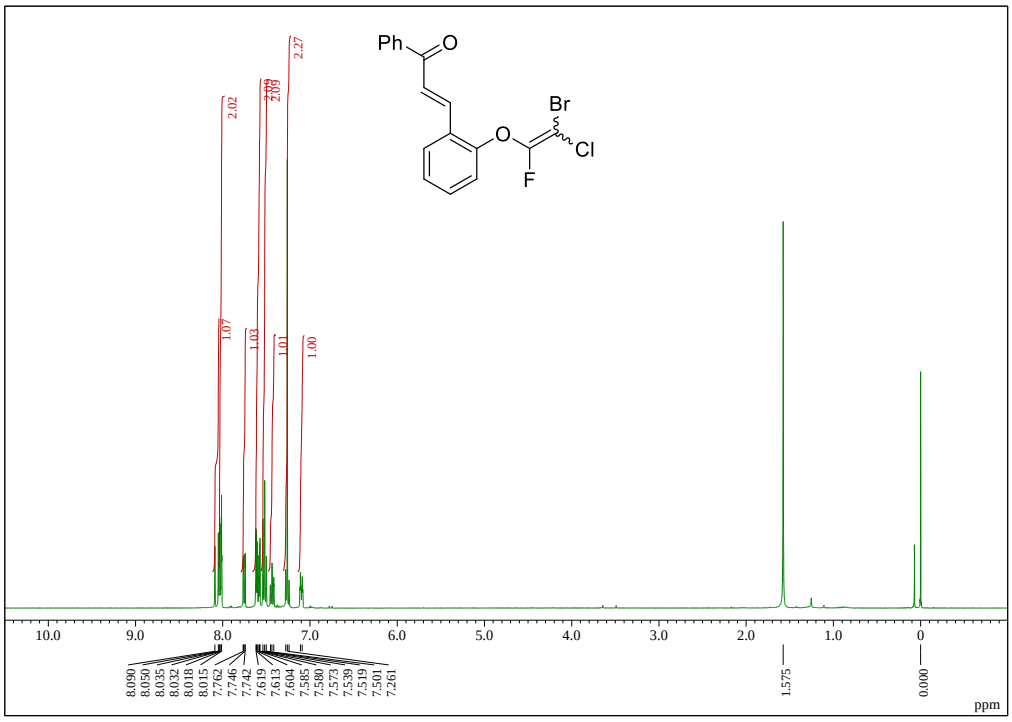


^{19}F NMR of **2k**

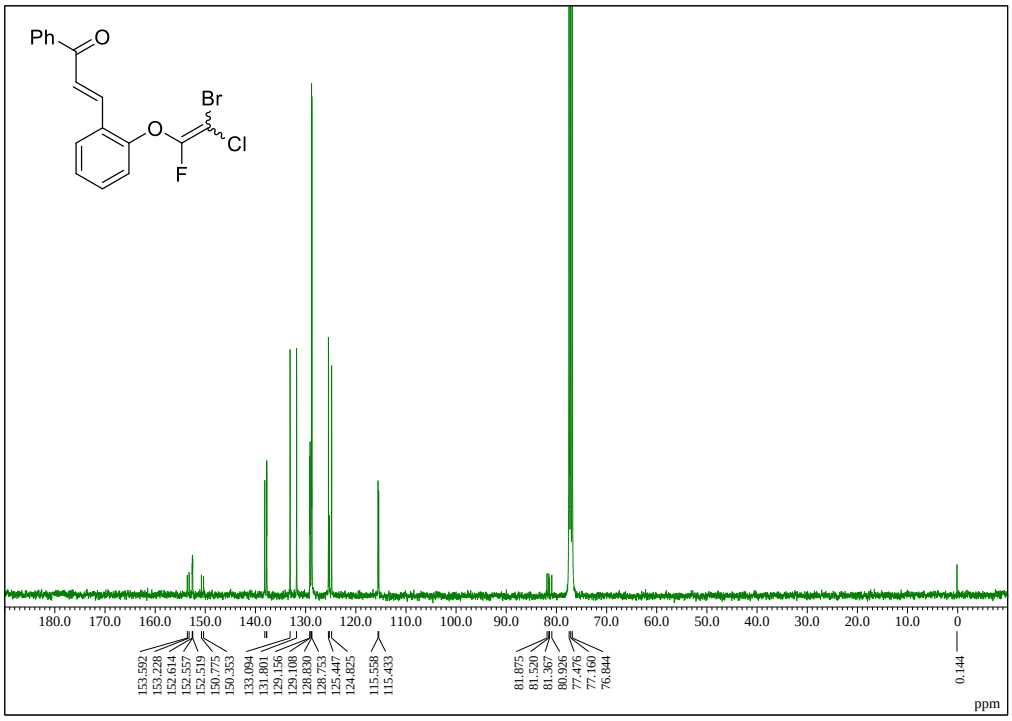


(*E*)-2'-(2-Bromo-2-chloro-1-fluoroethenyloxy)-chalcone (2l)

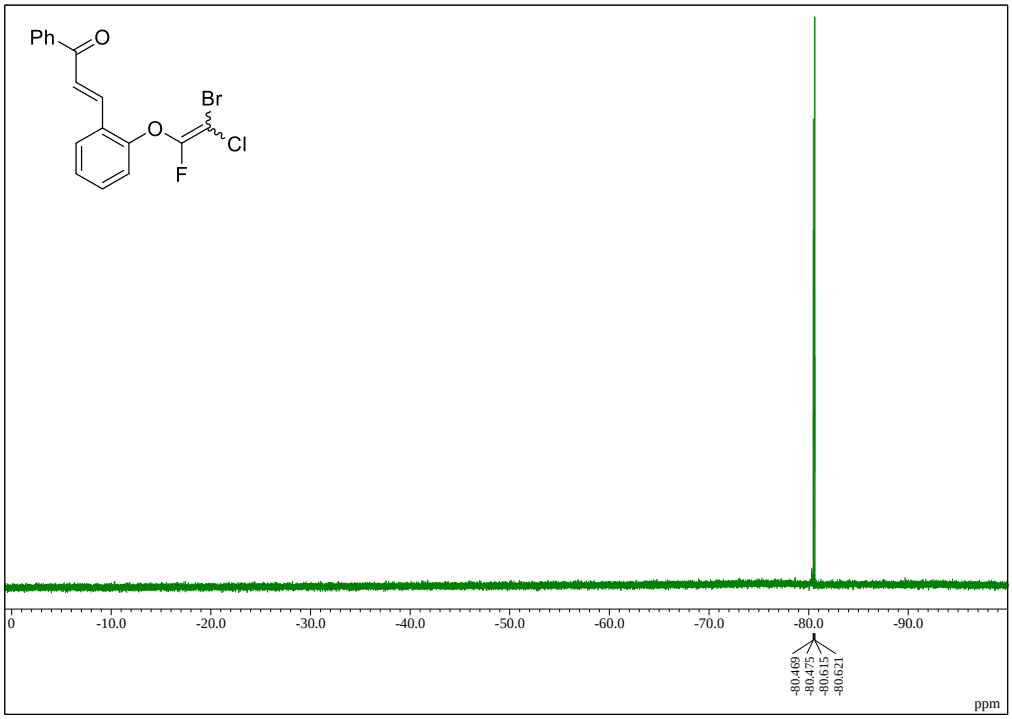
^{1}H NMR of **2l**



^{13}C NMR of **2l**

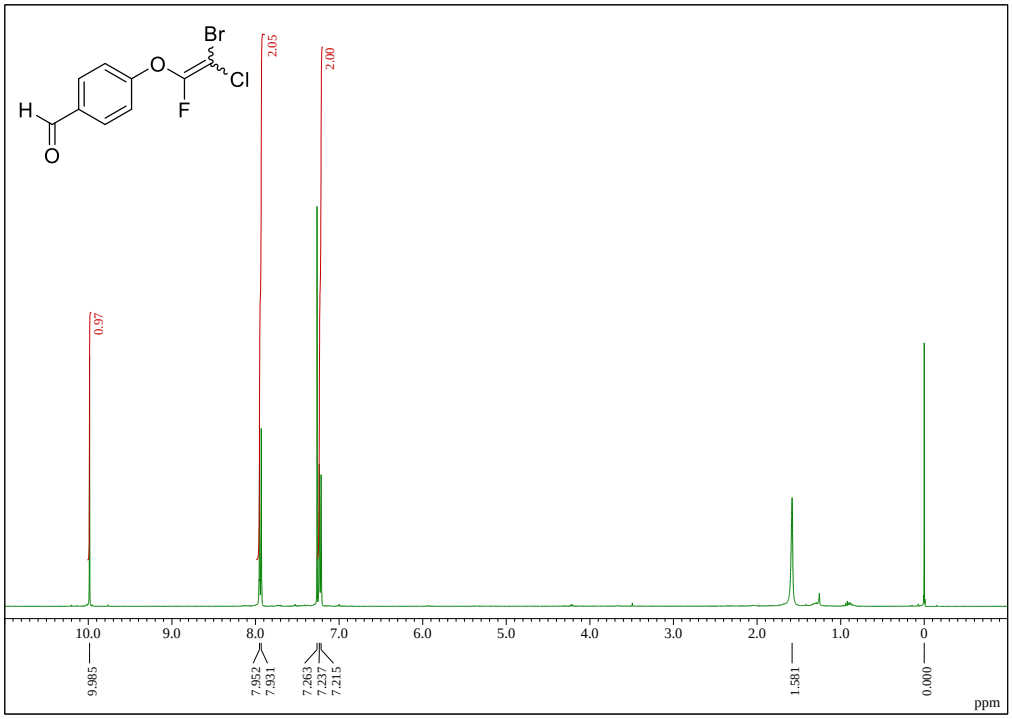


^{19}F NMR of **2l**

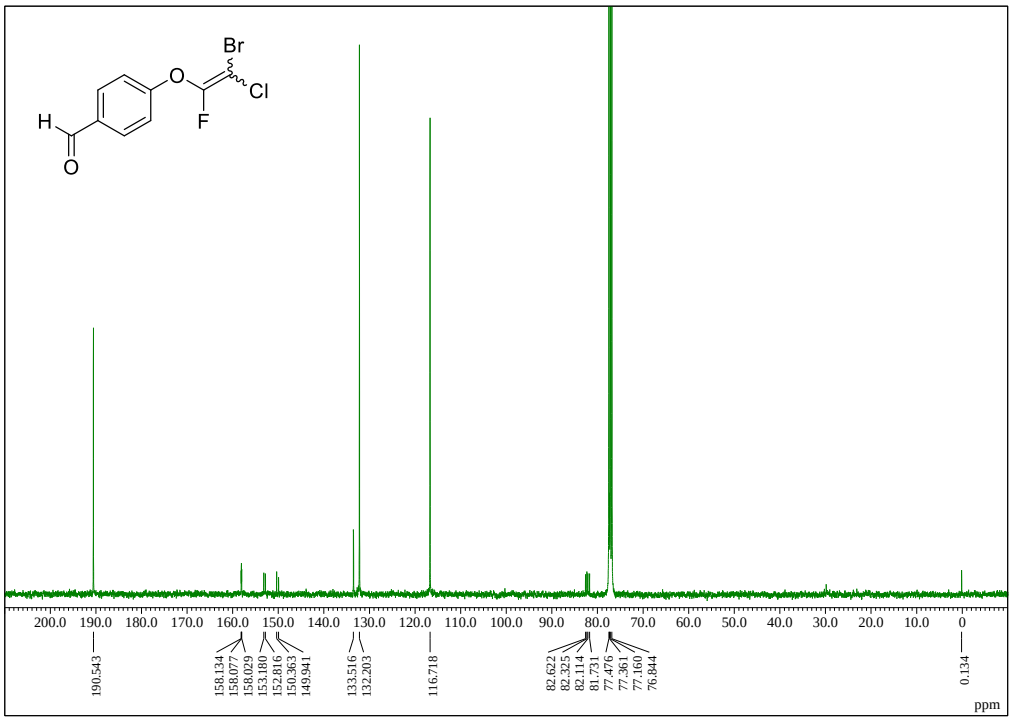


2-Bromo-2-chloro-1-fluoroethenyl *p*-formylphenyl ether (2m)

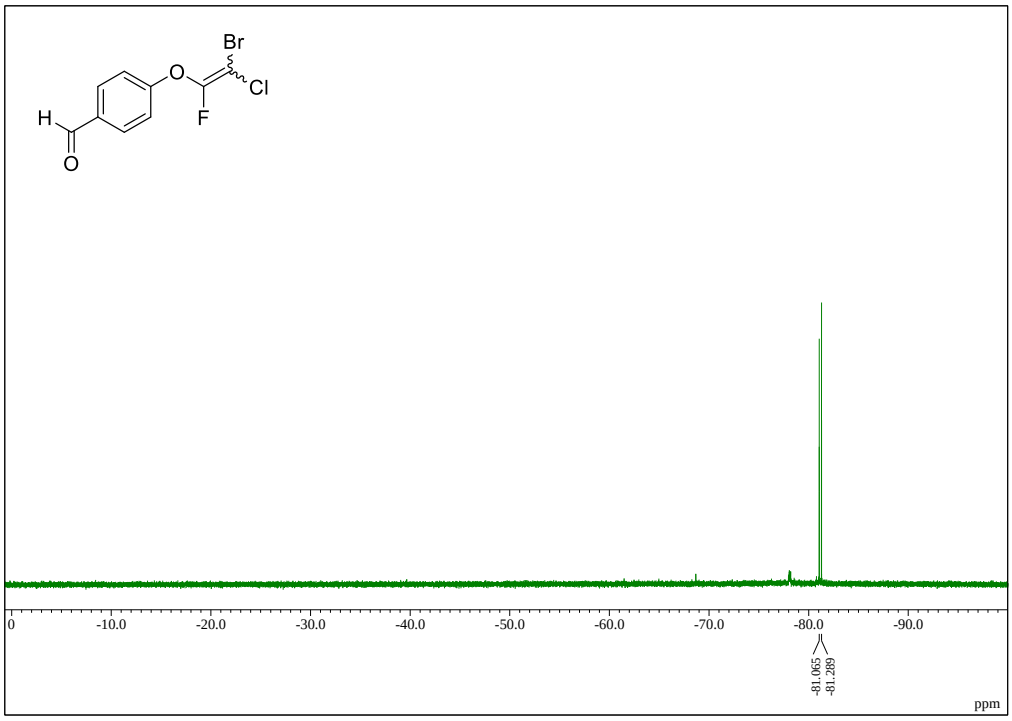
^{1}H NMR of **2m**



^{13}C NMR of **2m**

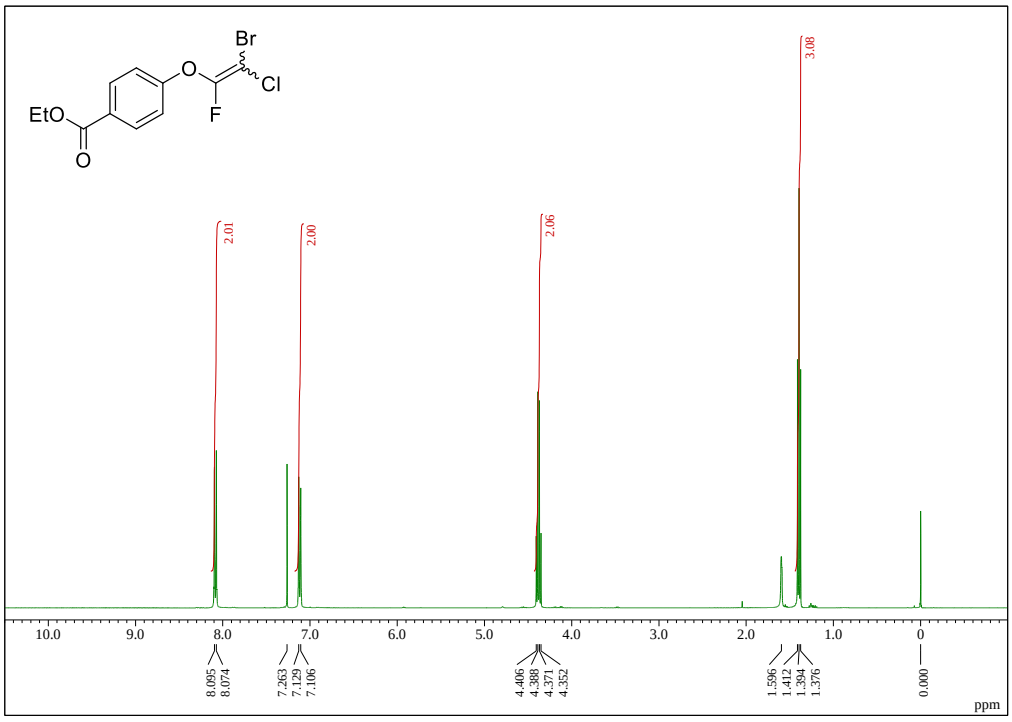


^{19}F NMR of **2m**

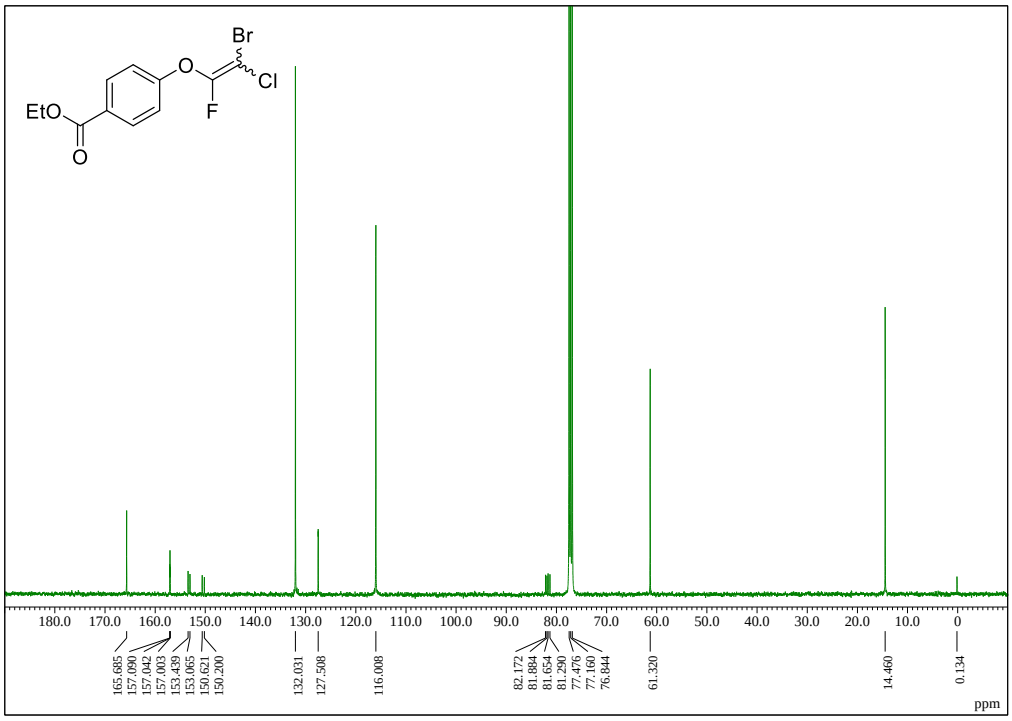


2-Bromo-2-chloro-1-fluoroethenyl *p*-ethoxycarbonylphenyl ether (2n)

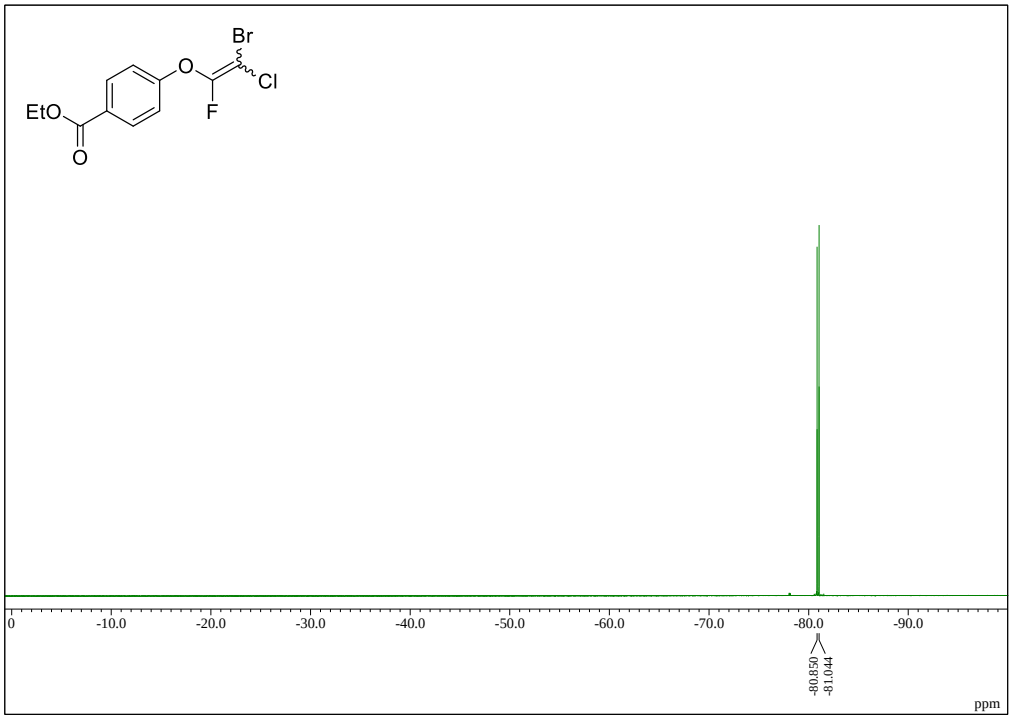
^{1}H NMR of **2n**



^{13}C NMR of **2n**

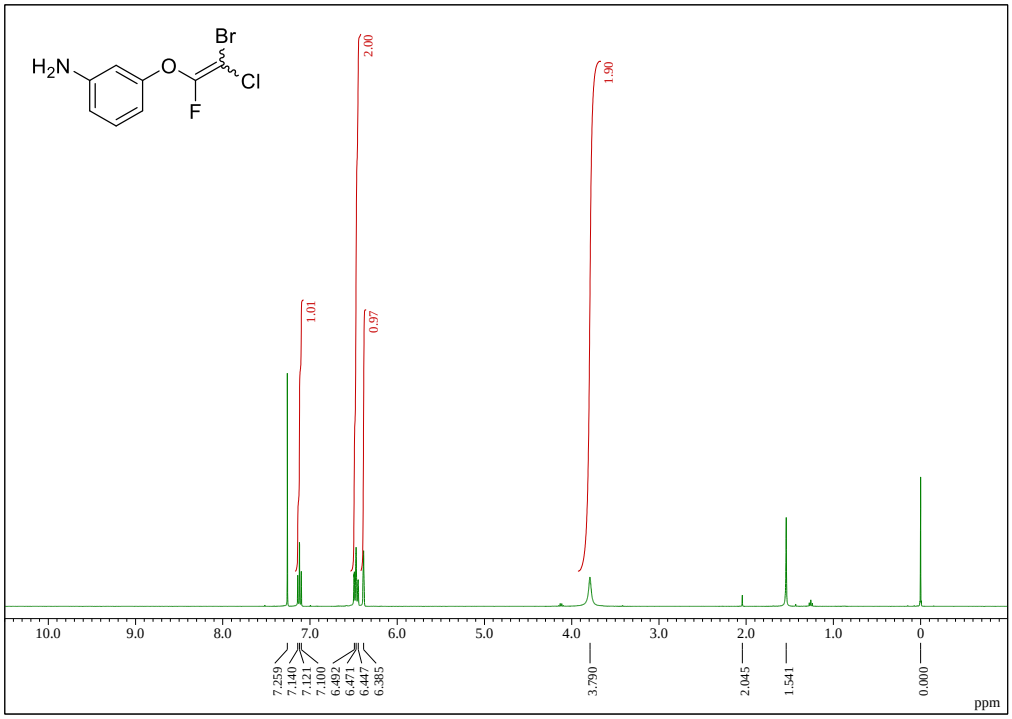


^{19}F NMR of **2n**

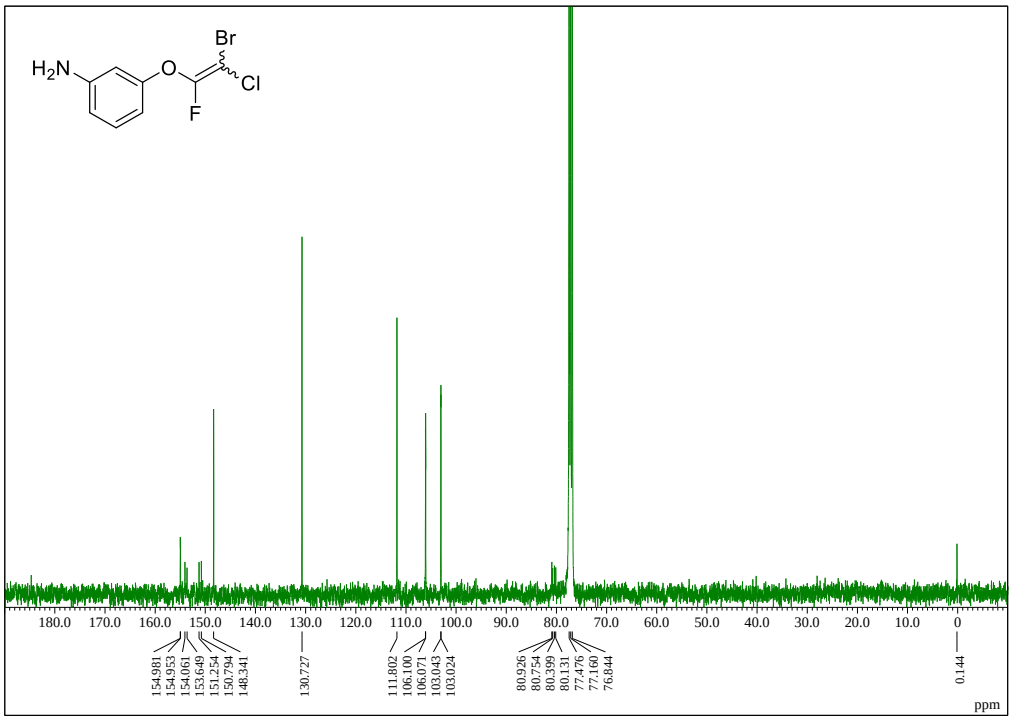


***m*-Aminophenyl 2-bromo-2-chloro-1-fluoroethenyl ether (2o)**

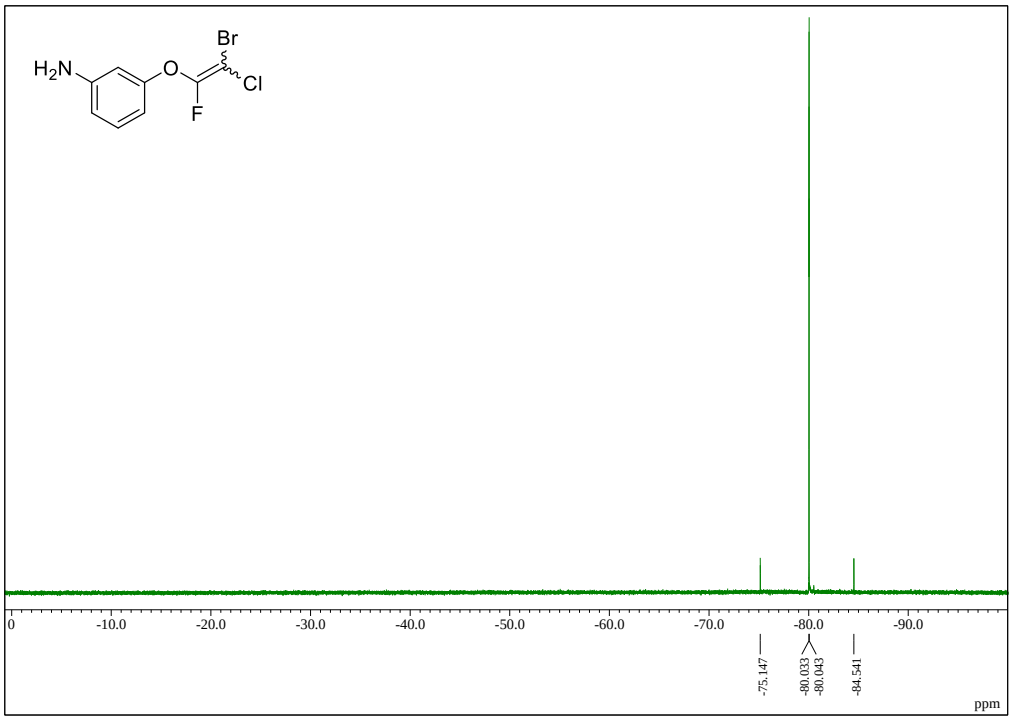
^{1}H NMR of **2o**



^{13}C NMR of **2o**

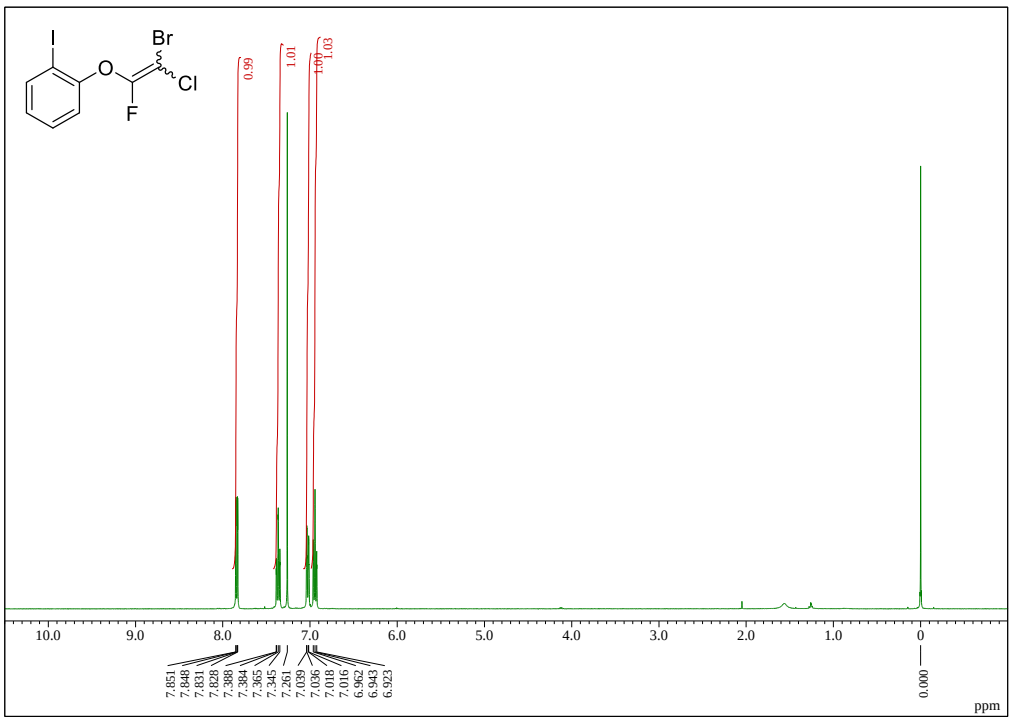


^{19}F NMR of **2o**

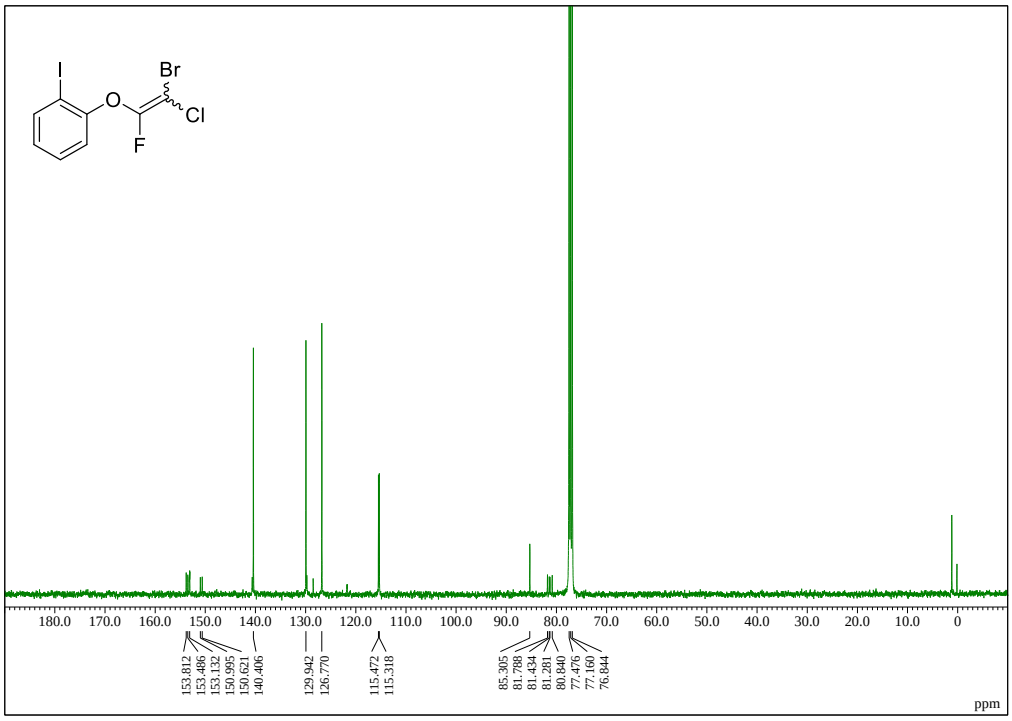


2-Bromo-2-chloro-1-fluoroethenyl *o*-iodophenyl ether (2p)

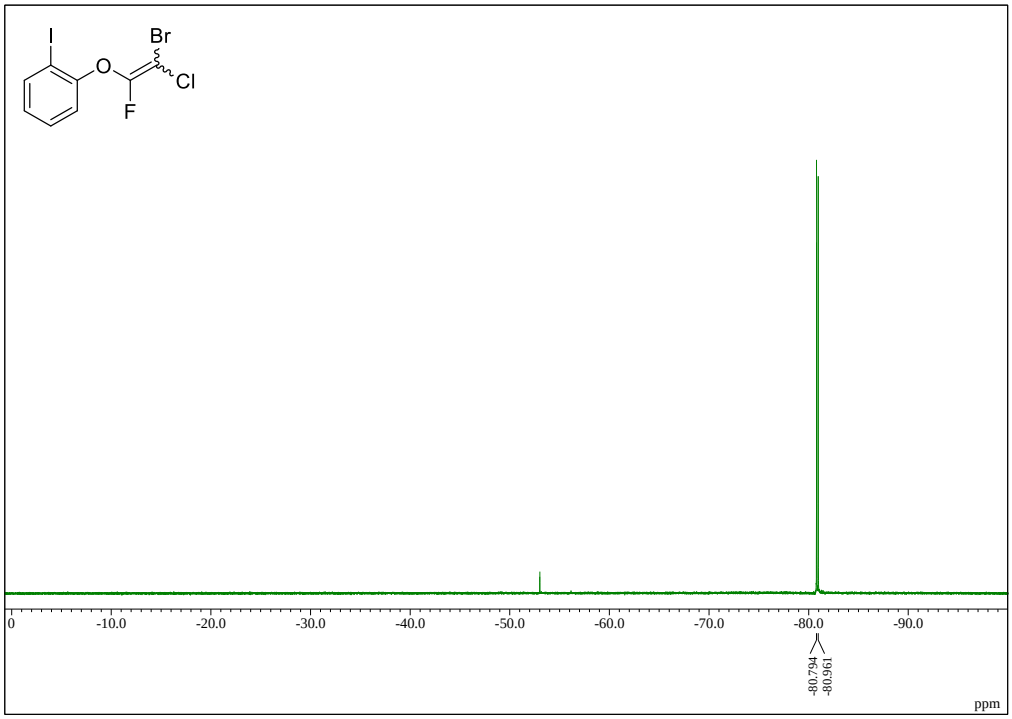
^{1}H NMR of **2p**



^{13}C NMR of **2p**

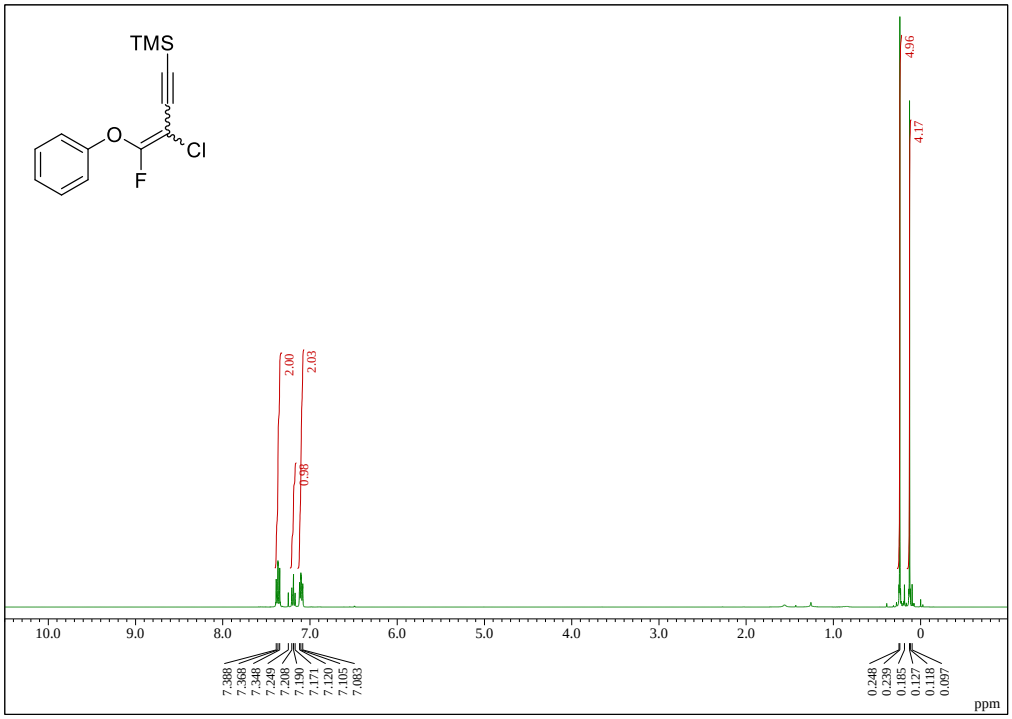


^{19}F NMR of **2p**

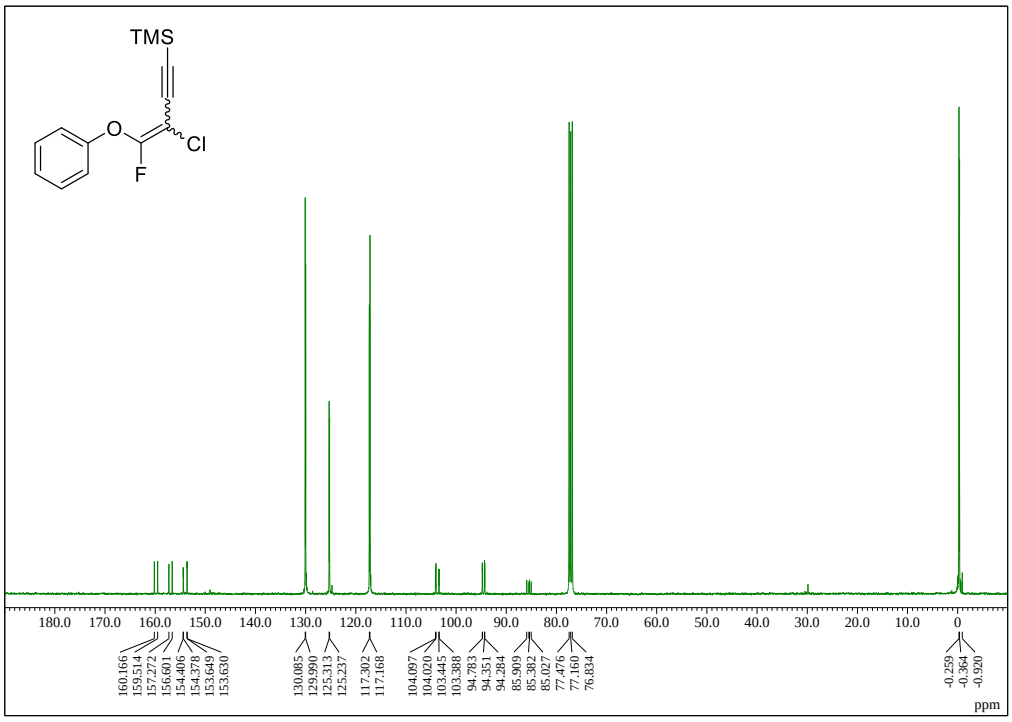


(3-chloro-4-fluoro-4-phenoxybut-3-en-1-yn-1-yl)trimethylsilane (7)

^{1}H NMR of **7**



^{13}C NMR of **7**



^{19}F NMR of **7**